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Detecting Potential Mating through Trajectory Analysis of Fertile Male and Female Wild Boar

Semester Project CMA FS21

by

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Inhalt

1. Introduction

1.1 Motivation

In many regions of the world wild boar populations are a major concern for the agricultural sector, as they are responsible for significant financial losses due to crop damages (Schley et al. 2008). In addition, wild boar are very intelligent and ecologically adaptive, allowing them to quickly populate a range of habitats and geographic locