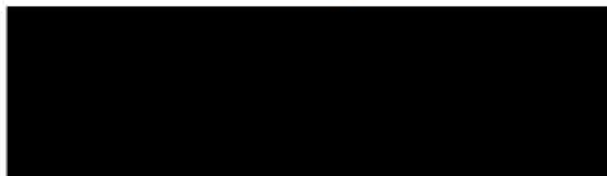


BO-Postbus 9101 | 6700 HB Wageningen

UITSLUITEND PER E-MAILGeachte ,

Op 10 april jl. heeft Wageningen University uw verzoek om informatie ontvangen. U vraagt om openbaarmaking van documenten die betrekking hebben op het onderzoek op de Veluwe waarbij jonge raven van gps-zenders zijn voorzien. In het bijzonder verzoekt u om documenten die betrekking hebben op de samenhang tussen dit onderzoek en de aanwezigheid, ecologische rol, monitoring en de beleidsmatige betekenis van wolven. Uw verzoek ziet op de periode van 1 januari 2021 tot de datum van indiening van uw verzoek. Een uitgebreide omschrijving van de documenten die u wenst te ontvangen is opgenomen in het eerste deelbesluit op uw verzoek dat u op 19 juni jl. ontving. Dat besluit betrof een eerste selectie documenten die binnen de reikwijdte van uw verzoek vallen.

Dit deelbesluit is het tweede deelbesluit op uw verzoek en heeft betrekking op het tweede deel van documenten die binnen de reikwijdte van uw verzoek vallen.

Behandeling van uw verzoek

In het eerste deelbesluit hebben we de behandeling van uw verzoek om informatie reeds grotendeels beschreven. Zoals u bekend hebben wij uitvraag gedaan bij verschillende organisatieonderdelen van Wageningen University, waaronder het universiteitsblad 'Resource', de leerstoelgroep Gedragsecologie, de leerstoelgroep Wildlife Ecology en Beheer, de afdeling Corporate Communications & Marketing en de decentrale communicatie-afdeling, waarbij om documenten en communicatie-uitingen is verzocht zoals geformuleerd in uw verzoek en is benadrukt dat alle documenten die ook maar enigszins verband houden met het betreffende onderzoek relevant kunnen zijn. Ook is uitvraag gedaan bij het centraal en decentraal archief, waarbij gebruik gemaakt is van de volgende zoektermen: 'raaf', 'raven', 'wolfbird', 'wolfbirds'.

Bij de zoekslag zijn verschillende documenten geïnventariseerd die binnen de reikwijdte van uw Woo-verzoek vallen.

Besluit

Het college van bestuur van Wageningen University besluit uw verzoek om informatie te honoreren. Hierbij nemen wij de kaders van de Wet open overheid ('Woo') in acht. Dit betekent dat wij de door u verzochte documenten verstrekken indien en voor zover Wageningen University die informatie onder zich geeft en indien en voor zover de uitzonderingsgronden van de Woo zich niet tegen openbaarmaking van deze informatie verzetten. Wij hebben in de betreffende documenten aangegeven op welke grond wij eventueel informatie hebben afgeschermd. U vindt de inventarislijst als bijlage bij dit besluit.

Wageningen
UniversityDATUM
16 juli 2026ONDERWERP
Besluit op uw Woo-verzoekONZE REFERENTIE
2615219POSTADRES
Postbus 9101
6700 HB WageningenBEZOEKADES
Wageningen Campus
Gebouw 104
Droevendaalsesteeg
6708 PB WageningenINTERNET
www.wur.nl/universityKUK NUMBER
09215846CONTACTPERSOON
E-MAIL
woo@wur.nl

Overwegingen

Wageningen University hecht veel waarde aan het algemeen belang van openbaarheid van publieke informatie voor de democratische samenleving. Dat belang dient op grond van de Woo afgewogen te worden tegenover de andere belangen die in de uitzonderingsgronden en in andere toepasselijke wetgeving zijn beschreven, waaronder het fundamentele recht op onderwijs en het daaruit voortvloeiende belang om een veilige leeromgeving aan studenten te bieden.

DATUM
XX juli 2026

PAGINA
2 van 3

Zoals wij per e-mail met u hebben gedeeld, is een aantal studenten van Wageningen University en andere onderwijsinstellingen betrokken geweest bij het onderzoek dat centraal staat in uw Woo-verzoek. Wageningen University besluit in het licht van het voorgaande om documenten die betrekking hebben op de opleiding van de studenten niet openbaar te maken. Dit zijn stukken met als primaire strekking het begeleiden en beoordelen van (het werk van) studenten en deze stukken bevatten een bespreking van de vaardigheden van de studenten en een didactische beoordeling van de kwaliteit van het werk. Voor zover die documenten niet reeds buiten de scope van het Woo-verzoek vallen, doorkruist de openbaarmaking het goed functioneren van Wageningen University als onderwijsinstelling en weigert Wageningen University die documenten openbaar te maken onder verwijzing naar artikel 5.2, lid 2 sub i van de Woo.

De definitieve eindproducten van de studenten maakt Wageningen University wel openbaar. Wageningen University hecht er wel waarde aan te benadrukken dat de theses van studenten leerdocumenten zijn die uitsluitend dienen ter beoordeling van de kennis en vaardigheden van de student en geen wetenschappelijke publicaties van de universiteit. Om die reden besluit Wageningen University om deze producties bij de openbaarmaking te voorzien van een disclaimer.

Verwijzing naar reeds openbare documenten

Bij de zoekslag zijn ook documenten geïnventariseerd die reeds openbaar zijn. Het college van bestuur van Wageningen University is niet gehouden om deze documenten nogmaals openbaar te maken, maar verwijst u graag naar de vindplekken conform artikel 4.5 lid 2 Woo. U vindt de links naar de digitale stukken onderaan de inventarislijst

Toepassing van de uitzonderingsgronden

In de verstrekte documenten zijn gegevens die te herleiden zijn naar individuele medewerkers, zoals namen en telefoonnummers, geredigeerd op grond van artikel 5.1 lid 2 sub e Woo. De openbaarmaking van deze gegevens weegt niet op tegen het belang van de eerbiediging van de persoonlijke levenssfeer van de betrokken personen.

In een aantal verstrekte documenten is tevens toepassing gegeven aan artikel 5.1 lid 2 sub h Woo. De openbaarmaking van deze gegevens weegt niet op tegen het belang van het voorkomen van gerichte sabotage. Deze grond is in de stukken toegepast waar het gaat om specifieke locaties van raven(nesten) en wildcamera's. Daarbij laten wij in het bijzonder meewegen dat openbaarmaking van die exacte gegevens tot veiligheidsrisico's kan leiden voor het milieu en de leefomgeving van beschermde diersoorten en tot sabotage aan onderzoeksmaterialen.

Daarnaast is een aantal keer in stukken toepassing gegeven aan artikel 5.1 lid 2 sub f Woo waar de openbaarmaking van de informatie niet opweegt tegen de bescherming van concurrentiegevoelige gegevens. In de specifieke gevallen gaat het om accountinformatie die bij openbaarmaking de belangen van de betrokken organisaties en het project kunnen schaden.

Tot slot is artikel 5.1, lid 2 sub i Woo toegepast in de documenten waarbij het goed functioneren van Wageningen University als onderwijsinstelling zwaarder weegt dan het belang van openbaarmaking. Het gaat hier om informatie met als primaire strekking het begeleiden en beoordelen van (het werk van) studenten en deze stukken bevatten een bespreking van de vaardigheden van de studenten en een didactische beoordeling van de kwaliteit van het werk. De overige informatie in die documenten maakt Wageningen University wel openbaar.

DATUM
XX juli 2026

PAGINA
3 van 3

Informatie en termijn voor bezwaar

Wij vertrouwen erop u hiermee voldoende te hebben geïnformeerd. Indien u vragen heeft over dit besluit kunt u contact opnemen met onze woordvoerder Vincent Koperdraat, via vincent.koperdraat@wur.nl.

U kunt binnen zes weken na de dag waarop dit besluit bekend is gemaakt een bezwaarschrift indienen. U dient in dat geval schriftelijk uw bezwaren te richten aan het college van bestuur van Wageningen University, Postbus 9101, 6700 HB Wageningen, dan wel per e-mail gericht aan woo@wur.nl.

[Redacted]
Hoogachtend,

[Redacted]
Dr.ir. S. Helmoaara
voorzitter college van bestuur
Wageningen University

Bijlage 1 - Inventarislijst

Nummer	Type*	Titel document
<i>(Nummering loopt door vanaf de stukken van het eerste deelbesluit)</i>		
22		Final report from grant Dobberke foundation
23		Dobberke Grant 2023
24		Potentiele locaties raaf De veluwe_ dec '22 <i>(bijlage bij 1)</i>
25		Re interview nav Dobberke Beurs
25a		Interview-dobberke-beurs-voorstel
25b		Interview-dobberke-beurs-voorstel
26		OrniTrack_user_manual
27		Scripts overview
28		2210958- GLO ARK WU-DES 24-5-2022
29		Artikel Raven Natura_0422
30		Thesis_1
31		Thesis_2
32		Thesis_3
33		FW_ Dobberke application
33a.		Ornitela_Invoice_ORN_Nr_23183
34		FW_ Dobberke Beurs.Resource
34a		210427 3 jongen ww 1x zenderen.jpg
34b		210530 H27 vliegend met zender_foto.jpg
34c		220519_zenderen
34d		IMG-20220519-2022 nest met gezenderde jongen
35		Vragen_interview_Dobberke_Beurs
36		2.0 Application Form Dobberke Grant_Social behaviour of Ravens (Corvus corax) on the Veluwe
37		RE_ Dobberke application
38		FW: yes! ravenonderzoek in nederland
39		RE_Subsidie projectmaterialen
40		FW_ ter check_ artikeltje Resource
40a		Raven_nwsbrf WUR_red_opm
41		RE_Ethogram in Agouti en Boris
41a		Ethogram DDL Veluwe ARK en WUR - concept
42		FW_ BTW factuur buitenland
42a		Ornitela_Invoice_ORN_Nr_24238
43		Fw_Fw_ OrniTrack-E25 4G black housing for raven project Netherlands
44		FW_Landelijke dag SOVON 2025
45		FW_ overzicht kosten data portaal en zenderen 2025
46		FW_ Send data to MoveBank

47		Overleg projectfinanciering zenderen van raven 28 feb 2023
48		Overleg raven zenderen 2023 13 maart 2023
49		Instructie Vrijwilligers
50		Final presentation
51		Raven GPS
52		Raven_red
53		RE_ Datumprikkers raven zenderen
54		RE_FW_ Interessant paper!
55		Re_FW_Raven in BinnensteBuiten
56		RE_Send data to Movebank
57		191222 Wolf en Raaf - ARK WUR SOVON en Ravenwerkgroep
58		Article Final BSc Thesis
59		Research proposal presentatie
60		RE_ Master studenten raven data.pdf
61		Thesis_4
62		Internship report
63		EndColloquium
	RO	Ravenwerkgroep NL Corvus corax rapportage raven
	RO	Raven-onderzoek verbreed dankzij beurs - Resource online
	RO	Onderzoek over wadvogels en raven ontvangen financiering van de Dobberke Stichting - KNAW
	RO	Nature Today Wolfenvogels op de Veluwe
	RO	Frontiers Scavengers use natural and anthropogenic resources connecting protected areas with surrounding lands
	RO	GPS tracking of non-breeding ravens reveals the importance of anthropogenic food sources during their dispersal in the Eastern Alps Current Zoology Oxford Academic
	RO	Fission-fusion dynamics over large distances in raven non-breeders Scientific Reports
	RO	Common ravens, Corvus corax, preferentially associate with grey wolves, Canis lupus, as a foraging strategy in winter - ScienceDirect
	RO	Raven-onderzoek verbreed dankzij beurs - Resource online

* E = E-mail; B = Bijlage; P = Presentatie; N = Notitie; O = Overig; RO = verwijzing naar geïnventariseerde stukken die reeds openbaar zijn en te raadplegen via de opgenomen link

FORM FINAL REPORT GRANT DR. J.L. DOBBERKE FOUNDATION

Deadline

You must submit your final report within three months of the end date of the project.

More information?

Please contact [5.1.2e](#)

By email: wetenschapsfondsen@knaw.nl

TITLE OF RESEARCH PROJECT

Juvenile development of raven (*Corvus corax*) feeding preferences on the Veluwe

Starting date 1-1-2024

End date 1-1-2025

RECIPIENT'S PERSONAL DETAILS

Name 5.1.2e

Dossier number (see award letter) Dobberke/2349/20237313

Account number (IBAN): NL61ABNA0539509388 *Do not use a private bank account number*

Name and address of account holder Name: WUR; Address: Postbus 338, 6700 AH Wageningen

FINANCIAL ACCOUNT

List the most important expenses with reference to the budget in your funding request. The amount you receive will be based on your expense statement and will not exceed the amount referred to in the award letter. Please add copies of invoices.

Ornitrack-E25B 4G transmitter	€	<u>5450.00</u>	5 pieces X 1090.00
Insured shipping and handling	€	<u>75.00</u>	Total = 85.00 – 10.00 euro from other sources
	€	<u></u>	
	€	<u></u>	
Total	€	<u>5525.00</u>	

BRIEF REPORT ON CONTENT OF RESEARCH PROJECT

Give a brief description of the purpose of your research project, the methods used and the conclusions/results (max. 500 words)

Ravens are highly adaptable generalist feeders, showing individual differences in their dietary preferences—ranging from mostly natural to primarily anthropogenic food sources. However, how these preferences develop remains largely unknown. Due to their cognitive complexity and neophobia, ravens likely rely heavily on social information, both from their parents and later from other conspecifics in communal roosts. This study aimed to investigate the role of the social environment in shaping the feeding behaviour of juvenile ravens, focusing on the effects of early-life exposure.

We attached five GPS/Accelerometer devices (Ornitrack-E25B 4G), made possible by the Dobberke Foundation, to complement an existing dataset of GPS-tracked juvenile ravens on the Veluwe (N = 21, median tracking duration = 167 days; 14 individuals tracked past independence at 180 days). This builds on an existing project (since 2021), originally designed to examine raven-wolf interactions, involving Ravenwerkgroep, ARK Natuurontwikkeling, Sovon, and Staatsbosbeheer. Our research now shifts the focus toward the development of



feeding preferences in juvenile ravens, taking advantage of this rare opportunity to track individuals from fledging through independence.

Specifically, the OrniTrack-25 devices, solar-powered and GSM-connected, weigh under 3% of a healthy juvenile raven's body weight. Each harness is fitted to the bird to prevent hindrance or detachment. Selection criteria include weight, appearance, and behaviour, with one or two nestlings per nest chosen. Device attachment accompanies routine colour ringing procedures to reduce disturbance. In a recent statistical comparison of resighting data for GPS-tagged versus ring-only birds from similar conditions, we showed no negative effects, supporting the method's safety and reliability. The new devices are also barometer-equipped. By combining barometer data, accelerometer data, and GPS spatial clustering, we can detect ground-based foraging events with even greater accuracy.

In spring 2024, we deployed three of the five planned devices. Due to poor breeding success—likely caused by a wet spring—many juveniles were in too poor a condition to tag. Fortunately, breeding conditions improved significantly in 2025, allowing deployment of the remaining units. We are still in the process of collecting spatial data until after the latest tagged juveniles reach independence (approx. >180 days of hatching). This we will use to test our main hypothesis that juvenile ravens exposed to anthropogenic food by their parents (in the dependent phase) will more readily and frequently use these sources after independence (Figure 1). Thus, to be continued...



Figure 1. shows a tagged fledgling in a 2025 nest (©5.1.2e [redacted]) and six-day GPS tracks from two ravens (19-06-2025). Yellow was tagged in spring 2024 (independent) and green in spring 2025 (likely still dependent). The tracks nicely illustrate visits to 'Afvalverwerking Vink' in Barneveld (yellow pin)—highlighting the importance of anthropogenic resources in the foraging ecology of Dutch ravens on the Veluwe. Recently, the ravens in Barneveld also made an appearance on national tv: [BinnensteBuiten Video](#)

RECIPIENT'S SIGNATURE

5.1.2e [redacted]

Name

5.1.2e [redacted]

City and date

Wageningen, 23-06-2025

SUBMISSION AND ENCLOSURES

E-mail this form and the relevant attachments (copies of invoices) to wetenschapsfondsen@knaw.nl



KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN

5.1.2e
5.1.2e @wur.nl
By E-mail

Amsterdam, 1 December 2023
Reference: Dobberke/2349/20237313
Subject: Dr J.L. Dobberke Foundation

Foundation name Dr J.L. Dobberke Foundation
Contact: 5.1.2e
E-mail: 5.1.2e @knaw.nl

Dear 5.1.2e,

You recently submitted an application for a financial contribution from the Dr. J.L. Dobberke Foundation for your research project with the title: *Juvenile development of raven (Corvus corax) feeding preferences on the Veluwe*. Your application has now been reviewed the Board of the Dr. J.L. Dobberke Foundation and we are pleased to inform your application has been selected for funding. The Dobberke foundation will award you with a maximum of EUR 5.525.- for your project.

Please confirm your acceptance of the grant no later than 10 December 2023 by e-mail stating that you accept the grant. In your e-mail, please also give permission that your name and affiliation and the title of the awarded project will be published on the website of the KNAW. Please send this e-mail to the secretary of the Dr. J.L. Dobberke Foundation, 5.1.2e, at the e-mail address given above.

Note that by accepting the grant, the recipient undertakes to comply with the conditions as set out in Appendix 1 to this letter. Note that the grant needs to be spent during the period you specified (1-1-2024/1-1-2025). Failure to comply with the conditions may result in your being required to repay some or all of the grant.

We wish you every success with your project,

Kind regards,
on behalf of the board of the Dr J.L. Dobberke Foundation,

5.1.2e

Chair of the Dr J.L. Dobberke Foundation



Conditions Dobberke Grant 2023 of the Dr. D.L. Dobberke Foundation

- 1 The Board of the Dr. D.L. Dobberke Foundation may decide to award part of the requested grant.
- 2 The Dobberke Grant has been awarded on the basis of the budget you have specified in your application. In the case that you are awarded other grants for the same purpose after being awarded the Dobberke Grant, you should state this in the final accountability, after which it will be assessed whether and to what extent the other grants will be deducted from the awarded grant.
- 3 The Dobberke Grant should be spent in the period specified in the grant letter.
- 4 If there are valid reasons for deviating from the approved budget or spending period, the recipient must submit a change request to the KNAW on time.
- 5 A maximum of one change request can be submitted during the course of the grant activities.
- 6 The recipient may request 100 percent of the awarded grant as an advance of the grant. This amount is earmarked and transferred to a bank account of a university in the Netherlands to which the recipient is affiliated.
- 7 This request cannot be made earlier than 1 month before the start of the grant activities.
- 8 Within three months after the grant activities have ended, the recipient should submit a final accountability to the KNAW by email. The final accountability consists of a report on the grant activities and a financial account. The form for the final accountability is available [on the website of the KNAW](#).
- 9 The KNAW determines the definite amount of the grant on the basis of the final accountability.
- 10 If the recipient does not submit the final accountability on time, the grant may be withdrawn by the KNAW and any advance payment may be reclaimed.
- 11 The grant can be reclaimed, up to 5 years after determination, if the KNAW has sufficient reasons to believe that the recipient and/or third parties engaged by the recipient have violated scientific standards in the application, implementation and or reporting of the grant activities. These standards are laid down in national and international documents, placed in the List of Basic Documents for Scientific Integrity, which is available [this website](#).
- 12 The recipient must state in all publicity communications and publications arising from the grant activities that the grant activities were made possible (in part) by the Dobberke Grant of the Dr. J.L. Dobberke Foundation.
- 13 The KNAW announces on the KNAW website that the recipient has been awarded a Dobberke Grant. If the recipient does not agree with the publication of these details (name, research institution and title and short summary of grant activities) on the website, the recipient must inform the KNAW of this within one week of receiving the grant letter.

[illegible]

5.1.2h			
5.1.2h		5.1.2h (Gld)	
5.1.2h		5.1.2h (Gld)	
5.1.2h		5.1.2h (Gld)	
5.1.2h		5.1.2h (Gld)	5.1.2h
5.1.2h		5.1.2h	5.1.2h
5.1.2e	- beheerder)		33-55-15

WOO

Van: 5.1.2e
Verzonden: woensdag 17 januari 2024 18:46
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: Re: interview nav Dobberke Beurs

Dag 5.1.2e

Resource heeft interesse. En ze nemen contact met jou op.

Groet, 5.1.2e

Verzonden vanaf [Outlook voor Android](#)

From: 5.1.2e
Sent: Wednesday, January 17, 2024 2:13:29 PM
To: 5.1.2e
Cc: 5.1.2e
Subject: RE: interview nav Dobberke Beurs
Dag 5.1.2e

Dank voor je bericht en info !

Is een leuke pagina geworden op [KNAW-site](#). En gefeliciteerd met de Dobberke-beurs ! Raaf is een aaibare en aanspreekbare soort !

Heel goed om te weten dat je hieraan werkt. Houd me op de hoogte van timing veldwerk etc.. Misschien iets voor Vroege Vogels radio ?

Ik ga even polsen bij LinkedIn Animal Sciences en koppel je z.s.m. terug. Want mooi wapenfeit van jullie relevantie voor dierecologie-onderzoek ook in Nederland.

En ik heb het naar Resource doorgezeten. Niet geschoten is altijd mis.

Groet, 5.1.2e

From: 5.1.2e
Sent: Wednesday, January 17, 2024 10:45 AM
To: 5.1.2e
Cc: 5.1.2e
Subject: FW: interview nav Dobberke Beurs
Beste 5.1.2e

Misschien is dit leuk/interessant om te delen? Het gaat om een (kleine) onderzoeksbeurs die ik heb ontvangen om te onderzoek hoe en waarom sommige jonge raven op de Veluwe vaker gebruik maken van menselijke voedselbronnen (bijvoorbeeld afval) dan anderen.

Groetjes,

5.1.2e

From: 5.1.2e <[@knaw.nl](#)>
Sent: 17 January 2024 09:11
To: 5.1.2e <[@wur.nl](#)>
Subject: RE: interview nav Dobberke Beurs
Beste 5.1.2e

Dank! Het artikel staat nu online: [Onderzoek over wadvogels en raven ontvangen financiering van de Dobberke Stichting - KNAW](#)

Groetjes, 5.1.2e

From: 5.1.2e <[@wur.nl](#)>
Sent: dinsdag 16 januari 2024 5:34

To: 5.1.2e @knaaw.nl>
Subject: RE: interview nav Dobberke Beurs
Hoi 5.1.2e,
Raven in de title zou inderdaad beter zijn.
Groetjes,
5.1.2e

From: 5.1.2e @knaaw.nl>
Sent: 16 January 2024 17:13
To: 5.1.2e @wur.nl>
Subject: RE: interview nav Dobberke Beurs
Hoi 5.1.2e
Mijn excuus dat ik je naam verkeerd heb geschreven. Een foto met raven zou moeten lukken.
Ik wil toch expliciet een vraag stellen over de titel: Onderzoek over wadvogels en wilde dieren ontvangen financiering van de Dobberke Stichting.
Is het beter om 'wilde dieren' te vervangen door raven? En ook in de eerste alinea?
Met vriendelijke groet,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: maandag 15 januari 2024 3:23
To: 5.1.2e @nioz.nl>; 5.1.2e @knaaw.nl>
Cc: 5.1.2e @knaaw.nl>
Subject: RE: interview nav Dobberke Beurs
Hoi 5.1.2e,
Nog een paar kleine aanpassingen met betrekking tot de leesbaarheid van mijn stukje. En een aantal keer stond mijn naam niet helemaal goed. Mocht er nog een stock foto met raven beschikbaar zijn, dan is dat ideaal maar anders helemaal prima!
Groetjes,
5.1.2e

From: 5.1.2e @nioz.nl>
Sent: 15 January 2024 15:11
To: 5.1.2e @knaaw.nl>; 5.1.2e @wur.nl>
Cc: 5.1.2e @knaaw.nl>
Subject: RE: interview nav Dobberke Beurs
Beste 5.1.2e,
Wat een leuk stukje, zo deze 2 onderzoeken gecombineerd!
Ik ga akkoord met de tekst en intro.
De stockfoto van de meeuwen zou wellicht beter kunnen vervangen worden voor een steltlopersoort, omdat we geen werk doen aan meeuwen. Ik heb wat foto's bijgevoegd van vogelsoorten die wij onderzoeken. Ik hoop dat er wat tussen zit!
Groetjes,
5.1.2e

From: 5.1.2e @knaaw.nl>
Sent: Monday, January 15, 2024 2:32 PM
To: 5.1.2e @nioz.nl>; 5.1.2e @wur.nl>
Cc: 5.1.2e @knaaw.nl>
Subject: interview nav Dobberke Beurs
Hoi 5.1.2e en 5.1.2e
Dank voor jullie beantwoording van mijn vragen voor het interview op de KNAW-website.
Wat een leuk onderzoek doen jullie allebei! Aan jullie tekst heb ik alleen een paar kleine redactionele wijzigingen aangebracht, niets bijzonders, want jullie tekst is heel helder.
Gaan jullie akkoord met de tekst en de intro? Dan kan ik het interview morgen plaatsen.
Ik heb ter verlevendiging nog twee stockfoto's erbij gezocht, maar als jullie betere foto's hebben, dan ontvang ik die heel graag.
Hartelijk dank!
Met vriendelijke groet,

Onderzoek over wadvogels en wilde dieren ontvangen financiering van de Dobberke Stichting

Hoe zien leefgebieden van wadvogels er in de toekomst uit? Hoe ontwikkelen wilde dieren hun voedselvoorkeur? Dit zijn slechts enkele onderzoeksvragen uit de laatste ronde toekenningen van de Dobberke Beurs op het gebied van diergedrag. Onderzoekers **5.1.2e** en **5.1.2e** vertellen in dit interview over de impact van hun onderzoek en wat de toekenning van de Dobberke Beurs voor hen betekent.

Waar gaat jouw onderzoek over?



5.1.2e: Ik onderzoek het effect van zeespiegelstijging op verschillende soorten wadvogels in de Waddenzee. Om voorspellingen te kunnen doen over hoe toekomstige leefgebieden van vogels zullen zijn, moeten we eerst begrijpen hoe zij dit leefgebied nu gebruiken. We doen daarom onderzoek naar hun dieet door middel van DNA-onderzoek. Zo kunnen we uit de uitwerpselen van vogels kleine stukjes DNA halen van de prooidieren die zij hebben gegeten. Ook onderzoeken we waar deze prooidieren leven in de Waddenzee op basis van bodemonderzoek, en volgen we de vogels met kleine zendertjes om te bekijken of zij ook daadwerkelijk deze locaties selecteren. Uiteindelijk zullen we voor iedere vogelsoort hotspots identificeren: leefgebieden die voor hen het belangrijkste zijn. Aan de hand van zeespiegelstijgingmodellen, kunnen we dan voorspellen wat er van deze gebieden over zal blijven in de toekomst.

5.1.2e Ik ben nieuwsgierig naar de invloed van individuele verschillen en de sociale omgeving op het gedrag van wilde dieren. Hierbij focus ik me vooral op hoe dieren hun eten vinden, omdat dit gedrag een kritieke rol speelt in de overleving. Tussen soorten zien we vaak verschillende strategieën om aan eten te komen. Sommige soorten gaan vooral in hun eentje op pad, terwijl andere soorten voordeel halen uit de informatie van soortgenoten over beschikbare voedselbronnen. En ook binnen een soort kunnen individuen verschillen in welke mate ze zich door hun sociale omgeving laten beïnvloeden. Deze variatie is vaak ook mooi terug te zien in het gedrag van tuinvogels op de voedertafels. Het is bijvoorbeeld opvallend hoe sommige soorten vaak pas op komen dagen wanneer andere soorten al aanwezig zijn.



Waarom is jouw onderzoek belangrijk?

5.1.2e De Waddenzee is het grootste intergetijdengebied ter wereld en vormt een onmisbaar knooppunt voor miljoenen trekvogels die hier tijdens hun doorreis afhankelijk zijn van het ruime voedselaanbod. Ook zijn er enorme aantallen vogels die de hele winter door in de Waddenzee blijven. Als dit leefgebied verdwijnt, zullen zij nergens anders heen kunnen. Het is daarom belangrijk om goed de effecten van klimaatverandering te begrijpen als we willen zorgen dat deze vogels een leefgebied overhouden.

5.1.2e De beschikbaarheid van voedselbronnen voor wilde dieren is niet altijd voorspelbaar. Mensen hebben vaak een grote invloed op de voorspelbaarheid en beschikbaarheid van voedsel. Deze invloed laat zich, bijvoorbeeld, gelden via het aanbod van eetbaar 'afval' (direct), maar ook via klimaatverandering (indirect). Het is belangrijk om te weten hoe wilde dieren met veranderingen in voorspelbaarheid en beschikbaarheid omgaan en hoe flexibel ze zijn in het aanpassen van hun gedrag. Een beter begrip van de (sociale) strategieën die dieren volgen om hun voedselzoekgedrag en eetpatroon te vormen geeft ons ook beter inzicht in de flexibiliteit en kwetsbaarheid van deze soorten.

Wat voor mogelijkheden brengt de Dobberke Stichting voor jouw onderzoek?

5.1.2e Met het geld van de Dobberke Stichting, kunnen we DNA-onderzoek doen op meer dan 150 vogelpoepjes. In totaal kunnen we het dieet van acht verschillende steltlopersoorten in de Waddenzee in kaart brengen, waarvan sommige soorten nog nooit eerder zijn onderzocht in de Waddenzee. Dit is hele waardevolle fundamentele kennis waar we weer verder op kunnen bouwen in de toekomst.



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Toekenningen 2023

Twaalf onderzoekers op het gebied van diergedrag hebben een Dobberke Beurs toegekend gekregen voor de ondersteuning van een onderzoeksproject, een studiereis naar een buitenlandse onderzoeksgroep of de organisatie van een wetenschappelijke bijeenkomst. De onderzoekers ontvangen ieder een bedrag tussen de € 2.000 en € 6.000.

[overzicht opnemen]

Over de Dobberke Beurs

Alinea over de Dobberke Beurs

Quotes voor de pagina Dobberke Beurs

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Onderzoek over wadvogels en wilde dieren ontvangen financiering van de Dobberke Stichting

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OrniTrack User Manual

Please read this user manual carefully before using the transmitters. This user manual contains important safety precautions as well as detailed instructions on transmitter operation, management and data download.

Transmitter start-up

Precautions/Warnings

Do not overheat the transmitter. This may happen especially quickly when exposed to direct sunlight without ventilation (e.g. the car dashboard is the most frequent place where transmitters are overheated) or near other heat sources (e.g. hot lightbulb, radiator, fireplace). The transmitter's temperature sensor allows the monitoring of its internal temperature. It is advisable not to exceed 50°C, even though technical characteristics define a slightly higher tolerance.

Avoid extreme sudden changes in temperature.

Do not place the device next to strong magnetic fields.

Although the transmitter is constructed of durable materials and has no moving parts, avoid dropping it onto solid surfaces.

Do not disassemble the device.

Do not turn on and use the transmitter in areas with poor GPS reception (e.g. indoors) – this may lead to rapid battery depletion, particularly at high GPS fixing rates.

The device contains lithium-polymer batteries – please dispose of the unit responsibly, following the local regulations.

Transmitter energy management

Logging GPS positions is a relatively expensive process in terms of energy use. When developing OrniTrack transmitters we paid particular attention to achieving the highest possible energetic efficiency of this task. Extensive transmitter testing in an open terrain revealed that a fully charged OrniTrack-20 is sufficient for logging about 1,000 GPS positions without additional recharge, OrniTrack-25 and OrniTrack-30 – approximately 1,500 positions, while OrniTrack-50 – about 5,000 positions. But please note that data transfer via GPRS/3G was set to infrequent intervals of one data upload per day during the testing.

Connection to the GSM network and data upload is by far the most energetically expensive process. Therefore, the GSM module is turned off most of the time and activated only at predefined intervals, when it searches for a network, connects, receives pending new settings (if any) and uploads the collected data. If no network is available, the GSM module switches off after a timeout period until the next scheduled connection attempt. The battery consumption of a single GSM session is equal to logging approximately 25 GPS positions. Obviously, energy consumption of data uploads depends on GSM signal strength and the amount of data uploaded.

In order to prevent excessive discharge of the internal battery, GPS position logging is discontinued when the battery is depleted to 0% (3675 mV). However, the battery retains a certain energy reserve, used for data transmission and basic functioning of the device until it is recharged by the solar panel. However, it is recommended to always maintain battery charge above 20% by managing transmitter operation accordingly.

Turning the transmitter ON and OFF

The transmitters are supplied turned off and charged (above 90% battery charge). The transmitter is equipped with a magnetic switch – the unit is turned off by placing the transmitter into a special holding pad that contains a built-in magnet. The transmitter turns on once it is taken out of the holding pad (Figure 1). After removing the transmitter from the holding pad, a red LED will flash at a slow rate several times, indicating correct start-up of the transmitter. Very rapid and brief flashing of a LED after removing the magnet indicates complete discharge of the battery. When the transmitter is placed back into the holding pad, the LED will light-up once, indicating that the transmitter was successfully turned off. Location of the LED differs on different models of OrniTrack transmitters – on OrniTrack-20 and OrniTrack-25 it is at the back of the transmitter (Figure 1A), on OrniTrack-50 it is at the front of the transmitter (Figure 1B), while in OrniTrack-30 LED is located near the right wall of the transmitter and could be a little hard to see in full daylight (Figure 1C). Some transmitter models (e.g. neck collars, leg-mount transmitters, patagial transmitters) do not have a magnetic pad and their switch is activated by attaching the magnet with a sticky tape or clip-on magnet holder. For example, magnet attachment location on the neck collar transmitter is on the upper part of the solar panel next to the LED (Figure 1D).

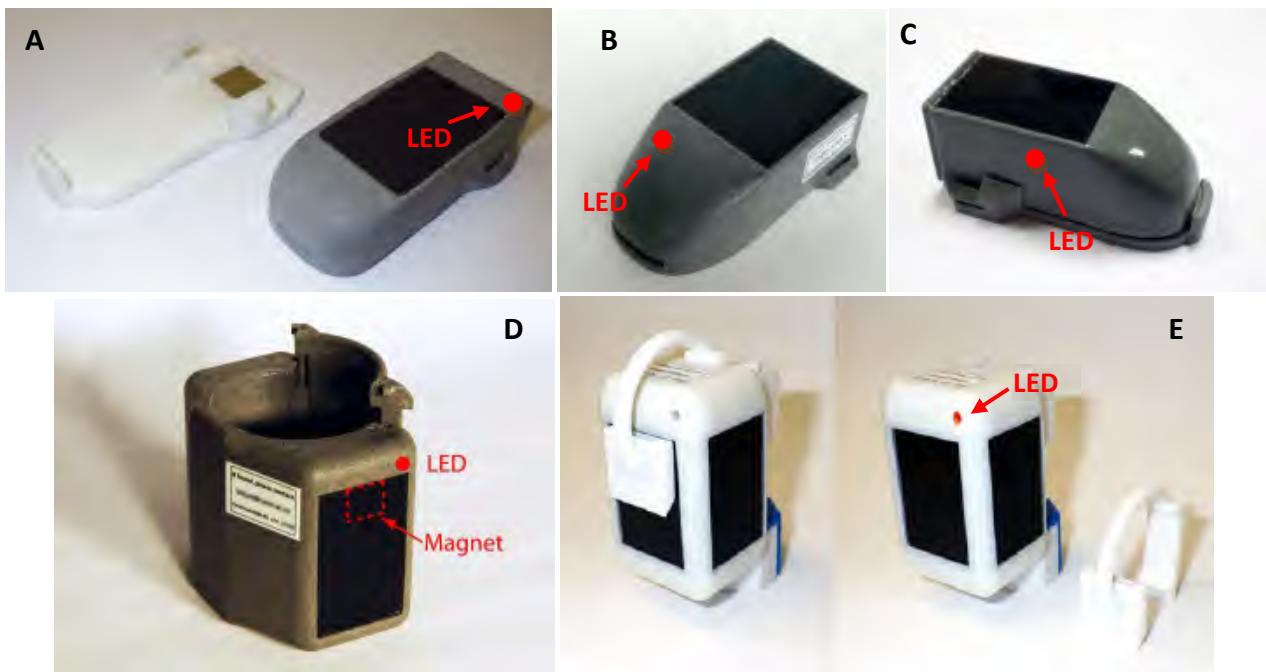


Figure 1 OrniTrack transmitters with shown position of LED indicator. The photos show A) OrniTrack-20 (next to a holding pad), B) OrniTrack-50, C) OrniTrack-30 (on a holding pad), D) OrniTrack-N30, and E) OrniTrack-L40 with clip-on magnet.

Starting the transmitter for the first time – initial test

The aim of the initial transmitter test is to verify correct operation of the unit – acquisition of GPS positions, data transfer via GSM network and the correct operation of internal sensors prior to the deployment of the transmitter on a bird. Please note that the initial transmitter test is a prerequisite for the fulfilment of warranty conditions.

The transmitter is supplied with pre-defined GPS and GSM settings (GPS fix interval – 60 s, data transmission interval – 600 s), which shall be used during the first start-up of the transmitter by the user. The initial start-up should preferably be carried out well in advance of the expected deployment of the transmitter. Please inform Ornitela at support@ornitela.eu of the approximate planned time of the initial transmitter test. The initial test should be carried out outdoors in an area with an open sky view and with good GSM coverage. For the test, please remove the transmitter out of the holding pad and place it on a level surface for at least 30 minutes. After 30 minutes, re-insert the transmitter into the holding pad and the transmitter will turn off. The initial test is complete. You will be informed of the successful test (or any detected problems) by Ornitela within 12 hours following the test.

After the transmitter test, in the on-line control panel (see description below) you will see that the transmitter has transferred the acquired data. If the transmitter continues to connect to the GSM network (as seen from the timestamp of the "Last GPRS data" in the main page of the OrniTrack Control Panel) after the initial test, this may indicate incorrect placement of the transmitter into the holding pad.

Alternatively, you may choose to keep the transmitter on until deployment and test different settings, including a geofence feature (described below). However, GPS and GSM settings should be adjusted to longer intervals, as pre-set testing settings are of high frequency and would lead to rapid battery drain. If the transmitter is kept running, it is advisable to keep it outside in a sunny but well ventilated place. Keeping it indoors may lead to rapid depletion due to poor GPS reception and lack of sunlight.

When the transmitter is moved a large distance from its previous location or has been off for a long time, it might take a while for the GPS module to acquire a new position. Thus it should not come as a surprise if positions are not acquired on several connections during the initial start-up and testing.

Deploying the transmitter

OrniTrack solar GPS-GSM/GPRS/3G transmitters have been developed to be deployed as backpacks using harness on birds of appropriate size.

In case deployment of the transmitter is planned in an area with potentially poor GSM coverage, it is advisable to set the desired transmitter settings through the on-line control panel (GPS and GSM intervals, geofences, day/night regime) prior to the deployment (by entering the new settings, turning the transmitter on and off with a magnet and making sure that the transmitter has accepted the settings). The transmitter communicates with the server each time it is started by removing from the holding pad, and receives the settings that are pending on the server. However, during normal transmitter operation, new settings are delivered when transmitter connects to GPRS/3G network for uploading the data.

Storing the transmitter

The transmitters should be stored turned off and, if stored for prolonged periods of time, their charge should be regularly checked (by turning the transmitter on and checking the battery voltage on the on-line control panel). A complete battery discharge should not be allowed, as in the long run this may compromise battery performance. The most effective way to recharge the transmitter is exposing it to the direct sunlight. The battery-charging control circuit is functioning even when the transmitter is turned off, therefore transmitters may be exposed to the light while in storage – there is no risk of overcharging them.

There could be situations when transmitters need to be stored for an extended period of time before they are deployed, e.g. until the next fieldwork season. We recommend storing the transmitters turned off (on a magnetic pad) with battery having ~60% charge at the start of the storing period. Transmitters should be kept at room temperature in a place without large temperature fluctuations. They should not be placed on a window or other place exposed to the sun as this would cause temperature fluctuations and full battery charge (the transmitter charges even when turned off). Continuous state of being fully charged or completely discharged may reduce the capacity or even damage internal lithium batteries.

When storing the transmitters, it is a good idea to turn them on once per two-three months, let them run briefly so that battery level could be checked. If the battery charge drops below 40%, the transmitters should be exposed to the sun and allowed to charge up to 60%.

IMPORTANT: transmitters should be fully charged prior to their deployment on birds!

Please note, that even when transmitters are not used and are stored on a shelf, the base service subscription fee of ~6 EUR/month is being charged because GSM subscription is kept active. However, the service subscription may be temporarily suspended (see below).

Temporary suspension of service subscription

Upon special request, service subscription may be suspended and reactivated later. The duration of service suspension cannot be shorter than 2 months and longer than 12 months. Once reactivated, the transmitter can be repeatedly suspended after no less than 2 months. It is important to note that battery charge level cannot be checked if the service subscription is suspended. A request for the temporary service subscription deactivation must be sent by e-mail to Ornitela (support@ornitela.eu) with indicated transmitter serial number, deactivation date and deactivation duration requested. Deactivation will be confirmed by Ornitela by e-mail. Device settings page of the deactivated transmitter will be inactive throughout the duration of the deactivation period.

Temporary suspension of service subscription should only be applied for transmitters that are not deployed on birds and are turned off.

Terminating transmitter operation

All transmitters reach the end of their life time at some point. Service subscription does not terminate automatically even when no data are received from a transmitter for a prolonged period of time.

IMPORTANT: It is sole obligation of the user to decide when service subscription of each transmitter should be terminated and to inform Ornitela of this decision. This will also permanently deactivate the transmitter.

This should be done by sending an email to support@ornitela.eu and providing serial number(s) of the transmitter(s) for which the subscription should be terminated and the requested date of the termination. We will acknowledge receiving such a request and terminate the service subscription. This will stop charges of data transfer fees. No data will be further received from the terminated transmitter and its reactivation will not be possible.

Before sending such a request users should consider carefully whether a transmitter stopped sending positions temporarily or not. Sometimes the transmitters may stop sending data for extended periods and come back to life later. Typical situations could be: a bird migrates to a region with no GSM coverage (e.g. Arctic or other remote areas) and stays there for months; or battery discharges during poor light conditions (e.g. winter at high latitudes), but recharges when light conditions subsequently improve. Thus, such factors and knowledge about species biology and habitats should be taken into consideration before requesting to terminate the subscription.

Upon termination of the transmitter operation, the data received from the transmitter throughout its lifetime will continue to be available for download from the OrniTrack Control Panel for another 3 months. Afterwards, the data will be transferred to a permanent archive and will be available for retrieval only upon special arrangement.

Online control panel and data server

The online control panel and data server can be accessed by clicking “Access my devices” in the bottom right corner of the Ornitela website (www.ornitela.com) or going directly to www.glosendas.net/users/. After entering your user name and password you will be taken to the OrniTrack devices main page (Figure 2).

Main page



Figure 2 Main page of the user panel prior to selecting any particular device.

The main page lists all of your tracking devices in a table and has an embedded map below showing the last location of each of your OrniTrack transmitters. The table has several columns displaying key information about the devices:

- **Name** – the name of the device or tagged bird, which is set by the user under the *Device settings* menu (described below).
- **S/N** – the unique serial number of the device.



- **Battery icon** – shows the percent of the remaining battery charge that was registered during the last data connection.
- **Status** – displays warning/information icons. An explanatory text is displayed when hovering computer mouse over the icon. No icon means that the transmitter is functioning as expected and there are no new settings pending for transmission to the device. Currently, the following icons are used:
 - **SMS** – indicates that the most recent data transmission occurred via SMS message, but not GPRS upload.
 - **Exclamatory mark in yellow triangle** – indicates possibly invalid transmitter position based on accelerometer measurements (only used for backpack transmitters).
 - **Skull and crossbones** – the transmitter is not moving, possible mortality of a bird.
 - **Cogwheel** – indicates that there are new settings waiting to be sent to the transmitter.
- **Last GPRS data (UTC±x)** – date and time when last GPRS data were received. Text in black font indicates that the data were received according to the schedule, and text in grey font indicates that the last scheduled data upload was missed. Date and time can be displayed in UTC or in a time zone selected by the user under the *Settings* menu (described below).
- **Next GPRS data expected (UTC±x)** – date and time when next GPRS data uploading session is scheduled. Text colour follows the same rules as in the previous column described above.
- --- – currently empty reserved field.

User settings menu

In the upper right corner of the main page there is a *Settings* button, which takes you to the general user settings page (Figure 3).

OrniTrack user settings

Welcome, user
Settings
Logout

Time zone: (GMT+01:00) DST Madrid, Paris, Warsaw, Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna ▼

Send notifications to e-mail address: notify@notifications.eml

Movebank user name:

☒ Include altitude information in *.KML file

☐ Include coordinates received by SMS in *.KML file

Device name	S/N	Enabled	Show in MAP	Notify by e-mail	Movebank live feed
OT-30 - AQUHYB	15005	☒	☒	☐	☒
OT-30.2 ACCGEN - Ad1F	15008	☒	☒	☐	☐
OT-50.2 - GRUGRU Ad1	15015	☒	☒	☐	☒
OT-H test	15016	☒	☒	☐	☐
OT-H14 - ANAPLA	16007	☒	☒	☐	☐

Save settings

Return to main page

Figure 3 View of OrniTrack user setting page.

Here, the user can choose the desired time zone to be displayed on the Main Page.

An e-mail address can be entered here to which e-mail notifications are sent when new data is received from selected transmitters.

In order to enable live feed of tracking data into the www.movebank.org database, the user must provide Movebank user name in the following field and request activation of this feature by sending an email to support@ornitela.eu.

If check box *Include altitude information in *.KML file* is selected, KML files generated by the server display bird tracks in 3D. If not selected, bird position and tracks in KML files are displayed as clamped to the ground.

The following check box allows you to *Include coordinates received by SMS in *.KML file*.

The table listing all OrniTrack devices that belong to the user offers three check boxes for each device:

- **Enable** – displays the device on the main page.
- **Show in MAP** – displays the device on the map embedded on the main page.
- **Notify by e-mail** – sends e-mails to the provided e-mail address whenever new data are received from the transmitter.
- **Movebank live feed** – enables a possibility for live data feed into Movebank (this feature will be available shortly), which needs to be further configured on Movebank portal directly.

It is important to *Save settings* after making changes on this page.

Back to the main page. Accessing each transmitter is done by clicking on the device name in the table. Once clicked, a new menu with transmitter-specific information appears below the main table. This device menu provides more information about the device settings and allows you to download the data.

Device menu

OrniTrack devices

Welcome, user [Financial](#) [Settings](#) [Logout](#)

Show 25 devices per page Search:

Name	S/N		Status	Last GPRS data	Next GPRS data	---
OT-L40 - GRUGRU Ad 2	16121	87		2017-01-01 09:01:37	2017-01-01 17:01:37	
OT-50.2 - GRUGRU Ad1	15015	30		2016-12-31 13:45:36	2017-01-01 13:45:36	
OT-30 - AQUHYB	15005	100		2016-12-30 04:16:32	2017-01-01 16:16:32	
OT-H45 test	15018	0		2016-12-31 10:27:08	2017-01-01 19:27:08	
OT-H14 - ANAPLA	16007	0		2016-12-31 19:59:07	2017-01-01 09:59:07	
OT-30.2 ACCGEN - Ad1F	15006	0		2016-12-17 12:09:52	2016-12-17 12:09:52	

Showing 1 to 6 of 6 devices Previous **1** Next

Name: OT-L40 - GRUGRU Ad 2, S/N: 16121, FW: 1002161212

1 Last data received by GPRS: 2017-01-01 09:01:37 (UTC+2)

2 Next data session expected: 2017-01-01 17:01:37 (UTC+2)

3 Battery status: 87% (4069mV)

4 Settings pending for transmission to device: 0

5 Data bytes in memory before last data session: 132 bytes

Download data from/to UTC:

2016-12-25T00:00:00

2017-01-01T13:22

[Device settings](#)

[Graphs](#)

Map Satellite

Google

Map Data Terms of Use Report a map error

Figure 4 OrniTrack device menu that becomes available after selecting a particular device (by clicking the respective line in the available device list).

The top row contains transmitter **Name**, **sn** – serial number and **fw** – firmware version.

The lower section contains more technical information (for this manual numbered in **red font**):

1. States whether the last data were received by GPRS (irrespective of whether it was 2G or 3G data upload) or SMS and gives the date and time when that happened.
2. Date and time when the next data session is expected (the same as in the main table above).
3. Battery status as a percentage of the total voltage remaining and actual voltage.
4. Indicates how many new settings are pending, if any, for the transmission to the device. Settings are transmitted during GPRS data sessions. SMS connections do not transfer new settings.
5. Shows how many data bytes were in the transmitter memory before the last data session. Occasionally, only part of the data is transferred from the transmitter, which could happen due to an interrupted connection, poor GSM/GPRS signal strength, or low battery. A single GPS position and all the sensor information associated with this position occupy 66 bytes; if sensor-only data are also collected on a separate schedule, 66 bytes contain four data points of all sensors (accelerometer, magnetometer, light intensity and temperature) or 12 data points of accelerometer only.

The bottom section is for data downloading. The desired period for data download can be selected. The default is the most recent 7 days. Please note that the time in these fields and in the data files is always in UTC, irrespective of the selected time zone on the *Settings* page. Dates could be selected from the drop-

down menu, which is optimized for Internet Explorer and Google Chrome browsers. In other browsers you may need to type in the desired date. Once the period is selected, data can be downloaded in one of three formats by clicking the icons below: KML, GPS and CSV. If some of the data were received by SMS, then SMS data can be downloaded in CSV format by clicking the respective icon.

Data downloaded in CSV format is presented in 22 columns:

1. ***device_id*** – unique identification number of OrniTrack device
2. ***UTC_datetime*** – UTC date & time
3. ***UTC_date*** – UTC date
4. ***UTC_time*** – UTC time
5. ***satcount*** – number of satellites during GPS fix
6. ***U_bat_mV*** – battery voltage in millivolts (mV)
7. ***bat_soc_pct*** – battery charge in percent
8. ***solar_I_mA*** – battery charging current by solar panel in milliamperes (mA)
9. ***hdop*** – horizontal dilution of precision of GPS fix
10. ***Latitude*** – Latitude in decimal degrees
11. ***Longitude*** – Longitude in decimal degrees
12. ***Altitude_m*** – GPS measured altitude above mean sea level in meters
13. ***speed_km_h*** – GPS measured ground speed in kilometres per hour
14. ***direction_deg*** – GPS measured movement direction in degrees
15. ***temperature_C*** – transmitter internal temperature in degrees Celsius
16. ***light*** – light intensity (0–2047, unitless)
17. ***mag_x*** – magnetometer X-axis measurement
18. ***mag_y*** – magnetometer Y-axis measurement
19. ***mag_z*** – magnetometer Z-axis measurement
20. ***acc_x*** – accelerometer X-axis measurement
21. ***acc_y*** – accelerometer Y-axis measurement
22. ***acc_z*** – accelerometer Z-axis measurement

Data received by SMS is not integrated into the main dataset as SMS information is meant only to inform about the whereabouts of the tracked birds when a proper data download is not possible. Data transmitted by SMS remains on the transmitter's internal memory until it is uploaded via GPRS data transfer.

To the right from the data download panel there is a *Device settings* button (described below).

A small embedded map shows a track using 250 most recent GPS positions.

OrniTrack device settings

The device settings page is accessed by clicking the *Device settings* button on the Device menu page (Figure 5).

This page is for setting the operational schedules for each transmitter. The available menu might differ in the number of features available depending on the transmitter type.

Setting general GPS and GSM schedules

Setting	Out of zones	Geofence zone 1	Geofence zone 2
GSM data session interval 600..691200 seconds	14400	14400	86400
GPS fix interval 0..172800 seconds	300	900	900
GPS fix interval when battery less than 75% 0 - setting disabled, 1..172800 seconds	0	0	0
GPS fix interval when battery less than 50% 0 - setting disabled, 1..172800 seconds	0	0	0
GPS fix interval when battery less than 25% 0 - setting disabled, 1..172800 seconds	0	0	0
GPS sleep interval 0..21600 seconds	0	0	0
Enable GPS sleep 0 - disabled, 1 - enabled	0	0	0
GPS sleep from dusk -18..18 - sun angle	0	0	0
GPS sleep till dawn -18..18 - sun angle	0	0	0

Figure 5 Part of the Device settings menu for defining GSM and GPS schedules.

In the first editable cell you can name the transmitter using up to 32 characters. This name will appear in the device list on the *Main page*.

Three columns in the setting page allow defining three sets of the device settings described below: general transmitter settings "Out of zones", and separate settings for "Geofence zone 1" and "Geofence zone 2". Please read *Geofence explained* on the last chapter of this manual.

The rows in the user settings page are used for defining key operational settings of the transmitter.

The first line "*GSM data session interval*" is for defining GSM data upload intervals in seconds, which can range from 600 to 691200 (10 min to 8 days). We recommend setting data uploads to once or twice per day, i.e. every 43200 or 86400 seconds. GSM connections are more energetically expensive compared to GPS position fixes and thus result in higher battery drain. Furthermore, every connection to the GSM

network has associated charges by telecommunication companies, and frequent connections may result in increased consumption of data transfer fees.

The second line *"GPS fix interval"* is for defining GPS fix intervals in seconds, which could range from 1 to 172800. For example, if 60 is entered in the field, the transmitter will be logging GPS positions every 60 seconds. While GPS fix intervals may be automatically adjusted according to the battery charge level (see below), it is important to consider the expected solar exposure of the transmitter, based on bird's behaviour, daylight duration, weather conditions, etc., when setting the initial GPS fix intervals. If a transmitter is exposed to direct sunlight several hours per day, we recommend to start by selecting 600–900 second intervals (10–15 minutes) and monitor battery voltage for several days. If the solar panel charges transmitter battery more than it spends on operations, GPS fixing interval could be shortened. We experienced that for some species it was sustainable to log GPS positions every 60 seconds for months. But there are also situations when solar panel provides very little charge, e.g. when birds cover solar panels with feathers, constantly hide in a shade, live in conditions with very little sunlight or during prolonged periods of poor weather. In such instances GPS positions should be fixed less frequently.

Line *"GPS fix interval when battery less than 75%"* is optional and could be used for defining an automatic change of GPS logging intervals when battery level drops below 75%. This could be useful when standard GPS fix interval is short and could drain the battery fast if not adjusted. When a value of this field is set to 0, GPS logging interval remains unchanged when the battery level drops below 75%.

Line *"GPS fix interval when battery less than 50%"* is optional and could be used for defining an automatic change of GPS logging intervals when battery level drops below 50%. When a value of this field is set to 0, GPS logging interval remains unchanged when the battery level drops below 50%.

Line *"GPS fix interval when battery less than 25%"* is optional and could be used for defining an automatic change of GPS logging intervals when battery level drops below 25%. When a value of this field is set to 0, GPS logging interval remains unchanged when the battery level drops below 25%. However, we do recommend setting GPS fixing interval to a higher value here, particularly if the normal GPS fixing interval is rather short.

Line *"GPS sleep interval"* is for setting GPS logging interval during the night, if transmitter night-sleeping is enabled in the following line. Many bird species are not active at night, therefore logging GPS positions is often not needed or is sufficient at infrequent intervals during the dark period. Turning the transmitter off or slowing down GPS recording at night reduces unnecessary battery drain. Important to note that a value of 0 in this field means that no GPS positions will be logged during the night sleep period. Of course, for nocturnal species GPS sleep interval may be set to be more frequent than the normal (day) GPS fix interval, but it cannot be automatically adjusted according to the battery charge level.

Line *"Enable GPS sleep"* is for enabling or disabling night settings for GPS logging. Settings for sleep period affect only GPS position fixing, whereas GSM connections take place following standard settings.

Line *"GPS sleep from dusk"* is for setting when GPS sleep period starts in the evening depending on Sun angle above or below the horizon. Available settings for Sun angle range from -18 to 18° defining the position of the Sun relative to the horizon, which is automatically calculated using transmitter geographic location and date. Negative angles indicate Sun position below the horizon, e.g. civil (Sun angle = -6), nautical (Sun angle = -12) or astronomical twilight (Sun angle = -18) (see illustration in Figure 6). Positive angles indicate Sun position above the horizon (could be useful when studying species that become inactive some time before sunset).

Line “GPS sleep till dawn” is for setting when GPS sleep period ends in the morning depending on Sun angle above or below the horizon. The same as above, available settings for Sun angle range from -18 to 18° defining the position of the Sun relative to the horizon. Positive angles indicate Sun position above the horizon (could be useful when studying species that do not become active at first light).

Please pay attention when setting Sun angles for night-time transmitter sleep! Values with negative sign indicate Sun angle below the horizon and values with positive sign indicate Sun angle above the horizon. At high latitudes (e.g. northern Europe) Sun does not even reach 18 degrees above the horizon in winter time and similarly it does not go down to -18 degrees below the horizon in summer. Thus, wrong settings may prevent the transmitter functioning altogether!

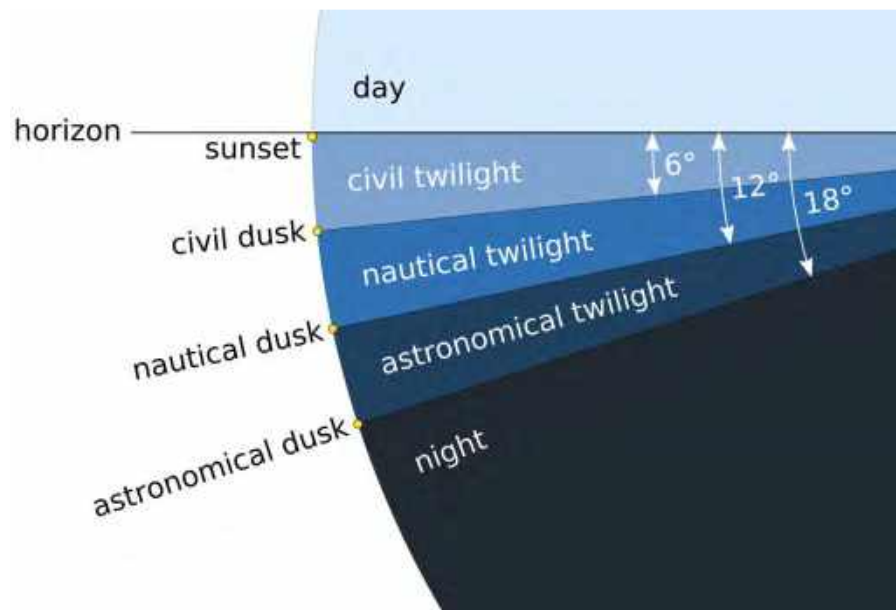


Figure 6 Illustration showing twilight classification according to Sun angle below the horizon. Taken from Wikipedia (<https://en.wikipedia.org/wiki/Twilight>).

Logging GPS positions in bursts (optional)

Setting		Out of zones	Geofence zone 1	Geofence zone 2
	GPS burst 0..600 - seconds	0	0	0
	Disable GPS burst when battery less than x% 10..90 %	50	50	50

Figure 7 Part of the Device settings menu for controlling GPS burst logging.

Line “GPS burst” is an optional field for setting GPS logging in bursts. It is a possibility to define that more GPS positions are logged (up to 600) at standard GPS fix intervals instead of one. GPS positions are logged at 1 Hz, i.e. 1 position every second. For example, if “GPS burst” is set for 60, the transmitter will log 60 consecutive GPS positions at defined GPS fix intervals. Zero value in “GPS burst” field means that the feature is disabled and GPS position logging follows general schedule of position logging.

Please note that using GPS bursts is an energetically expensive procedure and could drain the transmitter battery fast!

Line “Disable GPS burst when battery less than x%” could be used to set the battery level between 10-90% below which GPS logging in bursts would be disabled and only single GPS positions would be logged at predefined intervals.

Logging sensor information

All OrniTrack transmitters are equipped with several sensors: 3-axial accelerometer, 3-axial magnetometer, temperature sensor and light intensity sensor. Instantaneous values of these sensors are recorded together with each GPS position fix.

It is possible, however, to log sensor data at higher frequencies and independently from GPS position fixing.

Please note, that data logging using sensors is the feature for advanced users who need such information and understand limitation and associated risks. Sensor data logging at high frequencies may fill up the transmitter memory fast, drain battery power and result in higher data transfer fees. Please consult Ornitela if you are uncertain about sensor use and settings (support@ornitela.eu).

	Setting	Out of zones	Geofence zone 1	Geofence zone 2
	Sensors log interval -1 - log after GPS fix, 0 - log disabled, 1..172800 seconds	-1	0	0
	Sensors burst time 0..600 seconds	5	0	0
	Sensors burst frequency 1..50 Hz	20	1	1
	Sensors logging options 0 - log only accelerometer, 1 - log all sensors	1	0	0
	Disable sensors burst when battery less than x% 10..90 %	50	50	50
	Disable sensors burst when free memory less than x% 10..90 %	50	50	50

Figure 8 Part of the Device settings menu for controlling sensor logging.

Line “*Sensor log interval*” sets interval at which sensors will turn on and start logging the data. Possible values range from -1 to 172800 seconds. As indicated in the explanatory notes, value -1 means that sensor data will be logged following each GPS position fix (thus, it is not independent schedule but linked to GPS logging). Value 0 means that sensor logging is disabled. Values between 1 and 172800 are available for setting an interval at which sensor logging will be turned on.

Line “*Sensor burst time*” is for setting how long sensor data will be recorded once sensors are activated at intervals defined in the line above. Possible values range from 0 to 600 seconds. Zero meaning that the feature is deactivated.

Line “*Sensors burst frequency*” is for setting frequency in Hertz, which will be used for logging sensor data. E.g., selected 20 Hz frequency means that sensor data will be recorded 20 times per second.

Line “*Sensor logging options*” is for defining which sensor data will be saved in the transmitter memory: value 0 means that only accelerometer data will be saved (this is most commonly used sensor) and value 1 means that all sensor data (accelerometer, magnetometer, light intensity and temperature) will be saved. Recording all sensors occupies more memory and uploading larger volume of data might be difficult in areas with poor telecommunication network coverage.

Line “*Disable sensor bursts when battery less than x%*” is for defining a battery charge threshold below which intensive sensor logging will be automatically turned off. The threshold can be set by a user entering values between 10 and 90% of battery charge. The default is 50%. This setting could be useful aiming to save battery and reserving resources for standard GPS logging and data transfer.

Line “Disable sensor bursts when free memory less than x%” is for defining a memory used threshold below which intensive sensor logging will be automatically turned off. The threshold can be set by a user entering values between 10 and 90% of memory used. The default value is 50%. This setting could be useful aiming to save memory for standard GPS logging, when, for example, a bird is outside of telecommunication areas and thus cannot upload the recorded data and free up its memory. It is important to note that if the transmitter memory is completely filled up, no additional data will be recorded until all the data from the memory are downloaded.

Logging diving sensor data (optional)

If a transmitter is equipped with the optional diving sensor, device settings will have menu options for such sensor. Diving sensor continuously measures pressure once per second and when it senses the pressure indicating that the transmitter is submerged below 0.3 m underwater, it starts recording the data into transmitter memory. Depth data recording stops once the bird crosses the same 0.3 m threshold and resurfaces.

Setting		Out of zones	Geofence zone 1	Geofence zone 2
	Enable diving sensor 0 - disabled, 1..10 Hz	10	0	0
	Diving sensor options 0 - log only diving sensor, 1 - log all sensors	0	0	0

Figure 9 Part of the Device settings menu for controlling diving sensor operation.

Line “Enable diving sensor” is used for enabling the diving sensor and setting the desired frequency of data recording. Available values are 0 to 10 where 0 means that the sensor is disabled, 1 that data are recorded at frequency of 1 Hz (once per second) and 10 that data are recorded at frequency of 10 Hz (10 times per second). All integer values are possible within that range.

Line “Diving sensor options” is for defining whether only diving sensor value will be recorded (option 0) or values of all sensor (accelerometer, magnetometer, temperature and light) – option 1. Logging all sensors would occupy more transmitter memory and require more data to be uploaded, which might influence transmitter battery use and data transfer costs.

Geofence setting

Geofence zone1 configuration					
Rectangle 1	lat/lon top-left: 55.254	24.777	bot-right: 55.248	24.79	Enable ☒
Rectangle 2	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 3	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 4	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 5	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 6	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 7	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 8	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle 9	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐
Rectangle10	lat/lon top-left: 0	0	bot-right: 0	0	Enable ☐

Figure 10 Part of the Device settings menu for defining geofenced areas.

Geofence settings are only activated if geofence areas are defined and enabled. This is done using the Geofence zone configuration menu. Each geofence zone can be defined using up to 10 rectangles. Rectangles are defined by typing in the latitude and longitude of the top-left and bottom-right corners. The coordinates should be entered as decimal degrees. Once the corner coordinates are entered, a rectangle is displayed in the index map on the right. The index map can also be used for finding out the coordinates: when clicked on the desired position on the map – the coordinates of that position are displayed above, and could be used for looking up and typing in as rectangle defining coordinates.

In order to activate the geofence(s), the defined rectangles need to be enabled by clicking the “Enable” check box.

For new settings to take an effect, they need to be saved by clicking the “Save settings” button. If saving has been successful, all pending setting are displayed in red font, allowing you to review them and adjust if needed before transmission to the device (Figure 11).

OrniTrack device settings

Welcome, user [Settings](#) [Logout](#)

Name: OT-H14 - ANAPLA, sn: 16007, fw: 1003160224

8 settings waiting for transmission to device.

Setting	Out of zones	Geofence zone 1	Geofence zone 2
---------	--------------	-----------------	-----------------

Figure 11 Part of the Device settings menu showing an example of new settings waiting for the transmission.

Important: new settings are sent to a transmitter during the next GSM session. It is advisable to limit the number of new settings to 10 that are uploaded during a single GSM session.

Finally, at the bottom of the page there is a field labelled *Device notes* for making text notes about the device. They need to be saved separately by pressing the “Save notes” button.

Despite the rather lengthy description above, we believe that the online user panel is intuitive and easy to navigate. However, if you encounter difficulties using it please contact us by email:

support@ornitela.eu

Geofence explained

Geofence is a virtual perimeter defined by geographic coordinates inside which a transmitter can be set to operate at different position logging and data transmission rates as well as different day/night activation periods. OrniTrack transmitters can support two geofences with different settings. Each geofence can be comprised of up to 10 rectangles, which can be used to construct one complex area or can be located separately.

This feature allows maximizing data collection from areas where it is most needed and saving battery power when intensive position logging is unnecessary.

Geofence is only sensed by GPS, thus if positions are logged infrequently outside of the geofence or in a certain geofence zone, it will take until the next position fix for the transmitter to sense that it has moved to a different geofence zone and change its duty cycle accordingly.

The two geofence zones may overlap, in which case their settings follow a hierarchy: geofence 1 settings are superior to geofence 2 settings. For example, if a geofence 1 zone is placed within the geofence 2 zone, the geofence 2 zone will create a buffer with different settings around the geofence 1 zone.

Geofence settings can be controlled remotely by the user through the online control panel (described above in this manual).

CAUTION: Please consider battery power when setting a geofence with frequent data logging. It does not take long to completely drain the transmitter battery at high logging rates. Uploads of large volumes of data via GSM/GPRS network is also energetically expensive. If the battery is drained, it can take a while until the transmitter recharges, depending on available sunlight. Battery power monitoring and selecting appropriate duty cycles, including geofence use, is the sole responsibility of the user. The geofence feature should only be used by experienced users who are well familiar with bird telemetry and using OrniTrack transmitters.

For a more detailed explanation on the geofence feature, transmitter power management and other details please consult the Frequently Asked Questions section on the Ornitela website at www.ornitela.com.

Script name	Subject/aim of script
transitionperiods	Exploring the transition periods of ravens and plotting flying behaviour over time
overview5.1.2e	Easy and well described overview to track gps data daily and create clusters and maps etc. Used by 5.1.2e and 5.1.2e during my holiday
overview	Final script with overview of daily cluster analysis and mapping of gps data of ravens. Also has option to select data of ravens on the ground
homeranges	Selecting the data of the ravens from a specific life phase and calculating the homeranges. Cropping the rasters of the variables to the correct extent and reprojecting
variablesGLMM	This script creates trial variables from the preselected raven GPS data inside precalculated homeranges for an GLMM analysis
variablesGLMMfinished	finished script to calculate variables of preselected dataset of raven GPS data inside predefined homeranges for the GLMM analysis
GLMM	Performing a GLMM analysis on the precalculated variables. Random effect is the raven AID. Fixed effects are the calculated variables in 'variablesGLMMfinished'. Output is plotted and different GLMM's need to be compared
functions	Functions for all processing and analysing steps of different scripts.
filterdata	Creation of function to remove outliers in all preprocessing steps.
comparingACCclusters	Comparing ACC characteristics of clusters to find out differences in flying, eating and resting acc data
clustering	Figuring out how to preprocess Ornitella data and how to cluster it (first using DBscan, later using GPSeqclus)
unsupervisedACCanalyses	Trying out and preparing data for unsupervised ACC analysis. conclusion: Doesn't say much about data and supervised would be better but need more labels for that. (I do have a nice Script from one of 5.1.2e students for supervised analysis).
gier	Exploring and plotting the data we got from the Lammergier with DBscan clustering method and leaflet maps
mapmaking	Plotting Ornitella data into leaflet and ggplot maps for first exploration

GEGEVENSLEVERINGSOVEREENKOMST WOLVENDATA WU-DES-ARK

PARTIJEN:

- I. **Het Interprovinciaal Overleg, vestiging BIJ12**, uitvoeringsorganisatie van de gezamenlijke provincies, een vereniging statutair gevestigd te Den Haag, en kantoorhoudende aan de Leidseveer 2 3511 SB Utrecht, ingeschreven in het Handelsregister van de Kamer van Koophandel onder nummer 27261712 ("**BIJ12**"), en
- II. **Wageningen Universiteit, Departement Omgevingswetenschappen**, gevestigd aan de Droevendaalsesteeg 3, 6708 PB te Wageningen en ingeschreven in het Handelsregister van de Kamer van Koophandel onder nummer 09215846 (de "**Ontvanger**"),

Overdrager en Ontvanger hierna elk afzonderlijk ook te noemen "**Partij**" en gezamenlijk ook te noemen "**Partijen**";

OVERWEGINGEN:

- A. BIJ12 is in opdracht van de provincies verantwoordelijk voor het laten uitvoeren van de gecoördineerde organisatie en rapportage van wolvenmonitoring in afstemming met de betrokken provincies, terreinbeheerders en (vrijwilligers)organisaties;
- B. De Ontvanger wenst bepaalde data die verzameld is in het kader van de wolvenmonitoring als gespecificeerd in **Bijlage 1** (de "**Gegevens**") te gebruiken voor de uitvoering van haar werkzaamheden, zijnde het bestuderen van interactie tussen wolf en raaf aan de hand van activiteitenpatronen op de Veluwe conform het onderzoeksvoorstel van Ontvanger, d.d. 5-5-2022 (zie **Bijlage 2** voor het onderzoeksvoorstel); en
- C. Partijen zijn overeengekomen dat BIJ12 de Gegevens eenmalig beschikbaar stelt aan Ontvanger onder de voorwaarden als opgenomen in deze gegevensleveringsovereenkomst (de "**Overeenkomst**").

Gegevensleveringsovereenkomst wolvendata WU-DES-ARK

PARTIJEN ZIJN HET VOLGENDE OVEREENGEKOMEN:

1. DEFINITIES

- 1.1. Behoudens voor zover uit de context anders blijkt, zijn de woorden en uitdrukkingen die in deze Overeenkomst met een hoofdletter zijn geschreven gedefinieerde woorden en uitdrukkingen, die de daaraan hieronder toegekende betekenis hebben:

Doeleinden/Doel-einde	de doeleinden waarvoor de Gegevens worden verstrekt aan- en mogen worden gebruikt door Ontvanger, zoals omschreven in artikel 2 van deze Overeenkomst;
Gegevens	de gegevens omschreven in <u>Bijlage 1</u> ;
Intellectuele Eigendomsrechten	alle op grond van Nederlandse, Europese en/of buitenlandse wet- en regelgeving en/of internationale verdragen geldende intellectuele eigendomsrechten, daaronder begrepen (rechten op): (i) aanduidingen (met inbegrip van maar niet beperkt tot handelsnamen) waaronder een onderneming wordt gedreven; (ii) al dan niet gedeponeerde merken en merkaanvragen (met inbegrip van maar niet beperkt tot woord-, beeld- en vormmerken); (iii) auteursrechten (met inbegrip van maar niet beperkt tot vormgeving producten, technische tekeningen en ontwerpen, software, broncodes, objectcodes, voorbereidend materiaal, algoritmes, flowcharts, documentatie, websites, promotiemateriaal, etc); (iv) sui generis databankrechten en klantenbestanden; (v) know-how en bedrijfsgeheimen; (vi) overige intellectuele eigendomsrechten; en (vii) alle roerende zaken verbandhoudende met het hiervoor genoemde (met inbegrip van maar niet beperkt tot geschriften, technische tekeningen en ontwerpen, CD's, CD-ROM's, DVD's, papier, harde schijven en andere gegevensdragers, documentatie, etc.) alsmede alle bewijzen en bescheiden (met inbegrip van maar niet beperkt tot registratiedocumenten, eigendomsbewijzen, etc.) die voor

Gegevensleveringsovereenkomst wolvendata WU-DES-ARK

	een eventuele beoordeling of uitoefening door van hier-voor genoemde intellectuele eigendomsrechten naar het oordeel van BIJ12 van belang zijn of kunnen zijn;
Overeenkomst	deze gegevensleveringsovereenkomst, met de daarbij behorende overwegingen en bijlagen;
Persoonsgegevens	elk gegeven betreffende een geïdentificeerde of identificeerbare natuurlijke persoon als bedoeld in de toepasselijke Privacywetgeving, die Ontvanger op grond van de Overeenkomst ontvangt en verwerkt;
Privacywetgeving	alle toepasselijke wet- en regelgeving met betrekking tot de verwerking en bescherming van Persoonsgegevens, waaronder maar niet beperkt tot de Algemene Verordening Gegevensbescherming en de Uitvoeringswet AVG.

2. LEVERING

- 2.1. BIJ12 stelt de Gegevens eenmalig op een niet-exclusieve basis beschikbaar aan Ontvanger, onder de voorwaarden als bepaald in deze Overeenkomst.
- 2.2. Met de terbeschikkingstelling van de Gegevens als omschreven in artikel 2.1 verleent BIJ12 aan Ontvanger het recht om de Gegevens (enkel) te gebruiken voor de volgende doeleinden:
 - a. Het bestuderen van de interactie tussen wolf en raaf aan de hand van activiteitenpatronen op de Veluwe van 1 april 2021 tot en met 9 mei 2022 (zie bijlage 2 voor het onderzoeksvoorstel).
- 2.3. Iedere Partij draagt zijn eigen kosten voor de ter beschikkingstelling en ontvangst van de Gegevens.

3. VERPLICHTINGEN VAN ONTVANGER

- 3.1. Ontvanger is niet toegestaan de Gegevens voor enig ander doeleinde te gebruiken dan de Doeleinden genoemd in artikel 2.2. Dit houdt in dat Ontvanger de Gegevens niet mag gebruiken:
 - a. voor commerciële of direct marketing doeleinden;
 - b. om eigen databases te creëren of te ontwikkelen;

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- c. voor het opstellen van publicaties of nieuwsberichten, anders dan bedoeld in het kader van het in deze Overeenkomst genoemde doel.
- 3.2. Ontvanger zal (i) de Gegevens niet delen met derden, onderaannemers, entiteiten en/of andere personen, tenzij dit anderszins schriftelijk tussen Partijen is overeengekomen en; (ii) geen verklaringen afleggen op een wijze die schadelijk is of kan zijn voor de reputatie van BIJ12; (iii) de Gegevens niet gebruiken op een wijze die schadelijk is of kan zijn voor de reputatie van BIJ12; en (iv) de Gegevens langer bewaren dan nodig voor de Doeleinden.
- 3.3. Ontvanger zal bij publicatie van enige tekst, kaart of afbeelding waarin de Gegevens zijn verwerkt, BIJ12 als bron vermelden, inclusief de datum van de gegevenslevering.
- 3.4. Ontvanger zal bij publicatie van enige tekst, kaart of afbeelding waarin de Gegevens zijn verwerkt, rekening houden met de gevoeligheid van de data. Dat wil ook zeggen dat – indien aan de orde – geen (locatie) nauwkeurige data wordt weergegeven in enige publicatie of nieuwsbrief (nimmer nauwkeuriger dan 10 x 10 kilometer).

4. INTELLECTUELE EIGENDOMSRECHTEN

- 4.1. Alle Intellectuele Eigendomsrechten, alsmede alle soortgelijke rechten ter bescherming van informatie, met betrekking tot de Gegevens, alsmede de daarbij behorende materialen en documentatie, zijn het exclusieve eigendom van BIJ12 of haar licentiegever(s). Ontvanger erkent dat de Intellectuele Eigendomsrechten die rusten op de Gegevens toekomen aan BIJ12 of haar licentiegever(s).
- 4.2. BIJ12 verleent hierbij aan Ontvanger het niet-exclusieve, niet-overdraagbare recht om, om niet, de Gegevens voor het in deze Overeenkomst omschreven doel te gebruiken.
- 4.3. Niets in deze Overeenkomst kan worden opgevat als de overdracht van enig Intellectueel Eigendomsrecht van de ene Partij aan de andere Partij.
- 4.4. BIJ12 staat er voor in dat zij bevoegd is tot de Gegevenslevering zoals bedoeld in deze Overeenkomst alsmede dat de Gegevens rechtmatig zijn verkregen en vrijwaart Ontvanger van alle aanspraken terzake.

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5. AANSPRAKELIJKHEID

- 5.1. Ontvanger erkent en aanvaardt dat BIJ12 de Gegevens levert op basis van een inspanningsverbintenis. Voor zover BIJ12 tekortschiet in de voornoemde verstrekking van de Gegevens, vormt dit geen inbreuk op deze Overeenkomst.
- 5.2. Hoewel met betrekking tot de Gegevens de uiterste zorg is nagestreefd, kan voor de afwezigheid van fouten of onvolledigheden daarin, of in de doorgifte daarvan, niet worden ingestaan. BIJ12 is nimmer aansprakelijk voor enige schade van welke aard ook verband houdende met het niet, niet juist of niet volledig beschikbaar zijn van de Gegevens en/of het Platform waarop de Gegevens beschikbaar zijn/worden gesteld.
- 5.3. Behoudens voor zover bepalingen van dwingend recht zich hiertegen verzetten, is BIJ12 niet aansprakelijk voor enige schade, materieel dan wel immaterieel, die door Ontvanger, overige gebruikers of derden wordt geleden in het kader van het gebruik van de Gegevens.
- 5.4. Indien ondanks het bepaalde in dit artikel 5 sprake is van aansprakelijkheid zijdens BIJ12, en behoudens voor zover bepalingen van dwingend recht zich hiertegen verzetten, is de totale aansprakelijkheid van BIJ12 uit welchen hoofde ook voor schade die door Ontvanger wordt geleden beperkt tot het maximumbedrag waarvoor BIJ12 verzekerd is.

6. DUUR EN BEËINDIGING

- 6.1. Deze Overeenkomst wordt aangegaan vanaf het moment van de gegevenslevering, voor bepaalde tijd, en zal van rechtswege eindigen op 31 augustus 2022, tenzij deze Overeenkomst eerder door één van Partijen rechtsgeldig wordt beëindigd.
- 6.2. Onverminderd haar overige rechten kan BIJ12 deze Overeenkomst schriftelijk ontbinden:
 - a. zonder dat rechterlijke tussenkomst vereist is, indien Ontvanger toerekenbaar tekortschiet in de nakoming van een of meer van de verplichtingen uit deze Overeenkomst, daarvoor door BIJ12 in gebreke wordt gesteld en de bedoelde toerekenbare tekortkoming niet binnen een redelijke termijn, welke in geen geval langer zal zijn dan dertig dagen na ontvangst van de ingebrekestelling, is hersteld;

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- b. zonder dat enige ingebrekestelling of rechterlijke tussenkomst vereist is, indien Ontvanger misbruik maakt van de Gegevens, zulks te bepalen naar oordeel van BIJ12. Onder misbruik wordt in ieder geval, maar niet beperkt tot, gerekend de in 3.1 genoemde doeleinden.
 - c. In geval van ontbinding van de Overeenkomst door BIJ12 is zij niet gehouden tot enige schadevergoeding jegens Ontvanger.
- 6.3. Na beëindiging of ontbinding van de Overeenkomst, om welke reden dan ook, zal Ontvanger niet meer gerechtigd zijn tot gebruik van de Gegevens. Ontvanger zal alle Gegevens waarover zij op enigerlei wijze nog de beschikking heeft, in dat geval vernietigen dan wel verwijderen.
- 6.4. Verplichtingen uit deze Overeenkomst welke naar hun aard bestemd zijn om ook na het einde van deze Overeenkomst voort te duren, blijven na het einde van deze Overeenkomst bestaan. Tot deze verplichtingen behoren in ieder geval de bepalingen over privacy en geheimhouding, aansprakelijkheid, intellectuele eigendomsrechten en toepasselijk recht en geschillenbeslechting.

7. **PRIVACY**

- 7.1. Voor zover Persoonsgegevens door BIJ12 aan Ontvanger worden verstrekt onder deze Overeenkomst, en *vice versa*, zullen Partijen deze Persoonsgegevens verwerken in overeenstemming met de toepasselijke Privacywetgeving.
- 7.2. Na de ontvangst van de Gegevens door Ontvanger is Ontvanger verantwoordelijk en aansprakelijk voor de verwerking van en het gebruik van de Gegevens in overeenstemming met de toepasselijke Privacywetgeving.
- 7.3. Persoonsgegevens verstrekt onder deze Overeenkomst worden door de ontvangende Partij vertrouwelijk behandeld en worden niet aan een derde partij verstrekt of anderszins bekend gemaakt.

8. **DIVERSEN**

- 8.1. Wijzigingen in deze Overeenkomst zijn alleen geldig als deze schriftelijk zijn vastgelegd en door of namens alle Partijen zijn ondertekend.
- 8.2. Partijen zijn verplicht alle direct of indirect van de andere Partij verkregen vertrouwelijke informatie en gegevens vertrouwelijk te behandelen.

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- 8.3. Beide Partijen maken in publicaties of reclame-uitingen geen melding van deze Overeenkomst en gebruiken de naam en/of het logo van de andere Partij niet als referentie, tenzij de andere Partij daarmee vooraf schriftelijk heeft ingestemd.
- 8.4. Indien een bepaling in deze Overeenkomst ongeldig of niet-afdwingbaar is of wordt, blijven de Partijen aan de overige bepalingen gebonden. In dat geval vervangen de Partijen de ongeldige of niet-afdwingbare bepaling door bepalingen die wel geldig en afdwingbaar zijn en die met het oog op de aard en strekking van deze Overeenkomst, voor zo veel als mogelijk, eenzelfde werking hebben als de ongeldige of niet-afdwingbare bepaling.
- 8.5. Een enkele of gedeeltelijke uitoefening van een recht of rechtsmiddel onder deze Overeenkomst door een Partij staat niet in de weg aan een andere of nadere uitoefening van dat recht of rechtsmiddel of de uitoefening van een ander recht of rechtsmiddel. Een afstand van recht ter zake van een schending van het bepaalde in deze Overeenkomst door een Partij geldt niet als een afstand van recht ter zake van een opvolgende schending van deze Overeenkomst.

9. TOEPASSELIJK RECHT EN GESCHILBESLECHTING

- 9.1. Op deze Overeenkomst is Nederlands recht van toepassing.
- 9.2. Alle geschillen welke mochten ontstaan in verband met deze Overeenkomst zullen bij uitsluiting aanhangig worden gemaakt bij de bevoegde rechter te Den Haag.

Aldus overeengekomen en in tweevoud ondertek

5.1.2e

IPO, vestiging BIJ12

Door: ir. J.D.C. van der Endt MPA
Functie: Directeur BIJ12
Datum:
Plaats: Utrecht

Wageningen Universiteit, Departement Omgevingswetenschappen

Door: **5.1.2e**
Functie: Directeur bedrijfsvoering
Datum: 30 juni 2022
Plaats: Wageningen

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Paraaf
BIJ12

blad 8 van 21

Paraaf
Ontvanger

BIJLAGE 1 – GEGEVENS

BIJ12 stelt eenmalig alle gevalideerde wolvenwaarnemingen die sinds 1 april 2021 bij het wolvenmeldpunt ingevoerd zijn voor de provincie Gelderland, beschikbaar aan de Ontvanger. Het beheer en de validatie van het wolvenmeldpunt wordt uitgevoerd in opdracht van BIJ12.

- De data omvatten:
 - o Wolvenwaarnemingen
 - o Validatie categorieën: C1 en C2¹
 - o Het gebied: provincie Gelderland
 - o Periode: 1 april 2021 – 9 mei 2022
 - o Type waarnemingen: wolf gezien, waaronder camerabeelden en zichtwaarnemingen wolf.
- De data wordt geleverd in een Excel-bestand.

¹ De standaard voor het beoordelen van waarnemingen van wolven en sporen wordt gedefinieerd door de mogelijkheid tot verificatie, omschreven in de SCALP-criteria. C1 staat voor 'Harde bewijzen', zoals middels DNA-analyse en C2 staat voor 'Bevestigde waarneming', zoals goed gedocumenteerde wolvensporen of bijtsporen.



Werkt voor provincies

BIJLAGE 2 – ONDERZOEKSVOORSTEL

Wolfbirds on the Veluwe

Investigating the interactions between the common raven (*Corvus corax*) and the grey wolf (*Canis lupus*) in the Netherlands

MSc Thesis

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Introduction

Many vertebrate carnivores, not only obligate scavengers, make use of carrion by including scavenging as part of their feeding strategy ^{1,2}. The transfer of energy across trophic levels due to scavenging is thought to be an important process which can increase the stability of ecological communities ¹⁻⁴. Classically, predation and scavenging are seen as independent processes with predator-prey and scavenger-carrion interactions occurring separately ⁵. However, more recent studies have focussed on interspecific interactions between predator and scavenging species and on how these interactions can influence behaviour and population sizes of different trophic levels ^{1,2,4-8}. In many cases, large predators play a facilitative role by providing carrion which can in turn be utilised by scavenging species ^{3,8,9}. However, predator and scavenger species compete for carrion as well ^{3,6,7,10,11}.

By making use of the same resource, in this case carrion, species may experience competition as well as facilitation. Studies have shown that temporal niche partitioning is an important mechanism which may facilitate the coexistence of species sharing a similar niche ¹²⁻¹⁴. Species may alter their activity pattern in order to avoid encountering competitors and thus reducing competition ¹⁵. Via the same reasoning, species may alter their activity pattern in order to associate with facilitative species. By studying activity patterns, a lot of insight can be created about how interactions such as competition and facilitation influence wildlife behaviour and about possibilities as well as limitations for the coexistence of niche-sharing species. This has been studied for different territorial ecosystems across the globe including Africa, north America and southern Europe ^{1-9,11,13,16-24}. However, this has not been done for the Netherlands, mainly due to the long term absence of an apex predator.

With the reappearance of the grey wolf (*Canis lupus*) as of 2015 ²⁵, studying activity patterns may create insights on possible interactions between this apex predator and species within the same ecological community. This can help in understanding population dynamics and behaviour of species which have not experienced an apex predator before.

In order to contribute to the understanding of the coexistence of predator and scavenging species, and how this may be influenced by interspecific interactions such as competition and facilitation, this study will focus on a predator and a scavenger species which are living in the Netherlands, namely; the grey wolf (*Canis lupus*) as predator and the common raven (*Corvus corax*) as scavenger. Here, the following research questions will be addressed:

1. *What is the amount of temporal overlap of daily activity patterns between the grey wolf and the common raven, in the Netherlands?*
2. *Is the temporal activity pattern of the common raven, as well as the temporal overlap of activity between the grey wolf and the common raven, influenced by wolf abundance?*

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3. *Does seasonality affect the temporal overlap of activity between the grey wolf and the common raven?*

Wolf-raven interactions

Wolves are found to lose significant proportions of food due to raven scavenging. Per capita, wolves have been estimated to lose 2 to 4 kg of food per day as a result of scavenging ravens²⁶. For entire wolf packs this may be up to 20 kg, depending on the abundance of present ravens, the effort made by wolves to chase ravens away and wolf pack sizes, including many more factors^{10,27}. In order to compensate for the loss of food due to raven scavenging, wolves may kill up to twice as many prey as they would if ravens were absent¹⁰.

In addition, studies suggest that ravens associate with wolves as a feeding strategy. One study¹⁷ showed that ravens in Yellowstone National Park (YNP) discovered all observed wolf-killed carcasses almost immediately after the kill. Discovery time of experimentally placed carcasses was significantly higher or carcasses were not found at all despite the availability of fresh and exposed meat. Furthermore, when wolves were observed to be chasing prey, 87.2% of these observations included the presence of ravens. When wolves were observed to be present at a killed prey, ravens were also present for all observations. These results suggest that ravens are likely to be in close vicinity of wolves, especially when wolves are traveling or hunting¹⁷.

Finally, ravens may minimize competition with mammalian scavengers by associating with wolves. Scavengers with a high search efficiency, typically avian scavengers, often arrive first at a carrion site after which they are outcompeted by more dominant scavengers^{28,29}. This shows the importance of search efficiency for avian scavenger species, which can be increased by associating with predators. This behaviour in which avian scavengers respond to predator activity is also supported by a study¹⁸ in the Serengeti National Park in which auditory cues were used to simulate the sounds of predator hunting activity (sounds of wildebeest calves in distress and sounds of spotted hyenas and lions competing over a kill). They found that, in many cases, avian scavengers arrived first at the site, suggesting that avian scavengers respond to auditory clues of hunting activity¹⁸.

The competition wolves may experience from ravens will only be exploitation competition, as opposed to interference competition, since ravens do not have the ability to physically harm a wolf. Wolves have been reported to chase away ravens in order to minimize this exploitation competition¹⁰. Because of this and considering the advantages ravens may experience by associating with wolves, I predict a high temporal overlap in activity between the wolf and the common raven. Furthermore, I predict that temporal overlap will increase with an increase in wolf abundance since ravens will have a higher chance of being aware of wolf presence and will thus

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be more likely to take advantage of associating with wolves. Finally, I predict that temporal overlap will be higher in seasons where food availability is lower (i.e. autumn and winter) since ravens are found to be more dependent of carrion as food source in those periods.

Methods

Study area

This study was conducted in National park The Veluwe, in the Netherlands (Fig. 1). The Veluwe is the largest protected area in the Netherlands (912 km²) and mainly consists of coniferous and deciduous forests, heather and drift sands. Average annual precipitation on the Veluwe amounts to 950mm and the average annual temperature is 14 °C. Common wildlife species include wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), pine marten (*Martes martes*), red fox (*Vulpes vulpes*), and badger (*Meles meles*). Several wild cattle species such as Highland cattle (*Bos taurus*) and European bison (*Bison bonasus*) also graze on the Veluwe.



Figure 1: Location of the Veluwe in the Netherlands. On the left hand side the Veluwe is outlined in red, on the right hand side a zoomed in picture.

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Data sampling

Wolves

In order to measure temporal activity patterns, two sampling methods were used. For the wolf this was done by making use of camera trap data. Data were provided by BIJ12, the organisation which coordinates the monitoring, data storage and analyses of wolves in the Netherlands. The provided dataset includes locations, dates and time of wolf observations made by camera traps on the Veluwe. When a wolf was captured by a camera trap, the captured individual was considered as being active at that moment.

Ravens

For ravens, solar powered GPS and accelerometer (ACC) transmitters were used. Prior to this research, in the spring of 2021, six juvenile ravens from different nests were fitted with mentioned transmitters. This was done in accordance with Dutch legislation concerning animal experiments and handling. Shortly after ravens were fitted with the GPS transmitters, two of the six ravens either managed to remove the transmitter or suffered an injury impairing their ability to fly.

The four remaining transmitters recorded GPS locations once every five minutes. At the same time ACC data was recorded during one second at 20Hz in three perpendicular axes. Frequencies of these recordings were decreased depending on battery level of the transmitters. In order to select only datapoints which resembled a raven being active, flying behaviour was determined based on the ACC values. Only data points which resembled flying were used for the calculation of temporal activity patterns.

Data analyses

Determining flying behaviour

ACC values were measured in g's ($1g = 9.81 \text{ m/s}^2$). For each individual measurement, the ACC value consists of a static and a dynamic component. Here the static component is determined by the position of the transmitter in relation to the earth's gravitational field. The dynamic component is determined by the change in velocity as a result of body motion. Calculating the static component in each axis enables the determination of the body position; the angle of the device, and thus the angle of the body of the raven, is calculated as the arcsine of the static acceleration in the corresponding axis. This determines the body pitch in both the x (surge) and z (heave) axis, as well as the body roll in the y (sway) axis (Fig 2a, Fig 2b) ³⁰.

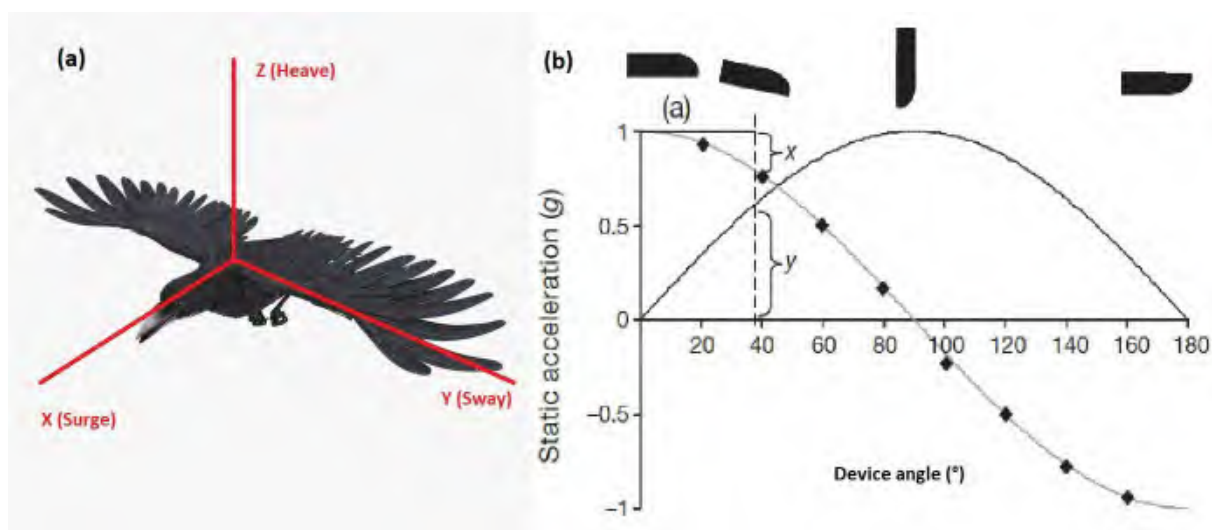


Figure 2: (a) Raven with the three axes in which ACC values are measured. (b) Relationship between static acceleration and body angle along the heave axis (shown in blocked line) and the surge axis (shown in straight line), device position is shown above the graph. Source: Shepard et al., 2008.

In order to derive the static component from the total ACC values, the data was smoothed. As mentioned, for each fix ACC values were measured for one second at 20Hz, resulting in 20 data points for each fix. By taking the mean of these 20 datapoints, the data is smoothed and this results in the static acceleration component for one fix. Thereafter, the dynamic acceleration component, for each individual data point, was calculated by subtracting the static component from the total ACC value. Taking the mean of the 20 dynamic acceleration components results in the mean dynamic body acceleration of each axis, for one fix. Subsequently, values of the mean dynamic body acceleration for the three axes are added up to calculate the overall dynamic body acceleration during one fix^{30–32}. By making these calculations, and by using other variables measured by the GPS/ACC transmitters, a number of variables were created which can be used to determine whether or not a raven was flying during a fix (table 1).

Table 1: Variables used to predict flying behaviour, derived from GPS speed and accelerometer sensors.

Variable	Direction	Label	Explanation
GPS speed (km/h)	3D	speed	Ground speed measured by the GPS/ACC transmitter
Body pitch (°)	X (surge)	pitch_x	Body angle along the X (surge) axis
	Z (heave)	pitch_z	Body angle along the Z (heave) axis
Body roll (°)	Y (sway)	roll_y	Body angle along the Y (sway) axis
Overall dynamic body acceleration (g)	X (surge)	odba_x	Mean dynamic body acceleration along the X (surge) axis
	Y (sway)	odba_y	Mean dynamic body acceleration along the Y (sway) axis
	Z (heave)	odba_z	Mean dynamic body acceleration along the Z (heave) axis
	3D	ODBA	Overall dynamic body acceleration (odba_x + odba_y + odba_z)

In order to determine flying behaviour, an unsupervised classification was performed on the calculated predictor variables. This was done in R in the form of a k-means clustering algorithm. The subset of the predictor variables which could explain the highest percentage of the variation within the data, based on the calculated clusters, was used for the classification. The number of clusters (k) was determined by selecting the cut-off point on which more clusters would not result in substantial less variation within each cluster (elbow method). Hereafter, the cluster which would resemble flying behaviour the best (e.g. highest dynamic body acceleration, highest speed or least body pitch in heave axis (horizontal position)) was classified as flying behaviour. This was done for each raven individually in order to account for individual differences between ravens and transmitters.

Activity patterns and overlap

By making use of kernel density estimation, density estimates of activity patterns were determined separately for both species. These density distributions give the probability of encountering an event, in this case an animal being active, at any given time of day. This was done with the R package *activity*³³. Thereafter, the coefficient of overlap (Δ) was used to quantify temporal overlap of activity patterns between raven and wolf, where Δ can range from 0 to 1 ($\Delta = 0$ meaning no overlap and $\Delta = 1$ meaning identical activity patterns)³⁴. This was done by making use of the R package *overlap*³⁵. This package produces several density estimators. The most suitable one, depending on sample size, was selected in accordance with recommendations made by Ridout & Linkie (2009)³⁴.

Temporal activity patterns were compared between locations with relatively high and low wolf passage rates, in order to investigate the effects of wolf presence on the temporal activity of ravens. Wolf passage rates were calculated by dividing the number of independent wolf captures by the number of days on which cameras were operating. One location was defined as an area of

10 by 10 kilometres. Furthermore, temporal activity patterns were compared for different seasons in order to investigate the effects of seasonality on temporal overlap of activity between the grey wolf and the common raven.

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De raaf

Terugkeer van een mythische vogel



Ravenparen blijven een levenlang bij elkaar | Foto Shutterstock

Met zijn imago als onheilsbrenger staat de raaf (*Corvus corax*) bij ons niet bekend als populaire vogel. In andere culturen staat hij beter aangeschreven. Aan het begin van de twintigste eeuw was de vogel door bejaging uit Nederland verdwenen. In 1936 volgde de eerste poging tot herintroductie. Inmiddels is de raaf weer wijdverspreid in ons land. **5.1.2e** verdiept zich in deze mythische soort. Hoe is de relatie tussen raaf en mens en wat weten we van ze? We kunnen het niet vragen, maar ongetwijfeld zijn ze blij zijn met terugkeer van de wolf in Nederland.

Tekst **5.1.2e**

De eerst genoemde vogel in de Bijbel is de raaf. Na de grote vloed waarbij alleen de ark van Noach met alle dieren over blijft, laat Noach de raaf na veertig dagen als eerste uitvliegen, op zoek naar droog land (*Genesis 8*). En als Jezus vindt dat zijn leerlingen zich te druk maken over dagelijkse dingen, zegt hij: "Kijk naar de raven: ze zaaien niet, ze oogsten niet, ze hebben geen voorraadkamer en geen schuur, het is God die ze voedt" (*Lucas 12:24*).

In de Noordse mythologie zijn twee raven Huginn (gedachte) en Muninn (herinnering) in dienst van oppergod Odin. Zij vliegen rond en fluisteren aan het einde van de dag het nieuws in de oren van Odin. Uit de Griekse godenleer komt het verhaal van de god Apollo die een witte raaf als zijn metgezel heeft. Als deze hem op een

dag vertelt over de ontrouw van zijn geliefde, wordt de god woedend en doodt haar en haar minnaar. Ook de witte raaf moet het ontgelden. Apollo verschroeit zijn verenkleed. De raaf wordt zwart! Helemaal indrukwekkend is de rol van de raaf bij de Inuit en andere Indianenvolken. Vader raaf (Tulungersag) is namelijk de schepper van het leven en dus ook van de mensen op aarde.

De raaf wordt zowel geassocieerd met de zon en het licht als met de dood en het duister. Het negatieve imago van onheilsbrenger krijgt in de loop der eeuwen de overhand. Bijvoorbeeld in het volgende gedicht van **5.1.2e** (1905-1997):

*De afwijzing
Ik schrijf u met de ravenveer,
Mijnheer,
Mijn eer uw eer
Uw hart mijn hart
Heeft niets gemeen*

Ik schrijf u met de ravenveer.

Ik schrijf u met het ravenzwart

Het teken: neen.

Mensen zien de grote, donkere vogel met kenmerkend schor geluid vaak plotseling opduiken bij aas. Uit de middeleeuwen kennen we de combinatie heks en raaf. Vervolging en bejaging is helaas wijd verbreid en heel gebruikelijk.

Empathisch

De raaf is de grootste zangvogel ter wereld. Kenmerken zijn de sterke licht gebogen snavel, de lange smalle vleugels en de wigvormige staart. De raaf is een alleseter, maar leeft vooral van knaagdieren, insecten, wormen, jonge vogels en kadavers. Hij is op vrijwel het gehele noordelijk halfrond te vinden, maar in meerdere Europese landen zeldzaam of uitgeroeid. Op dit moment zijn in Nederland al bijna tweehonderd broedparen te

vinden In de winter zijn er nog veel meer vogels.

De jonge vogels worden relatief lang door hun ouders verzorgd. De vogels zijn duidelijk in staat tot het tonen van empathie. Na een conflict tussen twee raven, wordt het 'slachtoffer' wel getroost door een omstander. Ze raken elkaar aan met de snavel en poetsen elkaars veren. Helaas houden mensen hun twijfels over het karakter van de raaf, zoals blijkt uit een gedicht van **5.1.2e** (1929-2010):

*Oh zeg ons toch eerwaarde raaf.
Waart gij uw hele leven braaf.
Het antwoord luidde kort en bondig.
Ik was mijn hele leven zondig.*

In het wild kunnen de dieren vijftien jaar oud worden. In gevangenschap, zoals de raven die worden gehouden bij The Tower of London, worden ze ouder, soms wel meer dan veertig jaar. Op dit moment wonen er zeven raven bij de Tower: Jubilee, Harris, Gripp, Rocky, Erin, Poppy en Georgie. Op raadselachtige wijze verdween Merlina in 2021. De raven worden goed in de gaten gehouden, want volgens de legende moeten altijd minstens zes raven bij de Tower blijven. Anders komen de vesting én het Engels koningshuis in gevaar. Dat deze vogels intelligent zijn is al lang bekend en dat blijkt ook weer uit recent onderzoek. Wetenschappers in Osnabrück vergelijken in 2020 de fysieke en sociaal-cognitieve vaardigheden van raven met die van chimpansees en orang-oetans. Hieruit blijkt dat vier maanden oude raven net zo goed als volwassen apen presteren!

Vocaal

In het boek *Wijsheid van wolven* van **5.1.2e** gaat de schrijfster uitgebreid in op de bijzondere relatie tussen raven en wolven. Ze baseert zich hierbij op haar eigen langdurige ervaring met de dieren in het Yellowstone Park in de Verenigde Staten en de ideeën van bioloog en wolvenexpert **5.1.2e**. De bijzondere relatie tussen raaf en wolf heeft zich gedurende miljoenen jaren ontwikkeld. Interessant is bijvoorbeeld dat door proeven is aangetoond dat door mensen neergelegde hertenkadavers niet door raven worden gegeten. Maar als een wolf een prooidier heeft gedood, zijn ze er snel bij. Daarbij speelt ongetwijfeld een rol dat wolven het lichaam voor raven toegankelijk maken. Wolven zijn voornamelijk



Jonge raven krijgen een oranje pootring | Foto **5.1.2e**

geïnteresseerd in het vlees en de spieren. Het maagdarmsstelsel eten ze in ieder geval niet. Raven eten de resten op. Raven hebben wel tweehonderdvijftig klanken te beschikking en wolven lijken enkele daarvan te verstaan. **5.1.2e** noemt raven zelfs een soort huisdieren van de wolven. Ze gaan mee op jacht en doen soms spelletjes met de welpen, zoals ze aan hun staart trekken en kort opjagen.

Als de wolfjes wat ouder zijn, plagen zij de raven. Er zijn sterke aanwijzingen dat raven wolven attenderen op een mogelijke prooi. Dat zou niet alleen kunnen door bepaalde geluiden van raven, maar het lijkt ook wel alsof ze met de vleugels 'wijzen' naar een zwak dier. Overigens is het goed mogelijk dat de Nederlandse raven zich anders gedragen dan die in de Verenigde Staten.



Voor het ringen wordt de pootdikte opgemeten | Foto **5.1.2e**

Succesvolle herintroductie

In 1936 importeert **5.1.2e** de Vereniging Natuurmonumenten, negen jonge vogels uit Litouwen. Het wordt geen succes. Bij de volgende herintroductiepoging, in 1966, maakt men gebruik van grote kooien, geplaatst in drie voor publiek afgesloten gebieden (Veluwe, Utrechtse Heuvelrug en Drenthe). In 1973 zijn nog eens 66 jongen en 11 volwassen vogels uit Duitsland geïmporteerd. Er vindt paarvorming plaats en uiteindelijk krijgen 160 vogels de vrijheid. In 1976 zijn de eerste jongen in het wild geboren. Op de Veluwe profiteren de raven van het traditionele bijvoeren van de wilde zwijnen. Omdat raven langlevende vogels zijn en pas na enige jaren gaan broeden, duurt het tot 1989 voor de kenners zeker zijn van een levensvatbare populatie in Nederland. In het boek *Gewilde dieren* staat een uitgebreid hoofdstuk van **5.1.2e** over de introductie van de raaf. Achteraf kun je je afvragen of herintroductie nodig was, want met de kennis van nu weten we dat de raaf waarschijnlijk ook op

eigen kracht naar ons land was gekomen, zoals de zeearend en de kraanvogel. Deze succesvolle herintroductie is beslist een inspiratiebron geweest voor andere herintroducties.

Onderzoek

Jonge raven worden, indien mogelijk, geringd zowel met een metalen ring als, sinds 2013, met een oranje kleurring. Nog meer informatie geven gps-loggers. Op dit moment zijn er tien raven met zogenoemde dataloggers (zenders) uitgerust. Ark Natuurontwikkeling is met een project op de Veluwe gestart en daarbij zijn ook de Ravenwerkgroep, de Wolvenwerkgroep, SOVON, Universiteit Wageningen en Staatsbosbeheer betrokken. Het project heet 'Wolf, aasleverancier en aaseter' en is onderdeel van het programma 'Dood doet leven' en rewilding de Veluwe. De gps-loggers uploaden dagelijks data naar een dataportaal waar ze door de onderzoekers kunnen worden bekeken. Op deze manier kunnen ze verplaatsing, beweging en temperatuur volgen. Dat biedt belangrijke

informatie over habitatgebruik, roestplekken, foerageerplekken en zo voort. Om de vijf minuten wordt de gps-locatie geregistreerd. Dankzij een recent ontwikkeld algoritme kan uit deze berg aan gegevens snel een zogenaamde cluster worden gedestilleerd. In de praktijk is dit in de Veluwse natuurgebieden een plek met aas. De zenders zijn in principe niet belastend voor de vogels. Volgens de wet op dierproeven mogen ze niet meer wegen dan 3% van het lichaamsgewicht. Als de jonge raven gezenderd worden wegen ze al minimaal 1 kilo. De zenders zijn ongeveer 25 gram zwaar. Met de zenders willen de onderzoekers antwoorden op verschillende vragen krijgen. Zo willen ze bijvoorbeeld beter zicht krijgen op de relatie tussen raaf en wolf.

Een belangrijke vraag is ook hoe de vogels omgaan met de logger? Proberen ze die te slopen en misschien wel met hulp van ouders, broertjes en zusjes? Tot nu toe is er een losgekomen datalogger gevonden waarbij predatie niet is bewezen. De logger had piksporen en het tuigje was – ver-



De wolf en de raaf trekken vaak samen op | Foto Shutterstock



Aanbrengen van een zender bij een van de Nederlandse raven | Foto 5.1.2e

moedelijk door de ouderdieren – gesloopt. Een toekomstige terugmelding van de kleurring J86 (die bij de vogel met de nu ontbrekende zender was aangebracht) kan meer informatie opleveren. Het zenderen geeft een zeer nauwkeurig inzicht in de verspreiding. Waar gaan de (jonge) raven heen na uitvliegen? Is er interactie met andere groepen, en zo ja waar? Vormen ze onderdeel van groepen? Duidelijk is wel dat het nog even duurt voor betrouwbare, eenduidige conclusies kunnen worden getrokken.

Raven zien

5.1.2e (Ark Natuurontwikkeling) vertelt over jonge raven. Deze trekken eerst een tijd met elkaar op. Dit noemt men ravensoos. Ook hebben zij gezamenlijke slaapplekken. Op 24 oktober 2021 ziet 5.1.2e op de Veluwe wolf en raven samen bij een edelhertenkadaver. Zijn filmpje is op YouTube te vinden. Er blijkt dat twee jonge gezenderde raven, die op verschillende plaatsen de nacht doorbrachten, onafhankelijk van elkaar naar deze plek zijn toegevlogen. Zij hebben op hun slaapplek de informatie van hun soortgenoten gekregen. De jonge raven gaan later op zoek naar een eigen territorium.

Het laatste en goede nieuws van dit jaar is dat de gezenderde raven volgens 5.1.2e (Ravenwerkgroep) “vrolijk” rondvliegen. Bijna allemaal zijn ze op bezoek geweest bij de vuilstort van Barneveld. Op 15 september 2022 meldt 5.1.2e enthousiast op Facebook dat er die avond bij de vuilstort 200 tot 300 raven aanwezig zijn en 29 daarvan hebben een kleurring. Drie vogels met een metalen ring komen uit Duitsland. Overigens kun je tegenwoordig in vrijwel heel Nederland raven zien en horen (kijk maar eens op waarneming.nl).

Toekomst

5.1.2e (Drents vogeldeskundige en kritisch denker) ziet de toekomst van de raaf zonnig in. Op mijn opmerking dat vrij veel nesten mislukken, stelt 5.1.2e dat “sterfte erbij hoort”. Raven leven lang en grote delen van het land zijn al dusdanig ‘verzadigd’ met raven dat er sowieso niet meer bij kunnen. Hij denkt dan aan de Veluwe, waar de dichtheid al geruime tijd niet toeneemt omdat ruimte en voedselaanbod beperkt zijn. Raven zijn talrijker dan ooit tevoren. Bij toenemende dichtheid is afnemende reproductie het gevolg. “De loop der dingen”, aldus 5.1.2e. “Er is maar één diersoort, die zich (vooralsnog)

aan die wetmatigheid onttrekt en dat is de mens. Soortbescherming in het algemeen is volslagen flauwekul. Alleen ecosystemen doen er toe. Ga er maar vanuit dat iedere reddingsactie ten faveure van een soort ten nadele is van heel veel meer andere soorten. Plus dat zo’n actie nooit het door mensen gewenste resultaat oplevert (al wordt er vaak gelogen dat het wel het geval is).”

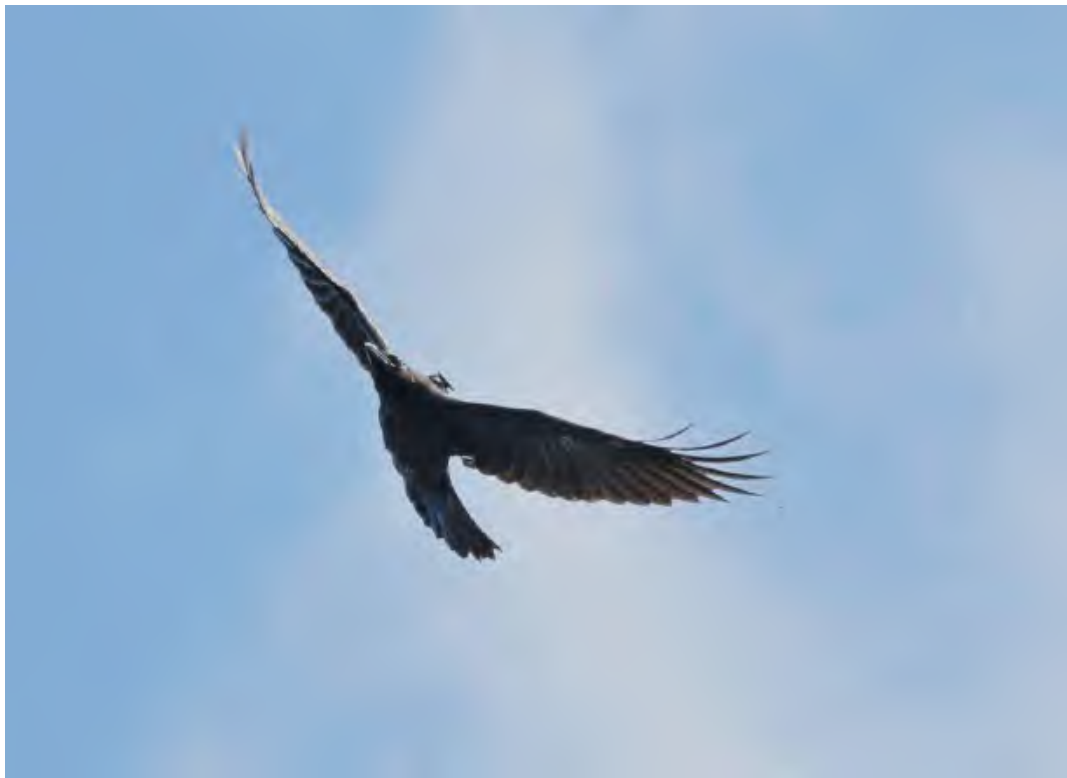
5.1.2e heeft ook geen zorgen over de toekomst van de raaf, maar hij benadrukt dat aandacht nodig blijft om duidelijk te maken wat de rol is van deze prachtige vogel binnen de ecologie en de natuur. ■

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What do the eyes of the forest see?

A study using GPS and accelerometer data of the common raven (*Corvus corax*) in the Netherlands to determine habitat preferences and detect food sources.



Raven with transmitter 5.1.2e, 27-04-2021)

5.1.2e

November 2021

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The author declares

- 1) that this work is her own and
- 2) that she has adhered to The Netherlands Code of Conduct for Academic Practice



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Abstract

The continuing growth of human populations and their demand for a growing food production results in habitat fragmentation, which limits the habitat use of many species. Often habitat use studies focus on breeding adults and their territories, neglecting the needs and preferences of juveniles, which are also important for the success of a population. Therefore, it is important to study the habitat preference of juvenile ravens (*Corvus corax*) in the highly fragmented Netherlands. Four juvenile ravens, equipped with GPS/GSM and accelerometer transmitters, were used to determine habitat preferences and detect food sources. The influence of eight environmental and anthropogenic variables, which were expected to determine habitat preferences, was studied with general linear mixed models as a resource selection function. Additionally, foraging, sleeping, and flying behaviour of the raven were determined using density-based clustering of sequential data. To these supervised clusters a random forest was fitted, in order to predict behaviour during unvisited clusters. Results of the resource selection function indicate poor performance, which might be due to the limited individuals and investigated variables. Additionally, this might be due to the fact that ravens are generalists, which causes them to have a wide range in feeding and roosting sites. The random forest had a moderate fit and most clusters were found in forest and agriculture. However, predictions for unsupervised clusters seemed poor, which was due to the imbalanced supervised data. This study was a pilot with only four ravens, which made clear predictions difficult, therefore continuing and expanding this study might be beneficial to compare differences over seasons and with more individuals. However, ravens are generalists, meaning they are flexible in their use of food sources and home ranges, which might make it difficult to determine a specific preference for the whole population.

Keywords: Raven, Accelerometer, GPS clustering, Habitat, Food sources.

1 Introduction

The habitat use of a species has great consequences for their survival, as it influences reproduction and mortality rates¹. A species will have an optimal chance of survival, if the effort needed for feeding and the risks for predation and competition are low in their habitat². These interactions with elements in the environment of a species determine their spatial behaviour³. Studying this spatial behaviour offers insight in the species' habitat requirements, relationship with the environment, and threats from competitors⁴⁻⁸. For instance, the continuing growth of human populations and their demand for a growing food production results in habitat fragmentation effecting many species^{9,10}. Habitat requirements of a species can be explored at different scales using habitat selection analysis, as specified by Johnson (1980). These scales for habitat selection are based on the dependence of one order on the other, zooming in on specific requirements of habitat selection for every order. First order habitat selection is the whole geographical range with the species occurrence, on which the second order of selection depends. The second order is the selection of the home range, which can be bigger than an animals territory, as it consists of the whole area where an animal frequently returns for feeding, interacting and exploring¹². Third order habitat selection analysis focuses on the habitat use and requirements of a species within its home range, while fourth order habitat analysis focuses on spatial behaviour during specific activities like feeding, sleeping and moving. How species select their habitat on different scales can vary throughout their life stages, because of dispersal and changing needs due to breeding^{13,14}. Species that take a long time to mature and start breeding, generally spend their juvenile years exploring wide areas to locate food sources, which increases the area in which they can encounter threats of competitors or predators¹³⁻¹⁶. Often conservation studies are focused on breeding adults and their territories, neglecting the needs and preferences of juveniles,

which are important for the success of a population ^{14,17}. It is therefore important to fill this gap in knowledge and conservation, by unravelling habitat requirements and spatial behaviour of juveniles.

Common ravens (*Corvus corax*) are such a species that take around four years to mature ^{18,19}. The spatial behaviour of juveniles can be divided into three transition periods: 1) The raven is on the nest site and does not really fly yet; 2) Nest stage, when the young raven leaves the nest but is still in close proximity of the parents and mostly sleeps at the nest site; and 3) Wandering stage, when the young raven explores the area more, becomes independent of the parents, and can join a roosting group ^{7,14,20-22}. These three stages indicate differing spatial behaviour and therefore different habitat requirements, which is often related to the availability of food sources ^{11,19,23,24}. To locate new food sources, range expansion of young ravens can be beneficial ²⁵. The common raven is an opportunistic scavenger, who scavenges on road-, hunting- and wolf-kills ^{18,24,26,27}. Ravens are also known to utilize human food sources, like garbage dumps, restaurants and take-out restaurants ^{24,27}.

The current IUCN red list status of the common raven is least concern, as the species has increased significantly in North America and Europe since 1980 ²⁸. Previously, intensification of agriculture decreased habitat availability for ravens ^{29,30} and reorganisation of livestock farming decreased the availability of carcasses in northern Europe ^{18,24,26}. This had great ramifications for raven populations, which became evident in the beginning of the 20th century. In the Netherlands prosecution by humans, due to alleged damage and superstition, aggravated these consequences with extinction as a result ³⁰. After several unsuccessful reintroduction attempts, ravens were imported from Germany and placed into breeding cages in the Netherlands. The resulting juveniles were released and managed to start a growing population, which increased till 180 breeding pairs in 2019 ³¹. Despite this success, the raven is still listed as a red list species in the Netherlands ³². Determining habitat requirements of a species is of great importance when a species is reintroduced after extinction, as it can help to assess the success of a reintroduction project and determine long-term adaptation of a population (IUCN/SSC Re-introduction Specialists Group, 1998; King et al., 2011; Seddon, 1999). The Netherlands offers a diverse, but highly fragmented landscape with the highest human population density of Europe, which might explain the challenges during reintroduction of the ravens ^{33,34}. However, the raven is known as an opportunistic and flexible animal, which is not necessarily affected by fragmentation as long as food sources are abundant ^{19,35}.

The main research question of this study was; What are the characteristics of young raven habitat in the Netherlands and does a fragmented landscape influence their habitat use? This was done as a 3rd order habitat analysis ¹¹, as this offers the opportunity to focus on spatial behaviour and preferences in the small home range of these young individuals. It was expected that the ravens would not avoid more fragmented areas, as they are highly opportunistic and flexible animals ^{19,35}. It was also expected to find that ravens mostly spend their time on the edge between forest and heather area, using the trees for shelter and the open heather areas to easily locate food sources, as this is seen in many other areas ³⁵⁻³⁷. These hypotheses indicate that ravens would have differing behaviour when they are inside forests, which caused me to also study their habitat preferences at a finer scale with the sub question; What are the characteristics of spatial behaviour of young raven inside Dutch forests and does a fragmented, densely populated landscape influence their habitat use? It was expected that they would prefer to be in proximity of the forest edge, and that they are less bothered by human disturbance and infrastructure, due to the sheltering function of the forest. The infrastructure of highways was expected to be avoided, as the noise can disrupt communication ^{38,39}. It was also hypothesized that

the ravens prefer higher trees as a look out point, over lower trees in the forest. Additionally, this study aimed to answer the question; Can spatial behaviour and accelerometer data be used to detect different behaviours and determine the habitat types during certain behaviours? This question was analysed as a 4th order habitat analysis ¹¹, as the spatial behaviour during certain activities might influence the chosen environment. It was hypothesized that ravens would be attracted by human food sources, like take-out restaurants, and that they would be attracted to carcasses or other remains, to which they return several times in a short time period to feed ^{23,24,27}. It was also expected that the habitat during these behaviours will be similar as the above mentioned hypothesis, a preference for the edge between forest and heather areas.

2 Methods

2.1 Study area

The Netherlands is a densely populated country with 517 inhabitants per km² in 2020 ⁴⁰. In the study area, the Veluwe, the population increased with more than 4% since 2015. This increase has caused desiccation, deforestation, eutrophication, acidification, pollution and fragmentation, which reduces habitat quality, quantity, and accessibility for many species ⁴¹. However, the study area is the largest protected area of the Netherlands under Natura 2000 regulations, with 912 km² (Dijkhuizen & Schimmel, 1976). It is a varied and sloping landscape, as it is the largest moraine in the Netherlands with heights of 110 metres ^{43–45}. The protected area mainly exists of forest, heather, sand drifts and some small lakes, alternated and surrounded by towns and agriculture (Figure 1). There is a high variety in plant species present and both deciduous and coniferous forest can be found. However, coniferous forest is the most abundant forest type, in which the raven population mostly breeds ^{30,41}. This heterogenic terrain is also inhabited by many mammals, such as wild boar (*Sus scrofa*), wolf (*Canis lupus*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), pine marten (*Martes martes*), red fox (*Vulpes vulpes*), and badger (*Meles meles*) ^{42,46}. Additionally, semi wild horses and cattle graze in the area, such as highland cattle (*Bos taurus*), Icelandic horse (*Equus ferus caballus*), and European bison (*Bison bonasus*) ⁴⁶.

2.2 Data collection

For this study, six juvenile ravens from six different nests were tagged in the Netherlands with a solar powered GPS/GSM (Global system for Mobile communications) and accelerometer transmitter, which was mounted as a 27-28 gram backpack with a Teflon cord (Ornitela, n.d.). On the 27th of April 2021, ravens who were not able to fly out of the nest yet were tagged (Figure 1). Since this study required animal handling, several permits were acquired prior to conducting the fieldwork for this study. First of all, permission was granted by site managers to carry out transmitter work for raven in their areas and ringing permits were issued by the bird migration central. In accordance with this protocol, all fledglings were ringed on the right leg with a coloured ring and on the left leg with a metal ring to enable identification. Secondly, a permit was granted under the Animal Experiments Act (Wet op Dierproeven). This permit required a protocol in which the weight of the transmitter, the method of attachment, the number of animals, the weight of the animals (in relation to the transmitter) and the people who carry out the work have been described. This protocol was approved by the Dutch Animal Welfare Authority and the permit holder is Sovon Vogelonderzoek Nederland. In accordance with this protocol the biggest fledgling of each nest was chosen to fit the transmitter. Their biometry was determined by measuring their weight, wing length, leg thickness and claw size (Table 1). The general

regulation of 3% transmitter and attachment weight per body weight has been pursued ⁴⁸. Only raven 3 had a higher percentage of 3.34 %. Thirdly, the people handling the ravens have been authorized under Article 12 of the Animal Experiments Act to handle animals. Lastly, no permit was needed from the Province of Gelderland for the Nature Protection Act (Wet Natuurbescherming).

Table 1 - Characteristics of raven nests, transmitters, rings and biometry. Supplied by the Raven Workgroup.

Raven	Age at ringing (days)	Start of egg lay	Number of young in nest	Coloured ring	Wing length (mm)	Weight (gr)	Leg thickness (mm)	Claw length (mm)
1	43	19/02/2021	3	H24	320	1076	10.45	112
2	38	24/02/2021	5	J51	292	1133	10.05	115
3	36	27/02/2021	3	H27	272	834	9.5	100
4	36	26/02/2021	2	J87	276	950	9.7	105
5	42	21/02/2021	3	J86	315	1004	10.34	113
6	31	03/03/2021	1	J50	240	1016	9.39	105

At the moment of tagging, the trackers recorded GPS locations once every hour, since the young ravens were mostly covered by tree canopy in the first period and the solar panels were thus not able to fully recharge the battery. From 25-05-2021 the ravens started to fly more, and therefore the trackers were reprogrammed to record GPS coordinates once every five minutes if the battery stayed above 75%. Accelerometer data were recorded for one second at 20 Hz in three perpendicular axes at the same time as the GPS coordinates were recorded. If the battery was lower than 50%, data were only recorded once every half hour and different settings were tried to increase battery power. At night, GPS coordinates were recorded once every four hours. This period was defined with a sun angle of minus four degrees, which was for example between 20:00 UTC until 03:00 UTC on 20th of May, 2021. Collected records were uploaded to Movebank every six hours to make analysis of the data and field inspections more feasible; 10:00, 16:00, 22:00, and 4:00 UTC+2 (<https://glosendas.net/cpanel/>). When the batteries dropped below 75%, uploads were reduced to once a day at 16:00 UTC+2. GPS data for this study was collected from 27-04-2021 until 15-09-2021.

Raven 5 managed to remove its transmitter within a month of placement, which was subsequently placed on another fledgling. The raven on which it was placed secondly was found killed and predated within two days of leaving its nest site. After observing a divergent movement pattern, raven 6 was found with an injured wing and impaired condition. As such the tracker was removed and the bird was placed in a shelter to recuperate on the 18th of June 2021.

5.1.2h

Figure 1 - Locations of raven nests from which fledglings were tagged on map of the Veluwe. Black dotted line resembles the border of the Veluwe. Inside the border, green is forest and purple is heather. The two red pins resemble the raven that removed transmitter after a few weeks (raven 5) and the one that was taken into a shelter (raven 6). The background map is the Land Use Map of the Netherlands from 2019 ⁵⁹.

2.3 Data analysis

2.3.1 Data preparation

Data were cleaned and filtered using R packages *Tidyverse* and *move* ^{49,50}. Data were filtered to only use the data with five minute intervals between GPS coordinate fixes, which removes the data that were collected at night. The GPS coordinates of the transmitter occasionally show an evident outlier, which indicates an inaccurate location. These were removed by calculating the step length (distance between one location and the subsequent location in meters), the two steps length (distance between one location and second location after that in meters), and the ratio between these (step length/ two steps length). Data points with a relatively extreme step ratio of twenty or higher were deemed outliers and therefore removed from the data set.

2.3.2 Third order habitat analysis

To determine the habitat preferences of young ravens inside their home range, I performed a third order habitat analysis ¹¹. The development of flight behaviour of young ravens was studied to assess transition periods.

2.3.2.1 Transition periods

Transition periods indicate ageing of the young ravens and can be divided in; 1) on the nest, 2) left the nest but is still in close proximity of parents, and 3) independent of parents ^{14,51}. As the individual ravens might have a different pace of development, these transition periods were considered when selecting data for the habitat analysis instead of astrological periods. This study focused on the second period, when the ravens are still under influence of their parents ^{14,51}, as this influences their dispersal behaviour in later life stages ⁵²⁻⁵⁵. The date of fledgeling (period 2) was taken as the fifth time a raven was over 100 meters from the nest to omit outliers. These outliers were not removed yet in the preparatory steps, because the GPS accuracy was lower in the begin period, since GPS locations were recorded less often. The date of independence is very difficult to determine. Krüger & Amar (2017) have suggested for bearded vultures (*Gypaetus barbatus*) that this period starts when a fledgeling is outside the home range of the parents for 14 days, as this is how long a fledgeling can stay alive

without additional feed. However, average home ranges of parental ravens in the Netherlands have not been studied yet. In other countries parental ravens have an average home range of at least 10 km² ^{19,37}. Considering the high human population density and fragmented nature of the Netherlands, this may not be applicable in this study. Therefore, an optimum has been sought with a period from 10 to 14 days and a radius around five kilometres. To make sure the correct periods were selected, I visually compared flight behaviour of every individual by calculating minimum, mean, and maximum distance to the nest, mean and maximum step length (distance flown in five minutes), and total flight length per day and per week.

2.3.2.2 Home ranges

Data from the second period (individual left the nest but is still in close proximity of parents) was used to determine habitat selection using a resource selection function. This analysis was done under the assumption that the expected spatial distribution of a population is random in the area of their home range, and any deviation from randomness shows a preference ⁵⁶. The home range was estimated with the 95% kernel utilization distribution of the GPS locations, using the *adehabitatHR* package in Rstudio. The ad hoc method (h_{ref}) was used as a smoothing parameter. This method was shown effective and adequate in studies on vulture species ^{51,57}. The number of GPS locations inside this home range was seen as the observed points and the random points (not-observed) were created within the calculated home range with the *sp* package, with an amount of ten times the observed points.

2.3.2.3 Variables

Eight variables in total were used for the resource selection function to answer the proposed research questions (Table 2). All continuous variables were standardized for analysis using the scale function in Rstudio, which transforms the data into a variable with a mean of 0 and a standard deviation of 1. Next, the correlation between the numeric variables was tested before conducting the analysis, using the Spearman correlation coefficient with a cut-off value of $|r| > 0.4$ for removal of variables ⁵⁸.

Table 2 – Characteristics of variables used in habitat analysis with resource selection function.

Variable	Categorical / Continuous	Source	Resolution
Open / Closed habitat	Categorical	Land Use Map Netherlands ⁵⁹	5*5 m
Nature area / Inhabited area	Categorical	Land Use Map Netherlands ⁵⁹	5*5 m
Distance to nearest forest	Continuous	Land Use Map Netherlands ⁵⁹	5*5 m
Distance to nearest build-up area	Continuous	Land Use Map Netherlands ⁵⁹	5*5 m
Distance to forest edge	Continuous	Land Use Map Netherlands ⁵⁹	5*5 m
Core area index (CAI)	Continuous	Land Use Map Netherlands ⁵⁹	5*5 m
Mean tree height	Continuous	Tree Height in the Netherlands ⁶⁰	10*10 m
Presence of highways	Categorical	National Road Register ⁶¹	160*160

Available habitat in the average home range was determined using the open source Land Use Map of the Netherlands ⁵⁹. This map contains 37 land use classes, which I reclassified to create two new layers. The first layer had the categories 1) open and 2) closed, in which open contained the habitat classes; agriculture, water, drift sand, grass, roads and railways, heather, wetlands, and shrub vegetation. Closed contained the habitat classes; deciduous forest, coniferous forest, build-up area, forest at

build-up area, build-up agricultural areas, and plantations. For the second layer the habitat classes were reclassified into the classes; 1) nature area and 2) (human inhabited) non-nature area. Nature areas contained the habitat classes; water, drift sand, grass (not at build-up areas), heather, wetlands, deciduous forest, coniferous forest, and shrub vegetation. Non-nature areas contained the habitat classes; agriculture, roads and railways, build-up area, grass at build-up areas, forest at build-up area, build-up in agricultural areas, and plantations.

Distance to the nearest forest, nearest build-up area, and forest edge were calculated with the `gridDistance` function in the *raster* package in RStudio, which calculates the distance in meters to a specified feature and creates a new distance raster ⁶². The open source Land Use Map of the Netherlands was used as input raster for the forest and build-up areas. To calculate the distance to the forest edge, a distance raster was created to all non-forest habitat, which therefore only works for locations inside the forest.

Core area index (CAI) was calculated with the *landscapemetrics* package ⁶³. Core area is calculated as all raster cells that do not share a border with another habitat type, which is then divided by the total patch area to get the core area index. A patch in this case is a definite area of habitat, for instance a forest patch surrounded by heather. This measure gives an indication on the shape of preferred areas of habitat. Additionally, it functions as a fragmentation measure, as more fragmented areas have more patches with a lower CAI.

Mean tree height was extracted from a national tree height raster, which shows an average tree height of all trees above 2.5 meters ⁶⁰.

To determine the influence of highways, the presence was calculated as a binomial factor, since it would only affect a raven until a certain extent into the forest areas that lie directly around highways. A buffer of 20 meters was taken around highways from the National Road Documentation raster of the Netherlands ⁶¹. It is expected that smaller roads will not affect raven spatial behaviour, as they are very abundant on the Veluwe.

2.3.2.4 General linear mixed model

To determine the characteristics of young raven habitat inside their home range in the fragmented and densely populated Netherlands, five variables were used in the analysis; open or closed habitat, nature or (human inhabited) non-nature area, distance to nearest forest, core area index, and distance to nearest build-up area. In this case the influence of fragmentation and high human population was measured with the variables core area index, distance to nearest build-up area, and nature or inhabited area.

To determine the habitat preferences and effects of human influences on a finer scale inside the forest, only data of the observed and random locations inside forest habitat were used. During this analysis four variables were included; mean tree height, distance to the edge of the forest, presence of highways, and distance to nearest build-up area. Where the influence of fragmentation and avoidance of human infrastructure is measured using presence of highways and distance to nearest build-up area.

To answer these questions generalized linear mixed models (GLMM) with a binomial distribution were fitted. The ID of the four ravens were added as a random effect. The 1 in the binomial distribution represents the observed GPS locations of the ravens and the 0 represents the randomly available

points. Multiple candidate models were created for both research questions with subsets of the variables and Akaike's Information Criterion (AIC) values were compared to determine the best fitting models ⁶⁴. The best fitting models were chosen with an AIC weight above 0.9 ⁶⁵. If this was not available, an average would have been taken from all models with an AIC delta lower than 5. To examine the goodness of fit of the chosen models, the conditional R^2 was calculated with the `r.squaredGLMM` function in the *MuMIn* package ⁶⁶. The conditional R^2 resembles the variance that is explained by the fixed and random effects of the model. After binomial model fitting, the predicted values for raven presence and estimates for the fixed effects were transformed back from logit link with the `plogis` function in Rstudio to represent outcomes that are easier to interpret ⁶⁷.

2.3.3 Fourth order habitat analysis

In order to obtain the habitat during different activities for the fourth order habitat analysis ¹¹, the locations of foraging, sleeping and flying ravens needed to be identified. Since the ravens' behaviour was not observed in the field, it was difficult to determine if a raven was actually feeding based on the GPS locations alone. I located potential feeding sites by identifying clusters of GPS points using a geographical clustering algorithm in Rstudio in the form of density-based clustering of sequential data, utilizing the *GPSeqclus* package ⁶⁸. I identified these possible food source sites based on two criteria; 1) An individual raven showed more than seven GPS records in a radius of ten meters within nine hours, and the location is not the nest site; 2) Multiple ravens with transmitters visited the same location within 24 hours. A third indicator of ravens being on the ground was explored, but due to the lack of a barometer on the transmitters, bird height was not accurate enough. Two separate algorithms in Rstudio were needed to inspect these indicators daily. The first indicator could be easily analysed with the *GPSeqclus* package, which gave clusters with recognizable ID, cluster characteristics and maps as an output. For the second indicator, I developed an algorithm that indicates where and when two of the four ravens have been within 15 meters of each other's locations within 24 hours.

When a geographical cluster or other indicator pointed out a possible food source, this location was visited by an intern or employee of ARK Natuurontwikkeling to determine what the cause of interest was. After visiting a few agricultural areas it became clear that it was difficult to determine what the food source was in these areas. As such the focus for this field work was changed to heather and forest areas, where distinct food sources like hunting left-overs could be found. The aim was to visit a location within 24-48 hours, to make sure a possible food source was still present. During every field visit a protocol was followed to gather the observations correctly and consistently (Appendix 1).

Sleeping sites were found with the *GPSeqclus* package during the search for feeding clusters, by selecting the clusters that started in the evening and ended in the morning. For flying behaviour, data was selected with a step length (distance between two consecutive GPS locations, which is five minutes apart) higher than 800 meters. Afterwards, I used the found scavenging and sleeping clusters, together with the flying data, to examine if there were any differences in average accelerometer data during these behaviours. This was done using visual comparison methods with the *ggplot* package in Rstudio ⁶⁹.

2.3.3.1 Random forest

Additionally, a random forest was fitted on the accelerometer data of the found sleeping and feeding clusters to classify all clusters (clusters with more than seven GPS records in a radius of ten meters within nine hours) in the study period in the two behavioural classes (food and sleep), using the *randomForest* package in Rstudio ⁷⁰. The input data for the random forest consisted of all

accelerometer records (recorded at the same time of GPS records) that formed the known food source and sleeping clusters. These data offered the variables; acceleration in X, Y, and Z axes, and also the one step (distance between two consecutive GPS locations in meters), and two step (distance between one location and second location after that in meters) were calculated based on the corresponding GPS records. These data were split into a testing and training dataset maintaining the groups of cluster ID and raven with a 0.45 to 0.55 proportion respectively. A total of 500 trees were fitted with two variables at each split. The fit of the random forest was judged with the confusion matrix, out-of-bags error rate, ROC curves, and AUC value. This random forest was used to predict the behavioural classes of the other GPS clusters in the full study period. Habitat characteristics from these predicted sleeping and feeding clusters were explored visually using the *ggplot2* package in Rstudio ⁶⁹.

3 Results

3.1 Habitat selection within home range (third order habitat selection)

3.1.1 Transition periods

The optimum for distance and time away from the nest for raven 1 was found at 5,000 meters from the nest for more than 14 days. The start data of this optimum was seen as the end of the second transition period. For raven 2, this was 1,800 meters for more than 12 days. Raven 3 and raven 4 were not considered independent from their parents in the study period (from 27-04-2021 until 14-09-2012) as their optimum lies at a range of 100 meters for three days for raven 3 and a range of 600 meter for six days for raven 4. The most visible change is that raven 1 and 2 do not often return to their nest site anymore, while raven 3 and 4 return to the nest location daily (Figure 2). However, other factors like the mean step length do not show a distinct pattern in behaviour for the four ravens (Figure 3).

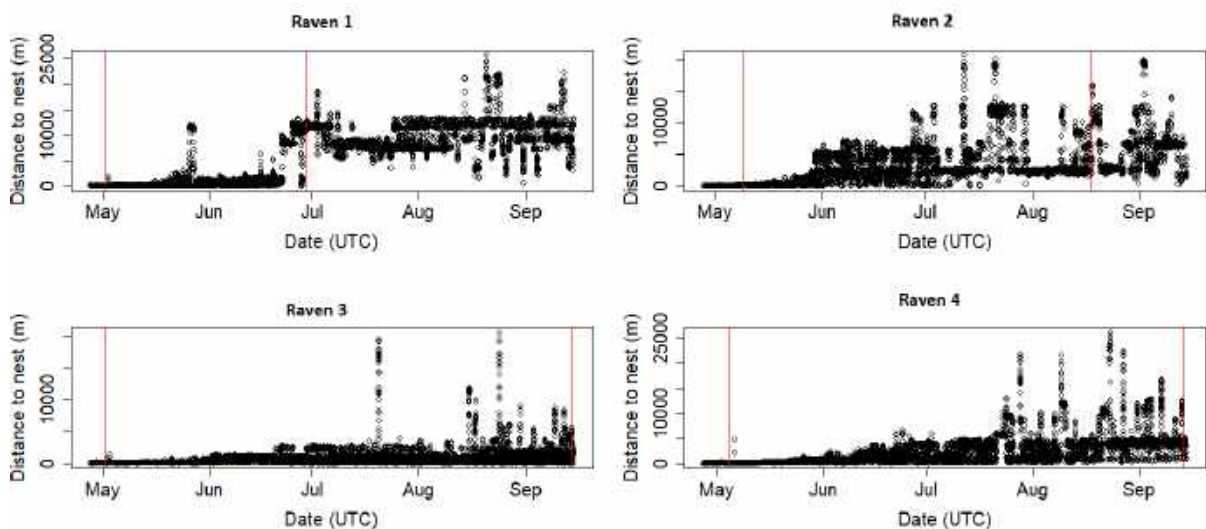


Figure 2 – Daily distance to the nest site in meters for the four ravens as a measure of development and ageing. The vertical red lines indicate the start and end of the data that was used to estimate the home ranges.

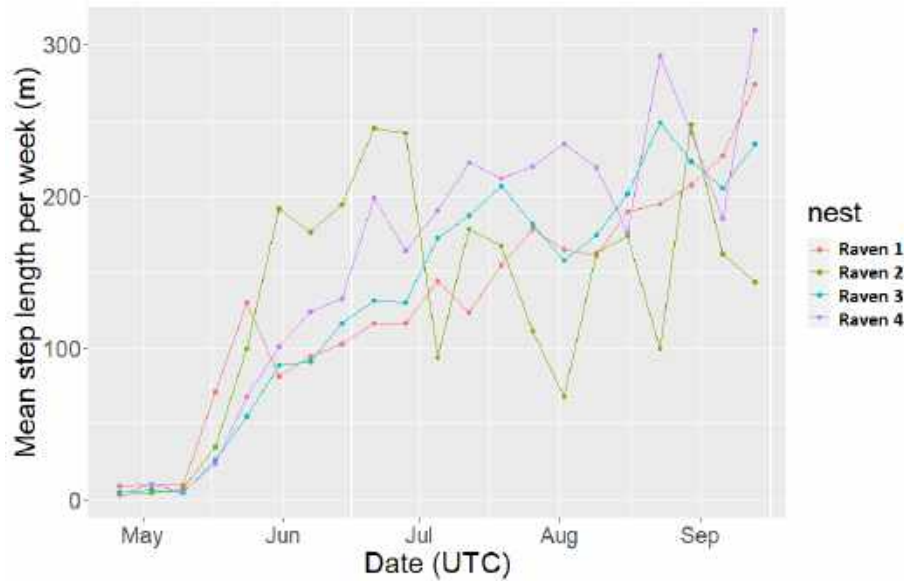


Figure 3 - Mean step length (distance flown in five minutes) per week in meters for the four ravens as a measure of development.

3.1.2 Home ranges

The average estimated 95% kernel home range of the four ravens was 26.94 km² in their second transition period (Figure 4; Table 3).

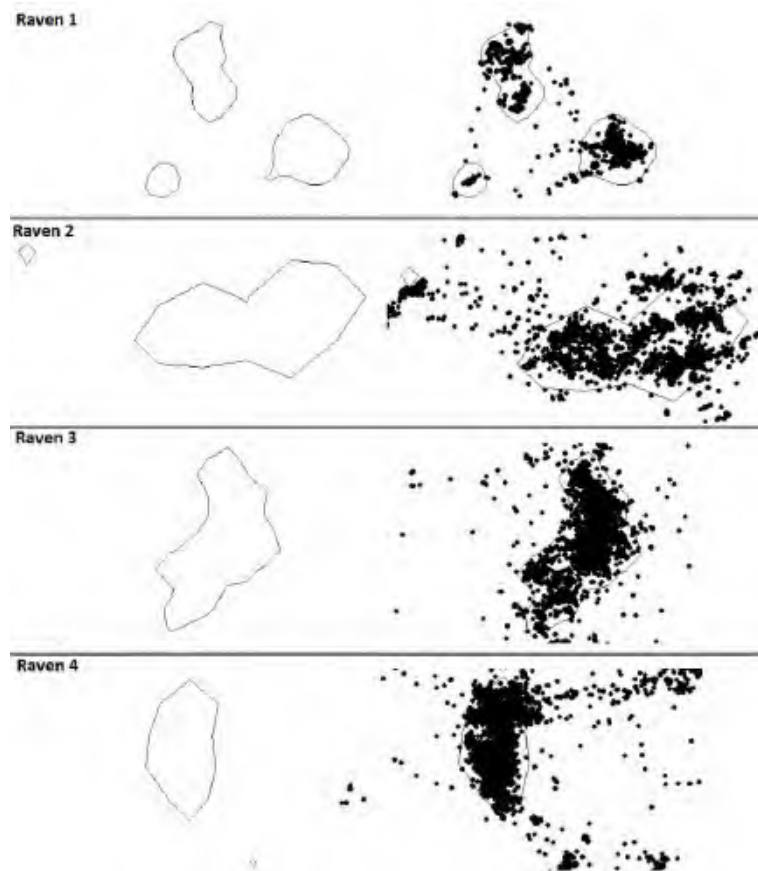


Figure 4 - Outline of the 95% kernel of GPS locations of the four ravens in the second period of development, which is considered to be their home range. Left side of images shows the outline of the home range and right side of images shows the outline with the considered GPS locations.

Table 3 - Size of home range in km².

Raven	Size home range (km ²)	Dates of used data	Number of days of used data	Number of observed locations
Raven 1	49.51	02-05-2021 to 29-06-2021	58	8,021
Raven 2	28.07	09-05-2021 to 18-08-2021	101	17,964
Raven 3	11.17	02-05-2021 to 14-09-2021	135	22,812
Raven 4	19.01	05-05-2021 to 14-09-2021	132	22,658

3.1.3 General linear mixed model

The correlation values between the continuous variables used for the main research question (CAI, build-up distance, and forest distance) of this dataset were all below the cut off value ($|r| > 0.4$), therefore they were all used for model fitting (Appendix 2 figure 1a). The best fitting model (Appendix 2 table 1) estimated that raven habitat choices were mostly influenced by a preference of nature areas over non-nature areas (estimate=0.229, SE=0.012), and a preference to be close to forested areas (estimate= -0.225, SE=0.006). Moreover, areas with a higher core value (estimate=0.092, SE=0.005) and open habitat (estimate=0.081, SE=0.010) were preferred, but these variables had less effect on the distribution of the ravens than the variables nature area and distance to forest. Interestingly, raven habitat preference was only slightly negatively influenced by distance to build up area (estimate= -0.012, SE=0.005). However, plotting the back transformed (from logit link) variables against the predicted possibility of raven presence indicate less clear preferences of the ravens, as the lines are very flat (Figure 5). The R^2 of this model is 0.024, which indicates a very bad fit. Additionally, The random effects of the model indicate that the habitat use of raven 4 differed the most from the other ravens (Figure 6).

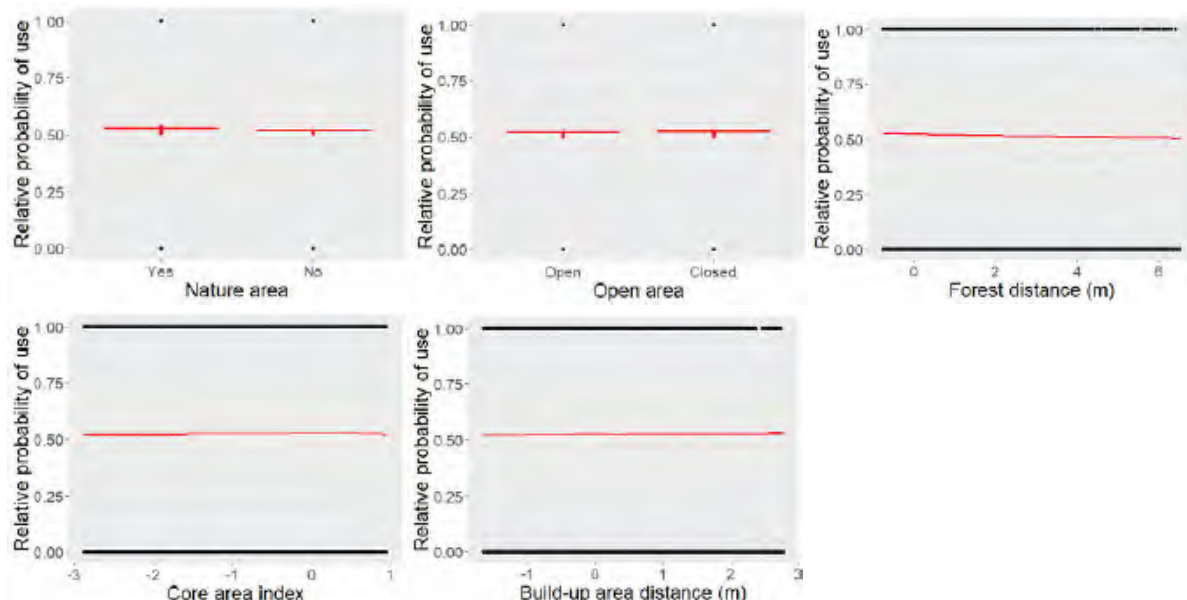


Figure 5 – Effect plots of the different variables in the best fitting GLMM for the first research question on habitat preferences of ravens inside their home range and the effect of fragmentation. Shows a positive (ascending line) or negative effect (descending line), which estimates if the ravens would use an area under the circumstances of the y-axis variable. Numeric variables on the x-axis are standardized and predicted probability values on the y-axis are back transformed from logit link.

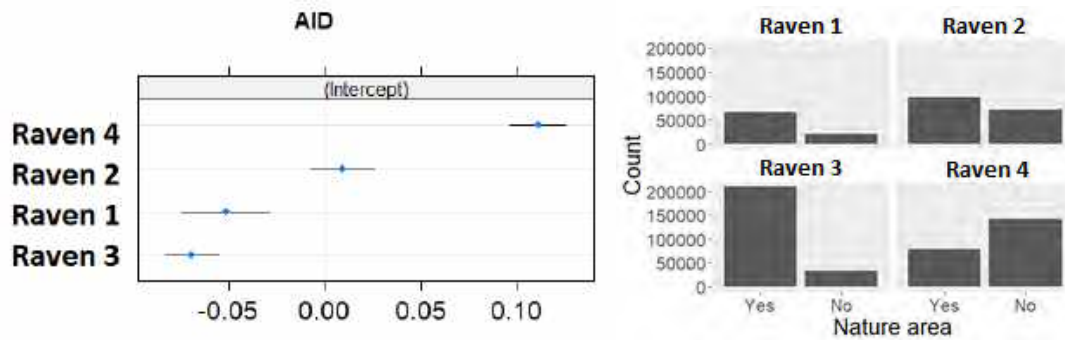


Figure 6 – Left: Random effects on the model for the first research question on habitat preferences of ravens inside their home range and the effect of fragmentation, which are the individual ravens (AID). Right: The location of observed and random locations divided in nature and non-nature area. Example of a variable that has a very different distribution of data for raven 4, opposed to ravens 1 and 3.

The numeric variables for the research question on the finer scale inside forests (distance forest edge, mean tree height, and build-up distance) also showed minor correlation (lower than the cut off value of $|r| > 0.4$), therefore they were all used for model fitting (Appendix 2 figure 1b). The best fitting GLMM for this sub question (Appendix 2 table 4) showed that highway presence had the highest effect on the data (estimate = 1.425, SE = 0.028), estimating a high preference for the presence of highways by ravens. As this is probably influenced by one nest being located on a highway parking lot, this variable was not included in the final GLMM. The final best fitting GLMM (Appendix 2 table 7) estimated that ravens locations were mostly influenced by a preference for higher trees (estimate = 0.264, SE = 0.007), and being close to the edge of the forest (estimate = -0.218, SE = 0.008) (Figure 7). Distance to build-up area only had a minor negative influence on raven distribution (estimate = -0.034, SE = 0.007). However, plotting the back transformed (from logit link) variables against the predicted possibility of raven presence indicate less clear preferences of the ravens again, as the lines are very flat (Figure 7). The R^2 for this model was 0.061, which indicates a very bad fit. The random effects of the model indicate that the spatial behaviour of raven 1 differed the most from the other ravens (Figure 8).

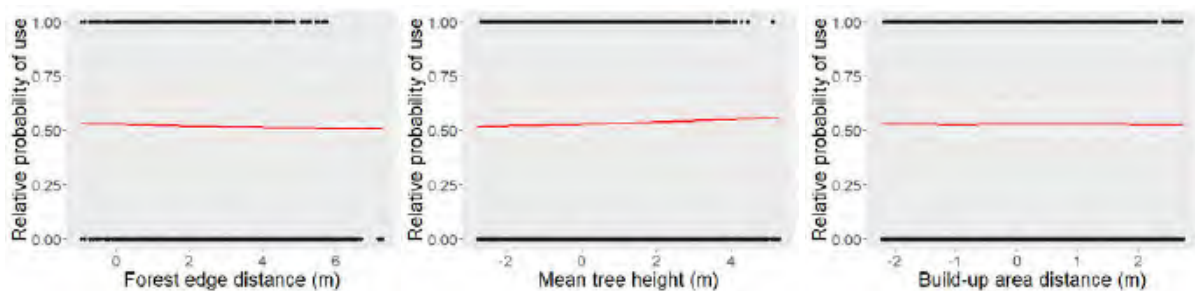


Figure 7 – Effect plots of the different variables in the best fitting GLMM for the sub question on habitat preferences and the influence of fragmentation inside forest habitat. Shows a positive (ascending line) or negative effect (descending line), which estimates if the ravens would use an area under the circumstances of the y-axis. Variables on the x-axis are standardized and predicted probability values on the y-axis are back transformed from logit link.

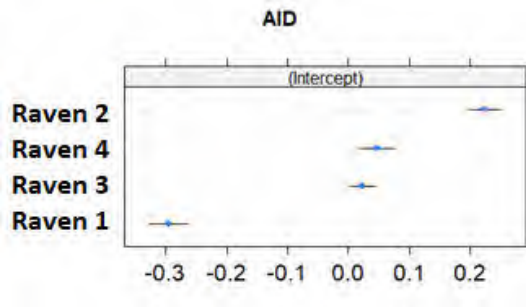


Figure 8 – Random effects on the model for the sub research question on habitat preferences and the influence of fragmentation inside forest habitat, which are the individual ravens (AID).

3.2 Spatial behaviour during different activities (fourth order habitat selection)

3.2.1 GPS clusters

During this study, we managed to visit 25 cluster locations in heather or forested area, of which seven offered a food source (Figure 9a; Appendix 3). Some locations were visited by the managers of the area and were therefore not recorded according to the protocol, but this made a total of 20 observations of food source clusters in heather and forest areas (Appendix 3). Additionally, we visited often recurring cluster locations that were not in heather or forest areas, but were of great interest for the ravens. These locations consisted of agricultural fields, one take-out restaurant, and one garbage dump (Figure 9b).

5.1.2h

Figure 9a – Overview of all clusters in the second transition period of the four tagged ravens. Maps are generated using the GPSeqClus package, with the parameters; search radius in meters= 10, window in days= 0.4, minimum cluster locations= 7⁶⁸. The yellow dots show the centres of the found clusters and the black dots show all observed locations from the ravens in the second transition period.

5.1.2h

Figure 9b – Example from home range of raven 2 with locations at build-up that were highly visited by the four ravens. Square is the garbage dump and circle is the take-out restaurant.

3.2.2 Accelerometer differences for activities

The average values of the Y accelerometer axis showed a clear distinction between food, flying and sleep clusters (Figure 10). The difference in mean step length clearly sets the data from flying activities apart from food and sleep activities (Figure 11).

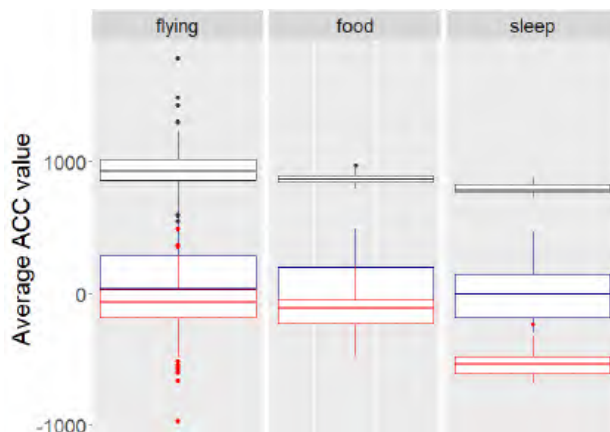


Figure 10 - Average accelerometer values for the X, Y and Z axes during flying, feeding and sleeping activities. The blue boxplots show the distribution of the X values, the red boxplots represent the Y values, and the black boxplots the Z values.

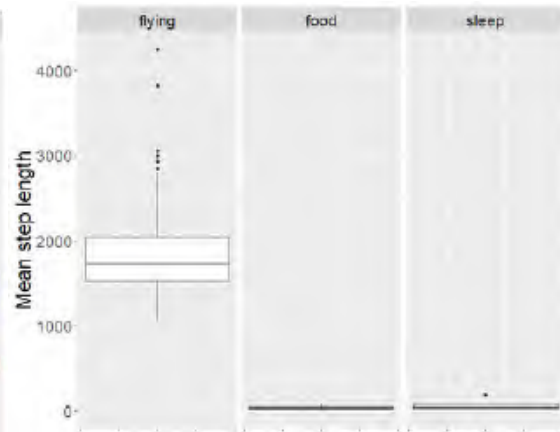


Figure 11 - Average step length during the flying, feeding and sleeping activities.

3.2.3 Random forest to categorise activities

The outcome of the visual comparison of the accelerometer values led to believe that clear distinctions between food and sleep clusters could be found. A random forest was fitted on the data of the 346 GPS records that formed the clusters to see if accelerometer data could be used to predict cluster type (food or sleep). This model had an out-of-bags error rate of 21.43% (Table 4) and an AUC of 84.47% on the testing set (Figure 12). As expected from the visual accelerometer analysis (Figure 10), feature importance was the highest for Acceleration in the Y axis (Table 5). Comparing the average accelerometer values in the found clusters with the effect of a tilting transmitter on the accelerometer values, indicates that the ravens sit more upright during sleeping and their back is more flat during feeding (Appendix 4). The AUC showed that the model has moderate results in prediction^{71,72}, therefore it was used to predict the activity during the records of the other found clusters in the study period of the four ravens, consisting of 7,925 records. This predicted 2,613 records as part of a sleep cluster and 5,312 records as part of a food cluster. Habitat recorded during these clusters were mostly

forest (2,608 records in predicted food clusters and 1,047 records in predicted sleep clusters) and agriculture (1,351 in predicted food clusters and 845 in predicted sleep clusters) (Figure 13). However, the ratio of predicted clusters differed between the four ravens, indicating a poor prediction of cluster types for at least some of the ravens (Figure 14). If the cluster predictions were more adequate, statistical analysis would have been performed on the habitat types.

Table 4 - Confusion matrix of random forest on testing data. Results in OOB error rate of 21.43%.

	Food	sleep	Class error
Food	89	25	0.25
sleep	11	43	0.16

Table 5 - Feature importance per variable measured as Mean Decrease Gini, which measures how much worse the predictions of the model become if a feature was not used.

Variable	Mean Decrease Gini
Acceleration X	12.3
Acceleration Y	39.8
Acceleration Z	14.1
Step	8.7
Two step	8.2

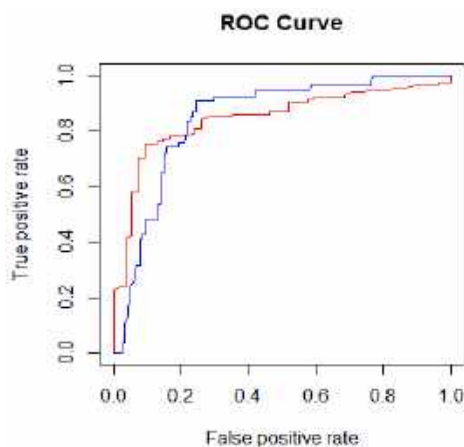


Figure 12 – ROC curves of the two classes (food = red, sleep = blue) from the predictions on the testing dataset of the fitted random forest.

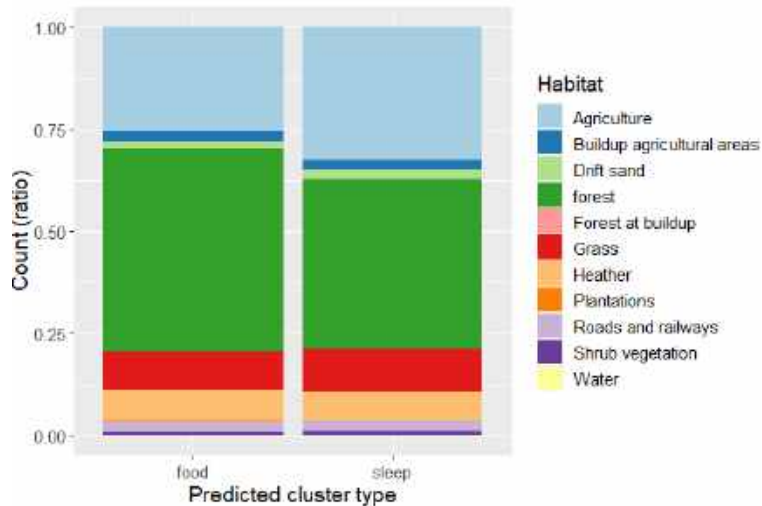


Figure 13 – Habitat type from the records in the predicted activity clusters.

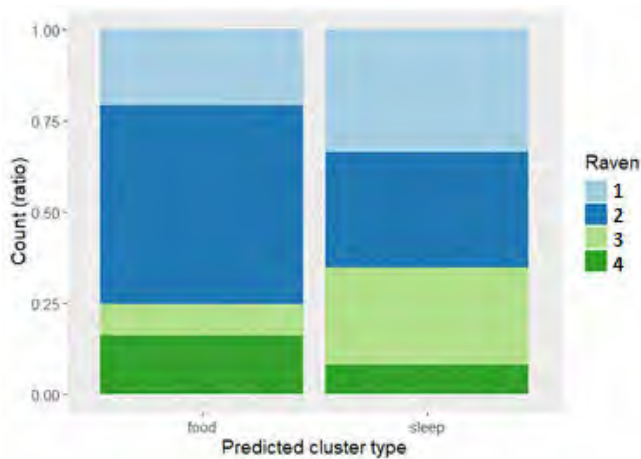


Figure 14 – The ratio of predicted cluster types for both activities (sleeping and feeding) per raven using the fitted random forest.

4 Discussion and recommendations

4.1 Third order habitat selection

This study shows that young ravens prefer to be close to forest and close to the edge when they are located at forest habitat. Additionally, nature areas (e.g. heather and drift sands) were preferred over non-nature areas (e.g. agriculture). This implies that the ravens were more in nature areas close to forest, which is in line with the hypothesis that ravens prefer to be on the edge of forest and heather. The study shows no clear avoidance of fragmented landscapes, as the four ravens had only a slight preference for areas with a higher core value (meaning less edges and therefore less fragmentation). Additionally, distance to build-up area only had a minor influence on habitat selection, inside and outside the forest, which indicates that the ravens were not disturbed by presence of human infrastructure, as the hypothesis suggested.

These findings are based on the best fitting general linear mixed models (GLMM), under the assumption that the models are adequately accurate for prediction of raven preference on third order habitat analysis. However, further investigation of these GLMM's showed that the fit of the models was quite poor, as the R^2 for both models was below 0.1, which means that not even ten percent of

the variance in the data is explained by the model. Additionally, the AIC delta's and weights estimated that the best fitting models were much better than all the other candidate models, which could indicate overfitting⁶⁵. Moreover, the predicted values for the probability that a raven would be present were all around 50%, which means that there are no clear preferences shown by the fitted models (Figure 5 and 7). The influence of the variables in the models were also diminished by the big differences in random effects of the four ravens (Figure 6; Figure 8), which could be due to the generalist and highly flexible characteristics of the ravens^{19,35}. This flexibility causes ravens to have a wide variety in their diet (and therefore feeding sites) and nesting sites, which makes it difficult for a model with only few ravens and few variables to predict their preferences^{19,29,73,74}. Being a flexible generalist is beneficial when habitat selection is costly, which is the case in the Netherlands, as finding unfragmented natural habitats costs a lot of effort^{41,75}. In this study no avoidance of fragmentation was shown, which indicates that fragmentation was not necessarily a problem during reintroduction in the Netherlands, as they could use their generalist behaviour as a coping mechanism. However, several reintroduction attempts in the Netherlands failed, as the ravens 'disappeared', so it might have been more costly for the ravens to adjust to their new environment, than to fly back to their previous habitat³⁰. Additionally, the core area index that was used in this study to analyse the influence of fragmentation might have been insufficient, as this represents natural fragmentation (e.g. alternation of forest and heather) with similar values as fragmentation by human development. The other used variable to test fragmentation, distance to build-up areas, might also not function for the generalist ravens, since they utilized human food sources, which are seen as build-up. The relationship between the abundance of specific food sources and presence of ravens can be studied with functional responses⁷⁶. This would offer a way to study the influence of human food sources separately from the influence of fragmentation. In such a study the possibility of temporal changes should be considered, as many birds are known to change from generalists to specialists periodically⁷⁷. Ravens in other countries are known to depend more on scavenging of large carcasses in the winter, while they are found more on agricultural fields and near restaurants in summer^{18,27,78,79}. It would be very interesting to study the differences in functional responses over the seasons for the raven population in the Netherlands.

The differences between the individuals, could also be due to the differences in nest locations and parental guidance, as these factors have a high influence on dispersal behaviour of many bird species⁵²⁻⁵⁵. Additionally, the nests of the tagged ravens were chosen for this project based on maturity of juveniles on date of ringing, cooperation of local ringers and area owners. The proximity of the nest to wolf territories was also considered, as a potential relationship between raven and wolf was of interest to ARK Natuurontwikkeling (Organisation that set up the project). This might cause these ravens to be less suitable for habitat analysis, as the individuals might not serve as comparable repetitions. To study the influence of the nest locations further, it would be very interesting to explore if the habitat preferences change when the young ravens have entered the third stage of development. At the third stage, young ravens can join a group of ravens for roosting and foraging, which decreases risks and flight costs^{18,19,36,80}. These roosting groups can wander over wide areas or stay around certain foraging sites, which would influence their habitat preferences significantly^{18,19,81}. When repeating the habitat selection analysis for individuals in the third stage of development as GLMM, a different selection of random GPS locations might be beneficial, as the currently used data set might suffer from imbalances. There are now ten times more random GPS locations (0, no raven presence) created than observed locations (1, raven presence), which might skew the distribution of

the data. Future research might use a model with an equal amount of observed as random location, as this seems to be done more often ^{82–85}. Another option would be the usage of Step Selection functions instead of the Resource Selection function used in this study, which is a method that compares environmental attributes at each taken step (movement between two consecutive GPS locations) with the available environmental attributes at randomly generated steps from the same starting point ⁸⁶. With this method the habitat preferences during dispersal and area exploration of the individuals in roosting groups can be studied, while individual differences are also considered ⁸⁷.

4.2 Fourth order selection

This study showed that spatial behaviour of ravens can be easily and adequately used to detect behaviours like feeding, sleeping and flying. The clusters where we did find food sources showed that the ravens on average visit a cluster for twelve GPS fixes spread over nine hours, proving the hypothesis that ravens would return several times in a short time period to feed on these food sources ^{23,24,27}. The data of predicted food clusters was located mostly in forest and agricultural areas (Figure 13), which could indicate that ravens prefer to be on the edge of forests and agriculture during the study period, contradicting the hypothesis that ravens prefer to be on the edge of heather and forest. However, to accurately determine preferences, the observed habitats should have been compared to available habitats, which was not done in the fourth order habitat selection. Additionally, the study period was in summer (when crops are abundant) and their preferences might change in winter, as is known from other countries ^{18,27,78,79}. Moreover, observations of possible food sources for this study were only done in heather and forest areas, which might increase the accuracy of predictions from the fitted random forest for these habitats, while it decreases the accuracy for other habitats. The accuracy of predictions might also be impaired by the different amounts of sleep and food clusters that were used as supervised data per raven (Table 5), resulting in different ratios of food and sleep clusters predicted per raven (Figure 14), while in reality all ravens probably eat and sleep daily. It might benefit the model if averages and summary statistics are calculated for accelerometer values per cluster, instead of using all accelerometer records from the clusters. This is done in many similar studies, but much more supervised clusters are needed for this approach ^{88,89}. We did not manage to visit more clusters, because the Dutch conserved nature areas are managed by many different organisations (e.g. Natuurmonumenten, Staatsbosbeheer, Nationaal Park Hoge Veluwe, and Kroondomein Het Loo) and all areas are only partly open to the public. Hence, approval had to be granted by different organisations and local managers to leave the public paths and look for a cluster, which was difficult to establish in some cases. This random forest also only had two categories available in categorisation; sleep and food. These sleeping clusters could also be seen as stationary clusters, as the ravens might be sitting in an area for a longer time during the day, which results in the same posture, and therefore same ACC values, as during sleeping. Additionally, at field visits of numerous clusters, the source of interest or activity could not be determined. I recommend to change the sleep category into stationary behaviour, to add a third category for unknown behaviour, and observing the individuals in the field to create more supervised data of different activities. At these locations of food sources ravens can interact differently with each other and show specific behaviours, like food caching ^{24,90,91}. Locations where ravens interacted could therefore be used to locate food sources (second indicator 2.3.3), but these were not visited or recorded during this study, since the GPS clustering method (first indicator) seemed adequate enough to locate food sources. However, I would recommend further exploration of interaction of ravens at known food sources to better understand their behaviour. This could be done in Rstudio with dynamic interaction analysis as Long

& Nelson (2013) suggest. Another difficulty in locating food sources was the lack of barometers on the transmitters, since this would give more accurate height of the ravens (third indicator), which is a common indicator in detecting feeding behaviour of birds ⁹³.

5 Conclusion

Habitat preferences were investigated using general linear mixed models and spatial behaviour was used to determine habitat during different activities. However, this study has not found any definite answers to the research questions, since the models had a poor fit (GLMM's) and poor prediction quality (random forest). This study was a pilot with only four ravens, which made clear predictions difficult, therefore continuing and expanding this study with more individuals and more parameters might be beneficial to compare differences. However, ravens are generalists, meaning they are flexible in their use of food sources and home ranges, which might make it difficult to determine a specific preference for the whole population. For future research I recommend using methods like Step Selection functions, and response curves on specific food sources, in which seasonal variation should be considered. Transition stages seemed to be an adequate method to divide development stages of individuals, but I would recommend to study the home range of parents for more certainty in estimations. In conclusion, studying of juvenile habitat requirements is crucial for better suiting conservation methods of whole populations, but individual differences of flexible animals pose a challenge to capture their behaviour in a statistical model.

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Appendix 1: Protocol for field visits of GPS clusters.

For this study it is important that data is filled in according to the guidelines below to be applicable for later analysis. In case of any unclarities or ideas for improvements, please contact **5.1.2e**.

Table 1 – General cluster information

Name	Name of observer
Nest	Raven 1-4
datafile	name of excel data file with gps locations and cluster characteristics if indicated by 5.1.2e . Has format of: "raven 2_1506_2206_10_2_10" = nest_startdate_enddate_clusterparameters
Cluster number	Number of cluster, if indicated by 5.1.2e otherwise=unknown. Can be found in column of Clus_ID in excel datafile.
Time of cluster	Time of last clustering point, should be in UTC (= Dutch summertime – 2) with format: "YYYY-MM-DD HH:MM:SS" for example: "2021-04-27 10:44:05". Can be found in column of clus_end in excel datafile.
Time of visit	Time during the visit, should be in UTC (= Dutch summertime – 2) with format: "YYYY-MM-DD HH:MM:SS" for example: "2021-04-27 10:44:05"
Duration of cluster	Duration of the cluster in minutes, only applicable if the visit was not requested by 5.1.2e with a cluster number and excel datafile.
Radius of cluster	Radius of cluster in meters, only applicable if the visit was not requested by 5.1.2e with a cluster number and excel datafile.
GPS Coordinates 1	GPS coordinates of cluster center. Can be found in columns of g_c_long and g_c_lat in the excel datafile.
Number of fixes	number of fixes/points in the cluster if known. Can be found in column of n_clus_locs in the excel datafile

To describe the observations four labels are defined below with several categories each, which should be used to consistently identify clusters. The first label indicates the general category of the location. The second label is used if the location is a food source and indicates the origin of the food source. The third label indicates the type of food source. If a carcass or other remains are found, the fourth label indicates the type of remains that are present.

Table 2 – Observations at cluster location and labelling.

Location Category	1=Roosting (groups of non-breeding ravens sighted at location), 2=Food source, 3=nest site, 4=sitting (observation of ravens at look out spot/resting spot/'playing'), 5=unknown
Food source origin	1=human related (restaurants, garbage dump, hunting carcass or road kill, livestock pasture), 2=non-human (carcasses of natural death, wolf kill, small prey)
Food source type	1=hunting carcass, 2= road kill, 3=wolf kill, 4=carcass of natural death, 5=carcass unknown origin, 6=restaurants, take-out restaurants etc., 7=small prey, 8=garbage dump, 9= livestock pasture and agricultural area, 10=other
Type of remains	1=feathers, 2=bones, 3=hairs, 4=blood, 5=viscera (ingewanden), 6=whole carcass, 7=other
Prey species	Species (remains) found at location in scientific name
Ravens present	If ravens are seen at the location within visual distance, enter amount here
Notes	Room for; suspicions about location category and food sources, mistakes or unclarity in data, other observations and highlights, DNA samples taken

Appendix 2: GLMM Model selection

For both sets of data (full dataset and subset with only forest habitat) correlation was calculated for the numerical values in advance of fitting the GLMM (Figure 1). Build-up distance and forest distance showed the biggest correlation of -0.35 for the full dataset (Figure 1a). In the forest subset, the biggest correlation of 0.21 was between tree height and distance to forest edge (Figure 1b). Since these are minor correlation factors, all variables were used in the model fitting.

The first GLMM was fitted on the whole dataset

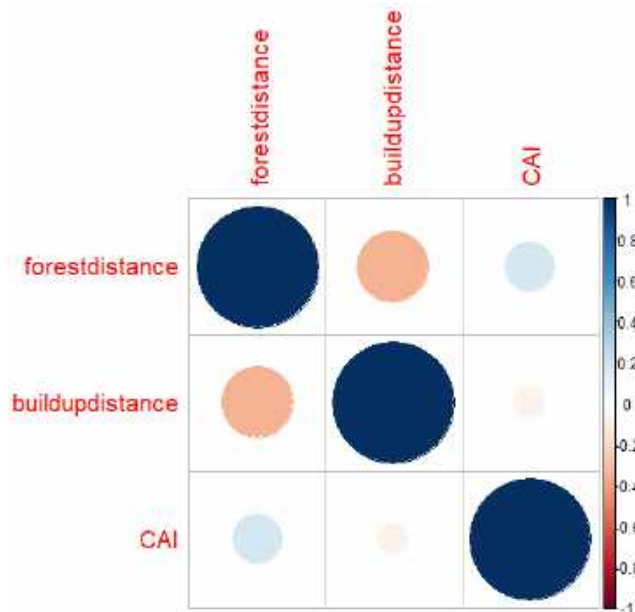


Figure 1a - Correlation matrix between numeric variables of the full dataset of the four ravens combined, calculated with the Spearman method for non normally distributed data.

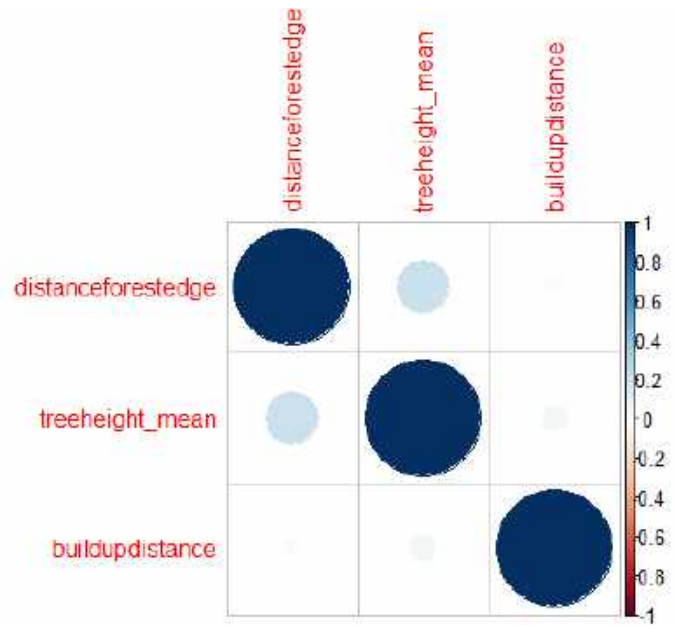


Figure 1b - Correlation matrix between numeric variables of the subset dataset on forest habitat of the four ravens combined, calculated with the Spearman method for non normally distributed data.

with a binomial distribution and the formula: **observed ~ naturearea + CAI + buildupdistance + forestdistance + openclosed + (1 | AID) .**

Observed is the 0 or 1 value that is assigned to each record to indicate if the raven is observed in this location or if it is a randomly calculated location.

Table 1 – AIC values for different variable combinations of first GLMM on whole dataset. AIC delta is the difference between AIC value of model and the lowest AIC value of any fitted model. The likelihood of one model being in favor over the other models is shown by AIC weight. Best fitting model is in bold. Bld= build-up distance, fst= forest distance, CAI= core area index, open= Open or Closed area, na= Nature area yes / no

Variables	AIC	Delta AIC	AIC weight
fst + CAI + open + bld + na	433775.7	0	1
CAI + fst + bld + na	433836.2	60.5	0
fst + CAI + open + bld	434149.8	374.1	0
CAI + fst + bld	434154.1	378.4	0
fst + open + bld + na	434201.2	425.5	0
fst + bld + na	434212.4	436.7	0
fst + open + bld	434605.5	829.8	0
fst + bld	434608.5	832.8	0
CAI + open + bld + na	435283.7	1508	0
open + CAI + na	435298.9	1523.2	0
bld + CAI + na	435362.6	1586.9	0
open + bld + na	435448	1672.3	0

Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

CAI + open + bld	436060.3	2284.6	0
open + bld	436228.9	2453.2	0
open + CAI	436330.6	2554.9	0
bld + CAI	436514.2	2738.5	0

Table 2 – Fixed effect estimates, standard errors and Z values for the best fitting GLMM on the whole dataset. Inverse logit estimate is the back transformed estimate from logit link.

	Estimate	Std. Error	z value	Pr(> z)	Inverse logit estimate
(Intercept)	-2.530	0.037	-67.487	< 2e-16 ***	0.074
natureareaYes	0.229	0.012	19.291	< 2e-16 ***	0.557
CAI	0.092	0.005	20.305	< 2e-16 ***	0.523
buildupdistance	-0.012	0.005	-2.553	0.0107 *	0.497
forestdistance	-0.229	0.006	-37.129	< 2e-16 ***	0.444
openclosedOpen	0.081	0.010	7.899	2.82e-15 ***	0.520

Table 3 – Correlation of fixed effect for the best fitting GLMM on the whole dataset.

	(Intr)	ntrrYs	CAI	bldpds	frstds
natureareYs	-0.256				
CAI	-0.041	-0.013			
buildpdstnc	0.088	-0.335	-0.022		
forestdstnc	0.048	0.199	-0.210	0.164	
openclsdOpn	-0.225	0.273	0.211	-0.072	-0.405

The second GLMM was fitted on a subset of the dataset of only forest habitat with a binomial distribution and the formula: **observed ~ distanceforestedge + highwaypresence + treeheight_mean + buildupdistance + (1 | AID) .**

Table 4 – AIC values for different variable combinations of second GLMM on subset of the dataset. AIC delta is the difference between AIC value of model and the lowest AIC value of any fitted model. The likelihood of one model being in favor over the other models is shown by AIC weight. Best fitting model and chosen model are in bold. Bld= build-up distance, dst = distance to forest edge, hgh= presence of highways, trh = mean tree height

Variables	AIC	AIC delta	AIC weight
bld + dst + hgh + trh	159924.3	0	1
dst + hgh + trh	160007.4	83.1	9.02E-19
bld + hgh + trh	160595.0	670.7	2.29E-146
hgh + trh	160698.1	773.8	9.36E-169
bld + dst + hgh	161597.7	1673.4	0
dst + hgh	161618.6	1694.3	0
bld + hgh	161950.0	2025.7	0
bld + dst + trh	162063.8	2139.5	0
trh + dst	162086.0	2161.7	0
bld + trh	162942.3	3018	0
bld + dst	163485.4	3561.1	0

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Table 5 – Fixed effect estimates, standard errors and Z values for the best fitting GLMM on the forest subset. Inverse logit estimate is the back transformed estimate from logit link.

	Estimate	Std. Error	z value	Pr(> z)	Inverse logit estimate
(Intercept)	-2.228	0.112	-19.967	<2e-16 ***	0.097
Distanceforestedge	-0.193	0.008	-24.874	<2e-16 ***	0.452
highwaypresence	1.425	0.028	50.264	<2e-16 ***	0.806
treeheight_mean	0.288	0.007	41.482	<2e-16 ***	0.572
buildupdistance	-0.066	0.007	-9.226	<2e-16 ***	0.484

Table 6 – Correlation of fixed effect for the best fitting GLMM on the subset dataset.

	(Intr)	dstncf	hghwyp	trhgh
dstncfrstdg	0.009			
highwyprsnr	-0.013	0.085		
treehght_mn	-0.016	-0.177	0.105	
buildpdstnc	0.005	-0.037	-0.123	-0.121

Since highways probably showed a bias, another GLMM was chosen as the final GLMM with the formula: **observed ~ distanceforestedge + treeheight_mean + buildupdistance + (1 | AID) .**

Table 7 – AIC values for different variable combinations of second GLMM on subset of the dataset without the highway variable. AIC delta is the difference between AIC value of model and the lowest AIC value of any fitted model. The likelihood of one model being in favor over the other models is shown by AIC weight. Best fitting model and chosen model are in bold. Bld= build-up distance, dst = distance to forest edge, hgh= presence of highways, trh = mean tree height

Variables	AIC	AIC delta	AIC weight
bld + dst + trh	162063.8	0	0.99998489
trh + dst	162086.0	22.2	1.51E-05
bld + trh	162942.3	878.5	1.72E-191
bld + dst	163485.4	1421.6	0.00E+00

Table 8 – Fixed effect estimates, standard errors and Z values for chosen GLMM on the forest subset without highway variable. Inverse logit estimate is the back transformed estimate from logit link.

	Estimate	Std. Error	z value	Pr(> z)	Inverse logit estimate
(Intercept)	-2.178	0.094	-23.129	< 2e-16 ***	0.102
distanceforestedge	-0.218	0.008	-28.285	< 2e-16 ***	0.446
treeheight_mean	0.264	0.007	38.230	< 2e-16 ***	0.566
buildupdistance	-0.034	0.007	-4.922	8.55e-07 ***	0.491

Table 9 – Correlation of fixed effect for the chosen GLMM on the subset dataset.

	(Intr)	dstncf	trhgh
dstncfrstdg	0.013		
treehght_mn	-0.018	-0.184	
buildpdstnc	0.004	-0.028	-0.117

Appendix 3: Cluster observations

At the visited food source locations many different types of carcass left overs were found (Table 1). This resulted in 20 food clusters, 15 sleep clusters and 335 flying days, which were used for accelerometer analysis.

Table 1 – Observations from field visits at cluster sites with food sources in forest and heather areas of the four ravens. The protocol can be found in Appendix 1. Transition period 2 is the period on which the habitat analysis was performed.

Raven	Time of visit (Hours since end cluster)	Fixes	Duration cluster (Hours)	Food source origin	Food source type	Type of remains	Prey species	Ravens present	Transition period
4	23	18	26		10	4	Unknown	3	2
4	119	21	7	1	7	1 & 2	<i>Gallus gallus domesticus</i>	2	2
4	46	8	3	1	5	5	Unknown	0	2
3	9	7	4	1	1	5	Unknown	0	2
2	28	8	9	1	1	5 & 7	<i>Sus scrofa</i> , <i>Capreolus capreolus</i>	2	2
2	22	19	8	1	5	6	<i>Cervus cephalus</i>	20	3
1	380	7	7	2	3	6	<i>Ovis gmelini</i>	40	3

Table 6 – Amount of clusters (food and sleep) or daily averages (flying) per raven in the period between 27-04-2021 and 14-09-2012 used for ACC analysis.

Raven	Flying	Food	Sleep
1	83	2	5
2	79	11	3
3	87	2	5
4	86	5	2

All pictures shown below are close-up pictures to make sure that the exact locations cannot be derived. These images are just to give an example of the types of food sources the ravens are drawn to.



Figure 1 – Shooting left overs. Left: wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*). Right: Full carcass of wild boar (*Sus scrofa*).



Figure 2 – Moeflon (*Ovis orientalis*). Right: spine and leg. Left: leg.



Figure 3 – Spine of chicken (*Gallus gallus domesticus*).



Figure 4 – Decaying carcass of red deer (*Cervus elaphus*).

Appendix 4: Interpretation XYZ axis of accelerometer

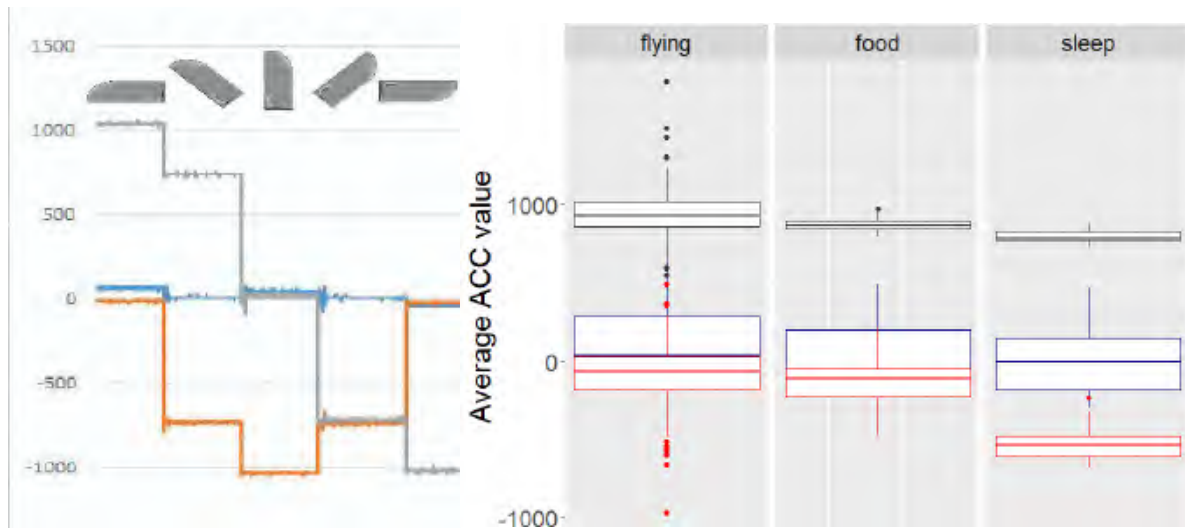


Figure 1 – The average accelerometer values found during different activities can be compared to the values during tilting of the transmitter, which indicates bird posture during that activity. Left: Accelerometer values related to tilting of the transmitter (provided by Ornitella). Orange line is Y, blue line is X, and grey line is Z. Right: Average accelerometer values for the X, Y and Z axes during flying, feeding and sleeping activities. The blue boxplots show the distribution of the X values, the red boxplots represent the Y values, and the black boxplots the Z values.

Wolfbirds on the Veluwe

Investigating the temporal activity patterns of the common raven (*Corvus corax*) and the grey wolf (*Canis lupus*) in the Netherlands

MSc Thesis

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Abstract

Scavenging is an important process for the transfer of energy between organisms and it can increase the stability of ecosystems. Predator and scavenger species influence each other significantly through both facilitation and competition and those interactions may have consequences through all trophic levels. Other studies have shown that the common raven (*Corvus corax*) associates with the grey wolf (*Canis lupus*) as a feeding strategy, increasing its search efficiency for carrion and thus decreasing its competition with other scavenger species. In order to investigate the extent to which ravens associate with wolves in the Netherlands, temporal activity patterns were created for both species and temporal overlap of activity was investigated. This was done by making use of GPS and accelerometer data as well as camera trap data. Temporal overlap of activity between both species was moderate with the highest overlap occurring around sunrise. Furthermore, temporal overlap of activity did not increase with an increase in wolf abundance. These results suggest that, in the Netherlands, ravens do not alter their temporal activity pattern in order to associate with wolves as a feeding strategy. This is in contrast with findings of other studies and it is likely that, due to relatively low abundances and high nocturnality of wolves in the Netherlands, it is not favourable for ravens to associate with wolves in terms of energy requirements. However, with wolf populations increasing, this might change in the future and as a result, top-down effects and nutrient dispersal might increase as well. This study has stressed the complexity of predator-scavenger interactions and how the implications might heavily differ between ecosystems, making it important to consider these interactions for different situations.

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Introduction

Many vertebrate carnivores, not only obligate scavengers, make use of carrion by including scavenging as part of their feeding strategy ^{1,2}. The transfer of energy across trophic levels due to scavenging is thought to be an important process which can increase the stability of ecological communities ¹⁻⁴. The effects of scavenging on food webs are often heavily underestimated and it has been shown that scavenging is, in some cases, responsible for 45% of all links in a food web. In addition, substantially more amount of energy is found to be transferred through scavenging links than through predation links ⁴. Classically, predation and scavenging are seen as independent processes with predator-prey and scavenger-carrion interactions occurring separately ⁵. However, more recent studies have focussed on interspecific interactions between predator and scavenging species and on how these interactions can influence behaviour and population sizes of different trophic levels ^{1,2,4-8}. In many cases, large predators play a facilitative role by providing carrion which can in turn be utilised by scavenging species ^{3,8,9}. However, predator and scavenger species compete for carrion as well ^{3,6,7,10,11}. Large carnivores are often an important cause of adaptation for many scavenger species and their effects on scavenger communities are heavily species-specific ¹. By controlling the timing and quantity of available carcasses, and by facilitating, as well as competing with, other scavenging species, predators play an important role in structuring entire ecological communities through all trophic levels ⁴.

Studies have shown that temporal niche partitioning is an important mechanism which may facilitate the coexistence of species sharing a similar niche ¹²⁻¹⁴. Species may alter their activity pattern in order to avoid encountering competitors and thus reducing competition ^{15,16}. Via the same reasoning, species may alter their activity pattern in order to associate with facilitative species ¹⁷. By studying activity patterns, insights can be created about how interactions such as competition and facilitation influence the coexistence of niche-sharing predator and scavenger species. This has been studied for different territorial ecosystems across the globe including Africa, north America and southern Europe ^{1-9,11,13,18-26}. However, this has not been done for the Netherlands, mainly due to the long term absence of an apex predator. Considering the species-specificity of predator-influences on scavenger species, and the significant influence of scavenging on the transfer of energy within ecological communities, it is of importance to study predator-scavenger interactions for different situations since the implications might differ between ecosystems. In the case of the Netherlands, the new addition of an apex predator, namely the grey wolf (*Canis lupus*), as well as the growing populations of a scavenger which has been shown to efficiently scavenge on wolf kills ^{18,19,27}, namely the common raven (*Corvus corax*), make it important to consider the consequences of the interactions between these two species.

Wolves are found to lose significant proportions of food due to raven scavenging. Per capita, wolves have been estimated to lose 2 to 4 kg of food per day as a result of scavenging ravens ²⁸. For entire wolf packs this may be up to 20 kg, depending on the abundance of present ravens, the effort made by wolves to chase ravens away and wolf pack sizes, including many more factors ^{10,29}. In order to compensate for the loss of food due to raven scavenging, wolves may kill up to twice as many prey as they would if ravens were absent ¹⁰. This shows that, by scavenging on wolf kills, ravens may have a significant influence on top-down effects.

In addition, studies suggest that ravens associate with wolves as a feeding strategy. One study ¹⁹ showed that ravens in Yellowstone National Park (YNP) discovered all observed wolf-killed carcasses almost immediately after the kill. Discovery time of experimentally placed carcasses was significantly higher or carcasses were not found at all despite the availability of fresh and exposed meat. These results suggest that ravens prefer to scavenge on wolf killed carcasses. Furthermore, when wolves were observed to be chasing prey, 87.2% of these observations included the presence of ravens.

When wolves were observed to be present at a killed prey, ravens were also present for all observations. These results suggest that ravens are likely to be in close vicinity of wolves, especially when wolves are traveling or hunting ¹⁹. By associating with wolves, ravens may minimize their energy requirements to locate food sources.

Finally, ravens may minimize competition with mammalian scavengers by associating with wolves. Scavengers with a high search efficiency, typically avian scavengers due to their ability to cover large areas with a relatively low energy requirement, often arrive first at a carrion site after which they are outcompeted by more dominant terrestrial scavengers ^{30,31}. This shows the importance of search efficiency for avian scavenger species, which can be increased by associating with predators. This behaviour in which avian scavengers respond to predator activity is also supported by a study ²⁰ in the Serengeti National Park in which auditory cues were used to simulate the sounds of predator hunting activity (sounds of wildebeest calves in distress and sounds of spotted hyenas and lions competing over a kill). They found that, in many cases, avian scavengers arrived first at the site, suggesting that avian scavengers respond to auditory clues of hunting activity ²⁰.

In order to contribute to a better understanding of the interactions between the grey wolf and the common raven in the Netherlands, the following research questions will be addressed:

1. *What is the amount of temporal overlap of daily activity patterns between the grey wolf and the common raven, in the Netherlands?*
2. *Is the temporal activity pattern of the common raven, as well as the temporal overlap of activity between the grey wolf and the common raven, influenced by wolf abundance?*

The competition wolves may experience from ravens will only be exploitation competition, as opposed to interference competition, since ravens do not have the ability to physically harm a wolf. Wolves have been reported to chase away ravens in order to minimize this exploitation competition ¹⁰. Because of this and considering the advantages ravens may experience by associating with wolves, I predict a high temporal overlap in activity between the grey wolf and the common raven. Furthermore, I predict that temporal overlap will increase with an increase in wolf abundance since ravens will have a higher chance of being aware of wolf presence and will thus be more likely to take advantage of associating with wolves.

Methods

Study area

This study was conducted on The Veluwe, in the Netherlands (Fig. 1). The Veluwe is the largest protected nature area in the Netherlands (912 km²) and mainly consists of coniferous and deciduous forests, heather and drift sands. Average annual precipitation on the Veluwe amounts to 950mm and the average annual temperature is 14 °C. Common wildlife species include wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), pine marten (*Martes martes*), red fox (*Vulpes vulpes*), and badger (*Meles meles*). Several wild cattle species such as Highland cattle (*Bos taurus*) and European bison (*Bison bonasus*) also graze on the Veluwe.



Figure 1: areal map of the Netherlands with in the red rectangle The Veluwe. Source: Esri.

Data sampling and analyses

Wolves

In order to measure temporal activity patterns, two sampling methods were used. For the wolf this was done by making use of camera trap data and wolf observations. Data were provided by BIJ12, the governmental organisation which coordinates the monitoring, data storage and analyses of wolves in the Netherlands. The provided dataset included locations, dates and times of wolf observations made by camera traps on the Veluwe as well as verified wolf observations made by people. When a wolf was captured by a camera trap or observed by a person, the observed individual was considered as being active at that moment. The wolf dataset consisted of 1027 records ($n = 1027$) ranging from April 1st 2021 until May 9th 2022.

Ravens

For ravens, solar powered GPS and accelerometer (ACC) transmitters were used (OrniTrack-25). Prior to this research, in April 2021, six juvenile ravens from different nests were fitted with mentioned transmitters. This was done in accordance with Dutch legislation concerning animal experiments and handling. Shortly after ravens were fitted with the GPS transmitters, two of the six ravens either managed to remove the transmitter or suffered an injury impairing their ability to fly.

The four remaining transmitters recorded GPS locations, as well as ACC data in three perpendicular axes, once every five minutes if the battery level of the transmitter was sufficient. This frequency was lowered if battery levels were low due to insufficient sunlight. In order to select only datapoints which resembled a raven being active, flying behaviour was determined based on the ACC values. Only data points which resembled flying were used for the calculation of temporal activity patterns.

ACC values were measured in g's ($1g = 9.81 \text{ m/s}^2$). For each individual measurement, the ACC value consists of a static and a dynamic component. Here the static component is determined by the position of the transmitter in relation to the earth's gravitational field. The dynamic component is determined by the change in velocity as a result of body motion. Calculating the static component in each axis enables the determination of the body position; the angle of the device, and thus the angle of the body of the raven, is calculated as the arcsine of the static acceleration in the corresponding axis. This determines the body pitch in both the x (surge) and z (heave) axis, as well as the body roll in the y (sway) axis (Fig 2a, Fig 2b) ³².

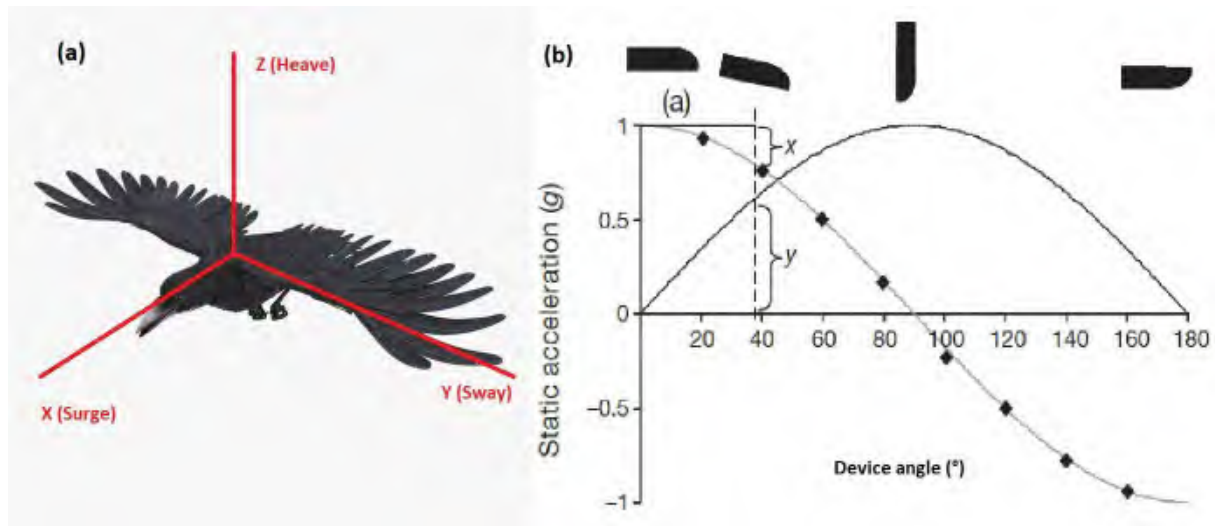


Figure 2: (a) Raven with the three axes in which ACC values are measured. (b) Relationship between static acceleration and body angle along the heave axis (shown in blocked line) and the surge axis (shown in straight line), device position is shown above the graph. Source: Shepard et al., 2008.

In order to derive the static component from the total ACC values, the data was smoothed. For each measurement ACC values were measured for one second at 20Hz, resulting in 20 data points for each measurement. By taking the mean of these 20 datapoints, the data is smoothed and this results in the static acceleration component for one measurement. Thereafter, the dynamic acceleration component, for each individual data point, was calculated by subtracting the static component from the total ACC value. Taking the mean of the 20 dynamic acceleration components results in the mean dynamic body acceleration of each axis, for one measurement. Subsequently, values of the mean dynamic body acceleration for the three axes are added up to calculate the overall dynamic body acceleration during one measurement ³²⁻³⁴. By making these calculations, and by using other variables measured by the GPS/ACC transmitters, a number of variables were created which can be used to determine whether or not a raven was flying during a measurement (table 1).

Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Table 1: Variables used to predict flying behaviour, derived from GPS speed and accelerometer sensors.

Variable	Direction	Label	Explanation
GPS speed (km/h)	3D	speed	Ground speed measured by the GPS/ACC transmitter
Body pitch (°)	X (surge)	pitch_x	Body angle along the X (surge) axis
	Z (heave)	pitch_z	Body angle along the Z (heave) axis
Body roll (°)	Y (sway)	roll_y	Body angle along the Y (sway) axis
Overall dynamic body acceleration (g)	X (surge)	odba_x	Mean dynamic body acceleration along the X (surge) axis
	Y (sway)	odba_y	Mean dynamic body acceleration along the Y (sway) axis
	Z (heave)	odba_z	Mean dynamic body acceleration along the Z (heave) axis
	3D	ODBA	Overall dynamic body acceleration (odba_x + odba_y + odba_z)

In order to determine flying behaviour, an unsupervised classification was performed on the calculated predictor variables. This was done in R³⁵ in the form of a k-means clustering algorithm. First a Pearson correlation matrix was calculated for all predictor variables in order to select a subset of variables which did not correlate strongly with each other. Only this subset was used for the classification of flying behaviour. The number of clusters (k) was determined by selecting the cut-off point on which more clusters would not result in substantial less variation within each cluster (elbow method). Hereafter, the cluster which would resemble flying behaviour the best (e.g. highest dynamic body acceleration, highest speed or least body pitch in heave axis (horizontal position)) was classified as flying behaviour.

Activity patterns and overlap

By making use of kernel density estimation, density estimates of activity patterns were determined separately for both species. These density distributions give the probability of encountering an event, in this case an animal being active, at any given time of day. Thereafter, the coefficient of overlap (Δ) was used to quantify temporal overlap of activity patterns between raven and wolf, where Δ can range from 0 to 1 ($\Delta = 0$ meaning no overlap and $\Delta = 1$ meaning identical activity patterns)³⁶. Both the temporal activity patterns as well as the overlap of activity were calculated by making use of the R package *overlap*³⁷. This package produces several density estimators. The one most suitable for sample sizes higher than 50 (D_{hat4} / Δ_4) was selected in accordance with recommendations made by Ridout & Linkie (2009)³⁶. Finally, in order to account for differences in sunrise and sunset throughout the year, clock times were transformed to “sun times” by determining the angle of the sun in radians (depending on clock time, date and location) and mapping sunrise at $\pi/2$ and sunset at $3\pi/2$ ³⁸.

In order to investigate the influence of wolf presence on the temporal activity pattern of the raven, temporal activity patterns were compared between locations with a relatively high number of wolf observations and locations where no wolves are present. Locations with a relatively high number of wolf observations were selected by making a raster layer for the Veluwe in ArcGIS pro (version 2.6.1)³⁹ with a cell size of 5 x 5 km. Cells with more than 30 wolf observations were considered as locations with relatively many wolves since 30 was the average amount of wolf observations per cell for the Veluwe. For locations where no wolves were present, locations surrounding the Veluwe (mainly agricultural areas west of the Veluwe) were used since these areas are known to have no wolves present because of their unfavourable characteristics such as human population density and landcover type. Finally, the 95% confidence intervals (95% CI) for the overlap coefficients for temporal activity patterns were calculated by making use of 10,000 bootstrapping iterations. Temporal activity patterns of ravens for areas with and without wolves were tested for significant differences with the Watson two-sample test for homogeneity in the R package *CircStats*⁴⁰.

Results

Determining flying behaviour

Based on the Pearson correlation matrix (Appendix A), three of the predictor variables were selected to use for the k-means clustering algorithm. Overall Dynamic Body Acceleration (ODBA), body pitch in the heave (z) axis (pitch_z) and speed (speed_kmh) showed no strong correlation between each other. Body pitch in the surge (x) axis, although showing no correlation with other predictor variables, was not selected since this variable offers no distinction between flying behaviour and other types of behaviour (e.g. resting). The ideal number of clusters (k), based on selecting the cut-off point after which more clusters would not result in substantial less variation within each cluster (elbow method), showed to be four ($k = 4$) (Appendix B).

The k-means clustering algorithm, performed on the three selected predictor variables (ODBA, pitch_z and speed_kmh), resulted in 73.2% of the variation within the data being explained by the four clusters. Cluster 4 resembled flying behaviour since this clusters showed the highest cluster means for ODBA and speed and the cluster mean for pitch_z closest to 0° (horizontal position) (Appendix C). The flying cluster consisted of 7531 data points and dates ranged from May 21st 2021 until April 12th 2022. Subsequently, data points within the flying cluster were split into two separate datasets; one for areas with wolves present ($n = 3213$, May 21st 2021 until April 12th 2022) and one for areas without wolves present ($n = 2363$, May 26th 2021 until April 12th 2022).

Temporal activity patterns and overlap

Overall, overlap of temporal activity patterns between the common raven and the grey wolf was moderate, based on kernel density estimates as indicated by the overlap coefficient ($\Delta_4 = 0.44$, 95% CI 0.41 – 0.46). Overlap was highest shortly after sunrise (Fig. 3).

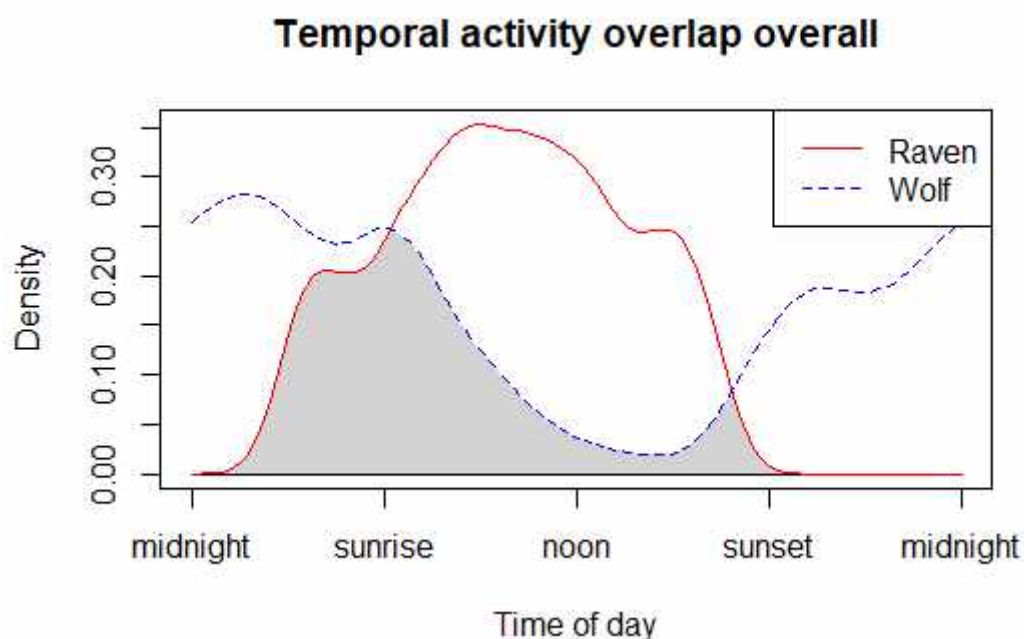


Figure 3: Density estimates of temporal activity patterns for the common raven and the grey wolf on The Veluwe. Solid red line represents the kernel density estimates for the common raven ($n = 7531$), blue dashed line represents the kernel density estimates for the grey wolf ($n = 1027$). The overlap coefficient ($\Delta_4 = 0.44$, 95% CI 0.41 – 0.46) is indicated as the shaded area.

The temporal activity patterns of the ravens did significantly differ between locations with and without wolves (test statistic = 0.26, critical value = 0.19, p-value < 0.05). For areas without wolves present, the overlap coefficient for temporal overlap between raven and wolf was 0.44 ($\Delta_4 = 0.44$, 95% CI 0.42 – 0.47) with the highest overlap hours before and shortly after sunrise (Fig. 4). For areas with wolves present, the overlap coefficient was 0.42 ($\Delta_4 = 0.42$, 95% CI 0.39 – 0.45) with the highest overlap at sunrise (Fig. 5).

Temporal activity overlap, no wolves present

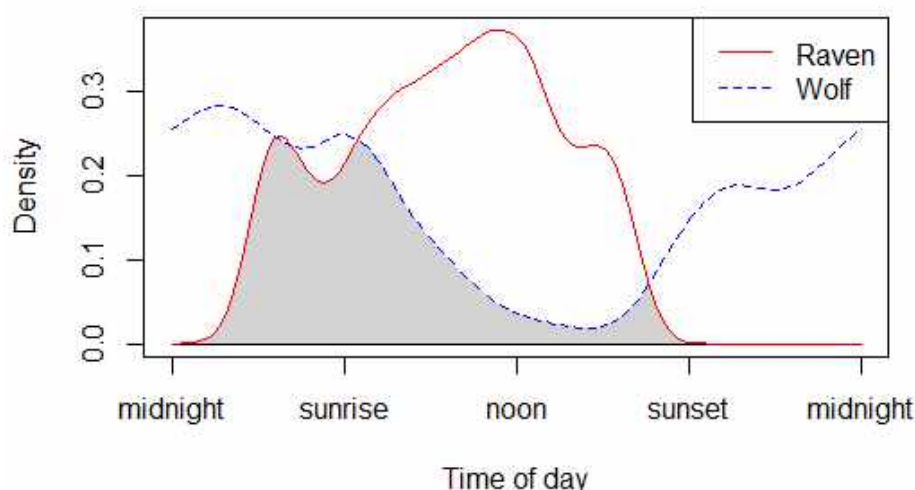


Figure 4: Density estimates of temporal activity patterns for the common raven and the grey wolf in areas without wolves present. Solid red line represents the kernel density estimates for the common raven ($n = 2363$), blue dashed line represents the kernel density estimates for the grey wolf ($n = 1027$). The overlap coefficient ($\Delta_4 = 0.44$, 95% CI 0.42 – 0.47) is indicated as the shaded area.

Temporal activity overlap, wolves present

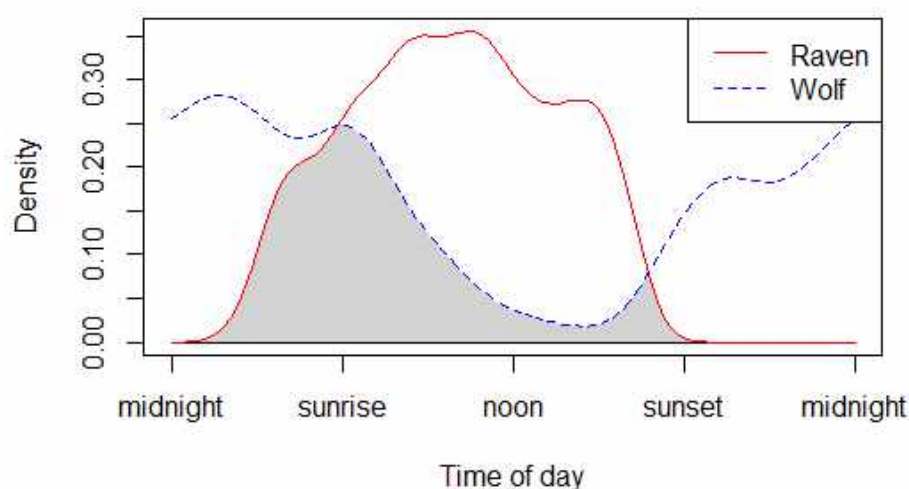


Figure 5: Density estimates of temporal activity patterns for the common raven and the grey wolf in areas with wolves present. Solid red line represents the kernel density estimates for the common raven ($n = 3213$), blue dashed line represents the kernel density estimates for the grey wolf ($n = 1027$). The overlap coefficient ($\Delta_4 = 0.42$, 95% CI 0.39 – 0.45) is indicated as the shaded area.

Although statistically, the temporal activity pattern for ravens in areas with wolves present compared to the temporal activity pattern for ravens in areas without wolves present differed significantly, the two activity patterns showed a high similarity with a high overlap ($\Delta_4 = 0.93$, 95% CI 0.91 – 0.95) (Fig. 6).

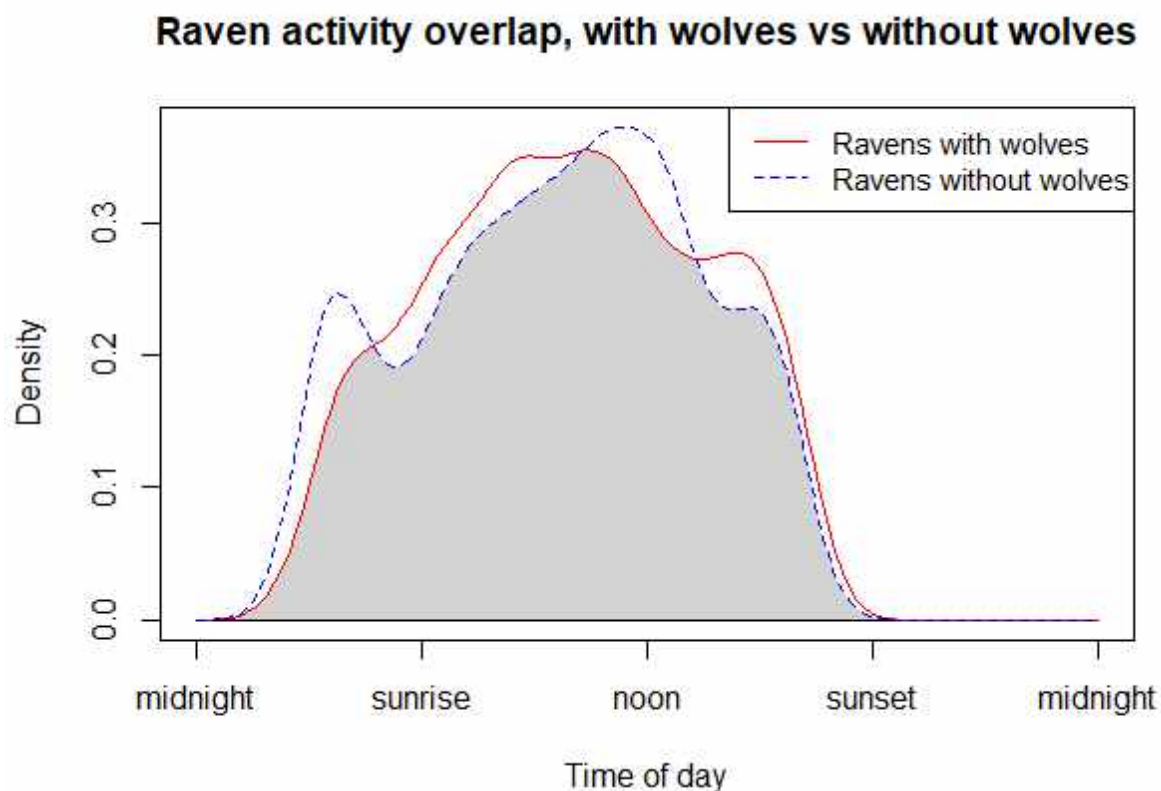


Figure 6: Density estimates of temporal activity patterns of the common raven (for both areas with and without wolves present). The solid red line represents the kernel density estimates for the common raven when wolves are present ($n = 3213$), the dashed blue line represents the kernel density estimates for the common raven when wolves are absent ($n = 2363$). The overlap coefficient ($\Delta_4 = 0.93$, 95% CI 0.91 – 0.95) is indicated as the shaded area.

Discussion

This paper focussed on assessing the temporal activity patterns of the common raven and the grey wolf in the Netherlands. Temporal overlap of activity between these two species was investigated in order to create insights on the possible interactions between raven and wolf.

Overall, temporal overlap of activity between the common raven and the grey wolf in the Netherlands was moderate. Furthermore, temporal activity patterns of ravens for locations with and without wolves showed a high similarity. This would suggest that ravens do not alter their temporal activity pattern in order to associate with wolves. Since ravens are facultative scavengers (as opposed to obligate scavengers), they can also utilise food sources other than carrion. For example, ravens are found to make use of food sources associated with anthropogenic activity ^{41,42} such as waste dumps, restaurants or agricultural fields with high insect abundances. These food sources may be more available than wolf kills, especially as wolf populations in the Netherlands are still relatively new and low in numbers. According to the optimal foraging theory, first described by MacArthur & Pianka ⁴³, animals will select for food sources with the highest net gain in energy. Meaning that, in many cases, food sources which require less effort to find will be selected. This could explain the fact that ravens do not seem to associate with wolves in the Netherlands, as it might require more energy to associate with wolves, than it does to locate other food sources.

Considering the optimal foraging theory, it can be said that the advantages ravens may experience by associating with wolves will be dependent on wolf abundance, as it requires less energy to associate with wolves when wolf populations are high in numbers and thus, are easier to find and provide more carrion. This can also explain the differences between the findings of this study and other studies where ravens are found to indeed associate with wolves. For the Veluwe, only one confirmed pack consisting of only a few individuals, two separate breeding pairs and some individual wolves are occupying certain territories ^{44,45}. Whereas for areas where ravens are found to associate with wolves and consume large parts of wolf killed carcasses, such as Yellowstone National Park (YNP) in the USA, the studied wolf population consisted of three established wolf packs with each pack consisting of a minimum of 7, and up to 22, individuals ¹⁹. Furthermore, ravens are diurnal animals since they need daylight in order to have clear vision. This results in the fact that the time during which they can associate with wolves will be limited to the daylight. The results of this study show that wolves on the Veluwe are mainly nocturnal, with the highest activity shortly after midnight and in addition with activity peaks around sunrise and sunset. Because of this, there is a limited timeframe in which ravens are able to associate with wolves. However, this might not be the case for areas such as YNP. Wolves, as well as many other wildlife species (both predator and prey), are found to avoid human activity by increasing their nocturnality ^{46,47}. Considering the relative high human activity on and around the Veluwe (compared to areas such as YNP) it is to be expected that wolves will be more nocturnal here which results in fewer possibilities for ravens to associate with wolves.

The still relatively low abundances of wolves on the Veluwe, as well as the miss-match between the mainly nocturnal activity pattern of wolves and the diurnal activity pattern of ravens on the Veluwe, result in limited possibilities for ravens to increase their net energy gain by associating with wolves as feeding strategy. However, the wolf population on the Veluwe is still increasing. In addition, the highest temporal overlap of activity between ravens and wolves was found around sunrise. During that time of day, ravens have sufficient light to see clearly while wolves are most likely to be hunting in order to temporally overlap with their preferred prey ⁴⁸⁻⁵⁰. This shows that possibilities exist for ravens to take advantage by associating with wolves, especially with increasing wolf populations. Because of this, it still remains important to monitor the wolf-raven interactions on the Veluwe and to consider the implications they might have on the ecosystem.

Implications

If indeed the facilitating effects wolves may have on ravens increase, due to growing wolf populations, this could impact wolf pack sizes and killing rates. As has been shown in other studies, wolves are found to kill more prey when experiencing exploitation competition from ravens¹⁰. Furthermore, wolves are found to experience less competition from ravens when hunting in larger packs, since this poses more opportunities to have individuals be present at killed prey and chase ravens away²⁹. Although these effects of raven scavenging on wolf kills being heavily dependent on raven abundance and carrion consumption rates, it shows that predation by wolves might increase due to raven scavenging. Predation pressure is often an important mechanism which influences herbivore populations and behaviour and thus, in turn through trophic cascading effects, influences vegetation as well⁵¹⁻⁵⁴. Because of this, ravens scavenging on wolf kills might increase the top-down effects wolves have on their ecosystem.

Furthermore, the speed and extent to which nutrients from carrion are dispersed, are related to the scavenger species which consume the carrion. Microbial decomposition of carrion results in aggregated concentrations of nutrients directly below and around carrion⁵⁵. For large carcasses, increased nutrient levels can be found in soil and foliar directly surrounding the carcass, even years after decomposition^{56,57}. Vertebrate scavengers however, increase the dispersal of nutrients from carcasses since these species distribute over a broader scale in the landscape⁵⁸. If indeed ravens can effectively scavenge on wolf kills, this might influence the spatial distribution of resources in a relatively nutrient-poor area such as the Veluwe.

Raven populations in the Netherlands are increasing, counting 375 breeding pairs and 1264 non-breeding individuals as of 2020, having doubled in size over the last 15 years²⁷. This increase might be boosted even more with the reestablishment of the wolf, since increased wolf abundance has been reported to increase raven populations¹⁸. This shows that the effects of raven scavenging on wolf kills might indeed have significant consequences for the ecosystem.

Recommendations

In order to further examine the possible interactions between the common raven and the grey wolf in the Netherlands, it is advisable to cope with some of the limitations of this study. Firstly, raven behaviour was determined via an unsupervised classification in this study. This method, although it being able to make distinctions between flying and non-flying behaviour, fails to distinguish between multiple behaviour types on a more detailed level since no field observations were correlated to the ACC data, making it hard to differentiate between similar behaviour types. By purely making distinctions between flying and non-flying behaviour in this study, it was assumed that flying behaviour was equal to foraging behaviour. In reality this will not be the case since ravens may be flying when looking for breeding mates, collecting nest material or looking for nesting/roosting locations. This could have resulted in part of the used data points corresponding to behaviour other than foraging, and thus behaviour for which associating with wolves will not result in any advantages. By making use of supervised classification, where field observations are linked to the ACC data, accuracy of classifying behaviour types, as well as the amount of behaviour types which can be classified, will be improved. This has been shown for other bird species such as the oystercatcher where behaviour types such as flying but also foraging, body care, standing and sitting were classified³⁴. Currently the number of ravens on the Veluwe which are being tracked with GPS/ACC trackers is increasing through collaborative efforts from different organisations such as Wageningen University & Research, ARK nature and SOVON. This poses opportunities to study raven behaviour in more detail, via supervised classification algorithms.

By doing so, it can be examined where and when ravens forage, or distinctions might be possible between foraging on carrion and other food sources. This can help in studying raven wolf interactions further.

In addition, this study made use of wolf observation data provided by BIJ12. This dataset consisted of captures made by camera traps and sightings by people. However, this sampling method was not set up specifically for this research objective and large parts of the Veluwe still remain unsampled, while other parts are overrepresented. This makes it difficult to accurately quantify the amount of individual wolves in certain areas. Because of this, it could have been the case that certain areas which were assumed to have a relatively high number of wolves were in fact oversampled, and vice versa, areas which were assumed to have no or few wolves present could be classified as such due to undersampling. Because of this, areas outside of the Veluwe were classified as areas without wolves, in order to be certain that in fact no wolves would be present. However, by doing this, areas with and without wolves differed from each other in terms of landscape characteristics while ideally one would want to use areas which are more similar to each other in order to exclude the effects of landscape characteristics on raven activity. By setting up a more systematic approach for sampling wolf presence, for instance by means of a grid of camera traps, wolf abundance on the Veluwe can be quantified more accurate. Doing so enables possibilities to examine not only temporal, but also spatial overlap between ravens and wolves. Another powerful addition to these research means would be GPS tracking of wolves. These additions can help in further investigating raven wolf interaction but can also create a better understanding about wolf behaviour in the Netherlands in general.

Conclusion

Overall, ravens showed a moderate temporal overlap of activity with wolves on the Veluwe. Furthermore, ravens did not increase their temporal overlap of activity with wolves when flying in areas where wolves are present. This suggests that, currently, ravens do not associate with wolves as a feeding strategy. However, it is likely that the advantages ravens may experience by associating with wolves are dependent on wolf abundance, and that the relatively low number of wolves and wolf packs on the Veluwe form a constraint on the possibilities for ravens to increase their net energy gain by associating with wolves. Although the dissimilarity between the mainly nocturnal activity pattern of wolves and the diurnal activity pattern of ravens also plays a part in this constraint, both species showed to be active around sunrise, the time during which wolves are likely to be hunting. This shows that, with the increasing wolf population, the constraints on ravens associating with wolves as an optimal foraging strategy might decrease in the future. More research needs to be done in order to further examine these possibilities. This can be achieved in more detail by making use of supervised (instead of unsupervised) classification for raven behaviour and in addition, by making use of a more systematic sampling method for wolf abundance as well as GPS tracking of wolves. By doing so, both temporal and spatial overlap between the two species can be investigated which can help to create a better understanding of wolf raven interaction. Considering the influences of raven scavenging on both top-down effects and nutrient dispersal within an ecosystem, it is important to create a better understanding of raven wolf interactions as it may have implications through all trophic levels of an ecosystem.

Finally, this study has stressed the complexity of predator-scavenger interactions and how abundance of involved species and temporal overlap or partitioning may affect the consequences of scavenging on predator-killed carrion. Furthermore, it has shown that predator-scavenger interactions may differ between ecosystems and that it is important to consider these interactions for different situations.

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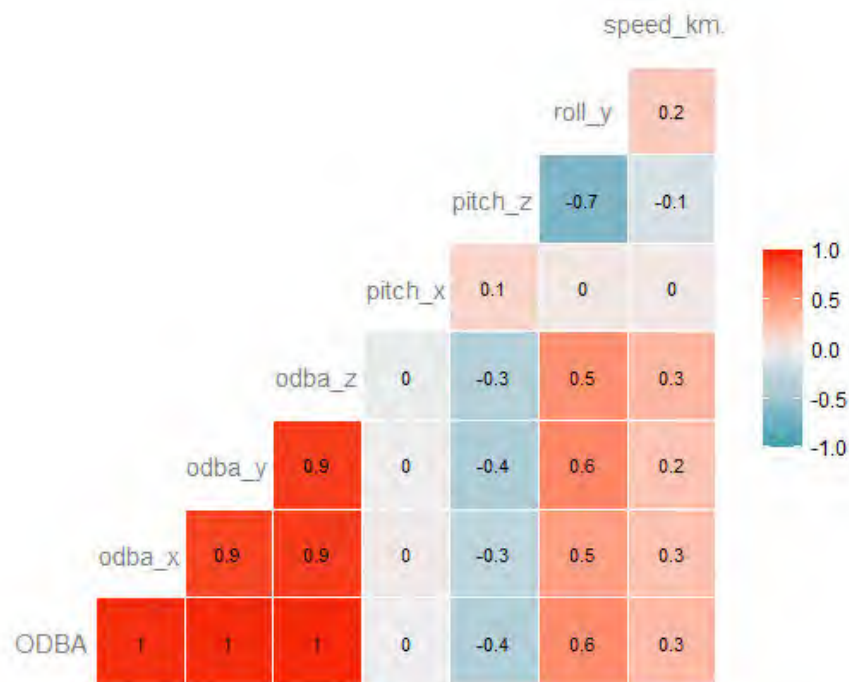
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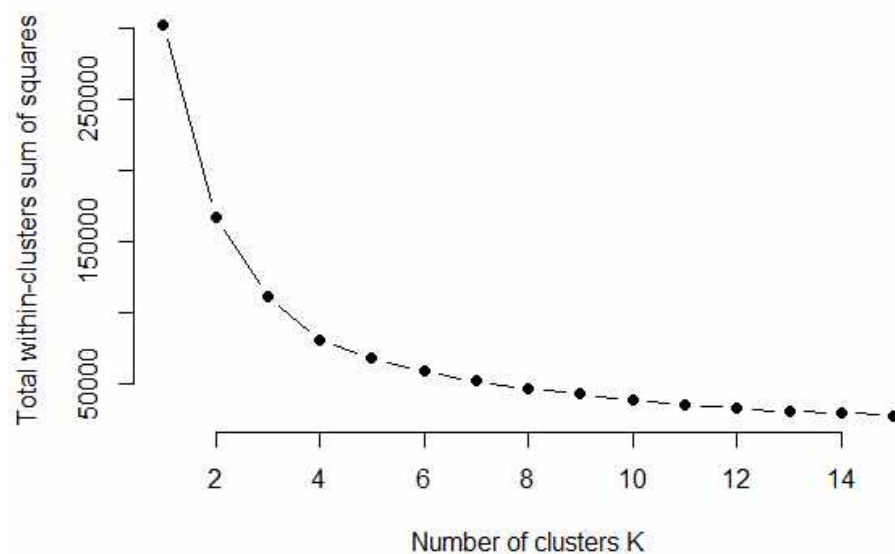
Appendix

A. Pearson correlation matrix for predictor variables for flying behaviour



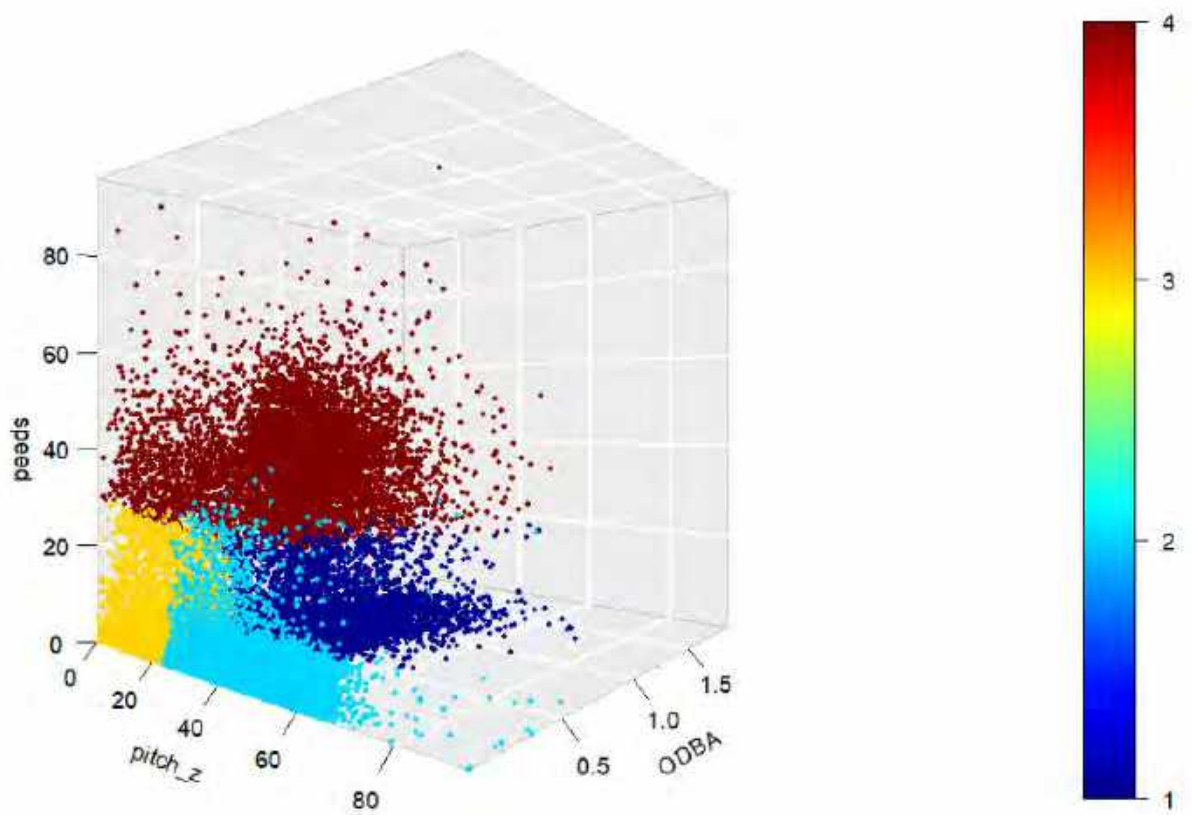
Pearson correlation matrix for all predictor variables. Red colours indicate a positive correlation, blue colours indicate a negative correlation. The closer the correlation coefficient is to 1 (or -1 for negative correlations) the stronger the correlation.

B. Elbow plot for determining ideal number of clusters



Elbow plot with number of clusters (k) on the x axis and measure for variation within each cluster on the y axis. The cut-off point (or elbow) is at $k = 4$.

C. K-means clustering result (3D cluster plot)



Three dimensional cluster plot with cluster 1 in dark blue with cluster means: ODBA = 0.64 g, speed = 1.40 km/h, pitch_z = 27 °. Cluster 2 in light blue with cluster means: ODBA = 0.08 g, speed = 0.6 km/h, pitch_z = 36.52 °. Cluster 3 in yellow with cluster means: ODBA = 0.16 g, speed = 0.84 km/h, pitch_z = 11.94 °. Cluster 4 in red with cluster means: ODBA = 0.88 g, speed = 35.88 km/h, pitch_z = 11.58 °. Cluster 4 represents flying behaviour.

Ravens (*Corvus corax*) on the Veluwe: Social behaviour at abundant and scarce food sources



5.1.2e

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Abstract

The relative abundance or scarcity of food sources plays an important role in influencing social behaviour. However, possible variations in social behaviours (within the same species) at distinct food sources remains understudied. I conducted live observations of ravens at the landfill 5.1.2h representing an abundant food source, and analysed video footage from wildlife cameras at three carrion sites across the Veluwe, representing scarce food sources. Six behavioural categories were defined to investigate potential differences in social behaviour: 1) agonistic behaviour, 2) submissive behaviour, 3) affiliative behaviour, 4) co-feeding behaviour, 5) social calls and 6) feeding behaviour. I hypothesized that abundant food sources entail reduced competition and higher levels of tolerance among individuals, in contrast to scarce food sources. Secondly, I hypothesized that abundant food sources require less foraging effort and experience in comparison to scarce food sources. In contrast to my first hypothesis, I observed higher levels of agonistic behaviour and reduced co-feeding at the landfill in comparison carrion sites. Moreover, submissive behaviour, affiliative behaviour and the total number of social calls were comparable between the two food sources. A potential explanation may be attributed to the familiarity between individuals at the two locations. Ravens at carrion sites may have been more familiar with each other, while ravens at the landfill possibly consisted of mostly unfamiliar individuals. However, my study included only one abundant food source, and the carrion locations may not have been as unpredictable as expected, mainly because carrion was consistently deposited at the same locations. These limitations may have influenced the results and future research could benefit from including more diverse abundant food sources and more unpredictable scarce food sources. Overall, my research contributed to an improved understanding of social behaviour of ravens at distinct food sources across the Veluwe.

Key words: abundant food sources, scarce food sources, social behaviour, accessibility and predictability, foraging effort, tolerance.

Introduction

Species may adapt their foraging behaviour and corresponding social behaviour in response to the prevailing environmental conditions, thereby optimizing their foraging outcomes. The relative abundance or scarcity of food sources is one of these factors that plays an important role in influencing social behaviour (Beauchamp, 2005; Sheppard et al, 2018). When a food source is abundant, inter- and intra-species competition tends to be minimal, resulting in a high level of tolerance among species (Miller et al., 2014). In contrast, a scarce food source can intensify competition between species, both within and among species (Goldberg et al., 2001). Dominant individuals often monopolize the food source, thereby making it challenging for subordinate individuals to access it (Heinrich, 1988). Such heightened competition may be accompanied by increased levels of aggressive behaviour to defend the food source (Goldberg et al., 2001; Heinrich, 1988). Additionally, highly clustered food sources, concentrated in a specific area, may further intensify agonistic interactions among individuals as they compete for access. Furthermore, abundant food sources require less foraging effort, because they are relatively easy accessible and predictable in terms of temporal and spatial distribution (Barton et al., 2013b; Deygout et al., 2010). Specifically human activity has made a substantial contribution to the overall availability of (abundant) food sources, such as landfills, agricultural land and human food waste (Becker et al., 2015). Scarce food sources often require increased foraging effort, due to difficulties in temporally and spatially locating, which could make them an unpredictable food source (Barton et al., 2013b, Cortés-Avizanda et al., 2014; Deygout et al., 2010). However, even when a food source is scarce, it can still be predictable if it is consistently available during a specific time (Monsarrat et al., 2013).

An example of a scarce, clustered, and in this case, unpredictable food source is carrion. Carrion serves as a valuable source of nutrients for a variety of (opportunistic) scavengers, such as wild boars (*Sus scrofa*), red foxes (*Vulpes vulpes*) and common ravens (*Corvus corax*) (DeVault, et al., 2011; Wilson & Wolkovich, 2011; Wenting et al., 2022). Carrion availability depends on the natural occurrence of animal deaths caused by aging, diseases,

and predation, and human activities such as hunting, population management and wildlife traffic accidents (Moleón et al., 2019). Carrion availability in the Netherlands has significantly increased since the permanent settlement of wolves (*Canis lupus*), since 2018 (Wolven in Nederland, n.d.). In addition, the Dutch government has revised their policy regarding carrion management in natural environments. Up until 2009, carrion removal from natural environments was mandatory. Since then, two specific areas in the Netherlands, namely the Oostvaardersplassen and the Veluwe zoom, have now been designated sites where carcasses, primarily of large herbivores inhabiting those areas, may decompose and serve as a food source for scavengers (NVWA bureau risicobeoordeling, 2009; Barton et al., 2013a; Wenting et al., 2022). Additionally, carrion from road kill and culled wildlife may be deposited in these designated areas (NVWA bureau risicobeoordeling, 2009).

An interesting scavenger species to study in the context of various food sources is the common raven due to its highly diverse diet and distinctive foraging strategies. The diet of ravens consists of grains, fruit and berries, insects, small mammals, eggs, human garbage and carrion (Boarman & Heinrich, 2020). It has been observed that ravens are inhabiting overlapping habitats with wolves, strategically seeking and exploiting the remains of prey animals that have been killed by wolves (Stahler et al., 2002). In addition, wolves open up the carcasses, which makes it easy accessible for ravens. Moreover, foraging strategies and corresponding social behaviours in ravens change as individuals mature and gain experience (Loretto et al., 2017). Ravens reach maturity at approximately three years of age (Heinrich & Marzluff, 1992), which is associated with a shift from social group foraging to a more territorial approach, often in breeding pairs (Loretto et al., 2017). Breeding pairs have acquired the necessary skills and experience to efficiently identify and defend food sources themselves (Marzluff & Heinrich, 1991). Conversely, immature individuals lack experience and would be at a disadvantage when competing with a territorial pair for access to a food source. Consequently, juvenile and non-breeding ravens gather in roosts at night, facilitating the exchange in knowledge regarding food source locations, and thereby recruiting multiple ravens (Dall, 2002; Marzluff et al., 1996; Wright et al., 2003). These aggregations of ravens benefit from group foraging advantages, enabling them to outcompete territorial breeding pairs and obtain access to the food source (Braun et al., 2012; Dall, 2002; Loretto et al., 2017; Marzluff & Heinrich, 1991).

Overall, when comparing scarce and abundant food sources in combination with the variability in diet and foraging behaviour in ravens, differences emerge that may influence social behaviour of ravens. Previous studies have examined the adaptability of various species in response to changing availability of food sources, and how such changes influence movements (Restani et al., 2001; Yoda et al., 2012). For instance, a decline in the number of ravens was found, when the local human population decreased (Restani et al., 2001). Moreover, black-tailed gulls (*Larus crassirostris*) show adaptability by selectively foraging at anthropogenic food sources that are available within a specific time frame (Yoda et al., 2012). Even several studies on ravens investigated how these birds exploit natural and anthropogenic food sources across the different seasons (Ho et al., 2023; Jain et al., 2022; Restani et al., 2001). These studies found that anthropogenic food sources attract more ravens during winter as opposed to summer. In addition, landfills tend to attract more juveniles, subadults and non-breeding adults during spring and summer, whereas territorial breeding pairs are more drawn towards carrion (Restani et al., 2001). All these studies provide insight into how birds respond to various food sources, however, the possible effects of different type of food sources on social behaviour within the same species, and specifically in scavenger species, remains understudied.

This research aims to explore the variation in social behaviour among common ravens across distinct food sources. These food sources are categorized into abundant food sources, represented by the landfill 5.1.2h, and scarce food sources, represented by carrion sites monitored by wildlife cameras across the Veluwe. Abundant food sources are typically easily accessible due to their widespread nature and high availability. In contrast, scarce food sources are limited in availability and are more challenging to access. Therefore, I hypothesized that abundant food sources entail reduced competition and higher levels of

tolerance among individuals, in comparison to scarce food sources. Therefore, I expected to observe more agonistic (1) and more submissive behaviour (2) at scarce food sources in comparison to abundant food sources. In addition, I expected individuals to display less affiliative behaviour (3) and reduced levels of co-feeding (4) at scarce food sources in comparison to abundant food sources. Furthermore, abundant food sources are easier to locate due to their spatial and temporal predictability. Food items at these locations are loose and scattered, making them easy to consume. In contrast, scarce food sources are spatially and temporally less predictable, making them more challenging to locate. Obtaining food from carrion requires more tearing and pulling in order to obtain a food item. In addition, scarce food sources may require recruitment of conspecifics to outcompete territorial ravens. Consequently I hypothesized that abundance food sources require less foraging effort and less experience in comparison to food sources. I expected that social calls (5) to be more pronounced at scarce food sources than at abundant ones. Finally, I expected that foraging effort (6) would be lower at abundant food sources compared to scarce food sources.

Methods

1.1 Subjects and study site

Subjects

I studied free-ranging common ravens (*Corvus corax*) in the Netherlands. The Ravenwerkgroep Nederland has been monitoring ravens since 2008, and in 2013 they started monitoring ravens with identifying, coloured rings (Ravenwerkgroep Nederland, n.d.). Moreover, the Ravenwerkgroep collects data on age, sex (from 2020 onwards) and biometrics of colour ringed ravens.

Furthermore, the Ravenwerkgroep Nederland (n.d.) closely monitored six ravens with GPS transmitters attached to a harness on their back, which was approved by the Animal Experiments Committee. During this study six more ravens were provided with a GPS transmitter in April 2023. The GPS transmitters fix the locations of the tagged ravens every five minutes and upload this data every 24 hours during my study. In the event that the GPS points form a cluster, which are several GPS fixes in one location in a short period of time, it is an indication of a potential food source.

Study site

I observed the ravens in distinct locations encompassing both abundant and scarce food sources. The identification of abundant food sources was based on the clusters derived from the GPS data. Initially, I considered several potential locations, such as a landfill, a trout farm, a small diner at a forest edge and agricultural land. However, most locations were unsuccessful study sites due to either the absence of ravens or the ravens would fly away upon closer approach. As a consequence, only one location, 5.1.2h, proved to be suitable to perform proper observations. 5.1.2h processes various waste types, such as construction and demolition waste, clean rubble, bulky household waste, roof waste and green and wood waste 5.1.2h). Mainly the household waste and green waste form a food source for the ravens, and other bird species present, such as storks, gulls, rooks and jackdaws. Prior authorization was obtained to observe the ravens at the terrain. The observations took place just behind the gates (Figure 1, yellow star).

Scarce food source locations were represented by the presence of carrion on the Veluwe. Specifically, seven locations across the Veluwe have been allocated for the deposition of carrion (and monitored



Figure 1 – Map of 5.1.2h from above. The yellow star indicates the position from where observations were performed. The red dot indicates where the ravens mainly foraged.



Figure 2 – Seven carrion locations on the Veluwe. Letters are used to prevent identification of the locations where carcasses were monitored with wildlife cameras. Location A, C* and D were included in this research.

with wildlife cameras), with two located in the northern part, one in the central region, and four in the southern part of the Veluwe (Figure 2). The carrion deposited here, originates from road kill or culled wildlife. The availability of carrion is subject to variability, due the hunting season. This leads to varying numbers of carcasses present at each location, and thereby the presence of ravens as well. As a result, at some locations no or limited carrion was deposited, resulting in the absence of ravens. Therefore, only three locations were included, one in the North and two in the South of the Veluwe. Each location was monitored through the use of wildlife cameras directed towards the carcass. The cameras were motion-activated and heat-activated and initiated recording upon detection of an animal within the range of view.

1.2 Study design

Observation period

The observation period was from April 10th to June 18th 2023, which was a total duration of approximately 2,5 months and a total of 15 live observation days. Throughout this period, I conducted observations at the landfill on average two days per week, and the remaining days were dedicated to video analyses. This resulted in a total of 169 live observations and a total of 109 videos. I used approximately two weeks to get familiar with the observational methods.

Observation methods

The identification and observation of ravens with rings was prioritized. These rings contain information on number of offspring in the nest, biometrics, age and sex. However, identifying the rings proved to be challenging, resulting in the identification of only 11 distinct individuals (Appendix 1). Unfortunately, this limited sample size was insufficient for conducting comprehensive analyses. Therefore, I observed mainly unringed individuals. Each individual was observed for a minimum duration of 30 seconds and a maximum of six minutes. If an individual went out of sight during the observation, the observation ended. Observations and videos of less than 30 seconds were removed from the dataset.

I used the focal sampling method to collect data. For this method I created an ethogram (Table 1), which was based on multiple papers (Boucherie et al., 2022; Braun & Bugnyar, 2012; Bugnyar & Kotrschal, 2002; Miller et al., 2014). This ethogram was divided into different behavioural categories, namely 1) agonistic behaviour, 2) submissive behaviour, 3) affiliative behaviour, 4) tolerance behaviour, 5) feeding behaviour, and 6) other behaviour and provides detailed descriptions of all the behaviours.

Table 1 – Ethogram of different behavioural categories. For each behaviour the abbreviation, a description and the type of behaviour (state or event) is given.

Agonistic behaviour		
Behaviour	Description	State or event behaviour
Peck (PEC)	An individual pecks an interaction partner with its beak.	Event
Pull feathers (PF)	An individual pulls the feathers of an interaction partner with its beak.	Event
Chase (flight) (CH-F)	An individual chases an interaction partner, which can either be on the ground or flying.	Event
Charge (CH)	An individual makes a sudden, intense movement towards an interaction partner.	Event
Fight (FI)	An individual attacks an interaction partners with its feet and/or beak, which can consist of short jumps up and down into the air and/or laying on the ground and sitting on top of each other.	Event
Steal (food) (ST)	Individual approaches an interaction partner, obtains food item and leaves.	Event

Submissive behaviour		
Behaviour	Description	State or event behaviour

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Avoid (AV)	An individual moves away from / makes room for an approaching interaction partner when coming in close proximity.	Event
Displace (DI)	An individual moves away from an interaction partner that will take its position after coming in close proximity.	Event

Affiliative behaviour		
Behaviour	Description	State or event behaviour
Allo-preening (AP)	An individual touches and/or runs its beak through the feathers of its interaction partner.	Event
Allo-feeding (AF)	An individual transfers food directly from its own beak to the beak of its interaction partner.	Event

Tolerance behaviour		
Behaviour	Description	State or event behaviour
Co-feeding (CF)	Two individuals eat from the same food item or from two food items, while in close social proximity.	Event
Co-manipulation (CM)	Two individuals manipulate (pull or peck) the same food item without any agonistic interactions or intentions.	Event

Feeding behaviour		
Behaviour	Description	State or event behaviour
Inspecting (IN)	An individual looks at food item, without touching it.	State
Pecking (PE)	An individual pecks at food item with its beak.	State
Pulling (PU)	An individual holds a food item while pulling at it.	State
Holding (HO)	An individual holds a food item in its beak.	State
Transfer (TR)	An individual takes a food item and moves to another spot.	Event
Consuming (CO)	An individual consumes an food item.	State

Other behaviour		
Behaviour	Description	State or event behaviour
Self-preening (SP)	An individual runs its beak through its feathers, thereby cleaning its feathers.	State
Interspecific agonistic behaviour (ING)	An individual has any agonistic interaction with a different species, which can be a gull, stork, rook, jackdaw or bird of prey.	Event
Interspecific submissive behaviour (INS)	An individual has any submissive interaction a different species, which can be a gull, stork, rook, jackdaw or bird of prey.	Event
Other behaviour (OB)	All other behaviours that are observed, but are not included in this ethogram.	State

In addition to the behaviours from the ethogram, I recorded several other measurements. These included, number of ravens, maximum group size and number of social calls. A detailed description of these measurements can be found in table 2. I counted the number of ravens at the beginning of each observation and determined maximum group size by counting the total number of ravens present within ten body lengths of the focal individual during an observation. I measured social calls differently for live observations and videos. For live observations, I counted the total number of social calls for a duration of two minutes upon arrival and between every two observations. While in videos, I counted the total number of social calls for the entire

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video duration. I chose this different approach because it proved challenging to simultaneously monitor social calls and other behaviours during a live observation.

Table 2 – Other behavioural measurements recorded during observations, provided with detailed description of how these were measured.

Behaviour	Description
Number of ravens	Total number of ravens present at the location.
Maximum group size	The maximum number of ravens located within ten body lengths of the focal individual, including the focal individual itself.
Social calls	Total number of calls heard at the location.

Observation methods abundant food source

I performed live observations at the landfill, representing an abundant food source. Observations were performed between 16.30 and 19.00. This specific time frame was chosen as it fell after closing hours, which was when the ravens tended to appear to forage. Subsequently, around 19.00, the site would become quieter. Upon arrival at the landfill, I wrote down the date and time, along with weather details such as the presence or absence of clouds and sunlight and the temperature. I observed the ravens using a telescope and a voice recorder to score all the behaviours from the ethogram. Afterwards, I documented these voice recordings in an Excel file.

Observation method scarce food source

During the day, videos were recorded at sites where carrion was deposited, representing scarce food sources. Every two weeks volunteers collected the video footage, and conducted a camera check. Videos from the same period as the live observation were prioritized, although there was no specific time frame. However, carrion availability was somewhat restricted as the observation period did not coincide with the hunting season. Consequently, carrion supply was solely dependent by roadkill incidents throughout the observation period. As a result, videos with ravens were limited and insufficient. Therefore, videos from the same period but a year earlier were also included, as well as videos from subsequent months from the same year or one or two years earlier. Table 3 gives an overview of the number of videos included for each month and year, and the location.

Table 3 – Overview of number of analysed videos with ravens per month, year and location. Letters are used to prevent identification of the locations where carcasses were monitored with wildlife cameras.

Location	Month and Year	Number of videos	Total number of videos
A	April – 2023	1	1
C	March – 2023	1	17
	April – 2023	12	
	May – 2023	4	
D	February – 2021	1	91
	June – 2022	50	
	July – 2022	1	
	August - 2022	1	
	March - 2023	39	

Before proceeding with the video analyses, a couple of preparatory steps were undertaken. First, I checked each video to determine whether a raven was present or not. Given that the duration of most videos was only 30 seconds, efforts were made to group compatible videos that could be treated as a single observation. Therefore, the time interval between each video was determined. Next, I calculated a threshold value to determine the maximum allowable time

gap between two videos and thus, defining these videos as a single observation. To calculate the threshold, I created a histogram (Appendix 2) of the time intervals between two consecutive videos to identify the range in which the majority of the observations fell. The range with the highest number of observations was between one second and 4 minutes and 56 seconds. As a result, a threshold of 4 minutes and 56 seconds was established. As a consequence, the video observations ranged from a minimum of 30 seconds to a maximum of 297 seconds. At the landfill site, the shortest observation lasted 38 seconds, while the longest reached 345 seconds. The average duration of the video observations was 64 seconds, whereas for the live observation at the landfill, it was 192 seconds on average.

Finally, the videos were analysed using the Behavioural Observation Research Interactive Software (B.O.R.I.S., v. 8.20.3) (Friard & Gamba, 2016). The same ethogram used during the live observations was applied for this analysis. Similarly, date, time, weather details, number of ravens and maximum group size were measured.

1.3 Statistical analysis

All statistical analyses were performed using R and RStudio version 4.3.1 (R Core Team, 2023). The significance level was set at 0.05.

1.3.1 Behavioural responses

To investigate social behaviours in ravens I made six behavioural categories. These categories consist of 1) agonistic behaviour, 2) submissive behaviour, 3) affiliative behaviour, 4) co-feeding behaviour, 5) social calls, and 6) feeding behaviour. The first three categories align exactly with those described in the ethogram, encompassing multiple behaviours that were summed up (Table 1). Co-feeding behaviour (fourth behaviour) consist of both co-feeding and co-manipulation (Table 1), and were summed up. Social calls (fifth behaviour) was previously described in table 2. Feeding behaviour (sixth behaviour) was divided into subcategories: low feeding effort, encompassing pecking; high feeding effort, encompassing pulling; and total feeding effort encompassing pecking, pulling, holding and consuming combined. For the analyses I used true frequencies, except for feeding behaviour, where proportions were calculated for each subcategory by dividing the behaviour by the total observation time of an individual.

1.3.2 Basic General Linear Mixed Model

Using the 'glmmTMB' package (Mollie et al., 2017), I created General Linear Mixed Models (GLMMs) to investigate five out of six behaviours, namely 1) agonistic behaviour, 2) submissive behaviour, 3) affiliative behaviour, 4) co-feeding behaviour and 5) social calls. Therefore, these behaviours served as response variables. Initially, I created a basic model for all the behavioural responses, including the following predictor variables: total observation time, location, temperature, number of ravens and maximum group size. Location was converted into a factor and included as a fixed effect to be able to compare between landfill and carrion sites. Furthermore, due to the presence of several carrion locations, location was included as random effect as well. However, after running the basic model no apparent effect was observed, resulting in the random factor being removed from the basic model. Continuing, I chose the nbinom1-family due to the count-based nature of the data. Given the substantial number of zero values in the dataset of all behaviours, I incorporated the zero-inflation model. This model calculates the probability that a behaviour will be observed within a group.

Then, I made a correlation matrix for the predictor variables using the 'corrplot()' function (Appendix 3). This revealed that 'number of ravens' and 'maximum group size' were moderately strongly correlated. Therefore, I removed 'number of ravens' from the basic model.

Next, I applied the 'scale()' function to all predictor variables in order to standardize the data and to help with potential model convergence problems. Figure 3 shows the basic model that was created and used for the behavioural categories.

The following step was, identifying the most appropriate models with the right predictor variables. I decided to consistently include total observation time and location, as total observation time is essential for correcting variations and location is the main interest.

Additionally, I consistently included maximum group size because evidence from the literature indicates that social interactions increase with a greater number of individuals (Pacala et al., 1996). Subsequently, the models were run, and in instances where temperature showed insignificance, it was excluded from the model. This resulted in temperature being removed from all models, except the model for agonistic behaviour.

The number of calls required to be corrected with the total number of individuals present at the observation sites. Therefore, the social calls model included 'number of ravens' instead of 'maximum group size'. Moreover, four observations were removed from the dataset for this model, as there obviously were begging juveniles present in the videos, causing elevated levels of social calls. Unfortunately, not all video observations with begging juveniles could be identified and excluded, due to the substantial time investment it would entail.

```
glmmTMB(Response Variable ~  
  scale(Total_Observation_Time) +  
  Location +  
  scale(Temperature) +  
  scale(Maximum_Group_Size),  
  family = "nbinom1",  
  ziformula =  
    ~ scale(Total_Observation_Time) +  
    Location +  
    scale(Temperature) +  
    scale(Maximum_Group_Size),  
  data = data)
```

Figure 3 – Basic General Linear Mixed Model

1.3.3 Model assumptions and outliers

Once all the models were established, I conducted several tests to further investigate the data and prevent potential issues within the models (Zuur et al., 2009). To begin with, I performed a collinearity check to identify any possible correlations among the predictor variables. All models showed low levels of correlation (Appendix 4), except for the affiliative model where location displayed a moderate correlation (VIF-value of 5.12). However, this was still within acceptable range.

Secondly, the models were assessed for homogeneity of variance, which assumes that the variances of independent groups are similar. To verify this, I made residual plots by plotting the model's residuals against the predicted values. When the residuals show a consistent pattern along a horizontal line, the variance is constant. The plots for all models aligned with this assumption.

Lastly, I detected outliers using the percentile method, in which all observations outside the predetermined interval of 2.5 and 97.5 were considered as potential outliers. All models were run with and without the outliers to investigate potential changes in the results. A change in results was evident in the model of agonistic behaviour, affiliative behaviour and social calls. Therefore, the outliers were investigated in more detail. In the agonistic behaviour mode, two outliers showed elevated values, attributed to a higher frequency of agonistic interactions during these observations. However, these values were not considered aberrant. In regard to affiliative behaviour, the occurrences of these behaviours were infrequent, leading to the appearance of these outliers. Similarly, these values were not considered aberrant. Lastly, regarding social calls, it was not possible to examine the outlier values from the landfill as these were scored in between live observations. However, it is likely that these values were not anomalous. Additionally, an outlier was detected at a carcass site, due to a higher frequency of interactions, leading to an increased number of social calls.

Overall, the outlier values did not indicate any concerning abnormal patterns, and therefore the models were run including all outliers. Nonetheless, it is important to note that in certain models, the exclusion of outliers did result in a different outcome. Therefore, the interpretation of these specific results needs to be approached with caution.

1.3.4 Feeding behaviour

Concerning feeding behaviour (sixth behaviour), no GLMM was employed, but several distinct analyses were conducted. First, a Wilcoxon test was employed, due to non-normal distribution of the data, for each subcategory ('low feeding effort', 'high feeding effort' and 'total feeding effort') to compare the variance of these behaviours between carcass sites and the landfill. Secondly, to test if tolerance is related to feeding effort I executed several spearman

correlation tests between all subcategories of feeding behaviour and tolerance and social calls. These correlation tests were conducted independently for both carcass sites and the landfill. An overview of all statistical output can be found in Appendix 6.

Results

Agonistic and submissive behaviour

Ravens did not show more agonistic behaviour at the carcass sites in comparison to the landfill (GLMM: estimate = 1.61, SE = 0.51, $p = 0.002$, $n = 278$) (Figure 4). In addition, I found a negative correlation between agonistic behaviour and temperature, as agonistic behaviour decreased with increasing temperature (GLMM: estimate = -0.39, SE = 0.15, $p = 0.008$, $N = 278$) (Appendix 5a). Maximum group size did not affect agonistic behaviour (GLMM: estimate = 0.19, SE = 0.12, $p = 0.12$, $N = 278$).

In regard to submissive behaviour, I did not observe notable distinctions between the two locations (GLMM: estimate = -0.49, SE = 0.44, $p = 0.26$, $N = 278$) (Figure 4). Nevertheless, I detected a positive correlation between submissive behaviour and increasing maximum group size (GLMM: estimate = 0.26, SE = 0.08, $p = 0.002$, $N = 278$) (Appendix 5b).

Affiliative behaviour

Ravens did not differ in the level of affiliative behaviour between carcass sites and the landfill (GLMM: estimate = 1.40, SE = 2.51, $p = 0.58$, $N = 278$) (Figure 5). Additionally, maximum group size did not have an influence on affiliative behaviour (GLMM: estimate = 1.38, SE = 0.84, $p = 0.10$, $N = 278$).

Co-feeding behaviour

The co-feeding model indicated that ravens showed higher levels of tolerance at carcass sites in comparison to the landfill (GLMM: estimate = -1.38, SE = 0.29, $p < 0.001$, $N = 278$) (Figure 6). Moreover, tolerance levels tended to increase with a larger maximum group size (GLMM: estimate = 0.27, SE = 0.09, $p = 0.002$, $N = 278$) (Appendix 5c).

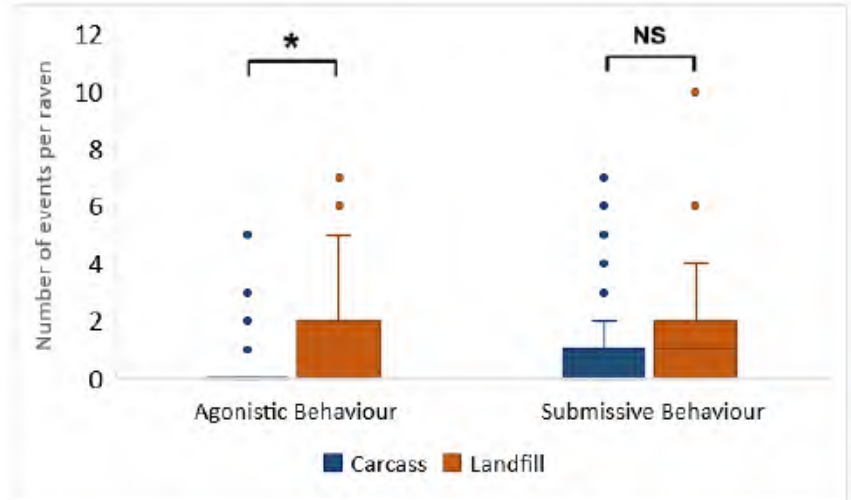


Figure 4 – Boxplot showing agonistic and submissive behaviour (number of events per raven) at the observation locations 'carcass' ($N = 109$) and 'landfill' ($N = 169$). Boxplots show the median (solid line), the 25th and 75th percentile (box), and the largest and smallest values (whiskers). Dots reflect outliers. '*' indicates a significant difference, $p < 0.05$.

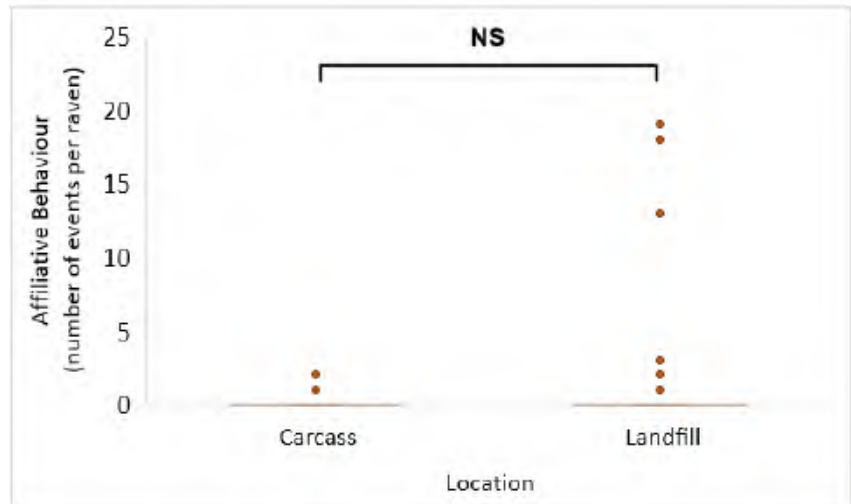


Figure 5 – Boxplot showing affiliative behaviour (number of events per raven) at the observation locations 'carcass' ($N = 109$) and 'landfill' ($N = 169$). Boxplots show the median (solid line), the 25th and 75th percentile (box), and the largest and smallest values (whiskers). Dots reflect outliers. '*' indicates a significant difference, $p < 0.05$.

Social calls

The number of (total) social calls at carcass sites and the landfill did not differ (GLMM: estimate = 0.22, SE = 0.27, $p = 0.41$, $N = 205$) (Figure 7). Furthermore, I found a positive correlation between the number of social calls and increasing number of ravens (GLMM: estimate = 0.44, SE = 0.09, $p < 0.001$, $N = 205$).

Feeding behaviours

I divided feeding behaviour into three subcategories: 'low feeding effort', 'high feeding effort', and 'feeding proportion'. All three of these subcategories were significantly different between the carcass sites and the landfill (Figure 8). Specifically, ravens exhibited higher levels of both 'high feeding effort' and 'feeding proportion' at the carcass sites compared to the landfill (Wilcoxon: $w = 6108$ and $w = 6588.5$, $p < 0.001$ and $p < 0.001$, respectively and $N = 278$). Only 'low feeding effort' showed an opposing pattern, with higher levels at the landfill than at the carcass sites (Wilcoxon: $w = 6607$, $p < 0.001$, $N = 278$). Moreover, I identified no significant correlations between social contact and all three subcategories (Spearman Correlation test: Landfill – rho = -0.07, -0.11, and -0.02, $p = 0.51$, 0.30 and 0.87; Carcass – rho = -0.10, -0.01 and -0.16, $p = 0.32$, 0.94 and 0.11, $N = 278$). However, I found a positive correlation with low feeding effort, high feeding effort and feeding proportion and tolerance, indicating that as time spent on feeding behaviour increased, tolerance levels became higher as well (Spearman Correlation Test: Rho = 0.45, rho = 0.4524 and rho = 0.29, $p < 0.001$, $p < 0.001$ and $p < 0.001$ respectively and $N = 278$) (Appendix 5d).

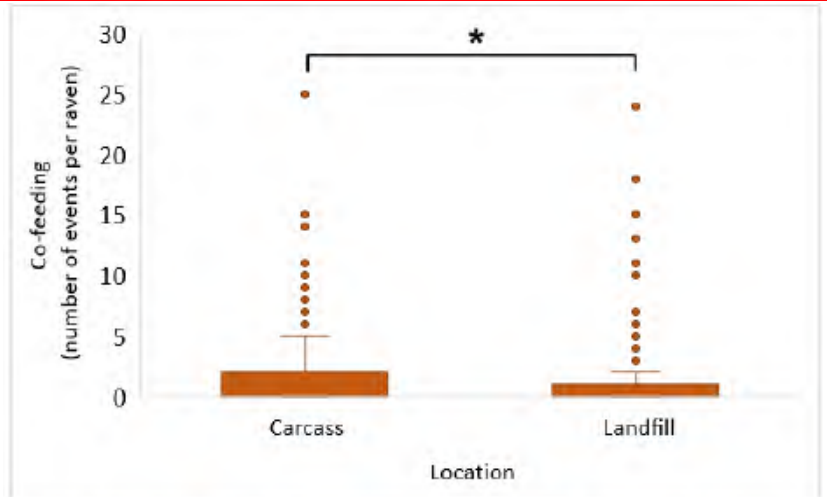


Figure 6 – Boxplot showing co-feeding behaviour (number of events per raven) at the observation locations 'carcass' ($N = 109$) and 'landfill' ($N = 169$). Boxplots show the median (solid line), the 25th and 75th percentile (box), and the largest and smallest values (whiskers). Dots reflect outliers. ** indicates a significant difference, $p < 0.05$.

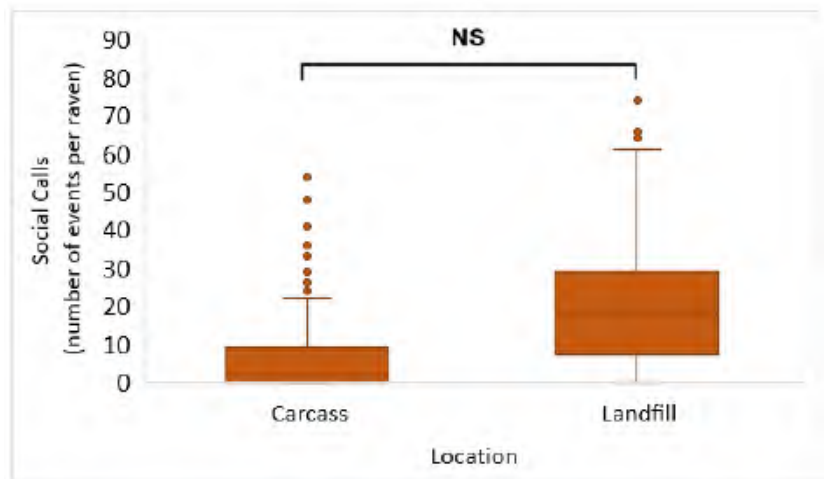


Figure 7 – Boxplot showing number of social calls (number of events per raven) at the observation locations 'carcass' ($N = 105$) and 'landfill' ($N = 100$). Boxplots show the median (solid line), the 25th and 75th percentile (box), and the largest and smallest values (whiskers). Dots reflect outliers. ** indicates a significant difference, $p < 0.05$.

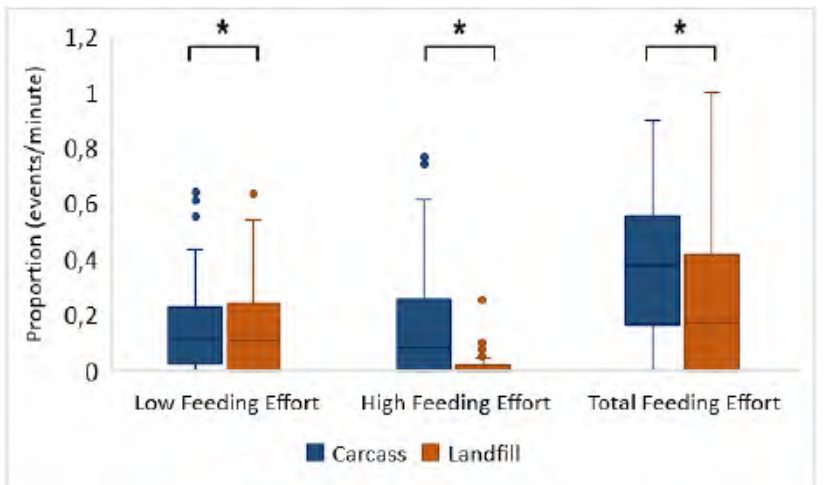


Figure 8 – Boxplot showing proportion of different feeding behaviours (events/time) at the observation locations 'carcass' ($N = 109$) and 'landfill' ($N = 169$). Boxplots show the median (solid line), the 25th and 75th percentile (box), and the largest and smallest values (whiskers). Dots reflect outliers. ** indicates a significant difference, $p < 0.05$.

Discussion

The abundance or scarcity of food sources is one of many environmental factors that can influence the behaviour and social interactions of various species. Abundant food sources are typically easy accessible due to their widespread nature and high food availability, in contrast to scarce food sources (Restani et al., 2001; Yoda et al., 2012). Furthermore, abundant food sources are often more predictable than scarce ones, because they are easier to locate temporally and spatially (Goldberg et al., 2001; Heinrich, 1988). Lastly, foraging efforts are generally lower at abundant food sources compared to scarce food sources (Barton et al., 2013b; Deygout et al., 2010). The aim of this research was to explore potential differences in social behaviours of ravens at these two distinct food source locations. The main hypothesis was to observe increased tolerance levels, due to reduced competition at abundant food sources compared to scarce food sources (Miller et al., 2014). Hence, I expected to observe lower levels of agonistic and submissive behaviour and higher levels of affiliative behaviour and co-feeding at abundant food sources. Surprisingly, the findings contradicted these predictions. I observed elevated levels of agonistic behaviour and reduced levels of co-feeding at abundant food sources in comparison to scarce food sources. While submissive behaviour and affiliative were more comparable between the two food sources. Furthermore, I hypothesized that abundant food sources require less foraging effort and less experience in comparison to scarce food sources. I observed a lower foraging effort at the landfill in comparison to carrion sites, and the amount of social calls was comparable between the two locations.

To begin, one potential explanation for elevated agonistic behaviour and reduced co-feeding observed at the landfill in comparison to the carrion sites, may be related to varying levels of familiarity between individuals at each food source location. Typically, abundant food sources attract more juvenile individuals, because they are less experienced in locating (scarce) food sources (Loretto et al., 2015; Webb et al., 2012). While, territorial breeding pairs or groups of juveniles, subadults and/or non-breeding adults are more commonly observed at scarce food sources (Marzluf & Heinrich, 1991; Webb et al., 2012). However, the video footage from carrion sites revealed instances of adult ravens accompanied by what appeared to be their offspring from the previous year(s). This assumption was made, because the juvenile individuals displayed begging behaviour and occasionally received bill-feedings from the adult individual. Furthermore, there were no videos where encounters occurred between two territorial breeding pairs or between a breeding pair and a group of ravens. This may be an indication that most observations included familiar ravens and not unfamiliar ravens. Several studies have shown that species prefer to (socially) interact more with familiar individuals (within the same species). For example, one study investigated social interactions among Barnacle geese (*Branta leucopsis*) in different contexts (Kurvers et al., 2013). The findings showed that geese preferred to interact more with familiar individuals during foraging. A similar pattern emerged in a study involving free-tailed bats (*Tadarida teniotis*), where aggression was lower and affiliation was higher between familiar individuals in comparison to unfamiliar individuals (Ancillotto & Russo, 2014). This preference toward associating with familiar individuals is consistent and has been observed in various species, including meadow voles, dairy cows, catsharks, siskins and sheep (Ferkin, 1988; Gutman et al., 2015; Jacoby et al., 2012; Senar et al., 2010; Winfield et al., 1981), and is likely present within raven populations as well.

Similarly, given that ravens at carrion sites may be more familiar with each other, ravens at the landfill may be less familiar with each other, potentially explaining the elevated agonistic behaviour and reduced co-feeding at the landfill. In general, juvenile, subadult and non-breeding ravens form large aggregations mainly for benefits during foraging, mobbing and/or roosting (Braun et al., 2012; Loretto et al., 2017). A research investigated whether these aggregations of ravens comprised unfamiliar individuals or individuals that consistently associate with one another (Braun et al., 2012). The findings revealed that these large groups consist primarily of unfamiliar individuals. However, these aggregations divide into smaller subgroups when not engaged in situations that offer advantages associated with a larger

group. These subgroups consist of familiar individuals that establish bonds with each other. Furthermore, the Braun et al (2012) found that aggression rates were higher during foraging within these large aggregations, while being practically absent within the subgroups. Affiliative behaviour was primarily observed within subgroups in comparison to the raven aggregations. This distinction was particularly evident outside of foraging contexts, during more relaxed moments (Braun et al., 2012). Given that the observations in my study were limited to foraging contexts, this may clarify the observed low levels of affiliation and the absence of discernible differences in affiliative behaviour between the landfill and carrion sites. The concept of a higher presence of familiar ravens at carrion sites and a greater proportion of unfamiliar ravens at the landfill seems plausible. However, a limitation of this research was the inability to identify ringed ravens at both locations. The rings contain information regarding the number of offspring in the nest, biometrics, sex and age (Ravenwerkgroep Nederland, n.d.). Particularly, sex and age could have provided insights into whether individuals were likely to be territorial breeders and whether an aggregation mainly consisted of younger ravens or not. Including observations of ringed ravens and considering their age and sex in future research could provide a stronger support for the concept of familiarity.

There often seems to be a correlation between tolerance behaviour and food availability (Miller et al., 2014; De La Fuente et al., 2014; Pfuhl et al., 2014). In my second hypothesis I expected that high food availability at abundant food sources would lead to lower foraging effort compared to scarce food sources. Therefore, there might be a correlation between tolerance behaviour and feeding effort as well. The findings seem to suggest a positive correlation between tolerance and feeding effort, as both co-feeding and “high feeding effort” were more pronounced at carrion sites compared to the landfill. However, according to Miller et al (2014) it seems to be more plausible to expect a negative correlation between tolerance and feeding effort. When individuals invest greater effort in obtaining food, they become less inclined to tolerate conspecifics, given the higher cost associated with losing a food item. This pattern of increased tolerance with lower feeding effort was observed in carrion and hooded crows (*Corvus corone* and *Corvus cornix* respectively) (Miller et al., 2014). This study revealed that crows displayed high levels of co-feeding relative to levels of agonistic and affiliative behaviour during foraging at abundant food sources. On the other hand, a separate study on common marmosets (*Callithrix jacchus*) indicated increased associations with conspecifics when food sources were scarce compared to when they were abundant (De La Fuente et al., 2021). Possibly, a correlation between tolerance and feeding can manifest in two directions and might also depend on the metrics used to assess tolerance levels. This aspect was demonstrated in a study involving ravens exposed to diverse conditions with varying levels of difficulty in accessing a piece of meat (Pfuhl et al., 2014). The study revealed that co-feeding was exclusively observed in conditions where feeding effort was low, suggesting high tolerance levels in situations requiring minimal effort. However, the same study found that agonistic interactions decreased in situations that required greater feeding effort, suggesting high tolerance in situations requiring increased effort. It is worth noting that they used different measures to determine tolerance levels. Pfuhl et al (2014) suggest that tolerance levels can increase, because by attempting to chase away a conspecific and potentially losing your own food item secured through prior effort, would not be advantageous. Additionally, exhibiting a substantial feeding effort may lead to diminished attention towards conspecifics, resulting in reduced agonistic interactions and consequently higher tolerance levels (Pfuhl et al., 2014). This illustrates that determining tolerance behaviour is not straightforward and can be influenced by multiple behaviours, including co-feeding and social interactions such as agonistic behaviour, submissive behaviour and affiliative behaviour. This underscores the importance of accurately defining and measuring tolerance behaviour.

I initially hypothesized that a greater number of social calls would be observed at carrion sites in comparison to the landfill. However, the findings revealed no differences in the number of social calls between the two locations. Understanding these social calls is important as ravens use a variety of vocalizations in diverse contexts and for different purposes (Enggist-Dueblin

& Pfister, 2002). It has been known that ravens communicate with conspecifics to inform them about food availability (Boeckle et al., 2012; Bugnyar et al., 2001; Sierro et al., 2019; Szpile et al., 2015). Especially when a food source is difficult to access, ravens call to attract conspecifics to gain access (Sierro et al., 2019; Szpile et al., 2015). For instance, when dominant individuals monopolize a carcass (Heinrich, 1988). Prior research investigated whether individual variation in food-associated calls may be explained by the social dynamics of foraging groups of ravens (Sierro et al., 2019). They discovered that individuals were less likely to produce a food-associated call when in close proximity with a familiar individual before feeding as compared to when they were alone. Additionally, they found that younger ravens called more often than adult ravens. Moreover, Szpile et al (2015) found that ravens respond to the individual characteristics and use this information to either join that individual at the food source or avoid the individual. This demonstrates that the frequency of social calls at a food source is dependent on the specific circumstances at the food source. For instance, you may expect a higher occurrence of food-associated calls from a young raven attempting to attract conspecifics to access a food source defended by a territorial breeding pair. Conversely, the occurrence of food-associated calls is likely to be lower when familiar ravens are already present and try to avoid drawing the attention of conspecifics, especially if they already have access to the food source. Crucial to emphasize here is that the method I used for assessing the social calls was rather simplified, while the complete vocal repertoire of ravens is more complex. Specifically, during foraging ravens have different types of calls with different meanings (Boeckle et al., 2012; Bugnyar et al., 2001; Szpile et al., 2015). Bugnyar et al (2001) discovered that so-called “haa calls” are primarily given at the presence of food and decreases during feeding, while “who-calls” increase during feeding. This suggests that “haa calls” mainly provide information about the food source, and “who calls” provide insights into the caller’s behaviour. Even though I observed no difference in the total number of social calls, there might have been differences in the frequencies of these distinct call types. In future research, it would be interesting to further investigate the variations in these calls used by individuals and deepen the knowledge on the contexts in which ravens utilize these vocalizations.

Finally, I would like to highlight two more limitations of this research that offer opportunities for improvement in future research. Firstly, I could only include one abundant food source, the landfill, in this study. Hence, I cannot confidently confirm that the observed results were related to the abundance of the food source or if the results were unique to the landfill itself. Therefore, I highly recommend including several other abundant food sources, including different types such as agricultural land or small diners along forests or the roads, in future studies. Secondly, the scarce food sources included in my research might not have been as unpredictable as indicated in the literature (Barton et al., 2013b; Cortés-Avizanda et al., 2014; Deygout et al., 2010). Specifically, natural carrion availability is both temporarily and spatially unpredictable, given that predators will hunt prey animals at various locations and times (Barton et al., 2013b; Deygout et al., 2010). The carrion sites in my research might have been temporally unpredictable as carrion deposition was irregular. However, carrion was consistently deposited at the same locations, indicating spatial predictability. Furthermore, the carrion locations included in this study have been all situated in the Veluwe. Home ranges of ravens vary between breeding and non-breeding ravens (Rossi, 2019; Webb et al., 2012). Breeding ravens typically maintain smaller territories that they defend for conspecifics, while non-breeding ravens travel more extensive distances, without having their own territory (Rossi, 2019; Webb et al., 2012). Consequently, the probability that territorial breeding ravens would detect the carrion locations may have been higher compared to non-breeding ravens. In future research, it would be preferable to include more unpredictable scarce food sources both in terms of time and location, such as actual wolf preys.

Conclusion

Even though, this research entailed some limitations, I provided valuable insight into the social behaviour of ravens at various food sources in the Netherlands. Surprisingly, I observed higher levels of agonistic behaviour and lower co-feeding levels at the landfill (abundant) compared

to carrion sites (scarce). Contrary to the expectations, these results seem to indicate that ravens exhibit elevated tolerance levels at scarce food sources than at abundant food sources. The findings may have been influenced because only one abundant food source was included and the scarce food sources may not have been as unpredictable as initially expected. Therefore, future research could benefit from including a broader range of abundant food sources and more unpredictable scarce food sources.

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5.1.2h [REDACTED]

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Appendix

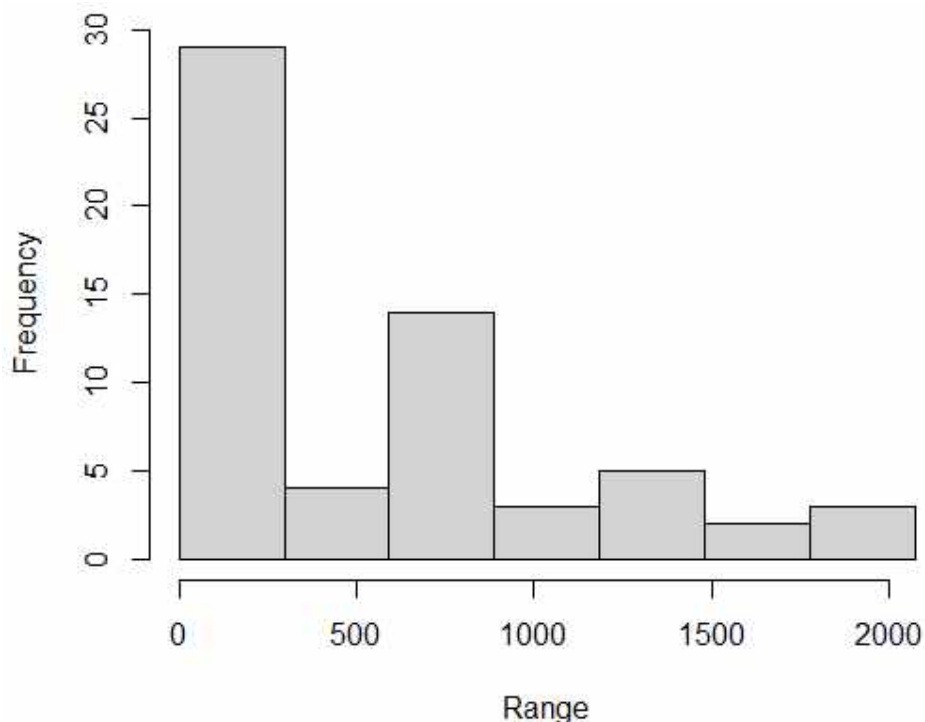
Appendix 1 – Uniquely identified ravens with coloured rings

Overview of the identified ringed ravens throughout the observation period. The table includes details about the nest location, the onset date of egg laying by the parents, the date the offspring were ringed, the number of offspring in the nest and the sex. A few individuals were observed and identified multiple times during the observation period. This was the case for H19, J33, J17 and J05, with H19 being observed three times and the others being observed twice.

Number	Ring number	Date of start egg laying	Date of receiving ring	Number of offspring in nest	Sex
1	J11	16-02-2022	08-04-2022	4	Unknown
2	J33	Unknown	14-04-2022	2	Unknown
3	H19	21-02-2021	14-04-2021	6	Unknown
4	J04	24-02-2021	16-04-2021	4	Male
5	J05	24-02-2021	16-04-2021	4	Female
6	H18	21-02-2021	14-04-2021	6	Unknown
7	H06	16-02-2021	15-04-2021	5	Female
8	K75	26-02-2022	27-04-2022	5	Unknown
9	J17	18-02-2022	18-04-2022	5	Male
10	J18	18-02-2022	18-04-2022	5	Unknown
11	H25	19-02-2022	27-04-2022	3	Unknown

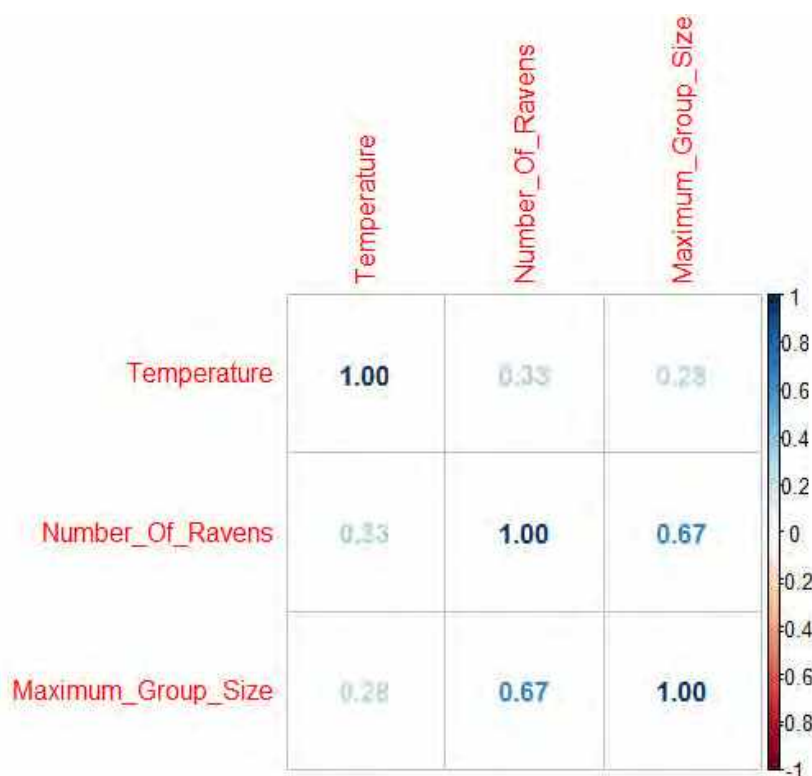
Appendix 2 – Histogram ranges video distances

Histogram to visualize the range in which the majority of the video distances between observations fall. A threshold value of 4 minutes and 56 seconds was established.



Appendix 3 – Correlation matrix

Correlation matrix of predictor variables basic model. It indicates that 'first closest neighbour' and 'second closest neighbour', 'second closest neighbour' and 'maximum group size' and 'number of ravens' and 'maximum group size' are moderately strong correlated with values of 0.64, -0.69 and 0.70 respectively.



Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Appendix 4 – Overview collinearity check

Overview of VIF-values from correlation checks for each behavioural response variable. All VIF-values indicate low correlations, except for 'location' of affiliative behaviour, which shows a moderately correlation with a VIF-value of 5.12.

Agonistic Behaviour

Conditional model		Zero-inflation model
	VIF-value	VIF-value
Total Observation Time	1.89	2.47
Temperature	1.51	2.36
Maximum Group Size	1.75	2.00
Location	2.50	2.29

Submissive Behaviour

Conditional model		Zero-inflation model
	VIF-value	VIF-value
Total Observation Time	1.15	1.87
Maximum Group Size	1.18	2.66
Location	2.48	1.00

Affiliative Behaviour

Conditional model		Zero-inflation model
	VIF-value	VIF-value
Total Observation Time	2.47	1.86
Maximum Group Size	3.28	1.24
Location	<u>5.12</u>	2.17

Co-feeding Behaviour

Conditional model		Zero-inflation model
	VIF-value	VIF-value

Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Total Observation Time	2.03	2.08
Location	1.79	1.80
Maximum Group Size	2.74	2.76

Social Calls

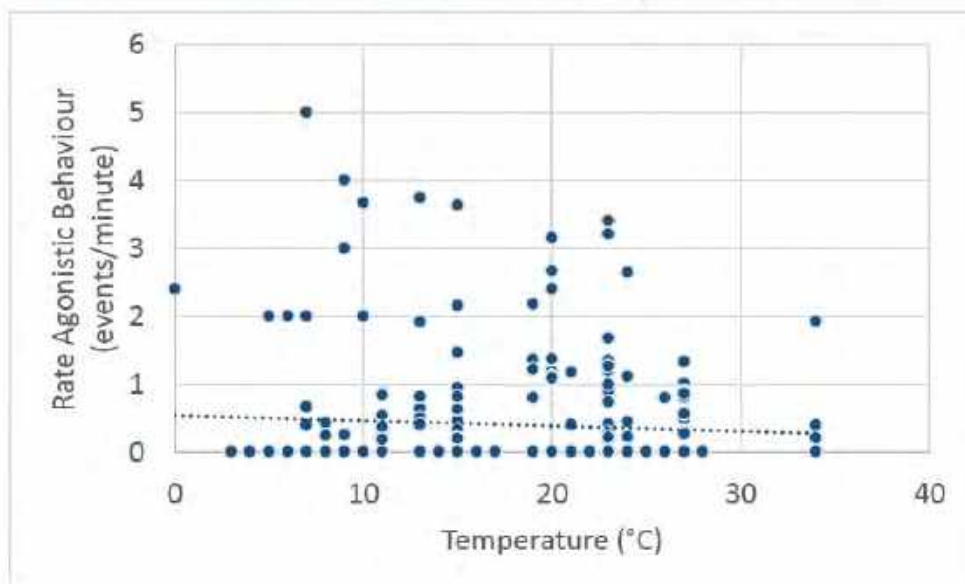
Conditional model		Zero-inflation model
	VIF-value	VIF-value
Total Observation Time	1.58	1.13
Location	2.11	1.13
Maximum Group Size	2.87	1.00

Appendix 5 – Other results

Graphs and figures of other results which were not provided in the results section.

5a) Correlation graph agonistic behaviour and temperature

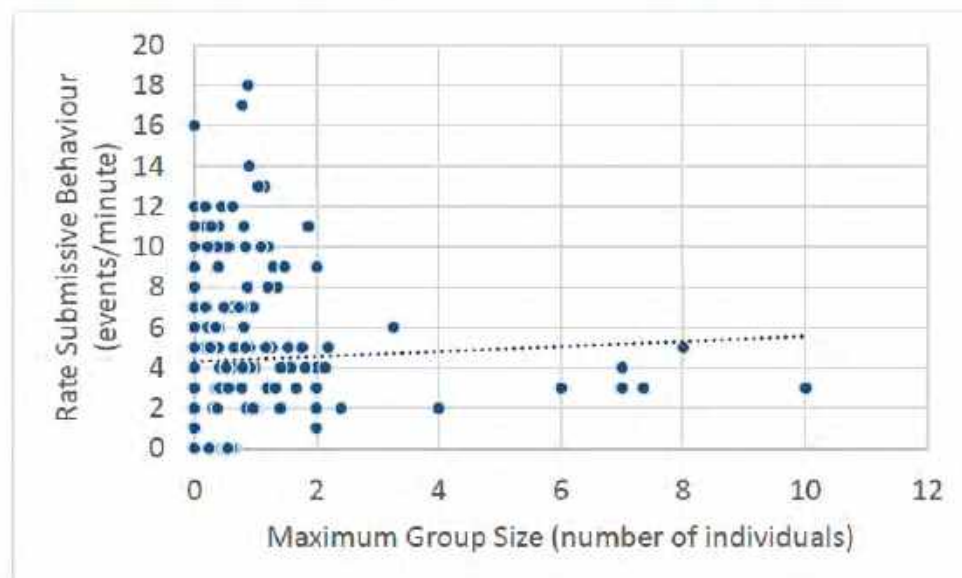
Scatterplot showing a negative correlation between agonistic behaviour (events/minute) and temperature (°C) (GLMM: estimate = -0.39, SE = 0.15, p = 0.008, N = 278).



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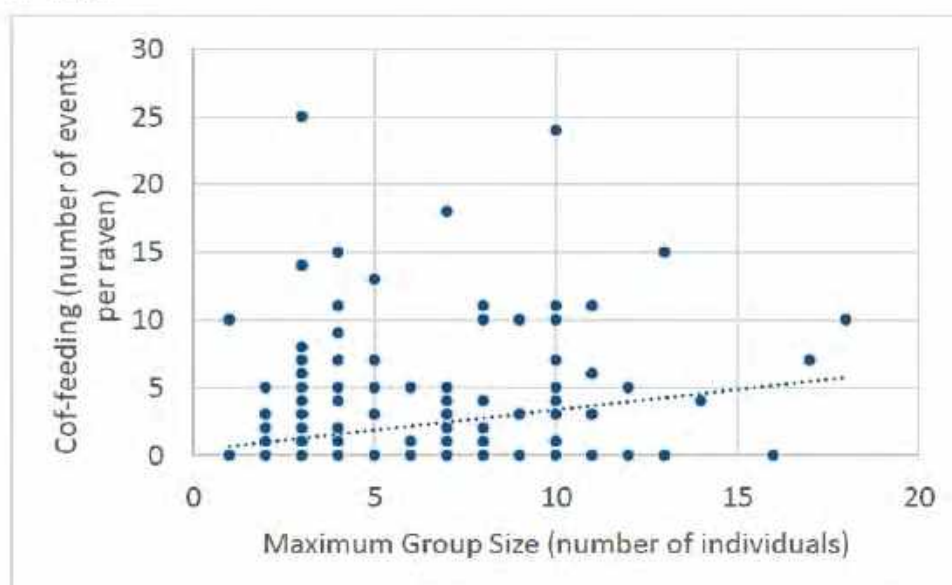
5b) Correlation graph submissive behaviour and maximum group size

Scatterplot showing a positive correlation between submissive behaviour (events/minute) and maximum group size (number of individuals) (GLMM: estimate = 0.26, SE = 0.08, $p = 0.002$, $N = 278$).



5c) Correlation graph co-feeding and maximum group size

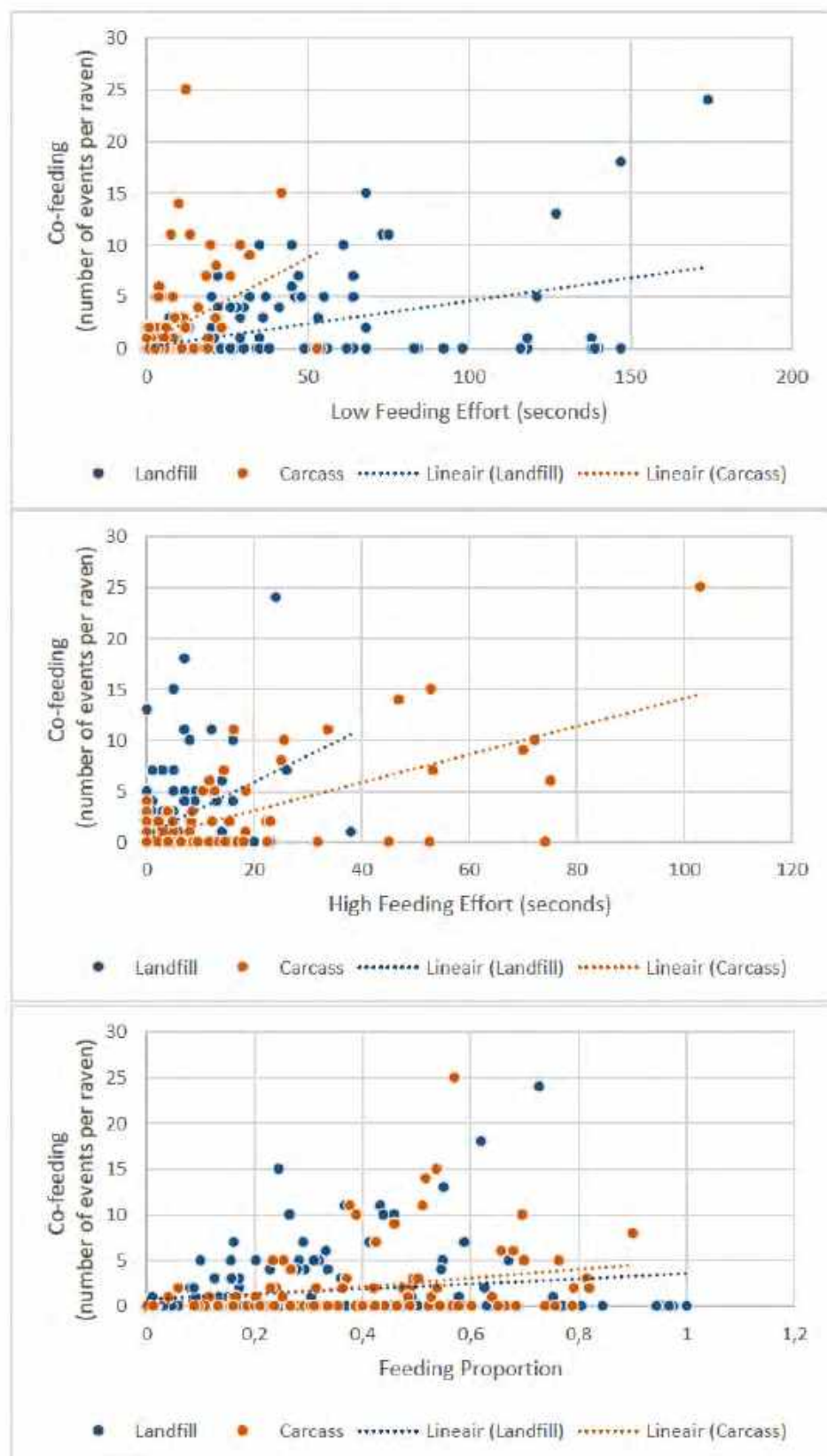
Scatterplot showing a positive correlation between co-feeding (number of events per raven) and maximum group size (number of individuals) (GLMM: estimate = 0.27, SE = 0.09, $p = 0.002$, $N = 278$).



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5d) Correlation graphs feeding behaviour and co-feeding

Scatterplots showing positive correlations between low feeding effort (seconds), high feeding effort (seconds) and feeding proportion and co-feeding (number of events per raven) (Spearman Correlation Test: $Rho = 0.45$, $\rho = 4524$ and $\rho = 0.29$, $p < 0.001$, $p < 0.001$ and $p < 0.001$ respectively and $N = 278$).



Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Appendix 6 – Statistical output

Complete overview of all statistical output, separately for each behavioural category: agonistic behaviour, submissive behaviour, affiliative behaviour, co-feeding behaviour, social calls and feeding behaviour.

6a) GLMM – Agonistic Behaviour

Conditional model				Zero-inflation model		
	Estimate	Std. error	P-value	Estimate	Std. error	P-value
Total Observation Time	0.27	0.16	0.08	0.91	0.82	0.27
Temperature	-0.39	0.15	0.01	-2.37	1.16	0.04
Maximum group size	0.19	0.12	0.12	-1.30	0.72	0.07
Location	1.61	0.51	0.002	6.90	8.00	0.39

6b) GLMM – Submissive Behaviour

Conditional model				Zero-inflation model		
	Estimate	Std. error	P-value	Estimate	Std. error	P-value
Total Observation Time	0.18	0.10	0.08	0.42	1.27	0.74
Maximum group size	0.26	0.08	< 0.001	-6.17	3.84	0.11
Location	-0.49	0.44	0.26	-24.27	5329.61	1.00

6c) GLMM – Affiliative Behaviour

Conditional model				Zero-inflation model		
	Estimate	Std. error	P-value	Estimate	Std. error	P-value
Total Observation Time	0.12	1.00	0.91	-1.83	1.33	0.17
Maximum group size	1.38	0.84	0.10	1.53	1.14	0.18
Location	1.40	2.51	0.58	4.60	3.22	0.15

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6d) GLMM – Co-feeding Behaviour

Conditional model				Zero-inflation model		
	Estimate	Std. error	P-value	Estimate	Std. error	P-value
Total Observation Time	0.79	0.13	< 0.001	0.07	0.25	0.78
Maximum group size	0.27	0.09	0.002	-0.91	0.23	< 0.001
Location	-1.38	0.29	< 0.001	1.56	0.57	< 0.001

6e) GLMM – Social Calls

Conditional model				Zero-inflation model		
	Estimate	Std. error	P-value	Estimate	Std. error	P-value
Total Observation Time	-0.01	0.08	0.91	1.78	1.53	0.25
Number of ravens	0.44	0.09	< 0.001	-39.41	15.43	0.01
Location	0.22	0.27	0.41	-7.13	3845.37	1.00

6f) Feeding behaviour

Behaviour	Test	Output	P-value
Low feeding effort	Wilcoxon	W = 6607	p < 0.001
High feeding effort	Wilcoxon	W = 6108	p < 0.001
Feeding proportion	Wilcoxon	W = 6588.5	p < 0.001

Behaviour	Test	Output	P-value
Low feeding effort – social contact – Landfill	Correlation test, spearman	Rho = -0.07	p = 0.51
Low feeding effort – social contact – carcass	Correlation test, spearman	Rho = -0.10	p = 0.32
Low feeding effort – tolerance – landfill	Correlation test, spearman	Rho = 0.45	p < 0.001
Low feeding effort – tolerance – carcass	Correlation test, spearman	Rho = 0.31	p = 0.001
High feeding effort – social contact – landfill	Correlation test, spearman	Rho = -0.11	p = 0.30
High feeding effort – social contact – carcass	Correlation test, spearman	Rho = -0.01	p = 0.94

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

High feeding effort – tolerance – landfill	Correlation test, spearman	Rho = 0.45	p < 0.001
High feeding effort – tolerance – carcass	Correlation test, spearman	Rho = 0.41	p < 0.001
Feeding proportion – social contact – landfill	Correlation test, spearman	Rho = -0.02	p = 0.87
Feeding proportion – social contact – carcass	Correlation test, spearman	Rho = -0.16	p = 0.11
Feeding proportion – tolerance – landfill	Correlation test, spearman	Rho = 0.29	p < 0.001
Feeding proportion – tolerance – carcass	Correlation test, spearman	Rho = 0.32	p < 0.001

From: 5.1.2e
To: [Equipment BHE](#)
Subject: FW: Dobberke application
Date: woensdag 6 december 2023 10:05:00
Attachments: [Ornitela Invoice ORN_Nr_23183.pdf](#)

Hoi 5.1.2e,

Bij deze wat meer info (loggers uit Letland en voorbeeld van factuur vorig jaar (voor ARK)).

Groetjes,

5.1.2e

From: 5.1.2e @ark.eu>
Sent: 05 December 2023 14:28
To: 5.1.2e @wur.nl>
Subject: Re: Dobberke application

Hoi 5.1.2e ,

De loggers komen uit Letland (Ornitela). 5.1.2e is onze contactpersoon
5.1.2e@ornitela.eu

Ik heb de factuur van afgelopen jaar bijgevoegd.

Groeten,

5.1.2e

From: 5.1.2e @wur.nl>
Sent: Tuesday, December 5, 2023 9:17 AM
To: 5.1.2e @ark.eu>
Subject: FW: Dobberke application

Ho 5.1.2e,

Ik heb de discussie al even aangezwengeld. Zie onder. Waar worden de GPS devices besteld?

Groetjes,

5.1.2e

From: Equipment BHE <equipment.bhe@wur.nl>
Sent: 05 December 2023 08:58
To: 5.1.2e @wur.nl>
Subject: RE: Dobberke application

Hoi 5.1.2e

Ik moet dit even navragen bij 5.1.2e want als ARK ons een factuur stuurt, zal er alsnog BTW op de factuur moeten staan, dus zie ik niet echt in welk voordeel het ons gaat opleveren. Ook ben ik er niet zeker van of we altijd BTW afdragen. Komen de GPS devices uit NL of worden ze in het buitenland besteld?

Groet, 5.1.2e

From: 5.1.2e [redacted] <[redacted]@wur.nl>
Sent: Monday, December 4, 2023 11:06 AM
To: Equipment BHE <equipment.bhe@wur.nl>
Subject: FW: Dobberke application

Hoi team,

Ik heb funding gekregen om GPS devices aan te schaffen voor een samenwerkingsproject met Ark. Nu blijkt dat Ark geen btw af te dragen als zij het bestellen. Is het mogelijk dat wij Ark betalen om de GPS te bestellen of wordt dat ingewikkeld?

Groetjes,
5.1.2e [redacted]

From: 5.1.2e [redacted] <[redacted]@ark.eu>
Sent: 04 December 2023 09:11
To: 5.1.2e [redacted] <[redacted]@wur.nl>; 5.1.2e [redacted] <[redacted]@ark.eu>
Cc: 5.1.2e [redacted] <[redacted]@ziggo.nl>
Subject: Re: Dobberke application

Geweldig nieuws!!!
En er ligt ook nog sneeuw

Wbt bestellen heeft Ark dit in het verleden gedaan omdat we niet BTW-plichtig zijn.
Van 5.1.2e [redacted] begreep ik eerder dat de WUR BTW moet afdragen. Iets om tzt uit te zoeken.

Groeten,
5.1.2e [redacted]

Reeds beoordeeld





PVM sąskaita-faktūra - Invoice

ORN Nr. 23183

2023-04-12

Pardavėjas Seller	
"Ornitela", UAB	
Adresas Address	
Švitrigailos g. 11K-109 Vilnius LT-03228 Lithuania	
Tel.: 5.1.2e	
E-mail: info@ornitela.eu	
Įmonės kodas Company number	304162369
PVM mokėtojo kodas VAT number	LT100009901714
Bankas Bank	"Swedbank", AB; SWIFT code HABALT22
Banko adresas Bank address	Konstitucijos pr. 20A, Vilnius LT-03502, Lithuania
Sąskaita (IBAN) Account number (IBAN)	LT637300010145513569

Pirkėjas Buyer	
ARK Natuurontwikkeling	
Adresas Address	
Molenveldlaan 43 6523 RJ Nijmegen The Netherlands Attn: 5.1.2e Tel.: 5.1.2e E-mail: 5.1.2e@ark.eu	
Įmonės kodas Company number	
PVM mokėtojo kodas VAT number	NL 8136.69.807.B01
Bankas Bank	
Banko adresas Bank address	
Sąskaita Account number	

Apmokėjimo sąlygos Payment terms	Payment via bank transfer is due within 15 days of the delivery of goods; Each transmitter has a balance of 180 Eur of data transfer fees
Pastabos Comments	Transmitter warranty period – 12 months; Serial numbers: 232701–232703; Delivery address: 5.1.2e The Netherlands

Nr. No.	Pavadinimas Description	Mat. vnt. Meas. unit.	Kiekis Quantity	Kaina Price Eur	Suma (be PVM) Total (excl. VAT) Eur	PVM tarifas VAT tariff %	PVM suma Total VAT Eur	Suma Total Eur
1	OrniTrack-E25B 4G transmitter OrniTrack-E25B 4G siųstuvas	Piece	3	1090.00	3270.00	0	0.00	3270.00
2	Insured shipping & handling Apdrausta siuntimo išlaidos	–	1	75.00	75.00	0	0.00	75.00

Prekės yra apmokestinamos taikant 0 % PVM tarifą pagal PVMĮ 49 str. 1 d. "Prekių tiekimas į ES valstybę narę"

Suma žodžiais: Trys tūkstančiai trys šimtai keturiasdešimt penki Eur 00 ct.
Amount due in words: Three thousand three hundred forty five Eur 00 ct.

Viso be PVM, Eur Sub-total excl. VAT, Eur	3345.00
Viso PVM, Eur Total VAT, Eur	0.00
Galutinė suma, Eur Grand total, Eur	3345.00

Sąskaitą išrašė: 5.1.2e
Invoice issued by:

5.1.2e

5.1.2e

Van: 5.1.2e
Verzonden: donderdag 11 juni 2026 14:13
Aan: 5.1.2e
Onderwerp: FW: Dobberke Beurs/ Resource
Bijlagen: 210530 H27 5.1.2h vliegend met zender_foto 5.1.2e.jpg; 210427 5.1.2h3 jongen ww 1x zenderen 5.1.2e.jpg; IMG-20220519-2022 nest 5.1.2h met gezenderde jongen 5.1.2e.jpg; 220519 5.1.2e zenderen 5.1.2h.JPG

From: 5.1.2e @wur.nl>
Sent: maandag 22 januari 2024 10:33
To: 5.1.2e @wur.nl>
Subject: FW: Dobberke Beurs/ Resource

FYI

From: 5.1.2e @ziggo.nl>
Sent: 20 January 2024 13:59
To: 5.1.2e @wur.nl>
Subject: RE: Dobberke Beurs/ Resource

Hallo 5.1.2e

Hierbij foto's van gezenderde raaf. De 'grootte'/kwaliteit is wisselend. Weet niet wat nodig is voor artikel

1. Van mindere grootte: foto's 5.1.2e en 5.1.2e
2. Betere kwaliteit , maar alleen bij aanbrengen zender gemaakt: foto 5.1.2e

5.1.2e kan zeker aanhaken bij ringen/zenderen raven. Wordt wel april/mei.

Groet
5.1.2e

Van: 5.1.2e [mailto:5.1.2e @wur.nl]
Verzonden: vrijdag 19 januari 2024 15:33
Aan: 5.1.2e
Onderwerp: FW: Dobberke Beurs/ Resource

Hoi 5.1.2e

Ik heb zojuist een kort interview met 5.1.2e gedaan mbt van de Dobberke beurs die we hebben gekregen voor het raven onderzoek. 5.1.2e is van de Resource, het universiteitsblad van Wageningen. Nu had ze nog twee vragen:

- Is er eventueel een foto van raaf met zender beschikbaar die ze zou kunnen gebruiken (met bronvermelding)?
- Is er een mogelijkheid dat 5.1.2e kan aanhaken bij het zenderen van de raven in het voorjaar voor een wat uitgebreider artikel?

Groetjes, en ik spreek je sowieso dinsdag!

5.1.2e

From: 5.1.2e @wur.nl>
Sent: 17 January 2024 21:06

To: 5.1.2e [redacted]@wur.nl>

Subject: Dobberke Beurs/ Resource

Hallo 5.1.2e [redacted]

Van 5.1.2e [redacted] kreeg ik de tip dat je een Dobberke beurs hebt ontvangen om onderzoek te doen naar raven. Gefeliciteerd!

Het klinkt als een onderzoek waar Resource nu in ieder geval graag een berichtje aan zou willen wijden (en later misschien een wat langer verhaal / reportage).

Ben je misschien a.s. vrijdagmiddag beschikbaar om me er iets meer over te vertellen (via Teams), of anders dinsdagmiddag?

Met vriendelijke groet,

5.1.2e [redacted],
redactie Resource
5.1.2e [redacted]
werkdagen: ma, di, wo

Universiteitsmagazine van Wageningen University & Research

Volg ons via [Instagram](#), [Twitter](#), [Facebook](#) en [LinkedIn](#)











KONINKLIJKE NEDERLANDSE AKADEMIE VAN WETENSCHAPPEN

Vragen interview voor ontvangers Dobberke Beurs

Wil je bij het beantwoorden van de vragen rekening houden met de doelgroep van de lezers? Dit is een breed publiek die bestaat uit in wetenschap geïnteresseerde personen. Zij hebben doorgaans geen inhoudelijke kennis van jouw vakgebied.

1. Met wat voor onderzoek hou jij je bezig? [max 150 woorden]

Ik ben heel nieuwsgierig naar de invloed van individuele verschillen en de sociale omgeving op het gedrag van wilde dieren. Ik focus me hierbij vooral op hoe dieren hun eten vinden, omdat dit gedrag een kritieke rol speelt in de overleving. Tussen soorten zien we vaak verschillende strategieën om aan eten te komen. Sommige soorten gaan vooral in hun eentje op pad, terwijl andere soorten voordeel halen uit de informatie van soortgenoten over beschikbare voedselbronnen. En ook binnen een soort kunnen individuen verschillen in welke mate ze zich door hun sociale omgeving laten beïnvloeden. Deze variatie is vaak ook mooi terug te zien in het gedrag van tuinvogels op de voedertafels. Het is bijvoorbeeld opvallend hoe sommige soorten vaak pas op komen dagen wanneer andere soorten al aanwezig zijn.

2. Waarom is jouw onderzoek belangrijk? [max. 100 woorden]

De beschikbaarheid van voedselbronnen voor wilde dieren is niet altijd voorspelbaar. Mensen hebben vaak een grote invloed op de voorspelbaarheid en beschikbaarheid van voedsel. Deze invloed laat zich, bijvoorbeeld, gelden via het aanbod van eetbaar 'afval' (direct) maar ook via klimaatverandering (indirect). Het is belangrijk om te weten hoe wilde dieren met veranderingen in voorspelbaarheid en beschikbaarheid omgaan en hoe flexibel ze zijn in het aanpassen van hun gedrag. Een beter begrip van de (sociale) strategieën die dieren volgen om hun voedselzoekgedrag en eetpatroon te vormen geeft ons ook beter inzicht in de flexibiliteit en kwetsbaarheid van deze soorten.

3. Wat voor mogelijkheden brengt de Dobberke Stichting voor jouw onderzoek? [max. 100 woorden]

De raaf laat verschillende strategieën zien om eten te vinden. Dit is een fascinerende soort omdat ze bekend staat als erg schuw, maar tegelijkertijd zich goed aan de mens lijkt aan te passen. We zien raven bijvoorbeeld veel terug op locaties waar mensen mogelijke voedselbronnen achterlaten. Hoe vinden ze deze bronnen? Hoe overwinnen ze hun instinctieve angst voor mensen? En waarom lijken er verschillen te zijn tussen individuen? Via de Dobberke Stichting kunnen we GPS zenders aanschaffen om jonge raven te volgen en te achterhalen welke rol de sociale omgeving speelt in hoe en wanneer raven een bepaalde voedselvoorkeur ontwikkelen.

Op de hoogte blijven van de symposia, lezingen en openbare bijeenkomsten van de KNAW?

Volg ons op Twitter of Facebook. Of meld u aan voor onze mailings.

Meer informatie: knav.nl/blijfopdehoogte

APPLICATION FORM DOBBERKE GRANT OF THE DR. J.L. DOBBERKE FOUNDATION FOR COMPARITIVE PSYCHOLOGY 2023

Who can apply?

PhD-candidates and PhD's who work at (or are affiliated with) a university or research institute in the Netherlands

When?

The deadline for submitting applications is 15 October 2023

The Dobberke Grant supports scientific research in the field of animal behaviour

More information?

For guidelines, see [this webpage](#).

TITLE OF PROJECT FOR DOBBERKE GRANT

Social behaviour of Ravens (*Corvus corax*) on the Veluwe: Foraging behaviour and collaboration with wolves (*Canis lupus*) as supplier of carrion

APPLICANT'S PERSONAL DETAILS

Please attach a CV, including date and place of graduation and (where applicable) receipt of PhD

Surname and first name, title(s) [Fill in](#)

Current position [Fill in](#)

University [Fill in](#)

Address [Fill in](#)

E-mail [Fill in](#)

Website [Fill in](#)

INFORMATION ON PROJECT

Please attach a description of the research question and the approach (methods and techniques) of the proposed project (max 2 A4 sheets)

Starting date [01-04-2024](#)
(between 01-12-2023 and 01-12-2024)

Total duration [12 months](#)

Location of the project (institute, city, country) [Wageningen University and Research, Wageningen, The Netherlands](#)

Affiliation of collaborators (institute, city, country) [Fill in](#)

Brief summary stating purpose of research project and relevance to field (max 100 words)

Since 2018 the wolf (*Canis lupus*) returned to the Veluwe (Netherlands) resulting in 7 territories (2023). As a carrion supplier the wolf has an impact on the reliability and predictability of food sources. Ravens (*Covus corax*) can profit and could collaborate with wolves in finding food sources. We want to study how the raven population on the Veluwe will adapt to new food sources, such as carcass remains left by wolves, and learn from social behavior at abundant and scarce food sources.



We will collect data from ravens with GPS transmitters to study their feeding behavior at different food sources.

Which publications or other forms of knowledge dissemination are expected to result from the project?

One or two thesis reports. We intend to publish our results in a Dutch professional journal. We intend to publish our results in a scientific journal.

REASON FOR APPLYING

Why are you applying from the Dr. J.L. Dobberke Foundation? In case of integrating the project into a larger ongoing research project: Why is the project not being financed from the regular budget? The project was initiated and financed by the Dutch NGO ARK Rewilding Netherlands. Together with other partners, such as Sovon, The Raven Workgroup Netherlands, State Forestry, and Wageningen University and Research, ravens were tagged with GPS transmitters for the first time in the Netherlands. In the first year the main goal was to study whether equipping juvenile ravens with a GPS transmitter would be a proofed method to study raven behaviour, which happened to be the case. To scale up the research, and to be able to perform decent statistical analyses, more data needs to be collected and more raven need to be equipped with GPS transmitters. ARK Rewilding Netherlands was the project initiator and research is not their main objective. They would like others to take over the research project and now funding is needed to continue the research. Therefore, we ask for funding of the research materials, the GPS transmitters, needed to equip more ravens to collect more data.

BUDGET

Please attach a brief budget that clearly specifies the types of costs and how they relate to the suggested project. If applicable also indicate the larger context of the research and its primary sources of funding (PhD-candidate, VENI, VIDI, other, please explain) and why additional funding is requested (max 1 A4 sheet, please check Article 4 in the guidelines as to whether the specified costs are fundable)

Dobberke Grant requested € 5525,- (five GPS transmitters)

Funding requested elsewhere € 0

DETAILS OF RESEARCH PROJECT SUPERVISOR (ONLY IF APPLICANT DOES NOT HAVE A PHD)

Please attach a letter of recommendation by the project's senior supervisor confirming support of this funding application and indicating the nature and scale of the project supervision.

Name N/A

Position and Organization ...

SIGNATURE OF APPLICANT

Name ...

Place and date ...



SUBMISSION (DEADLINE 15 OCTOBER 2023)

Please send this form to:

wetenschapsfondsen@knav.nl

Be sure to attach the following in a single PDF-file:

- a CV, a description of the research question and the approach (max 2 A4), a summary of the budget and a letter of recommendation (applicable only if applicant does not have a PhD)

Questions? Please contact wetenschapsfondsen@knav.nl.

5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: maandag 4 december 2023 11:21
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: RE: Dobberke application

Wat goed!!! 🥳🥳 Fijn dat het gelukt is en we de kosten voor de materialen nu gedekt hebben.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

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Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e [redacted]@ark.eu>
Sent: Monday, December 4, 2023 9:11 AM
To: 5.1.2e [redacted]@wur.nl>; 5.1.2e [redacted]@ark.eu>
Cc: 5.1.2e [redacted]@ziggo.nl>
Subject: Re: Dobberke application

Geweldig nieuws!!!

En er ligt ook nog sneeuw 😊

Wbt bestellen heeft Ark dit in het verleden gedaan omdat we niet BTW-plichtig zijn. Van 5.1.2e [redacted] begreep ik eerder dat de WUR BTW moet afdragen. Iets om tzt uit te zoeken.

Groeten,

5.1.2e [redacted]

From: 5.1.2e [redacted]@wur.nl>
Sent: Friday, December 1, 2023 6:16 PM
To: 5.1.2e [redacted]@ark.eu>; 5.1.2e [redacted]@ark.eu>
Cc: 5.1.2e [redacted]@ziggo.nl>
Subject: FW: Dobberke application

Hoi allen,

Goed nieuws, ik heb de funding voor de (vijf) GPS zenders die we hebben aangevraagd toegekend gekregen!

We kunnen dit (als het goed is) vanaf 1 januari besteden. Ik denk dat het handig is om dan begin januari informatie uit te wisselen met onze technisch assistenten om de zenders te bestellen via WUR en dat jullie deze dan bij ons kunnen ophalen. Mijn 5.1.2e [redacted] dus we zullen de betaling voor die tijd rond moeten hebben.

Groetjes en fijn weekend!

5.1.2e

From: 5.1.2e @knav.nl>
Sent: 01 December 2023 14:38
To: 5.1.2e @wur.nl>
Subject: RE: Dobberke application

Dear 5.1.2e

In October you submitted an application for a Dobberke Grant. The Board of the Dobberke Foundation have decided to award you a Dobberke Grant (see attached letter). Please confirm the grant by sending an email to 5.1.2e @knav.nl no later than December 10th.

We would like to congratulate you with the Dobberke Grant.

Kind regards,

5.1.2e

Afdeling Wetenschapsfondsen
Koninklijke Nederlandse Akademie
Van Wetenschappen

Het Trippenhuys
Kloveniersburgwal 29
Postbus 19121
1000 GC Amsterdam
The Netherlands

Tel 5.1.2e (di en do.)
Aanwezig: ma, di, do en vr.
Wetenschapsfondsen@knav.nl
5.1.2e @knav.nl

From: 5.1.2e @wur.nl>
Sent: vrijdag 13 oktober 2023 20:54
To: KNAW wetenschapsfondsen <wetenschapsfondsen@knav.nl>
Subject: Dobberke application

Dear Sir/Madam,

Herewith, I would like to submit my application for the current Dobberke Fund round. All requested documents are merged into one PDF file.

Thank you for your consideration. I am Looking forward to your response.

With kind regards,

5.1.2e

5.1.2e

Assistant Professor / NWO-Veni Fellow
Editor *Animal Behaviour*
Zodiac building – room 5.1.2e
Behavioural Ecology Group
Wageningen University & Research
www.5.1.2e.com
www.BehaviouralEcology.nl

5.1.2e

Van: 5.1.2e
Verzonden: donderdag 11 juni 2026 14:12
Aan: 5.1.2e
Onderwerp: FW: yes! ravenonderzoek in nederland
Bijlagen: Dobberke_Research_plan.pdf

From: 5.1.2e @wur.nl>
Sent: dinsdag 20 februari 2024 11:23
To: 5.1.2e @nioz.nl>
Subject: RE: yes! ravenonderzoek in nederland

Hoi 5.1.2e,

Even snel tussendoor. Buiten reikwijdte

Ik denk dat het een heel leuk idee is om op de raven een Veni over te schrijven en hier op samen te werken. Zoals je begrijpt, lig ik er even uit maar toegevoegd mijn (kleine) Dobberke aanvraag (vertrouwelijk) op het onderwerp (geeft een beetje mijn interesse richting aan, e.g. social foraging en individual differences). Het project loopt al sinds 2021 (begonnen met focus op raaf-wolf relatie) en ik ben sinds ongeveer 1.5 jaar betrokken. Voor meer gedetailleerde info (en een leuk gesprek) raad ik aan om contact op te nemen met 5.1.2e (5.1.2e Ravenwerkgroep, heel enthousiast en kundig): 5.1.2e @ziggo.nl en daarnaast eventueel 5.1.2e (Ark Rewilding): 5.1.2e @ark.eu

Op het moment co-begeleid ik samen met 5.1.2e in onze groep een bijvakstudent die met de huidige GPS data aan de slag gaat dus 5.1.2e kan evt meer info geven over de technische details.

Groetjes,

5.1.2e

From: 5.1.2e @nioz.nl>
Sent: Tuesday, February 20, 2024 10:03 AM
To: 5.1.2e @wur.nl>
Subject: RE: yes! ravenonderzoek in nederland

O wat leuk! Gefeliciteerd. Het heeft geen haast, ik neem later nog wel een keer contact met je op.

Groeten, 5.1.2e

From: 5.1.2e @wur.nl>
Sent: Tuesday, 20 February 2024 10:00
To: 5.1.2e @nioz.nl>
Subject: Automatisch antwoord: yes! ravenonderzoek in nederland

Dear sender,

5.1.2e For urgent matters, please contact: office.bhe@wur.nl

With kind regards,

5.1.2e

5.1.2e

Van: 5.1.2e 5.1.2e^{5.1.2e}@ark.eu>
Verzonden: vrijdag 13 oktober 2023 11:17
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: RE: Subsidie projectmaterialen

Superfijn 5.1.2e Goed om de focus meer op (sociaal) ravengedrag te leggen als dat de kansen vergroot voor de aanvraag. En natuurlijk heel belangrijk om alle samenwerkende partners in de aanvraag te betrekken. En heel fijn dat je er vandaag (en eventueel dit weekend) nog de nodige uurtjes in wilt steken. Dank daarvoor!

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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6541 AH Nijmegen

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From: 5.1.2e @wur.nl>
Sent: Friday, October 13, 2023 11:09 AM
To: 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Ik ben een eindje gekomen maar heb vanmiddag nog nodig. Ik heb gisteren nog gesproken met iemand van de Dobberke stichting en die zei dat het belangrijk is dat het echt een apart project is. Dus ik probeer nog wat extra te benadrukken dat de oorspronkelijke focus de raaf-wolf samenwerking is/was maar dat we nu (ook) een andere kant op willen en hiervoor een grotere sample size voor nodig hebben.

Ik zal jullie cc' en in mijn email naar Dobberke. Heel misschien wordt het dit weekend. Als collaborators in het aanmeldformulier heb ik nu jullie twee, 5.1.2e en 5.1.2e staan.

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 13 October 2023 10:58
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hej 5.1.2e

Hoe ver ben je gisteren gekomen? Stuur jij de aanvraag uit naar Dobberke? En kunnen 5.1.2e en ik nog iets betekenen of even meelesen?

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e
Sent: Thursday, October 12, 2023 3:23 PM
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hej 5.1.2e

Hierbij de tabel waar ik mee bezig ben geweest voor de aanvraag. Het komt overeen met de tabel van 5.1.2e met iets andere informatie toegevoegd. Hopelijk helpt dit je. De tabel is in het Engels. Ik zal em ook op Google Drive zetten.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

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Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e
Sent: Thursday, October 12, 2023 1:56 PM
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hej 5.1.2e

De barometers hebben we sinds 2022. Dus let goed op in de tabel van 5.1.2e De zendernummers die beginnen met 21, hebben geen barometer.

Ik werk zelf ook nog even aan een tabel, waar dit in terug komt en zal je die vanmiddag toesturen.

Alle zenders hebben een accelerometer en thermometer. Bijgevoegd de gebruikshandleiding van de zenders.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e [wur.nl](mailto:5.1.2e@wur.nl)>
Sent: Thursday, October 12, 2023 1:48 PM
To: 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)>; 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)>
Subject: RE: Subsidie projectmaterialen

Yes, heb ik! Nog één vraagje: vanaf welk jaar hebben de zenders ook de barometers? Of meer algemeen, welke functionaliteiten hebben de zenders per aangebracht jaar? Accelerometer, thermometer, barometer?

Groet,
5.1.2e

From: 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)>
Sent: 12 October 2023 12:19
To: 5.1.2e [@wur.nl](mailto:5.1.2e@wur.nl)>; 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)>
Subject: RE: Subsidie projectmaterialen

Dankjewel!!

Als het goed is, heb je nu toegang. Je kunt ook deze link gebruiken →
5.1.2h

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e [@ark.eu](mailto:info@ark.eu)

Winselingseweg 95
6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?
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Weten wat we in 2022 allemaal gedaan hebben?
Klik op de cover van ons jaarverslag hieronder.



Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e @wur.nl>
Sent: Thursday, October 12, 2023 12:15 PM
To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Dank! Toegevoegd het overzicht wat ik van 5.1.2e heb. En ik snap helemaal dat de Drive gevoelige informatie bevat en ik zal deze niet delen.

Makkelijkst is mijn gmail: 5.1.2e @gmail.com

Groet,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 12 October 2023 12:10
To: 5.1.2e @wur.nl>; 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e

Zie geen bijlage, dus als je het overzicht van 5.1.2e nog wil delen, dan heel graag. 😊

Bijgevoegd alvast de thesis van 5.1.2e. Zij is bezig geweest met de ravenclusters analyseren en werd begeleid door 5.1.2e van WEC.

Ik zal je toegang geven tot onze Google Drive, waar je de meest belangrijke documenten kunt vinden, waaronder instructies van het Ornitela portaal (de video is te groot om als bijlage te sturen). Op onze Drive staan ook andere soms meer kwetsbare documenten en video's, welke niet zomaar met externen gedeeld kunnen worden. Zeker de video's van wolven niet; ik denk dat je wel begrijpt dat we voorzichtig moeten zijn met wat we met de buitenwereld delen. Het hele wolvengebeuren is zo'n hot topic met veel polarisatie in de media.

Misschien heb je ik je al eens gevraagd of je WUR-mailadres verbonden is aan Google, zo niet, dan bij deze de vraag. Of dat ik je beter via een privé/Gmail adres toegang kan geven. Laat maar even weten, en dan natuurlijk ook op welk mailadres. Dan regel ik dat je toegang op onze Drive krijgt.

Vriendelijke groet,

5.1.2e



Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
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From: 5.1.2e @wur.nl>
Sent: Thursday, October 12, 2023 11:57 AM
To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Ik zat in meetings de hele ochtend. Thanks! Ik ga er mee aan de slag! Ik heb van 5.1.2e een overzichtje gekregen van de gezenderde raven (zie toegevoegd) dus daar kan ik wel mee vooruit. Wel zou het fijn zijn als je me nog de instructies voor toegang tot Ornitela zou kunnen sturen en de thesis/report van de eerste student die met de clusters heeft gewerkt.

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 12 October 2023 09:38
To: 5.1.2e @wur.nl>; 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e

Heb jou zojuist per telefoon geprobeerd te bereiken, maar kreeg je niet te pakken.

Woensdag is mijn vrije dag, dus ik lees jouw e-mailtje zojuist pas. Onze huidige projectbeschrijving is wat knip- en plakwerk geweest uit het plan van het project Wolf: aasleverancier en aaseter. Zoals je begrijpt, is dat wat meer toegespitst op wolf. Omdat we deze aanvraag meer op ravengedrag focussen vroeg ik mij af hoe handig het is als ik nu veel tijd steek in het vertalen, als de focus toch meer op raaf gelegd gaat worden. Ik zal je onze huidige projectbeschrijving toesturen. Dan kun je daar de elementen uit halen die jij van belang acht voor deze aanvraag en dat wellicht direct om zetten naar het Engels.

Ondertussen zal ik een overzicht maken van de raven die gezenderd zijn en het gebruik van de zender, met ook een toelichting over de uitval van raven/zenders; ook een natuurlijk proces, denk aan predatie etc. Dat zal ik je zsm toesturen.

Bel mij deze ochtend anders nog even terug, zodat we de laatste dingen kunnen afstemmen. 5.1.2e is vandaag de hele dag bezet met een startevent van een Interreg project, dus niet bereikbaar.

Ohja, het lijkt mij prima om de startdatum naar januari te verplaatsen, zodat de funding dan op tijd binnen is.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e @wur.nl>

Sent: Wednesday, October 11, 2023 10:19 AM

To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>

Subject: RE: Subsidie projectmaterialen

PS ik zal de startdatum van april naar januari veranderen. Van feb-mei ben ik niet beschikbaar dus het is handiger om de funding al voor februari beschikbaar te hebben.

Groetjes,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: 11 October 2023 10:12
To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Het is erg kort dag en ik heb vrijdag ook een conferentie en het weekend geen tijd. Zou je de projectbeschrijving/plan en het budget uiterlijk eind van vandaag kunnen sturen? Dan kan ik er morgen nog mee aan de slag. Ook als het niet af is. Iets is beter dan niets. Ik kan dan wat achtergrond info die 5.1.2e en 5.1.2e en 5.1.2e al hebben verzameld erin verwerken. Vandaag zal ik dan aan het aanvraag formulier en de CV werken. Dobberke is fundamenteel onderzoek, dus goed om voornamelijk of ravengedrag te focussen en minder op wolven. Omdat we 'slechts' 5 zenders aanvragen is het goed om te vermelden hoeveel data er al is (hoeveel zenders zijn er al gebruikt, voor hoelang en welke data is hiervan beschikbaar).

Groet,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 10 October 2023 09:28
To: 5.1.2e @ark.eu>; 5.1.2e @wur.nl>
Subject: RE: Subsidie projectmaterialen

Hej 5.1.2e

5.1.2e liet al weten aan het aanvraagformulier voor de Dobberke subsidie gewerkt te hebben. Daar heb ik nog wat aanpassingen en aanvullingen aan gedaan. Bijgevoegd een concept van wat we nu hebben. Wil jij eens kijken of je de lege velden kunt invullen?

We zijn voornemens je de projectbeschrijving/-plan ook z.s.m. toe te sturen, maar daar moet nog een vertaalslag overheen.

Fijn als het aanvraagformulier in ieder geval alvast klaar ligt. De deadline is vóór 15 oktober, dus voor komende zondag.

Laten we proberen om alles komende vrijdag op te sturen. Ik hoop dat je deze week tijd hebt om de aanvraag door te lezen en evt. wat aanvullingen (o.a. referenties onderzoek) te doen.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

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From: 5.1.2e @ark.eu>
Sent: Thursday, October 5, 2023 2:39 PM
To: 5.1.2e @ark.eu>; 5.1.2e @wur.nl>
Subject: Re: Subsidie projectmaterialen

Hoi 5.1.2e
Proficiat met 5.1.2e ! Wat een fijn vooruitzicht om in het nieuwe jaar 5.1.2e
5.1.2e . Heerlijk om even helemaal in de bubbel te duiken!

Ik heb een start gemaakt met de application in te vullen. Daarbij leek het mij handig om de focus meer op de raaf te leggen. Met als voorlopige titel: Social behaviour of Ravens (Corvus corax) on the Veluwe: Foraging behaviour and collaboration with wolves (Canis lupus) as supplier of carrion

@5.1.2e de application staat op sharepoint. Aanvullend een summary van budget en start met description of the project. Dit laatste moet nog verder worden ingevuld, vertaald en references. Als je daarvoor kans ziet? Ik moet nu andere klussen gaan doen.

Groeten,

5.1.2e



ARK verlegt grenzen voor wilde natuur

5.1.2e

(vrijdag is mijn vrije dag)

M 5.1.2e
E 5.1.2e @ark.eu

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www.ark.eu / www.levenderivieren.nl / www.dooddoetleven.nl / www.wolveninnederland.nl

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From: 5.1.2e @ark.eu>
Sent: Monday, September 18, 2023 12:24 PM
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e

Dankjewel voor het voorbeeld. Dit geeft mij wel een beeld van wat Dobberke verwacht van ons, e.g. hoe uitgebreid etc. 😊

Hej, en van harte gefeliciteerd! 🎉🥳 Zeker goed om hier rekening mee te houden, want we zullen begin 2024 weer zenders moeten bestellen.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e [@ark.eu](mailto:info@ark.eu)

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From: 5.1.2e @wur.nl>
Sent: Wednesday, September 13, 2023 12:47 PM
To: 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

In aanvulling, misschien goed om rekening houden dat ik 5.1.2e plan te gaan 😊. Dit in relatie tot betalingen die uit het fund gedaan zouden moeten worden in die periode (mochten we de funding krijgen).

Groetjes,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: 13 September 2023 12:44
To: 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Toegevoegd een voorbeeld van een succesvolle Dobberke aanvraag (confidential). Ik heb de naam en CV even weggelaten.

Ik heb mijn leidinggevende gevraagd naar een voorbeeld voor Lucie Burgers maar hij heeft nog niet geantwoord. Hopelijk geeft het Dobberke voorbeeld een goede algemene indruk.

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 11 September 2023 09:59
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e

De laatste week van augustus heb ik zowel de Dobberke subsidie bekeken als die van Lucie Burgers.

Van **Dobberke** bleek al snel dat 15 augustus niet de openstelling van de subsidie-aanvraag was, maar juist de deadline. De volgende **deadline** voor het indienen van projectvoorstellen is op **15 oktober**. Voor **Lucie Burgers** is de volgende **deadline 30 november**.

Hele duidelijke richtlijnen voor een aanvraag voor Dobberke heb ik nog niet kunnen vinden. Heb jij wel eens iets ingediend bij Dobberke en ken jij de richtlijnen? Heb je misschien een voorbeeld van een aanvraag voor ons? En wellicht ook voor Lucie Burgers?

Ik hoor het graag van je!

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e
Sent: Monday, July 24, 2023 10:10 AM
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e

Oké, dan ga ik met 5.1.2e overleggen hoe we verder kunnen gaan met deze subsidieaanvraag.

Zelf werk ik deze week nog en daarna ben ik ook tweeënhalve week met vakantie. 5.1.2e is van 7 augustus t/m 27 augustus met vakantie.

Laten we eind augustus/begin september dan in ieder geval even contact hebben over hoe verder.

Fijne vakantie! 😊

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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Klik op de cover hieronder.



Kijk ook eens op onze website www.ark.eu

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From: 5.1.2e @wur.nl>
Sent: Friday, July 21, 2023 5:01 PM
To: 5.1.2e @ark.eu>

Cc: 5.1.2e [redacted]@ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e [redacted]

Dobberke zou kunnen en mogelijk Lucie Burgers Stichting. Ik ga vanmiddag voor 3 weken op vakantie en daarna volgt een drukke (onderwijs)periode.

Het lijkt mij het meest efficient, zoals eerder besproken, dat een student in samenwerking met jullie een opzetje maakt voor een onderzoeksplan (ong 2 pagina's) en een budget (wat willen jullie precies aanvragen (merk, type, gewicht, functies etc), hoeveel items en hoeveel kost het) en dat ik deze dan aanpas en aanvul naar behoefte van de funding agency. Jullie kennen het achtergrondverhaal van dit onderzoek, eerdere aanvragen over dit topic en jullie wensen voor de toekomst. Ik zou blanco moeten beginnen en dat is gewoon niet handig (en heb ik helaas geen tijd voor). Ik kan het bijvoorbeeld vertalen naar Engels, recente en relevante wetenschappelijke literatuur toevoegen en de wetenschappelijke innovatie toelichten. Ook moeten we bedenken hoe het met de financiën werkt als het geld bij mij terecht komt, want het lijkt me niet zo handig als dan alle logistiek voor de nieuwe materialen etc ook noodgedwongen via (alleen) mij gaat lopen.

Groetjes en een fijne zomer alvast!

5.1.2e [redacted]

From: 5.1.2e [redacted]@ark.eu>
Sent: 21 July 2023 13:04
To: 5.1.2e [redacted]@wur.nl>
Cc: 5.1.2e [redacted]@ark.eu>
Subject: RE: Subsidie projectmaterialen

Ha 5.1.2e [redacted]

Oké, ik twijfelde al af jij in aanmerking zou komen toen ik de tekst las. Dan is het van belang dat we op zoek gaan naar iets anders.

Ik zag ook het Dobberke fonds in het lijstje staan, <https://www.knaw.nl/en/funds-and-prizes/dobberke-grant>
Volgens mij is dat wel een goede optie, maar deze gaat al op 15 augustus open. En ik heb geen idee hoe snel we moeten indienen om kans te maken.

Een andere is het Betty Wiegman fonds, aanvragen moeten vóór 1 maart ingediend worden, zie <https://bettiewiegmanfonds.nl/aanvragen/>

Heb jij nog andere fondsen of subsidies op het oog om aan te schrijven?

Vriendelijke groet,

5.1.2e [redacted]



ARK Rewilding Nederland

Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e @wur.nl>
Sent: Friday, July 21, 2023 12:21 PM
To: 5.1.2e @ark.eu>
cc: 5.1.2e @ark.eu>
Subject: RE: Subsidie projectmaterialen

Hoi 5.1.2e

Hier hebben we het inderdaad over gehad en geconcludeert dat ik hier niet eligible voor ben. Alleen jonge wetenschappers (PhD studenten of mensen die niet langer dan 4 jaar geleden hun PhD hebben behaald) mogen m indienen.

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: 21 July 2023 11:56
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: Subsidie projectmaterialen

Ha 5.1.2e

Afgelopen dinsdag hebben 5.1.2e en ik even met ons Dood doet Leven team bij elkaar gezeten om te bekijken wat we dit jaar hebben bereikt en nog willen bereiken.

Een van de dingen die op de lijst staat is een subsidie aanvraag voor projectmaterialen voor het project Wolf: aasleverancier en aaseter.

Volgens mij hebben we het eerder gehad over het Academy Ecology Fund via KNAW dat aangevraagd kan worden via de WUR, zie <https://www.knaw.nl/en/funds-and-prizes/academy-ecology-fund>

Vanaf 14 oktober kunnen we hier een plan voor indienen. Zou jij daar een opzetje voor willen maken? 😊

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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Klik op de cover hieronder.



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From: 5.1.2e
To: 5.1.2e
Subject: FW: ter check: artikelte Resource
Date: donderdag 11 juni 2026 14:11:50
Attachments: [Raven_nwsbrf WUR_red 5.1.2e opm 5.1.2e.docx](#)

From: 5.1.2e @wur.nl>
Sent: donderdag 1 februari 2024 12:58
To: 5.1.2e @wur.nl>
Cc: 5.1.2e @ziggo.nl>
Subject: RE: ter check: artikelte Resource

Hoi 5.1.2e

Bij deze (ook met aanvulling van 5.1.2e 5.1.2e vroeg verder nog of hij een Word of PDF van de uiteindelijke versie kon krijgen en of hij het kan delen op de website van de Ravenwerkgroep?

Groetjes,

5.1.2e

From: 5.1.2e @wur.nl>
Sent: Wednesday, January 31, 2024 5:23 PM
To: 5.1.2e @wur.nl>
Subject: ter check: artikelte Resource

Dag 5.1.2e

Dat duurde wat langer dan ik had verwacht, excuus daarvoor (er kwamen een paar dingen tussen). Maar hierbij ter check het artikelte voor Resource over de Dobberke beurs voor je onderzoek.

Ik ben dichtbij jouw oorspronkelijke formuleringen gebleven, dus als het goed is staan er geen gekke dingen in. Maar wil je niettemin goed checken of alles inhoudelijk correct is?

De foto's van 5.1.2e heb ik in goede orde ontvangen. En ik leg contact met hem om aangehaakt te blijven om in april/mei voor een repo mee te gaan met zenderen - dank voor je bemiddeling.

Lukt het je om uiterlijk maandag 14 uur te reageren?

Alvast dank!

5.1.2e ,
redactie Resource
5.1.2e

werkdagen: ma, di, wo

Universiteitsmagazine van Wageningen University & Research

Volg ons via [Instagram](#), [Twitter](#), [Facebook](#) en [LinkedIn](#)

Raven-onderzoek verbreed dankzij beurs

5.1.2e, onderzoeker bij de leerstoelgroep gedragsecologie (Animal Sciences), heeft een zogenoemde Dobberke Beurs ontvangen. Daarmee kan ze vijf extra zenders bekostigen voor haar onderzoek naar raven, wat een substantiële uitbreiding betekent van de dataset rond het gedrag van deze ooit vrijwel uit Nederland verdwenen vogelsoort.

5.1.2e doet onderzoek naar voedselstrategieën van raven op de Veluwe. Daartoe werkt ze nauw samen met stichting ARK Natuurontwikkeling, Ravenwerkgroep Nederland en Sovon Vogelonderzoek. Deze organisaties voorzien al sinds 2021 jonge raven van kleine gps-zendertjes. Aanvankelijk waren die bedoeld om te kunnen volgen of raven profiteren van de in Nederland terugkerende wolf als aasleverancier. Maar de zendertjes bleken veel meer interessante informatie op te leveren.

Zo bleek bijvoorbeeld dat de vogels niet alleen bij karkassen foerageren, maar dat een aantal raven ook veel gebruikmaakt van voedselbronnen van menselijke oorsprong, zoals afvalbakken bij fastfoodrestaurants of de vuilstort – en dat zelfs op de Veluwe, waar het natuurlijke voedselaanbod relatief groot is. Dat heeft zowel te maken met de Veluwse wolvenroedels die aas achterlaten, als met het feit dat aangereden wild (zogenaamd ‘valwild’) er regelmatig wordt teruggebracht [in de kringloop](#), vertelt **5.1.2e**

Neofob

In zo’n omgeving met relatief veel natuurlijke voedselaanbod is de hang naar menselijke voedselbronnen extra opmerkelijk, want raven zijn van nature neofob: bang van nieuwe dingen. **5.1.2e** ‘Dat is een interessant aspect: dat je ontdekt dat een dier dat eigenlijk heel schuw is toch dit gedrag laat zien. Blijkbaar hebben ze geleerd dat het niet onveilig hoeft te zijn. Maar hoe: uit de interactie met de omgeving, door imitatie van soortgenoten?’

De voedselvoorkeuren van raven riepen dus veel nieuwe vragen op. Waarom is de ene raaf beduidend vaker te vinden bij een menselijke voedselbron dan de andere? Hoe maken ze zich die foerageerstrategie eigen? Kijken ze dat af van hun ouders, of is de manier van voedselzoeken in de ‘jeugdsoos’ waarin jongvolwassen raven zich verzamelen doorslaggevend? En blijft die individuele voorkeur bestaan in de loop der tijd? Of wordt hun voedselstrategie opportunistischer als ze eenmaal als volwassen dier een eigen territorium hebben – eten ze dan vooral ‘wat de pot schaft’? En varieert dat nog per sekse?

Sample size

Voor meer inzicht in deze mechanismen is een grotere *sample size* van grote waarde. Op dit moment zijn er op de Veluwe 21 raven gezenderd waarvan zeker acht nog met een werkende zender (inclusief twee al vanaf 2021). Dankzij de beurs kan **5.1.2e** het totaal uitbreiden met in ieder geval vijf, een uitbreiding van 25 procent, om raven te zenderen uit verschillende nesten op verschillende plekken op de Veluwe. Dat gebeurt komend broedseizoen al, door gespecialiseerde vrijwilligers van Ravenwerkgroep Nederland.

De zendertjes (< 3% lichaamsgewicht) worden met bijbehorende minuscule batterij en zonnecel (voor de stroomvoorziening van het datatransport) met een soort 'harnasje' bevestigd aan een jonge raaf, terwijl het dier nog (niet vliegvlug) in het nest zit. Ze zijn dan 5-6 weken oud. De vogel leert er dus van jongs af aan mee vliegen en omgaan. Gelijktijdig met het zenderen worden nekveertjes afgenomen waaruit later DNA-materiaal wordt geïsoleerd, zodat geslachtsbepaling mogelijk is. 'Op basis van uiterlijke kenmerken is dat bij (jonge) raven niet vast te stellen. Terwijl het natuurlijk heel interessant is om te weten of mannelijke of vrouwelijke dieren zich anders ontwikkelen en misschien wel ander (foerageer)gedrag vertonen', aldus **5.1.2e**

Geduld

De data uit de zenders zijn in principe vrijwel realtime beschikbaar, afhankelijk van de tijd van het jaar. 'Midwinter genereert de zonnecel maar weinig energie en is het batterijniveau heel laag. Dan daalt automatisch de frequentie van wanneer je een update krijgt', legt **5.1.2e** uit. Het duurt nog wel even voordat de nieuwe zenders tot bruikbare inzichten leiden, waarschuwt ze. 'We zijn ongeveer een half jaar verder voordat de gezenderde jonge raven individuele gedragingen laten zien. Raven verlaten pas na ongeveer drie maanden de familie. Maar die eerste data geven straks al wel de eerste aanzet van: oké, wat voor typeanalyses kunnen we gaan doen?'

Over nut en noodzaak van dit onderzoek – 'je gaat natuurlijk niet zómaar vogels zenderen', benadrukt ze – heeft **5.1.2e** een duidelijke opvatting: 'Fundamenteel gezien is het heel interessant om te doorgronden hoe sociale processen werken rond het vinden van voedsel. En meer op het toegepaste vlak is het relevant om te begrijpen hoe we onze sterk door mensen gedomineerde leefomgeving beter geschikt kunnen maken voor deze en andere dieren.'

[kader – 72 woorden]

Vier keer raak

De [Dobberke Beurs](#) is een door de KNAW gecoördineerde beurs voor onderzoek naar diergedrag. Naast die van **5.1.2e** werden in de ronde van dit jaar nog drie andere Wageningse aanvragen gehonoreerd:

- **5.1.2e** : Can a conspicuous predator camouflage through background matching?
- **5.1.2e** : Unravelling the diet of multiple shorebird species in a threatened ecosystem using DNA-Metabarcoding.
- **5.1.2e** : Coping strategies: understanding how individuals respond to uncertainty.

5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: maandag 20 maart 2023 10:47
Aan: 5.1.2e @hvh.nl
Onderwerp: RE: Ethogram in Agouti en Boris

Ha 5.1.2e

Oké, geen probleem dan spreken we elkaar online. Ik zal jullie zo een agenda-uitnodiging sturen voor teams. We kunnen dan ook met beeld delen tijdens het overleg. 😊

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

Ons nieuwe meerjarenplan al gezien?
Klik op de cover hieronder.



Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e [redacted]@wur.nl>
Sent: Monday, March 20, 2023 8:44 AM
To: 5.1.2e [redacted]@ark.eu>; 5.1.2e [redacted]@gmail.com>; 5.1.2e [redacted]@hvhl.nl
Subject: RE: Ethogram in Agouti en Boris

Hoi allen,

Ik kan vandaag enkel online afspreken. 15:30 kan.

Groetjes,
5.1.2e [redacted]

From: 5.1.2e [redacted]@ark.eu>
Sent: 19 March 2023 21:54
To: 5.1.2e [redacted]@wur.nl>; 5.1.2e [redacted]@gmail.com>;
5.1.2e [redacted]@hvhl.nl
Subject: RE: Ethogram in Agouti en Boris

Hej, excuus voor mijn late bericht.

Morgenmiddag zou ik kunnen! Zullen we om 15:30 afspreken op de WUR?

5.1.2e [redacted] zou jij ons op het Zodiac kunnen ontvangen? Bijgevoegd een document met ideeën voor ethogram in Agouti en Boris.

Vriendelijke groet,

5.1.2e [redacted]



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e [redacted]
E 5.1.2e [redacted]@ark.eu

Winselingseweg 95
6541 AH Nijmegen

Ons nieuwe meerjarenplan al gezien?
Klik op de cover hieronder.



Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e @wur.nl>
Sent: Monday, March 13, 2023 4:27 PM
To: 5.1.2e @gmail.com>; 5.1.2e @ark.eu> 5.1.2e @hvh.nl
Cc: 5.1.2e @ark.eu>
Subject: RE: Ethogram in Agouti en Boris

Hoi allen,

Maandagmiddag de 20^e (12:30-13:30 of 15:30-17:30)

Dinsdagochtend de 21^e (na 11:00 en voor 12:15)

Dinsdagmiddag de 21^e (na 15:30)

Donderdagmiddag de 23^e (voor 15:00)

Groetjes,

5.1.2e

From: 5.1.2e @gmail.com>
Sent: 13 March 2023 14:55
To: 5.1.2e @ark.eu> 5.1.2e @hvh.nl; 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: Re: Ethogram in Agouti en Boris

Hi allen,

Lijkt me helemaal goed om dit even samen te doorlopen. Maandagmiddag de 20e komt voor mij het beste uit, dan kan ik ook naar kantoor komen. Dinsdagochtend de 21e of donderdagmiddag de 23e zou ik ook kunnen, maar dan alleen online.

Groeten,

5.1.2e

Op ma 13 mrt. 2023 14:06 schreef 5.1.2e @ark.eu>:

Ha allen,

Zojuist met 5.1.2e even naar Agouti gekeken en het ethogram dat we daar in gebruik willen nemen voor annotatie van de foto's.

Videobeelden willen we in Boris gaan annoteren en het leek ons fijn om een keer met z'n allen af te spreken om te bekijken hoe we de gedragingen in Boris (en ook in Agouti) willen zetten

→ denk aan gebruik van point en state events in Boris & de manier van foto's annoteren in Agouti (alleen point events?).

5.1.2e het lijkt ons fijn om hier eens samen naar te kijken. Kun jij met ons afspreken op een van de volgende dagen? 5.1.2e wellicht kunnen we het dan combineren met het bekijken van het Ornitela portaal)

Maandagmiddag de 20^e

Dinsdagochtend de 21^e

Dinsdagmiddag de 21^e

Donderdagmiddag de 23^e

5.1.2e en 5.1.2e wanneer kunnen jullie?

Vriendelijke groet,

5.1.2e

ARK Rewilding Nederland

Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)

Winselingseweg 95
6541 AH Nijmegen

Ons nieuwe meerjarenplan al gezien?

Klik op de cover hieronder.

Kijk ook eens op onze website www.ark.eu

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.

Ethogram DDL Veluwe – concept

- o Beelden zonder kadaver -> niet annoteren, tenzij wolf of raaf in beeld
 - Wel een **kadaveroverzicht** bijhouden
 - Kadavertype: Valwild, afschot, prooidier (wolvenprooi -> bevestigd met DNA ja/nee)
 - Degene die beelden uploadt, noteert in gedeeld Excel bestand: datum dat kadaver neergelegd wordt - diersoort kadaver - open/gesloten - (# loodje - alleen voor valwild – kan gebruikt worden als valwild identificatienummer) - datum dat kadaver volledig ontbonden is
 - Beelden met bewegende vegetatie & mensen -> annoteren als blanco? **(Of in cameralogboek bijhouden waar welke camera staat en wanneer deze draait)**
- o Excel draaitijd camera's **(bijhouden in cameralogboek)**
 - Datum van onderhoud
 - Startdatum (eerste opname sd-kaartje) - einddatum (laatste opname sd-kaartje)
 - o Steeds zelfde format datum gebruiken
- o Noteren ontbindingsstadia -> **hoe willen we dit doen?**
 - Bij alle beelden noteren?! Of wanneer het ene ontbindingsstadium over gaat in het volgende stadium? Lukt het om bij foto's en video's onderscheidt te maken tussen de vijf onderstaande ontbindingsstadia? Of alleen onderscheidt maken tussen **bloated (A), active (B) and advanced decay (C)**

State of decay	Explanation
Fresh	No visible decay, closed carcass with no bloating
Bloated	Closed carcass in which bacteria have produced gasses trapped inside, bloating the torso/limbs
Active decay	Blowflies lay eggs in orifices and open wounds, skin is blackening
Advanced decay	Most remains are blackened, not much tissue left
Dry remains	Dry skeleton remains with little to no other tissue

- o Gedragingen (alleen voor wolf (en raaf) annoteren?! Of ook voor andere aaseters?!)
 - Passeren
 - Interesse tonen in kadaver
 - ~~Ruiken aan kadaver (direct aan kadaver ruiken)~~
 - Op het kadaver staan **(gaat om vogels – tegelijkertijd interesse tonen en eten kan niet)**
 - Eten van het kadaver (met bek/snavel kadaver aanraken - met kauwende/pikkende bewegingen) → **alleen voor wolf (en raaf) onderscheid maken tussen weefseltypes? – hierbij moeten altijd een of twee weefseltypes gekozen worden**
 - Botten/hoeven
 - Haren (zie ook verzamelen materiaal voor vogels)
 - Weke delen (neus, oren, ogen, anus, huid (oksels en buik)
 - Huid op andere delen van het lichaam
 - Spierweefsel
 - Organen
 - Insecten (indirect)
 - Onbekend
 - Verzamelen van materiaal
 - Kadaver (deels) verplaatsen/meenemen
 - Caching → vlees meenemen → alleen zeker door observatie in het veld
 - Haar verzamelen (zangvogels nestmateriaal)
 - Markeren (wolf, vos, andere roofdieren?)

- Intraspecific (annoteren voor deelnemende diersoorten)
- Interspecific (annoteren voor de verschillende diersoorten)
- Notities – bijzonderheden

Ethogram

First behavioural element = behaviour that scavenger shows the longest.

Second behavioural element = behaviour that scavenger shows the second longest.

Behaviour	Abbreviation	Description	Notes	Examples
Passing	PAS	Move in front of camera trap without moving body and/or head in the direction of the carcass.	Hardly ever combined with other behaviour.	European hare Beech marten Roe deer
Interest	INT	Body and/or head moves towards the carcass, or mouth/beak touches the carcass without any chewing/picking movements.	There is a targeted action to explore the carcass.	Wild boar Beech marten Wild boar
Eating	EAT	Mouth/beak touches the carcass, and removing carcass parts by chewing/picking movements.	Automatically, one or two "tissues" must be indicated.	Carion crow Wild boar Beech marten
Standing on carcass	STA	Touching the carcass with legs only, i.e. no other body parts than legs touch the carcass.	This is excluding EAT or INT on top of the carcass.	Buzzard Buzzard
Intraspecific interaction	INTRA	Physical and non-physical contact between individuals of the same species.	Only possible if 2 or more individuals are in front of the camera trap.	Wild boar
Interspecific interaction	INTER	Physical and non-physical contact between individuals of the different species.	The video should be annotated twice (i.e. for both species separately). INTRA must be noted for both species.	Red fox / carion crow
Collecting material	CM	Taking along carcass parts in the direct vicinity of the carcass.	Annotate as EAT when carcass parts are not visible at the moment the animal leaves. Automatically, one or two "tissues" must be indicated.	

Tissue types

First tissue = behaviour that scavenger shows the longest.

Second tissue = behaviour that scavenger shows the second longest.

Tissue type	Examples
Bones, hooves	Wild boar (sec: 33 – 42) Beech marten
Hairs	Great tit (sec: 24 – 28)
Nose, ears, eyes, anus, skin (armpits, abdominal region)	Raven (sec: 25 – 60) Beech marten (sec: 12 – 27) Carion Crow (sec: 20 – 60)
Skin on other parts of the body	Fox (sec: 23 – 40) Beech marten (sec: 13 – 60) Beech marten
Muscle tissue	Wild boar (sec: 9 – 25) Buzzard (whole video) Buzzard
Organs	Buzzard (whole video) Beech marten (whole video) Buzzard
Insects and larvae that are present on the carcass (Indirect)	European hedgehog

Stages of decomposition

Stage of decomposition	Description	Notes	Examples
Bloated stage (A)	Carcass has no or minor injuries that do not expose any entrails (e.g. abrasions, broken bones).	Anaerobic microbial activity may cause abdominal bloating (i.e. expanding of the abdomen due to gas-forming).	Raven Wild boar
Open stage: active decay (B)	Carcass' skin has ripped open, exposing some entrails.	Rapid mass and volume loss due to increased scavenger activity, fluid loss and aerobic microbial activity.	Raven Beech marten Buzzard
Open stage: advanced decay (C)	Period of rapid mass and volume loss around the abdomen has finished, leftovers remain.	The abdomen looks flat, (parts of) the skin and skeleton are still present, possibly supplemented by some other tissue leftovers.	Domestic dog Grey heron

(A) Bloated stage



(B) Open stage: active decay



(C) Open stage: advanced decay



From: 5.1.2e
To: 5.1.2e
Subject: FW: BTW factuur buitenland
Date: dinsdag 23 januari 2024 14:42:00
Attachments: [image001.png](#)
[Ornitela Invoice ORN Nr 23183.pdf](#)

Hoi 5.1.2e,

Ik heb een kleine grant (Dobberke stichting) om in samenwerking met ARK Natuurontwikkeling GPS zenders te kopen voor het volgen van raven op de Veluwe. Voorheen kocht ARK dit via eigen funding direct bij de supplier (Ornitela, Letland, <https://www.ornitela.com/pricing>) en betaalde 0% VAT (zie voorbeeld factuur).

Nu is de vraag of het belastingtechnisch handiger is om ARK weer de bestelling te laten doen en dat wij dan ARK betalen of dat wij direct de bestelling doen. Heb jij hier inzicht in? De Dobberke funding die ik heb gekregen heeft een budget voor 5 GPS zenders (1090 per stuk) + 75 euro (totaal 5525 euro) maar zonder VAT. Dus misschien dat we er dan maar 4 kunnen bestellen of als we het via ARK laten bestellen dat zij het aan ons voor een lagere prijs doorberekenen (kan dat?).

Bij voorbaat dank!

5.1.2e

PS ik kom uiterlijk volgende week terug op het Veni eindverslag

From: 5.1.2e @wur.nl>
Sent: 07 December 2023 14:18
To: 5.1.2e @wur.nl>
Subject: RE: BTW factuur buitenland

Hoi 5.1.2e,

5.1.2e geeft aan dat we voor de details bij de business controllers moeten zijn, dit zou in ons geval 5.1.2e zijn.
Ze geeft aan het per project verschilt en dat algemene projecten 35% belast zijn. Dan zouden we met een doorberekening van 21% vanuit ARK dus goedkoper uit zijn.
Ik vraag mij wel af of ARK hier ook niet alsnog BTW over moet betalen, maar dat is natuurlijk ook hun verantwoordelijkheid. We kunnen dit ook aan 5.1.2e voorleggen als je het helemaal wilt begrijpen en de beste keuze wilt maken.

Groet, 5.1.2e

From: 5.1.2e @wur.nl>
Sent: Thursday, December 7, 2023 12:00 PM
To: 5.1.2e @wur.nl>
Subject: RE: BTW factuur buitenland

Hoi 5.1.2e

Is het dan goedkoper om het via Ark te doen of maakt het dan eigenlijk niet uit? Is de BTW die wij voor een buitenlandse bestelling zouden betalen meestal hoger?

Groetjes,
5.1.2e

From: 5.1.2e [redacted] <[redacted]@wur.nl>
Sent: 07 December 2023 11:36
To: 5.1.2e [redacted] <[redacted]@wur.nl>
Subject: FW: BTW factuur buitenland

Ter info over de BTW.
Als ARK helemaal geen BTW betaald over goederen uit het buitenland, zouden zij het kunnen bestellen.
Echter kopen wij het dan in via hen, waardoor het in NL met 21% belast wordt, zou ik zeggen.
Er moet dan in ieder geval wel BTW op de factuur komen te staan.

Ik hoop dat dit een beetje helpt. Laat maar weten als ik iets kan doen.

Groet, 5.1.2e [redacted]

From: 5.1.2e [redacted] <[redacted]@wur.nl>
Sent: Thursday, December 7, 2023 7:42 AM
To: 5.1.2e [redacted] <[redacted]@wur.nl>
Subject: RE: BTW factuur buitenland

Goedemorgen 5.1.2e [redacted]

In principe zou deze vragen bij de businesscontrollers neergelegd moeten worden. Zij kunnen de projectleiders dan verder helpen.

Maar in het kort komt het hier op neer:

Op de meeste facturen buiten de Nederland moeten wij ook BTW berekenen. Het ligt aan de TR hoe het project belast wordt. Er zijn projecten volledig belast, of volledig onbelast. Algemene projecten zijn meestal belast voor 35%.

Met vriendelijke groet,

5.1.2e [redacted]

Van: Crediteuren ASG <crediteuren.asg@wur.nl>
Verzonden: woensdag 6 december 2023 18:32
Aan: 5.1.2e [redacted] <[redacted]@wur.nl>
Onderwerp: FW: BTW factuur buitenland

Hoi 5.1.2e [redacted]

Wil jij 5.1.2e [redacted] de onderstaande mail beantwoorden?
Dank je wel.

Groetjes,
5.1.2e [redacted]

Van: BHE, Office <office.bhe@wur.nl>
Verzonden: woensdag 6 december 2023 14:30
Aan: Crediteuren ASG <crediteuren.asg@wur.nl>
Onderwerp: BTW factuur buitenland

Beste collega,

Op facturen van bestellingen in het buitenland staat geen BTW, zowel binnen EU als daarbuiten.

Wordt er toch nog BTW uiteindelijk afgedragen? En zo ja, komt dit ten laste van het project waar het product op gekocht is of is BTW centraal geregeld? En hoeveel BTW is dit dan?

Ik krijg hier veel vragen over binnen onze groep, omdat er veel samenwerkingen zijn in het buitenland en ook sommige materialen alleen in het buitenland verkrijgbaar zijn.

Projectleiders willen dit graag weten, zodat ze hun budget juist kunnen besteden binnen het project.

Ik hoor graag van je.

Met vriendelijke groet,

5.1.2e

5.1.2e

Behavioural Ecology Group
Wageningen University & Research



Zodiac, Building 122, Room 5.1.2e

De Elst 1, 6708 WD Wageningen

[Behavioural Ecology Group - WUR](#)

5.1.2e



PVM sąskaita-faktūra - Invoice

ORN Nr. 24238

2024-04-18

Pardavėjas <i>Seller</i>	
"Ornitela", UAB	
Adresas <i>Address</i>	
Švitrigailos g. 11K-109 Vilnius LT-03228 Lithuania	
Tel.: 5.1.2e E-mail: info@ornitela.eu	
Įmonės kodas <i>Company number</i>	304162369
PVM mokėtojo kodas <i>VAT number</i>	LT100009901714
Bankas <i>Bank</i>	"Swedbank", AB; SWIFT code HABALT22
Banko adresas <i>Bank address</i>	Konstitucijos pr. 20A, Vilnius LT-03502, Lithuania
Sąskaita (IBAN) <i>Account number (IBAN)</i>	LT637300010145513569

Pirkėjas <i>Buyer</i>	
ARK Rewilding Nederland	
Adresas <i>Address</i>	
Winselingseweg 95 6541 AH Nijmegen The Netherlands Attn: 5.1.2e Tel.: 5.1.2e E-mail: 5.1.2e@ark.eu	
Įmonės kodas <i>Company number</i>	
PVM mokėtojo kodas <i>VAT number</i>	NL 8136.69.807.B01
Bankas <i>Bank</i>	
Banko adresas <i>Bank address</i>	
Sąskaita <i>Account number</i>	

Apmokėjimo sąlygos <i>Payment terms</i>	Payment via bank transfer is due within 15 days of the delivery of goods; Each transmitter has a balance of 180 Eur of data transfer fees
Pastabos <i>Comments</i>	Transmitter warranty period – 12 months; Serial numbers: 243672–243676

Nr. No.	Pavadinimas Description	Mat. vnt. Meds. unit.	Kiekis Quantity	Kaina Price Eur	Suma (be PVM) Total (excl. VAT) Eur	PVM tarifas VAT tariff %	PVM suma Total VAT Eur	Suma Total Eur
1	OrniTrack-E25B 4G transmitter OrniTrack-E25B 4G siųstuvas	Piece	5	1090.00	5450.00	0	0.00	5450.00
2	Insured shipping & handling Apdrausta siuntimo išlaidos	–	1	85.00	85.00	0	0.00	85.00

Prekės yra apmokestinamos taikant 0 % PVM tarifą pagal PVMĮ 49 str. 1 d. "Prekių tiekimas į ES valstybę narę"

Suma žodžiais: Penki tūkstančiai penki šimtai trisdešimt penki Eur 00 ct.
Amount due in words: Five thousand five hundred thirty five Eur 00 ct.

Viso be PVM, Eur Sub-total excl. VAT, Eur	5535.00
Viso PVM, Eur Total VAT, Eur	0.00
Galutinė suma, Eur Grand total, Eur	5535.00

Sąskaitą išrašė:
Invoice issued by:

5.1.2e

Direct

5.1.2e

5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: dinsdag 14 mei 2024 16:59
Aan: BHE, Office; 5.1.2e
CC: 5.1.2e
Onderwerp: Fw: Fw: OrniTrack-E25 4G black housing for raven project Netherlands
Bijlagen: Ornitela_Invoice_ORN_Nr_24238.pdf

Goedendag,
De zenders zijn door Ornitela geleverd. Factuur is door ARK betaald.
Kunnen we zoals hieronder is besproken een factuur sturen? welke gegevens zijn hiervoor van belang?

Met vriendelijke groet,

5.1.2e



ARK verlegt grenzen voor wilde natuur

5.1.2e

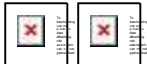
(vrijdag is mijn vrije dag)

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

www.ark.eu / www.levenderivieren.nl / www.dooddoetleven.nl / www.wolveninnederland.nl

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: BHE, Office <office.bhe@wur.nl>
Sent: 26 January 2024 13:22
To: 5.1.2e @wur.nl>
Subject: RE: BTW factuur buitenland

Hoi 5.1.2e

De betalingen worden normaalgesproken een keer per maand gedaan geloof ik, dus op het moment dat de facturen en/of formulieren ingeleverd zijn zou dit in principe binnen 30 dagen moeten zijn.

Groeten,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: 25 January 2024 13:06
To: BHE, Office <office.bhe@wur.nl>
Subject: FW: BTW factuur buitenland

From: 5.1.2e @wur.nl>
Sent: Thursday, January 25, 2024 1:05:54 PM (UTC+01:00) Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna
To: 5.1.2e @wur.nl>
Subject: FW: BTW factuur buitenland
Hoi 5.1.2e /Office

Om op de hoogte te blijven. Het lijkt erop dat ARK gaat bestellen (maar ze moeten nog even checken of ze het bedrag vooruit kunnen/mogen betalen). **Hoe snel kunnen wij ARK (terug) betalen nadat zij de bestelling geplaatst hebben?**

Het idee is dus dat wij dan ARK weer betalen op een manier dat het op 5525 euro gaat uitkomen (incl VAT). Dus dat ze evt 4 vd 5 zenders aan ons doorbereken (incl service kosten).

Ik vermoed dat de bestelling pas gaat lopen wanneer ik al weg ben.

Groetjes,
5.1.2e



ARK verlegt grenzen voor wilde natuur

5.1.2e

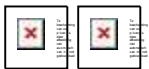
(vrijdag is mijn vrije dag)

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

www.ark.eu / www.levenderivieren.nl / www.dooddoetleven.nl / www.wolveninnederland.nl

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From: 5.1.2e @ornitela.eu>
Sent: Monday, April 22, 2024 10:17 AM

To: 5.1.2e [REDACTED]@ark.eu>

Subject: Re: Fw: OrniTrack-E25 4G black housing for raven project Netherlands

Dear 5.1.2e [REDACTED]

this is to let you know that the transmitters you have ordered, were shipped on April 18, 2024 via FedEx courier service. FedEx tracking number - 776007824730.

I have been informed by FedEx that they attempted to deliver the package, but failed to do so. Please contact your local Fedex office citing the above tracking number if the package is not delivered today.

Attached please find the cover letter and final invoice for this shipment as well as the transmitter user manual.

Let me know if you have any questions.

Best regards,

5.1.2e [REDACTED]

On Wed, 10 Apr 2024 09:58:59 +0300, 5.1.2e [REDACTED]@ark.eu> wrote:



5.1.2e [REDACTED] reacted to your message:

From: 5.1.2e [REDACTED]@ornitela.eu>

Sent: Tuesday, April 9, 2024 10:38:01 PM

To: 5.1.2e [REDACTED]@ark.eu>

Cc: 5.1.2e [REDACTED]@ark.eu>

Subject: Re: Fw: OrniTrack-E25 4G black housing for raven project Netherlands

Dear 5.1.2e [REDACTED]

according to our production logs, your transmitters should be ready for shipping on 16-17 of April. So hopefully they will be delivered by the end of the next week.

Best regards,

5.1.2e [REDACTED]

From: 5.1.2e
To: 5.1.2e
Subject: Fw: Landelijke dag SOVON 2025
Date: dinsdag 14 juli 2026 14:22:14
Attachments: [image001.png](#)
[image002.png](#)
[image003.png](#)
[image004.png](#)
[image005.png](#)

Verzonden vanaf [Outlook voor Android](#)

From: 5.1.2e @wur.nl>
Sent: Monday, 09 February 2026 17:25:53
To: 5.1.2e @ark.eu>; 5.1.2e @ziggo.nl>;
5.1.2e @ark.eu>; 5.1.2e @sovon.nl>; 5.1.2e
@sovon.nl>; 5.1.2e @outlook.com>
Subject: RE: Landelijke dag SOVON 2025

Heel fijn om te lezen!! Nogmaals, mooi gedaan, 5.1.2e

From: 5.1.2e @ark.eu>
Sent: maandag 9 februari 2026 17:16
To: 5.1.2e @ziggo.nl>; 5.1.2e @ark.eu>;
5.1.2e @sovon.nl>; 5.1.2e @sovon.nl>; 5.1.2e
@wur.nl>; 5.1.2e @outlook.com>
Subject: FW: Landelijke dag SOVON 2025

Ter info: heb positief bericht terug van 5.1.2e zie hieronder.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e [redacted]@gmail.com>

Date: Sunday, 8 February 2026 at 22:54

To: 5.1.2e [redacted]@ark.eu>

Subject: Re: Landelijke dag SOVON 2025

Geachte mevrouw 5.1.2e,

Hartelijk dank voor uw reactie. Ik heb veel respect en bewondering voor de zeer zorgvuldige en uitgebreide wijze waarop u bent ingegaan op mijn vragen en zorgen. Op basis van uw reactie is mijn conclusie dat dierenwelzijn bij u in goede handen is en op de juiste wijze verweven is met uw professionele beroepshouding. Ik wens u alle goeds toe met uw interessante onderzoeken.

Met vriendelijke groet,

5.1.2e

Op vr 30 jan. 2026 12:08 schreef 5.1.2e @ark.eu>:

Beste meneer 5.1.2e

Via ARK Rewilding Nederland is uw e-mail bij mij terechtgekomen naar aanleiding van mijn presentatie op de SOVON-dag op zaterdag 29 november. Dank voor uw bericht en voor het delen van uw zorgen en vragen. Uw betrokkenheid bij vogels en dierenwelzijn is duidelijk en waardeer ik zeer.

Uw e-mail bereikte mij net voor de kerstvakantie. Door vakantie en aansluitend gedeeltelijke ziekte, en omdat ik in diezelfde periode betrokken was bij een symposium over het belang van dode dieren in de natuur, is het mij helaas niet eerder gelukt om te reageren. Ik wilde hier echter graag de tijd voor nemen, om recht te doen aan uw zorgen en uw vragen zorgvuldig en inhoudelijk te beantwoorden.

Graag ga ik hieronder in op de opmerkingen en vragen die betrekking hebben op het zenderonderzoek bij raven, zoals besproken in mijn lezing 'Een wildere Veluwe met wolf en raaf'. De overige vragen over andere lezingen en publicaties laat ik graag aan SOVON en de betreffende medewerkers.

Allereerst wil ik een persoonlijke noot toevoegen. Ook ik heb in het begin van dit onderzoek kritische vragen gehad bij het zenderen van raven. Het feit dat dieren een zender de rest van hun leven met zich meedragen – ook nadat deze niet meer functioneert – is geen beslissing die je lichtvaardig neemt. Dit is een ethische afweging geweest waar ik persoonlijk vooral in het eerste jaar van het onderzoek mee heb geworsteld. Juist omdat dit mij zo bezighield, heb ik dierenwelzijn steeds als een zeer belangrijke randvoorwaarde gezien. De raven zijn vanaf het begin nauwlettend gevolgd, zowel in het eerste jaar als in de jaren daarna.

Na het eerste jaar is het zenderproject geëvalueerd. Daarbij konden we concluderen dat de raven geen aantoonbare hinder ondervonden van de zenders. Op basis daarvan is besloten het onderzoek voort te zetten. Het onderzoek is uitgevoerd in samenwerking met SOVON, de Ravenwerkgroep en Wageningen Universiteit. In 2024 is bij Wageningen Universiteit een survivalanalyse uitgevoerd, waarbij de overleving van gezenderde raven is vergeleken met die van niet-gezenderde raven. Daarbij is geen verschil in overleving aangetoond.

Het is goed om hierbij te vermelden dat ongeveer 40–50% van de juveniele raven het eerste kalenderjaar niet overleeft. Dit is, ter vergelijking, een hogere

overlevingskansen dan bij veel roofvogels, waarbij 60–70% het eerste jaar niet overleeft. Inzicht in deze overlevingspatronen hebben we mede dankzij het zenderonderzoek gekregen.

U geeft aan dat een eventuele uitbreiding van het zenderonderzoek mogelijk op gespannen voet staat met de Omgevingswet en de Wet op de dierproeven, en vraagt zich af of de onderzoeksvraag niet reeds is beantwoord en of sprake zou zijn van duplicering van onderzoek uit de Verenigde Staten (Yellowstone).

Een mogelijk vervolgonderzoek zou zich echter richten op een andere en bredere onderzoeksvraag, namelijk de rol van aaseters – waaronder de raaf – in de nutriëntenkringloop op de Veluwe. Wolven doden gemiddeld om de paar dagen een hoefdier. Raven en andere aaseters eten mee van deze wolvenprooien, waardoor wolven vaker moeten jagen. Daarmee versnellen aaseters indirect de nutriëntenkringloop.

Om de omvang van dit effect te kunnen meten, is het essentieel om wolvenprooien systematisch te kunnen vinden. Met het huidige onderzoek hebben we laten zien dat dit mogelijk is met behulp van gezenderde juveniele en subadulte raven. De steekproef van gezenderde raven is echter klein in verhouding tot de totale ravenpopulatie op de Veluwe. Een grotere steekproef zou de robuustheid van de analyses vergroten.

Daarnaast vertonen juveniele en subadulte raven ander gedrag dan adulte, territoriale raven. Het zou daarom interessant zijn om ook adulte raven te zenderen. Dit levert niet alleen beter inzicht op in de rol van de wolf als aasleverancier, maar ook in gedrag, activiteitspatronen en terreingebruik van raven.

Dit onderzoek is nadrukkelijk geen duplicering van onderzoek uit Yellowstone. De Veluwe is een geheel ander systeem, met een andere bodemgesteldheid, historie, ruimtelijke context en beheerdruk. Resultaten uit Yellowstone zijn daarom niet één-op-één toepasbaar op de Veluwe.

In dit verband wil ik nog kort terugkomen op mijn formulering tijdens de lezing, waarin ik aangaf dat het “gaaf zou zijn” als het zenderonderzoek uitgebreid kan worden. Ik kan mij goed voorstellen dat deze bewoording verkeerd kan zijn overgekomen. Graag wil ik u verzekeren dat wij het zenderonderzoek allesbehalve lichtvaardig nemen. Een eventuele uitbreiding van het onderzoek zou alleen plaatsvinden wanneer er duidelijke nieuwe onderzoeksvragen liggen, wanneer deze niet op andere wijze beantwoord kunnen worden, en na zorgvuldige ethische afweging en toetsing binnen de geldende wet- en regelgeving.

Sinds 2023 zijn alle wolventerritoria op de Veluwe bezet. Daarmee is een nieuwe fase aangebroken waarin wolven mogelijk een grotere invloed uitoefenen op hoefdierpopulaties en op het aanbod van aas, dat nu jaarrond en verspreid over de Veluwe aanwezig is. Interessante vervolgvragen zijn bijvoorbeeld of het broedsucces van raven toeneemt door dit jaarrond beschikbare aas, en wat de effecten zijn van seizoenen en beheermaatregelen.

In dat kader is het relevant dat van het afschot van hoefdieren momenteel gemiddeld slechts circa 30% op de Veluwe achterblijft; de overige 70% wordt afgevoerd voor consumptie. Kadavers bevatten belangrijke nutriënten zoals fosfor en calcium, beide van groot belang voor de Veluwe, die sterk verarmd, gedegradeerd en verzuurd is. Door het oogsten van kadavers worden jaarlijks grote hoeveelheden nutriënten aan het systeem onttrokken, met effecten die doorwerken in de hele voedselketen.

Wanneer we met onderzoek kunnen laten zien hoe groot de ecologische rol is van predatoren (zoals wolven) en aaseters (waaronder raven), kan dit bijdragen aan beter onderbouwde adviezen richting beleid. Dat kan mogelijk leiden tot meer ruimte voor natuurlijke processen en tot minder menselijk ingrijpen, zoals jacht en het afvoeren van kadavers.

Tot slot ga ik graag in op uw specifieke vragen over bevoegdheden en toezicht. Ik beschik zelf over een artikel 9-bevoegdheid in het kader van de Wet op de dierproeven en heb meegeschreven aan het studie- en werkprotocol. De personen die de raven daadwerkelijk hebben gevangen, gehanteerd en voorzien van zenders beschikken over een artikel 12-bevoegdheid. Het betreft zeer ervaren mensen met de juiste bevoegdheden en training. Het zenderen is bovendien gecombineerd met reguliere ringactiviteiten en het opnemen van biometrische gegevens, zodat juveniele raven niet meerdere keren uit het nest gehaald hoefden te worden.

Het onderzoek valt onder de proefdieronthefing van SOVON en staat onder toezicht van de DierenExperimentenCommissie (DEC). Elk project wordt afzonderlijk beoordeeld. Ons studie- en werkprotocol is vooraf zorgvuldig getoetst. Na het eerste jaar is het onderzoek geëvalueerd en opnieuw beoordeeld, waarna toestemming is gegeven om het onderzoek voort te zetten. Een eventuele opschaling van het onderzoek zou opnieuw gepaard gaan met het opstellen van een nieuw protocol en een nieuwe beoordeling door de DEC.

Ik hoop u hiermee voldoende inzicht te hebben gegeven in de afwegingen, uitvoering en achterliggende onderzoeksvragen van het zenderonderzoek bij raven op de Veluwe. Mocht u naar aanleiding van deze toelichting nog vragen hebben,

dan kunt u uiteraard contact met mij opnemen.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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RESULTATEN 2024

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Van: 5.1.2e [redacted]@gmail.com>

Verzonden: zondag 14 december 2025 15:09

Aan: info@sovon.nl <info@sovon.nl>

CC: ARK Rewilding Nederland <info@ark.eu>

Onderwerp: Landelijke dag SOVON 2025

Aan belanghebbende(n),

Graag wend ik mij tot u aangaande het volgende. Langjarig bezoek ik de jaarlijkse SOVON-dag. De Landelijke dag op 30 november 2025 noopt mij mijn teleurstelling te uiten over mijn impressie dat er in een aantal lezingen sprake was van een zorgwekkende teneur ten aanzien van het noodzakelijke respect voor individuele vogels en/of hun integriteit.

In dit kader wil ik de lezing noemen getiteld 'Een wildere Veluwe met wolf en raaf'. Het werd zeer enthousiast gebracht en het onderzoek leek te zijn geïnspireerd door vergelijkbaar onderzoek naar de samenwerking tussen wolf en raaf in het Yellowstone-park in de USA. De resultaten van dit onderzoek lijken gebaseerd te zijn op het zenderen van 26 nestjonge raven over een periode van 5 jaar, waarbij er inmiddels nog 9 met een functionerende zender aanwezig (b)lijken te zijn. Bekend is dat nesten van raven vrij verstoringsgevoelig zijn en terughoudendheid ten aanzien van het uitvoeren van handelingen op nesten van raven dient dan ook het uitgangspunt te zijn mijns inziens. Ik heb er ook nota van genomen dat in betreffende lezing werd aangegeven dat het zenderen (van de nestjongen) werd uitgevoerd binnen de 'proefdieronthefing' van SOVON. Het onderzoek wordt mijns inziens terecht dan ook als een dierproef in het kader van de Wet op de dierproeven gezien, hetgeen naar mijn mening vooronderstelt dat de betreffende handelingen ethisch en wetenschappelijk zijn gewogen [ondermeer ten aanzien van de drie V's (vermindering, vervanging en verfijning)]. De enthousiaste ontboezeming van de onderzoekster dat het 'gaaf zou zijn als dit zenderonderzoek uitgebreid gaat worden' staat mijns inziens op gespannen voet met de Omgevingswet (bescherming van het nest van de raaf) en de Wet op de proefdieren (is de vraagstelling niet al met het aantal benutte dieren beantwoord en in hoeverre is duplicering van onderzoek in de USA nuttig en noodzakelijk).

Buiten reikwijdte

[redacted]
[redacted]
[redacted]
[redacted]

Buiten reikwijdte

Graag wil ik u het volgende vragen:

Is de persoon die zenders plaatst bij nestjonge raven bevoegd overeenkomstig artikel 9 van de Wet op de dierproeven?

Welke Instantie voor Dierenwelzijn ziet toe op de 'proefdieronthefing' van SOVON?

Buiten reikwijdte

Bij voorbaat dank voor de beantwoording van mijn vragen.

Met vriendelijke groet,

5.1.2e

5.1.2e

Van: 5.1.2e
Verzonden: woensdag 22 oktober 2025 17:14
Aan: 5.1.2e
Onderwerp: FW: overzicht kosten data portaal en zenderen 2025

Hoi beiden,

Ik probeer de sensor instellingen nog wat beter te begrijpen. De meeste zenders hebben een interval van 0, wat volgens de handleiding zou betekenen dat sensor logging disabled is en dat -1 betekent dat ze het schema van de GPS volgen. Ik was daardoor bang dat er geheel geen sensor data werd opgeslagen. Maar, gelukkig, zie ik bij deze zenders dat voor elke gps locatie ook sensor data wordt doorgegeven (in het csv file). Het enige verschil dat ik zie in de data tussen -1 en 0 zenders is dat de -1 ook af en toe sensor data doorgeeft wanneer er geen gps locatie kan worden bepaald (0 satelieten). Is dat het verschil? Dus betekent 0, dat er wel nog alle sensor data wordt verzameld en opgeslagen maar enkel wanneer er ook locatie kan worden bepaald en -1 dat dit het geplande GPS interval volgt (zover mogelijk)?

Groetjes,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: dinsdag 21 oktober 2025 14:01
To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>
Cc: 5.1.2e @ziggo.nl>; 5.1.2e @ru.nl>
Subject: Re: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e

Dank je voor de uitleg! Dan ga ik deze week aan de slag met het aanpassen van de zenders.

Ik heb nog niks van Ornitela gehoord. Had ook meteen het miltje naar jullie contact persoon doorgestuurd. Ik zal eind vd week nog eens mailen en dan ook meteen naar de Movebank situatie vragen. Misschien kan ik ook een movebank account maken en bij die van 5.1.2e gevoegd worden zodat ik het ook vanaf de andere kant kan checken en eventueel een Readme file kan toevoegen. Als ik volgende week nog niks hoor dan maak ik evt een kleine persoonlijke betaling vr de datafee zodat de balans in ieder geval niet meer negatief is en we niet het risico lopen dat er data verdwijnt.

Groetjes,
5.1.2e

Verzonden vanaf [Outlook voor Android](#)

Van: 5.1.2e @ark.eu>
Verstuurd: maandag, oktober 20, 2025 4:36:40 p.m.
Aan: 5.1.2e @wur.nl>; 5.1.2e @ark.eu>
CC: 5.1.2e @ziggo.nl>; 5.1.2e @ru.nl>
Onderwerp: Re: overzicht kosten data portaal en zenderen 2025

Hej 5.1.2e

Hierbij de antwoorden op je vragen.

- Kunnen we het suspenden zelf in de settings doen (zo ja, hoe?) of is dit iets wat alleen Ornitela kan? **Voor zover ik weet, kan alleen Ornitela dit voor ons doen.**
- Naast de update frequentie zijn er ook een aantal andere instellingen anders tussen de verschillende zenders. Als ik bijvoorbeeld 5.1.2h 2025 de instellingen van 5.1.2h 2023_2 wil laten overnemen dan zijn er veel dingen anders (zie screenshot hieronder, in rood). Wat raad je aan? **Zolang er geen student met de ravendata aan de slag gaat, én ook in het veld observaties gaat doen, zou ik alle zenders instellen zoals 5.1.2h 2023_2. Bij 5.1.2h staat het gps-fix interval ingesteld op 300 (seconden, dus om de 5 minuten wordt de gps-locatie vastgelegd). Zo ook bij batterij minder dan 75%, maar vanaf een batterij met percentage onder de 50% wordt de GPS nog maar om de 30 minuten (1800 sec) vastgelegd. En bij batterij onder de 25% wordt gps-locatie om de 4 uur (14400 sec) vastgelegd. Wat het 'Sensors log interval' is, weet ik niet precies. 5.1.2e hebben dat toentertijd zo ingesteld. Is wel in de handleiding te vinden.**
- Ik zie nergens waar ik de tijd van de update kan instellen. Komt dat in een vervolgstap of is dat automatisch gelijk aan de tijd van de dag dat ik de settings aanpas? **Dit is wat je invult bij GSM data session interval, dus bij een update om de dag vul je hier 172800 sec in (48 uur). Maar let op: als je alle zenders om 14:00 wil laten uploaden dan moet je het verschil uitrekenen qu tijd met de volgende upload.**
 - Voorbeeldje voor 5.1.2h 2025 - upload staat ingesteld op elke 24 uur - we willen naar elke 48 uur om 14:00 (op even dagen - dus 22 okt - 24 okt etc.)
 - De volgende upload komt morgen (de 21e) om 14:05:25 → Als we dan de volgende upload op 22 okt om 14:00 willen, dan wordt de som:
 - $86400 \text{ sec (24 uur)} - ((5 \times 60) + 25) = 86400 - 325 = 86075$ → dit is dan de nieuwe instelling, maar let op, nadat deze instelling is overgenomen (zie next GPRS data - op 21 oktober rond 14:05) moet deze opnieuw aangepast worden en dan naar 172800 (anders komt de dan volgende upload wéér binnen 24 uur en dan op 22 okt om 13:54:35....)
 - **De volgende update komt dan op de 22e om 14:00 (als alles goed gaat en de instellingen overgenomen zijn) - de nieuwe instellingen moeten dan vóór 14:00 weer in het systeem gezet zijn - anders gaat alles scheef lopen**
 - We houden de instellingen van de zenders bij in een logboek in Excel op Google Drive - hierbij de link:
5.1.2h
- In het overzichtje (zie tweede screenshot), staat movebank voor alle zenders aangevinkt. Ik zal hier echter nog specifiek naar vragen. Is het dan echter duidelijk in movebank dat dezelfde zender soms voor meerdere vogels is gebruikt? En is er nog andere meta-data die hier aan verbonden kan/moet worden? Ik geloof dat alles via de movebank account van 5.1.2e gaat? Ik heb in ieder geval het meest recente meta-data overzicht (eerste sheet), met dank aan 5.1.2e (fouten mijnerzijds voorbehouden) aan deze email toegevoegd. **Zou Ornitela voor de zekerheid vragen naar hoe dat zit bij MoveBank, dat weet ik niet precies. Ik weet dat 5.1.2e dit eerder via Ornitela geregeld heeft. MoveBank hebben we zelf niet echt gebruikt, 5.1.2e, heeft hier wel mee gewerkt. Of je in MoveBank kunt zien of een zender voor meerdere raven gebruikt is, weet ik niet. Ik denk dat het aan de data van de zender wel te zien moet zijn (omdat een zender een lange periode op een plek ligt - of lange tijd 100% opgeladen was - en/of uit gezet is (zonder te 'suspenden'). 5.1.2e is volgens mij contactpersoon en 5.1.2e is in MoveBank 'principal investigator' - zelf ben ik ook aan het project verbonden.**

Ik hoop dat dit de belangrijkste vragen beantwoord. 😊

Heb je inmiddels al bericht terug van Ornitela?

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

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From: 5.1.2e @wur.nl>
Date: Friday, 17 October 2025 at 17:23
To: 5.1.2e @ark.eu>, 5.1.2e @ark.eu>
Cc: 5.1.2e @ziggo.nl>, 5.1.2e @ru.nl>
Subject: RE: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e

Dank voor de update. Ik heb nog een paar opvolgvraagjes:

- Kunnen we het suspenderen zelf in de settings doen (zo ja, hoe?) of is dit iets wat alleen ornitela kan?
- Naast de update frequentie zijn er ook een aantal andere instellingen anders tussen de verschillende zenders. Als ik bijvoorbeeld 5.1.2h 2025 de instellingen van 5.1.2h 2023_2 wil laten overnemen dan zijn er veel dingen anders (zie screenshot hieronder, in rood). Wat raad je aan?
- Ik zie nergens waar ik de tijd van de update kan instellen. Komt dat in een vervolgstap of is dat automatisch gelijk aan de tijd van de dag dat ik de settings aanpas?
- In het overzichtje (zie tweede screenshot), staat movebank voor alle zenders aangevinkt. Ik zal hier echter nog specifiek naar vragen. Is het dan echter duidelijk in movebank dat dezelfde zender soms voor meerdere vogels is gebruikt? En is er nog andere meta-data die hier aan verbonden kan/moet worden? Ik geloof dat alles via de movebank account van 5.1.2e gaat? Ik heb in ieder geval het meest recente meta-data overzicht (eerste sheet), met dank aan 5.1.2e (fouten mijnerzijds voorbehouden) aan deze email toegevoegd.

Groetjes en fijn weekend!

5.1.2e

Name: **5.1.2h** 2025, sn: 243673, fw: 2006241110

Device name
Max 32 characters

Copy settings

Copy settings from selected device

2122

Setting	Out
GSM data session interval 600..2073600 seconds	864 (Waiting)
GPS fix interval 0..172800 seconds, 0 - invalid value in GF1 and GF2 zones	720 (Waiting)
GPS fix interval when battery less than 75% 0 - setting disabled, 1..172800 seconds	720 (Waiting)
GPS fix interval when battery less than 50% 0 - setting disabled, 1..172800 seconds	144 (Waiting)
GPS fix interval when battery less than 25% 0 - setting disabled, 1..172800 seconds	288 (Waiting)
Enable GPS sleep 0 - disabled, 1 - enabled	Ena
GPS sleep from dusk -18..18 - sun angle	-4° (UT)
GPS sleep till dawn -18..18 - sun angle	-4° (UT)
GPS fix interval during sleep 0..21600 seconds	144
GPS burst 0..600 - seconds	0
Disable GPS burst when battery less than x% 10..90 %	50

All devices settings					
Device name	S/N	Visibilit	Map marker	E-mail	Mo
5.1.2h 2022-1	212235	☒	Default colors ▾	☐	
5.1.2h 2023_2	212236	☒	Default colors ▾	☐	
5.1.2h 2021	212237	☒	Default colors ▾	☐	
5.1.2h 2021	212238	☒	Default colors ▾	☐	
5.1.2h 5.1.2h 2023	212239	☒	Default colors ▾	☐	
5.1.2h 2021	212240	☒	Default colors ▾	☐	
5.1.2h 2022_1	222512	☒	Default colors ▾	☐	
5.1.2h 2023_1	222513	☒	Default colors ▾	☐	
5.1.2h 2022_1	222514	☒	Default colors ▾	☐	
5.1.2h 2022_2	222515	☒	Default colors ▾	☐	
5.1.2h 2022-1	222516	☒	Default colors ▾	☐	
5.1.2h 2022-2	222517	☒	Default colors ▾	☐	
5.1.2h 2023_1	232701	☒	Default colors ▾	☐	
5.1.2h 2023_2	232702	☒	Default colors ▾	☐	
5.1.2h 2023_1	232703	☒	Default colors ▾	☐	
5.1.2h 2 2024	243672	☒	Default colors ▾	☐	
5.1.2h 2025	243673	☒	Default colors ▾	☐	
5.1.2h 1 2024	243674	☒	Default colors ▾	☐	
5.1.2h - 5.1.2h	243675	☒	Default colors ▾	☐	
5.1.2h 2025	243676	☒	Default colors ▾	☐	

From: 5.1.2e @ark.eu>
 Sent: vrijdag 17 oktober 2025 14:08
 To: 5.1.2e @wur.nl>; 5.1.2e @ark.eu>
 Cc: 5.1.2e @ziggo.nl> 5.1.2e @ru.nl>
 Subject: Re: overzicht kosten data portaal en zenderen 2025

Ha allen,

Was net bezig een mail te typen toen ik het bericht van 5.1.2e aan Ornitela zag binnenkomen — hieronder toch nog even het overzicht van wat ik al had uitgewerkt.

5.1.2e : je hebt helemaal gelijk over de zenders 5.1.2h 2022-1, 5.1.2h 2022_2 en 5.1.2h 2024 – deze kunnen inderdaad gesuspend worden.

Voor de overige 9 actieve zenders en de maandelijkse kosten kom ik **tot eind 2025** op een totaalbedrag van **€226,60** (excl. BTW). Om zeker te zijn dat we genoeg hebben, stel ik **€275** voor (incl. 21% BTW).

Als je de zenders wilt bekostigen t/m **februari 2026**, kom je uit op ongeveer **€415 incl. BTW**. Voor heel **2026 (jan–dec)** zouden de kosten voor 9 zenders uitkomen op ongeveer **€810**.

Winterinstellingen:

- De meeste zenders staan nu op een update eens per twee dagen (172.800 sec). De volgende oudere zenders hebben deze instelling:
 - 5.1.2h 2023_2 – zendernr. 212236
 - 5.1.2h 2021 – zendernr. 212237
 - 5.1.2h 2021 – zendernr. 212238
 - 5.1.2h 2022_1 – zendernr. 222514
 - 5.1.2h 2022-1 – zendernr. 222516
- De nieuwere zenders kunnen op dezelfde instelling worden gezet:
 - 5.1.2h 2025 – zendernr. 243673
 - 5.1.2h _1 2024 – zendernr. 243774
 - 5.1.2h - Kijk Uit – zendernr. 243675
 - 5.1.2h 2025 – zendernr. 243676
- Het is handig als alle zenders bijvoorbeeld **rond 14:00 uploaden**.

Batterij & data

De zenders met 0% batterij zijn 5.1.2h en 5.1.2h 2021 (onze eerste gezenderde raven). Vermoedelijk laden ze nog af en toe op bij voldoende zonlicht, maar werkt de accu zelf niet goed meer.

De raven die in het overzicht grijs staan, hebben de laatste keer geen update gegeven (bijvoorbeeld door weinig bereik); de volgende update zou gewoon moeten doorkomen.

Aangezien jij inmiddels contact hebt met Ornitela, 5.1.2e, lijkt het handig als het contact nu via jou blijft lopen. Wij hadden eerder contact met 5.1.2e @ornitela.eu).

Samen met 5.1.2e (cc) hebben we besproken dat we graag willen dat de raven-data automatisch naar **MoveBank** wordt geüpload. Dit kan volgens mij door Ornitela in hun systeem een vinkje aan te zetten. 5.1.2e zou jij 5.1.2e willen vragen dit voor ons te regelen?

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?
Klik op de kaart hieronder om lid te worden van ons netwerk!



Ons nieuwe jaarverslag al gelezen?
Klik op de banner hieronder.



Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e @wur.nl>
Date: Thursday, 16 October 2025 at 16:13
To: 5.1.2e @ark.eu>, 5.1.2e @ark.eu>
Cc: 5.1.2e @ziggo.nl>
Subject: RE: overzicht kosten data portaal en zenderen 2025
Hoi allen,

Ik stel voor dat wij (als WUR) voor de komende maanden direct de data fee betalen aan Ornitela. Incl VAT zou dit ong 7.50 per device per maand zijn. Er lijken ook nog een aantal zenders actief op Ornitela die niet op een vogel zitten: 5.1.2h 2022-1; 5.1.2h 2022_2; 5.1.2h _2 2024. Kunnen we deze, zoals de andere oude zenders, suspenderen en zo ja, hoe? Er zijn dan nu nog max 9 actieve zenders om data fee voor te betalen de komende maanden.

Daarnaast staan er een aantal actieve zenders met 0% batterij maar die lijken nog wel gps data te verzenden. 5.1.2h 2025 staat in het grijs in het overzicht maar de tracking data lijkt OK op het eerste gezicht.

Groetjes, 5.1.2e

From: 5.1.2e @wur.nl>
Sent: woensdag 15 oktober 2025 20:58
To: 5.1.2e @ark.eu>; 5.1.2e @ark.eu>
Cc: 5.1.2e @ziggo.nl>
Subject: FW: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e en 5.1.2e

Dit is de laatste stand van zaken mbt de data fees in maart dit jaar. Op Ornitela staat dat de balans sinds eind Augustus negatief is. Betekent dit dat de data fees toendertijd niet (volledig) betaald zijn door jullie admin (zie mailtje 5.1.2e of dat Ornitela een te lage invoice heeft gestuurd voor 10 maanden en 10 GPS?

Ik kan proberen voor de afgelopen en komende maanden een directe betaling te doen en dit terug te vragen, maar mogelijk zou dit dan met VAT zijn. Maar wel belangrijk dit snel op te lossen om geen data te verliezen. Zo ver ik op de portal kon zien, is alle data er nog wel. Ik heb het voor de zekerheid ook gedownload tm vandaag voor alle zenders.

Nog een ander punt. Nu we richting winter gaan, moeten er misschien ook wat settings aangepast worden in de zenders? Kan ik dit eventueel overnemen als dit helpt? En zo ja, hoe 😊?

Groetjes,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: dinsdag 11 maart 2025 14:38
To: 5.1.2e @ark.eu>
Cc: 5.1.2e @wur.nl>; 5.1.2e @wur.nl>; 5.1.2e @wur.nl>; 5.1.2e @ziggo.nl>
Subject: RE: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e

Ik heb een order aangemaakt. Je zal de inkooporder ook nog automatisch vanuit ons systeem ontvangen.

Graag de factuur met de volgende gegevens sturen naar DDW, Invoices invoices.ddw@wur.nl (in pdf-formaat) met mij in de CC:

Ordernummer: WUR1829623

Factuuradres:

Wageningen University

Dierwetenschappen

T.a.v. crediteurenadministratie

Postbus 2176

8203 AD Lelystad

Nederland

Indien je nog vragen hebt, hoor ik het graag. Alvast heel erg bedankt!

Groet, 5.1.2e

5.1.2e

Behavioural Ecology Group
Wageningen University & Research



Zodiac, Building 122, Room 5.1.2e
De Elst 1, 6708 WD Wageningen
[Behavioural Ecology Group - WUR](#)

5.1.2e

From: 5.1.2e <[redacted]@wur.nl>

Sent: Monday, March 10, 2025 2:54 PM

To: 5.1.2e <[redacted]@ark.eu>; 5.1.2e <[redacted]@wur.nl>; 5.1.2e <[redacted]@ziggo.nl>

Cc: 5.1.2e <[redacted]@wur.nl>

Subject: RE: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e & 5.1.2e

Top! 5.1.2e zou jij dan een inkooporder willen maken en de facturering instructies naar 5.1.2e sturen? Het bedrag kan van mijn persoonlijk projectnummer afgeschreven worden.

Dank!

5.1.2e

From: 5.1.2e <[redacted]@ark.eu>

Sent: zaterdag 8 maart 2025 10:11

To: 5.1.2e <[redacted]@wur.nl>; 5.1.2e <[redacted]@ziggo.nl>; 5.1.2e <[redacted]@wur.nl>

Subject: Re: overzicht kosten data portaal en zenderen 2025

Hoi allemaal,

Prima voorstel.

Voor nu heb ik een invoice gevraagd voor de upload van de data fee (10mnd x €6,20 ex 21 VAT) tbv de bestaande (7) loggers. Nieuwe even afhankelijk van 3 of 4 loggers.

Ik ben ervan uitgegaan dat bij afrekening 21% VAT in rekening gebracht zou worden. Dit is/likt niet het geval. Zie bijlage.

Ik zal onze adm vragen de betaling te verrichten.

Groeten,

5.1.2e

From: 5.1.2e <[redacted]@wur.nl>

Sent: Friday, February 28, 2025 8:52 AM

To: 5.1.2e <[redacted]@ziggo.nl>; 5.1.2e <[redacted]@wur.nl>; 5.1.2e

5.1.2e [redacted]@ark.eu>

Subject: RE: overzicht kosten data portaal en zenderen 2025

Goedemorgen,

Zou inderdaad voor ons het makkelijkst zijn als we een factuur achteraf kunnen betalen.

Als dat niet te veel werk voor jullie is, heeft dat onze voorkeur.

Bij betalingen van abonnementen regelen we vaak dat we vooruit voor enkele maanden kunnen betalen of dat we een x bedrag overmaken en dat aanvullen wanneer nodig (als gebruik per maand niet een vast bedrag is). Maandelijks een abonnement betalen is voor ons nogal veel geregeld.

Voordat ARK een factuur stuurt, ontvang ik graag het bedrag, zodat ik een inkooporder kan aanmaken en zal dan de inkooporder + instructies naar jullie opsturen.

Groet, 5.1.2e

5.1.2e

Behavioural Ecology Group
Wageningen University & Research



Zodiac, Building 122, Room 5.1.2e

De Elst 1, 6708 WD Wageningen

[Behavioural Ecology Group - WUR](#)

5.1.2e

From: 5.1.2e [redacted]@ziggo.nl>

Sent: Thursday, February 27, 2025 1:20 PM

To: 5.1.2e [redacted]@wur.nl>; 5.1.2e [redacted]@ark.eu>

Cc: 5.1.2e [redacted]@wur.nl>

Subject: RE: overzicht kosten data portaal en zenderen 2025

Eens!!

Bij factuur aan Ravenwerkgroep Nederland graag vermelden 'Zenderproject Raaf, materiaal en analyse'

IBAN: NL52 INGB 5.1.2e [redacted] t.n.v. 5.1.2e [redacted]

Van: 5.1.2e [redacted]@wur.nl>

Verzonden: donderdag 27 februari 2025 13:11

Aan: 5.1.2e [redacted]@ark.eu>; 5.1.2e [redacted]@ziggo.nl

cc: 5.1.2e [redacted]@wur.nl>

Onderwerp: RE: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e [redacted] en 5.1.2e [redacted]

Even met 5.1.2e [redacted] in de cc, want die heeft daar beter zicht op. WUR betaald in principe op basis van factuur. Ik denk dat voor abonnements kosten zoals voor de data fee dit het handigst via ARK gaat, maar misschien weet 5.1.2e [redacted] dit beter.

De zenders deden we via ARK vanwege het grote NGO belastingvoordeel. Ik denk dat de kosten voor 5.1.2e [redacted] het makkelijkst via ons gaan dan. Dat de Ravenwerkgroep dan eventueel de harnasjes betaald en als de harnasjes niet nodig zijn (of minder kosten) dat we de data fee kosten dan verdelen (Dat ARK dit eerste betaald en dan aan ons en Hans factureerd(?)).

Groetjes,

5.1.2e

From: 5.1.2e [redacted]@ark.eu>

Sent: donderdag 27 februari 2025 09:00

To: 5.1.2e [redacted] [wur.nl](mailto:5.1.2e@wur.nl); 5.1.2e [redacted] [@ziggo.nl](mailto:5.1.2e@ziggo.nl)

Subject: Re: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e [redacted]

Wat een geweldig nieuws 5.1.2e [redacted] !

Dank hiervoor!

Klopt het dat het nog steeds het makkelijkst is als een partij (ARK?) dit voorschiet en achteraf factureert?

Groetjes,

5.1.2e [redacted]

From: 5.1.2e [redacted] [@wur.nl](mailto:5.1.2e@wur.nl)>

Sent: Wednesday, February 26, 2025 9:04 PM

To: 5.1.2e [redacted] [ark.eu](mailto:5.1.2e@ark.eu); 5.1.2e [redacted] [@ziggo.nl](mailto:5.1.2e@ziggo.nl); 5.1.2e [redacted] [ziggo.nl](mailto:5.1.2e@ziggo.nl)>

Subject: RE: overzicht kosten data portaal en zenderen 2025

Hoi 5.1.2e [redacted]

In overleg met mijn baas kunnen we de kosten van dit jaar coveren (even uitgaande van max 2000 euro, dus data fees, harnasjes en personeelskosten enkel voor de zenders die nog liggen). Een deel kan betaald worden uit mijn persoonlijke potje en wat overblijft wordt dan door de leerstoelgroep gecovered. Het is dan niet nodig voor mensen om persoonlijke donaties van de eigen rekening te doen!

Ik denk dat, indien nodig, we ook wel de data fees voor de jaren erop kunnen coveren. Het is unieke data, dus zou echt zonde zijn als we die nu verliezen.

Groetjes,

5.1.2e [redacted]

From: 5.1.2e [redacted] [@ark.eu](mailto:5.1.2e@ark.eu)>

Sent: dinsdag 25 februari 2025 11:59

To: 5.1.2e [redacted] [wur.nl](mailto:5.1.2e@wur.nl); 5.1.2e [redacted] [@ziggo.nl](mailto:5.1.2e@ziggo.nl)

Subject: overzicht kosten data portaal en zenderen 2025

Ha 5.1.2e [redacted] en 5.1.2e [redacted]

Dank nog voor de afstemming afgelopen donderdag. Een weloverwogen gedachte om de huidige 3 loggers wel te benutten binnen huidige WoD.

In de bijlage een opzetje met daarin de kosten voor data fee, zenderwerk 2025 en mogelijkheden voor budget. Ik hoor graag jullie ideeën hierover.

Voor de huidige loggers is er enige spoed ivm de data fee. Ik ga even na of betaling via bankaccount en facturering kan.

Groeten,

5.1.2e [redacted]

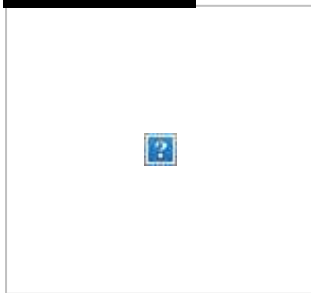
From: 5.1.2e
To: 5.1.2e
Cc: 5.1.2e
Subject: FW: Send data to MoveBank
Date: maandag 27 oktober 2025 08:29:23
Attachments: [ATT00001.png](#)
[ATT00002.png](#)
[ATT00003.png](#)
[ATT00004.png](#)
[ATT00005.png](#)
[image001.png](#)
[image002.png](#)
[image004.png](#)
[image005.png](#)
[image003.png](#)

Ha allen,

Hierbij de mail met de zenders die ik vorig jaar aan mijn MoveBank account heb laten koppelen. Ik wist toen nog niet dat dit een probleem kon gaan geven met permissies op MoveBank.

Vriendelijke groet,

5.1.2e



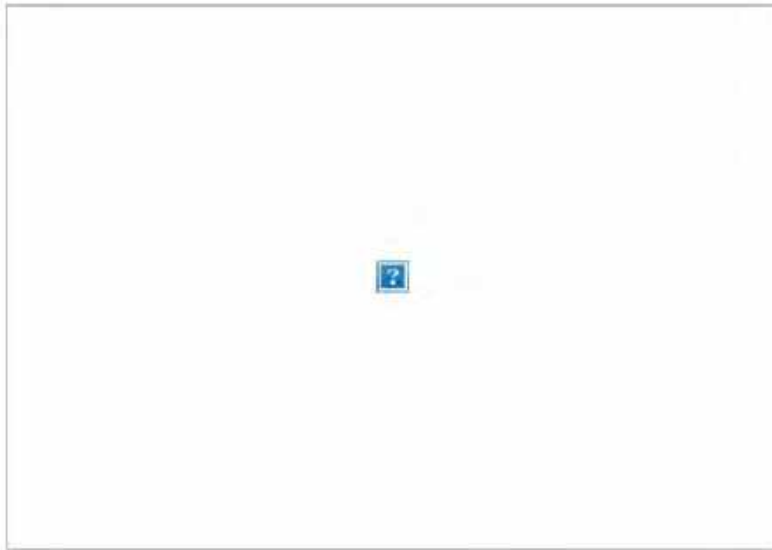
ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)

Winselingseweg 95
6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?
Klik op de kaart hieronder om lid te worden van ons netwerk!



Ons nieuwe jaarverslag al gelezen?
Klik op de banner hieronder.



Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e [REDACTED]@ornitela.eu>
Date: Monday, 30 December 2024 at 21:23
To: 5.1.2e [REDACTED]@ark.eu>
Subject: Re: Send data to MoveBank

Hi 5.1.2e

it is good to hear from you. I hope you are enjoying Christmas and New Year holidays.

I have now enabled Movebank live feed for the 14 transmitters listed in your e-mail below for the Movebank user '5.1.2f [REDACTED]'

With the best wishes for the coming New Year!

5.1.2e

On Mon, 30 Dec 2024 12:07:39 +0200, 5.1.2e [REDACTED]@ark.eu> wrote:

| Hi 5.1.2e

Hope you had very nice Christmas holidays.

Currently, I'm interesting myself in sending the raven data to MoveBank. This is already done for the transmitters we ordered in 2021 (transmitters 212235-212240). Could you also do this for our other transmitters? My username on MoveBank is

5.1.2f

Transmitter numbers:

- 222512
- 222513
- 222514
- 222515
- 222516
- 222517

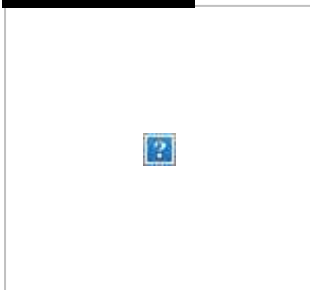
- 232701
- 232702
- 232703

- 243672
- 243673
- 243674
- 243675
- 243676

Wish you a very good New Year's Eve.

Vriendelijke groet, kind regards,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

Winselingseweg 95

6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?

Klik op de kaart hieronder om lid te worden van ons netwerk op LinkedIn!

signature_3008696725



Al een kijkje op onze splinternieuwe website genomen?

Klik op de banner hieronder.

signature_966785163



Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



Overleg projectfinanciering zenderen van raven

Dinsdagochtend 28 februari 2023 van 11:00-12:00

Aanwezig: 5.1.2e en 5.1.2e (ARK), 5.1.2e (SOVON), 5.1.2e (SBB), 5.1.2e (WUR – vakgroep Behavioural Ecology) en 5.1.2e (Ravenwerkgroep)

Mogelijkheden voor projectfinanciering

Fondsen/subsidiepotjes/beurzen

- KIEM - Een initiatief van Elise Mathilde Fonds, K.F. Hein Fonds en Cultuurfonds Utrecht
 - o Specifiek voor provincie Utrecht
 - SBNL Natuurfonds -> fonds voor particulieren voor natuurbeheer in landelijk gebied
 - Prins Bernhard Cultuurfonds -> [Biodiversiteit](#) → **biedt kansen!**
 - o Betrekken van **vrijwilligers** is belangrijk onderdeel
 - o Onderzoek naar gebruik van terrein en voedselbronnen op de Veluwe door subadulte raven en onderzoek naar rol van wolf als aasleverancier en aaseter
 - Bij Vogelbescherming navraag doen over fondsen en subsidies
 - Sovon - 5.1.2e ? (directie) of 5.1.2e doet veel aanvragen van fondsen
 - o Eens bij 5.1.2e navraag doen wat de mogelijkheden voor raaf zijn
 - o Dan wel eerst een project/onderzoeksplan hebben
 - KNNV ecologie -> geen idee wat daar de voorwaarden voor zijn
 - KNAW fonds -> voor beginnend onderzoekers
 - [August Fentener van Vlissingen Fonds](#) → **biedt mogelijkheden 3x per jaar selectie van projecten**
 - [Dobberke Beurs van KNAW](#) → **biedt kansen!**
 - o Kan 5.1.2e aanvragen via de WUR
 - Lucie Burgers: vraagt heel veel informatie - kost veel tijd om alle achtergrondinformatie aan te leveren
- **Student een plan laten maken dat kan dienen voor aanvraag van een of meerdere fondsen??**
- o Steekproef is nu nog te klein -> kans op uitval is groot bij raaf; slopen van zenders
 - o Dus we hebben geld nodig om meer zenders te bestellen voor grotere steekproef
 - o Wie kan en wil een student begeleiden?
 - Van belang dat de begeleiding bij iemand komt die veel ervaring heeft met het aanvragen van zo'n fonds.
 - Mogelijk bij 5.1.2e of 5.1.2e (Sovon)?
- **Actie allen:** dit jaar gebruiken om te bekijken welke fondsen/subsidiepotjes/beurzen we willen aanschrijven
- o Eventueel met inzet van een student

Overige besproken zaken

➤ Zenders

- o We hebben nu 4 oude zenders
 - Er ligt één zender op ISK - contact via 5.1.2e
 - ISK -> 5.1.2e doet 10 telgebieden (mag alleen onder begeleiding op het terrein van ISK komen)
 - Ecoloog van Sovon en ecoloog van RVB moeten onder begeleiding van iemand van defensie
 - Er ligt één zender bij 5.1.2e in Zutphen (5.1.2e klimt niet pro deo)
 - Er liggen twee zenders in Renkum bij 5.1.2e
 - Een oude zender en een nieuwe zender met barometer

➤ 5.1.2e

- o Actie 5.1.2e contact met 5.1.2e opnemen
 - 5.1.2e leren om tuigjes te maken en aan te brengen
- o Actie 5.1.2e contact met 5.1.2e opnemen → daarna zenders bestellen voor 2023
 - Toelichten waarom we minder geld ter beschikking hebben voor dit project
- o Wil 5.1.2e tuigjes (ism 5.1.2e) maken als dat betekent dat 5.1.2e zendert?

➤ 5.1.2e

- o Heeft afgelopen week een nieuwe verantwoording voor de DEC opgestuurd
 - Actie 5.1.2e doorsturen aan 5.1.2e en 5.1.2e

➤ Actie 5.1.2e Proefdieronthefing doorsturen aan 5.1.2e

➤ 5.1.2e

- o Een internationale studente, 5.1.2e, eerstejaars MSc dierwetenschappen
 - Heeft ervaring met 'spatial analysis' vanuit haar BSc thesis
 - Kan vanaf augustus beginnen -> kan eventueel helpen met opstellen van een plan voor een fonds of beurs -> dan wel alleen voor Engelstalige beurzen

Overleg raven zenderen 2023

Aanwezig: 5.1.2e (ARK), 5.1.2e (ARK), 5.1.2e (stagiair ARK) en 5.1.2e (Sovon)

- Nest/zender locaties
 - o 5.1.2e heeft eerder een overzicht van bekende nestlocaties op de Veluwe gedeeld
 - Dit overzicht kunnen we dit jaar weer benutten
 - Welke nesten dit jaar bezet zijn, is nog afwachten
- Nestlocaties 5.1.2h - 5.1.2h - 5.1.2h zijn (nog?) niet bezet
 - o 5.1.2h - is wél bezet (via 5.1.2e - Sovon)
 - o Zenderen bij 5.1.2h (via 5.1.2e) of bij Natuurmonumenten (via 5.1.2e)
 - o 5.1.2e gaat nog met 5.1.2e (SBB) bij Nunspeet kijken
- 5.1.2e heeft laten weten het zenderen het liefst zonder te veel mensen te willen doen
 - o 5.1.2e - 5.1.2e onderzoek bij Sovon en directe vervanger van 5.1.2e
 - Actie 5.1.2e → nummer van 5.1.2e delen met 5.1.2e
 - Actie 5.1.2e → 5.1.2e bellen over investering van Sovon in opleiding 5.1.2e voor zenderwerk
- Klimmers → regelen via 5.1.2e
- Zenders
 - o 2 oude zenders bij 5.1.2e (een met barometer een zonder barometer)
 - o 1 oude zender bij 5.1.2e
 - Met of zonder barometer? – check mailadres zender
 - o 1 oude zender bij 5.1.2e
 - Met of zonder barometer? – check mailadres zender
 - o 3 nieuwe zenders met barometer worden binnenkort bezorgd bij 5.1.2e
 - o Actie 5.1.2e (via 5.1.2e → 5.1.2e laten weten dat we in ieder geval 6 tuigjes nodig hebben voor het zenderen dit jaar – worden er misschien 7 of 8
 - o Actie 5.1.2e (student ARK) → **alle zenders verzamelen bij 5.1.2e voor voorbereiding tuigjes (door 5.1.2e) en gereed maken voor zenderen door 5.1.2e**
 - Actie 5.1.2e → zenders in zon leggen om op te laden
 - Actie ARK → checken of alle zenders nog goed functioneren
 - Laadt de zender goed op?
 - Loopt de zender niet te snel leeg?
 - Worden alle gps-locaties goed vastgelegd?
 - o En verstuurd/geüpload?

Volgende afspraak wordt eind maart gepland (over circa twee weken) - bij voorkeur in de avond!

Instructies vrijwilligers

Project wolf aasleverancier en aaseter

20 juli 2022

Aanleiding

Na een afwezigheid van 150 jaar is de wolf terug op de Veluwe. Daarmee is een aasleverancier bij uitstek terug en kan het voedselweb completer worden. Aasetergemeenschappen, waaronder raven, reageren wellicht op deze voedselbron die meer zekerheid kan bieden dan menselijk faunabeheer waarbij momenteel ca 50% van de geschoten dieren achterblijft en het beheeraantal in de maanden juli-februari wordt gerealiseerd. Om hier onderzoek naar te doen zijn een aantal raven op de Veluwe voorzien van een GPS-zender. Met analyse van de activiteitenpatronen van raven kan inzicht verkregen worden in benutting van wolvenprooien door raven én andere gewervelde aaseters.

Hoewel wolven in de eerste plaats leven van door hen gevangen prooidieren, zijn ze in buitenlandse situaties sporadisch tot frequent waargenomen als aaseter. Dit zou kunnen samenhangen met een vermindering in conditie, maar ook een mislukte jacht, wat aangeeft dat aas onderdeel uitmaakt van de overlevingsstrategie van wolven.

Wanneer we tot een meer wolf volgend faunabeheer willen komen, is monitoring van aaseetgedrag van belang om inzicht te verkrijgen in welke mate aas onderdeel uitmaakt van het dieet van de wolven op de Veluwe. Zodat er mogelijk rekening kan worden gehouden met prooidierbehoefte en spreiding van (noodzakelijk) afschot.

Om te onderzoeken in hoeverre aangereden wild (aangereden en/of afschot) onderdeel uitmaakt van het dieet van de Veluwse wolven worden locaties gemonitord met wildcamera's in samenwerking met Wageningen Universiteit (WUR).

Achtergrondartikel

<https://www.naturetoday.com/nl/nl/nature-reports/message/?msg=28929>

Werkzaamheden

- De cameravallocaties worden gemonitord door vrijwilligers van het Wolvenmeldpunt en door stagiaires. In overleg kan er bekeken worden of een locatie (tijdelijk) vraagt om een vrijwilligers. In afstemming met 5.1.2e en/of 5.1.2e
- Onderzoek naar activiteitenpatronen van raven, waarbij zogenaamde clusterlocaties bezocht worden in het veld om te bekijken of er sprake is van een voedselbron. Zijn de clusters te herleiden naar prooien van de wolf? Oftewel: Reageren raven op de beschikbaarheid van wolvenprooien op de Veluwe?

Activiteitenpatronen van raven/ clusterbezoek

- Volgen van activiteitenpatroon gezenderde raven via Ornitela portaal. User: 5.1.2f
Password: 5.1.2f (www.glosendas.net/cpanel)
Dit kan middels de site en via een export. Bijvoorbeeld als KML bestand in Google Earth. Bij een mogelijk foerageercluster afstemmen of een veldbezoek gewenst is.
- LET OP! Wijzigen van de instellingen van de loggers is voorbehouden aan ARK/WUR en studenten.
- Bij veldbezoek afstemming met Ravenzender appgroep en de terreinbeheerder (zie contacten).
- Bij mogelijke wolfprooi zie protocol Wolfspoor BIJ12 en ProtocolDDL_veldwerk_project wolf aaseter_20200120 volgen. Afstemming met regiocoördinator Wolvenmeldpunt

- Verzoek tot clusteranalyse kan binnenkomen vanuit ARK/WUR en studenten. Hiervoor kan een datafile (R-Studio) gedeeld worden met specifieke vragen over type voedselbron.

TRANSLATION

Work

The camera locations are monitored by volunteers of the Wolvenmeldpunt and by interns. In consultation, it can be considered whether a location requires volunteers (temporarily). In coordination with 5.1.2e and/or 5.1.2e.

Research into activity patterns of ravens, visiting so-called cluster sites in the field to see if there is a food source. Are the clusters traceable to wolf prey? In other words, do ravens respond to the availability of wolf prey on the Veluwe?

Activity patterns of ravens/ cluster visits

Tracking activity patterns of tracked ravens via Ornitela portal. User: 5.1.2f Password: 5.1.2f (www.glosendas.net/cpanel)

This can be done via the site and via an export. For example as a KML file in Google Earth. At a possible foraging cluster, coordinate whether a field visit is desired.

PLEASE NOTE: Changing the settings of the loggers is reserved for ARK/WUR and students.

In the event of a field visit, coordinate with Raven transmitter app group and the site manager (see contacts).

In case of possible wolf prey see protocol wolf prey BIJ12 and follow protocolDDL_fieldwork_project wolf scavenger_20200120. Coordination with regional coordinator Wolf hotline

Request for cluster analysis can come in from ARK/WUR and students. For this, a datafile (R-Studio) can be shared with specific questions on type of food source.



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WHERE DO RAVENS GO?

Exploring Foraging Habits and Habitat
Selection Base On The Spatial and Social
Behaviors Of Common Ravens (*Corvus
Corax*).

**Behavioural Ecology
Group**

Internal supervisor: 5.1.2e
Daily supervisors: 5.1.2e &
5.1.2e

Student: 5.1.2e





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INTRODUCTION

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Spatial Behaviour



- Spatial behavior is shaped by the dynamic interaction between species and their environment
- Insights into the habitat requirements of a species and its relationship with the environment
- Examining movement patterns provides valuable insights into flexibility in their habitat preferences.
 - Home range size
 - Social and foraging behaviors
 - Space utilization

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Family Stage

Parents and siblings

Non-Breeders Stage

Non-breeders peers

Territorial Breeding Stage

Reproductive partner
Offspring



Figure adaptation from Boucherie et al., 2019

Raven Cognitive Skills

- Ravens primarily learn during their first year of life.
- Adult ravens encounter frequent social changes, necessitating continuous learning and adaptation.
- Ravens gradually build a comprehensive understanding of individuals and group dynamics.





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Food sources



Ravens are versatile feeders and opportunistic scavengers, their diet is remarkably varied, including carrion often left by larger predators, small mammals, invertebrates, birds, eggs, amphibians, fish, and plant matter

They effectively utilize human-derived food sources such as roadkill, landfill waste, hunting remains, livestock feed, and crops.



What should I order?





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HYPOTHESIS

Where do ravens go?

There will be a correlation between ravens' early foraging experiences and their later foraging experiences, suggesting that their habitat preference can be predictable



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METHODS



Collection

GPS Data



GPS-GSM Tracking:

21 raven nestlings were equipped with Orni Track- 25 solar- powered GPS- GSM trackers.

Data Collection Frequency:

High-frequency data collection during summer (5 minutes) and lower frequency during winter (15 minutes).

Data Compilation:

Downloaded CSV data from Ornitela for each raven, including ID, name, and other relevant information.





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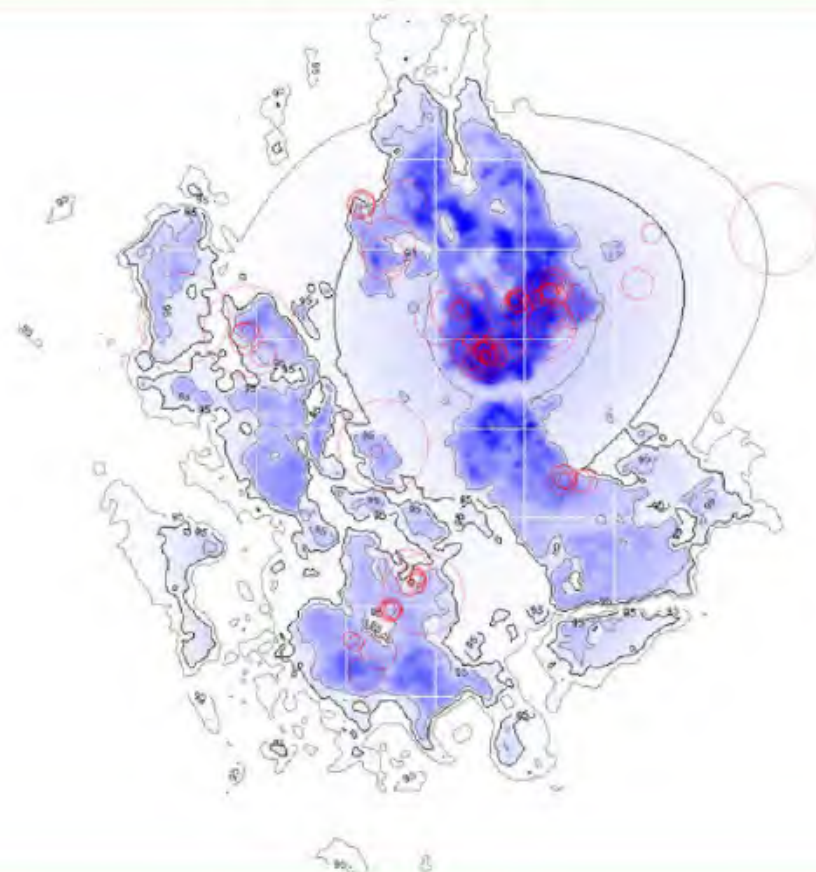
Data Preparation

Transition periods



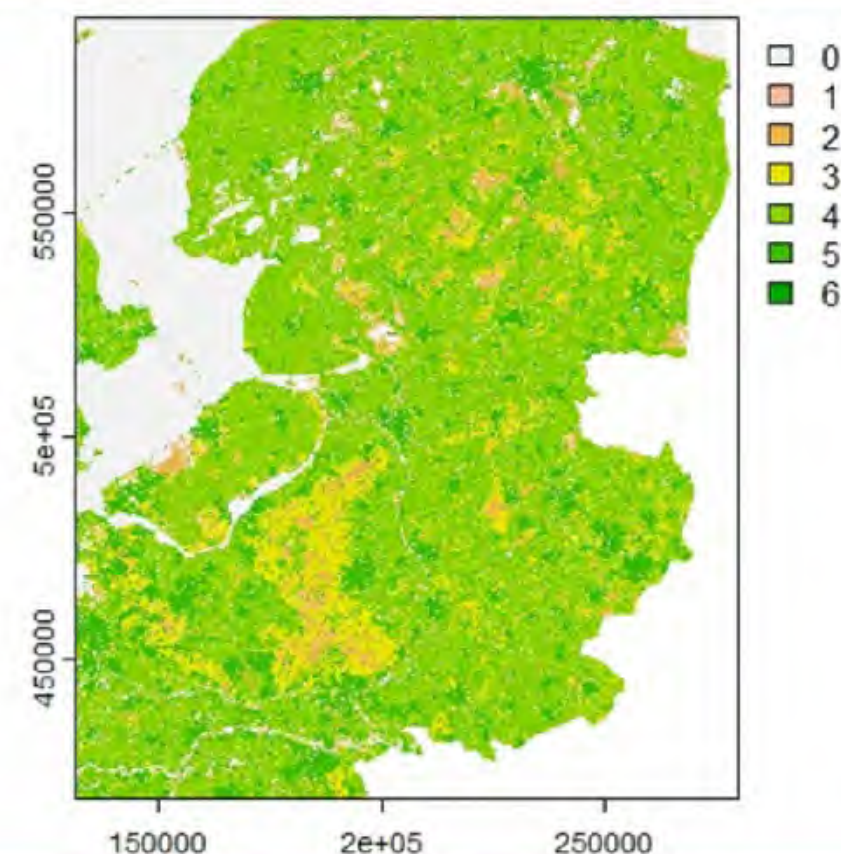
Family stage: Below 90 days (4)
Breeding stage: Below 365 days (11)
Non-breeding more than 365 days (6)

Telemetry



ctmm package
Rstudio

Land cover classification



Land Use Map of the Netherlands



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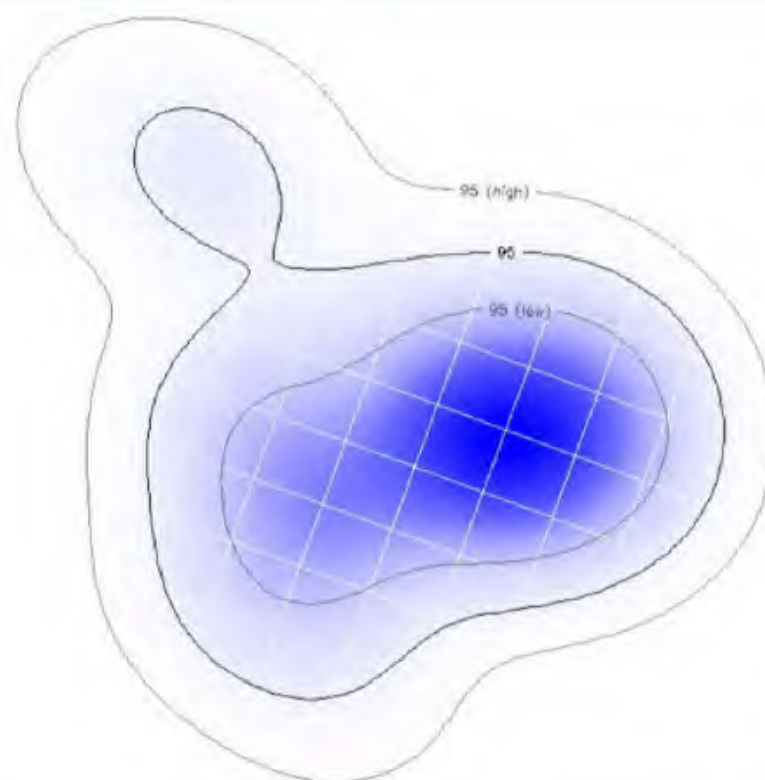
Methods

Clusters



Family stage: Below 90 days (4)
Breeding stage: Below 365 days (11)
Non-breeding more than 365 days (6)

Home range



AKDE models

Habitat Analysis



Use and availability proportions
Habitat ratios
Correlation

Survival Analysis



GPS vs no GPS



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ANALYSES AND RESULTS



Behavior identification for each cluster

- LL= low speed, low turn potentially represents a resting behavior
- **LH = low speed, high turn potentially represents an intense foraging behavior**
- HH = high speed, high turn potentially represents a soaring/searching behavior
- HL= high speed, low turn potentially represents commuting behavior

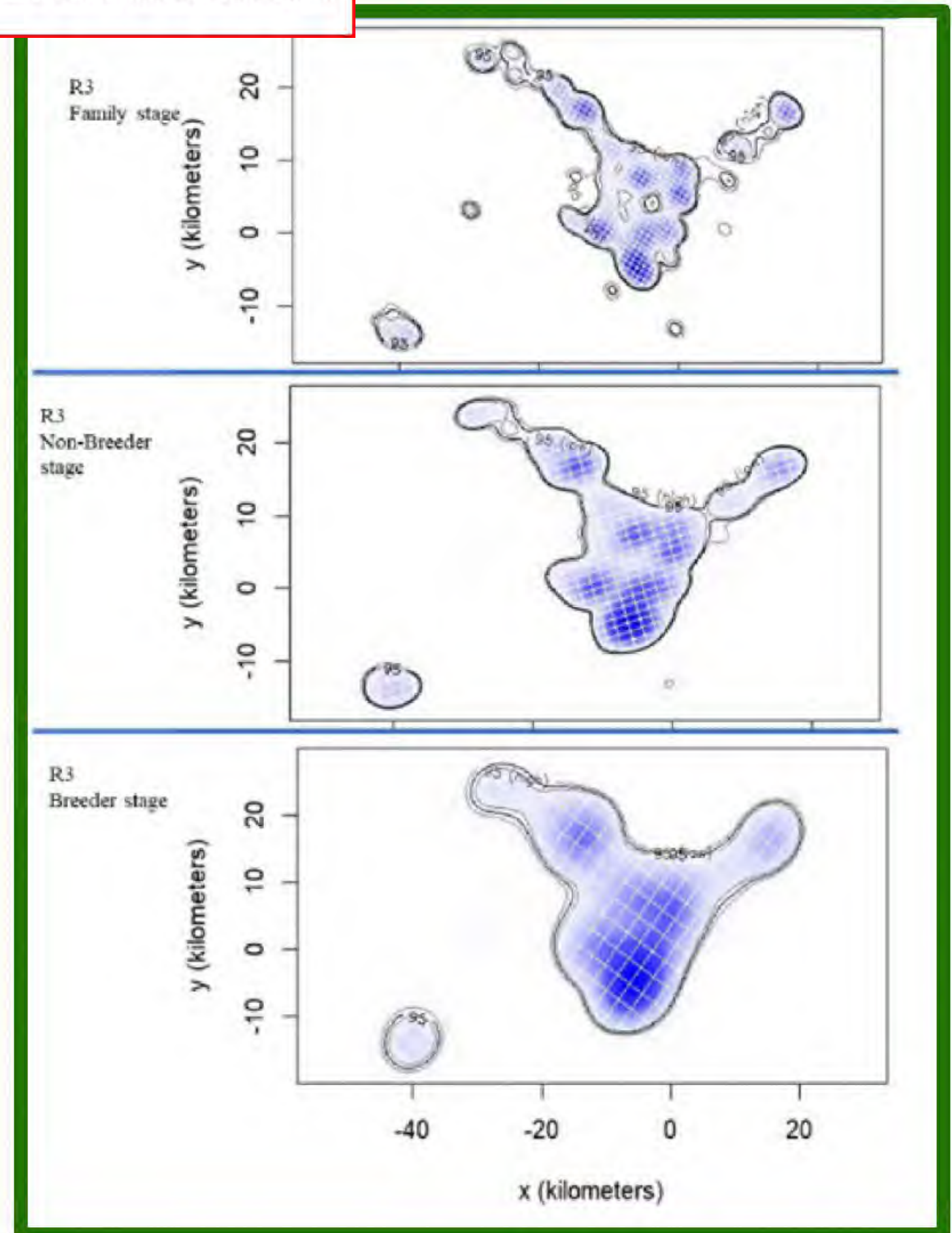


Home Range

- Successful model fitting for 15 out of 21 family-stage individuals, resulting in 14 home range estimates.
- Successful model fitting for 14 out of 16 non-breeder stage individuals, resulting in 12 home range estimates.
- Complete model fitting for all 5 breeder stage individuals with 3 successful home range estimates.

Home Range Size Variation

- Average home range size across all life stages: 1947.9 square units (SE: 1136.1).
- The breeder stage exhibits the largest home ranges.
- Non-breeder stage home ranges are 363.3 square units smaller than breeders.
- Family stage home ranges are the smallest, 691.5 square units smaller than breeders.



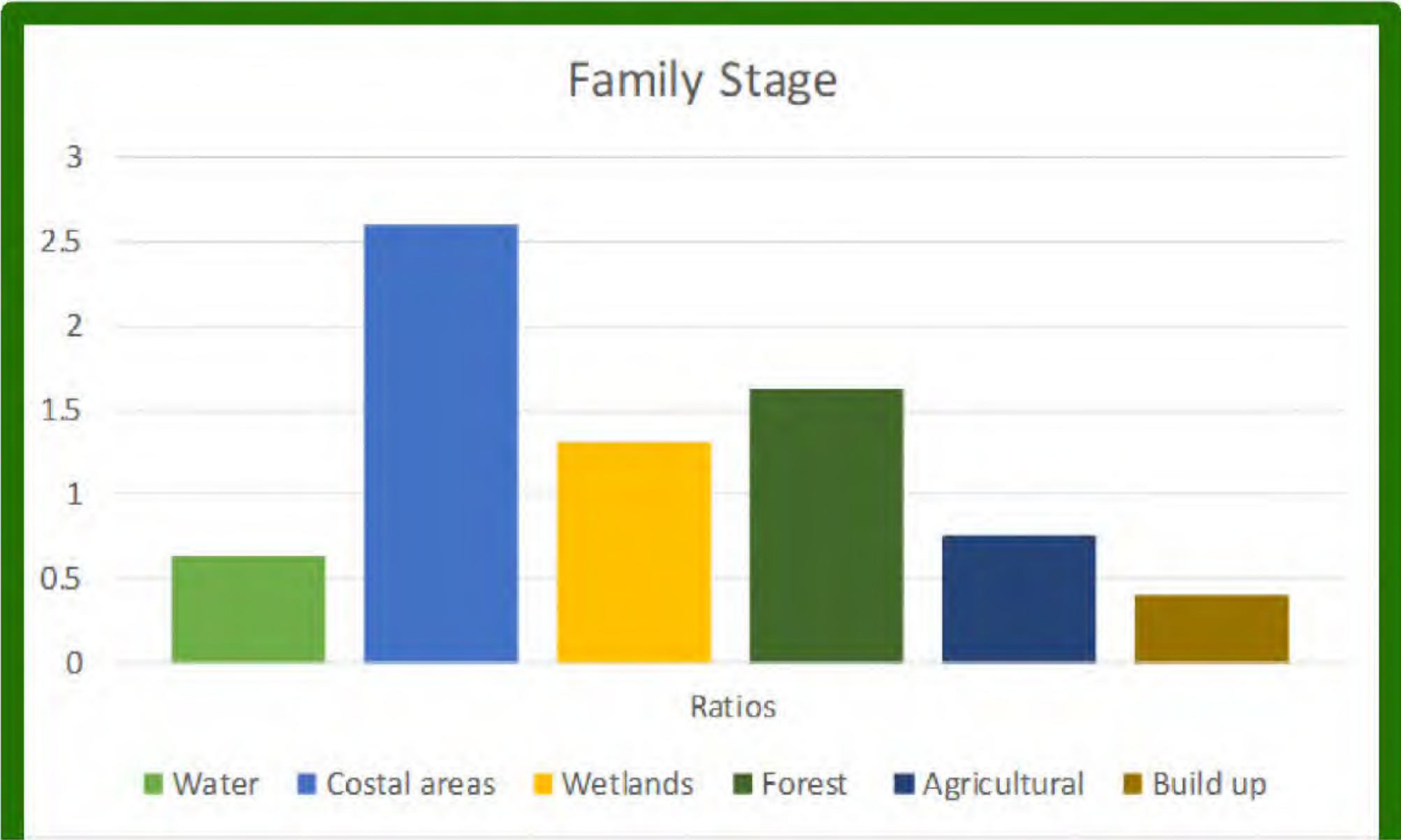
Habitat Analysis

1. Calculated habitat availability within home range polygons using land cover data and AKDEs

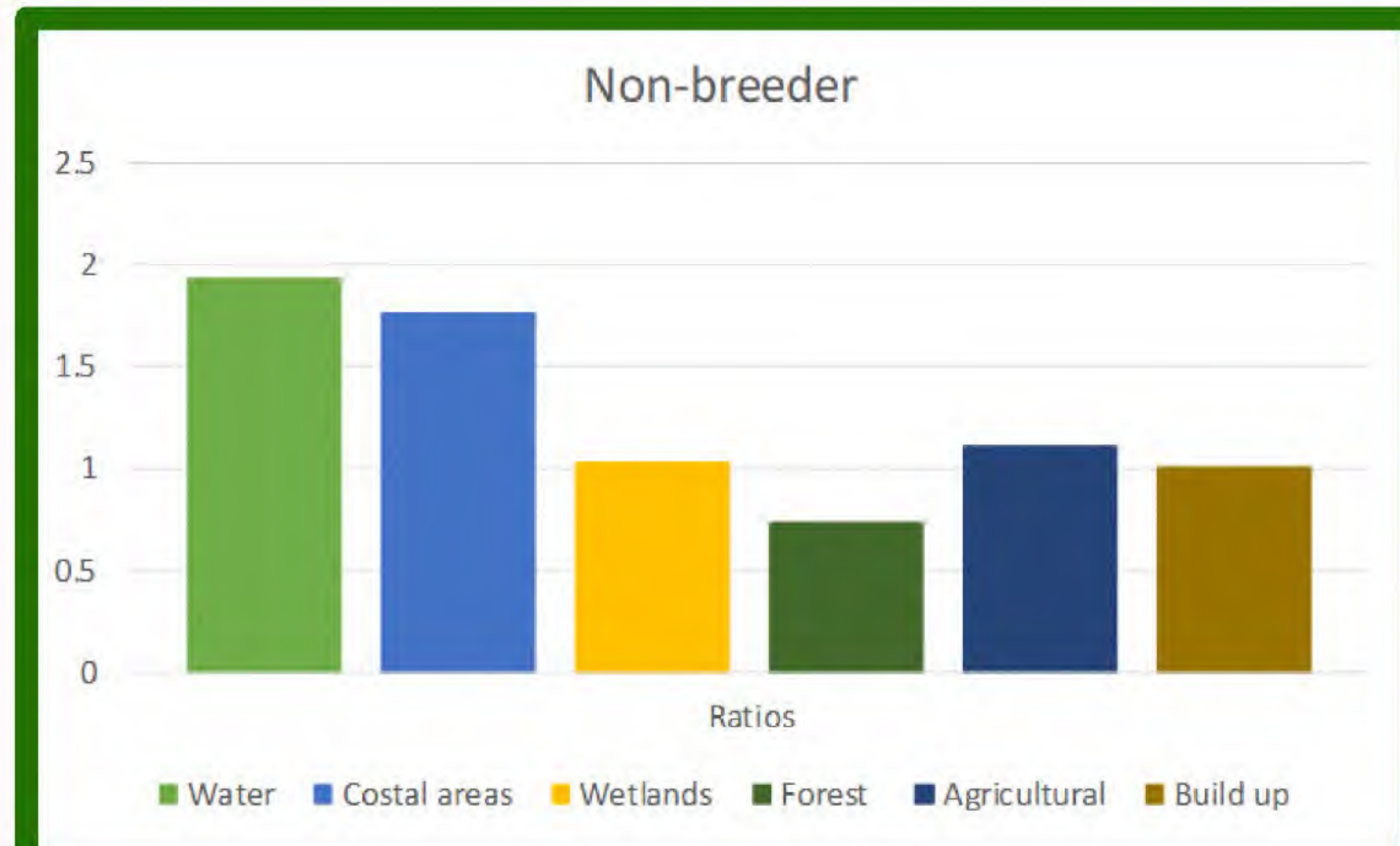
1. Determined habitat use based on tracking data and foraging behavior.



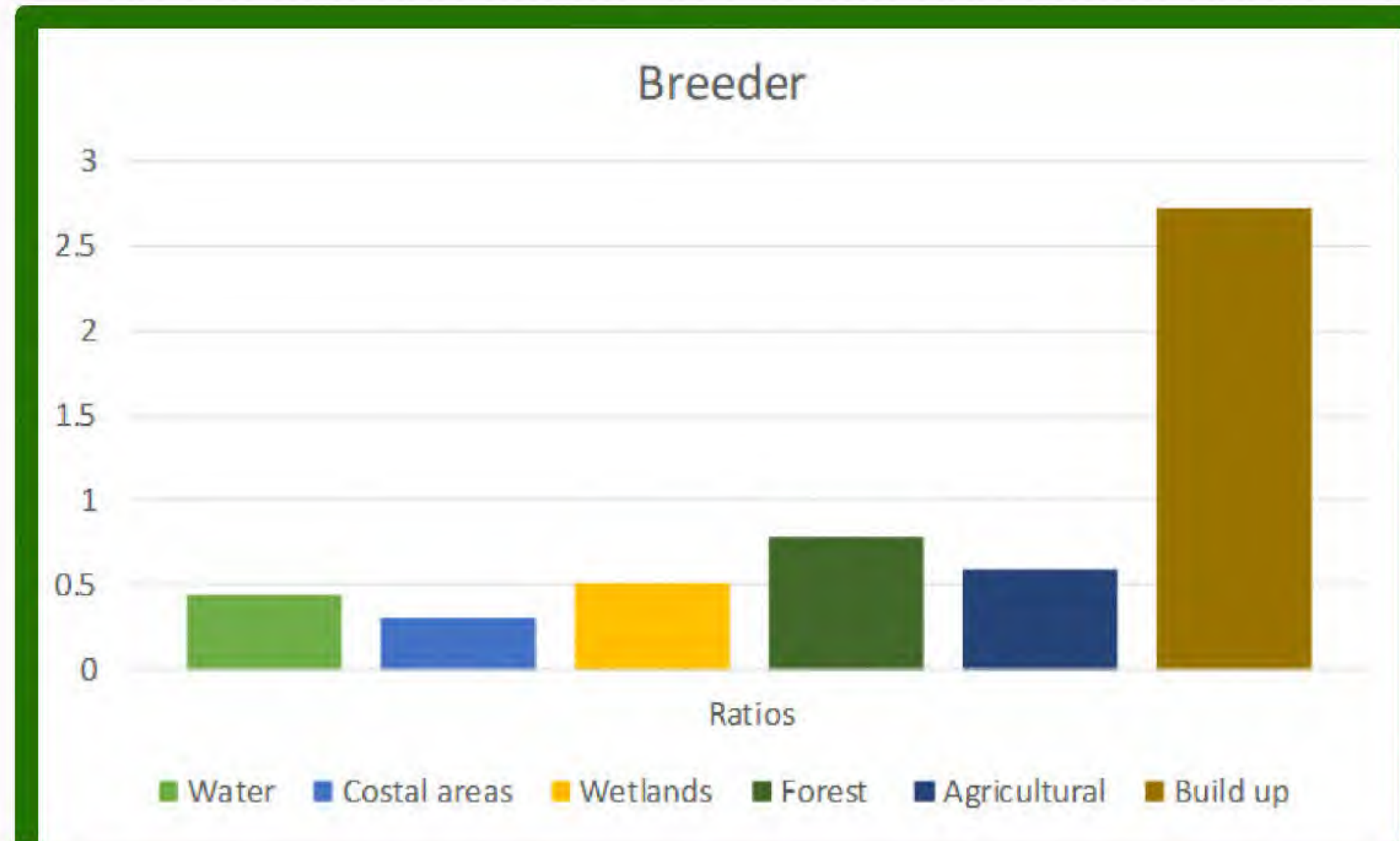
Habitat Selection Analy



Stages	Values	Water	Costal areas	Wetlands	Forest	Agricultural	Build up
Family Stage	Ratios	0.6286	2.5956	1.3104	1.6287	0.7607	0.4082
	SE	0.3165	0.6482	0.586	0.2494	0.1923	0.1148
	Mean use	0.0066	0.0098	0.0513	0.1488	0.0696	0.0344
	Mean available	0.0212	0.0145	0.1196	0.2771	0.3007	0.2071



Stages	Values	Water	Costal areas	Wetlands	Forest	Agricultural	Build up
Non-breeders	Ratios	1.9393	1.771	1.0331	0.7441	1.1114	1.0139
	SE	0.7546	0.3571	0.1595	0.0676	0.1546	0.2290
	Mean use	0.0092	0.0065	0.0239	0.0506	0.0865	0.0492
	Mean available	0.0220	0.0184	0.1157	0.3122	0.3245	0.2071



Stages	Values	Water	Costal areas	Wetlands	Forest	Agricultural	Build up
Breeder	Ratios	0.4392	0.3078	0.5133	0.7844	0.58701	2.7217
	SE	0.2121	0.0948	0.1462	0.0733	0.1978	0.2105
	Mean use	0.0012	0.0006	0.0092	0.0363	0.0197	0.0558
	Mean available	0.0247	0.0152	0.1432	0.3722	0.2781	0.1665

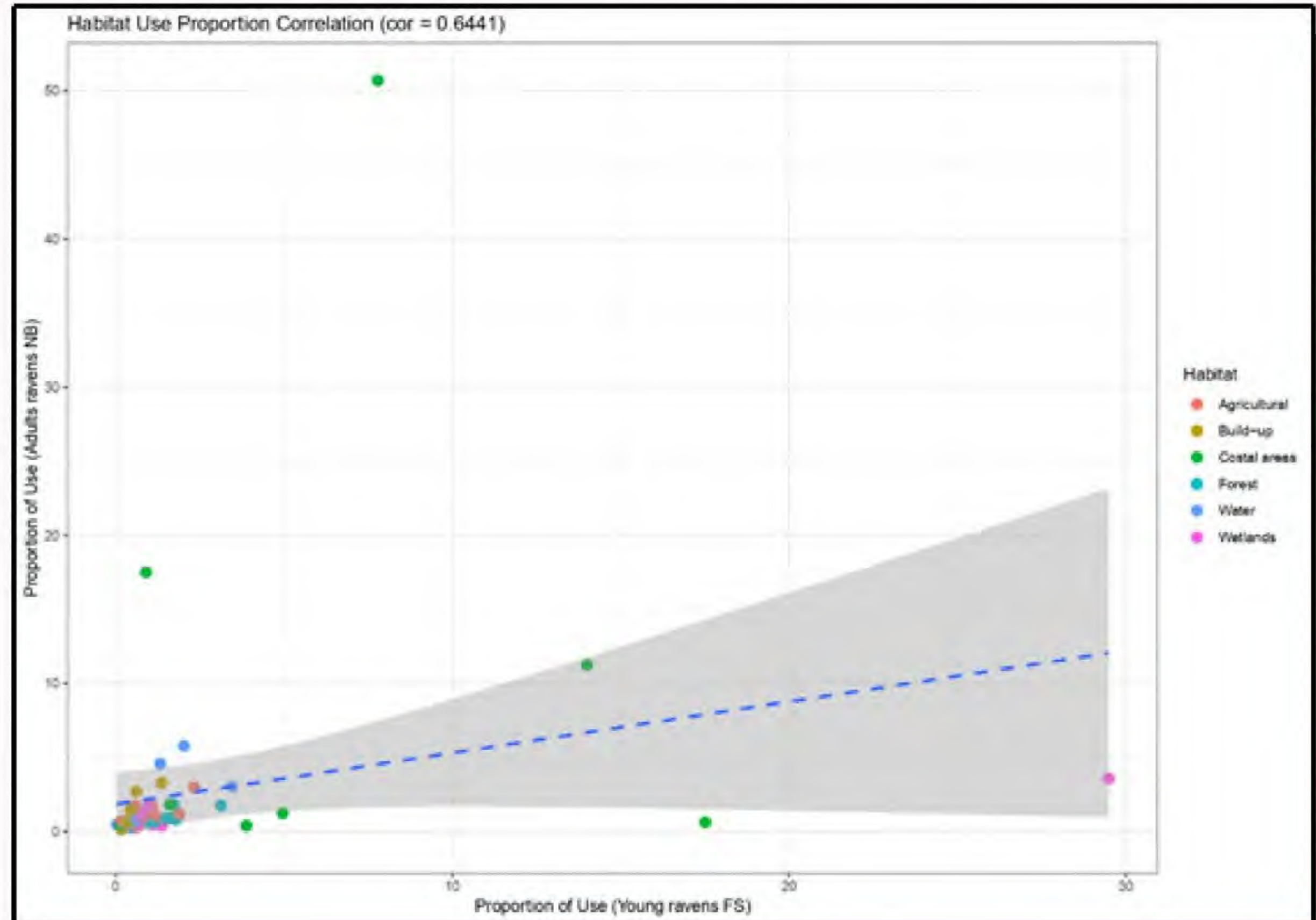
Correlation analysis to ex

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habitat selection.

and later life stage

Spearman's rank correlation shows a moderate positive association between habitat selection during the ravens family stage and habitat ratios at their non-breeder stage (Spearman's rank correlation: $\rho = 0.6441$, $p\text{-value} < 0.05$).





habitat use.

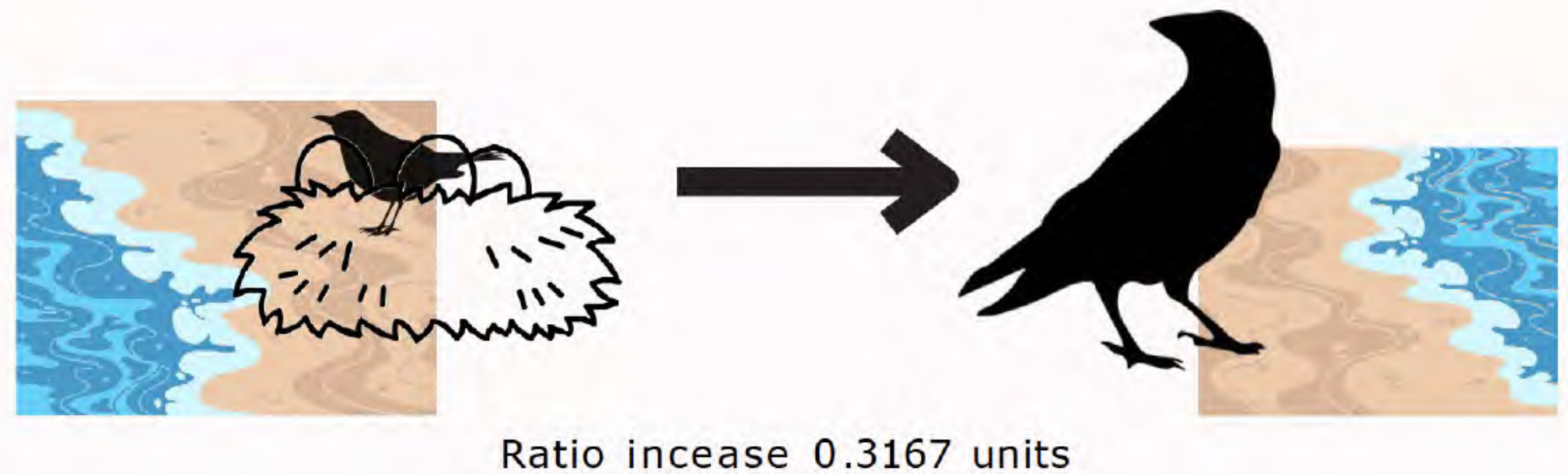
Young ravenes

Young-Adult ravens



Young ravenes

Young-Adult ravens



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adult ravens



Ratio incese 0.09555
units

Young ravenes

Young-Adult ravens



Ratio incese 0.5031 units



ult ravens



Ratio increase 0.8297
units

Young ravenes

Young-Adult ravens



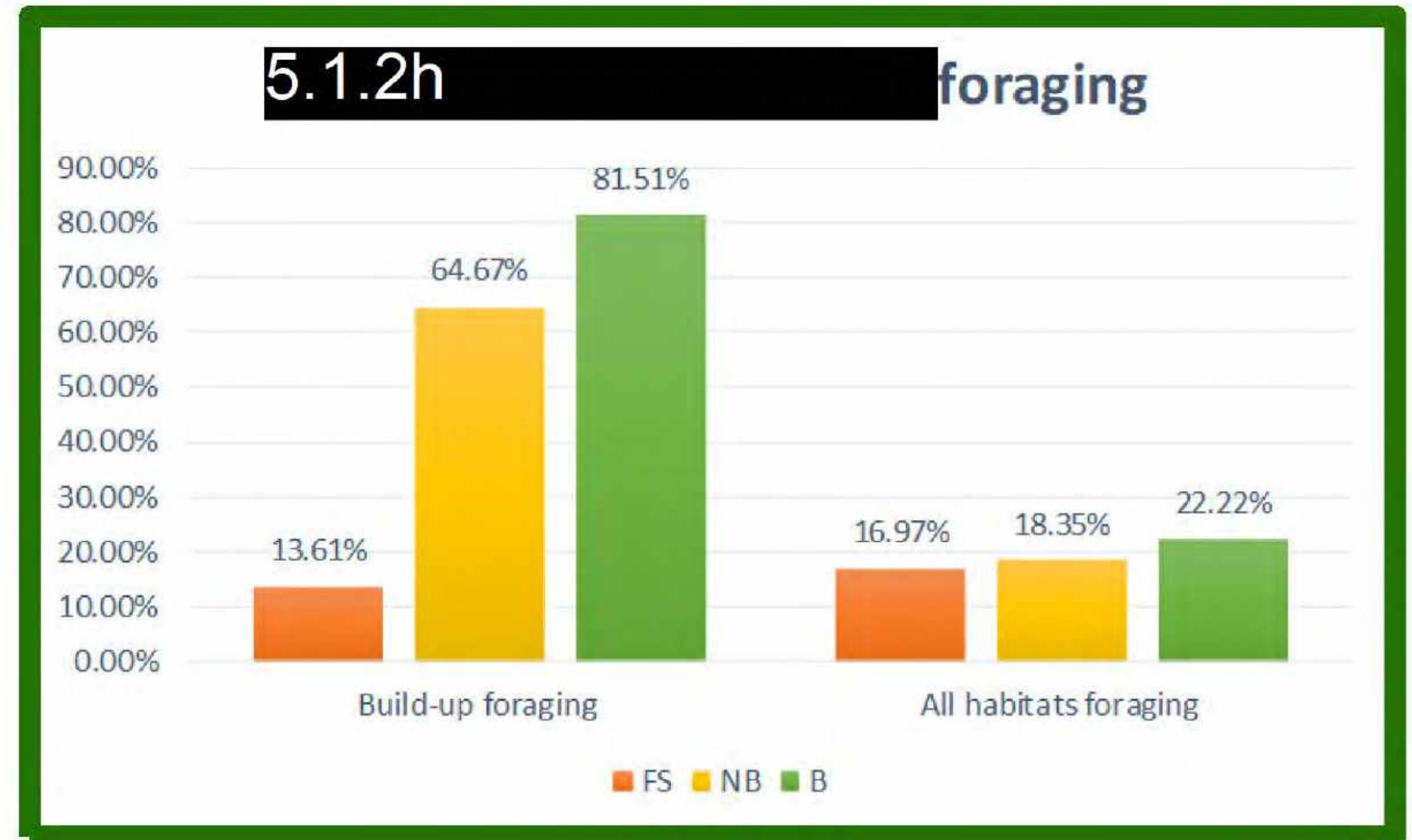
Ratio incease 1.6677 units

5.1.2h

During the family stage, 2974 GPS locations were referring to ravens foraging in built-up areas. 405 of these locations were within 5.1.2h V. This specific area constitutes 16.97% of the total space ravens utilize (their home range).

During the non-breeder stage, 8,118 GPS locations refer to ravens foraging in built-up areas. 5,250 GPS of these locations were within 5.1.2h This specific area constitutes 18.35% of the total space ravens utilize (their home range).

The breeder stage has a total number of 18,895, GPS locations in built-up areas. This area represented a notable portion of their space use within built-up areas (81.51%), which itself constituted 22.22% of their total space use.



This suggests that even within non-breeders' and breeders' stages some ravens actively select 5.1.2h 5.1.2h for foraging

Survival analysis

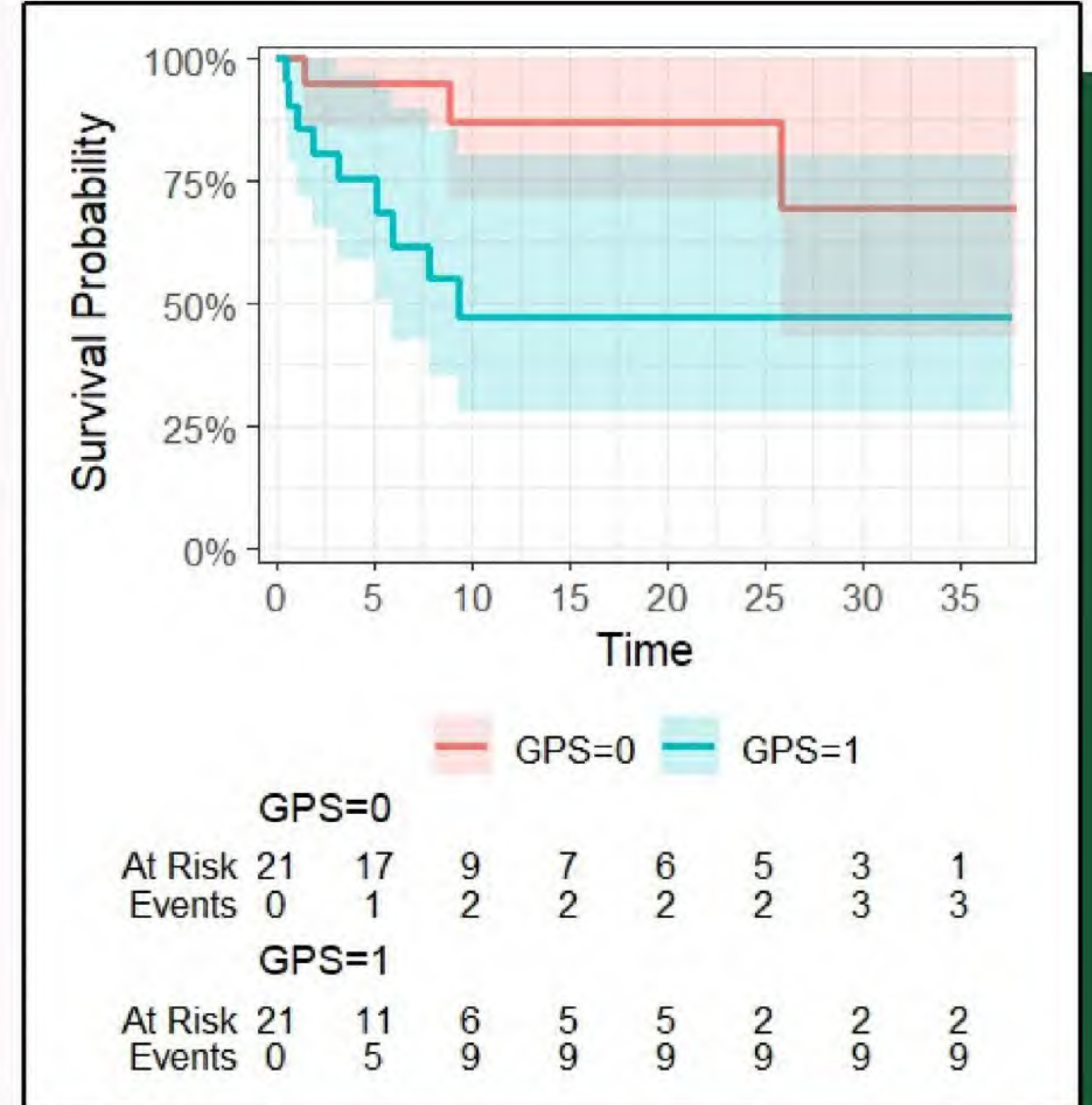
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Compared survival rates between GPS-tagged and untagged ravens.

Included information on birth year, weight, and last observation date in the analysis.

Employed Cox proportional hazards model to assess the effect of GPS tags on survival, controlling for weight and birth year

- GPS tag impact: Ravens with GPS tags exhibited significantly higher mortality risk ($HR = 5.29$) compared to untagged ravens.
- Weight influence: A trend towards lower mortality risk in heavier ravens was observed, though not statistically significant.
- Year effect: Potential yearly variations in survival were accounted for using a random effect for 'Year'.
- Model performance: The Cox proportional hazards model demonstrated good predictive ability (concordance = 0.808).





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DISCUSSION AND CONCLUSION

Habitat selection preferences evolve as ravens mature, leading to different foraging strategies and habitat choices.

Early foraging experiences influence later habitat preferences. This suggests that ravens' habitat preference is not only due to the habitat available but also due to the process of learning and moving with other ravens, developing preferences for certain foraging techniques and foraging sites (Bugnyar & Heinrich, 2006).

Ravens actively seek out anthropogenic food sources when available, expanding their foraging range beyond natural habitats.

Relationship between access to predictable anthropogenic food sources and modifications in social behavior during periods of food stress.



According to the survival analysis, the GPS-tagged ravens have a higher probability of mortality compared to the non-GPS-tagged ravens.

Further studies should consider other facts, such as nest location, size, age, and other health measurements to provide a more accurate result





By investigating how ravens' foraging habits evolve across life stages, particularly in relation to interactions with human-influenced food sources, the research underscores the impact of early experiences on later foraging behaviors.

Ravens, known for their cognitive prowess, serve as excellent subjects for studying foraging habits due to their social abilities and food source recognition.

Analyzing how early habitat use and human interventions shape raven behavior yields critical insights into the ecological and behavioral responses of this species.

These findings stress the importance of considering anthropogenic influences in wildlife conservation and management strategies.



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THANK YOU

Any questions?

5.1.2e

Van: 5.1.2e
Verzonden: dinsdag 19 september 2023 16:55
Aan: 5.1.2e
Onderwerp: Raven GPS

Hoi 5.1.2e en 5.1.2e

Mochten we uiteindelijk iets wetenschappelijk willen/kunnen publiceren met de raven gps data dan is het belangrijk dat de ethische toestemming goed geregeld is. Hoe wordt dat op dit moment gedaan? Is er toestemming vanuit de DEC (en zoja is er een referentie/vergunnings nummer)? Er stond me iets bij van toestemming om een bepaald aantal raven binnen een aantal jaar te zenderen?

Groet,

5.1.2e

From: 5.1.2e @wur.nl>
Sent: 15 September 2023 09:58
To: 5.1.2e @ark.eu>
Subject: RE: Leesvoer voor de eerste stagedagen

Hoi 5.1.2e

Zou je mij hier (nog eens) toegang tot kunnen geven? Of in ieder geval de Google Drive (5.1.2e @gmail.com), de Ornitela instructies en de thesis van 5.1.2e ? Ik ben met 5.1.2e in gesprek om evt een student te vinden die met de raven GPS data aan de gang zou kunnen gaan om hier meer uit te halen.

Groetjes en dank!

5.1.2e

From: 5.1.2e @ark.eu>
Sent: 05 February 2023 22:25
To: 5.1.2e @hvhl.nl>; 5.1.2e @gmail.com>
Cc: 5.1.2e @ark.eu>; 5.1.2e @wur.nl>
Subject: Leesvoer voor de eerste stagedagen

Ha 5.1.2e en 5.1.2e

Morgen beginnen jullie met je stage bij ARK en de WUR! Ik hoop dat jullie er zin in hebben! 😊

Zelf ben ik morgen de hele dag in Het Groene Woud, dus ik heb afgelopen week ik wat documenten bij elkaar gezocht die jullie alvast zelf kunnen bekijken.

Die documenten kunnen jullie via deze [WeTransferlink](#) downloaden. Ik heb een zipje gemaakt met daarin de volgende mappen:

- Annoteren en Agouti (oud) → Hierin vinden jullie oude Dood doet Leven ethogrammen met een oefen Excel (nog van Dood doet Leven in Limburg en Brabant) en het ethogram dat 5.1.2e en 5.1.2e gemaakt hebben voor dit project. Vervolgens vinden jullie een export van de video's en foto's die in Agouti verwerkt zijn; met een onvolledig ethogram en mogelijk foutief gelabelde data.... 🤔 Ennn een verouderd protocol dat gebruikt kan worden als hulpmiddel om met Agouti te leren werken.

- Artikelen → Hierin wat artikelen die over raven gaan en die jullie kunnen gebruiken om een beetje in de materie te komen
- Cameraprotocolen → twee **protocolen** (wolf aaseter voor dit project; en een oud DDL-protocol van Limburg en Brabant) waarin beschreven staat **hoe je de wildcamera's moet onderhouden en ophangen**
- Google Drive (online) → in deze map staan documenten die we op Google Drive up to date houden – voor nu even een offlineversie zodat jullie de docs alvast kunnen bekijken – ik zal jullie toegang geven tot de Google Drive – daarvoor hebben jullie wel een Google-account nodig (ik weet niet of jullie schoolmailadres aan Google gekoppeld is?) – **laat mij weten met wel mailadres ik jullie toegang kan geven** 😊
 - Ohja in de map:
 - Contacten Veluwe → telefoonnummers van terreinbeheerders en vrijwilligers die camera's checken
 - Overzicht gezenderde raven → overzicht met data van biometrie etc. erbij
 - Raven zender dagboek → dagboek waarin we bijzonderheden van de raven bijhouden – bijvoorbeeld wanneer je de raven een week checkt via het Ornitela portaal
 - Schema ravendata check → schema waarin we plannen en bijhouden wie de raven per week in de gaten houdt
- In de media → nieuwsberichten over dit project
- Monitoring valwildlocaties → pdf's van PowerPoints van 5.1.2e en 5.1.2e voor de partners van dit project en het vrijwilligers van Wolven in Nederland; en een **instructie** voor vrijwilligers **voor het controleren van wildcamera's op de Veluwe en voor clusterbezoeken**
- Studentenonderzoek → alle studentenonderzoeken die gedaan zijn in dit project onder begeleiding van ARK (met o.a. R scripts voor het clusteralgoritme van 5.1.2e)
 - Het onderzoek van 5.1.2e was voor Dood doet Leven in Brabant, maar ging specifiek over de raaf
 - Het onderzoek van 5.1.2e vond plaats in de voorfase van dit project en betreft een literatuurstudie
 - In een word bestand staan alle samenvattingen van de studentenonderzoeken in chronologische volgorde (van jaar van onderzoeksstage; van 2020 tot nu)
- En dan staan er nog wat losse documenten in de hoofdmap
 - Ethogram DDL Veluwe → hierin op de eerste pagina de afspraken over het annoteren van beelden en de gedragingen die geannoteerd moeten worden voor het Dood doet Leven project op de Veluwe; Wolf: aasleverancier en aaseter. Op de pagina's daarna volgt achtergrondinformatie met oude ethogrammen waarop het ethogram dat we nu in gebruik willen nemen gebaseerd is.
 - De foto's die we ophalen bij de wildcamera's willen we met dit nieuwe ethogram in Agouti verwerken
 - Hiervoor moeten we een nieuw Agouti project aanmaken
 - En vervolgens moet al het fotomateriaal dat we sinds de start van het project tot op heden verzameld hebben (op externe harde schijven) naar Agouti geüpload worden en geannoteerd worden
 - De video's willen die we ophalen bij de wildcamera's willen we met dit nieuwe ethogram in Excel verwerken (Agouti leent zich niet voor het annoteren van videomateriaal)
 - Hiervoor moet een standaard annotatie video format in Excel gemaakt worden (mogelijk dat het format van 5.1.2e en 5.1.2e aangepast kan worden op het nieuwe ethogram)
 - Instructie Ornitela portaal → opname met instructie voor gebruik van het Ornitela portaal door 5.1.2e 5.1.2e → eerst kijken voor je een week alleen de raven in de gaten mag houden
 - Zoekkaart lijkenpikkers → print em uit en hang em boven je bed ter inspiratie 😊

Oké, dit lijkt me voldoende voor nu. Veel plezier alvast met het volgende camerabezoek met 5.1.2e (voor hem de laatste keer)! En laten we deze week op donderdag of vrijdag een moment prikken om het verder over jullie stages te hebben.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e [@ark.eu](mailto:info@ark.eu)

Winselingseweg 95
6541 AH Nijmegen

Ons nieuwe meerjarenplan al gezien?
Klik op de cover hieronder.



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Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



Raven-onderzoek verbreed dankzij beurs

5.1.2e, onderzoeker bij de leerstoelgroep gedragsecologie (Animal Sciences), heeft een zogenaemde Dobberke Beurs ontvangen. Daarmee kan ze vijf extra zenders bekostigen voor haar onderzoek naar raven, wat een substantiële uitbreiding betekent van de dataset rond het gedrag van deze ooit vrijwel uit Nederland verdwenen vogelsoort.

5.1.2e doet onderzoek naar voedselstrategieën van raven op de Veluwe. Daartoe werkt ze nauw samen met stichting ARK en Ravenwerkgroep Nederland. Deze organisaties voorzien al sinds 2021 jonge raven van kleine gps-zendertjes. Aanvankelijk waren die bedoeld om te kunnen volgen of raven zich zouden verspreiden in het kielzog van de in Nederland terugkerende wolf. Maar de zendertjes bleken veel meer interessante informatie op te leveren.

Zo bleek bijvoorbeeld dat de vogels niet alleen bij karkassen foerageren, maar dat een aantal raven ook veel gebruikmaakt van voedselbronnen van menselijke oorsprong, zoals afvalbakken bij fastfoodrestaurants of bepaalde landbouwgewassen – en dat zelfs op de Veluwe, waar het natuurlijke voedselaanbod relatief groot is. Dat heeft zowel te maken met de Veluwse wolvenroedels die aas achterlaten, als met het feit dat aangereden wild er regelmatig wordt teruggebracht [in de kringloop](#), vertelt **5.1.2e**

Neofob

In zo'n omgeving met relatief veel natuurlijke voedselaanbod is de hang naar menselijke voedselbronnen extra opmerkelijk, want raven zijn van nature neofob: bang van nieuwe dingen. **5.1.2e** 'Dat is een interessant aspect: dat je ontdekt dat een dier dat eigenlijk heel schuw is toch dit gedrag laat zien. Blijkbaar hebben ze geleerd dat het niet onveilig hoeft te zijn. Maar hoe: uit de interactie met de omgeving, door imitatie van soortgenoten?'

De voedselvoorkeuren van raven riepen dus veel nieuwe vragen op. Waarom is de ene raaf beduidend vaker te vinden bij een menselijke voedselbron dan de andere? Hoe maken ze zich die foerageerstrategie eigen? Kijken ze dat af van hun ouders, of is de manier van voedselzoeken in de 'jeugdsoos' waarin jongvolwassen raven zich verzamelen doorslaggevend? En blijft die individuele voorkeur bestaan in de loop der tijd? Of wordt hun voedselstrategie opportunistischer als ze eenmaal als volwassen dier een eigen territorium hebben – eten ze dan vooral 'wat de pot schaft'? En varieert dat nog per sekse?

Sample size

Voor meer inzicht in deze mechanismen is een grotere *sample size* van grote waarde. Op dit moment zijn er op de Veluwe 21 raven met nog werkende gps-zenders. Dankzij de beurs kan **5.1.2e** dat uitbreiden met in ieder geval vijf, een uitbreiding van 25 procent, om raven te zenderen uit verschillende nesten op verschillende plekken op de Veluwe. Dat gebeurt komend broedseizoen al, door gespecialiseerde vrijwilligers van Ravenwerkgroep Nederland.

De zendertjes (exacte gewicht: xxx gram) worden met bijbehorende minuscule batterij en zonnecel (voor de stroomvoorziening van het datatransport) met een soort 'harnasje'

bevestigd aan een jonge raaf, terwijl het dier nog (niet vliegvlug) in het nest zit. De vogel leert er dus van jongs af aan mee vliegen en omgaan. Gelijktijdig met het zenderen wordt ook dna-materiaal afgenomen, zodat geslachtsbepaling mogelijk is. 'Op basis van uiterlijke kenmerken is dat bij jonge raven bijna niet vast te stellen. Terwijl het natuurlijk heel interessant is om te weten of mannelijke of vrouwelijke dieren zich anders ontwikkelen en misschien wel ander (foerageer)gedrag vertonen', aldus **5.1.2e**

Geduld

De data uit de zenders zijn in principe vrijwel realtime beschikbaar, afhankelijk van de tijd van het jaar. 'Midwinter genereert de zonnecel maar weinig energie en is het batterijniveau heel laag. Dan daalt automatisch de frequentie van wanneer je een update krijgt', legt **5.1.2e** uit. Het duurt nog wel even voordat de nieuwe zenders tot bruikbare inzichten leiden, waarschuwt ze. 'We zijn minstens een jaar verder voordat de gezenderde jonge raven individuele gedragingen laten zien. Raven verlaten pas na een maand of zes het nest en gaan de eerste tijd nog in familieverband op pad. Maar die eerste data geven straks al wel de eerste aanzet van: oké, wat voor typeanalyses kunnen we gaan doen?'

Over nut en noodzaak van dit onderzoek – 'je gaat natuurlijk niet zómaar vogels zenderen', benadrukt ze – heeft **5.1.2e** een duidelijk opvatting: 'Fundamenteel gezien is het heel interessant om te doorgronden hoe sociale processen werken rond het vinden van voedsel. En meer op het toegepaste vlak is het relevant om te begrijpen hoe we onze sterk door mensen gedomineerde leefomgeving beter geschikt kunnen maken voor deze en andere dieren.'

[kader – 72 woorden]

Vier keer raak

De [Dobberke Beurs](#) is een door de KNAW gecoördineerde beurs voor onderzoek naar diergedrag. Naast die van **5.1.2e** werden in de ronde van dit jaar nog drie andere Wageningse aanvragen gehonoreerd:

- **5.1.2e** : Can a conspicuous predator camouflage through background matching?
- **5.1.2e** : Unravelling the diet of multiple shorebird species in a threatened ecosystem using DNA-Metabarcoding.
- **5.1.2e** : Coping strategies: understanding how individuals respond to uncertainty.

5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: vrijdag 1 maart 2024 09:42
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: RE: Datumprikker raven zenderen

Hoi allen,

Maandagavond 11 maart lijkt de beste optie. **We starten een half uurtje later om 20:00.** Hopelijk lukt dat voor iedereen. Ik stuur jullie een Teams uitnodiging voor de meeting.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e
Sent: Friday, February 16, 2024 4:40 PM
To: 5.1.2e @ziggo.nl; 5.1.2e @sovon.nl; 5.1.2e @ark.eu; 5.1.2e @staatsbosbeheer.nl
Cc: 5.1.2e @ru.nl; 5.1.2e @wur.nl; 5.1.2e @wur.nl
Subject: Datumprikker raven zenderen

Hej allemaal,

De raven zijn er alweer druk mee, dus tijd dat wij de koppen ook weer bij elkaar steken. Ik heb een datumprikker aangemaakt om een geschikte avond te vinden waarop we allemaal kunnen 👍
<https://datumprikker.nl/p4xr45w5u6fq5dsq> Hopelijk past het tussen 19:30 en 20:30?? (een andere tijd vind ik ook prima). Laten we mikken op een avond in maart om te bekijken welke raven/ravennesten we kunnen selecteren voor het zenderen dit jaar en hoe we het verder praktisch willen gaan organiseren.

Vriendelijke groet,

5.1.2e (en 5.1.2e)



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: donderdag 27 juli 2023 10:42
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: RE: FW: Interessant paper!

Ha 5.1.2e

Zie dat deze mail een tijdje onbeantwoord is blijven liggen.

Ik wilde bij deze even reageren op de twee vragen uit jouw mail.

- 1) In hoeverre kunnen wij met onze data ook hier iets over zeggen (in de toekomst)???

Met de zenderdata van de raven zouden wij een vergelijkbaar onderzoek kunnen doen. Hoewel dit natuurlijk super interessant is, is het niet direct een van de doelen die we vanuit ARK nastreven. Het gaat er ons vooral om dat we middels de raven meer leren over de rol van de wolf als aasleverancier (en aaseter). De raven helpen bij het vinden van wolvenprooien. Nu zien we uit de recente ravendata wel dat er veel gefoerageerd wordt op de vuilnisbelt en andere antropogene voedselbronnen (veelal in agrarisch gebied). Het zou interessant zijn om te onderzoeken of wij vergelijkbare resultaten vinden als Loretto et al. Iedereen in onze werkgroep, Sovon, WUR en Ravenwerkgroep, heeft toegang tot het Ornitela portaal en kan de ravendata downloaden. Mocht je meer met de data willen doen en dit verder willen onderzoeken, dan is het wellicht goed om dit te bespreken met Sovon of de WUR. Wellicht dat je het zelf ook leuk vindt om een student te begeleiden in dit onderzoek 5.1.2e @ziggo.nl?

- 2) Welke kant willen we op met onze zenderdata van de raven??

Er valt veel te onderzoeken. Het foerageergedrag van de raven is voor ARK in zoverre interessant dat het iets zegt over het benutten van aas/kadavers op de Veluwe. Wij vinden (via de raven) maar een fractie van de kadavers die op de Veluwe te vinden zijn. We monitoren op 7 vaste locaties waar met regelmaat valwild wordt neergelegd. Daar zien we regelmatig raven op de beelden verschijnen, maar het aantal gezenderde raven dat we tot nu toe gezien hebben is erg klein. Nu het afschotseizoen weer begonnen is (sinds 1 juli) zullen er verspreid over de Veluwe weer veel meer kadavers te vinden zijn (niet alleen van wolvenprooien). Dit zal ongetwijfeld ook invloed hebben op het foerageergedrag van de raven. Ook hierin denk ik dat het mooi zou zijn om hier verder onderzoek te doen, maar ik verwacht niet dat ARK hier een grote rol in zal spelen.

Op het moment is 5.1.2e nog bezig met haar onderzoek afronden. En 5.1.2e (van Aeres Almere) loopt stage tot eind oktober. 5.1.2e borduurt verder op het onderzoek van 5.1.2e waaruit bleek dat aaseetgedrag van wolven gestuurd wordt door het seizoen en aan-/ afwezigheid van wilde zwijnen. De insteek van het onderzoek van 5.1.2e is om te bekijken hoe het aaseetgedrag van wolven samenhangt met de roedelgrootte en de populatiegrootte van wilde zwijnen in de verschillende gebieden op de Veluwe.

In 2024 zullen we weer nieuwe studenten begeleiden voor het wolven en ravenonderzoek. Het lijkt me goed om eind 2023 eens met elkaar af te stemmen wie wat onderzocht wil hebben en hoe we dit met elkaar kunnen oppakken. 😊

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e [@ark.eu](mailto:info@ark.eu)

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From: 5.1.2e [redacted]@ziggo.nl>
Sent: Sunday, July 2, 2023 6:20 PM
To: 5.1.2e [redacted]@ark.eu>; 5.1.2e [redacted]@ark.eu>
Cc: 5.1.2e [redacted]@gmail.com>; 5.1.2e [redacted]@wur.nl>
Subject: RE: FW: Interessant paper!

Mooi!!!

5.1.2e [redacted] is een van de bekende ravenonderzoekers (ook in relatie met wolf) die veel deed en doet in Yellowstone.

Mooi dat dit artikel nu verschenen is.

Sluit mooi aan bij eerder Oostenrijks onderzoek waarin ook gekeken is naar voedselbronnen van raven.

In hoeverre kunnen wij met onze data ook hier iets over zeggen (in de toekomst)???

Welke kant willen we op met onze zenderdata van de raven??

Groet,

5.1.2e [redacted]

Verzonden vanaf mijn Galaxy

----- Oorspronkelijk bericht -----

Van: 5.1.2e [redacted]@ark.eu>
Datum: 02-07-2023 13:02 (GMT+00:00)
Aan: 5.1.2e [redacted]@ark.eu>, 5.1.2e [redacted]@ziggo.nl
Onderwerp: FW: Interessant paper!

Super interessante nieuwe paper, via 5.1.2e [redacted] UU, over gebruik van antropogene voedselbronnen door raven in Yellowstone NP.

In de herfst en winter vliegen de raven verder en spenderen ze meer tijd buiten het NP om te foerageren op antropogene voedselbronnen.

<https://www.frontiersin.org/articles/10.3389/fbirs.2023.1119507/full>

Vriendelijke groet,

5.1.2e [redacted]



ARK Rewilding Nederland

Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

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From: 5.1.2e [redacted] <5.1.2e@uu.nl>
Sent: Friday, June 30, 2023 12:43 PM
To: 5.1.2e [redacted] <5.1.2e@students.uu.nl>; 5.1.2e [redacted] <5.1.2e@wur.nl>; 5.1.2e [redacted] <5.1.2e@ark.eu>; 5.1.2e [redacted] <5.1.2e@hvhl.nl>
Subject: Interessant paper!

Beste 5.1.2e (en anderen),

ik kwam dit paper tegen (<https://www.frontiersin.org/articles/10.3389/fbirs.2023.1119507/full>), en dat leek me heeeeeeel erg relevant voor je studie. Mocht je contact willen met de auteurs, ik ken 5.1.2e [redacted] erg goed, dus laat maar weten.

Groet,

5.1.2e [redacted]



Scavengers use natural and anthropogenic resources connecting protected areas with surrounding lands

www.frontiersin.org

5.1.2e

Assistant Professor, Animal Behaviour and Cognition, Utrecht University

5.1.2e

Padualaan 8 (room 5.1.2e), 3584 CH, Utrecht, the Netherlands

tel. 5.1.2e

<http://www.5.1.2e.com>

<https://www.researchgate.net/profile/5.1.2e>

From: 5.1.2e @students.uu.nl>

Sent: Thursday, May 25, 2023 11:40

To: 5.1.2e @wur.nl>; 5.1.2e @uu.nl>; 5.1.2e

@ark.eu>; 5.1.2e @hvh.nl>; 5.1.2e @hvh.nl>

Subject: RE: Veldbezoek 1 juni

Hi allen,

Fijn dat 12:00 ook voor jullie past! Tot volgende week!

Groeten,

5.1.2e

Van: 5.1.2e @wur.nl>

Verzonden: woensdag 24 mei 2023 16:04

Aan: 5.1.2e @uu.nl>; 5.1.2e @students.uu.nl>; 5.1.2e @ark.eu>; 5.1.2e @hvhl.nl

Onderwerp: RE: Veldbezoek 1 juni

Hoi allen,

Het gaat mij naar alle waarschijnlijkheid niet lukken om erbij te zijn. Dus ga vooral voor 12:00. Ik hoor graag hoe het was!

Groetjes,

5.1.2e

From: 5.1.2e @uu.nl>

Sent: 24 May 2023 15:38

To: 5.1.2e @students.uu.nl>; 5.1.2e @ark.eu>;

5.1.2e @hvhl.nl; 5.1.2e @wur.nl>

Subject: Re: Veldbezoek 1 juni

He 5.1.2e

dat gaat mij (en 5.1.2e , mijn PhD-student) ook wel lukken. Ik heb er zin in.

groet,

5.1.2e

Assistant Professor, Animal Behaviour and Cognition, Utrecht University

5.1.2e

Padualaan 8 (room 5.1.2e), 3584 CH, Utrecht, the Netherlands

tel. 5.1.2e

<http://www.5.1.2e.com>

<https://www.researchgate.net/profile/5.1.2e>

From: 5.1.2e <5.1.2e@students.uu.nl>

Sent: Wednesday, May 24, 2023 15:19

To: 5.1.2e <5.1.2e@ark.eu>; 5.1.2e <5.1.2e@uu.nl>;

5.1.2e <5.1.2e@hvh.nl>; 5.1.2e <5.1.2e@hvh.nl>; 5.1.2e <5.1.2e@wur.nl>

Subject: Veldbezoek 1 juni

Hi allen,

Ik heb zojuist van 5.1.2e te horen gekregen dat het handiger is als we er 12.00 kunnen zijn. Graag hoor ik of dat haalbaar is voor iedereen.

De locatie waar we afspreken is 5.1.2h. Wanneer je parkeert op de bezoekersparkeerplaats loop je richting het buitencentrum en zie je aan je linkerhand een groen hek, er staat ook een bord met 'beheerkantoor' en een pijl naar links. Daarachter vind je onze voordeur.

Groeten,

5.1.2e

5.1.2e

Van: 5.1.2e @ark.eu>
Verzonden: maandag 14 april 2025 09:11
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: Re: FW: Raven in BinnensteBuiten

Hej 5.1.2e

Dankjewel voor de update. Hopelijk gaat het jullie lukken om iets te organiseren. Zou toch leuk zijn om weer een beetje mediaaandacht voor de raven te krijgen.

Misschien is het praktischer direct contact te zoeken met 5.1.2e @gmail.com 5.1.2e

Succes met het ringen de komende periode! 🍁

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

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From: 5.1.2e @ziggo.nl>
Date: Thursday, 10 April 2025 at 20:32
To: 5.1.2e @ark.eu>, 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: FW: Raven in BinnensteBuiten

Hoi 5.1.2e en 5.1.2e

Het hier met 5.1.2e twee keer over gehad.

Ja, leuk om te doen.

Ben in principe 23 en 24 april beschikbaar. Weet 5.1.2e ook.

Hij is/ wij zijn op zoek naar geschikte locatie raaf. Dat valt niet mee voor die data. Raven lijken wat vroeger en ik ben bv vanaf vandaag elke dag aan het ringen. De 18e ook op de Veluwe. Begreep ook van 5.1.2e dat 'zijn' nesten ook al opschieten en dat ie bang is dat op 23/24 april ze al te ver zijn.... Heb voorgesteld of zij niet vroegere draaidag kunnen organiseren...

Maar, hij heeft contact met 5.1.2e hier over en zou er verder over communiceren, oa naar mij.

Groet

5.1.2e

Verzonden vanaf mijn Galaxy

----- Oorspronkelijk bericht -----

Van: 5.1.2e@ark.eu>

Datum: 10-04-2025 08:56 (GMT+01:00)

Aan: 5.1.2e@ziggo.nl, 5.1.2e@wur.nl>

Cc: 5.1.2e@ark.eu>

Onderwerp: FW: Raven in BinnensteBuiten

Ha 5.1.2e en 5.1.2e

Tijd geleden dat we elkaar gesproken hebben. Via 5.1.2e kwam onderstaande vraag van 5.1.2e voor opnames met Binnenstebuiten bij ons binnen.

Helaas kunnen 5.1.2e en ik beide niet op de genoemde data. Zou een van jullie het leuk vinden om met 5.1.2e op pad te gaan en te vertellen over het ravenonderzoek? We kunnen vanuit ARK wel beeldmateriaal aanleveren van raven bij kadavers.

Laat maar weten!

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland

Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

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From: 5.1.2e [redacted]@ark.eu>
Date: Wednesday, 9 April 2025 at 12:13
To: 5.1.2e [redacted]@ark.eu>, 5.1.2e [redacted]@ark.eu>
Subject: Fw: Raven in BinnensteBuiten

Ha 5.1.2e [redacted]

Ik weet niet in hoeverre je weer aan het werk bent.

Onderstaande lijkt me iets voor jou, maar je moet daar wel de ruimte voor voelen. Als alternatief 5.1.2e [redacted] vragen? en dn wel met de beelden van ons.

Groetjes,

5.1.2e [redacted]



ARK verlegt grenzen voor wilde natuur

5.1.2e [redacted]

(vrijdag is mijn vrije dag)

M 5.1.2e [redacted]

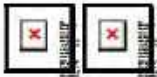
E 5.1.2e [redacted]@ark.eu

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www.ark.eu / www.levenderivieren.nl / www.dooddoetleven.nl / www.wolveninnederland.nl

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From: 5.1.2e [redacted]@ark.eu>
Sent: Wednesday, April 9, 2025 12:09 PM
To: 5.1.2e [redacted]@gmail.com>
Subject: Re: Raven in BinnensteBuiten

Hoi 5.1.2e [redacted]

Wat leuk dat jullie de raaf gaan promoten!

Het lijkt mij leuk en waardevol als we hier vanuit ARK aan meewerken. Leuke combi met 5.1.2e [redacted] van Sovon.

De geplande dagen komen voor mijzelf niet uit ivm kampeervakantie. Ik ga even navragen of een collega van mij dit zou kunnen doen.

Groetjes,

5.1.2e [redacted]



ARK verlegt grenzen voor wilde natuur

5.1.2e

(vrijdag is mijn vrije dag)

M 5.1.2e

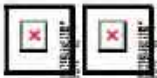
E 5.1.2e [@ark.eu](mailto:5.1.2e@ark.eu)

Winselingseweg 95

6541 AH Nijmegen

www.ark.eu / www.levenderivieren.nl / www.dooddoetleven.nl / www.wolveninnederland.nl

Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e <5.1.2e@gmail.com>

Sent: Tuesday, April 8, 2025 9:37 AM

To: 5.1.2e <5.1.2e@ark.eu>

Subject: Raven in BinnensteBuiten

Hoi 5.1.2e

Ik heb je mailadres van 5.1.2e . Ik had met hem een gesprek hoe leuk het zou zijn om aandacht te schenken aan het raven (en wolven) onderzoek bij tv-programma BinnensteBuiten. Ik ben ecooloog/vogelonderzoeker en presenteer maandelijks een item over vogels kijken bij BinnensteBuiten.

Ik was benieuwd in hoeverre jullie hier aan mee zouden willen werken?

Even het idee in het kort, maar andere ideeën zijn ook welkom.

- item van 8 minuten verdeeld over 2 blokjes
- natuurbeleving staat centraal, maar er is zeker ruimte voor onderzoek
- het idee is dat ik 1 blokje met 5.1.2e op pad ga om jonge raven te voorzien van kleurringen.
- dan zou ik graag een blokje opzoek gaan naar raven, bijv op een plek waar ze veel komen. Ik denk aan Barneveld. Of anders een plek waar bijv een wildcamera staat. Het zou natuurlijk leuk zijn als we beeldmateriaal van jullie wildcamera's kunnen gebruiken. Het lijkt me logisch als ik daarvoor iemand van ARK op pad ga.
- we hebben nu 23 of 24 april op het oog en 30 april als reservedag.

Normaal gesproken ga ik alleen op pad en vogels kijken of hooguit met 1 onderzoeker op pad, dus 2 onderzoekers vindt de redactie wel spannend, maar ik denk dat het wel nodig is om het verhaal goed te vertellen. Tegelijk met er dus voldoende ruimte blijven voor de fascinatie voor raven en natuurbeleving. Maar ik denk eigenlijk dat dat vanzelf gaat.

Even een grof beeld. Mochten jullie ook enthousiast zijn, dan kunnen we misschien even bellen?

Groetjes,

5.1.2e

5.1.2e

Van: 5.1.2e
Verzonden: maandag 17 november 2025 17:02
Aan: 5.1.2e
CC: 5.1.2e
Onderwerp: RE: Send data to MoveBank

Hoi 5.1.2e

5.1.2e 5.2.1

Hieronder onze geschreven evaluatie. 5.2.1

Underpinning

5.2.1

5.2.1

Ik heb inderdaad de survival analyse (opnieuw) gedaan voor de raven gezenderd in 21-22-23. Het belangrijkste hierbij was om de controls zoveel mogelijk hetzelfde te hebben als de gezenderde dieren (oa body conditie, jaar en locatie). Ik heb hiervoor de ringdata gebruikt en observaties van 'control' raven uit hetzelfde gebied, jaar en conditie vergeleken met de gezenderde dieren. Vooral de nestlocatie hetzelfde houden was cruciaal omdat er een verschil is in hoe waarschijnlijk ringen worden afgelezen op verschillende plekken in NL. Op basis van deze ringobservaties was er geen verschil in overleving (resighting) tussen de twee groepen. Dit is waar voor zowel at least one sighting (yes/no) en het aantal dagen tot de laatste sighting. Ik heb hier geen geschreven rapport van, enkel de datasets en r-script. Ik wilde deze eventueel nog een keer runnen als de nieuw gezenderde raven wat ouder zijn (dus alle raven meenemen, maar de ringobservatiedata uitzoeken kost best wat tijd) en/of integreren in een uiteindelijk paper over de raven data. Ik heb verschillende statistische modellen gedraaid, maar kort door de bocht was dit het resultaat:

# Observed	No	Yes
# no GPS	16	23
# GPS	9	12

Groetjes,

5.1.2e

From: 5.1.2e @ark.eu>

Sent: maandag 17 november 2025 16:15

To: 5.1.2e @wur.nl>; 5.1.2e @ru.nl>

Cc: 5.1.2e @ark.eu>

Subject: Re: Send data to MoveBank

Heeej 5.1.2e

Dankjewel voor de update!

En toch wel interessant onderzoek hoor. Houd ons op de hoogte.

Vanmiddag ook je voicemail ingesproken n.a.v. mailtje 5.1.2e (is op zoek naar project/onderzoek bij ARK) en haar onderzoek bij jou, haar resultaten en survivalanalyse van overlevingskans jonge raven (verkeerde analyse en conclusie). Ik begreep van 5.1.2e dat jij die analyse herhaald hebt en dat er geen verschil zit in overlevingskans gezenderde en niet-gezenderde raven. Wil je die delen? Kan die zo direct niet vinden.

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e

E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?

Klik op de kaart hieronder om lid te worden van ons netwerk!



Ons nieuwe jaarverslag al gelezen?
Klik op de banner hieronder.



Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e [redacted]@wur.nl>
Date: Monday, 17 November 2025 at 16:00
To: 5.1.2e [redacted]@ark.eu>, 5.1.2e [redacted]@ru.nl>
Cc: 5.1.2e [redacted]@ark.eu>
Subject: RE: Send data to MoveBank

Hi!

Ik heb net een mailtje naar 5.1.2e [redacted] gestuurd. Ik had dat zinnetje gemist in zijn vorige mail. Hij is echter tm de 24^e op reis, dus hopelijk weten we daarna meer.

In principe is alles geregeld met de data fees (order, invoice etc), alleen is de WUR langzaam met de betaling ook werkelijk doorzetten. Ik verwacht dat dit heel binnenkort gebeurt. Ik ben in contact met glosendas/ornitela hierover. Dan zouden we naar verwachting tot ong Feb gecovered moeten zijn.

Ik heb alle zenders nu gezet met een upload elke 2 dagen rond 13:00. Ik heb ook de andere instellingen voor alle zenders gelijk gezet maar misschien dat de instellingen niet de meest gunstige zijn (ik heb niks meer van 5.1.2e [redacted] gehoord maar ik hou de batterij status in de gaten).

Helaas stonden de nieuwe zenders (2024 en 2025) als default op een locatie opslaan elke 4 uur, wat een erg lage resolutie is om fourageer gedrag te onderzoeken. Dit heb ik nu aangepast, maar vanwege de winter is de batterij lager en dus ook de resolutie.

De student is inmiddels al begonnen, maar dit is slechts een kort Bachelor project en 5.2.1 [redacted]. Het idee is dat ze gaat kijken naar een op data gebaseerde onderscheiding van de afhankelijke en onafhankelijke fase (voortboordurend op

5.1.2e en dan specifiek de bezoeken aan de vuilnisbelt in Barneveld tussen deze twee fases gaat correleren. Dus komen raven die met hun ouders al regelmatig naar de vuilnisbelt gaan, hier ook vaker nadat ze onafhankelijk zijn geworden?

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: maandag 17 november 2025 15:19
To: 5.1.2e @ru.nl>; 5.1.2e @wur.nl>
Cc: 5.1.2e @ark.eu>
Subject: Re: Send data to MoveBank

Ha 5.1.2e

Ik denk dat 5.1.2e dit moet aanpassen. In zijn laatste mail schreef hij immers: “*Let me know what changes would you like me to make.*”

5.1.2e, het lijkt mij handig als dit via jou loopt, zeker omdat er in het nieuwe jaar weer een student met de ravendata aan de slag gaat. Eens? 😊 Zou jij dit dan ook met 5.1.2e kunnen oppakken?

Daarnaast zag ik in het Ornitela-portaal dat we nog steeds een negatief saldo hebben. Heb jij daar al contact over met Ornitela, of is er iets wat 5.1.2e en ik hierin kunnen betekenen?

Vriendelijke groet,

5.1.2e



ARK Rewilding Nederland
Aanjagers van wilde natuur

Vaste werkdagen: ma-di // do-vr

M 5.1.2e
E 5.1.2e @ark.eu

Winselingseweg 95
6541 AH Nijmegen

Al lid van het ARK Jonge Rewilders netwerk?
Klik op de kaart hieronder om lid te worden van ons netwerk!



Ons nieuwe jaarverslag al gelezen?
Klik op de banner hieronder.



Het werk van ARK wordt mede mogelijk gemaakt door de Nationale Postcode Loterij.



From: 5.1.2e @ru.nl>
Date: Monday, 17 November 2025 at 15:01
To: 5.1.2e @wur.nl>, 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Send data to MoveBank
Hoi allen,

Dat is misschien het gemakkelijkste? Dat we het samen online doen of dat (één van) jullie ons de inlog geven? Zodat we van beide kanten kunnen zien wat er gebeurt of (hopelijk) wat we zouden moeten doen.

Groeten,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: maandag 17 november 2025 14:48
To: 5.1.2e @ru.nl>; 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Send data to MoveBank

Hoi allen,

Voor mij dezelfde vraag. 5.1.2e en/of 5.1.2e kunnen jullie de datarechten/access op movebank naar één van ons of ons beiden doorzetten?

Als het makkelijker is, kun je eventueel ook je Movebank inlog met ons delen en dan proberen we het uit te zoeken.

Groetjes,
5.1.2e

From: 5.1.2e @ru.nl>
Sent: maandag 10 november 2025 10:42
To: 5.1.2e @wur.nl>; 5.1.2e @ark.eu>
Cc: 5.1.2e @ark.eu>
Subject: RE: Send data to MoveBank

Hoi allen,

Is hier inmiddels al meer over bekend? Als ik iets kan of moet doen, hoor ik het graag.

Groeten,
5.1.2e

From: 5.1.2e @wur.nl>
Sent: maandag 27 oktober 2025 12:45
To: 5.1.2e @ark.eu>; 5.1.2e @ru.nl>
Cc: 5.1.2e @ark.eu>
Subject: RE: Send data to MoveBank

Hoi 5.1.2e

Het maakt voor mij niet uit of alles via 5.1.2e of mij loopt. Ik denk echter wel dat jij en 5.1.2e dit via jullie accounts in Movebank moeten overzetten op een andere user.

Groetjes,
5.1.2e

From: 5.1.2e @ark.eu>
Sent: maandag 27 oktober 2025 08:29

Reeds beoordeeld

Overleg Wolf en Raaf

Maandagavond 20 december 2021 om 19:30

Aanwezig: 5.1.2e (ARK), 5.1.2e (ARK) en 5.1.2e (student ARK/WUR),
5.1.2e (WUR – vakgroep Behavioural Ecology), 5.1.2e (Ravenwerkgroep) en
5.1.2e (SOVON)

Agenda

1. Voorstelrondje

- 5.1.2e - Assistent professor vakgroep gedrag
 - Vooral geïnteresseerd in sociale component
- 5.1.2e - Ravenwerkgroep
 - Interesse in verspreiding & activiteitenpatronen
- 5.1.2e - Sovon
 - Is heel geïnteresseerd in raven

2. Terugblik 2022 (incl. communicatie)

- Er is een update gemaakt van het studieprotocol
 - Van 2022 t/m 2025 mogen we in totaal 30 raven zenderen
 - Dus nu nog 22 raven die we mogen zenderen!
- Stavaza gezenderde raven
 - 16 en K31 mogelijk beschoten?
 - NB Op 12-12-2022 is J59 overleden

Gezenderde raven in 2021

	gezenderd (stand met update 10-12)
	waarschijnlijk levend maar zonder zender (nec)
	waarschijnlijk dood (nec)

kleuring	leeftijd (dg)	grootte nest	geslacht	stand van zaken	terugmeldingen/afgelezen
ARK	42	3	V	15-5-21: 'flatline', zender met kapot tuig gevonden in nestteritorium. Tot vogel onbekend, waarschijnlijk dood.	-/-
ARK	36	2	V	5-12-21: 'flatline', zender (pavop) 16-3-22 gevonden met wat raveneren, waarschijnlijk predatie	-/-
H24	45	3	M		9-6-21: nestgebied 29-7-22 en 14-9-22: 5.1.2h
H27	36	3	V		28-5-21: nestgebied 7-10-21: 5.1.2h 26-8-21: nestgebied
J50	31	1	V	18-6-21: a.d.h.v. zender/raaf verzwaart in buurt nestteritorium gevonden. Bij vogelopvang	-/-
J51	38	5	M		30-7-21: 45-8-21: 16-9-21: 5.1.2h
J56	41	3	M	24-6-21: jong (enzenden) geoordeeld gevonden in nestteritorium	-/-



Gezenderde raven in 2022

	leegden vóór (met een priegel (rood))
	waarschijnlijk leegden/naar zender (rood)
	waarschijnlijk door (rood)

kleuring	leeftijd (dg)	grootte nest	geslacht	stand van zaken	terugneldingen/afgelezen
17	41	5	M		11-7 + 19-7 + 14-9-22 5.1.2h
18	38	5	M	18-9-22: afwijkingen grafieken: villegpatron en 'drop' temperatuur. 3-10-22: zender en kadaver gevonden op maisakker	29-7 + 18-8 + 14-9-22 5.1.2h
172	35	5	V		19-9-22 5.1.2h
178	35	8	M		7-10-22 5.1.2h
180	40	2	M	10-6-22: 'Flatline', kadaver o.d.h.w. zender gevonden in nestterrisarium. Waarschijnlijk predatie	9-10-22: schapen en masveld Hateren
159	39	2	V		-/-
130	39	3	V		-/-
131	39	3	M	10-9-22: geen uploads meer. Waarschijnlijk zender kapot	-/-



Hoe gaat het met de gezenderde raven van 2022?



- **Communicatie**
 - Ravententoonstelling
 - Artikel in Zoogdier – Voorjaar 2022
 - Roofvogeldag – Oktober 2022
 - Sovondag – November 2022
 - KNNV raaf – Najaar 2022
 - Tentoonstelling raaf en wolf in samenwerking met WiN in Soest
- **Vrijwilligers wolvermeldpunt**
 - 5.1.2e -> Coördinator midden Veluwe vanuit Wolven in Nederland
 - 5.1.2e -> monitort op de Veluwe; NB gaat nu tijdelijk voor stage naar Suriname (van 1 maart t/m 1 mei); studenten van ARK nemen de monitoring over
- **Samenwerking/ gedeeld eigenaarschap**
 - 5.1.2e geeft korte recap -> waarom ARK in dit project zit
 - Onderzoek met 5.1.2e
 - Vraag ARK -> onderzoek naar rol van wolf als aasleverancier en aaseter
 - Kennis en inzicht verzamelen over de invloed van de wolf, o.a. om beleid mee te laten groeien met de aanwezigheid van wolf als medebeheerder van hoefdierpopulaties
 - Begeleiding vanuit vakgroepen WUR -> duidelijke vraagstellingen
 - 5.1.2e -> nieuwe collega van 5.1.2e bij Sovon (doet ook veel met zenderdata)

3. Plannen voor 2023

- Mogelijkheden voor financiering
 - Fondsen
 - Raaf is geen Natura2000 soort, dus hier is geen reguliere subsidie voor beschikbaar
 - KNNV-ecologiefonds
 - Stichting Lucie Burgers
 - **Actie >> Februari/maart** met klein groepje bij elkaar zitten om aanvraag van subsidie in te vullen
 - National Geographic heeft ook fondsen
 - **Actie** 5.1.2e >> shortlist maken van fondsen die we kunnen aanschrijven
 - Klimmers -> pro deo wel mogelijk
 - 5.1.2e werkt veel samen met 5.1.2e voor het ringen van jongen in de omgeving van Lunteren
 - Zenderen
 - 5.1.2e heeft met 5.1.2e afgesproken om deze winter te oefenen met zenderen
- Benutten oude gps-zenders
 - Nu vier oude zenders
 - Waarvan bij een de vraag is of die het nog goed doet
 - Zender van 5.1.2h heeft piksporen
- Studentenonderzoek
 - Bij de WUR kunnen studenten op academisch niveau begeleid worden
 - ARK begeleid in het veld
 - Regelt ontheffingen voor studenten
 - Contact met beheerders
 - Monitoring en check van wildcamera's
 - Clustercontrole
 - NB Op 6 februari starten er weer twee studenten die verder gaan met onderzoek
 - 5.1.2e (Universiteit Utrecht) start met haar **stage bij de WUR** onder begeleiding van 5.1.2e bij de vakgroep Behavioural Ecology. 5.1.2e wordt vanuit de UU begeleid door 5.1.2e. 5.1.2e heeft PhD'er 5.1.2e (ravenonderzoek in Wenen) begeleid
 - 5.1.2e (Hogeschool van Hall Larenstein) loopt stage bij ARK
- Werkverdeling

4. Wvttk

- Braakballen pluizen
 - Wat je erin vindt, is locatie afhankelijk
 - 5.1.2e heeft veel braakballen uitgeplozen
- Slaapplaatsen worden in kaart gebracht door 5.1.2e
 - 5.1.2e maakt overzicht maakt een kaartje
- Er is een nieuwe ecooloog bij Veluwezoom (wie?)
- Willen we onze **zenderdata openbaar maken via MoveBank?**
 - **Actie >>** In februari nader bekijken

From nest to dump: Parental influence on anthropogenic foraging habits of the common raven

The role of parents in the anthropogenic diet preferences of ravens
(*Corvus corax*) for a waste processing facility

5.1.2e

YBI85812

Supervisors: 5.1.2e and 5.1.2e

Chair group: Behavioural Ecology

December 2025

BSc thesis Ecology

Abstract

Anthropogenic food resources are increasing in natural landscapes. Some animals, namely scavengers, utilize these resources which can have an effect on food webs and ecosystems. The development of diet preferences, such as the use of anthropogenic food resources, is determined by biological factors, social learning, and the environment. Besides that, the ability to adept to new food items is also important for the development of diet preferences. Neophobic species, such as ravens, are cautious about approaching new food items. The common raven (*Corvus corax*) is a generalist and scavenger and uses anthropogenic food resources. Social learning is important for ravens because it enables them to recognize when food is safe to eat, which is important for them given their neophobia. Parents may play a role in this social learning. I expect this because social behaviour and observance are important ways for ravens to overcome their caution toward new food items, and because parental influence plays an important role in the foraging behaviour in many other generalist species. This study focusses on the parental influence on the anthropogenic diet preferences of ravens. This study includes 26 ravens that were tracked using GPS devices. They were tagged with the devices when they were around one month old. The data has been collected from 27 April 2021 until 15 October 2025. This study focussed on one specific anthropogenic food resource: 5.1.2h waste processing facility 5.1.2h. This resource was chosen because ravens have been observed to visit this location often. The dependent and independent phase of ravens were first established. After that, visits to the facility in the dependent phase and independent phase were correlated, which is an indication of the influence of parents on the diet preferences of ravens. The visitation rates by ravens to 5.1.2h waste processing facility in the dependent phase was not significantly correlated with visitation in the independent phase. These findings were in contrast to the prediction that parents have an influence on the diet preference of ravens. The findings indicated however that ravens learn about anthropogenic food resources from peers or on their own. This emphasizes the importance of looking beyond parental guidance when studying how wildlife adapts its foraging behaviour to urbanization.

Introduction

Human activity continues to occur in natural landscapes by increasing recreation and ecotourism. These activities create anthropogenic food resources like landfills, roadkill, farms or campgrounds. These resources can be exploited by animals trying to find food efficiently as these resources are predictable (Oro et al., 2013). Particularly scavengers exploit anthropogenic food sources frequently (Loretto et al., 2016b; Webb et al., 2011). The availability and exploitation of anthropogenic food resources can have an effect on competition, predator-prey interactions, and nutrient transfer, which ultimately has an effect on food webs and ecosystems (Oro et al., 2013). This can be harmful for the ecosystem if it affects protected areas that maintain biodiversity (Watson et al., 2014). Therefore, understanding what influences the diet preferences of anthropogenic food resources, could provide important information.

Development of diet preferences by animals, such as the use of anthropogenic food resources, is determined by biological factors, learning, and the environment. Biological factors include taste preferences, physiological needs, and internal nutritional detectors and is often determined by genes. Animals can learn through individual experience or by social influences (Rozin, 1976 ; Sclafani, 1995). Individual experience encompasses trial-and-error, post-ingestive feedback, and prior exposure while social learning is shaped by observation and interaction with conspecifics, or sometimes even by other species (Rozin, 1976 ; Sclafani, 1995). For instance, primates and bears learn foraging techniques and food choices from their mothers (Jaeggi et al., 2009; Hopkins, 2013; Yi et al., 2020) while the Herring gull use human behavioural cues to choose which food item to eat (Goumas et al., 2020). Social learning from parents in early life stages can play an important role in the feeding preference of a lot of animals, mainly generalists (Avery, 1996; Franks et al., 2020; Mahmood et al., 2021; Jaeggi et al., 2009; Hopkins, 2013; Yi et al., 2020). Besides biological factors and learning, environmental factors such as availability of the food item can also play an important role in diet preferences (Greenwood, 1984). The ability to adapt to new food items is also related to the curiosity and caution of the species. Neophobic animals are hesitant to approach new food items while neophilic animals are curious and exploratory. Neophobic animals are likely to rely more on social learning, because observing others consume new food offers a signal that the food is safe to eat. In contrast, neophilic animals may learn more through individual experiences, since they approach new items with less caution.

An example of a neophobic species is the raven (Heinrich et al., 1995). The common raven (*Corvus corax*) in particular is an interesting species in the subject of anthropogenic food resources, as their neophobia would typically make them hesitant to approach new food items, and anthropogenic food sources are not part of their natural diet. Ravens have often been found to feed on anthropogenic food resources, like many other scavenger species (Loretto et al., 2016b; Webb et al., 2011). However, it remains undiscovered how ravens develop preferences for these food resources. It has been found that ravens feed more frequently on anthropogenic food resources in winter compared to summer (Ho et al., 2023). Mainly in summer, they still have a natural diet. The natural diet of ravens consists of carrion, small animals, eggs, and even plants, but this is mainly during summer periods (Nelson, 1934). However, variation in resource use does not only occur per season but there can also be strong variation among individuals in resource use (Ho et al., 2023). This variation shows that ravens are generalists.

Social dynamics are very important in feeding strategies of ravens because they are neophobes. Adult ravens call onto conspecifics before feeding, which can have multiple reasons (Heinrich & Marzluff, 1991). Younger ravens do it so the larger feeding group can overcome territorial adults who want to monopolize the carcass (Heinrich, 1988). Another reason is so the ravens can assess if the food is safe (Heinrich, 1988). Thus, social learning can facilitate the reduction of neophobia, allowing ravens to lose

their caution through observation and interaction with conspecifics, and not only by instinct (Heinrich, 1988; Heinrich et al., 1995).

Ravens also learn from non-conspecific carcass feeders and social interaction with other species (Stahler et al., 2002). One of such other species, is the wolf. An important foraging strategy of ravens is the stalking of wolves. Ravens associate with wolves even when the wolf has not killed a prey. This shows that ravens follow wolves throughout the day (Stahler et al., 2002). When a carcass is killed by wolves, ravens are less hesitant to approach and feed from the carcass (Stahler et al., 2002).

Parents may play a role in the social learning of ravens, as parental involvement in skill acquisition has been documented in other corvids such as New Caledonian crows. In New Caledonian crows (*Corvus moneduloides*) parents support learning of juveniles by permitting direct interaction during foraging (Uomini et al., 2020; Gray et al., 2010). Extended parental guidance in ravens could provide juveniles with an environment in which social conditions are created for substantial social learning from parents and other role models (Uomini et al., 2020). Ravens can stay with their parents until they are a couple months old. When ravens are about one to two months old they flee the nest (Miller et al., 2015). This means that they leave the nest but still stay with their parents. Shortly after fledging, young ravens exhibit a brief period of relative neophilia (Miller et al., 2015). During this period they are more willing to explore new food items. This temporary neophilia may facilitate learning about new food resources before caution (neophobia) increases with age. After fledging, the raven is in the dependent phase until they leave their parents, which is during their first summer, so when they are about 4-7 months old (Wright et al., 2003; Loretto et al., 2016a; Gallego-Abenza et al., 2022; Miller et al., 2015). Then they are in the independent phase. In the independent phase, they form non-breeding groups with peers for a few years (Wright et al., 2003; Webb et al., 2009). After about 3-4 years, and it can even take up to 10 years, they form pairs that are territorial (Loretto et al., 2016a). The extended stage of parental care during the dependent phase provides opportunity for juveniles to form diet preferences and social skill. However, direct research of parent to offspring transmission of diet preferences remains limited. Ravens have often been tracked while already in adulthood (Loretto et al., 2016b; Webb et al., 2011; Ho et al., 2023), but not while they were still under guidance of their parents. Understanding the role of parents in influencing the anthropogenic diet preferences of neophobic species, like the common raven, could provide insight into how species adapt to urbanisation.

This study focusses on the parental influence on the anthropogenic diet preferences of ravens. I expect that independent ravens who frequently use anthropogenic food resources learned this from their parents and therefore, also use these resources during their dependent phase. So, in other words, I expect that there is a correlation between the utilisation of an specific anthropogenic food in the dependent phase and the independent phase. I expect this because social behaviour and observance are such important ways for ravens to lose their caution and be able to feed (Heinrich, 1988; Heinrich et al., 1995). Also, since for many other generalist species, parental influence has shown to have large impacts on their foraging behaviour (Jaeggi et al., 2009; Hopkins, 2013; Yi et al., 2020). This study will be established by defining the dependent phase (when young ravens forage with their parents) and independent phase (when ravens have left their parents) of ravens to test whether there is a correlation between visiting anthropogenic food resources in the dependent phase and independent phase. If the visitations in the dependent phase are correlated to the visitation in the independent phase, it could show the parental influence on the diet preferences of this specific anthropogenic food resource, which could be an indicator for the general anthropogenic diet preferences of ravens.

Methods

Study population and study area

The study population consists of multiple individuals of the Common Raven (*Corvus corax*) that were born in the Veluwe. The Veluwe is located in the east of the Netherlands. The Veluwe is the largest protected area of the Netherlands and consists of forest, heather, and sand drifts (Hein, 2011). The landscape is composed of mainly coniferous and deciduous forests, alternated with heathland and grassland (Weterings et al., 2024). Ravens use coniferous trees to build nests in (Rösner & Selva, 2005). A variety of mammals inhabit the Veluwe, such as wolf (*Canis lupus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), horse (*Equus caballus*), red fox (*Vulpes vulpes*), and several others (Hein, 2011; Van Wieren & Groot Bruinderink, 2010; Van Der Maten et al., 2025). Although the Veluwe is a protected area, it is still affected by urbanization, deforestation, habitat fragmentation, and recreational pressure (Hein, 2011; De Jong et al., 2024).

For a long time, ravens were abundant species in the Netherlands. At the end of the 18th century, targeted control against ravens was initiated and the population of ravens in the Netherlands started to decline. During the 19th and early 20th century, strychnine was used to poison and kill ravens. In the mid 20th century, ravens in the Netherlands were extinct (van der Windt & Kneegting, 2005; Zekhuis et al., 2021). The reintroduction of ravens in the Netherlands started in 1966 (Timmerman, 1991; Zekhuis et al., 2021). In the period of 2008-2024, the minimal number of ravens that fledged increased substantially, with at least 281 ravens fledglings in 2024 (Vos Burchart et al., 2025). So, the reintroduction has evidently become a success, but the population size has not nearly reached the size it had in 1700, before the targeted control (Renssen & Vogel, 1993; Vos Burchart et al., 2025).

Multiple anthropogenic food resources are located in the Veluwe. One of these anthropogenic food sources visited by ravens is **5.1.2h** waste processing facility **5.1.2h**). Figure 1 shows this facility and two ravens who visited this location on 19 June 2025. This highlights the importance of anthropogenic food resources in the foraging ecology of ravens on the Veluwe.



Figure 1: Two ravens visiting **5.1.2h** waste processing facility in **5.1.2h** on 19 June 2025. The yellow lines represent the movements of an independent raven and the green lines the movement of a likely dependent raven. **5.1.2h** waste processing facility is highlighted with the pin (OrniTrack Control Panel, UAB Glosendas, June 2025).

Dataset and data collection

In this study, I used existing data collected by a total of 20 GPS devices on 26 ravens. GPS devices have been placed between 27 April 2021 and 18 April 2025. When the GPS devices were placed, the ravens

were between 30–43 days old (before fledging), with an average of 37 days. The placing of the GPS devices was carried out by Ravenwerkgroep Nederland and Sovon in collaboration with ARK Rewilding Nederland, under ethical permit (AVD25000202010465, Sovon22-01). Data used in this research was collected from 27 April 2021 until 15 October 2025. The GPS devices recorded locations at varying intervals. Across all ravens, the median recording interval was between 5 minutes to 2 hours, with an average of 40 minutes. The interval varied per season due to solar power availability. Intervals were shortest in summer, with a median of approximately 5 minutes in June, and longest in winter, with a median of approximately 4 hours in January. Some GPS devices have been reused. This is the case for ravens that had lost their tracker or for ravens that died and the tracker was found and reusable. The GPS devices are solar-powered and include a GPS/GSM transmitter and an accelerometer. Ornitela provided these transmitters. The ravens were ringed on the right leg with a coloured ring and on the left leg with a metal ring to enable identification. The dataset includes variables such as device_ID, the name of the raven, time, longitude and latitude, and other relevant variables. The dataset included 743,850 GPS locations from all birds combined after removing time-duplicates and rows with missing coordinates. Information for each raven can be found in Appendix A, Table A1.

Data preparation

I cleaned and filtered the data in R (version 4.5.1; R Core Team, 2025) using RStudio (version 2025/09/2; Posit Team, 2025). This included separating the data by raven instead of GPS devices, since some GPS devices were used for multiple ravens. Additionally, outliers were excluded based on two parameters. Firstly, if the speed between points was more than 100 km/hour, the row was excluded. Studies for many different bird species have shown that none of these bird species could exceed a speed of about 85 km/hour (Bruderer & Boldt, 2001; Alerstam et al., 2007). Secondly, if the distance between two points was more than 1000 km, the row was excluded. This excluded 5,193 datapoints from the dataset. Also, if the dataset of a raven did not possess 150 days of data, the data of the raven was excluded. This is because the data of these ravens did not include enough data about the independent phase of the raven, since ravens become independent when they are around 150 days old (Loretto et al., 2016a). A total of 9 ravens were excluded because of this reason, so 17 ravens were included in the analysis. All the data was combined in one dataframe that encompasses all ravens that will be studied.

Data analysis

Dependent phase and independent phase

I determined the dependent phase and independent phase of the ravens using multiple methods that identified two transition dates, one for fledging and one for the transition between the dependent and independent phases. I used spatial movement patterns to determine the two transition dates, specifically the distances between the ravens and their nest location. The nest coordinates for each raven, which were needed for both methods, were determined based on the first nightly roost locations of each raven. For ravens that came from the same nest, I took the average of these first nightly roost locations. This was necessary because GPS inaccuracy can cause ravens from the same nest to appear at slightly different locations. Ravens that came from the same nest were between 9 and 83 meters apart, except for one pair, Raven 22 and Raven 23, which had a 617 meters difference.

The first method was examining the distance from the nest to the nightly roost location of the raven. This was considered an indicator for the transitions because fledged ravens may start roosting in different locations in the territory of their parents, and independent ravens typically stop roosting within their parents' territory (Webb et al., 2012). To determine two clear transition dates, I used multiple approaches. In the first method, thresholds were used to determine the transitions. Fledging was

determined when the nightly roost location was more than 0.5 km away from the nest. This threshold was deliberately conservative, since it would have more effect on the results if classification would be premature instead of delayed. If data before the raven fledged was included in the dependent period, it would appear as if the raven did not visit the facility in the dependent phase, while in reality the raven did not fledge yet. Also, the 0.5 km buffer accounts for potential spatial inaccuracies in GPS positioning. The transition from dependence to independence was determined when the raven was over 10 km away from the nest. This threshold was taken because a study has shown that ravens have a territory size of about 13.1 km² (Rösner & Selva, 2005). If the raven was more than 10 km away from the nest, it is most likely that the raven did not spend the night in the territory of their parents and has therefore become independent. Next to this approach, I calculated a cumulative sum for the maximum distance of the nightly roost location to the nest. Transition times were identified using changepoint detection (Edelhoff et al., 2016; Gurarie et al., 2009) and segmented regression (Toms & Lesperance, 2003).

The second method was examining the minimum, median, and maximum daily distance from each raven to their nest. This was considered an indicator for the transitions because the maximum distance was predicted to increase when a raven has become independent. The minimum distance was also included because this distance should remain consistently higher once a raven does not return to the nest anymore and becomes independent. I calculated a cumulative sum for the daily maximum and daily minimum distance to the nest. For both the cumulative sums, transition times were established using changepoint detection and segmented regression.

Table 1: Overview of methods for determining fledging date and the transition date from dependent to independent. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Methods

Method 1 thresholds

Method 1 changepoint detection

Method 1 segmented regression

Method 2 changepoint detection maximum

Method 2 segmented regression maximum

Method 2 changepoint detection minimum

Method 2 segmented regression minimum

For each method, the time period of examination was until the ravens were nine months old. This is because after some time, other factors might influence the distance between the nest. For example, when the raven finds a partner and makes a nest of itself or when the raven flies to another country. Most methods, except the one based on thresholds, detect the transition dates based on change in behaviour, such as an increase in distance from the nest. However, if data beyond nine months is included, such a behavioural change might not indicate the transition to independence, but rather changes later in the life of the raven, when the raven is already independent for some time.

After all the dates for each of the seven methods was determined, I made two Pearson correlation matrices to compare the results between the different methods. One for the fledging dates for each method and one for the transition date from dependent to independent for each method. This was done to assess if the methods showed similar patterns for ravens that fledged relatively early or late, and for

ravens that became independent relatively early or late. I interpreted correlations as weak ($r < 0.40$), moderate ($r = 0.40$ to 0.69), or strong ($r \geq 0.70$). In addition, I calculated the mean absolute difference in days between each pair of methods to determine if the methods had similar enough results for the dates to be combined. Methods were considered similar enough to combine if the mean absolute difference was less than 14 days. When the methods could not be combined, the threshold method for the distance from the nest to the nightly roost location was used. I chose this method because it was based on prior research on ravens. Specifically, it was based on the territory size of ravens (Rösner & Selva, 2005). Also, because this method complied the most with the expected life cycle of ravens, which is that the ravens are about one to two months for fledging and reach independence in their first summer (Miller et al., 2015; Wright et al., 2003; Loretto et al., 2016a; Gallego-Abenza et al., 2022). Matrices were visualised using the *complot* package in R (Wei & Simko, 2024).

After the dates for fledging and transition from dependent to independent were determined, I took a temporal buffer around these dates. This buffer was taken to ensure that observations from one phase were not misclassified as belonging to the other, minimizing the risk of classification errors. For almost all ravens, a temporal buffer of 7 days after the fledging date, 7 days before the transition from dependent to independent, and 30 days after the transition from dependent to independent was taken. The buffers of 7 days after fledging and 7 days before independence were kept relatively short to limit the loss of data in the dependent period, which for most ravens was already quite short, with an average of only 2 to 3 months of data. The buffer of 7 days after fledging was also kept short, because a threshold of 0.5 km from the nest at night is already quite a considerable distance to be classified as an unfledged raven. The period after the found date for the transition to independence was buffered relatively long. This was because some ravens still returned close to the nest after reaching a 10 km distance from the nest, which may indicate they were not completely independent yet. On top of this, the found dates for reaching independence were early compared to the expected life cycle of ravens and the other methods (Miller et al., 2015; Wright et al., 2003; Loretto et al., 2016a; Gallego-Abenza et al., 2022). Therefore, a longer temporal buffer was taken. There were two ravens for which these temporal buffers were not similar as for the rest. The first one is Raven 4. Raven 4 exhibited a relative late transition date to the independent phase compared to the other ravens in this study, the dates identified by the other methods, and the expected life cycle of ravens (Miller et al., 2015; Wright et al., 2003; Loretto et al., 2016a; Gallego-Abenza et al., 2022). Therefore, a temporal buffer of 30 days before the found transition date for independence and 7 days after this date were taken. The buffer for the fledging date stayed the same for Raven 4. The second raven was Raven 20. Raven 20 had a very short dependent phase of only 30 days. The date for fledging was relatively late and the date for becoming independent was relatively early compared to the other ravens and life cycle of ravens (Miller et al., 2015; Wright et al., 2003; Loretto et al., 2016a; Gallego-Abenza et al., 2022). Thus, no buffer period was applied after the fledging date or before the transition to independence, so that there was enough data from dependent phase available for further analysis. However, a 30 day buffer was applied after the transition to the independent phase, as for all the other ravens except Raven 4.

Correlation between dependent and independent visitation

Before analysing the correlation between dependent and independent visitation to **5.1.2h** waste processing facility, it was necessary to establish what defines a visitation. Using satellite imagery, I drew a polygon around the facility to establish the boundaries (Figure 2). The facility area is around 29.4 hectares. I compared the coordinates of each raven to the facility area. I quantified visitation as the percentage of days visiting the facility per month. This approach aimed to control for variation in GPS logging intervals. GPS inaccuracy (as shown by variation in nest locations) could have influenced

determining the visitation, because for instance ravens that actually visited the area may occasionally have been tracked just outside the facility.



Figure 2: A map of 5.1.2h waste processing facility in 5.1.2h. The blue polygon marks the facility.

I determined the correlation between dependent and independent visitation to 5.1.2h waste processing facility by using a simple linear regression. A simple linear regression was chosen because each raven contributed a single data point to the model. To control for the possible effect of season, I analysed the correlation between dependent and independent visitation using a simple linear regression model, comparing visitation within the same months for dependent as independent only. Visitation in the independent phase (average % of days per month) was the response variable and visitation in the dependent phase (average % of days per month) was the predictor variable. The distance from the nest to the facility was also added as an predictor in an additional model as a covariate to assess whether this distance confounded the relationship. This covariate was included because nests closer to the facility could have an advantage in finding the location. Collinearity between the predictors was determined by using the Variance Inflation Factors (VIF=1.74), which indicates no problematic collinearity. Model assumptions were assessed visually with the use of diagnostic plots (Appendix B, Figure B1) and were reasonably met. All analysis were conducted in R (version 4.5.1; R Core Team, 2025).

Results

Dependent phase and independent phase

Out of the 26 ravens that were tracked, 9 ravens were excluded because they did not have 150 days of data. For the rest of the 17 ravens, the methods and approaches to determine the time of fledging and time of transition between dependent and independent phase gave seven separate results. For most of the ravens, the seven results were all very different (Raven 10, Table 2). More than a week between dates and sometimes even months was found. The results for the other ravens for every method with approach can be found in Appendix D (Tables D1-D16).

Table 2: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 10, which hatched on 23-03-2022. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest. Before applying a changepoint detection or a segmented regression, a cumulative sum was calculated.

Method	Fledging date	Transition date
Method 1 thresholds	23-05-2022	12-09-2022
Method 1 changepoint detection	12-09-2022	12-11-2022
Method 1 segmented regression	01-05-2022	18-07-2022
Method 2 changepoint detection maximum	16-07-2022	02-10-2022
Method 2 segmented regression maximum	30-06-2022	16-09-2022
Method 2 changepoint detection minimum	04-8-2022	12-10-2022
Method 2 segmented regression minimum	28-09-2022	08-12-2022

The correlation matrix for the fledging dates shows that there was no pattern between the different methods (Figure 3, left). The methods had weak to moderate agreement ($r=-0.35$ to 0.61), so there were no strong correlations ($r \geq 0.70$). The highest correlation was between the segmented regression on roost distance from the nest (method1_segmented) and segmented regression on minimum daily distance from the nest (method2_min_segmented), with an r of 0.61 . The method that used thresholds for the distance between roost location and the nest had the lowest agreement with the other methods. In contrast, the correlation matrix for the transition dates between the dependent and independent phase does show agreement between methods ($r=-0.21$ to 0.81) (Figure 3, right). The highest correlation was between the changepoint detection on roost distance from the nest (method1_changepoints) and changepoint detection on maximum daily distance from the nest (method2_max_changepoints), with an r of 0.81 . Although other methods also showed moderate agreement, these two methods were the only ones with a strong correlation ($r \geq 0.70$). The method that used thresholds for the distance between roost location and the nest again showed the weakest agreement with other methods.

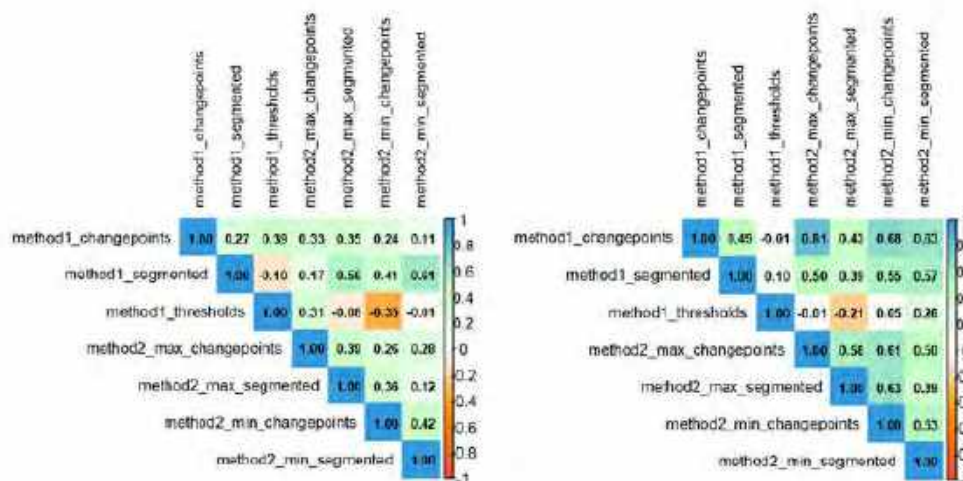


Figure 3: Pearson correlation matrices that compare the seven method for determining the fledging dates (left) and transition dates from dependent to independent (right). Colours indicate the strength between the correlations. It ranges from -1 (red) to 1 (blue) correlations. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest. Before applying a changepoint detection or a segmented regression, a cumulative sum was calculated.

The mean absolute difference between every method for the fledging dates and the transition dates from the dependent to independent phase exceeded the 14 day threshold required to combine them (Appendix C, Figure C1). The average number of days difference for the fledging dates ranged from 25.88 to 81.59 days. The average number of days difference for the transition dates from the dependent to independent phase ranged from 18.94 to 78.25 days. Therefore, the threshold method was used to determine the dependent and independent phase (Raven 10, Figure 4). The results for the other ravens for this method can be found in Appendix D (Figures D1-D16). Raven 23 did not have a result for this method because it never reached a distance of 10 km from the nest. Therefore, Raven 23 was also excluded from the analysis.

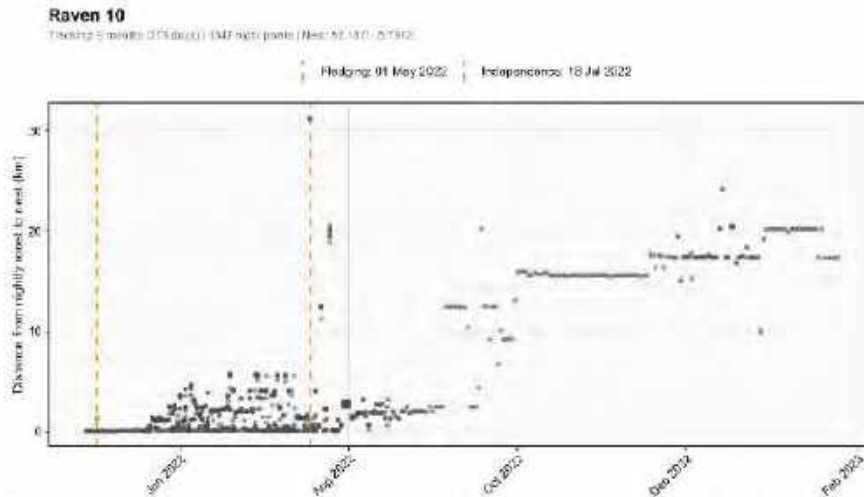


Figure 4: The transition periods for Raven 10. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

After buffering the transition periods as described in the methods, the dependent phase and independent phase were established (Table 3).

Table 3: Time period in days of each phase and age when each phase started in days after hatching, with buffers included.

Raven number	Dependent period (days)	Age starting dependent phase (days)	Number of observations dependent phase	Independent period (days)	Age starting independent phase (days)	Number of observations independent phase
3	27	69	5445	1542	133	74603
4	162	48	27974	1413	247	91969
6	41	66	8724	1103	144	80898
8	51	71	10383	463	159	17837
10	64	46	11476	1154	147	88038
11	94	66	18969	911	197	8133
13	40	68	8407	99	145	7021
14	63	74	7736	1106	174	59354
16	65	74	1608	98	176	1519
17	64	69	2042	35	170	5016
19	36	90	1766	83	163	2999
20	27	82	290	791	139	61231
22	74	44	636	416	155	2719
24	54	64	558	414	155	3922
25	43	83	444	47	163	477
26	61	66	632	47	164	434

Correlation between dependent and independent visitation

Visitation to **5.1.2h** waste processing facility in the dependent phase did not significantly predict visitation in the independent phase (estimate=2.94, SE=1.93, $t=1.52$, $P=0.17$, $R^2=0.23$). There was no statistically detectable relationship between visitation in the two phases (Figure 5). Distance from the nest to the facility was included as a covariate in an additional model but this did not improve the model (R^2 increased from 0.225 to 0.232) and was not a significant predictor ($P=0.81$). Some ravens that visited the facility frequently in the independent phase, did not visit the location once in the dependent phase. One raven visited the facility in the dependent phase, but not in the independent phase.

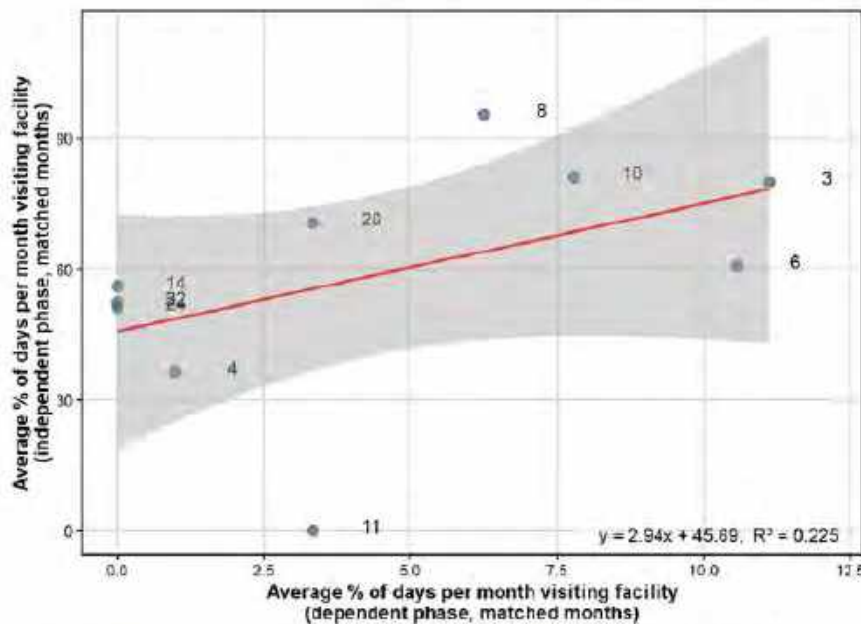


Figure 5: Linear regression showing relationship between visitation rates during the dependent phase and independent phase, matched by months. Each point represents a raven ($n=10$). The red line shows the linear regression ($y = 2.94x + 45.69$, $R^2=0.23$). The grey area shows the 95% confidence interval.

Discussion

The aim of this study was to determine if parents influenced the use of anthropogenic food resources with ravens by testing if there is a correlation between visiting anthropogenic food resources in the dependent phase and independent phase. Visitation to **5.1.2h** waste processing facility in the dependent phase of ravens did not predict the visitation to this facility in the independent phase. Some ravens visited the facility frequently in the independent phase but not at all in the dependent phase, based on the GPS tracking data, suggesting that parents do not influence the use of anthropogenic food resources in ravens. This contradicts my expectations. I expected to find a correlation between the utilization of an anthropogenic food resource in the dependent phase compared to the independent phase. This would have implied that parents have an influence on the use and preference of anthropogenic food resources. I expected this given the importance of social learning in ravens to reduce their neophobia (Heinrich, 1988; Heinrich et al., 1995) and because of the parental influence on foraging behaviour in other generalist species (Jaeggi et al., 2009; Hopkins, 2013; Yi et al., 2020). However, the results did not support these predictions and could instead indicate that ravens learn about anthropogenic food resources from peers or on their own.

Interaction between peers has been shown to influence the foraging behaviour and diet preference of ravens (Heinrich & Marzluff, 1991; Heinrich 1988). When ravens become independent, they spend multiple years in non-breeding groups. They use these groups to gather information and access food resources (Marzluff et al., 1996; Wright et al., 2003). The increased visitation rates to the waste facility during the independent phase observed in this study are aligned with this. A recent study that used GPS tracking found that juvenile ravens are attracted to locations used by local non-breeder groups, and that familiarity among peers predicted shared space use (Bapat et al., 2025). This also highlights the importance of peers in predicting the locations of ravens, including potential foraging sites. Nevertheless, the dependent phase may still contribute to foraging behaviour and diet preferences. A laboratory study demonstrates that raven siblings copy each other in tasks that were relevant for foraging (Schwab et al., 2008). This suggests that relationships between kin during the dependent phase can shape foraging behaviour. In addition, the size of the rearing group has been shown to influence the foraging development in juvenile ravens (Boucherie et al., 2025). These studies indicate that social influences, beyond learning from parents, in the dependent phase might play a role. Similar studies across different bird species provide additional context. In Hibi (*Notiomystis cincta*), early social experiences with parents affected the initial foraging behaviour. However, these preferences were overridden by behaviour learned from peers in social environments when they became independent (Franks et al., 2020). Furthermore, research on wild great tits (*Parus major*) suggests that foraging behaviour is transmitted primarily through siblings, but also by peers and parents (Wild et al., 2025).

To understand the influence of peers on the diet preferences of ravens, future research should directly study the influence of peers on the utilization of anthropogenic food resources. A valuable experiment would be to test whether ravens learn to use anthropogenic food resources from peers or by discovering these resources on their own. This could be investigated by comparing multiple non-breeding groups where individuals already have experience with an anthropogenic food resource to multiple groups in which no ravens have prior experience. These individuals with experience would visibly use a new resource in front of naïve group members, while the other groups would have access to the same resource but do not have individuals with experience that can demonstrate the utilization of this resource. If individuals from groups that received demonstrations use the resource sooner and more often than individuals from groups without demonstration, this would provide evidence that peers, rather than individuals on their own, discover these resources, suggesting that peers influence the diet preferences for anthropogenic food sources of ravens.

Even though this study found no evidence of parental influence on the diet preferences of ravens, several limitation in this study may have affected this conclusion. First, GPS inaccuracy could cause ravens to appear at slightly different locations than they actually were. This could lead to ravens being incorrectly classified as having visited, or not visited **5.1.2h** waste processing facility. One pair of ravens, Raven 22 and Raven 23, that were presumed to be from the same nest, had a 617 meter location difference on the first night. This could mean strong GPS inaccuracy or that the ravens were not from the same nest. The nest coordinates of these ravens could be inaccurate and impact the determination of the phases, since all methods relied on these coordinates. Second, GPS logging intervals varied both between ravens and within individuals, this could potentially affect calculations of daily distance from the nest and visitation rates. Although measuring the number of days visited rather than total visits aimed to address this, some intervals of 4 hours or more may have allowed ravens to visit and leave the facility without being recorded. Third, the determination of the dependent and independent phase was difficult due to inconsistent results across the different methods. To account for the inconsistency, one method was chosen and large temporal buffers were applied, which resulted in less data, especially for the dependent phase. Interestingly, the correlation matrix for the transition dates between the dependent and

independent phase showed that some methods have similar patterns, yet the method chosen, using thresholds for distance between nightly roost location and nest, was least consistent with these patterns. Fourth, a 10 kilometre distance from the nest was used as a threshold to define the transition from the dependent to the independent phase. This excluded one raven that never exceeded this distance. This could indicate that this threshold may be too large for ravens in the Veluwe, since the fragmented landscape can lead to smaller territories. Finally, the sample size of only 16 ravens may have caused limited statistical power.

Future studies would benefit from improved GPS accuracy with shorter and more consistent logging intervals and a larger sample size. Further research into methods that distinguish the phases and territory size specific to the study region would also be valuable. Additionally, future research on parental influence of the diet preference of ravens should account for the brief neophilic period after fledging (Miller et al., 2015). During this period, juveniles may independently discover anthropogenic food resources while still in parental territory. A correlation between the dependent and independent phase visitation could therefore reflect individual exploration instead of parental influence.

This study is relevant for the broader understanding of how animals develop diet preferences for anthropogenic food resources, with ravens as a model species. It also provides insights on the mechanisms behind wildlife adaptation to urbanisation. Many other species, including coyotes, red foxes, brown bears, and various corvids, also exploit anthropogenic food resources (Murray et al., 2015; Fletcher et al., 2025; Francioni et al., 2025; Benmazouz et al., 2021). The utilization of anthropogenic food resources can impact food webs and ecosystems by altering competition, predator-prey interactions, and nutrient transfer (Oro et al., 2013), which makes it important to understand how animals develop diet preferences. Beyond these broader implications, the monitoring of the relationship between ravens and anthropogenic food resources alone is also very important. The utilization of these food resources by ravens leads to an increasing population (Marzluff et al., 1994). This can form issues for endangered species on which these ravens predate (Kristan & Boarman, 2003; Coates & Delechanty, 2010). Furthermore, ravens are fundamental for the removal of carcasses (Wilmers et al., 2003), which is an important ecosystem service for nutrient transfer. The introduction of anthropogenic resources could affect the efficiency in carcass removal by ravens. Moreover, feeding on anthropogenic food resources could cause lead poisoning (Craighead & Bedrossian, 2008). Understanding how animals develop diet preferences for anthropogenic food resources could provide insights for land management strategies and help prevent possible harmful consequences of anthropogenic food resource use.

In conclusion, this study found no evidence that parents guidance of ravens during the dependent phase results in anthropogenic diet preferences of ravens. Instead, the increased visitation to the waste processing facility in the independent phase suggest that interactions between peers in non-breeding groups may be where ravens develop preferences for anthropogenic food resources. This study highlights the need to look beyond parental guidance when studying how wildlife adapts its foraging behaviour to urbanization.

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Let op: Deze thesis is een leerdokument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

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Appendix A

Table A1: General information for each raven that was tracked between 27 April 2021 until 15 October 2025.

bird ID	transmitter ID	nest ID	nest coordinates (lat, long)	days tracked	hatching date	tagging date	last date transmitting
1	212235	1	5.1.2h	18	16/03/2021	27/04/2021	15/05/2021
2	212236	2		15	22/03/2021	27/04/2021	12/05/2021
3	212237	3		1632	15/03/2021	27/04/2021	15/10/2025
4	212238	4		1632	22/03/2021	27/04/2021	15/10/2025
5	212239	5		52	27/03/2021	27/04/2021	18/06/2021
6	212240	6		1003	20/03/2021	27/04/2021	25/01/2024
7	212235	7		14	30/04/2021	10/06/2021	24/06/2021
8	222512	8		614	17/03/2022	27/04/2022	01/01/2024
9	222513	8		144	20/03/2022	27/04/2022	18/09/2022
10	222514	9		1267	23/03/2022	27/04/2022	15/10/2025
11	222515	9		280	23/03/2022	27/04/2022	10/02/2023
12	212235	10		51	09/04/2022	19/05/2022	19/06/2022
13	212236	10		206	10/04/2022	19/05/2022	11/12/2022
14	222516	11		1245	10/04/2022	19/05/2022	15/10/2025
15	222517	11		114	10/04/2022	19/05/2022	10/09/2022
16	232701	12		248	16/03/2023	28/04/2023	01/01/2024
17	232702	12		167	21/03/2023	28/04/2023	12/10/2023
18	232703	13		73	18/03/2023	28/04/2023	10/07/2023
19	222513	14		238	28/03/2023	08/05/2023	01/01/2024
20	212236	14		891	29/03/2023	08/05/2023	15/10/2025
21	212239	15		121	12/04/2023	18/05/2023	16/09/2023
22	243674	16		536	22/03/2024	27/04/2024	15/10/2025
23	243672	16		186	24/03/2024	27/04/2024	08/05/2024
24	243673	17		539	25/03/2024	24/04/2024	15/10/2025
25	243673	18		180	19/03/2025	18/04/2025	15/10/2025
26	243676	19		180	18/03/2025	18/04/2025	15/10/2025

Appendix B

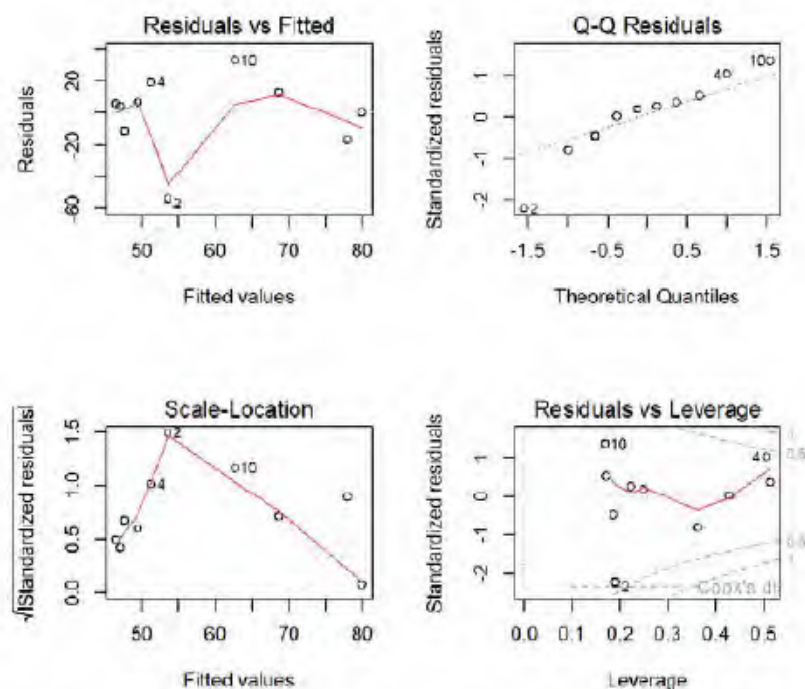


Figure B1: Diagnostic plots for the linear regression model.

Appendix C

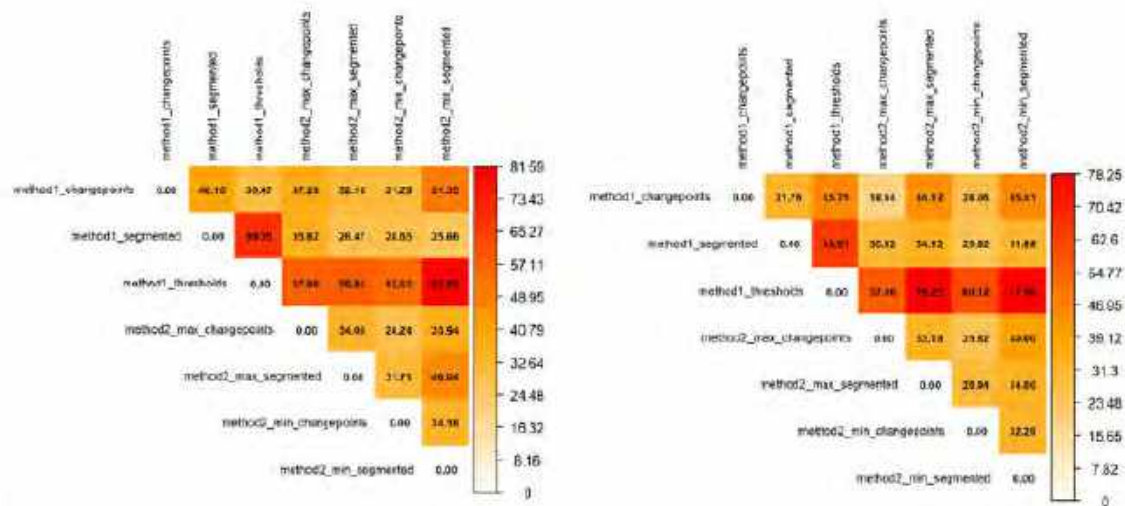


Figure C1: Mean absolute difference in days between each method for determining the fledging dates (left) and the transition dates from dependent to independent (right). The values in the plot show the average number of days difference between two methods across all ravens. It ranges from 0 (white) to the highest average that was found (red). The second method was examining the minimum, median, and maximum daily distance from each raven to their nest. Before applying a changepoint detection or a segmented regression, a cumulative sum was calculated.

Appendix D

Table D1: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 3. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2021-05-16	2021-06-26
Method 1 changepoint detection	2021-06-23	2021-09-08
Method 1 segmented regression	2021-06-25	2021-09-09
Method 2 changepoint detection maximum	2021-06-30	2021-09-10
Method 2 segmented regression maximum	2021-07-14	2021-12-18
Method 2 changepoint detection minimum	2021-06-24	2021-11-09
Method 2 segmented regression minimum	2021-06-23	2021-10-30

Raven 3

Tracking: 9 months (273 days) | 1293 night points | Nest: 5.1.2h

Fledging: 16 May 2021 | Independence: 26 Jun 2021

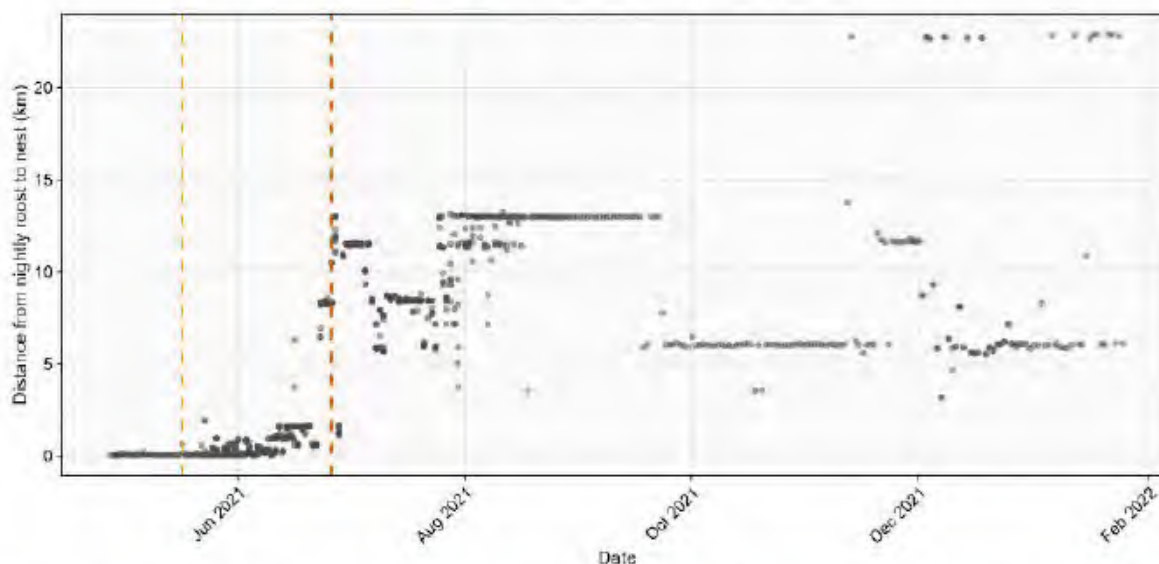


Figure D1: The transition periods for Raven 3. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D2: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 4. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2021-05-02	2021-11-17
Method 1 changepoint detection	2021-06-03	2021-09-20
Method 1 segmented regression	2021-08-29	2021-10-21
Method 2 changepoint detection maximum	2021-07-05	2021-09-12
Method 2 segmented regression maximum	2021-06-14	2021-09-09
Method 2 changepoint detection minimum	2021-09-08	2021-11-01
Method 2 segmented regression minimum	2021-10-30	2021-12-15

Raven 4

Tracking: 9 months (273 days) | 1302 night points | Nest: 5.1.2h

Fledging: 02 May 2021 | Independence: 17 Nov 2021

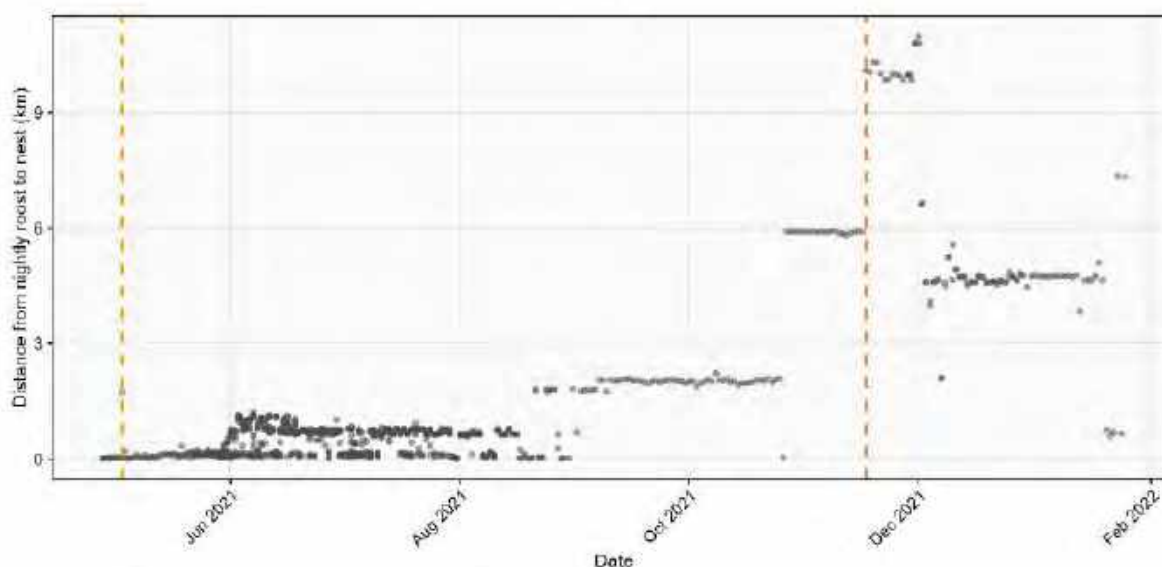


Figure D2: The transition periods for Raven 4. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D3: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 6. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2021-05-18	2021-07-12
Method 1 changepoint detection	2021-05-28	2021-09-04
Method 1 segmented regression	2021-06-25	2021-12-10
Method 2 changepoint detection maximum	2021-07-11	2021-09-23
Method 2 segmented regression maximum	2021-08-23	2021-11-10
Method 2 changepoint detection minimum	2021-07-19	2021-11-07
Method 2 segmented regression minimum	2021-07-04	2021-11-01

Raven 6

Tracking: 9 months (273 days) | 1298 night points | Nest: 5.1.2h

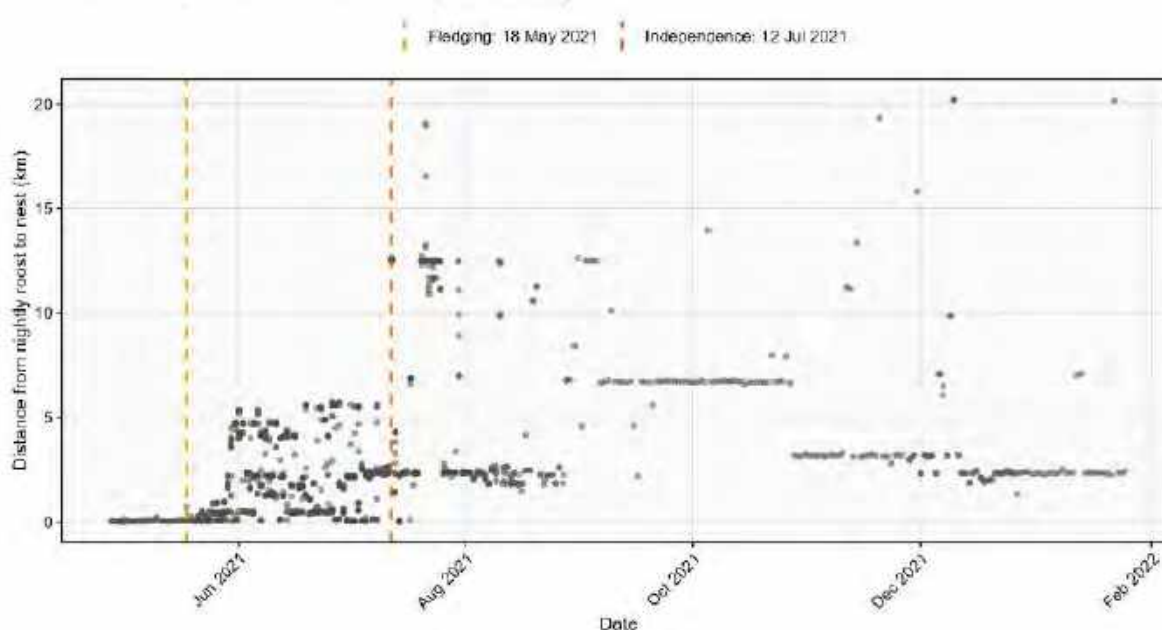


Figure D3: The transition periods for Raven 6. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D4: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 8. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2022-05-20	2022-07-24
Method 1 changepoint detection	2022-07-27	2022-10-18
Method 1 segmented regression	2022-07-18	2022-09-19
Method 2 changepoint detection maximum	2022-09-03	2022-11-07
Method 2 segmented regression maximum	2022-07-22	2022-12-22
Method 2 changepoint detection minimum	2022-07-25	2022-11-15
Method 2 segmented regression minimum	2022-08-08	2022-11-12

Raven 8

Tracking: 5.8 months (267 days) | 1291 night points | Nest: 5.1.2h

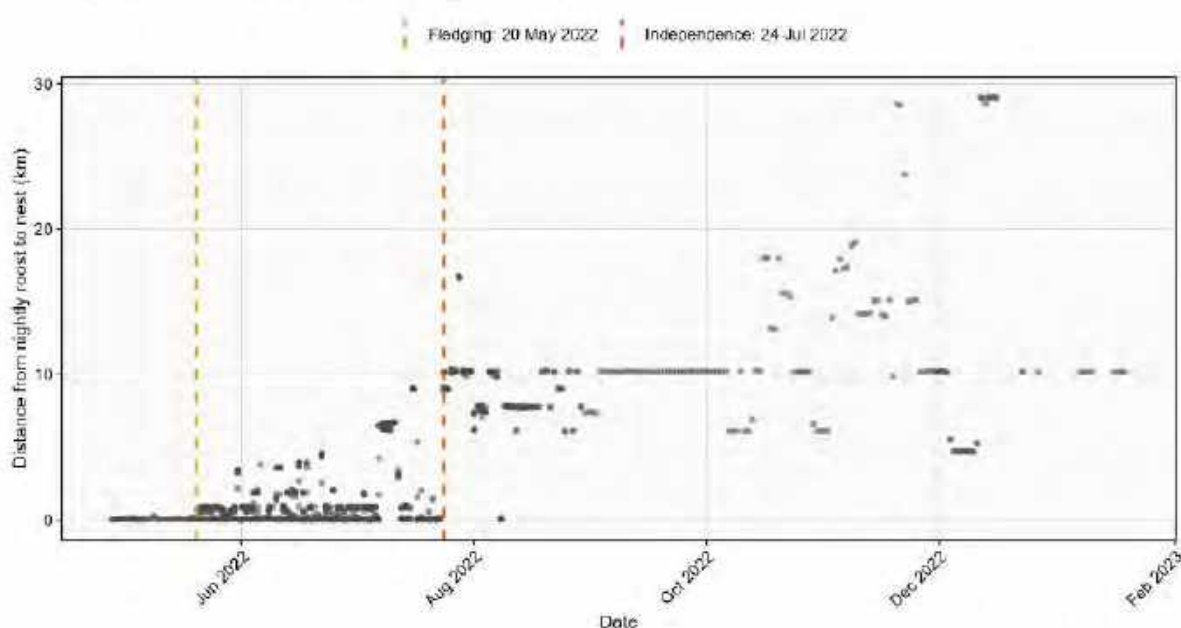


Figure C4: The transition periods for Raven 8. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D5: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 11. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2022-05-21	2022-09-06
Method 1 changepoint detection	2022-05-21	2022-09-20
Method 1 segmented regression	2022-09-08	2022-11-19
Method 2 changepoint detection maximum	2022-09-11	2022-11-08
Method 2 segmented regression maximum	2022-10-04	2022-11-20
Method 2 changepoint detection minimum	2022-08-01	2022-10-23
Method 2 segmented regression minimum	2022-08-14	2022-10-23

Raven 11

Tracking: 5.6 months (262 days) | Nest: 5.1.2h

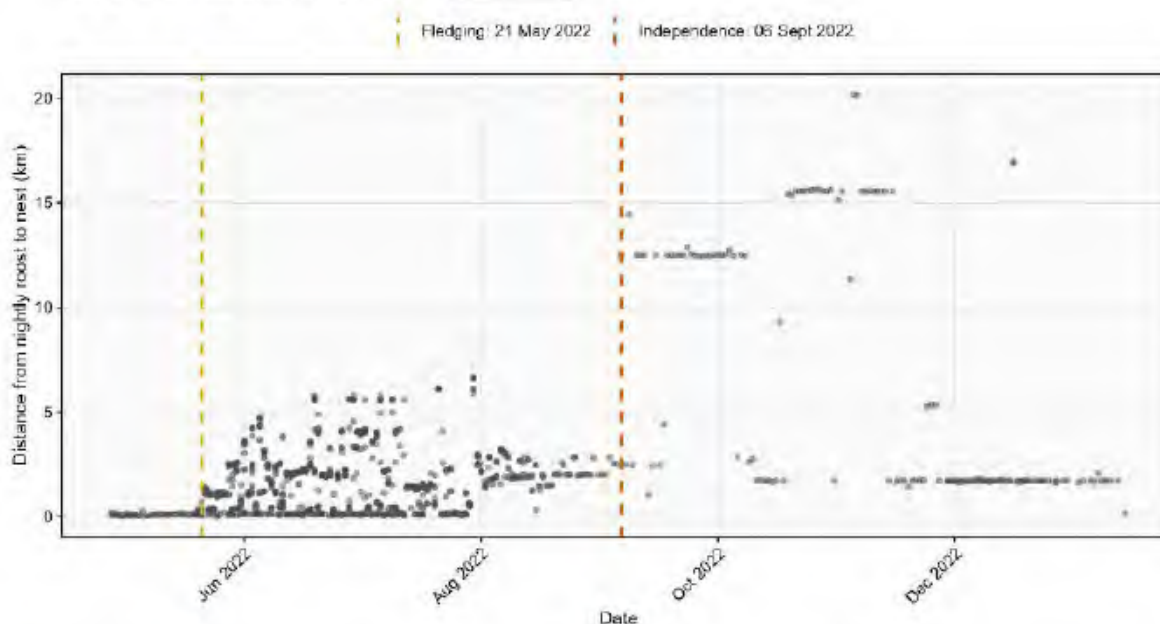


Figure D5: The transition periods for Raven 11. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D6: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 13. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2022-06-10	2022-08-03
Method 1 changepoint detection	2022-07-25	2022-09-23
Method 1 segmented regression	2022-07-28	2022-10-05
Method 2 changepoint detection maximum	2022-08-26	2022-10-15
Method 2 segmented regression maximum	2022-07-27	2022-10-17
Method 2 changepoint detection minimum	2022-07-26	2022-10-10
Method 2 segmented regression minimum	2022-07-26	2022-08-28

Raven 13

Tracking: 6.8 months (200 days) | 1083 night points | Nest: 5.1.2h

Fledging: 10 Jun 2022 | Independence: 03 Aug 2022

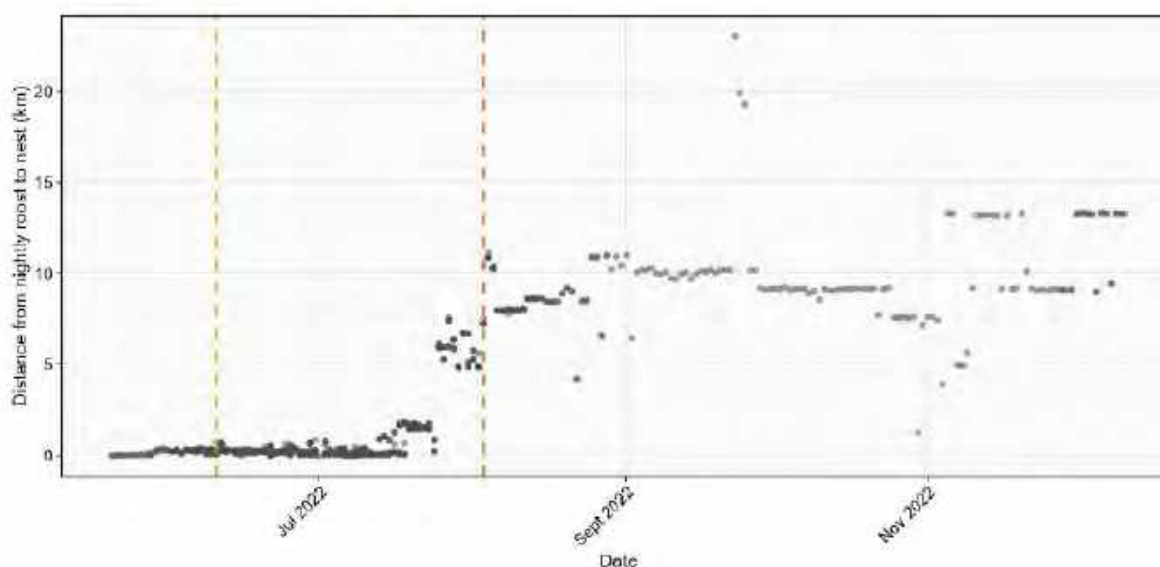


Figure D6: The transition periods for Raven 13. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D7: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 14. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2022-06-16	2022-09-01
Method 1 changepoint detection	2022-06-21	2022-09-11
Method 1 segmented regression	2022-08-26	2022-10-07
Method 2 changepoint detection maximum	2022-07-30	2022-10-09
Method 2 segmented regression maximum	2022-07-02	2022-11-22
Method 2 changepoint detection minimum	2022-06-18	2022-09-23
Method 2 segmented regression minimum	2022-09-13	2022-11-27

Raven 14

Tracking: 9 months (273 days) | 575 night points | Nest: 5.1.2h

Fledging: 16 Jun 2022 Independence: 01 Sept 2022

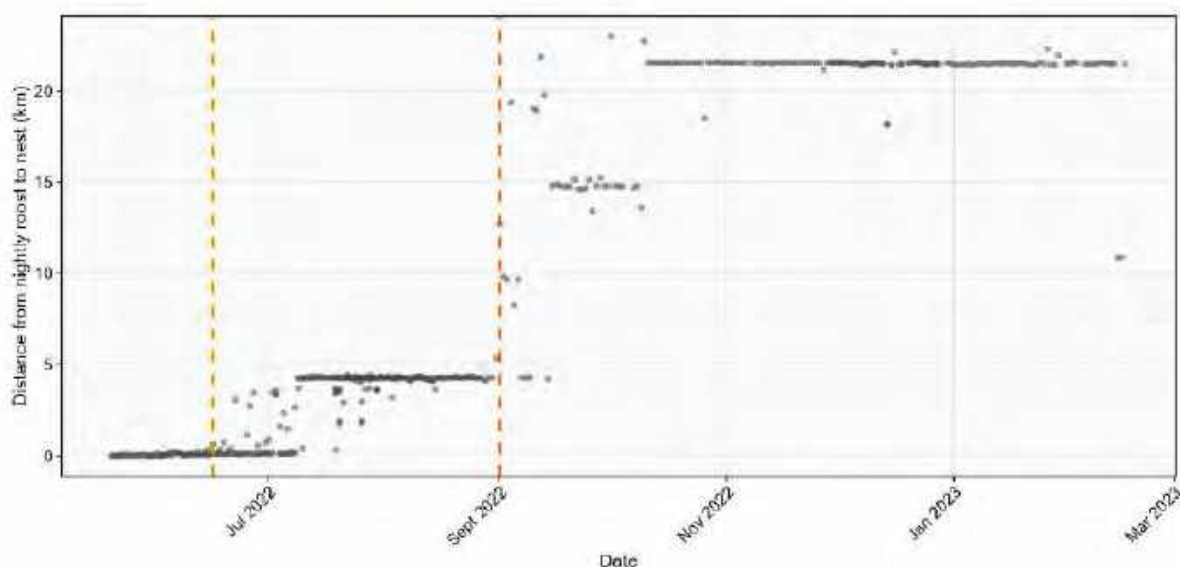


Figure D7: The transition periods for Raven 14. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D8: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 16. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2023-05-22	2023-08-09
Method 1 changepoint detection	2023-07-25	2023-09-10
Method 1 segmented regression	2023-08-07	2023-09-29
Method 2 changepoint detection maximum	2023-08-09	2023-10-06
Method 2 segmented regression maximum	2023-07-17	2023-10-25
Method 2 changepoint detection minimum	2023-08-08	2023-10-06
Method 2 segmented regression minimum	2023-08-04	2023-10-19

Raven 16

Tracking: 7 months (214 days) | 543 night points | Nest: 5.12h

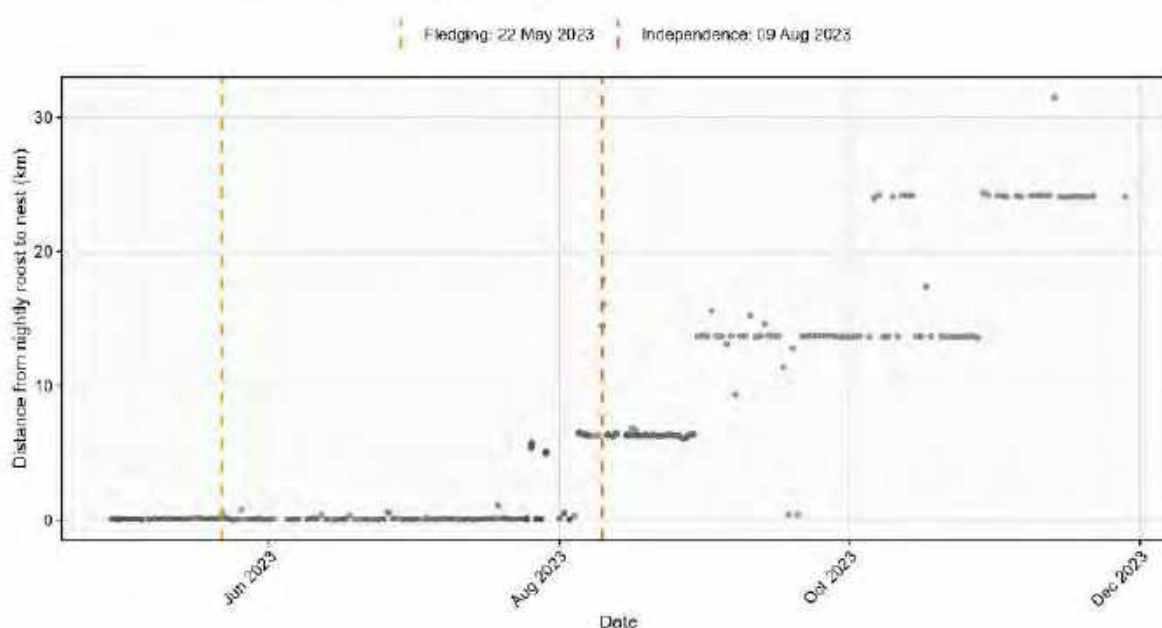


Figure D8: The transition periods for Raven 16. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D9: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 17. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2023-05-22	2023-08-08
Method 1 changepoint detection	2023-05-21	2023-07-25
Method 1 segmented regression	2023-07-30	2023-09-12
Method 2 changepoint detection maximum	2023-06-12	2023-07-28
Method 2 segmented regression maximum	2023-07-19	2023-09-30
Method 2 changepoint detection minimum	2023-07-08	2023-09-05
Method 2 segmented regression minimum	2023-08-23	2023-09-17

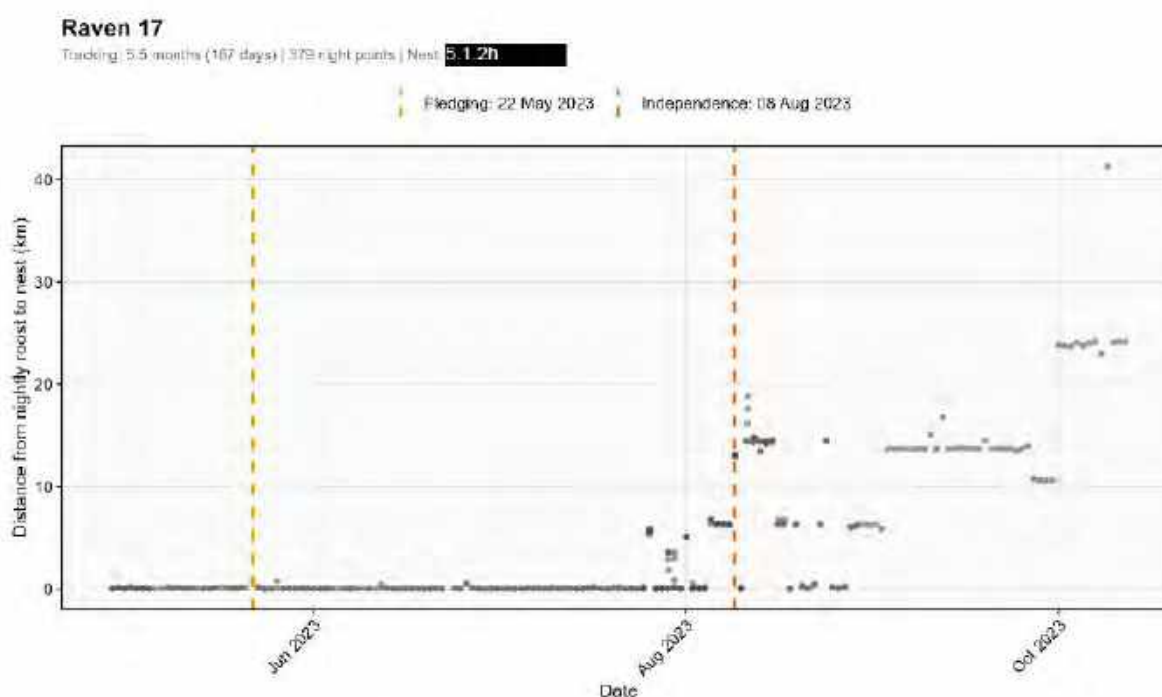


Figure D9: The transition periods for Raven 17. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D10: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 19. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2023-06-19	2023-08-08
Method 1 changepoint detection	2023-08-03	2023-09-20
Method 1 segmented regression	2023-08-03	2023-09-01
Method 2 changepoint detection maximum	2023-06-26	2023-08-18
Method 2 segmented regression maximum	2023-07-14	2023-08-02
Method 2 changepoint detection minimum	2023-07-01	2023-09-08
Method 2 segmented regression minimum	2023-08-31	2023-10-25

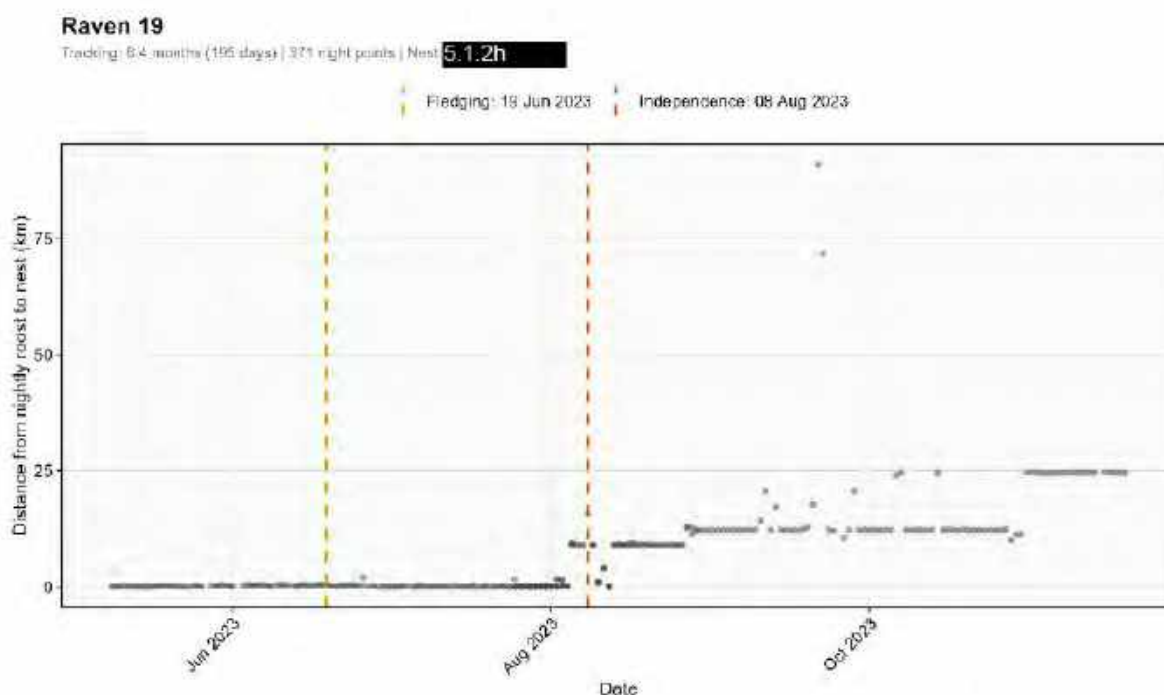


Figure D10: The transition periods for Raven 19. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D11: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 20. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2023-06-19	2023-07-16
Method 1 changepoint detection	2023-07-15	2023-11-03
Method 1 segmented regression	2023-08-02	2023-10-27
Method 2 changepoint detection maximum	2023-09-13	2023-11-22
Method 2 segmented regression maximum	2023-07-25	2023-10-05
Method 2 changepoint detection minimum	2023-07-13	2023-10-06
Method 2 segmented regression minimum	2023-09-28	2023-11-28

Raven 20

Tracking: 9 months (273 days) | 500 night points | Nest: 5.1.2h

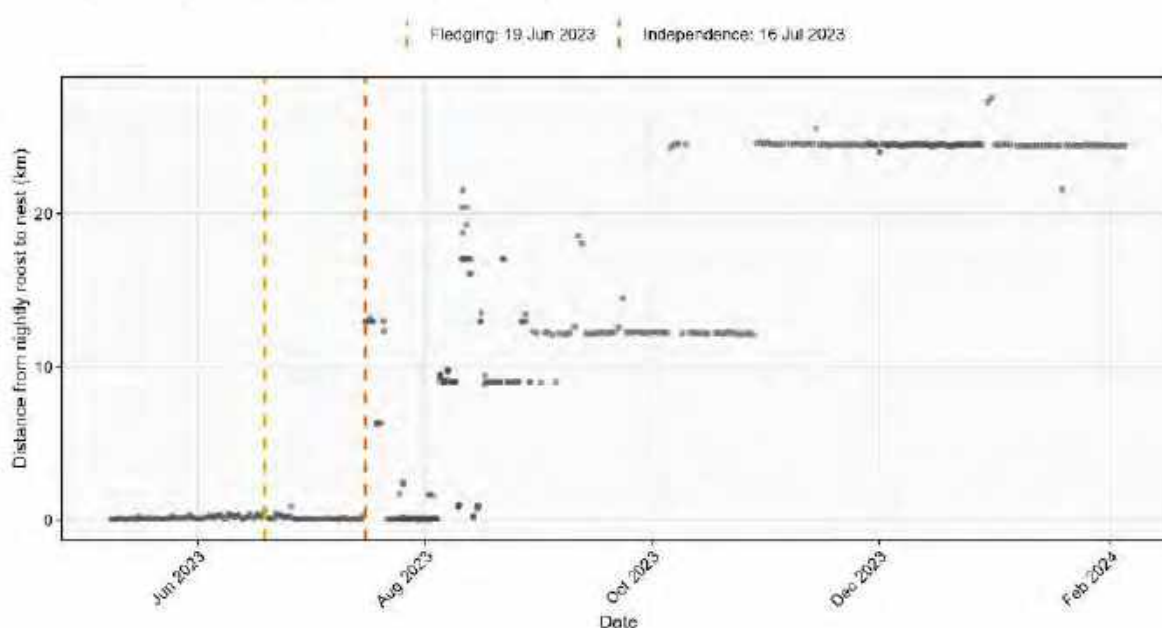


Figure D11: The transition periods for Raven 20. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D12: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 22. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2024-04-28	2024-07-25
Method 1 changepoint detection	2024-07-24	2024-09-23
Method 1 segmented regression	2024-10-09	2024-11-05
Method 2 changepoint detection maximum	2024-06-30	2024-09-08
Method 2 segmented regression maximum	2024-10-04	2024-11-26
Method 2 changepoint detection minimum	2024-07-13	2024-09-10
Method 2 segmented regression minimum	2024-08-27	2024-11-17

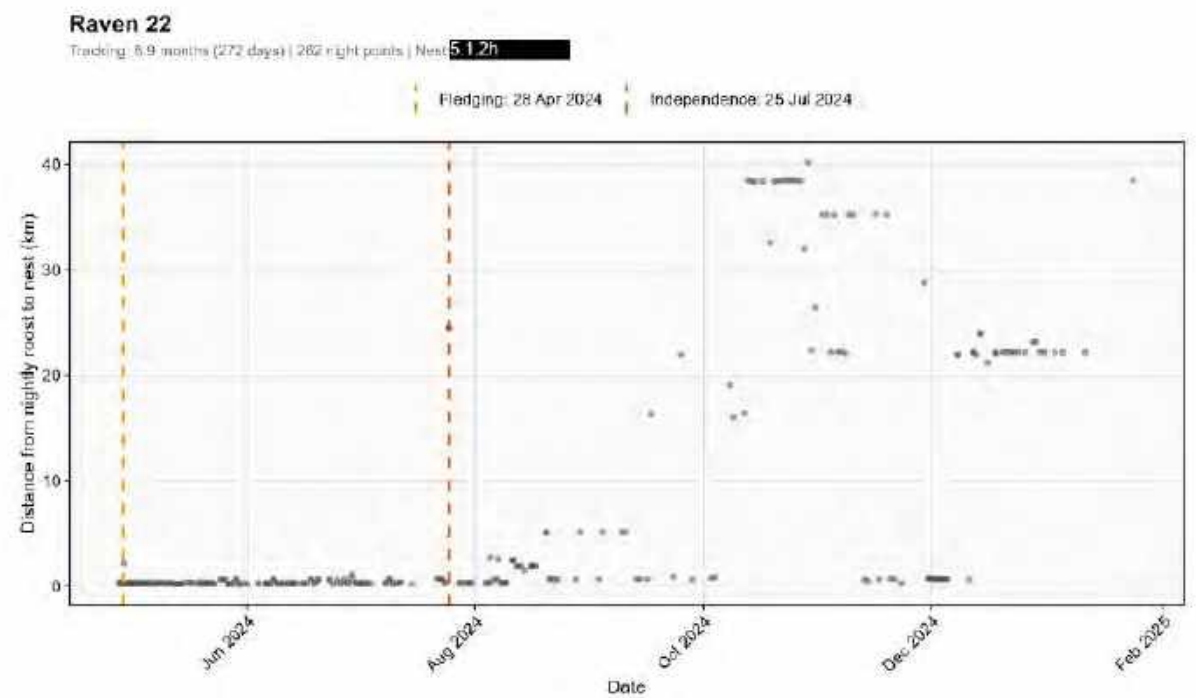


Figure D12: The transition periods for Raven 22. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D13: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 23. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2024-05-08	2024-07-19
Method 1 changepoint detection	2024-05-13	2024-09-06
Method 1 segmented regression	2024-06-10	NA
Method 2 changepoint detection maximum	2024-06-13	2024-07-27
Method 2 segmented regression maximum	2024-06-05	2024-09-07
Method 2 changepoint detection minimum	2024-07-05	2024-08-17
Method 2 segmented regression minimum	2024-06-21	2024-09-25

Raven 23

Tracking: 5.8 months (175 days) | 208 night points | Nest 5.1.2h

Fledging: 08 May 2024

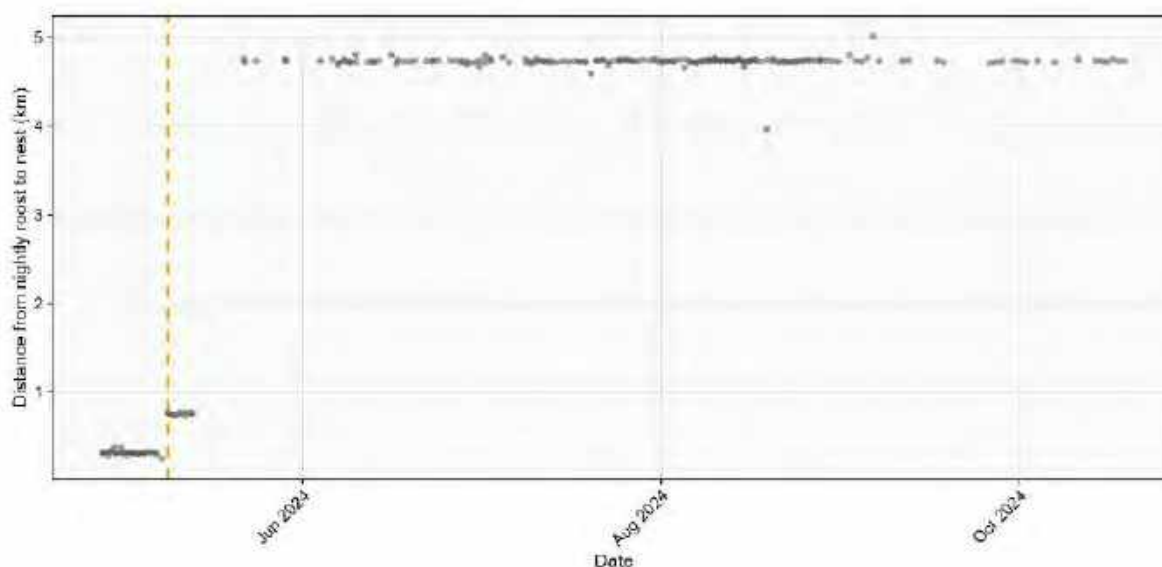


Figure D13: The transition periods for Raven 23. The yellow line represents the fledging time.

Table D14: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 24. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2024-05-21	2024-07-28
Method 1 changepoint detection	2024-07-29	2024-09-27
Method 1 segmented regression	2024-08-01	2024-09-30
Method 2 changepoint detection maximum	2024-07-09	2024-09-12
Method 2 segmented regression maximum	2024-07-31	2024-10-01
Method 2 changepoint detection minimum	2024-09-06	2024-11-09
Method 2 segmented regression minimum	2024-08-02	2024-10-02

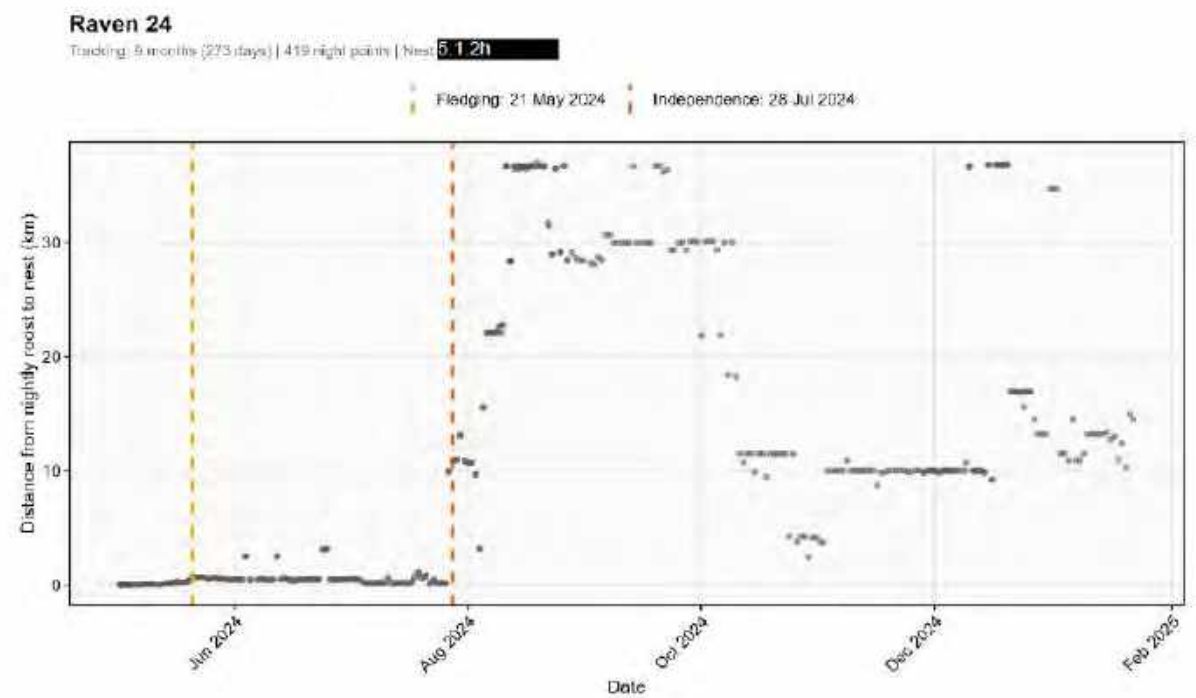


Figure D14: The transition periods for Raven 24. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D15: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 25. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2025-06-03	2025-07-30
Method 1 changepoint detection	2025-06-02	2025-07-31
Method 1 segmented regression	2025-07-28	2025-09-02
Method 2 changepoint detection maximum	2025-06-06	2025-07-25
Method 2 segmented regression maximum	2025-05-10	2025-07-23
Method 2 changepoint detection minimum	2025-06-09	2025-08-01
Method 2 segmented regression minimum	2025-06-17	2025-08-13

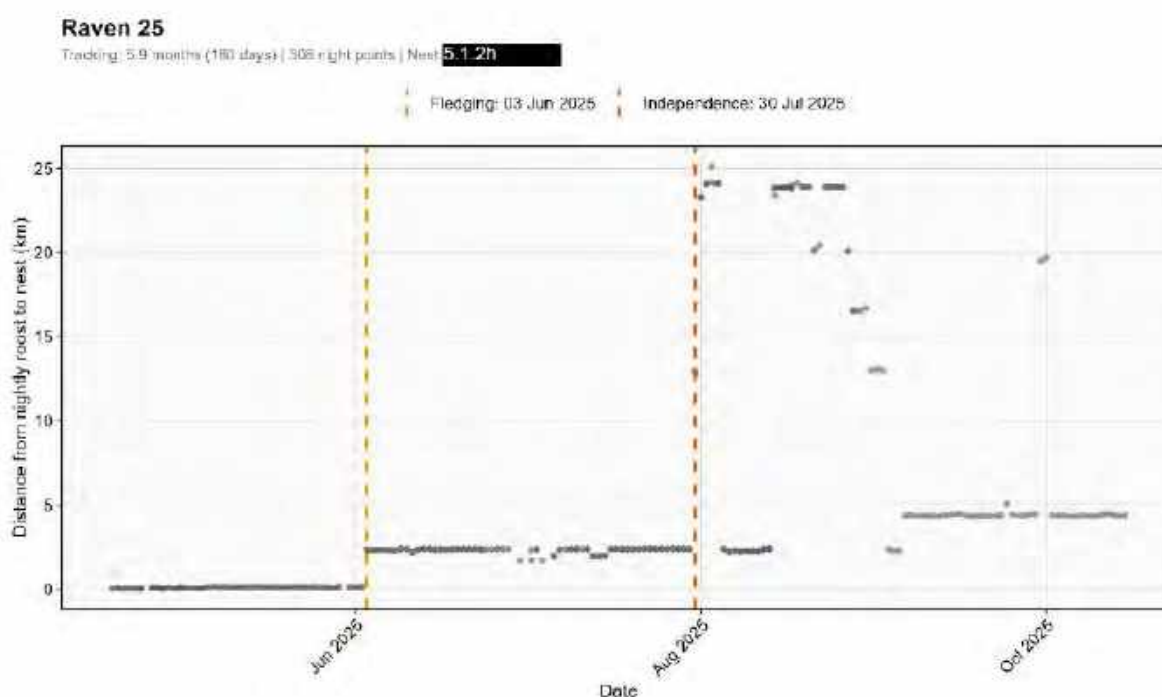


Figure D15: The transition periods for Raven 25. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

Table D16: Results of methods for determining fledging date and the transition date from dependent to independent for Raven 26. The first method was examining the distance from the nest to the nightly roost location of the raven. The second method was examining the minimum, median, and maximum daily distance from each raven to their nest.

Method	Fledging date	Transition date
Method 1 thresholds	2025-05-16	2025-07-30
Method 1 changepoint detection	2025-05-16	2025-07-31
Method 1 segmented regression	2025-05-17	2025-07-29
Method 2 changepoint detection maximum	2025-07-16	2025-09-05
Method 2 segmented regression maximum	2025-04-27	2025-08-30
Method 2 changepoint detection minimum	2025-06-09	2025-08-02
Method 2 segmented regression minimum	2025-08-02	2025-09-10

Raven 26

Tracking: 5.9 months (180 days) | 309 night points | Nest: 5.1.2h

Fledging: 16 May 2025 Independence: 30 Jul 2025

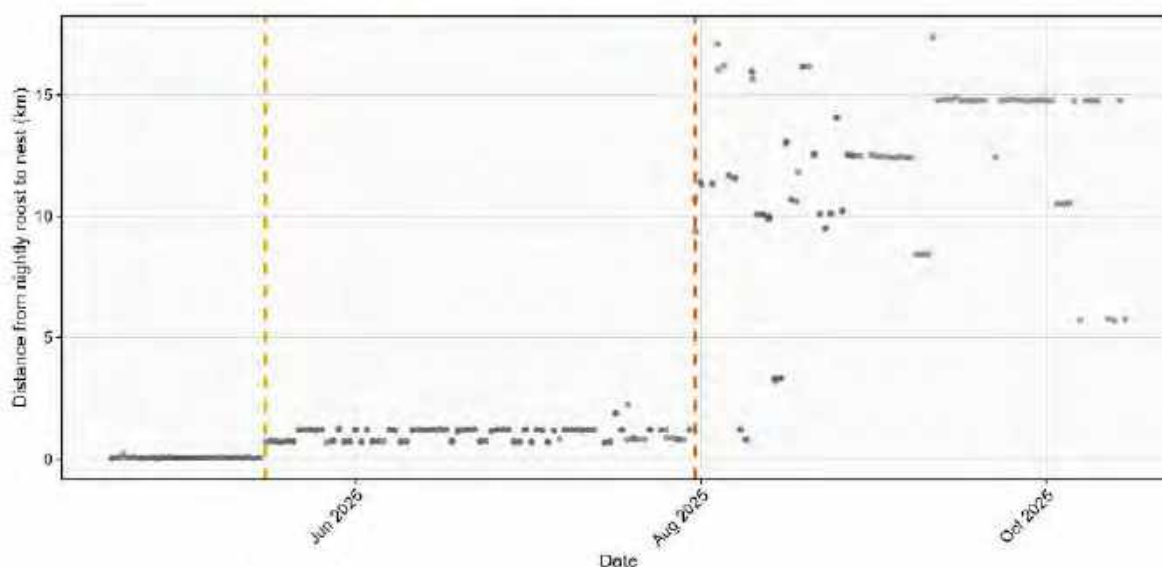


Figure D16: The transition periods for Raven 26. The yellow line represents the fledging time and the red line represents the transition time between dependent and independent.

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Ravens (*Corvus*) and rare food sources affect social behaviour and dynamics

By 5.1.2e

BHE-80324

Behavioural Ecology Group

Supervisor: 5.1.2e

Second supervisor: 5.1.2e
(ARK Rewilding Nederland)

Examiner: 5.1.2e (UU)

04-04-2023



Foraging strategies

- Solitary or social groups (Beauchamp, 2005; Sheppard et al., 2018)
- Change in foraging strategy → food availability (Beauchamp, 2005; Sheppard et al., 2018)
- Abundant food sources (Miller et al., 2014)
 - Minimal competition
 - High tolerance level
- Rare food sources (Goldberg et al., 2001; Heinrich, 1998)
 - Intensify competition → increased levels of aggression
 - Clustered → monopolisation

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Carrion in the Netherlands



- Carrion:
 - Natural deaths, diseases and predation
 - Valuable source of nutrients for scavengers
 - E.g. Red foxes (*Vulpus vulpus*), wild boars (*Sus scrofa*) and common ravens (*Corvus corax*) (Wilson & Wolkovich, 2011; Wenting et al., 2022)
 - Rare and unpredictable food source (Barton et al., 2013; Cortés-Avizanda et al., 2014)
- In the Netherlands
 - 2009: change in policy → Oostvaardersplassen & Veluwe zoom (NVWA, 2009)
 - 2018: permanent settlement wolves (*Canis lupus*) (Wolven in Nederland, n.d.)
 - Increase carrion availability

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Abundant food sources



- Human presence → anthropogenic food sources (Becker et al., 2015)
 - E.g. landfills, agricultural land or human food waste
- Highly abundant, predictable and easy accessible (Restani et al., 2001; Yoda et al., 2012)
- Abundant vs rare food sources
 - Different foraging strategies, social behaviour & social dynamics

The common raven (*Corvus corax*)

- Diverse diet: grains, fruit, insect, small mammals, human waste and carrion (Boarman & Heinrich, 2020)
- Different foraging strategies: (Heinrich & Marzluff, 1992; Marzluff et al., 1996)
 - Adults: territorial approach in pairs
 - Juveniles: social groups → roosts → social recruitment

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

How do rare and abundant food resources affect social behaviour and dynamics in the common raven (*Corvus corax*) on the Veluwe?

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Hypothesis 1

Abundant food sources are **widely distributed**, resulting in **less competition** over the food source and therefore **more tolerance** and a **less stricter hierarchy**.

Predictions	Abundant food source	Rare food source
Agonistic behaviour	↓	↑
Affiliative behaviour	↑	↓
Submissive behaviour	↓	↑
Linear hierarchy	↓	↑
Social distance*	↓	↑

*Distance to first and second closest neighbour in body lengths (from 1 to >10)

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Hypothesis 2

Juvenile individuals are **less experienced** and rely more on each other to locate a food source by social recruitment.

Tolerance	Juvenile	Adult
Juvenile	High	High
Adult	Low	Low

Agonism	Juvenile	Adult
Juvenile	Medium level	Low level
Adult	High level	Medium level

Submission	Juvenile	Adult
Juvenile	Medium level	High level
Adult	Low level	Medium level

Affiliation	Juvenile	Adult
Juvenile	Medium level	Low level
Adult	Low level	Medium level

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Hypothesis 3

Foraging for rare food sources demands **more effort**, but has a **greater risk**, due to limited time available for vigilance. Therefore, ravens are **more vigilant** at rare food sources in comparison to abundant food sources.

Predictions	Abundant food source	Rare food source
Vigilant behaviour	↓	↑
Social calls behaviour*	↓	↑

*Back-up

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Subject species

- Free-ranging ravens around the Veluwe
- Since 2013: ravens with coloured rings (Ravenwerkgroep Nederland, 2013)
 - Data on age, sex and biometrics
- Since 2021: ravens with GPS transmitters (Ravenwerkgroep Nederland, n.d.; Ark Rewilding Nederland, 2013)
 - Currently six ravens
- Small sample size? → unringed ravens



Study site

- Rare food sources
 - Eight locations around the Veluwe → carrion deposition
 - Wildlife camera → detects motion and body heat
- Abundant food sources
 - Landfill Barneveld
 - Other locations?
 - Based on GPS clusters
 - E.g. trout farm, agricultural land, small diners

Source: Ark Rewilding Nederland

Study design

- Observation period: 2,5 months from 11-04-2023 to 16-06-2023
- Behavioural categories:
 - Agonistic behaviour → event
 - Submissive behaviour → event
 - Affiliative behaviour → event
 - Neutral behaviour → event
 - Feeding behaviour → state
 - Vigilant behaviour → state
 - Social calls → event

Study de

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

- **Abundant food sources**

- Continuously focal sampling method → 2-5 minutes
- Information observation: location, date, weather, start & end time, total duration, number of ravens present, ring number focal individual
- Observation:
 - Define rings of interaction partners
 - Events → true frequencies
 - State → using interval of 10 seconds
 - Number of social calls divided by number of individuals

- **Rare food sources**

- Similar approach
- Video analysis using BORIS
- Undefinable rings → except one camera?

Back-up plan B

- Undefined rings
- Exclusion comparison immature and mature individuals
- Exclusion social dynamics
- Still continuous focal sampling method → 2-5 minutes
- Same observation method
- Observe 50% of total individuals 'from left to right'

Back-up plan C

- Undefined rings
- Exclusion comparison immature and mature individuals
- Exclusion social dynamics
- Different observation method:
 - Behaviour sampling method of the whole group – 5 minutes
 - Reducing behavioural categories
 - Most observed behaviours

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Are there any questions or recommendations?



Agonistic behaviour		
Behaviour	Description Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.	State or event behaviour
Avoid (AV)	An individual moves away from / makes room for an approaching interaction partner before coming in close proximity (< 1 body length).	Event
Displace (DI)	An individual moves away from an interaction partner that will take its position after coming in close proximity (> 1 body length).	Event
Peck (PE)	An individual pecks an interaction partner with its beak.	Event
Pull feathers (PF)	An individuals pulls the feathers of an interaction partner with its beak.	Event
Chase (flight) (CH-F)	An individual chases an interaction partner, which can be on the ground or flying.	Event
Charge (CH)	An individual makes a sudden, intense movement towards an interaction partner.	Event
Threat display (TH)	An individual displays ‘thick head approach’, possibly with a visual threat, like pecking or charging.	Event
Fight (FI)	An individual attacks an interaction partners with its feet and/or beak, which can consist of short jumps up and down into the air and/or laying on the ground and sitting on top of each other.	Event
Steal (food) (ST)	Individual approaches an interaction partner, obtains food item and leaves.	Event
Submissive behaviour		
Behaviour	Description	State or event behaviour
Submissive display (SD)	An individual pulls its head into its shoulders, fluffs feathers and/or spread wings a little.	Event
Roll on side (RS)	An individual lays down on the ground on its side.	Event

Affiliative behaviour		
Behaviour	Description	State or event behaviour
Allo-preening (AP)	An individual preens the feathers of its interaction partner.	State
Allo-feeding (AF)	An individual transfers food directly from its own beak to the beak of its interaction partner.	Event
Courtship display (CP)	A female and male showing off against each other by a more erect posture, fluffing feathers, bowing head and spreading wings on the ground. In the air an individual displays dives and rolls.	Event
Neutral behaviour		
Behaviour	Description	State or event behaviour
Social proximity (SP)	Two individuals being within n (ranging from one to >10) body length from each other.	State
Co-feeding (CF)	Two individuals eat from the same food item or from two food items, while in social proximity.	State
Co-manipulation (CM)	Two individuals manipulate (pull or peck) the same food item without any agonistic interactions.	State
Vigilance (VI)	An individual being alert with its head up or looking around and scanning its environment.	State
Social calls (SC)	An individual making calls to maintain social contact with conspecifics.	Event
Feeding behaviours		
Behaviour	Description	State or event behaviour
Inspecting (IN)	An individual looks at food item, without touching it.	State
Pecking (PE)	An individual pecks at food item with its peak.	State
Pulling (PU)	An individual holds an food item while pulling at it.	State
Holding (HO)	An individual holds an food item in its beak.	State
Transfer (TR)	An individual takes a food item and moves to another spot.	State
Consuming (CO)	An individual consumes an food item.	State

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

From: 5.1.2e
To: 5.1.2e
Subject: RE: Master studenten raven data
Date: zaterdag 26 augustus 2023 14:37:41
Attachments: [Scavengers use natural.... Ho. Cameron et al: 2023: Front Bird Sci. 2 1119507: Sec. Bird Ecology and Behavior.pdf](#)

Hallo 5.1.2e

Dank voor je mailtje.

Ja, het zou leuk (en zinvol zijn volgens mij) om meer met de zenderdata van de raven te doen. Er zijn nu een aantal studenten geweest en (vanuit ARK begrijpelijk) is er vooral gericht op de wolf als aasleverancier en de rol van de raaf om aasplekken te vinden.

De eerste student, 5.1.2e, is begonnen met de interpretatie van vliegdata raaf en koppeling aan cluster/voedselplekken. Maar dat was het begin van het zenderproject. Daar is zover ik dat kan inschatten, niet veel meer mee gedaan dan het vaststellen en bezoeken van clusterplekken.

Naar mijn mening moet er meer gedaan kunnen worden met de zenderdata.

Vanuit de Ravenwerkgroep Nederland is de interesse vooral gericht op

1. Verspreidingsgedrag en -ranges van de raaf; vliegbewegingen en -routes. Is er patroon in te herkennen? Wat zijn drivers voor de verplaatsingen? Is er een koppeling met terreingebruik/-bezoek?
2. Koppeling aan foerageerplekken/-gedrag. Zie ook het bijgesloten artikel waarbij de auteurs vaststellen dat raven van Yellowstone NP meer gebruik maken van anthropogene voedselbronnen buiten het NP dan van natuurlijke voedselbronnen (kadavers) in het NP. Op zich opmerkelijk gezien de hypothese dat raven/aaseters zich vooral richten op eiwitrijke voedselbronnen
Is dit ook zo bij de gezenderde Veluwe raven?? Ik heb het idee van wel gezien hun frequente vuilstort bezoek in 5.1.2e. Maar 'wetenschappelijk' vastgesteld is dit nog niet.
Het lastige lijkt me dat voor het goed kunnen vaststellen veldwerk nodig is en dus tijd en mensen (deel wat ARK nu wel doet). De vraag is of zenderdata afdoende zijn om te beantwoorden of en wat voor type voedselbronnen worden gebruikt door de raven.
3. Is er een patroon in het foerageer gedrag? Is er een dagritme, tijdstip(pen) waarop voornamelijk wordt gefoerageerd? De barometer op de nieuwe GPS zenders zou hier iets over kunnen laten zien denk ik (hoogte waar de raaf verblijft zou zichtbaar moeten zijn).
4. Bij bovenstaande kan ook het geslacht van de raaf meegenomen worden. Van de gezenderde raven is het geslacht bepaald (raven die in 2023 zijn gezenderd moeten nog geanalyseerd worden, maar dat is dit jaar wsch nog mogelijk).
Is er verschil in verspreiding tussen mannen en vrouwen? Is er verschil in foerageer plekken en -gedrag tussen mannen en vrouwen?

Kortom, ik denk dat het nodige onderzoek nog gedaan kan worden. Zaak is wel dat het duidelijk is welke zenderdata beschikbaar zijn, met terugwerkende kracht boven water te krijgen zijn, waar deze zich bevinden en hoe toegankelijk ze zijn/kunnen worden gemaakt. De mensen van ARK zouden daar uitsluitsel over moeten kunnen geven.

Ik ben het met je eens dat een Research Master Practice het meest voor de hand ligt om dergelijk onderzoek uit te voeren. 4 Maanden is dan best wel aan de korte kant, maar het is een voordeel dat het aan de WUR uitgevoerd kan worden.

uitvoeren van data onderzoek (en daar ervaring mee) is belangrijk. Daarnaast zal ook literatuursearch gedaan moeten worden. Uiteraard affiniteit met vogels en gedrag is een wenselijke eigenschap van de student.

Ik wil voorstellen om binnenkort een keer af te spreken en een en ander verder te overleggen, als je je kunt vinden wat ik hier naar voren breng.
met alle liefde kom ik dan naar je toe op de WUR.

Ik hoor van je.

Met vriendelijke groet

5.1.2e

Van: 5.1.2e [mailto:5.1.2e@wur.nl]

Verzonden: vrijdag 25 augustus 2023 17:53

Aan: 5.1.2e

Onderwerp: Master studenten raven data

Hoi 5.1.2e

Ik begreep van 5.1.2e dat je interesse zou hebben om gezamenlijk een Master student te begeleiden op de raven GPS data. Dit lijkt me een mooi plan. We hebben bij WUR de mogelijkheid tot een minor (4 maanden) of major thesis (6 maanden). Daarnaast, en dat is misschien het meest toepasselijk, hebben we ook een mogelijkheid tot Research Master Practice (4 maanden). Dit lijkt op een stage maar wordt dan binnen WUR uitgevoerd ipv bij een externe organisatie (zoals ARK).

Misschien kunnen we binnenkort samen een klein textje opzetten (een paar zinnen) over het type data en de mogelijke onderzoeksvragen (+ mogelijke vaardigheden die we al van de student verwachten).

Groetjes en fijn weekend!

5.1.2e

5.1.2e

5.1.2e

Zodiac building – room 5.1.2e

Behavioural Ecology Group

Wageningen University & Research

www.5.1.2e.com

www.BehaviouralEcology.nl



Where Do Ravens Go? Exploring Foraging Habits and Habitat Selection Base On The Spatial and Social Behaviors Of Common Ravens (*Corvus Corax*).

5.1.2e

BHE79324

Supervisors:

5.1.2e

5.1.2e

ARK Rewilding Nederland

The Ravenwerkgroep

Behavioural Ecology Group

Wageningen University

The Netherlands

Abstract

Common ravens (*Corvus corax*) exhibit diverse social and movement patterns throughout their lives, reflecting their adaptability and cognitive abilities. These patterns are crucial for comprehending how ravens use and respond to different habitats during their foraging activities. By examining their spatial behavior, we can gain insights into their habitat preferences and the factors influencing their movement decisions. This study investigated the foraging habits and habitat preferences of common ravens across different life stages, with a particular focus on the impact of anthropogenic food sources. I explored how spatial and social behaviors influence their choices. I hypothesized that early foraging experiences influence later habitat preferences, potentially leading to predictable shifts in behavior as ravens progress through their life trajectory. I examined the movement patterns and habitat use of GPS-tagged ravens, focusing on the correlation between their life stage and their habitat use. In addition, a survival analysis was performed not only to ensure a representation of the raven's population in The Veluwe but also to evaluate potential tag effects. This analysis compared the survival rates of ravens with GPS tags to untagged. The survival analysis revealed a potential difference in survival rates between ravens with and without GPS tags. The GPS tag ravens have a higher mortality risk in ravens. The ravens showed a significant variation in spatial behavior across life stages. Early foraging experiences influenced later habitat preferences, suggesting learned components to their foraging strategies. Ravens exhibited a preference for anthropogenic food sources, particularly during the non-breeder stage, highlighting the potential impact of human activity on their behavior. The survival analysis revealed a potential difference in survival rates between ravens with and without GPS tags. The GPS tag ravens have a higher mortality risk in ravens. This study contributes to our understanding of how life stages, social dynamics, and access to anthropogenic food sources influence raven foraging behavior and habitat selection.

Key words: Ravens, Foraging habits, Habitat preferences, Life stages, GPS-data, Spatial and Social behavior.

1.0 Introduction

The spatial behavior of a species is shaped by the dynamic interaction between the species and its environmental elements (Deygout *et al.*, 2010). Exploring this spatial behavior reveals crucial insights into the habitat requirements of a species. The examination of movement patterns, which represent strategies at both individual and population levels, provides valuable insights into flexibility in their habitat preferences. These patterns incorporate characteristics such as home range size, social and foraging behaviors, space utilization, and species conservation (Delgado & Penteriani, 2008). These movement patterns help us understand how species respond to changing environmental conditions, habitat preferences and optimize their foraging outcomes.

Common ravens (*Corvus corax*), the most widely distributed member of the corvid family, undergo three distinct life stages with different social and spatial behaviors. Ravens that are dependent on their parents are known as the family stage. As they become independent around their first summer, they become non-breeding (Sierro *et al.*, 2020). Finally, they become fully independent adults, a stage known as breeders (Boucherie *et al.*, 2019). This stage typically starts around 4-5 years old (Loretto *et al.*, 2016). Throughout these stages, ravens are known for their sophisticated social cognitive skills including the formation of alliances, cooperative foraging, dominance hierarchies, and communication strategies (Bugnyar, 2013). Recently research has demonstrated highly developed physical cognitive abilities, including the ability to master caching behavior, spatial memory, object permanence, and inference by exclusion (Lambert *et al.*, 2019; Pika *et al.*, 2020).

The family environment plays a crucial role in raven's cognitive abilities. Ravens start learning particularly during the first year of life (Bugnyar *et al.*, 2007). They learn social cues from their parents based on the competition for parental resources and social information availability (Bugnyar *et al.*, 2007). According to this research, smaller families may produce ravens that are more perceptive to social cues because they depend more on their parents' interactions. When ravens become independent, they will experience a higher degree of fission-fusion dynamics which will require them to repeatedly learn or update information about unfamiliar individuals (Bugnyar, 2013) and their group efforts in foraging or mutual support (Bugnyar & Heinrich, 2005). This

suggests that ravens accumulate knowledge about others, often over extended periods (Bugnyar, 2013).

In terms of social and movement patterns, common ravens exhibit different behaviors across their lives (Boucherie *et al.*, 2019). Breeding and non-breeding ravens use space and resources in different ways. Breeding ravens prefer to stay in specific areas and do not overlap much with nearby breeding pairs, displaying loyalty to their chosen sites. On the other hand, non-breeding ravens are more social and explore larger areas. They often share territories, especially around places with lots of food (Loretto *et al.*, 2016). As common ravens are versatile feeders and opportunistic scavengers (Ho *et al.*, 2023), their diet is remarkably varied, including carrion often left by larger predators, small mammals, invertebrates, birds, eggs, amphibians, fish, and plant matter (Boarman & Heinrich, 2020). However, ravens are also adept at utilizing resources provided by human activities (Marzluff & Neatherlin, 2006).

The variation in their spatial behavior is influenced by factors such as breeding status and resource availability. For instance, ephemeral food sources like carcasses or road kills can attract large numbers of ravens due to the temporary availability of food. However, permanent anthropogenic point subsidies, such as farms, landfills, or game parks, can have an even greater appeal for ravens (Loretto *et al.*, 2016). of anthropogenic food sources. Their diet includes animals killed on roads (Boarman Ravens have gained a reputation due to their ability to exploit a broad spectrum & Heinrich, 2020), waste from landfills and garbage bins (Howe *et al.*, 2014), remains from hunting activities (White, 2005), feed associated with livestock farming, crops (Engel & Young, 1989), and the remnants of hunting activities (Howe *et al.*, 2014).

Despite this knowledge, the extent of ravens' preference for anthropogenic food sources and their influence on their spatial behavior remains unclear (Ho *et al.*, 2023). This study will aim to understand the foraging habits and preferences of ravens, particularly in relation to anthropogenic food sources, and to contribute to our knowledge of how human activities and resources influence the spatial behavior of wildlife (Ho *et al.*, 2023). The cognitive abilities of common ravens make them particularly interesting subjects for studying the impact of anthropogenic food sources on their foraging behavior (Ho *et al.*, 2023; Pika *et al.*, 2020).

Therefore, the hypothesis of this study suggests that there will be a correlation between ravens' early foraging experiences and their later foraging experiences, suggesting that their habitat preference can be predictable. Investigating such correlations will help us elucidate the factors influencing raven behavior and shed light on the predictability of their responses to anthropogenic food sources. These findings will be valuable for informing wildlife management strategies and conservation efforts in human-impacted environments.

2.0 Method

2.1 Study area

De Hoge Veluwe National Park was established in 1935 and comprises about 5,400 hectares within Gelderland province, Netherlands (Hein, 2011). Occupying a significant portion of Ede municipality with a smaller area in Arnhem, it is situated on the undulating terminal moraine deposits characteristic of the area (Hein, 2011). Its diverse ecosystems include coniferous and deciduous forests, heathlands, sand dunes, and agricultural lands (Stichting Het Nationale Park De Hoge Veluwe, n.d.).

De Hoge Veluwe National Park also displays a dynamic interplay between human actions and natural processes in shaping a landscape rich in biodiversity. The area was once covered in trees, but after centuries of human cutting and grazing, it is now a mixture of heathlands and shifting dunes. Later, as park managers realized the ecological significance of this change, they concentrated on reforestation (De Hoge Veluwe, n.d.).

The park management prioritizes maintaining the current balance of flora and fauna, with targeted interventions to improve the habitat for specific species where necessary. Nowadays, the Veluwe is home to various wildlife, including red and roe deer, wild boar, pine marten, badger, and boasts the largest raven population in the country (Rewilding Europe, 2017).

The common raven has made a stunning comeback in recent years after being eradicated from the Netherlands and other parts of Western Europe in the 1920s as a result of persecution. Due to intensive reintroduction and breeding operations that started in the 1960s, the raven population has been rising gradually since 1980 (Rewilding Europe, 2017). The population has since then increased gradually at a rate of 5% per year. According to Ravenwerkgroep, as of the present day, the population is thought to consist of 125–150 breeding pairs, 100 territorial pairs that have not yet given birth, and 500–600 juveniles. However, the common raven is still listed as a species of concern in the Netherlands despite this encouraging trend.

The Ravenwerkgroep have followed the development of the raven's population originally by public more aware of and educating them about the species. In 2013 they started the color ring project for nestling ravens, affixing orange rings with black inscriptions for

identification purposes. Furthermore, in 2021 the transmitter project for nestling ravens started.

2.2 Data Collection

Certified personnel from The Ravenwerk groep in collaboration with ARK Rewilding Nederland and Sovo meticulously tagged 21 raven nestlings with OrniTrack-25 solar-powered GPS-GSM trackers details. These devices were securely attached to nestling ravens in the upper back of each bird using specially designed harnesses that prioritize the well-being of the ravens, expecting minimal interference with their flight capabilities and natural behaviors. The data were recorded during summer every 5 minutes and during winter every 15 minutes. At night, GPS coordinates were recorded once every four hours. This period was defined with a sun angle of minus four degrees.

Subsequently, the tracking data for each of the 21 ravens, from 2021 to 2024, was downloaded in CSV format from the database Ornitela panel, compiling a comprehensive dataset that includes variables such as individual identification, weight, datum, coordinates, speed, and altitude.

2.3 Data Preparation

All the analysis on this study was performed in R (R Core Team, 2023) using multiple packages as well as most of the figures found in this study.

The data underwent a thorough filtering and cleaning process to compile a new data frame that incorporated all 21 ravens studied. First, a new variable named timestamp was created by using the “*Tidyverse*” packages (Wickham *et al.* 2019). Afterward, the data was grouped by individual identification, and duplicate timestamps within each individual's data were removed. Data points with zero values for latitude and longitude were excluded from the dataset. The final data-frame included variables such as individual identification, datum, coordinates, speed, altitude, hdop, and time-stamp.

Subsequently, I applied the Continuous-Time Movement Model (ctmm) package (Fleming *et al.*, 2023) to transform the final data frame into a telemetry object. I addressed

the identification and exclusion of outliers by implementing a for-loop, ensuring the data's integrity and relevance for further analysis. Initially, I tackle the most significant outliers before proceeding with the filtering process based on speed and distance criteria. Specifically, I eliminate any data points where speeds exceed 100 meters per second or distances surpass 1000 kilometers.

2.3.1 Transition periods

To investigate how habitat use changes throughout a raven's life, I categorized my data based on these life stages: 1) Dependent young raven (below 90 days). Representing the family stage. 2) Independent Young ravens (90 - 360 days) Corresponding to the non-breeding stage. 3) Independent adults ravens (over 360 days). This category represents breeding adults.

By analyzing data from all three stages, I aim to estimate home range size and habitat preferences across these transitional periods. Following this classification, I found 21 ravens in the first category, 16 in the second, and only 5 in the third. The lower number of independent adults in my study might be due to the availability of data and the timing of the study.

2.3.2 Land cover classification

In order to understand the preferred habitats of ravens within their established territories, I prepared a land cover raster for a habitat analysis. The raster was provided by an open-source Land Use Map of the Netherlands (WENR, ArcGIS. Landgebruik Nederland, 2020). The original raster map contained 51 land use classes, which I reclassified them into different habitats. First, I defined the relevant area based on the extent of the ravens tracking data. I then cropped and reclassified a land cover raster (LGN2022.tif). Then I provided in a separate table the new classification for the land used. The reclassification had the categories 0) water, 1) coastal areas, 2) Wetlands and shrubland, 3) Forest, 4) Agriculture and managed land, 5) Build-up areas, and 6) Others. The reclassification allowed a more focused analysis of the primary habitats used by ravens. Grouping similar

land cover types facilitated the identification of potential trends in habitat selection and use of ravens, as well as their potential reliance on human-modified landscapes.

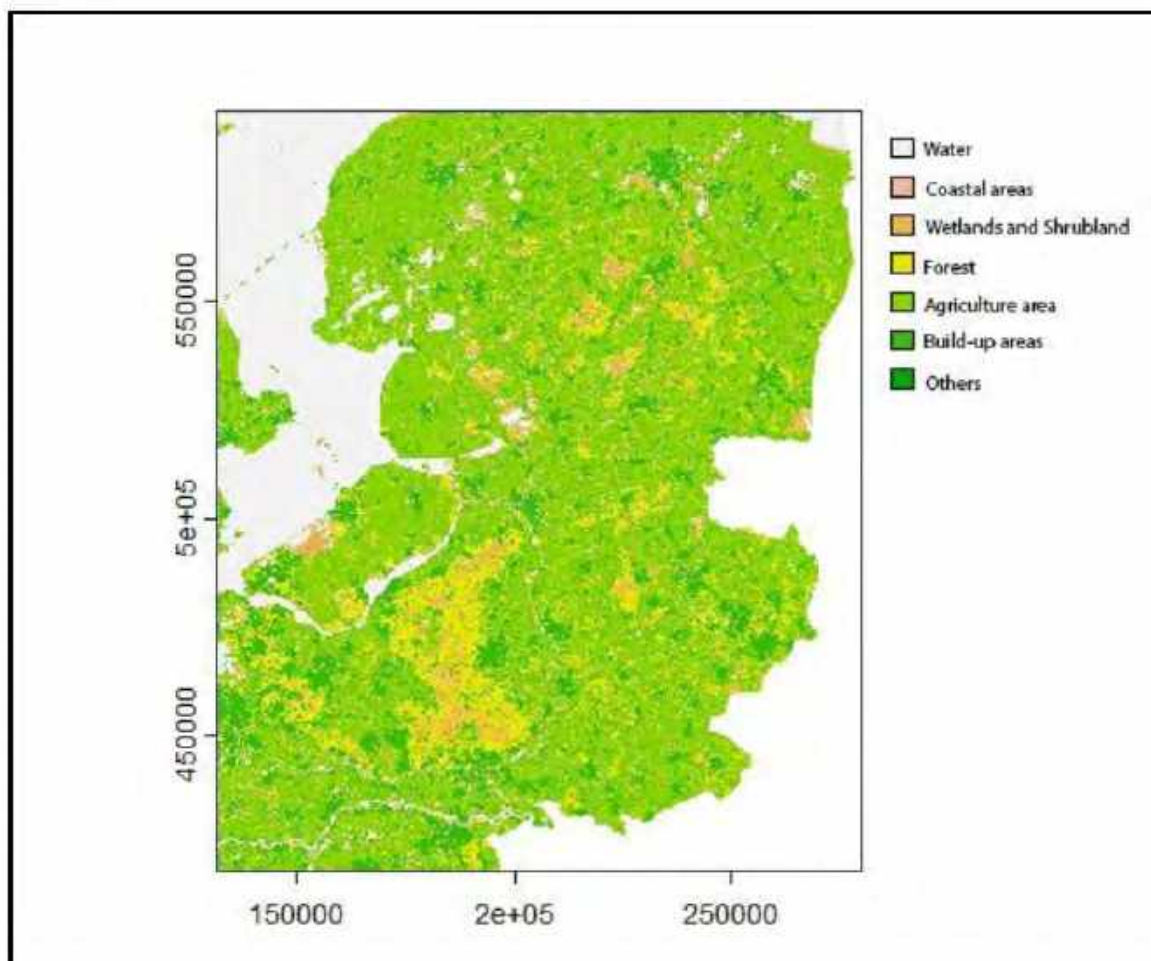


Figure 1: Reclassified raster of The Netherlands. 1) Coastal areas category include habitats such as open sand in coastal area. 2) Wetlands and shrublands category include habitats such as heavily grassed heath, swamp vegetation. 3) Forest category include habitats such as deciduous forest, coniferous forest. 4) Agriculture and managed land category include habitats such as corn, potatoes, beets, Green house horticulture. 5) Build-up areas category include habitats such as bare land in build-up area, buildings in primary and secondary build-up area. 6) Other category include habitats such as solar parks.

2.4 Data analysis

2.4.1 Clusters

To identify the different behaviors that each cluster represents, I conducted a spatial clustering analysis using the Expectation-Maximization Based Clustering (EMbC) algorithm (Garriga J, *et al.*, 2023). This technique groups spatial data points with similar geographic attributes (longitude, latitude, and time) into distinct clusters. By analyzing these clusters, we can gain insights into the ravens' spatial behavior. The EMbC algorithm achieves this by focusing on two key aspects of movement: speed and turning rate. These categorize movements into either "low" or "high." By combining these categories, the algorithm creates four main types also known as clusters: 1) LL which stands for low speed and low turn, 2) LH which stands for low speed and high turn, 3) HL which stands for high speed, and 4) HH which stands for high speed and high turn.

The function “*stts*” offers a fast compact view of the parameter set. For each cluster, the EMbC algorithm also provides additional insights by calculating two statistics, mean and standard deviation, for both speed and turn rate. The average speed shows how fast the ravens move within that cluster. It also analyzes the turn rate, indicating how frequently they change direction. The standard deviation for both speed and turn rate, essentially shows how spread out these values are. A high standard deviation suggests a wider range of speeds and turn rates within the cluster, while a low standard deviation indicates more homogeneity in movement patterns. Furthermore, I visualize the clusters for each raven by using the “*sctr*” function, which provides the clustering as a colored scatter plot (individual plots in the appendix).

Following the clustering analysis, I filtered the results based on the start and end dates of each raven to identify data points belonging to specific life stages. This allows me to examine how behavior patterns differ across the ravens' transition periods (family stage/dependent, non-breeder stage/independent young adult, and breeder/independent adult). Concentrating on ravens' foraging behavior to be able to identify the habitats used during such behavior.

2.4.2 Home ranges

The use of the Continuous-Time Movement Model (ctmm) package help considers all the parameters estimates repeats through all of the candidates and selects the best one based on Akaike Information Criterion (AIC). Subsequently, I used the fitted “ctmm” models for the home range calculation using the Animal Kernel Density Estimation (AKDE)

I used the Adaptive Kernel Density Estimator (AKDE) in the Continuous-Time Movement Model method (ctmm) package to measure the spatial extent used by individual ravens. This method made it possible to estimate home ranges while taking behavioral traits and individual mobility patterns into consideration. To select the most appropriate model for each individual, I applied the package's model selection features, which iteratively assessed several model parameters following the Akaike Information Criterion (AIC). By selecting the model that fits each individual the best, I ensured that the top movement model was used to calculate the AKDEs.

The home range results provided for each raven the home range estimates (low, estimate, and high) measured in square kilometers. The home range analysis was not possible for all ravens in each life stage.

I employed a linear mixed model (LMM) to examine the influence of life stage on home range size, accounting for individual variation. The model incorporated three distinct life stages: family stage, non-breeder stage, and breeder stage as categorical predictors.

$$Home_range_model \leftarrow lmer (estimate_area \sim Stage + (1|ID), data=data) (Eq1)$$

2.4.3 Habitat analysis

I looked into the proportion of different habitat types within animal home ranges and compared it to habitat use at individual locations. First, I processed the Animal Kernel Density Estimates (AKDEs) based on their life stage and extracted utilization distribution (UD) polygons representing the core home range area (95% percentile). The tracking data was transformed and combined with the UD polygons. The land cover data was prepared as a factor raster. Afterward, I calculated the proportion of each habitat type within each home range polygon. I accomplish this by intersecting the habitat raster with the home range polygons within the boundaries of each polygon. This resulted in a table

summarizing the availability of different habitat types within each raven's core home range. Then, I calculated the proportion of habitat use during foraging behavior. This by calculating the relative frequency of an individual in a particular habitat during foraging behavior.

I considered the proportion of habitat use at individual locations within raven's home ranges and compared it to habitat availability. I extracted habitat types for each point in the tracking data using the land cover raster. I then summarized habitat use frequency for ravens, considering their foraging behavior (previously provided by the EMbC algorithm) at each location. This resulted in a table summarizing the proportion of each habitat type used relative to the total number of locations for a specific behavior type within the raven's home range.

Afterward, I applied a habitat selection analysis using the WIII function from the package "*adehabitatHS*" (Calenge C. & Basille M., 2023). This function calculates the Manly Selectivity Index for each raven and then conducts statistical tests (Chi-square for each animal, and the overall habitat selection) to determine if there is a general pattern of habitat selection across all ravens.

To explore if early foraging experiences influence ravens later foraging experiences I conducted a correlation test. Due to the limitation of the breeder stage data. I conducted the correlation between the habitats ratios during the family stage and the last habitats rations of each raven, ether non-breeder stage or breeder stage.

Correlation_use <- cor.test(FS_ratios, NB_ratios, method = "spearman") (Eq2)

To investigate more if ravens habitats preference is predictable, I preformed separate linear regression models for each habitat type using the package (Zeileis A. & Hothorn T., 2002). The models incorporated the last habitat ratios during either the non-breeder stage or the breeder stage as a response variable, and the habitats ratios during the family stage as a predictor variable.

Correlation_model <- lm (NB_habitat_ratio ~ FS_habitat_ratio , data = data) (Eq3)

2.4.4 Survival Analysis

To assess the potential impact of GPS tags on raven survival, a survival analysis was conducted using the survival package (Therneau T., 2024). For this analysis, half of the ravens (21 individuals) were equipped with GPS tags, while the other half were left untagged for comparison purposes. Among the 42 ravens in the study, 13 were born in 2021, 15 were born in 2022, and 14 were born in 2023. The ravens exhibited similar weights ranging from 700 to 1700 grams, with a mean weight of 100 grams. This ensured that the weight distribution was consistent across the GPS tagged and untagged groups, minimizing the potential impact of weight variations on survival outcomes.

In survival analysis, censored events occur when the exact outcome (death) is not observed within the study period. The data included information on the date of birth, last observation date, vital status, GPS tagging status, and weight of each raven, enabling the determination of survival outcomes. For censored events, the status of the ravens was recorded as alive if they were not observed to have died by the end of the study period.

To provide a more comprehensive assessment of the effect of GPS tags on survival I used a Cox proportional hazards model (m1) which considered the relevant variables such as weight, and years.

$$\text{Survival_model} <- \text{coxph}(\text{surv_obj} \sim \text{GPS} + \text{scale}(\text{weight (gr)}) + (1|\text{Year}), \text{data} = \text{data})$$

(Eq4)

The model was fitted to estimate survival probabilities, incorporating GPS tag status as a predictor. Model assumptions, including proportional hazards, were assessed using standard diagnostic tests.

3.0 Results

3.1 Behavior identification for each cluster

The EMbC algorithm provided the delimiters in combination with the matrix of the values for maximum and minimum speed and turn within each cluster. This makes it easier to understand what kind of behavior each category represents (Table 1). In addition, I calculated the mean altitude in each cluster just to have an extra confirmation of what the cluster represents.

With all of this information, I was able to conclude the behaviors that each cluster represented:

- 1) LL= low speed, low turn potentially represents a resting behavior
- 2) LH = low speed, high turn potentially represents an intense foraging behavior
- 3) HH = high speed, high turn potentially represents a soaring/searching behavior
- 4) HL= high speed, low turn potentially represents commuting behavior

As the study aims to understand the foraging habits and preferences of ravens, only the data of the cluster LH represents intense foraging behavior was used.

Delimiters	Mean values LL	Mean values LH	Mean values HL	Mean values HH
mn speed	0.0929	0.1076	3.9305	1.1871
sd speed	0.1000	0.1200	3.1638	0.8767
mn turn	1.1186	2.7819	0.5571	2.2924
sd turn	0.7229	0.2757	0.6114	0.9595
kn	15336.2381	7215.0000	2162.7619	3122.4762
kn(%)	53.7581	30.3495	6.1071	9.9338
min speed	0.0000	0.0000	0.5886	1.7524
max speed	0.5890	1.8457	20.1610	20.1610
min turn	0.0000	2.1514	0.0210	1.5557
max turn	2.2471	3.1357	1.5810	3.1386

Table 1: Mean values of the delimiters in each behavior of all ravens: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH). Mean (mn) and standard deviation (sd) for turn rate and speed, respectively. The average speed indicates the speed at which the ravens travel within that group. The speed and rotation rate standard deviations effectively illustrate the range of these values. While a low standard deviation denotes greater

homogeneity in movement patterns, a high standard deviation points to a greater range of speeds and turn rates within the cluster. The marginal distribution Represents the absolute number of data points assigned to a specific cluster (kn) and relative (percentage) values (kn%)

3.2 Home ranges

For the family stage, out of 21 ravens, 15 fitting models were calculated successfully, and 14 home range estimates were produced. For the non-breeder stage, out of 16 ravens, 14 fitting models were calculated successfully, resulting in 12 home range estimates. And, for the breeder stage: all 5 ravens in the breeding were able to go through the model fitting process. However, only 3 home range estimates were calculated successfully.

The model (Eq1) revealed significant differences in home range size across the three life stages. The average estimated home range size across all life stages is 1947.9 square units (with a standard error of 1136.1). Ravens in the breeder stage exhibited the largest estimated home range size, followed by the non-breeder stage, with an estimated home range size that was 363.3 square units smaller (t-value -2.571). The family stage has the smallest home ranges. Compared to the intercept, individuals in this stage group have an estimated home range size that is 691.5 square units smaller (t-value -4.895).

The inclusion of a random intercept for individual ID accounted for substantial variation (21650189) in home range size among ravens, emphasizing the importance of individual-level factors in determining spatial behavior.

3.3 Habitat analysis

The habitat analysis examined how ravens forage different habitat types across their life stages. I compared the proportion of habitat types available within a raven's home range to the proportion of each habitat type actually used by the ravens while foraging.

For ravens in the family stage, forests were the dominant habitat type within their home ranges (available mean = 0.2771). Forests also showed the highest proportion of use compared to other habitat types (use mean = 0.1488). In simpler terms, ravens in the family stage tended to have both a high availability of forest habitat and a high preference for using it. For ravens in the non-breeder stage, the habitat analysis revealed a general preference for the habitats of agricultural and managed fields (mean use = 0.0864), which is also the habitat more available during this phase (available mean = 0.3245). For the breeder stage, the habitat analysis showed that the most used habitats are forest and build-up areas (use mean = 0.0363, 0.0558). However, forest and agriculture areas are the most available habitats (available mean = 0.3722, 0.2781).

Stages	Values	Water	Costal areas	Wetlands	Forest	Agricultural	Build up
Family Stage	Ratios	0.6286	2.5956	1.3104	1.6287	0.7607	0.4082
	SE	0.3165	0.6482	0.586	0.2494	0.1923	0.1148
	Mean use	0.0066	0.0098	0.0513	0.1488	0.0696	0.0344
	Mean available	0.0212	0.0145	0.1196	0.2771	0.3007	0.2071
Non-breeder	Ratios	1.9393	1.771	1.0331	0.7441	1.1114	1.0139
	SE	0.7546	0.3571	0.1595	0.0676	0.1546	0.2290
	Mean use	0.0092	0.0065	0.0239	0.0506	0.0865	0.0492
	Mean available	0.0220	0.0184	0.1157	0.3122	0.3245	0.2071
Breeder	Ratios	0.4392	0.3078	0.5133	0.7844	0.58701	2.7217
	SE	0.2121	0.0948	0.1462	0.0733	0.1978	0.2105
	Mean use	0.0012	0.0006	0.0092	0.0363	0.0197	0.0558
	Mean available	0.0247	0.0152	0.1432	0.3722	0.2781	0.1665

Table 2: This table contains the habitat analysis ratios, standard error (SE), mean use and mean habitat availability of each habitat in every life stage of the ravens.

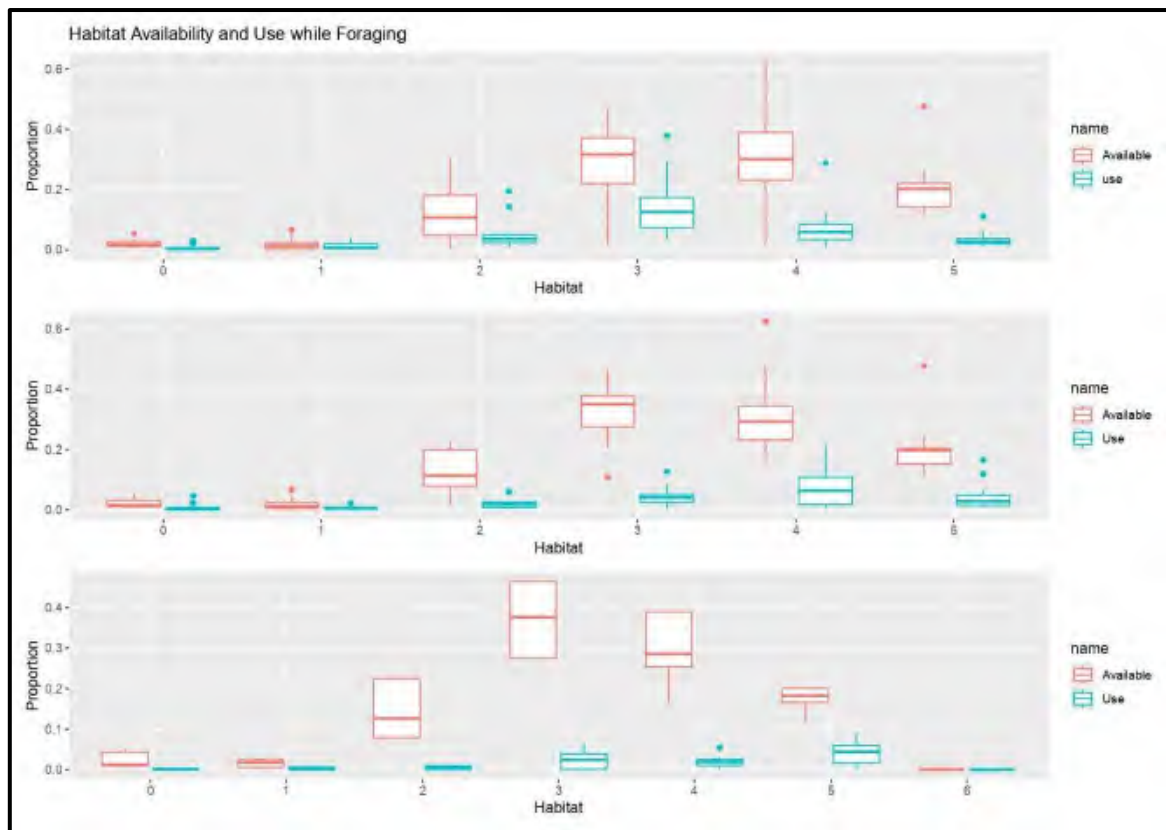


Figure 2: This figure provides a visual comparison of the proportion of habitat types available/orange within home ranges to the proportion of habitat types actually used/blue by the ravens in their different life stages. This creates a visual representation of how the proportion of habitat usage changes through their life stages.

According to the habitat selection analysis, during the family stage, coastal areas and forests exhibit relatively high selection ratios (ratios=2.5956, 1.6287), suggesting potential preference compared to all other habitat types. However, the coastal areas have a higher standard error compared to the forest habitats (SE= 0.6482). Agricultural and Build-up areas are generally underutilized (ratios=0.7607, 0.4082). During the non-breeder stage coastal, agricultural, build-up, and wetlands areas exhibit relatively high selection ratios (ratios=1.771, 1.01391, 1.1114, 1.0331). Water also had a high selection ratio, but also a high standard variation (ratio=1.9393, SE=0.7546). The lowest selection ratio was in the forest habitat type (ratio=0.7441, SE=0.0676). During the breeder stage, build-up areas show a relatively high selection ratio (ratio=2.7217, SE=0.2105) compared to all other habitat types.

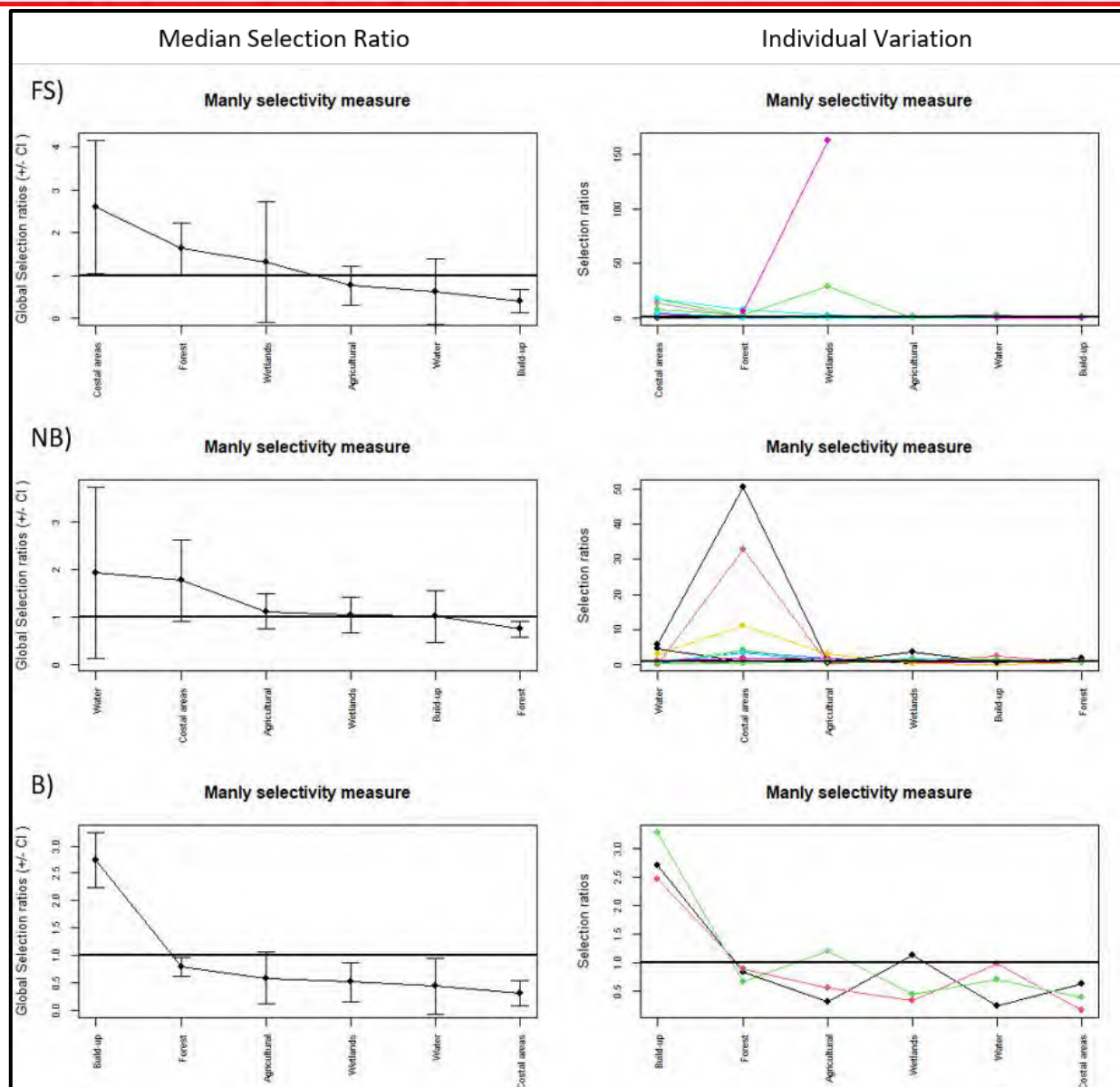


Figure 3: In this figure we see the Median Selection Ratio (left panels) and Individual Variation (right panels) in each life stage of the ravens (FS= Family stage, NB=non-breeders, B=Breeders). The horizontal line within each box represents the median selection ratio for that habitat type. In the left panels the boxplots illustrates the distribution of selection ratios across different habitat types. A median value greater than 1 indicates an overall preference for that habitat, while a value less than 1 suggests avoidance. In the right panels are a scatterplot showing individual selection ratios for each habitat type. Each dot represents the selection ratio for a specific individual and habitat type. This visualizes the variability in habitat selection among individuals.

3.3.1 Correlation between first foraging activities and last foraging activities

Spearman's rank correlation (Eq2) shows a moderate positive association between habitat selection during the ravens family stage and habitat ratios at their non-breeder stage (Spearman's rank correlation: $\rho=0.6441$, $p\text{-value}<0.05$). In other words, as the selection ratio increases in the family stage, there is a tendency for the selection ratio to increase in the non-breeding stage as well.

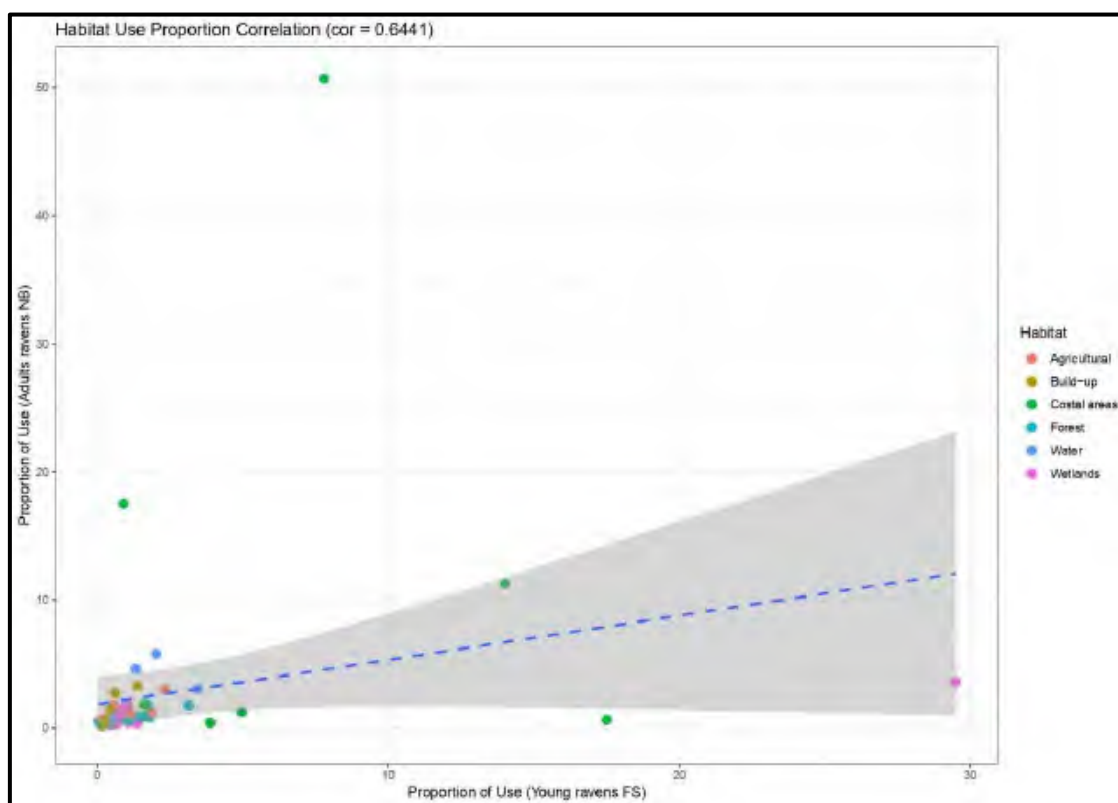


Figure 4: The scatterplot visualizes the relationship between habitat ratios during the family stage (F-Stage) and the non-breeding (NB-Stage) for different habitat types. The data points are relatively scattered around the regression line, indicating some variability in habitat use between individuals. Different colored points represent different habitat types.

The statistically significant positive correlation between the proportion of habitat use during the family stage and the proportion of use by adult ravens, suggests that when young ravens use a habitat more, they are also more likely to make use of that habitat as adults. However, the confidence interval tells us there is some variability in the strength of this relationship across different data points.

The linear regression models (Eq3) examine the impact of family stage ratios on non-breeder stage ratios, revealing variations across distinct habitat types. Certain habitats exhibit a notably higher significance and strength in the relationships between life stage ratios.

In Agricultural habitats, the family stage ratios demonstrate a positive relationship with a coefficient of 0.8297 ($p < 0.05$), implying an increase in these ratios during the non-breeding stage. Similarly, Forest and Wetlands habitats exhibit significant coefficients of 0.5031 and 0.09555, respectively, suggesting that family stage ratios influence an increase in non-breeder ratios within these environments.

In the other hands, some habitats demonstrate weaker significance. Water and Coastal habitats display positive coefficients of 1.1873 and 0.3167, respectively, yet both habitats exhibit low significance levels (0.0852 and 0.000759, respectively). Similarly, Build-up areas present a positive coefficient of 1.6677; however, the p-value of 0.0754 suggests a trend towards significance.

3.3.2 Use of anthropogenic food sources

Another thing to notice during the habitat analysis is that as they go through their life stages ravens seem to have an increase in the use of the agricultural and build-up areas, which are considered anthropogenic habitat types. During their family stage five out of the fourteen ravens made use of these habitats (28.57%). Within their non-breeder stage, ten out of eleven ravens use anthropogenic food sources (63.63%) and during their breeder stage, two out of three ravens use anthropogenic food sources (66.66%).

The habitat selection analysis further supports this observed trend. During the family stage, the build-up ratio is 0.4082, during the non-breeders stage this habitat ration increases to 1.0139 and finally reaching a ratio of 2.7421 during the breeder stage. Build-up stands out as the only habitat exhibiting a consistent increase across these stages.

Not that far from the study area we found an anthropogenic food source, which has multiple ravens occurrences. 5.1.2h is a waste processing company located in 5.1.2h Netherlands. The company processes and stores various types of waste, including construction and demolition waste, soil, and artificial grass mats. They

also operate a landfill site. This area enters the category of Build-up areas in the land cover classification. To see how significant this area was to the ravens in this study I repeated the habitat analysis in this area during foraging behavior.

For ravens in the family stage, 5.1.2h was more available than use (available mean = 0.1697, use mean = 1.0). During non-breeders and breeders stages the proportion use surpass of this habitat increased (use mean = 0.7692, 0.375) but the availability stayed similar between these two phases (available mean = 0.1835, 0.2218). This suggests that even within non-breeders' and breeders' stages some ravens actively select 5.1.2h for foraging (Figure 5)

During the family stage, there were 2974 GPS locations revealed that ravens foraged within built-up areas. Interestingly, 405 of these locations (roughly 13.61%) were within 5.1.2h. This specific area constitutes 16.97% of the total space ravens utilize (their home range). It's important to note that only five ravens actually used 5.1.2h for foraging during this family stage.

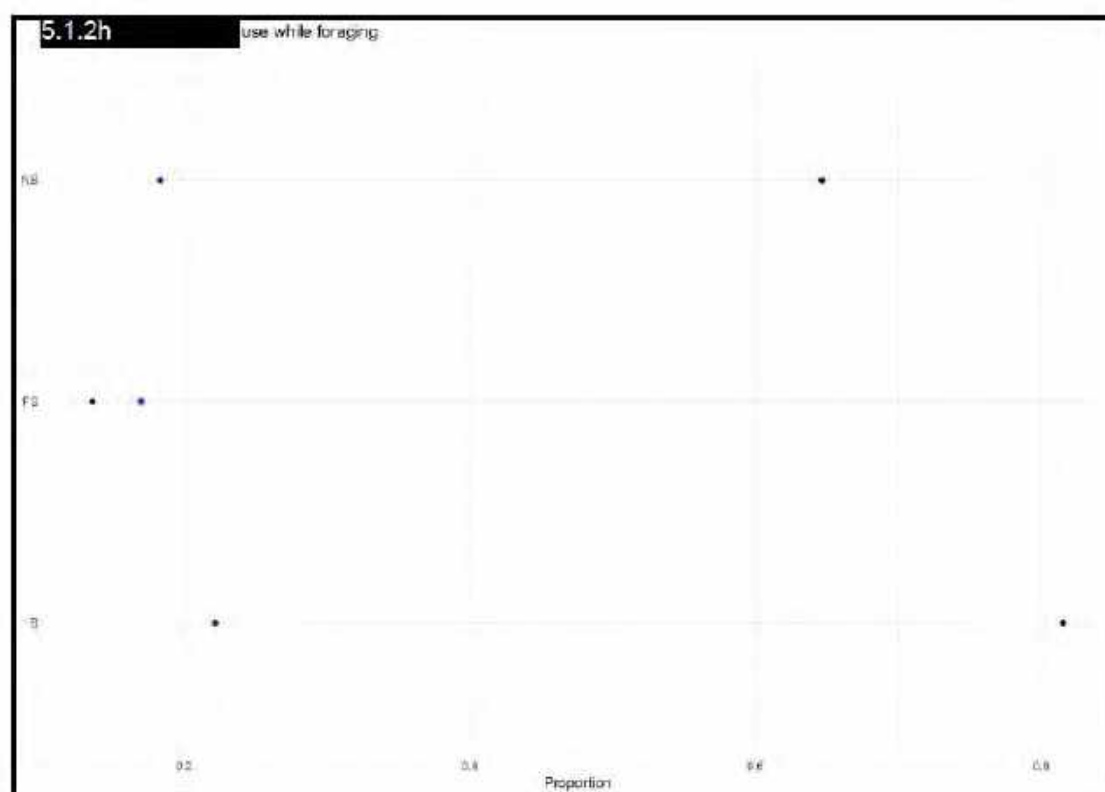


Figure 5: Visualization of the mean build-up habitat availability within the home ranges in each life stage (NB= non-breeder stage/young independent ravens, FS = family stage/dependent ravens, B = breeder stage/adult ravens) and habitat use while foraging within 5.1.2h. The red points represent the proportion of use within 5.1.2h area. The blue points represent the mean availability of build-up habitats.

The non-breeder stage presented a different picture. Here, the analysis of 8,118 GPS locations showed a higher frequency of ravens foraging within built-up areas. 5.1.2h was used in a much larger proportion of these locations (5,250, translating to 64.67%). However, the overall area used by ravens within built-up areas remained similar, representing 18.35% of their total space use. Ten ravens utilized 5.1.2h during the non-breeding stage.

The breeder stage has a total number of GPS locations showing foraging within built-up areas reached 18,895, a substantial increase compared to other stages. Three ravens present in this stage, use the 5.1.2h during foraging. This area represented a notable portion of their space use within built-up areas (81.51%), which itself constituted 22.22% of their total space use.

3.4 Survival analysis

The model results (Eq4) revealed a potential difference in survival rates between ravens with and without GPS tags. The coefficient and p-value for the GPS variable (1.6653, p-value 0.0195) suggest a significant positive effect. The hazard ratio (HR) of 5.29 indicates that ravens with GPS tags are 5.29 times more likely to die compared to those without tags.

On the other hand, the weight variable (scaled) showed a negative coefficient (-4.7487), suggesting a potential protective effect of weight (heavier ravens might have a slightly lower mortality risk). However, the non-significant p-value (0.1003) indicates this finding might be due to chance and requires further investigation. The model accounts for potential yearly variations in survival through a random effect for "Year." Examining the

details of this effect can reveal if there are significant differences in survival rates between years.

The model demonstrated good performance with a high concordance (0.808), indicating its ability to distinguish between ravens with higher and lower mortality risks based on the included variables. Likelihood ratio, Wald, and score tests all supported the model with both GPS and weight (even with weight's borderline significance) as a better fit compared to a model without these variables.

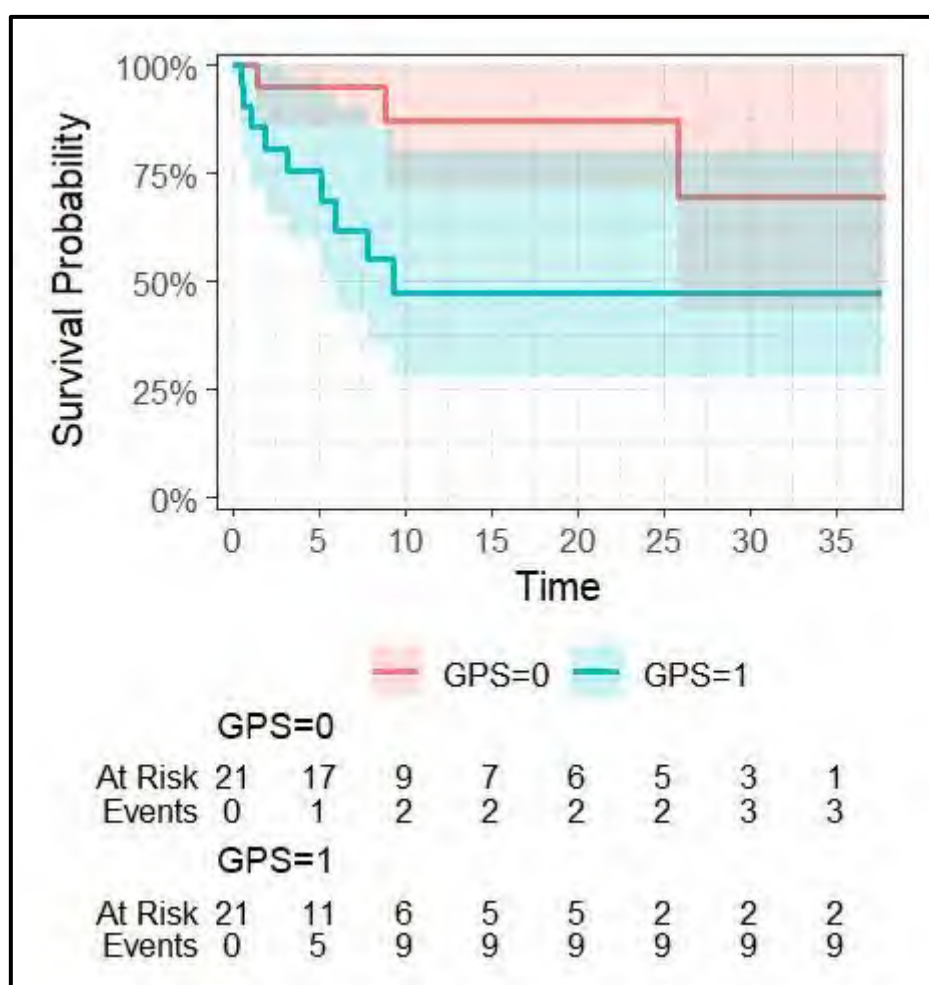


Figure 6: the plot shows two survival curves, orange/ no GPS tag ravens and blue/GPS tag ravens. These curves represent the estimated probability of surviving for months (y-axis) for each group (GPS tag and no GPS tag ravens). The vertical lines (represented by | symbols) at specific time points on the x-axis indicate censored observations. The table shows the number of individuals at risk (not yet experienced the event) at each time point for both groups.

The Kaplan-Meier survival curve analysis supports the initial observation. Estimates suggest that ravens with GPS tags (GPS = 1) might have a lower survival rate compared to untagged ravens (GPS = 0) across most time points (Figure 6). However, confidence intervals become wider as time increases, indicating less certainty due to fewer ravens being tracked.

These analyses suggest a strong association between having a GPS tag and a higher mortality risk in ravens. The effect of weight is less clear but hints at a possible protective role. The model also considers potential yearly variations in survival.

4.0 Discussion

The findings in this study show distinct home range sizes and habitat preferences across ravens' life stages. With a preference for forests in the family stage, agricultural/managed fields in the non-breeder stage, and forest/build-up areas in the breeder stage. There is a positive correlation between habitat selection in family and non-breeder stages, with linear regression models revealing varying impacts of family stage ratios on non-breeder stage ratios across different habitat types. These results suggest that the earlier foraging experience in ravens correlates with their late foraging behavior. The study also shows that the use of anthropogenic food seems to be related to their life stage. There is an increase in build-up areas as ravens go through their life trajectory. One specific area is the most build-up habitat visited by ravens in this study. According to the survival analysis, the GPS-tagged ravens have a higher probability of mortality compared to the non-GPS-tagged ravens. Further studies should consider other facts, such as nest location, size, age, and other health measurements to provide a more accurate result.

As ravens are in a dependent phase their opportunities for social interaction are limited by their parents and siblings (Boucherie *et al.*, 2019). This is why this stage is mostly known as the family stage. As they sexually mature and become independent, their social interaction is more extended, including other peers, leading to a more fluid fission–fusion social system (Silk *et al.*, 2014). Finally, ravens enter their breeding stage. During this stage their social interactions are more selective, providing a highly structured fission–fusion social (Loretto *et al.*, 2017; Silk *et al.*, 2014). To be able to change status from a non-breeder to a breeder, individuals have to become sexually mature, find a partner, and be able to defend a territory, that does not occur before the age of 3–4 years (Boucherie *et al.*, 2019). Unfortunately, the sample data was limited by a timeframe. As the obtained GPS data only reported approximately two years; I do not have an actual representation of ravens during breeders. Therefore, the best way to classify the ravens in this study is dependents ravens (FS), young independent ravens (NB), and adult ravens (B).

A significant variation in their spatial behavior is noticeable between ravens' life stages (Loretto *et al.*, 2016). These variations can also be appreciated in the home range sizes calculation, which are increasing as the ravens also go through their life trajectory. I see the largest home range size in ravens during the independent adult phase. However, if we had more representation for the independent adults, also known as the breeder's stage I

would expect to see a less large home range size, as breeders are known for being territorial (Loretto *et al.*, 2016; J. M. Marzluff & Heinrich, 1991).

Another factor that also influences the spatial behavior is the resource availability. We can also see a different preference in habitat selection during foraging behavior. In this study, we see that most ravens during their family stage have a preference for coastal and forest habitats. For ravens in the family stage, forests were the dominant habitat type within their home ranges. Forests also showed the highest proportion of use compared to other habitat types). The habitat selection also shows coastal areas to have a greater selection ratio than forest, however it also has a large standard deviation value due to ravens individual variation. Forest have the second selection ratio during this stage. The preference of forest habitats might be due to the fact that their nests are located within this habitat, and as we see in the home ranges there is more limited near the nest (Loretto *et al.*, 2017).

During the ravens' young independent phase (beginning of the non-breeder phase), we can observe an increase in anthropogenic food sources (the habitat analysis revealed a general preference for the habitats of agricultural and managed fields). As ravens during this phase tend to often form groups during foraging (Bugnyar & Kotrschal, 2002; Loretto *et al.*, 2017) where they gain experience and exchange knowledge. These foraging groups are characterized by a high degree of fission-fusion dynamics, which require repeated learning about unfamiliar individuals or updating information about those hardly familiar as well as attractive areas of food sources. This suggests that ravens accumulate knowledge about others, often over extended periods (Bugnyar, 2013).

The positive correlation between the habitats used during their dependent phase (FS) and the habitat used during the independent adult phase (NB and B) shows that the earlier foraging experience influences their later habitat preferences. This suggests that ravens' habitat preference is not only due to the habitat available but also due to the process of learning and moving with other ravens, developing preferences for certain foraging techniques and foraging sites (Bugnyar & Heinrich, 2006). The exposure to diverse food types and foraging challenges during their developmental stages helps them build a range of skills that they can draw upon in later life stages (Restani *et al.*, 2001).

Ravens can adjust their foraging strategies based on changing environment, optimizing their resource acquisition in different habitats (scavenger, selection). This behavior is

influenced by their cognitive flexibility and problem-solving abilities honed through early learning experiences (Bugnyar, T., 2013; Bond et al., 2003). The research by Boeckle & Bugnyar, 2012 shows that ravens possess excellent memory not only for past group members but also foraging areas. The ability to gather information from others has important implications for the transmission of new behavior patterns within a population, regardless of the specific learning mechanism involved. (Fritz & Kotrschal, 1999)

Ravens do not form numerous bonds simultaneously; instead, they prioritize and invest in one to a few partner relationships at any given time. Despite this focus on a few partnerships at a time, ravens spending multiple years in non-breeder groups can accumulate a substantial network of affiliated individuals and potential food sources (Bugnyar, 2013)

It is also important to acknowledge that permanent food sources are also factors that influence their spatial and foraging behavior (Restani *et al.*, 2001). As ravens navigate an environment increasingly shaped by human presence, their spatial and foraging behavior is expected to change. The movement patterns of ravens, which already fluctuate with the life stages, are particularly sensitive to the presence of food sources created by human activities (Restani *et al.*, 2001).

The results of this study indicate that when ravens discover or learn about anthropogenic food sources which are more predictable in quantity, quality, and location than natural resources (Restani *et al.*, 2001; Jain *et al.*, 2022), they actively go beyond their usual home range to forage in these areas. This specifically happened in 5.1.2h [REDACTED], which is considered an anthropogenic food source near the study area. The exploitation of food resources that are out of their habitat availability might be linked to their social behavior. Ravens are capable of learning about these foraging spots, either individually or socially by following others (Szipl *et al.*, 2015).

Ravens that rely on anthropogenic food sources appear to have a great potential to modify social behavior during periods of food stress. (Restani *et al.*, 2001). Compared to ephemeral resources such as skiing huts or small compost stations are limited by daytime and season, others such as zoos and garbage dumps exist year-round and will therefore attract a higher number of ravens continuously. (Loretto *et al.*, 2016). Further studies should concentrate on the seasonal variation in the use of anthropogenic sources in this area.

In conclusion, this study explores the complex interaction that exists between ravens' foraging behavior, their preference for anthropogenic food sources, and the subsequent impacts on their spatial behavior. By focusing on understanding how ravens' foraging habits change across different life stages, especially concerning their interactions with human-altered food sources, this research highlights the influence of early experiences on later foraging patterns. Ravens, with their remarkable cognitive skills, make ideal research subjects for examining foraging habits. They are capable to form large social networks and recognize a variety of food sources (Bugnyar, 2013). Examining how early habitat uses and human activities shape raven behavior (Pika et al., 2020) provides crucial insights into the ecological and behavioral responses of this species. These findings emphasize the need for careful consideration of anthropogenic impacts on wildlife conservation and management strategies.

5.0 Acknowledgments

This project was conducted in collaboration with Wageningen University and Research, ARK Rewilding Nederland and The Ravenwerkgroep. I would like to thank my supervisors: 5.1.2e for allowing me to work on this project, taking the time to clear up my questions providing insightful advice during the project. 5.1.2e for assisting me with this research, for being patient and always being present whenever I had a question.

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7.0 Appendix

7.1 Cluster visualization for each raven by using “*sctr*” function from the EMbC package.

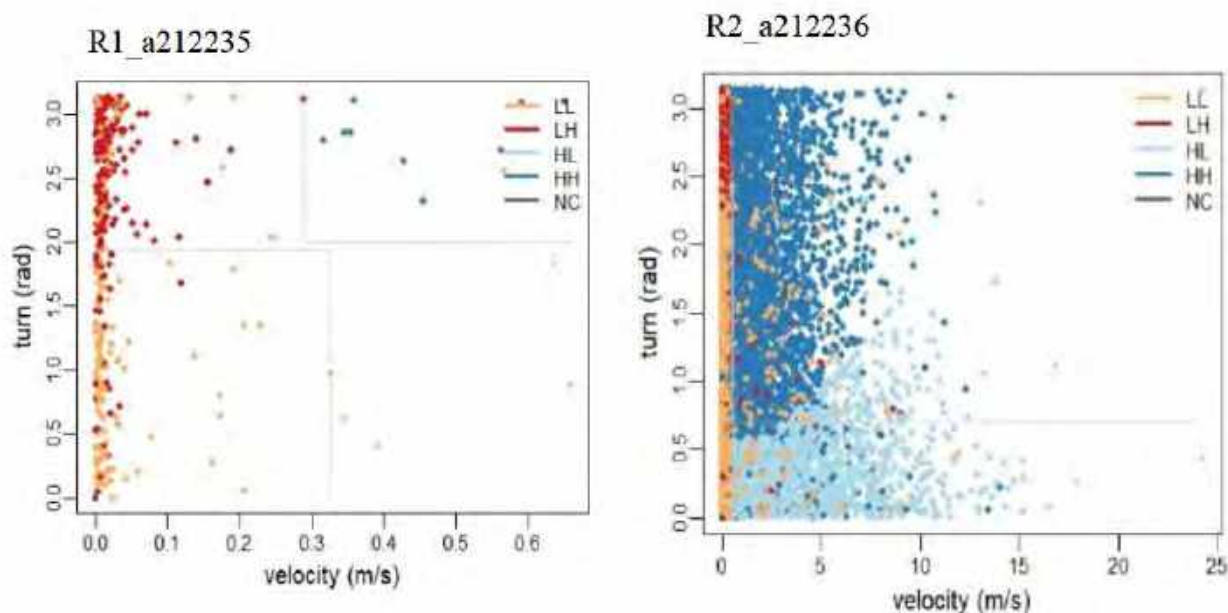


Figure 7: This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R1 and R2: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH)

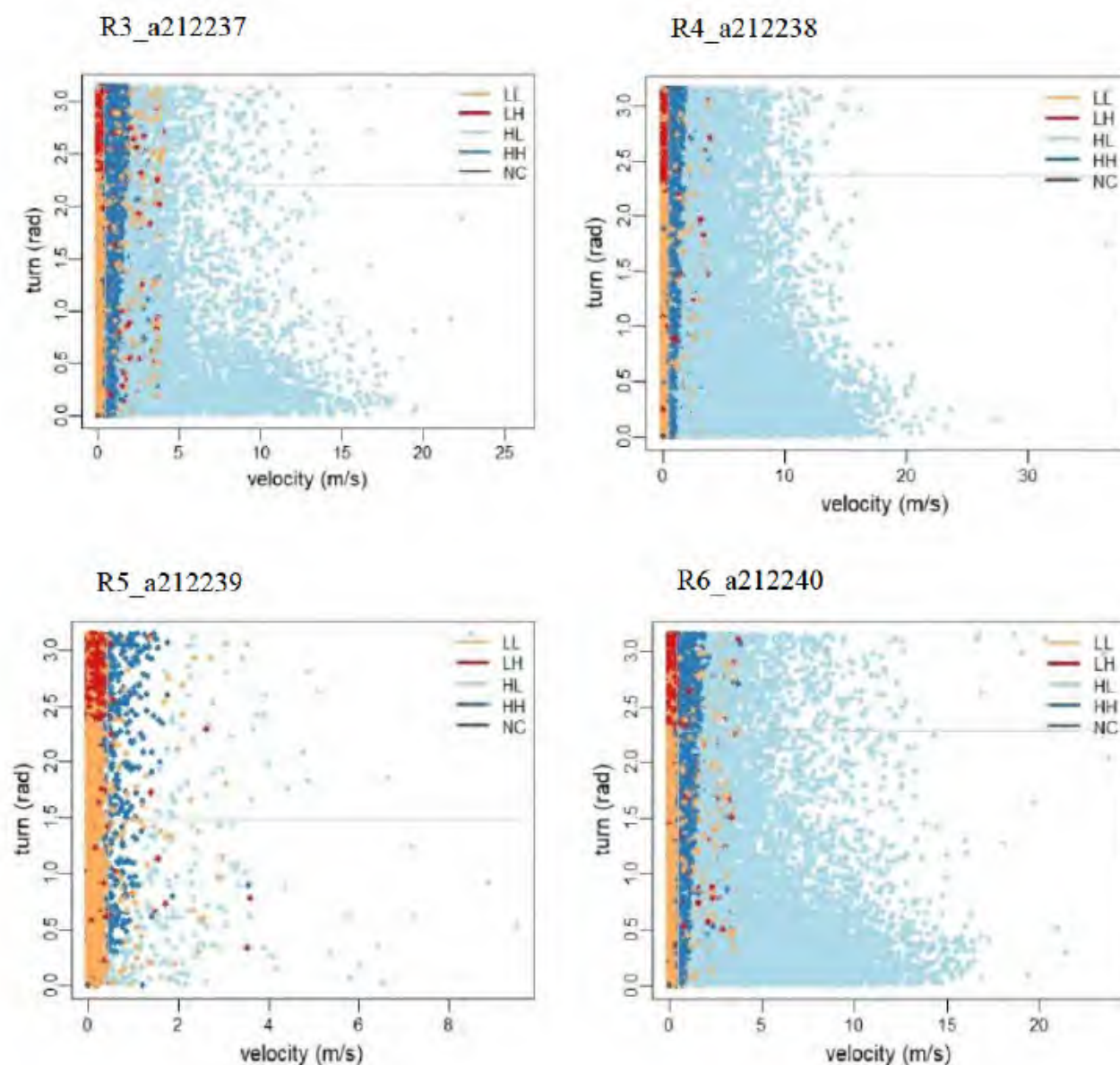


Figure 7 (continued): This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R3, R4, R5 and R6: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH).

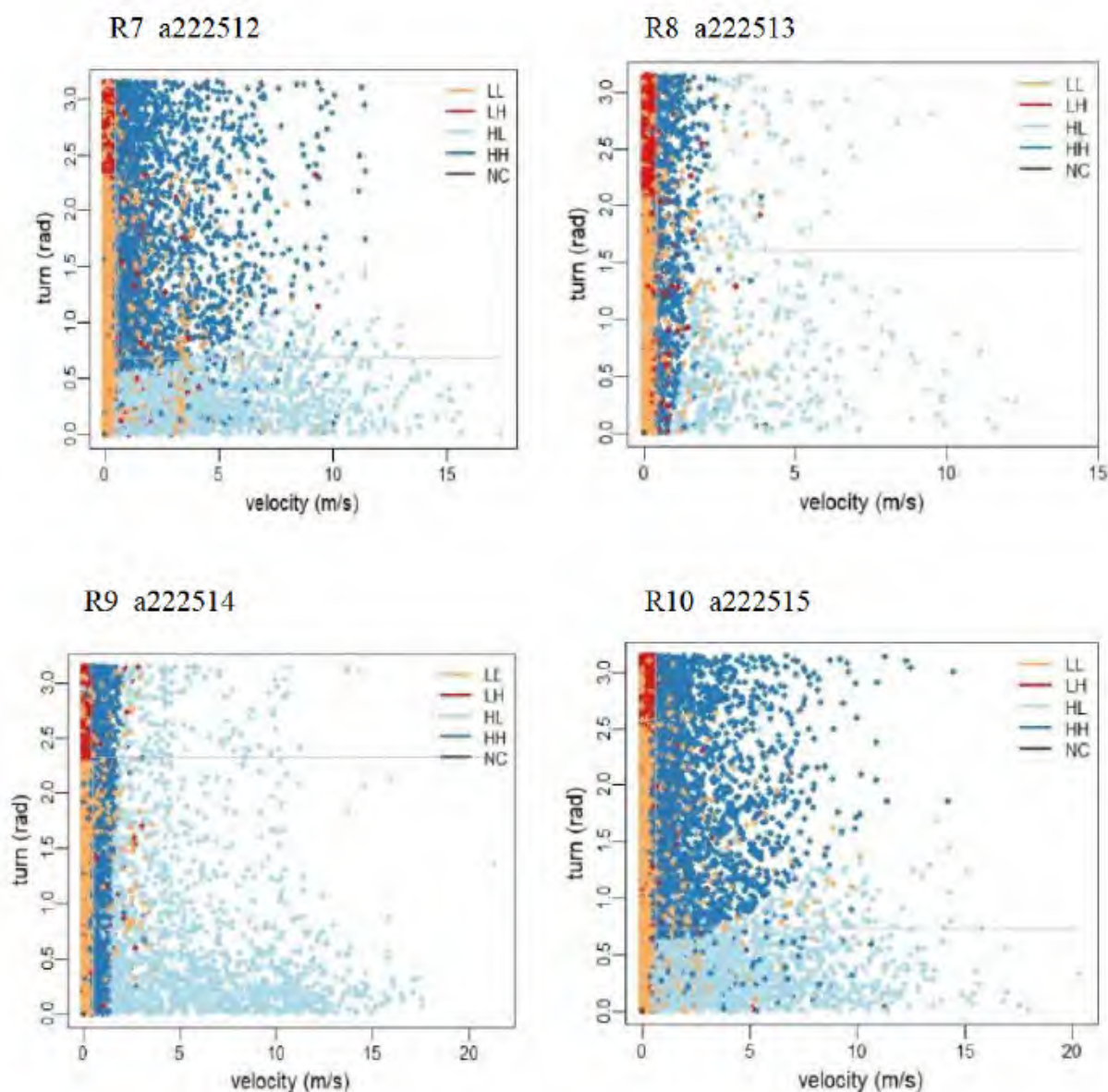


Figure 7 (continued): This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R7, R8, R9 and R10: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH).

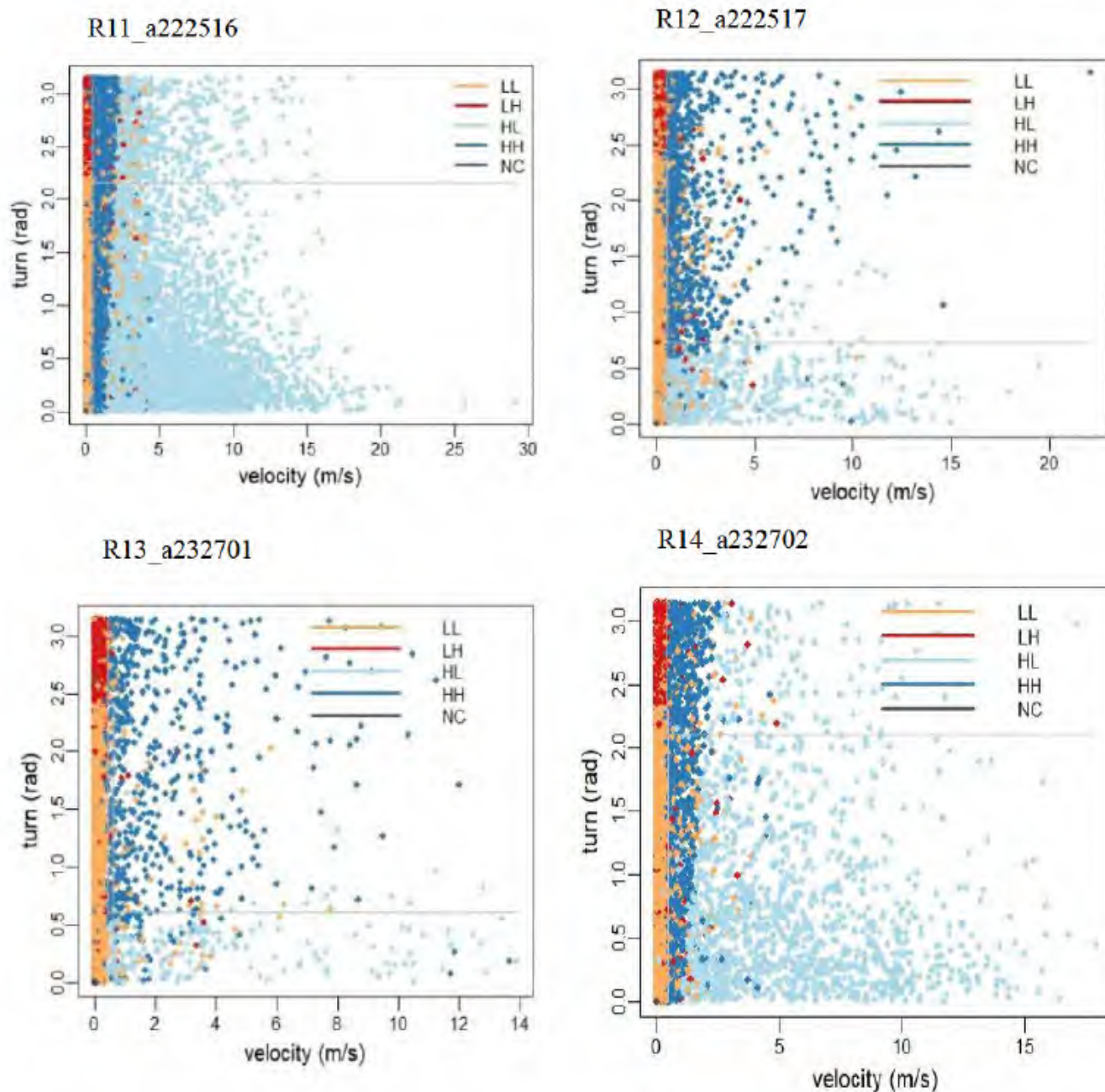


Figure 7 (continued): This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R11, R12, R13 and R14: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH).

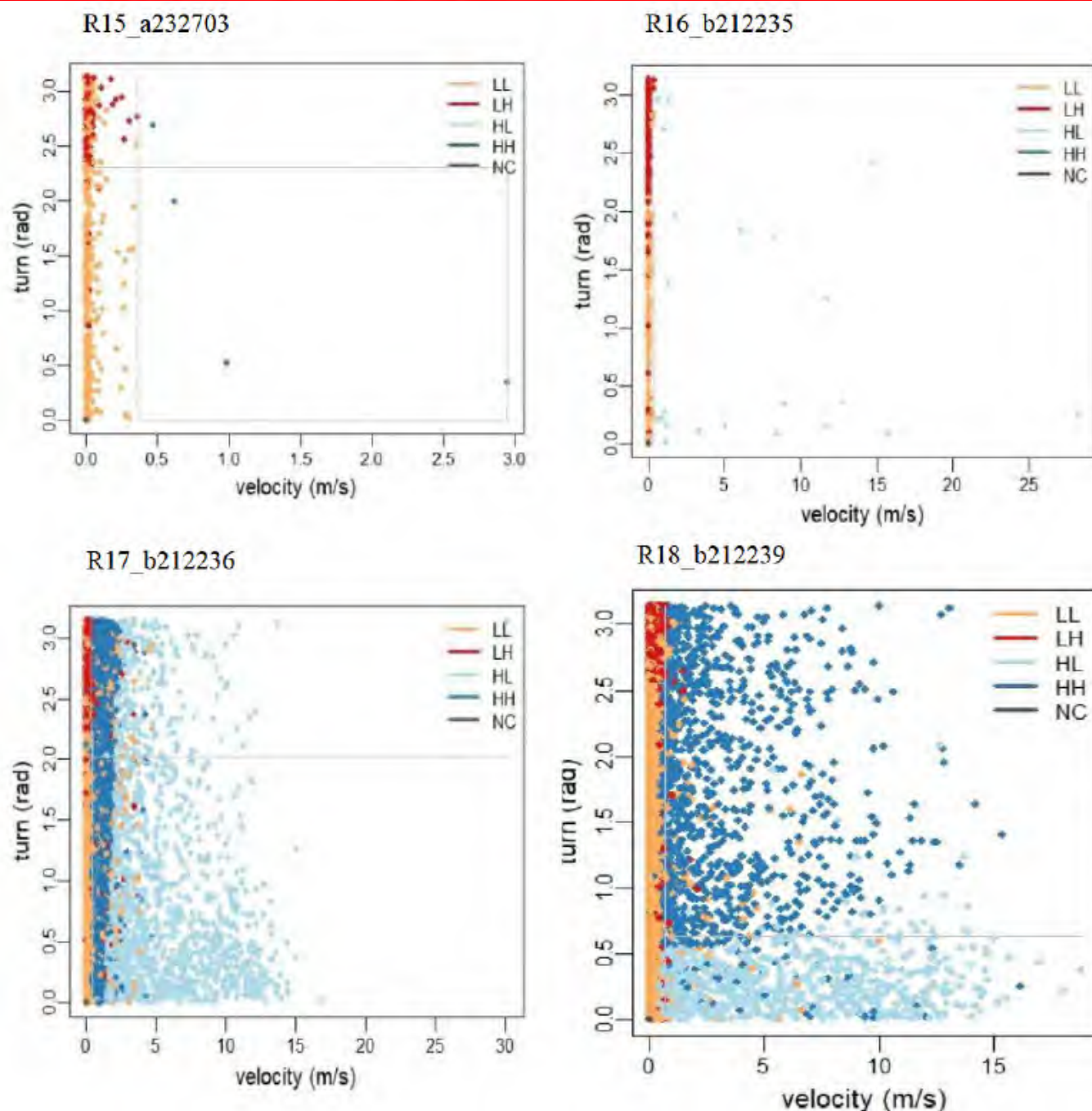


Figure 7 (continued): This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R15, R16, R17 and R18: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH).

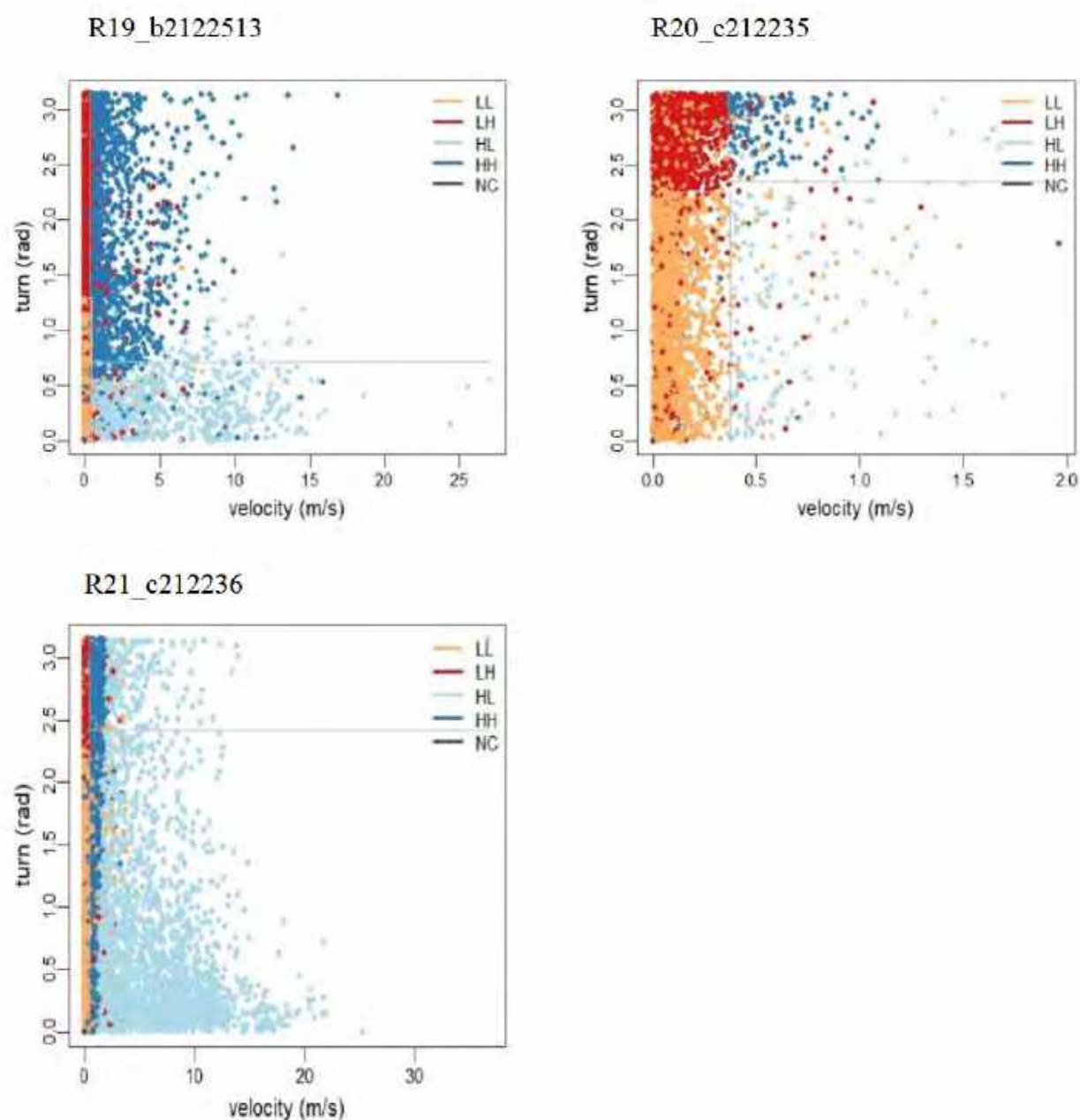


Figure 7 (continued): This visualization provides the clustering as a colored scatter-plot which illustrates the different types of movement in each behavior for R19, R20 and R21: Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH).

7.2 Home range estimations

ID	Stage	Area low	Area est	Area High	Unit
a212235	FS	30.3229	34.2379	38.3871	hectares
a212236	FS	61.0918	66.1074	71.3181	km ²
	NB	264.8457	307.0105	352.2442	km ²
a212237	FS	315.4858	400.2815	495.0766	km ²
	NB	506.8913	554.5866	604.3957	km ²
	B	812.2759	904.6676	1001.964	km ²
a212238	FS	89.5021	94.2521	99.1231	km ²
	NB	347.0409	370.869	395.4771	km ²
	B	898.853	983.01	1070.879	km ²
a212239	FS	4.8692	5.4851	3.1371	km ²
a212240	FS	185.4343	206.072	227.7828	km ²
	NB	336.9989	367.1424	398.5586	km ²
	B	624.5875	693.7084	766.4045	km ²
a222515	FS	72.4801	77.7904	83.2856	km ²
	NB	308.5562	354.7433	404.1047	km ²
a222517	FS	46.4465	50.8481	55.4462	km ²
	NB	94.0548	124.978	160.2288	km ²
	B	812.2759	904.6676	1001.964	km ²
a232702	FS	138.7194	151.7078	165.2692	km ²
	NB	687.2944	936.0539	1222.641	km ²
b212236	FS	150.8795	183.3169	218.8655	km ²
	NB	275.8165	314.556	355.8041	km ²
b212239	FS	219.0681	253.5344	290.4819	km ²
b222513	FS	274.9878	315.8817	359.569	km ²
	NB	849.0537	1049.818	1271.569	km ²
c212235	FS	37.5912	42.1916	47.0537	hectares
	NB	691.2259	753.3271	818.0614	km ²
a222513	NB	96.2127	109.7484	124.1619	km ²

Table 3: The 14 calculation of the home range size. ID of each raven, the different stages they went through and the size of the home range in low, estimate and high.

7.3 Delimiters in each behavior per raven.

Raven	Delimiters	LL	LH	HL	HH
R1_a212235	mn speed	0.02	0.02	0.5	0.46
	sd speed	0.1	0.4	0.15	0.12
	mn turn	0.95	2.69	0.96	2.82
	sd turn	0.63	0.37	0.53	0.25
	kn	150	180	4	9
	kn(%)	43.6	52.33	1.16	2.62
	min speed	0	0	0.32	0.29
	max speed	0.32	0.29	0.65	0.65
	min turn	0	1.94	0	1.99
	max turn	1.94	3.13	1.99	3.13
R2_a212236	mn speed	0.11	0.12	3.47	1.73
	sd speed	0.1	0.1	3.08	1.51
	mn turn	1.19	2.82	0.3	1.98
	sd turn	0.76	0.24	0.29	0.83
	kn	15391	6529	1984	5194
	kn(%)	52.89	22.44	6.82	17.85
	min speed	0	0	0.53	0.42
	max speed	0.53	0.42	24.29	24.29
	min turn	0	2.36	0	0.69
	max turn	2.36	3.14	0.69	3.14
R3_a212237	mn speed	0.1	0.12	4.41	0.81
	sd speed	0.1	0.1	3.54	0.37
	mn turn	1.16	2.8	0.71	2.76
	sd turn	0.74	0.26	0.88	1.31
	kn	45256	21015	5123	8817
	kn(%)	56.42	26.2	6.39	10.99
	min speed	0	0	0.45	0.41
	max speed	0.45	0.41	25.84	25.84
	min turn	0	2.31	0	2.2
	max turn	2.31	3.14	2.2	3.14
					40

R4_a212238	mn speed	0.1	0.12	5.09	0.79
	sd speed	0.1	0.1	3.69	0.36
	mn turn	1.15	2.8	0.7	2.84
	sd turn	0.74	0.26	0.89	1.33
	kn	61973	30019	13332	13168
	kn(%)	52.3	25.33	11.25	11.11
	min speed	0	0	0.44	0.41
	max speed	0.44	0.4	36.61	36.61
	min turn	0	2.31	0	2.37
	max turn	2.31	3.14	2.37	3.14
R5_a212239	mn speed	0.1	0.11	1.94	0.79
	sd speed	0.1	0.1	1.55	0.35
	mn turn	1.19	2.82	0.58	2.51
	sd turn	0.79	0.24	0.91	1.07
	kn	3664	1688	207	368
	kn(%)	61.81	28.48	3.49	6.21
	min speed	0	0	0.44	0.41
	max speed	0.44	0.41	9.49	9.49
	min turn	0	2.35	0	1.48
	max turn	2.35	3.14	1.48	3.14
R6_a212240	mn speed	0.1	0.11	4.48	0.78
	sd speed	0.1	0.1	3.36	0.35
	mn turn	1.14	2.81	0.72	2.8
	sd turn	0.74	0.26	0.89	1.33
	kn	57611	24877	7568	8025
	kn(%)	58.74	25.36	7.72	8.18
	min speed	0	0	0.44	0.4
	max speed	0.44	0.4	23.77	23.77
	min turn	0	2.31	0	2.29
	max turn	2.31	3.14	2.29	3.14
R7_a222512	mn speed	0.1	0.11	4.1	1.78
	sd speed	0.1	0.1	3.44	1.71
	mn turn	1.13	2.81	0.29	1.97
	sd turn	0.75	0.26	0.24	0.85
	kn	22506	9685	1736	3644
	kn(%)	59.9	25.78	4.62	9.7
	min speed	0	0	0.55	0.43
	max speed	0.55	0.43	17.36	17.36
	min turn	0	2.31	0	0.68
	max turn	2.32	3.14	0.68	3.14

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R8_a222513	mn speed	0.1	0.1	2.83	0.87
	sd speed	0.1	0.1	2.23	0.43
	mn turn	1.01	2.72	0.57	2.47
	sd turn	0.66	0.33	0.84	1.13
	kn	3333	2322	429	878
	kn(%)	47.87	33.35	6.16	12.61
	min speed	0	0	0.43	0.39
	max speed	0.43	0.39	14.44	14.44
	min turn	0	2.08	0	1.06
	max turn	2.08	3.08	1.6	3.14
R9_a222514	mn speed	0.09	0.1	5.47	0.76
	sd speed	0.1	0.1	3.95	0.35
	mn turn	1.12	2.8	0.61	2.82
	sd turn	0.74	0.26	0.87	1.43
	kn	16796	7874	1508	2803
	kn(%)	57.95	27.17	5.2	9.67
	min speed	0	0	0.45	0.39
	max speed	0.45	0.39	21.54	21.54
	min turn	0	2.29	0	2.33
	max turn	2.29	3.14	2.33	3.14
R10_a222515	mn speed	0.12	0.16	4.04	2.11
	sd speed	0.1	0.14	3.48	1.77
	mn turn	1.35	2.9	0.31	2
	sd turn	0.82	0.19	0.28	0.81
	kn	17892	5052	1686	3568
	kn(%)	63.45	17.92	5.98	12.68
	min speed	0	0	0.58	0.58
	max speed	0.58	0.58	20.38	20.38
	min turn	0	2.58	0	0.74
	max turn	2.58	3.14	0.73	3.14
R11_a222516	mn speed	0.11	0.13	4.82	0.86
	sd speed	0.1	0.1	3.68	0.42
	mn turn	1.19	2.82	0.66	2.74
	sd turn	0.76	0.24	0.87	1.32
	kn	26579	11276	4175	6806
	kn(%)	54.42	23.09	8.55	13.94
	min speed	0	0	0.45	0.41
	max speed	0.45	0.42	29.15	29.15
	min turn	0	2.36	0	2.16
	max turn	2.36	3.14	2.16	3.14

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R12_a222517	mn speed	0.11	0.13	4.01	1.78
	sd speed	0.1	0.12	3.77	1.8
	mn turn	1.17	2.83	0.29	2.02
	sd turn	0.76	0.23	0.28	0.85
	kn	5396	2280	589	1244
	kn(%)	56.74	23.97	6.19	13.08
	min speed	0	0	0.54	0.49
	max speed	0.54	0.49	22.13	22.13
	min turn	0	2.39	0	0.73
	max turn	2.39	3.14	0.73	3.14
R13_a232701	mn speed	0.1	0.11	4.03	2.08
	sd speed	0.1	0.1	3.58	1.9
	mn turn	1.21	2.84	0.28	1.95
	sd turn	0.77	0.23	0.21	0.88
	kn	3232	1227	202	687
	kn(%)	60.42	22.94	3.78	12.84
	min speed	0	0	0.6	0.44
	max speed	0.6	0.44	13.89	13.89
	min turn	0	2.4	0	0.6
	max turn	2.4	3.14	0.6	3.14
R14_a232702	mn speed	0.1	0.11	4.81	0.92
	sd speed	0.1	0.1	3.4	0.47
	mn turn	1.12	2.8	0.66	2.69
	sd turn	0.74	0.26	0.8	1.24
	kn	7935	3580	1356	1398
	kn(%)	55.61	25.09	9.5	9.8
	min speed	0	0	0.44	0.41
	max speed	0.44	0.41	17.88	17.88
	min turn	0	2.3	0.44	2.1
	max turn	2.3	3.14	2.1	3.14
R15_a232703	mn speed	0.03	0.03	0	1.31
	sd speed	0.1	0.1	0	1.07
	mn turn	1.13	2.82	0	1.49
	sd turn	0.71	0.25	0	0.97
	kn	349	117	0	4
	kn(%)	74.1	28.84	0	0.85
	min speed	0	0	2.94	0.35
	max speed	2.95	2.3	2.94	2.94
	min turn	0	2.3	0	0
	max turn	2.3	3.13	0	3.13

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R16_b212235	mn speed	0.03	0.03	6.79	0
	sd speed	0.1	0.1	6.9	0
	mn turn	1.05	2.71	1.01	0
	sd turn	0.67	0.32	1.05	0
	kn	145	194	23	0
	kn(%)	39.94	53.44	6.34	0
	min speed	0	0	0.36	28.27
	max speed	0.36	28.27	28.27	28.27
	min turn	0	2.06	0	3.13
	max turn	2.06	3.13	3.13	3.13
R17_b212236	mn speed	0.1	0.11	4.44	0.88
	sd speed	0.1	0.1	3.44	0.45
	mn turn	1.08	2.77	0.67	2.68
	sd turn	0.71	0.28	0.88	1.28
	kn	13199	7961	1494	3451
	kn(%)	50.56	30.49	5.72	13.22
	min speed	0	0	0.45	0.4
	max speed	0.45	0.4	30.16	30.16
	min turn	0	2.21	0	2.02
	max turn	2.21	3.14	2.02	3.14
R18_b212239	mn speed	0.12	0.18	5.93	3.01
	sd speed	0.1	0.16	4.28	2.58
	mn turn	1.32	2.89	0.26	1.86
	sd turn	0.81	0.2	0.2	0.81
	kn	6600	2082	751	1361
	kn(%)	61.14	19.29	6.96	12.61
	min speed	0	0	0.69	0.71
	max speed	0.69	0.71	18.83	18.83
	min turn	0	2.55	0	0.63
	max turn	2.55	3.14	0.63	3.14
R19_b222513	mn speed	0.11	0.12	5.02	1.83
	sd speed	0.1	0.1	4.32	1.85
	mn turn	0.58	2.41	0.3	2.01
	sd turn	0.42	0.56	0.25	0.87
	kn	1823	6602	767	1690
	kn(%)	16.75	60.66	7.05	15.53
	min speed	0	0	0.44	0.42
	max speed	0.44	0.42	27.02	27.02
	min turn	0	1.29	0	0.71
	max turn	1.29	3.14	0.71	3.14

R20_c212235	mn speed	0.09	0.11	0.71	0.57
	sd speed	0.1	0.1	0.37	0.2
	mn turn	1.14	2.79	1.15	2.87
	sd turn	0.74	0.27	0.82	0.21
	kn	2340	1652	156	150
	kn(%)	54.43	38.43	3.63	3.49
	min speed	0	0	0.37	0.36
	max speed	0.37	0.36	1.96	1.96
	min turn	0	0.24	0	2.34
	max turn	2.24	3.14	2.34	3.14
R21_c212236	mn speed	0.11	0.13	5.65	0.81
	sd speed	0.1	0.1	4.23	0.35
	mn turn	1.11	2.77	0.67	2.86
	sd turn	0.72	0.28	0.86	1.38
	kn	9891	5303	2328	2307
	kn(%)	49.88	26.74	11.74	11.63
	min speed	0	0	0.45	0.41
	max speed	0.45	0.42	36.78	36.78
	min turn	0	2.24	0	2.42
	max turn	2.24	3.14	2.42	3.14

Table 4: Delimiter of each cluster for each raven. Low velocities and low turns (LL). Low velocities and high turns (LH). High velocities and low turns (HL), and High velocities and high turns (HH). Mean and standard deviation for turn rate and speed, respectively. The average speed indicates the speed at which the ravens travel within that group. The speed and rotation rate standard deviations effectively illustrate the range of these values. While a low standard deviation denotes greater homogeneity in movement patterns, a high standard deviation points to a greater range of speeds and turn rates within the cluster.

7.4 Models outputs

Water linear regression model output.

	Estimate	Std. Error	P_value
Intercept	0.5463	0.9251	0.5734
FS_Water	1.1873	0.5926	0.0852

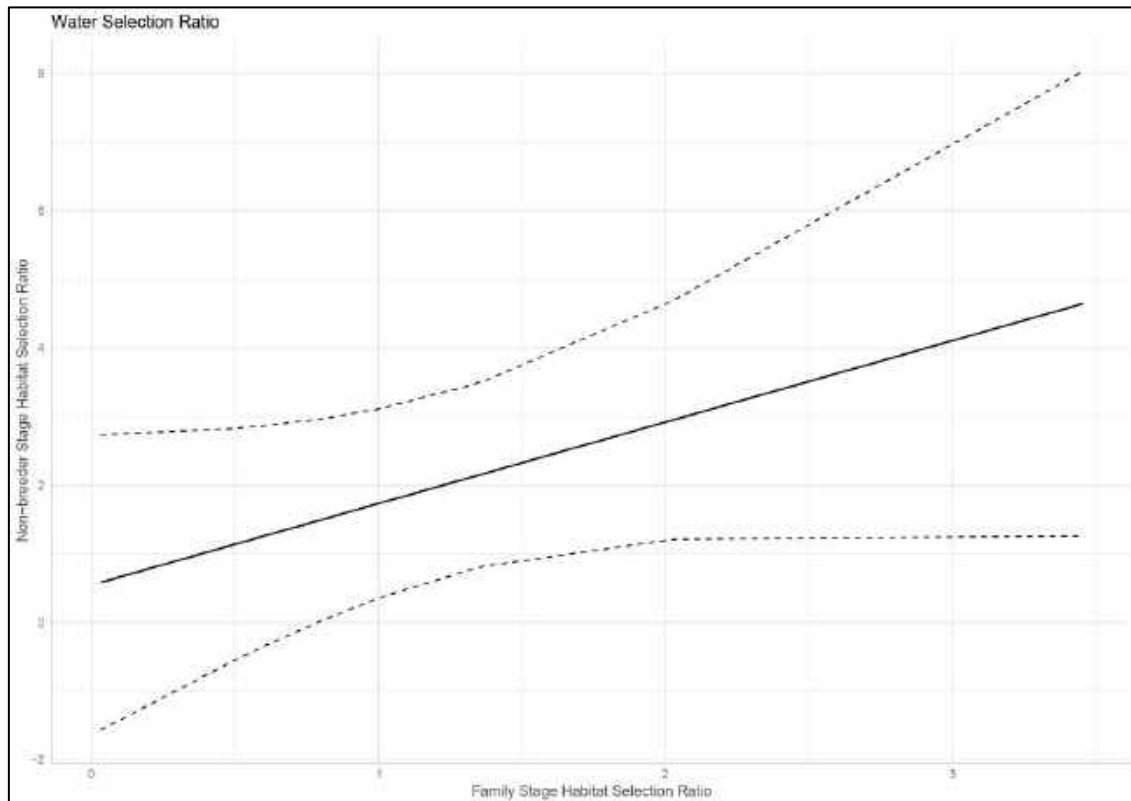


Figure 8: Scatterplot illustrating the relationship between the family stage water selection ratio (x-axis), and the non-breeder stage water selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases; there is also a tendency for the non-breeder stage habitat selection ratio to increase.

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Coastal linear regression model output.

	Estimate	Std. Error	P_value
Intercept	7.5891	8.3326	0.393
FS_Coastal	0.3167	1.0126	0.764

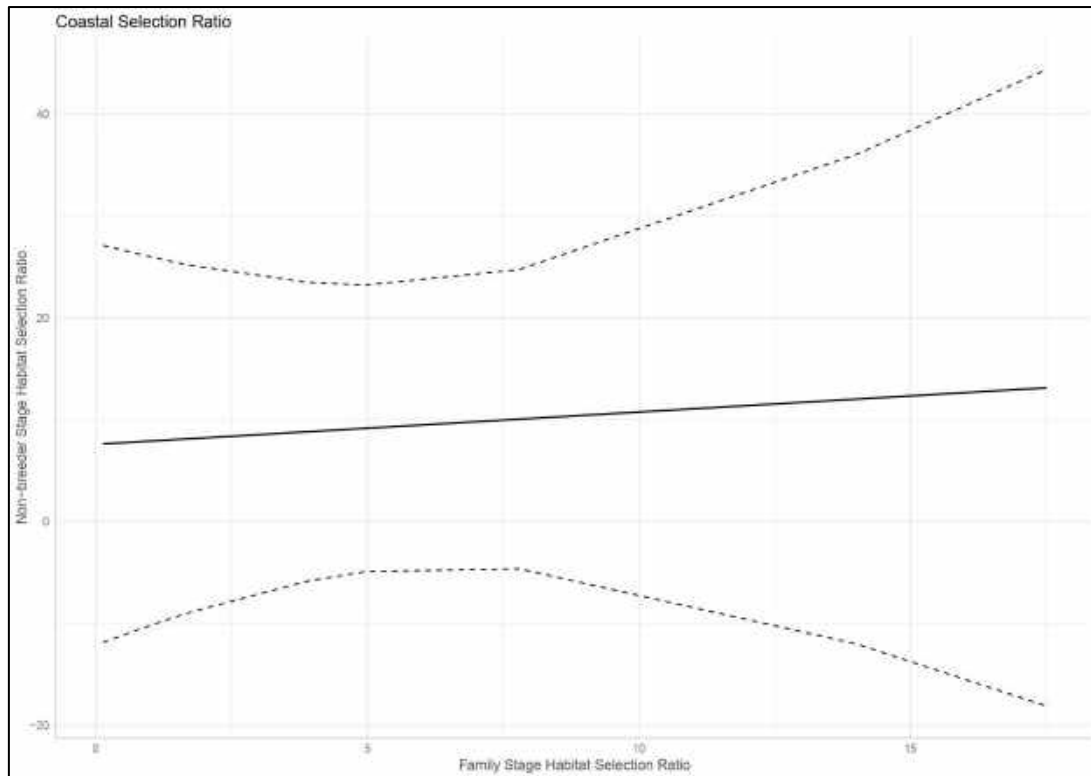


Figure 9: Scatterplot illustrating the relationship between the family stage coastal selection ratio (x-axis), and the non-breeder stage coastal selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases, there is also a tendency for the non-breeder stage habitat selection ratio to have a small increase.

Wetland linear regression model output.

	Estimate	Std. Error	P_value
Intercept	0.7712	0.1664	0.0023
FS_Wetland	0.0955	0.0168	0.0007

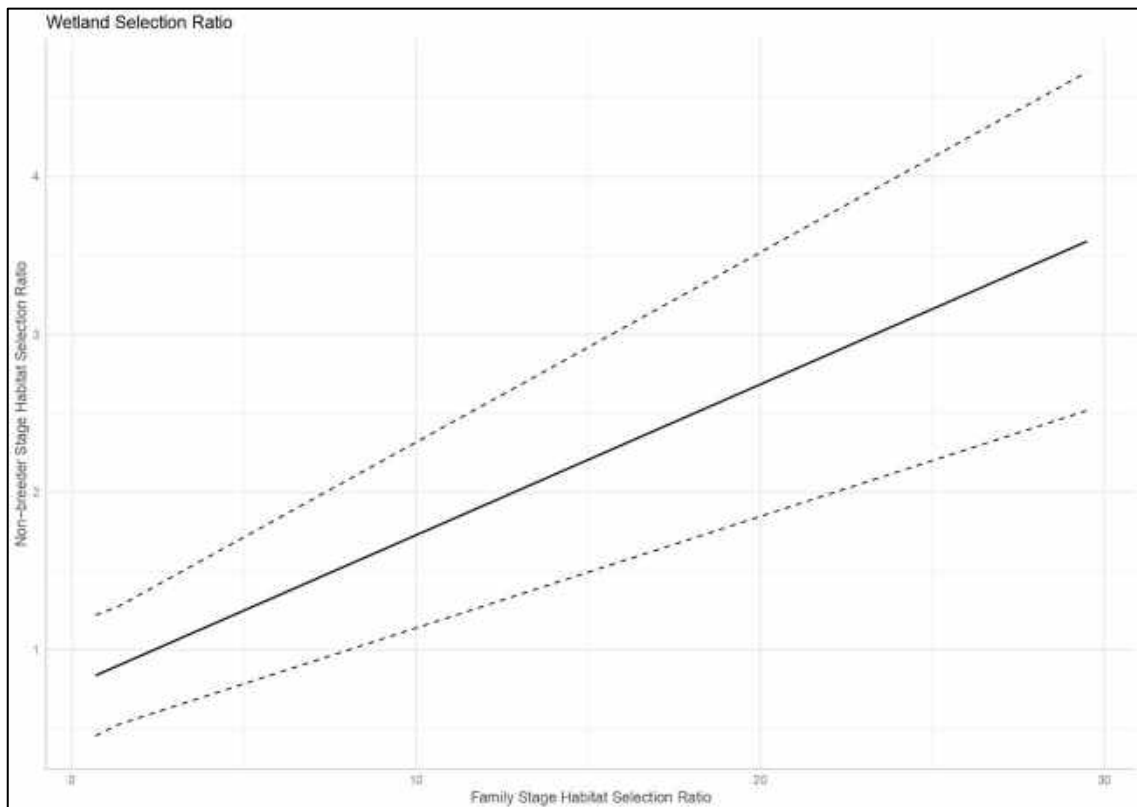


Figure 10: Scatterplot illustrating the relationship between the family stage wetland selection ratio (x-axis), and the non-breeder stage wetland selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases, there is also a tendency for the non-breeder stage habitat selection ratio to increase.

Forest linear regression model output.

	Estimate	Std. Error	P_value
Intercept	0.2179	0.2511	0.4143
FS_Forest	0.5031	0.1543	0.0138

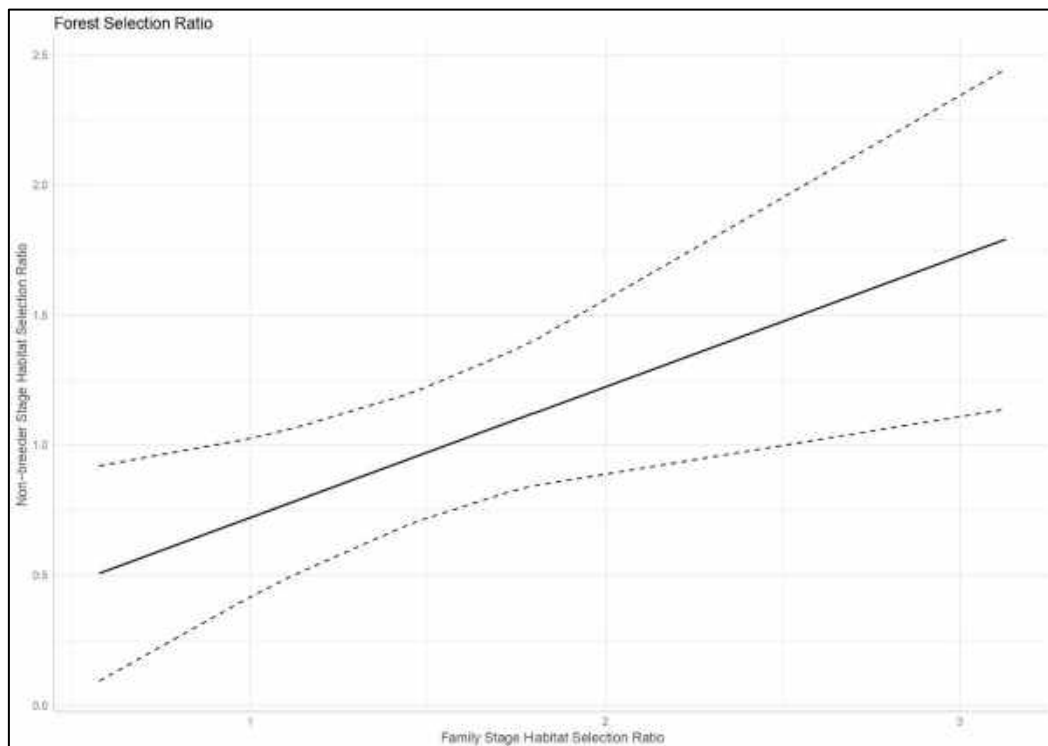


Figure 11: Scatterplot illustrating the relationship between the family stage forest selection ratio (x-axis), and the non-breeder stage forest selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases, there is also a tendency for the non-breeder stage habitat selection ratio to increase.

Agricultural linear regression model output.

	Estimate	Std. Error	P_value
Intercept	0.441	0.3532	0.252
FS_Agricultural	0.8297	0.2932	0.0254

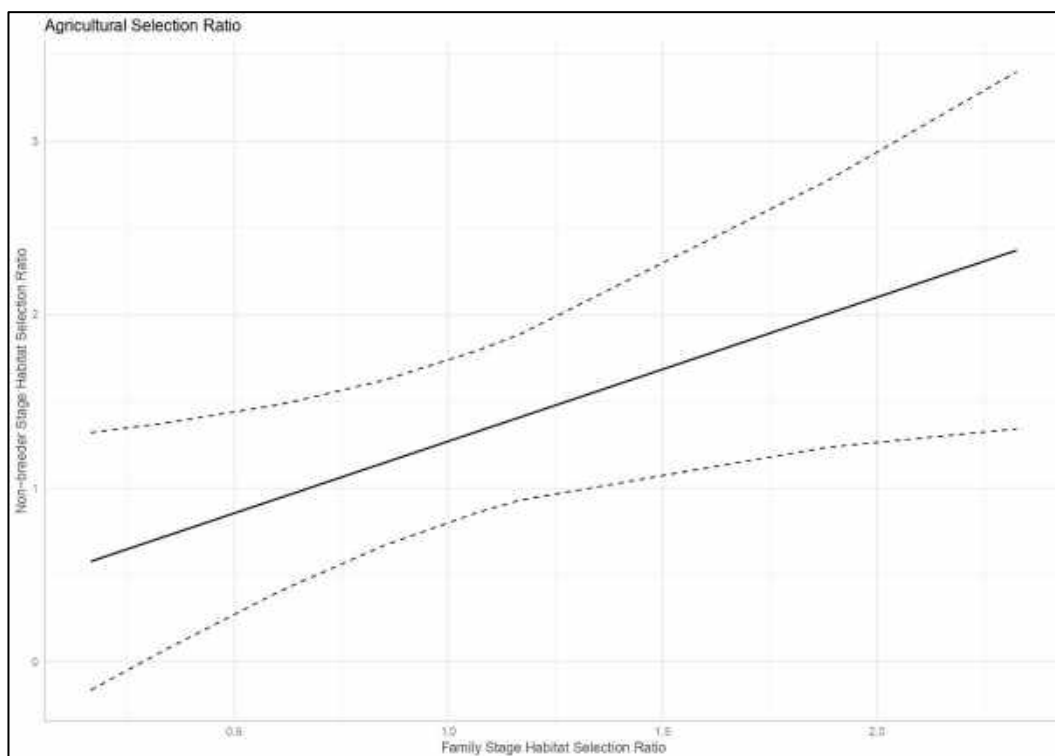


Figure 12: Scatterplot illustrating the relationship between the family stage agricultural selection ratio (x-axis), and the non-breeder stage agricultural selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases, there is also a tendency for the non-breeder stage habitat selection ratio to increase.

Build-up linear regression model output.

	Estimate	Std. Error	P_value
Intercept	0.2182	0.5646	0.7106
FS_Build-up	1.6677	0.7993	0.075

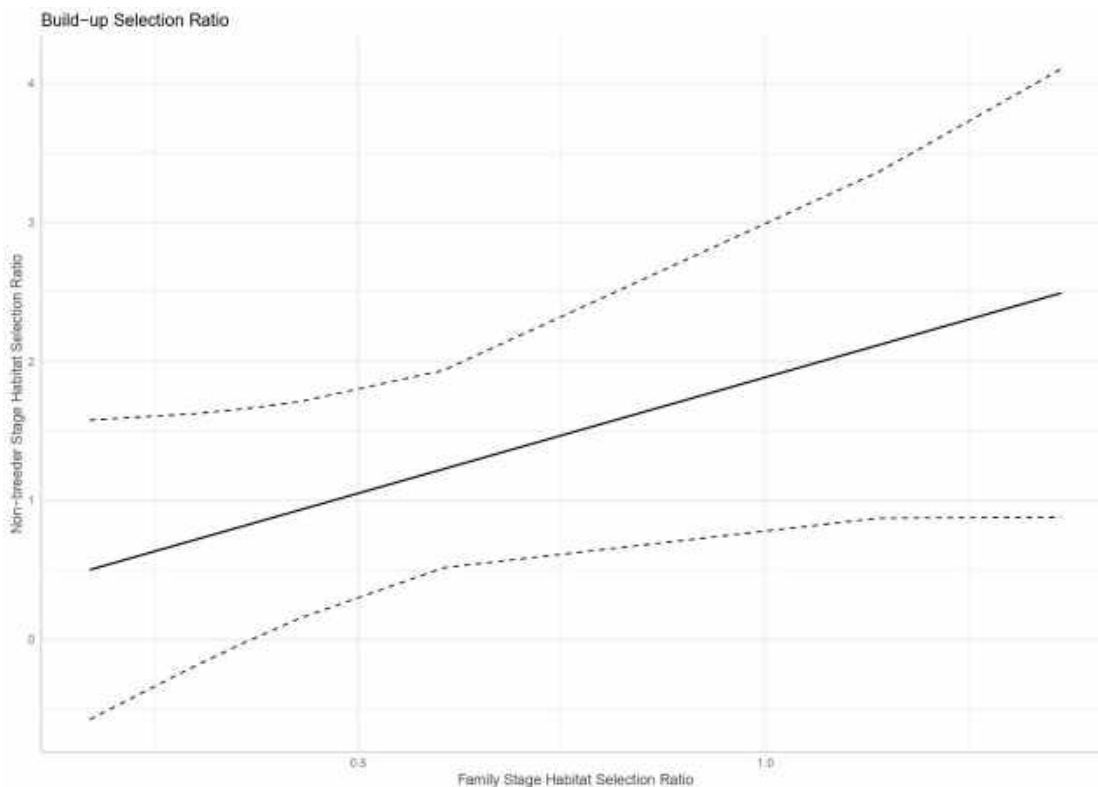


Figure 13: Scatterplot illustrating the relationship between the family stage build-up selection ratio (x-axis), and the non-breeder stage build-up selection ratio (y-axis). The regression line shows a slightly positive slope, suggesting that as the family stage habitat selection ratio increases, there is also a tendency for the non-breeder stage habitat selection ratio to increase.

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Carcass use and the role of social recruitment in juvenile ravens on the Veluwe

5.1.2e (Wageningen University & Research, BHE70324)

Supervisors: 5.1.2e (Behavioural Ecology Group), 5.1.2e (ARK Rewilding Nederland)

09-02-2023

1. ABSTRACT

Due to its high nutritional value, carrion is a highly beneficial resource for many species and has the potential to drive ecosystem processes. Changes in policies and the re-establishment of the wolf (*Canis lupus*) as an apex predator has led to more abundant and reliable carrion availability on the Veluwe, the largest terrestrial nature reserve of the Netherlands. To understand how this new situation affects the scavenging community on the Veluwe, it is important to understand the use of carrion by the most abundant avian scavenger, the raven (*Corvus corax*). Juvenile ravens are known to use roost-associated social recruitment, in which ravens share information at their roost to recruit multiple conspecifics to the carcass. This is thought to be a main driver of raven abundance at carcasses. Here, I used a combination of camera footage at human-originated carrion and GPS locations of ten tagged juvenile ravens to assess how abundant roost-associated social recruitment is in this ecosystem. In contrast to other studies, I found little support for a key role of roost-associated social recruitment on carrion use by juvenile ravens on the Veluwe. Additionally, I observed a relatively low amount of scavenging behaviour in general. To better understand why I found such divergent patterns from those described in literature, I propose that more research should be done into the habitat use and dietary composition of ravens on the Veluwe. This might shed more light on the ecological role ravens have in this human-dominated system.

2. INTRODUCTION

Carrion is an important – yet underestimated – factor in nutritional ecology (DeVault, Rhodes, & Shivik, 2003; Wilson & Wolkovich, 2011). It provides high-quality nutrients that can prove valuable to a wide range of organisms. It can drive foraging patterns in obligate scavengers, such as vultures (DeVault et al., 2003; Handler et al., 2021) and several insect species (Barry et al., 2019; Woelber-Kastner, Frey, Howard, & Hall, 2021), as well as predators and herbivores that supplement their diet opportunistically by feeding upon carrion (DeVault et al., 2003; Wenting, Rinzema, & van Langevelde, 2022). Furthermore, local plant communities are known to profit from carrion, with a stark increase in productivity and nutritional quality over long timespans in areas where nutrients from carcasses have leached into the soil (Barton et al., 2016; Towne, 2000; van Klink, van Laar-Wiersma, Vorst, & Smit, 2020), and even an increase in pollination rates in the presence of carrion (Cusser, Pechal, & Haddad, 2021). However, carrion is an unpredictable resource that is distributed unevenly both geographically and temporally (DeVault et al., 2003; Kane, Healy, Guillaume, Ruxton, & Jackson, 2017). Therefore, there is often fierce competition over access to a carcass both between and within species (Handler et al., 2021; Scott, 1998).

In 2002, a change in policy of wildlife managers of the largest terrestrial nature reserve of the Netherlands, the Veluwe, promoted the intentional deposition of road kill or culled wildlife to re-introduce carrion into the natural nutrient cycle (Bijlsma & ten Seldam, 2013). Additionally, in the last decade, multiple wolf packs have re-established themselves in the Netherlands (BIJ12, 2022). These developments should thus result in the more regular presence of carrion in the Veluwe. However, aside from the generally positive effect of carrion availability on raven (*Corvus corax*) reproduction (Bijlsma & ten Seldam, 2013), the impact on the scavenging community has not yet been extensively described. Since ravens are the most abundant avian scavengers present at carcasses on the Veluwe (Wenting et al., 2022), it is important to understand how and to what degree these animals use carrion. Juvenile ravens are thought to transmit information about resource locations, which can quickly lead to ravens monopolizing carrion and consuming large quantities in short amounts of time (Heinrich, 1988b; Marzluff, Heinrich, & Marzluff, 1996). In this way, ravens can restrict the availability of carrion to other scavengers. Additionally, they are likely to play a crucial role in the redistribution of nutrients due to their high abundance and caching behaviour, in which they move pieces of meat for later consumption (Bugnyar, Stoewe, & Heinrich, 2007; Heinrich & Pepper, 1998). Therefore, a better understanding of carrion use by ravens is especially relevant to understand the role of carrion on the scavenger community and nutrient cycle in this ecosystem.

Ravens are relatively abundant facultative scavengers throughout large parts of the northern hemisphere (Boarman & Heinrich, 2020). During their adult life, which they generally reach from their fourth year onwards (Webb, Boarman, & Rotenberry, 2009), ravens tend to form pairs and take up a territory. This territory, with the food sources therein, is defended against other conspecifics (Marzluff & Heinrich, 1991). During their sub-adult life, however, individuals are known to roost in large and dynamic aggregations (Cotterman & Heinrich, 1993; Loretto et al., 2017). One major benefit of these communal roosts is thought to be the facilitation of information transmission about the presence of food sources between individuals (Marzluff et al., 1996; Wright, Stone, & Brown, 2003). Information transmission in communal roosts would allow ravens to recruit multiple conspecifics to a carcass and overcome the defences of territorial ravens and other scavengers that may be present (Heinrich, 1988b; Marzluff et al., 1996). Aside from local enhancement, which states that individuals may learn about a food source through using cues of individuals already there (see for example Pöysä, 1992), social recruitment seems to be the main way for juvenile ravens to attract others to the carrion (Marzluff et al., 1996; Mesterton-Gibbons & Dugatkin, 1999). Recruited ravens tend to leave the roost around dawn (Heinrich, 1988b; Wright et al., 2003) and, in a coherent group, fly straight towards the food source (Heinrich, 1988b; Marzluff & Heinrich, 1991; Marzluff et al., 1996; Wright et al., 2003). Wright et al. (2003) and Marzluff & Heinrich (1991) found such a group to consist, on average, of five to six individuals, with each recruitment event (potentially every day) adding another six (although Heinrich (1988b) found these groups to be substantially larger). Due to these recruitment events, I expect ravens to discover a significant proportion of the carrion they visit through following conspecifics.

In this report, I examine the degree to which juvenile ravens benefit from social recruitment at communal roosts to locate carrion on the Veluwe, as well as provide a more general overview of carrion use by the ravens in this area. To do so, I used video footage of deposited carcasses at seven locations on the Veluwe. I assumed roost-associated social recruitment to take place when all of the following criteria were met: i) the number of ravens present at the carcass exceeded the number present the previous day, ii) the number of ravens increased by at least five individuals (Marzluff & Heinrich, 1991; Wright et al., 2003), and iii) I observed the increase in ravens within two hours after sunrise (Heinrich, 1988b; Wright et al., 2003). To quantify the importance of social recruitment compared to local enhancement, I also assessed the number of cases in which an increase in ravens was observed, yet no pattern of recruitment was found. Additionally, I will use GPS data of ten juvenile

ravens that were tagged for five to 21 months as part of the circle-of-life project launched by ARK Rewilding Nederland. In this project, the ravens are used to help locate natural carrion, such as wolf kills (ARK Rewilding Nederland, 2021). Using these GPS data, I will assess if observed movement patterns of the tagged ravens match patterns expected due to social recruitment: i) movement towards a site where carrion is present, ii) a flight path that corresponds to a minimal amount of distance flown towards the carrion, iii) the carrion being the first site that was visited during the day, and iv) the individual not having visited the site for at least a week.

3. MATERIALS AND METHODS

Study population

My study took place on the Veluwe (52.209190, 5.827501), a large nature reserve in the Netherlands. The area is made up of approximately 88.000 ha of relatively nutrient poor forest, both deciduous and evergreen, heather, and drift sand. Multiple populations of large mammals are present, among which wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), wolf (*Canis lupus*), fox (*Vulpes vulpes*), badger (*Meles meles*), and wild cattle (*Bos taurus*).

Carrion Footage

On seven locations spread across the Veluwe (Figure 1A), local wildlife managers deployed carrion originating from culling or road kills throughout the study period (i.e. between the 4th of February 2020 and the 8th of January 2023). In total, footage of 79 deposition events was recorded (Figure 1B), with a mean of 2.2 deposition events per month ($SD \pm 2.5$). The majority of this footage was recorded in 2021 (73.4%). Deposition events consisted of one to three carcasses. Of the 94 carcasses deposited, 35.1% were boar, 28.7% roe deer, and 11.7% red deer. The remaining carcasses were either infrequent (i.e. one badger and one fox) or I was unable to identify them. The 79 depositions were not made evenly across locations (Appendix A) nor months (Appendix B), with the majority of deposition events being centred in the southern part of the Veluwe and the months October to March. At these locations, one to three wildlife cameras were deployed, taking either pictures or videos (recording 20 or 30 seconds) with a time lag of one second. Volunteers and interns collected images and maintained the cameras every two weeks. On average, footage was available for 47.8% of the total study period ($SD \pm 18.4\%$, min = 20.1%, max = 76.8%).

Tagging procedure

Certified associates of ARK Rewilding Nederland attached tags (OrniTrack-25 - solar-powered GPS-GSM tracker) to the upper back of 15 raven nestlings. The tags were fastened using a harness designed to minimize impairment of flight and other behaviours (for a more detailed description of the attachment process, see Senhorst (2021)). Of the tagged ravens, seven are currently still active on the Veluwe. Six ravens were tagged on 27th of April 2021, one on the 10th of June 2021, four on the 27th of April 2022, and another four on the 19th of May 2022. The ravens were still nest-bound at the moment of tagging, with a mean age of 38 days (± 2.7 SD). In 2021, the taggers chose the healthiest nestling in each nest based on appearance, weight, and morphology. For later tagging efforts, they selected two nestlings per nest.

5.1.2h



Figure 1. A) Locations of carrion deposition sites on the Veluwe. At these locations local roadkill and culling carcasses were deposited. Generated in Google Earth. **B)** Video footage of ravens present at a red deer carcass.

Out of the 15 ravens, I selected the GPS data of 10 individuals for this study since the other five did not wear the tag long enough to generate high-quality data (i.e. less than three months after tagging. This is shortest amount of time it took four ravens to become independent from their nest, as described by Senhorst (2021)). The GPS data used ranged between the 27th of July 2021 and the 8th of January 2023. Ravens do generally not mature before their fourth year of life (Webb et al., 2009), and do not form breeding pairs and defend territories until that time. Until breeding pairs are formed, juvenile behaviour is characterized by communal feeding and roosting (Wright et al., 2003). According to this definition, all ravens used here fall into the category of juvenile ravens.

The tags were solar-powered, capable of uploading collected data using GSM networks. These tags record the date, time, and GPS location, as well as several other parameters not used in this study. These parameters were collected every five minutes during the day (defined as the period with the sun angle being $> -4^{\circ}$ UTC), and every four hours during the night (sun angle being $\leq -4^{\circ}$ UTC). When the battery voltage of the tags dropped below 50%, the recording frequency was lowered to once every 30 minutes and below 25% to once every 4 hours. These default settings could be overwritten if deemed necessary. Due to these settings, GPS resolution was lower during the months of November through January (Appendix B). The deviation in GPS position of the old tags (as used in 2021) has a median of 22.0m (1st Quartile (Q1): 12.3m, Q3: 42.8m), and the deviation of the new tags (as used since 2022) has a median of 16.8m (Q1: 9.5m, Q3: 30.3m), both based on 150 GPS fixes of one stationary tag. Therefore, I included a range of 50m around points of interest to ensure no data was omitted due to variation in location accuracy.

Data analysis

Camera trap data

To test whether the time since discovery (in days) was correlated with the maximum number of ravens observed each day, I monitored the time at arrival of ravens at carrion throughout the study period. I did this through evaluated footage of carrion deposition sites (spanning 2491 days). As it was not possible to distinguish individual ravens, I noted down every increment in the maximum number of ravens I saw at the carrion throughout the day. I tested whether a correlation was present between the time since discovery (in days) and the highest number of ravens observed each day using a

generalized linear mixed-effects model (GLMM) using the *lme4* package in R 4.2.1 (R Core Team, 2018). I utilised the Gauss-Hermite quadrature (GHQ) parameter estimation method, with 25 iterations. The unique identifier for each carrion deposition event was added as a random factor.

For each individual case in which the number of ravens increased by at least five individuals between days, I assessed whether this increase was within the first two hours after dawn. I repeated this process for increases of three or four individuals to include cases in which roost-associated social recruitment patterns on the Veluwe might have resulted in smaller groups than those found in literature. As a measure of the importance of local enhancement, I quantified the increase in numbers of ravens after the arrival of the initial ravens on the day of discovery. On subsequent days, I counted the number of individuals arriving over two hours after sunrise.

GPS data

To examine if the ten GPS-tagged ravens showed patterns of roost-associated social recruitment, I noted when they were present within a radius of 50m of any one of the seven carrion locations. In cases that a tagged raven visited at the moment carrion was present, I evaluated i) the distance flown compared to the minimal distance, ii) the time spent at the carrion, iii) the number of sites visited previously that day, and iv) the last known time the deposition site was visited by the individual. Due to the low frequency of GPS-tagged ravens visiting carrion deposition sites, I provided a broader overview of the raven's behaviour around the time that they visited the deposition site. This included their roosting site and other high-activity areas over at least the last six days prior to the visitation. GPS data was available for a median of 165 days (Inter-Quartile Range (IQR) = 318.6, min = 22, max = 530) and consisted of a median of 14698 GPS fixes (IQR = 41005, min = 1567, max = 222516) for the individual ravens.

To understand the carcass use at carrion deposition sites by the tagged ravens, I compared how many carcasses each raven could theoretically have found with how many were actually visited. I determined their home range using a Kernel Density Estimation (KDE), using the *raster* and *ks* packages in R 4.2.1. (Appendix C). I estimated the bandwidth value using a Least-Square Cross Validation. The probability limit for this KDE was set to 95%, based on visual inspections of overlap between the GPS fixes and home range size for the different ravens under differing probabilities in QGIS (3.28.1, Firenze) (QGIS.org, 2023) Next, I assessed whether each carrion location (Figure 1) was located within the home range of each raven to quantify how many carcasses were present in each raven's home range and for how long they remained there.

4. RESULTS

General Patterns of Carrion Usage

Of the 79 instances of carrion deposition, ravens visited 33, with no clear preference for specific months (Appendix D). It took a median of one day before I sighted the first raven at a carcass after the carrion was deposited (N = 30, IQR = 1, min = 0, max = 10). This arrival occurred at a median of 3.8 hours after sunrise (N = 31, IQR = 5.8, min = -0.3, max = 12.3). Generally, one or two ravens initially arrived at the carrion (Figure 2A, N = 33, median = 1, IQR = 1), yet in several instances larger groups arrived together without ravens visiting the carrion beforehand. The maximum number of ravens present at any day was 29 individuals (Figure 2B, N = 33, median = 3, IQR = 4). In 14 out of 33 cases, the maximum number of ravens was two or less, making it difficult to distinguish between breeding pairs and juveniles.

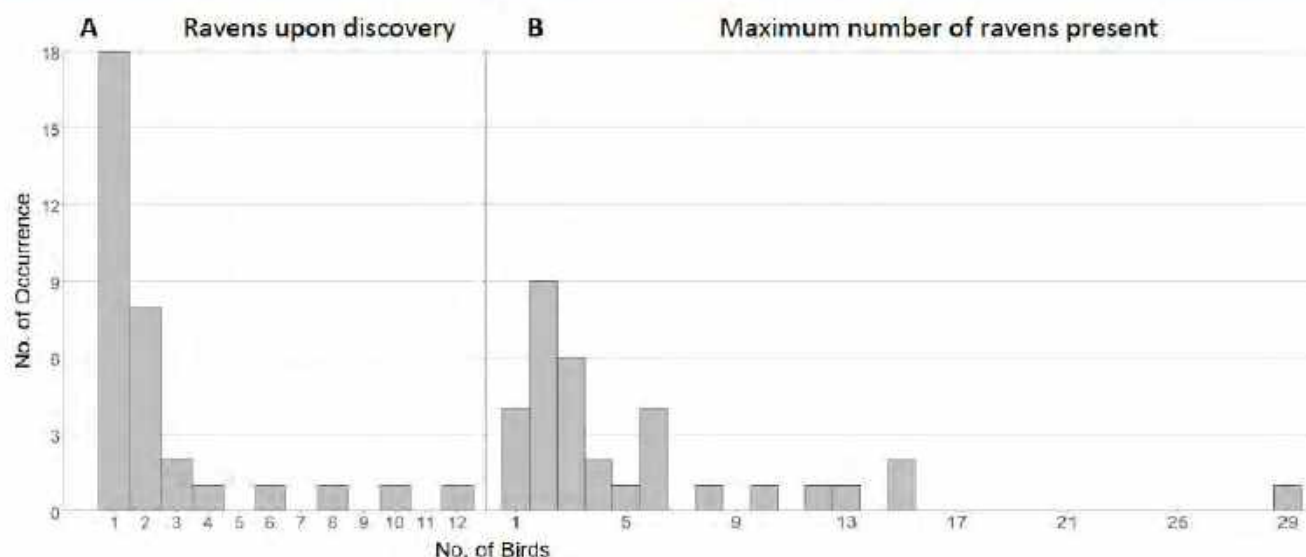


Figure 2. The number of ravens present **A)** upon discovery of the carrion, and **B)** when their numbers were highest during any one day.

Recruitment Patterns

If social recruitment plays a significant role in how ravens locate carrion, I expect an increase in raven numbers on post-discovery days. Out of the 33 visited carrion depositions, ten were only visited for a single day. I observed no increase in ravens between days for three other events. For the remaining 20 carrion deposition events, the effect of the number of days since discovery on the maximum number of ravens present was practically absent (GLM; slope = 0.05, SE = 0.05, $P = 0.32$, Figure 3). In only four days out of 97, I observed an increase of five or more ravens after the discovery of the carrion (an increase of five, six, ten, and 21 ravens). In seven cases, I observed an increase of three or four

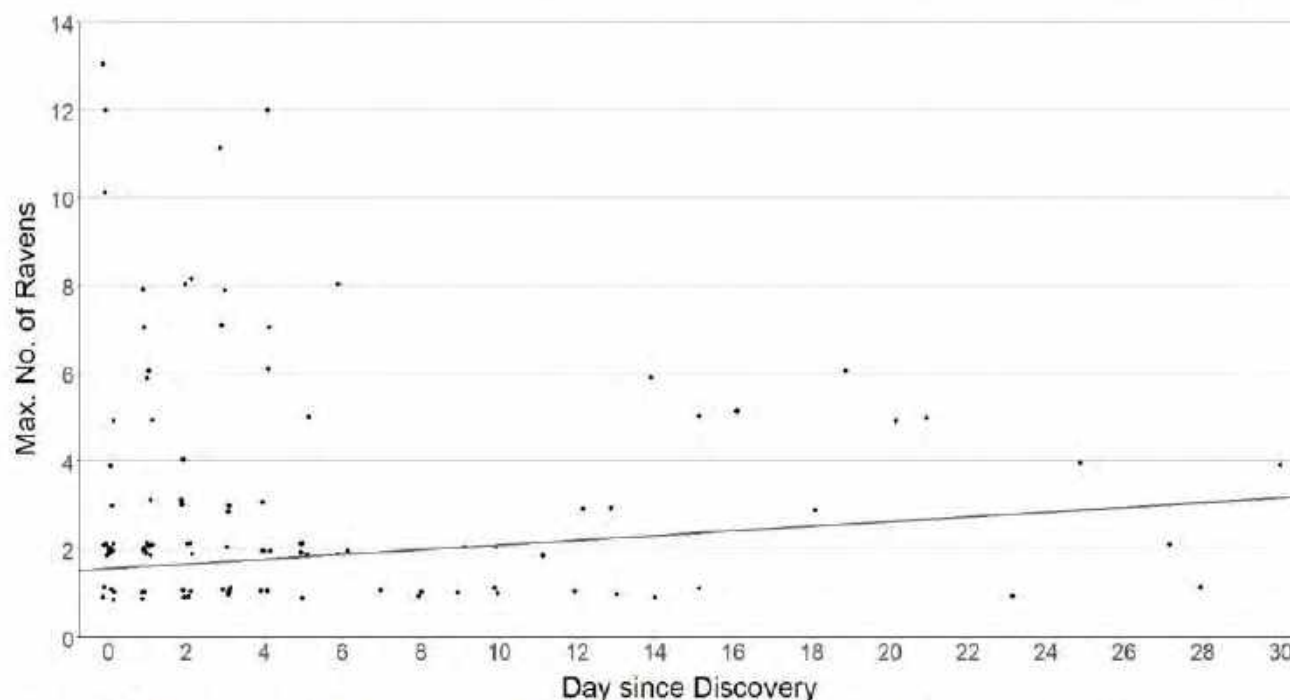


Figure 3. The maximum number of ravens that were present at the carrion each day, as expressed in days since the carrion was discovered (day = 0). The model fitted is a generalized linear mixed-effects model (slope = 0.05, SE = 0.05, $P = 0.32$). Note that the points slightly deviate from their actual value to provide a clearer overview of the data. Each point corresponds to the closest integer for both axes. The data is based on 20 instances of carrion deposition.

ravens in the post-discovery days. In six cases out of the eleven cases in which raven numbers increased by three or more between days (median = 3, IQR = 3, max = 10), I observed this within two hours after sunrise (median = 50.5 minutes, IQR = 40.75, min = 21, max = 84). Notably, for one carrion deposition event, I observed an increase of three ravens compared to the previous day within two hours after sunrise on three different days. The maximum number of ravens at that carcass never exceeded six individuals.

Local Enhancement

As a proxy of local enhancement, I assessed the number of times an increase in ravens was observed that could not be explained through roost-associated social recruitment. After the arrival of the first ravens (median = 1 raven, IQR = 2.75, max = 8, sum = 36) at the carrion deposition sites, additional ravens (median = 1 raven, IQR = 1, max = 5, sum = 25) arrived on the same day in 14 instances. Furthermore, on the days after the discovery of the carrion, 85 ravens arrived later than the two hours after sunrise (median = 257 minutes, IQR = 309.5, min = 123, max = 835) that was used as a criterium for social recruits, compared to 166 ravens that arrived within these two hours (median = 36.5 minutes, IQR = 50.5, min = -24, max = 120).

GPS patterns of tagged ravens

Thirteen independent carrion deposition events occurred within the 95% Kernel Density Estimation (KDE) home ranges of the tagged ravens (Table 1). Of these depositions, five were visited by ravens, and one of them was visited by GPS-tagged ravens. Two GPS-tagged ravens visited this carcass independently.

Table 1. The number of instances of carrion deposition at carrion deposition sites and days each was present within the 95% KDE home range of each raven. Additionally, the number of carrion deposition sites locations within each raven's 95% KDE home range are given, as well as the number of carrion depositions that were visited and for how long.

Raven ID	Locations in Home Range	Carrion Depositions	Carrion Present (days)	Carrion Depositions Visited	Carrion Visited (days)
7119215	1	3	12	0	0
7119218	1	3	12	0	0
7119222	2	12	166	0	0
7119231	1	1	9	1	1
7119232	1	1	9	1	1
7119233	0	0	0	0	0
7155853	0	0	0	0	0
7155854	1	1	6	0	0
7155870	0	0	0	0	0
7155871	1	1	6	0	0

The instance of ravens 7119231 and 7119232 visiting the carrion follows the patterns expected from roost-associated social recruitment, and thus provides some anecdotal evidence. Ravens 7119231 (Figure 5.1) and 7119232 (Figure 5.2) frequently shared the same roost and spent their days in the same agricultural area southwest of their roost in the month prior to the visitation event on the 30th of October 2022. They spent night before they visited the carrion in separate roosts,

with raven 7119231 roosting 7.5km away from the carrion deposition site, while raven 7119232 roosted 2.2km away. For both ravens, the carrion was not located in between their roost and the agricultural area where they spent most of their days for the last month. This made visiting this site a detour of at least 3.9km for raven 7119232 and 5.3km for raven 7119231. On the morning of their visitation, raven 7119232 arrived 27 minutes before sunrise and spent over 30 minutes in the area. Raven 7119231 arrived 33 minutes after sunrise and spent at least 1.5 hours at the carrion. Afterwards, both ravens independently returned to agricultural areas. Both ravens had never visited the carrion deposition site before this event and have not been there since. Video footage of that morning showed a large aggregation of ravens arriving around the same time. Despite an erroneous time setting of the camera, the difference in the number of ravens present between two frames was 24 individuals within fifteen minutes. This aggregation vastly outnumbered the number of ravens present the previous two days, with 12 ravens being present on the first day and eight on the second. After an hour, the number of ravens present at the location decreased substantially, with a maximum of seven ravens being present afterwards. This was most likely the case because of the carrion being very depleted, having been foraged upon the night before by foxes (*Vulpes vulpes*) and boars (*Sus scrofa*), and thus not being able to sustain the large number of ravens.

5.1.2h

Figure 4. The locations of **1)** raven 7119231 and **2)** raven 7119232 ranging from six days prior to the visit until 12:00 AM on the day they arrived at the carrion on the 30th of October 2022. Location A represents the roost where both raven predominantly spent the night, B the agricultural area to the southeast of the roost, where both ravens spent most of their days, C the carrion deposition site, and D a secondary roost where both ravens were observed. The images were generated in Google Earth.

Another anecdotal pattern supporting the idea of roost-associated social recruitment was made opportunistically after a park visitor observed a wolf feeding on a carcass on the 24th of October 2021. At the same location, multiple non-tagged ravens were sighted. The next morning, two tagged ravens flew directly to the carrion from two separate roosts after becoming active that day (Figure 6). Raven 7119218 (Figure 5.1) spent its nights the entire previous month at the same roost and its days at either a local gas station or agricultural areas spread across central Veluwe. Its roost was located 10.0km from the location of the carrion. On the morning after the carcass was found by the park visitor, raven 7119218 arrived at the carcass 15 minutes before sunrise. The path it used was not a straight line from its roost to the carrion, leading to a detour of at least 1.5km. It spent roughly half an hour at the carrion before heading to the gas station, which was only 2km from its roost. The second raven, raven 7119215 (Figure 5.2) also spent its nights in a single roost over the month preceding the carrion visit. During the day, raven 7119215 visited various agricultural areas east of the Veluwe, or in

the centre of the Veluwe. Its roost was located 5.9km from the carrion. On the morning of the 25th of October 2021, raven 7119215 flew relatively straight and uninterrupted towards the carrion and arrived 11 minutes before sunrise. It was present at the carrion simultaneously with raven 7119218, and also spent roughly half an hour there before departing towards agricultural areas. The two ravens did not depart together. Neither raven was seen at that location before or after this morning.

5.1.2h

Figure 5. The locations of **1)** raven 7119218 and **2)** raven 7119215 during the six days before visiting the carrion on the 25th of October 2021. Location A represents the roost where raven 7119218 predominantly spent the night, B the carrion location, and C the location where raven 7119215 predominantly spent the night. The images were generated in Google Earth.

5. DISCUSSION

I found no general patterns supporting the presence of roost-associated social recruitment amongst juvenile ravens on the Veluwe, based on the data of ravens scavenging on human-originated carrion. I did find several events that match social recruitment patterns. Six groups of several ravens (from three to ten individuals) arrived shortly after sunrise in the days after the first raven was present at the carrion. Based on literature, I expected to see an increase of at least five ravens (Marzluff & Heinrich, 1991; Wright et al., 2003), which only matches two of these instances. Even through lowering this criterium to three or more individuals, I only found six instances across a total of 97 days where this could have occurred. Additionally, the GPS-tagged ravens rarely visited carrion present at the carrion deposition sites. Despite this, their GPS data revealed four separate events, at two different carcasses, matching roost-associated social recruitment patterns. However, this means that aside from circumstantial evidence, I did not find more robust general patterns supporting the importance of social recruitment as would be expected based on literature (Dall, 2002; Heinrich, 1988b; Marzluff & Heinrich, 1991; Marzluff et al., 1996; Wright et al., 2003).

I observed a substantial quantity of ravens (36% of all observed ravens) to arrive either after the initial discovery, but before roosting had taken place, or later than two hours after sunrise. One likely explanation for the arrival of these ravens is local enhancement. Local enhancement is often defined as individuals being recruited, actively or passively, to a food source through cues (e.g. audiovisual) of individuals already there (see for example Pöysä, 1992). In literature, local enhancement has been described as relatively unimportant when compared to social recruitment in increasing numbers of ravens at the carrion (Marzluff et al., 1996; Mesterton-Gibbons & Dugatkin, 1999). Yet, based on the data described here, it might be one of the primary mechanisms for ravens to locate carrion on the Veluwe. Juvenile ravens are known to actively recruit others to a carcass using

particular calls (Bugnyar, Kijne, & Kotrschal, 2001; Heinrich, 1988b; Heinrich & Marzluff, 1991). However, they supposedly only do so if the carcass is already defended by a territorial pair or other scavengers. Therefore, in order to get an indication of competition between juveniles and territorial adults, it would be valuable to gather data on conflicts at the carcasses. This could be facilitated by changing the setting of the wildlife cameras to videos rather than photos, since these allow for easier interpretation and open the option of quantifying the vocalizations of the ravens.

The use of wildlife cameras limits observations to the area directly surrounding the carcass. Therefore, the latency until discovery, as well as the number of discovered carcasses might be underestimated. In literature, ravens were occasionally observed to discover carcasses, yet not approach them (Heinrich, 1988b; Stahler, Heinrich, & Smith, 2002). This, in turn, could explain the larger groups of ravens that I observed to 'discover' the carcasses (i.e. more than two individuals). These larger groups may already be the result of a recruitment event of a juvenile raven that discovered the carcass, yet did not approach it. Indeed, Heinrich (1988b) never observed more than two individuals simultaneously discovering carrion. Meanwhile, Wright et al. (2003) suggested that in landscapes dominated by human-originated resources, such as agricultural fields, different foraging strategies can arise. The foraging strategy described by Wright et al. (2003) is that non-breeding paired ravens can forage in a cohesive group. This could alternatively explain the larger groups of ravens arriving at the carrion upon initial discovery. Yet, Wright et al. (2003) hypothesised that these groups would primarily consist of paired individuals that have not yet secured a territory. Therefore, this explanation will only be supported if territories prove to be limiting on the Veluwe, which seems unlikely due to the relatively young raven population (Bijlsma & ten Seldam, 2013).

Similarly, the used GPS-data likely led to underestimations of carcass use. During months in which the tags received less solar energy (November through January), the GPS resolution dropped drastically. This resulted in ravens potentially visiting carrion deposition sites without a GPS fix being taken. This period coincides with the period when natural food sources are most likely to be scarce, and thus when carrion may prove to be one of the most important food sources. Therefore, the data presented here may lead to an underestimation of carcass use by the tagged ravens, at least at the fixed carrion deposition sites.

Furthermore, the origin of the carrion may prove to be a confounding factor in the conclusions drawn here. Ravens are known to be neophobic, and may need conspecifics or other scavengers to feed before approaching the carrion (Heinrich, 1988a; Stahler et al., 2002; Stöwe, Bugnyar, Heinrich, & Kotrschal, 2006). This effect is seemingly enhanced if the carrion is less familiar (Heinrich, 1988a), or human-originated (Stahler et al., 2002). In the research by Stahler et al. (2002) ravens never fed on discovered road-kill carcasses, even when opened and made to look like a wolf kill. This may explain the low frequency (41.8%) of ravens that fed upon carrion on the Veluwe. However, unlike the ecosystems in which Heinrich (1988a) and Stahler et al. (2002) observed raven feeding patterns, an apex predator providing ungulate carcasses has been absent from the Veluwe until the last decade. The raven population pre-dates this event by several decades (Bijlsma & ten Seldam, 2013), and roadkill is likely to have been one of the main sources of carrion into their system. Therefore, the ravens on the Veluwe may be less deterred by human-originated carrion than their American counterparts. This is supported by multiple observations of ravens arriving at freshly deposited carcasses within two hours of deposition, without showing the characteristic neophobic behaviour described by Heinrich (1988a). Nonetheless, neophobic tendencies in ravens likely result in an underestimation of carcass use when only taking human-originated carcasses into consideration.

Even when considering methodological constraints, I still found a remarkable lack of recruitment patterns. This lack of evidence remained even when I lowered the threshold of increase in raven numbers. In trying to understand why the patterns observed here differ so starkly from those described in the literature, I think it is pivotal to first better understand the ecology of this particular

raven population. For example, the study population is characterized by a relatively great reliance upon agricultural areas or other anthropomorphic areas for food. This is in contrast to North American raven populations, that are less affected by human resources (see the work of Heinrich, Marzluff, and colleagues on the North American population). The presence of human-originated food sources can lead to more consistent roosting patterns through providing stable, relatively abundant resources over shorter distances (Wright et al., 2003). Accordingly, through coarsely inspecting their GPS patterns, I observed a large percentage of time spent by the tagged ravens outside of the Veluwe area in agricultural regions. Indeed, significant sections of their home ranges fell outside the Veluwe area. If this is the case, the main part of the raven's diet may not consist of carrion, but rather of human-originated food sources, which is supported by the relatively low frequencies and numbers of ravens actually feeding on the carrion in this study. Indeed, in comparison with numbers from the literature (96.8% of all carcasses and close to all carcasses were consumed by ravens in the studies of Wright et al. (2003) and Heinrich (1988) respectively, yet 'only' 63.2% in the study of Marzluff & Heinrich (1991)), the attending rates of carrion by the ravens on the Veluwe are remarkably low with 41.8%. The role of human resources in raven foraging dynamics should be considered before increasing the number of tagged ravens, as the role of ravens as scavengers may be limited. One excellent way of approaching this would be analyzing the content of regurgitated pellets underneath known roosts (See Wright et al. (2003) for inspiration), supported by observations at several important agricultural sites and other anthropomorphic resources and compare raven numbers and time spent in these areas with observations at carrion.

To better understand the low visitation rate of the deposited carcasses, it might also be valuable to map the roosting sites. Ravens discovering carrion are likely to roost nearby (Dall, 2002). Understanding the roost density on the Veluwe can thus be crucial in understanding whether ravens can potentially be recruited. Similarly, by identifying large and stable roosts (Wright et al., 2003), we may be able to understand the area use of the Veluwe by juvenile ravens, as well as better estimate the likelihood of finding carrion at any specific location.

Here, I showed that, surprisingly, I found little support for a key role of roost-associated social recruitment on carrion use in juvenile ravens on the Veluwe, both in tagged and untagged ravens. Additionally, a remarkably low amount of scavenging behaviour was observed amongst ravens in general. This raises the question of whether the abundance of human resources on and around the Veluwe may have influenced the dietary preferences, and therefore also the ecological role, of the ravens. Therefore, I recommend future studies to assess the habitat use and dietary composition of the ravens to better understand their suitability as a way to find non-human related carcasses for the circle-of-life project.

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7. APPENDICES

Appendix A: Carrion Distribution Across the Deposition Sites

Table S1. The number of carrion deposition events, as well as the number of days it was available for scavengers for each carrion deposition site.

Location	Carrion deposition events	Carrion present (days)
5.1.2h	5	37
	0	0
	8	128
	38	143
	18	145
	5	32
	5	50

Appendix B. GPS Resolution Across Months

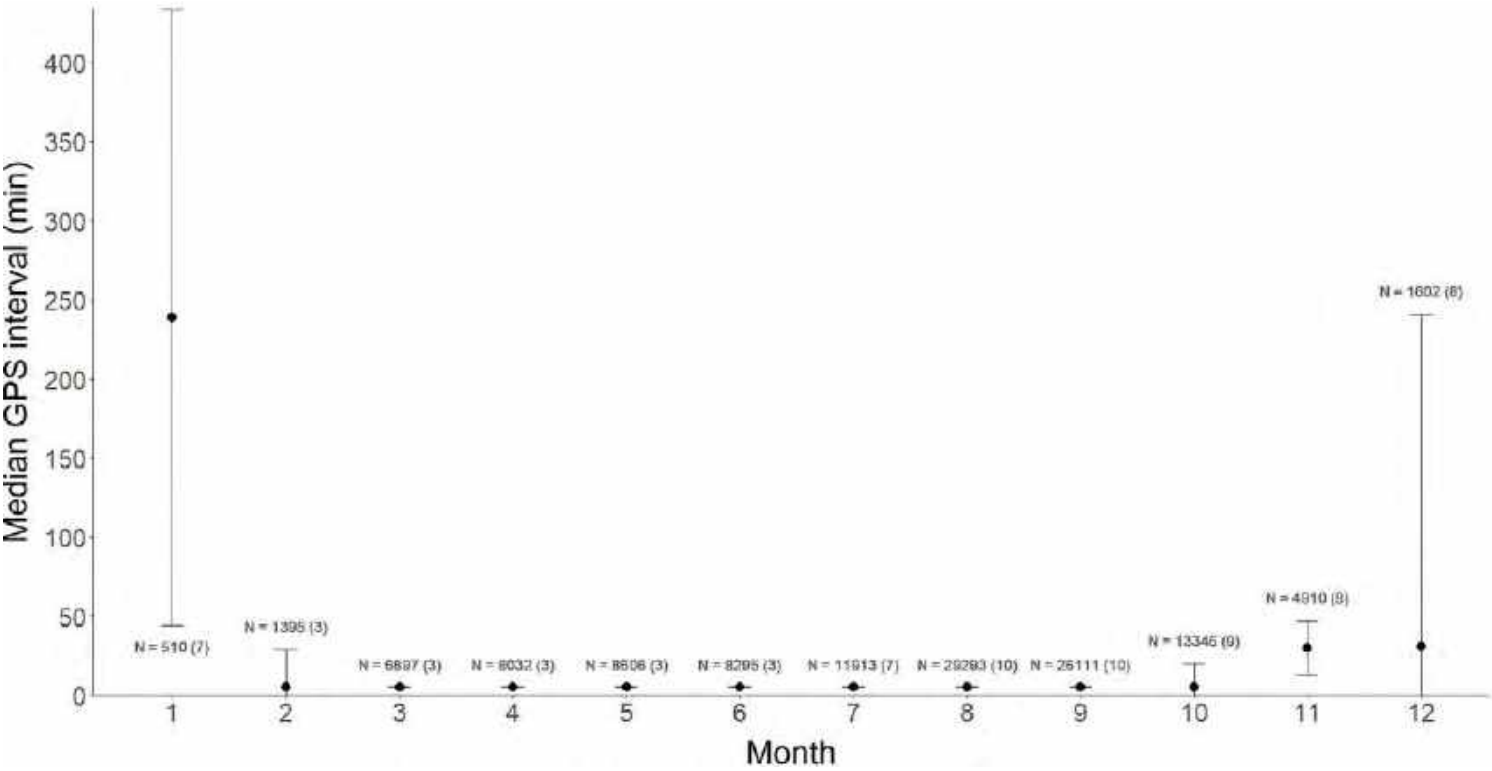


Figure S1. The median value of time in minutes between consecutive GPS intervals for each month. The error bars represent the Inter-Quartile Range (IQR), with negative values having been omitted. The sample size quantifies the number of GPS locations each metric is based on, as well as the number of individual tagged ravens that were active during that month (represented as 'N = GPS locations (Ravens)'). Note that despite ravens being tagged in the fourth month, the number of individual ravens is lowest during the fourth until the sixth month, due to the removal of GPS data that falls within the first three months after tagging (see methods).

5.1.2h

Figure S2. The home ranges of raven **A)** 7155870 (based on 16213 GPS fixes), **B)** 7119231 (N = 9560), **C)** 7119222 (N = 52682), and **D)** 7119215 (N = 46889), based on a 95% Kernel Density Estimation. The yellow dots indicate carrion deposition sites. The images were generated in Google Earth.

5.1.2h

Figure S2 (continued). The home ranges of raven **E**) 7155854 ($N = 12236$), **F**) 7155853 ($N = 1567$), **G**) 7155871 ($N = 13182$), and **H**) 7119232 ($N = 222516$), based on a 95% Kernel Density Estimation. The yellow dots indicate carrion deposition sites. The images were generated in Google Earth.

5.1.2h

Figure S2 (continued). The home ranges of raven I) 7119218 (N = 62188), and J) 7119233 (N = 2186). I constructed the home range using a 95% Kernel Density Estimation. The yellow dots indicate carrion deposition sites. The images were generated in Google Earth.

Appendix D: Carrion Distribution and Visitation Rate Throughout the Year

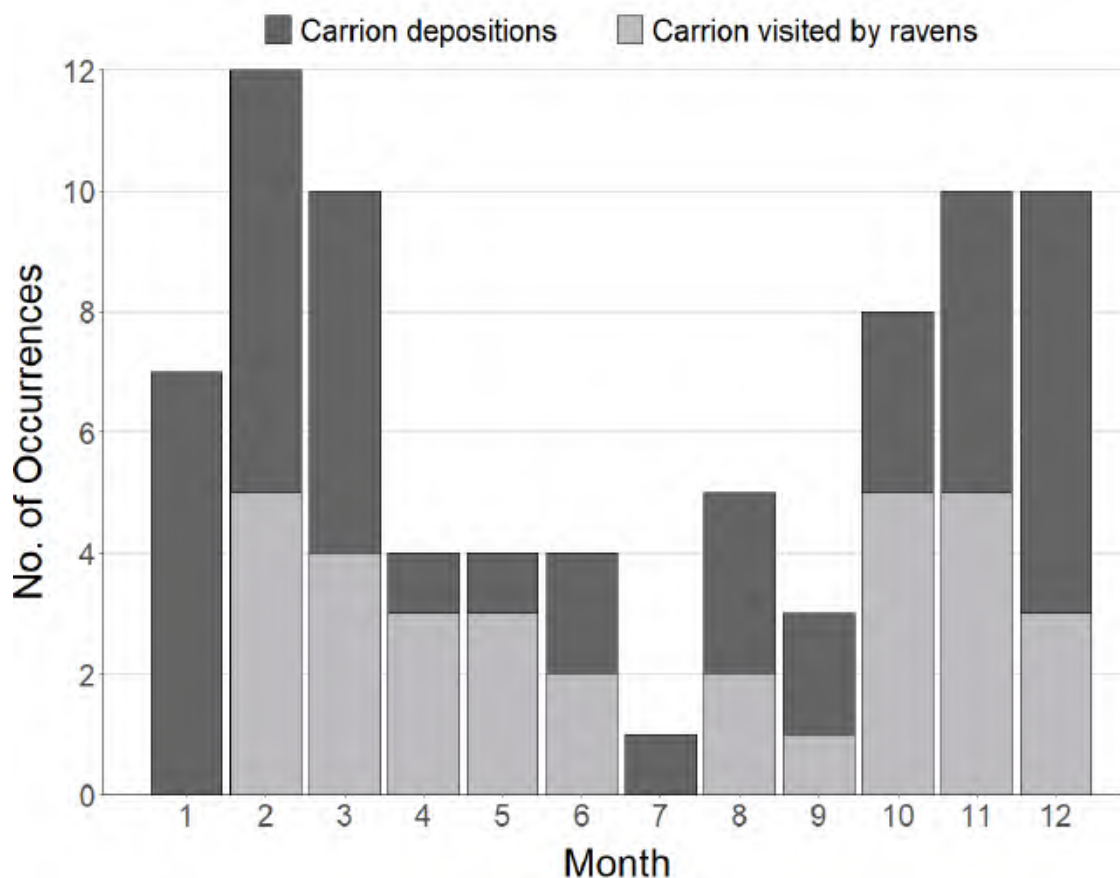


Figure S3. The number of instances carrion was deposited for every month, summed across three years. Overlaid is the number of instances this carrion was visited by ravens, summed across three years.

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What do the eyes of the forest see?

A study using GPS and accelerometer data of the common raven (*Corvus corax*) in the Netherlands to determine habitat preferences and detect food sources.



5.1.2e

REG80436

Supervisors:

5.1.2e

(Wageningen University)

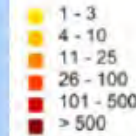
5.1.2e

(ARK Natuurontwikkeling)

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- Human growth -> habitat fragmentation
- Reintroduction ravens (*Corvus corax*)
- Habitat use and preferences
 - Juveniles
 - 4 orders of habitat selection analysis

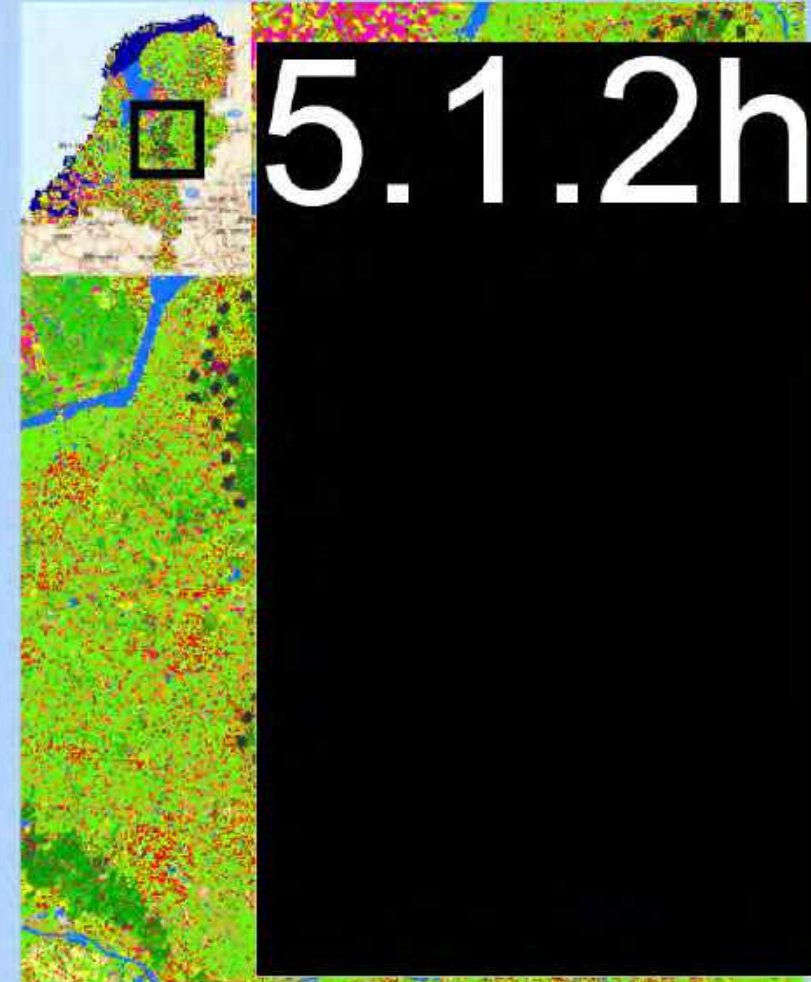
Raaf - *Corvus corax*
broedvogels
verspreiding
2017-2019



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4 ravens

- GPS/GSM transmitters with accelerometer
- Transmitter weight / body weight < 3%
- Data cleaning: *Tidyverse* & *move* in Rstudio
 - 5 minute intervals
 - Step length/ 2 step length < 20



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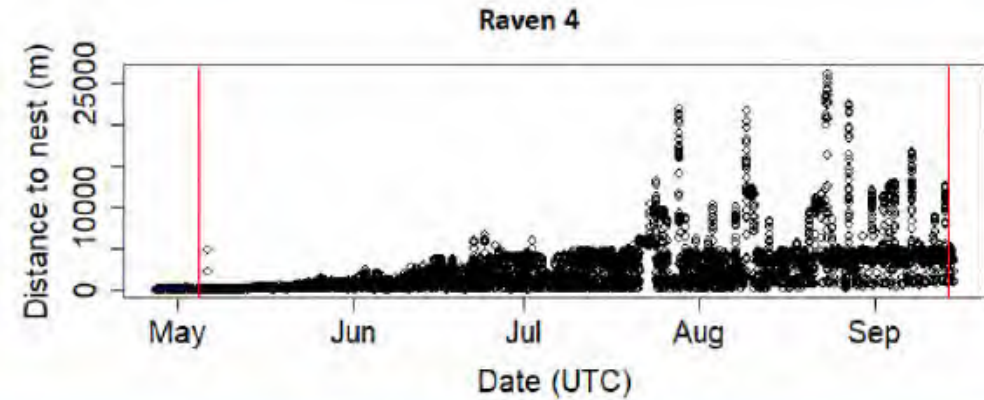
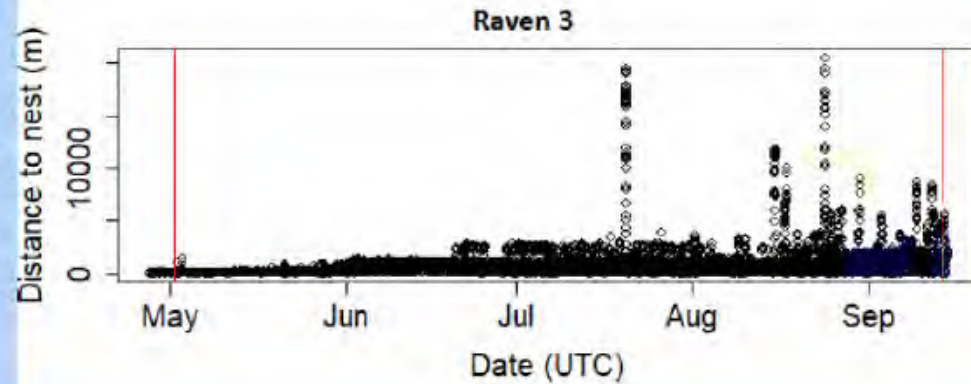
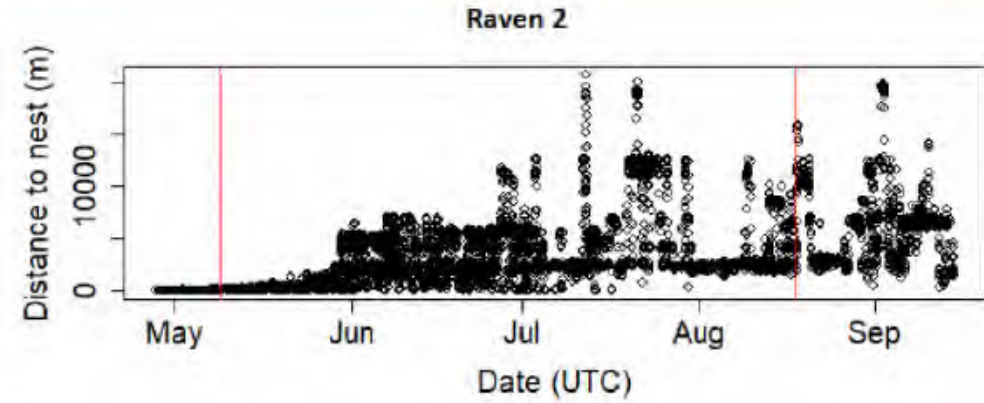
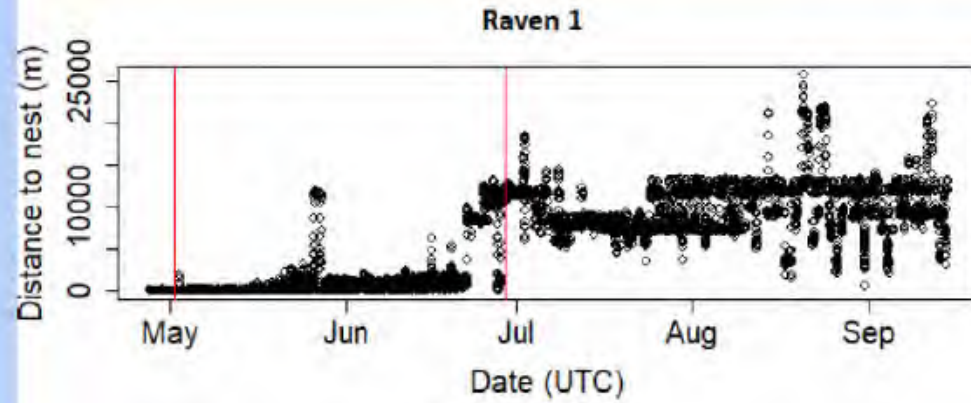
3rd order: Juvenile raven habitat and influence of fragmentation.

- Transition period
- Home ranges
- General linear mixed models
 - 7 variables

1. Open / closed ●
2. Nature area / inhabited area ●
3. Distance to forest
4. Distance to build-up area ● ●

5. Distance to forest edge ●
6. Core area Index ●
7. Mean tree height ●

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Raven 1



Raven 2



Raven 3

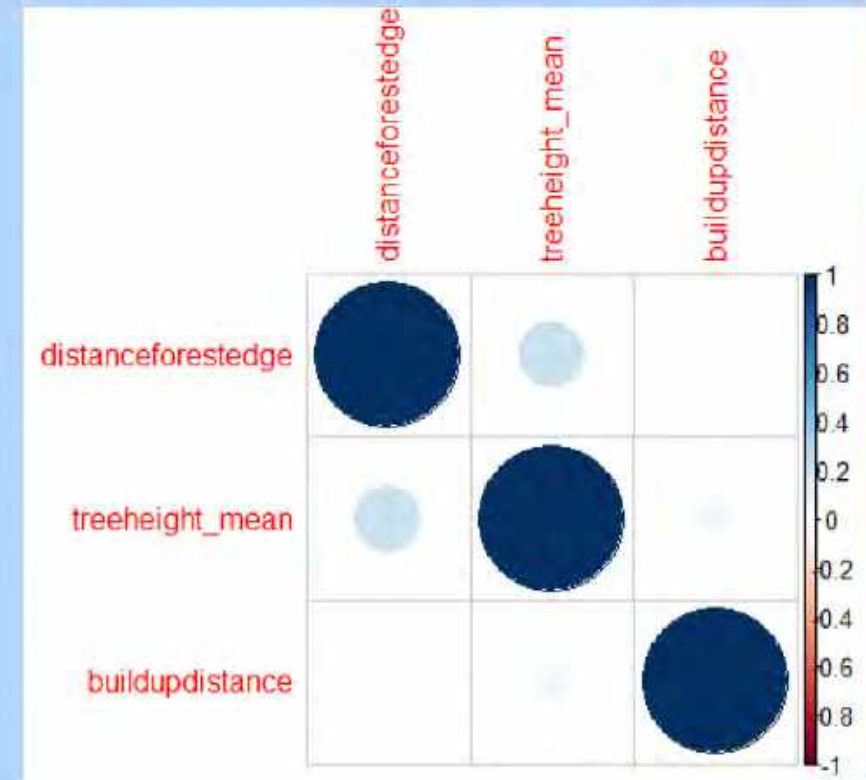
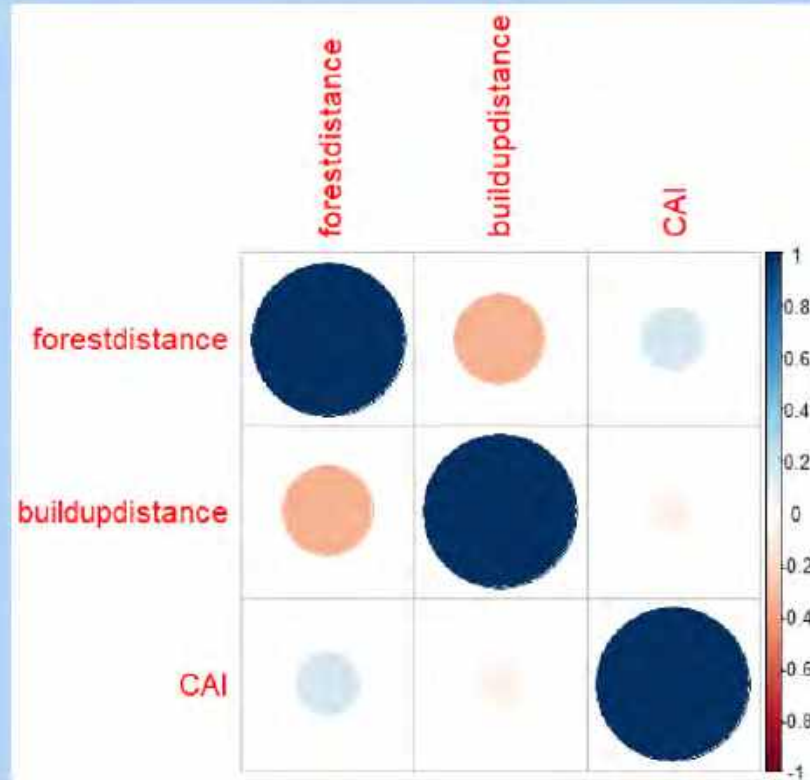


Raven 4



Raven	Size home range (km ²)
1	49.51
2	28.07
3	11.17
4	19.01

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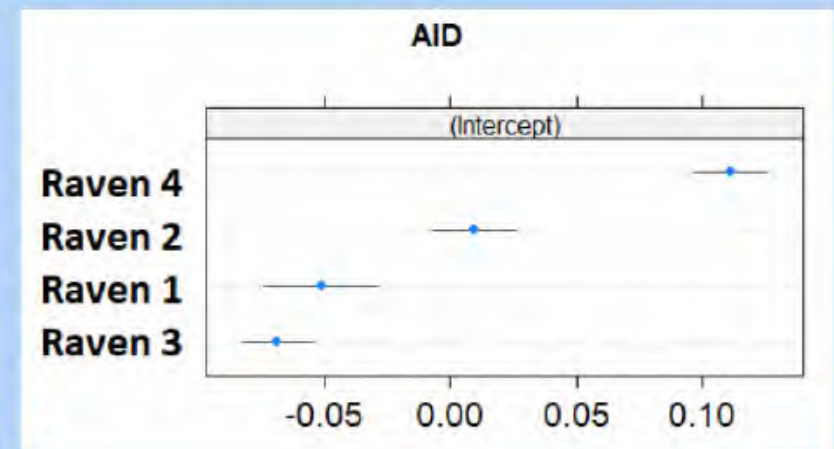
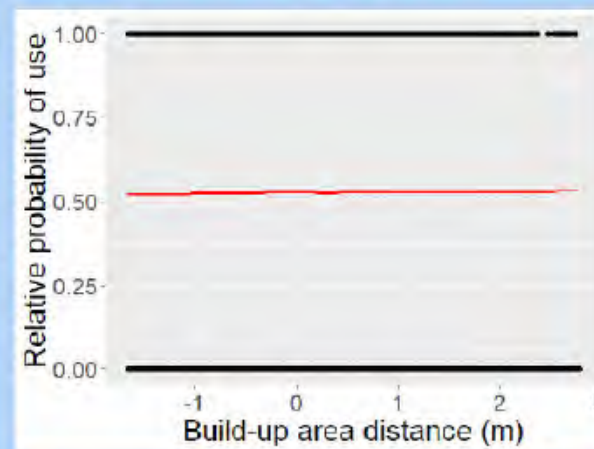
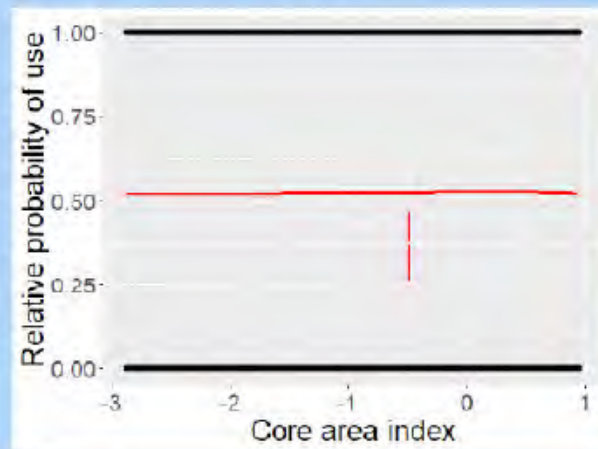
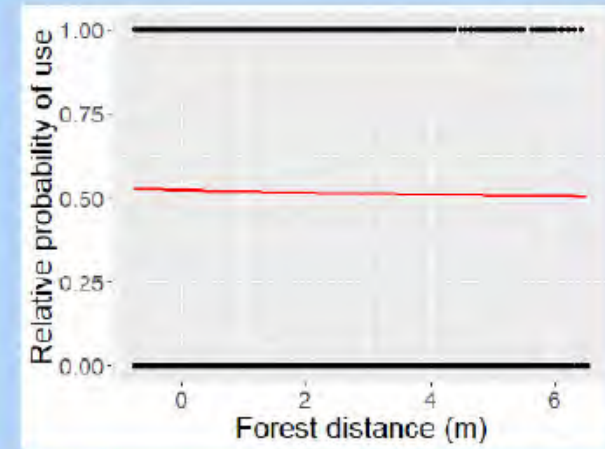
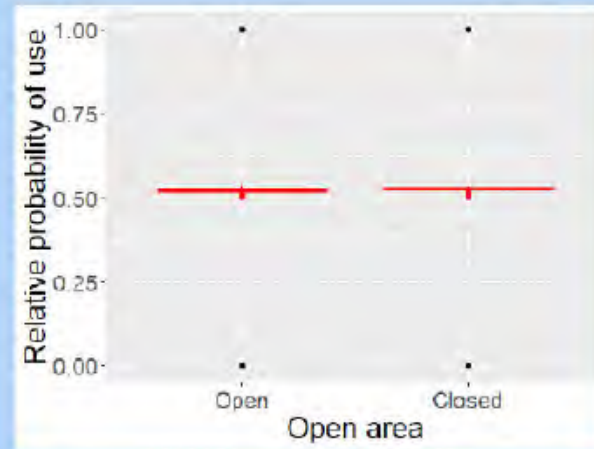
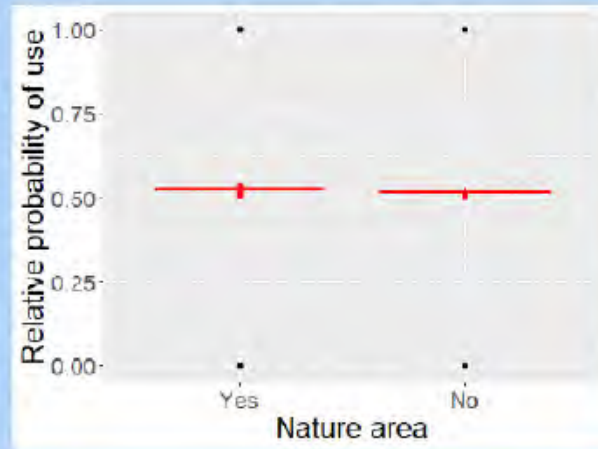


Spearman correlation of variables = $|r| < 0.4$

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Observed ~ Natural

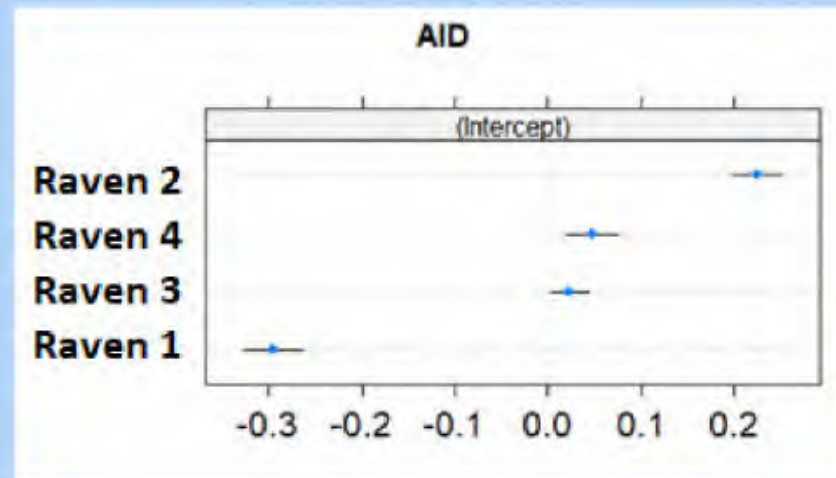
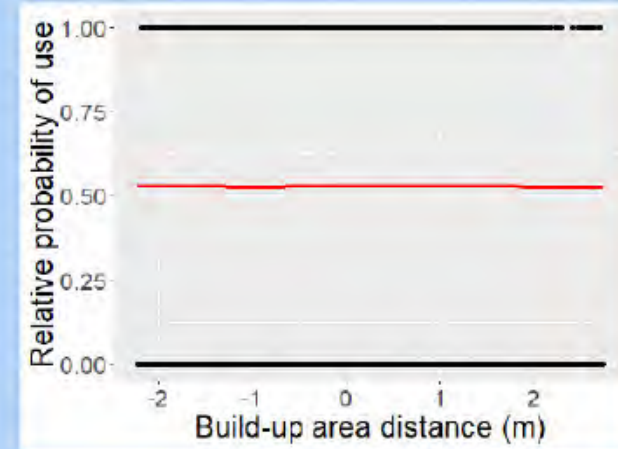
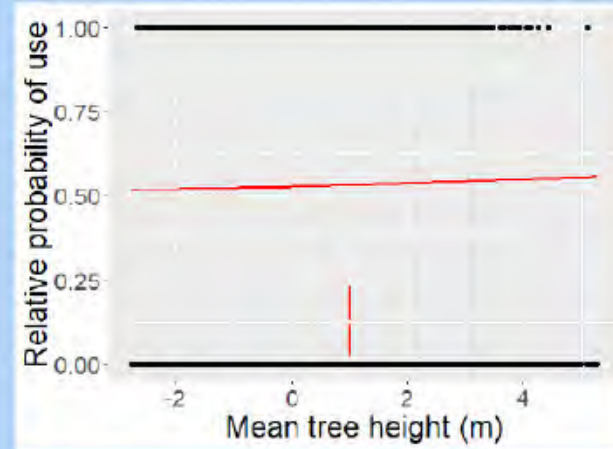
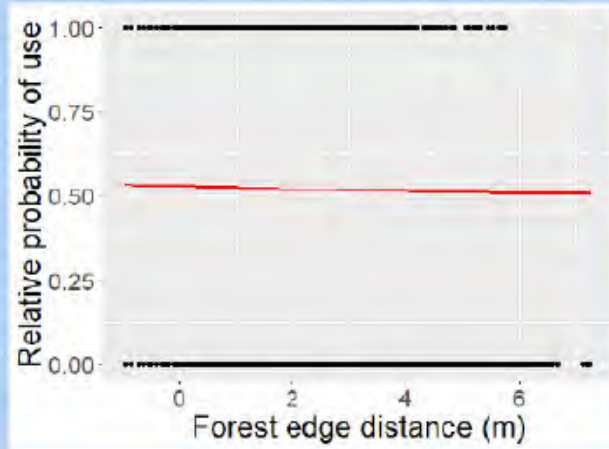
+ (1 | ravenID)



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Observed

D)



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4th order: Using spatial behaviour and accelerometer data to determine habitat types during certain behaviours.

- Generalists
- Identify locations of behaviours (sleeping, feeding and flying)
- Density-based clustering of sequential data
 - > 7 GPS locations within 10 meters and 8 hours
- Random forest
 - Sleep and food clusters
 - X, Y, Z axis, Step length

5.1.2h

All clusters in

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d sources

5.1.2h



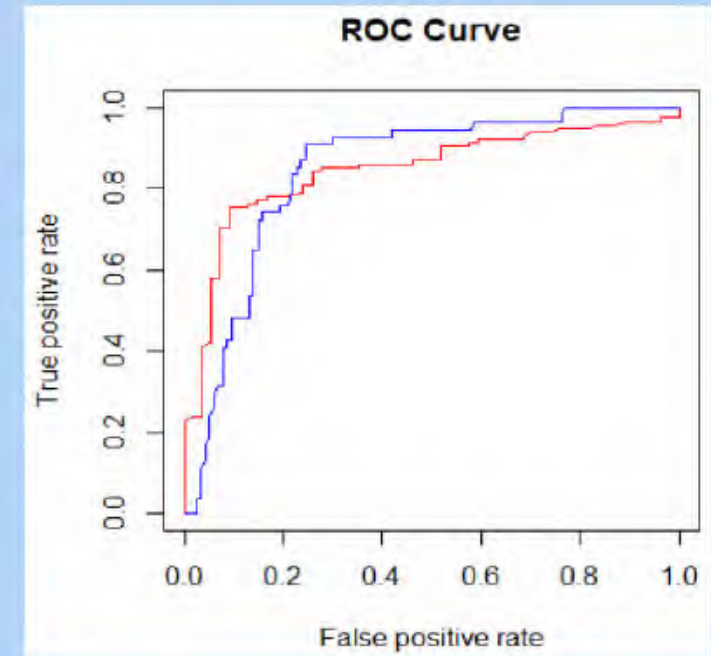
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Input supervised clusters

Raven	Food	Sleep
1	2	5
2	11	3
3	2	5
4	5	2

	Food	sleep	Class error
Food	89	25	0.25
sleep	11	43	0.16

Variable	Mean Decrease Gini
Acceleration X	12.3
Acceleration Y	39.8
Acceleration Z	14.1
Step	8.7
Two step	8.2

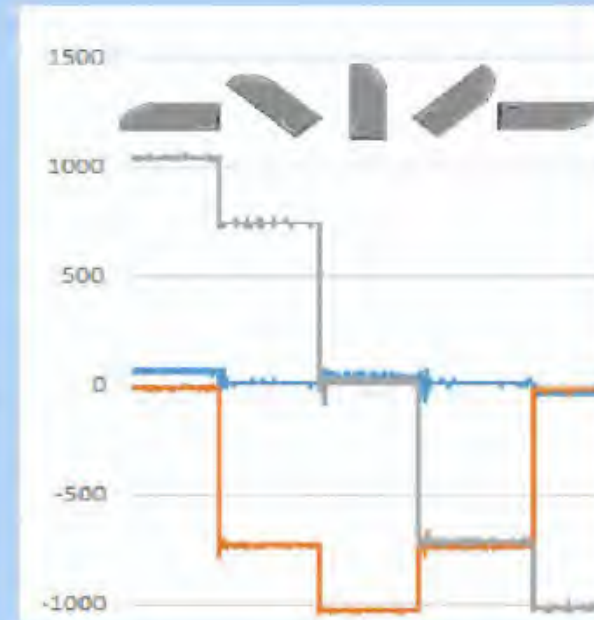
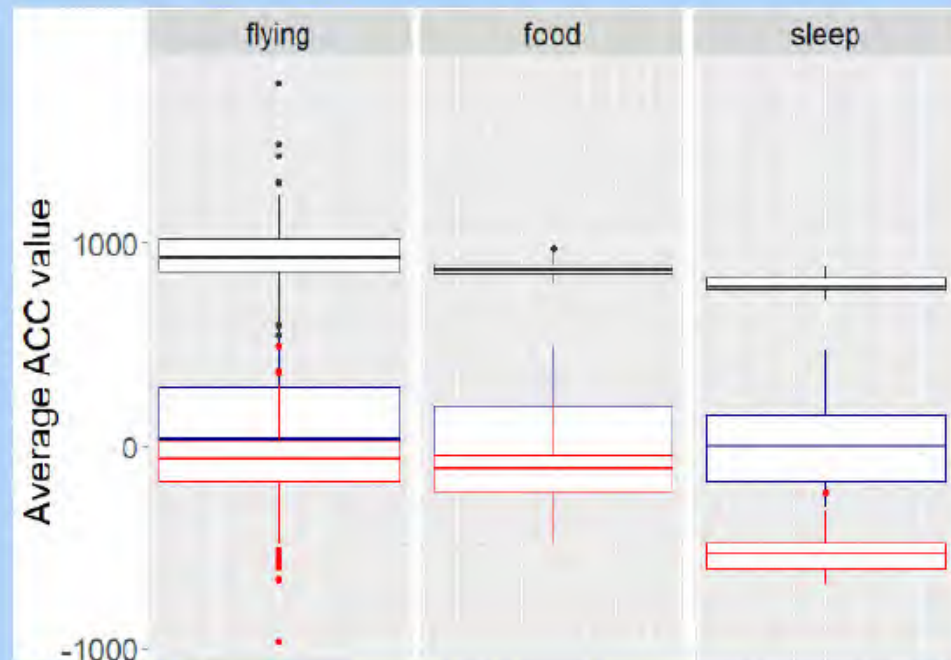


Error rate of 21.43% and AUC of 84.47%

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Variable	Mean decrease Gini
Acceleration X	12.3
Acceleration Y	39.8
Acceleration Z	14.1
Step	8.7
Two step	8.2

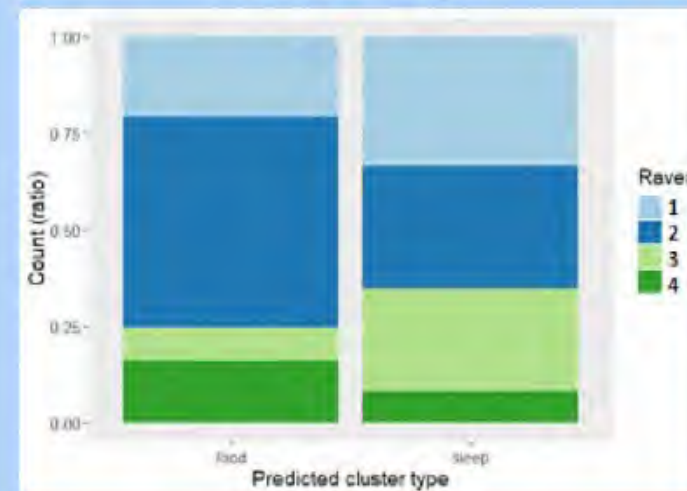
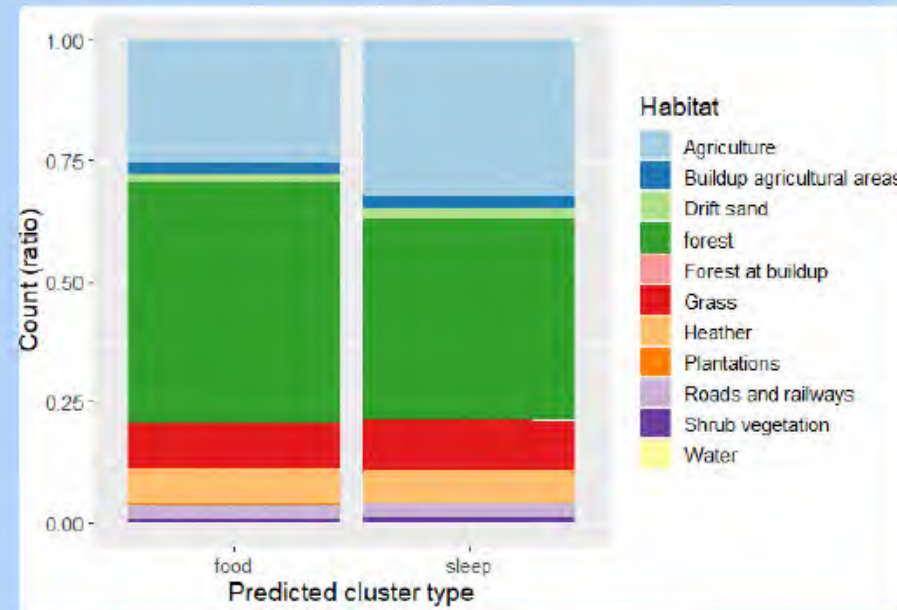
← Most important feature



Supervised c

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Raven	Flying	Food	Sleep
1	83	2	5
2	79	11	3
3	87	2	5
4	86	5	2



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Flexible generalist → individual differences

- Incorrect variables fragmentation
 - Natural fragmentation
 - Human food sources
- Seasonal differences
 - Winter – scavenging
 - Summer – restaurants and crops
- Parental guidance
- Random forest categories
- Barometers

Let op: Deze thesis is een leerdocument dat uitsluitend dient ter beoordeling van de kennis en vaardigheden van de student. Dit is geen wetenschappelijke publicatie; **aan de inhoud kunnen geen wetenschappelijke conclusies worden verbonden.**

Individual differences → statistical challenge

- No answers
- Pilot
 - More individuals and more parameters
 - Generalists
- Response curves
 - specific food sources
 - Seasonal differences
- Home ranges of parents

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“Let my heart be st

- The raven, Edgar Allan Poe



5.1.2e

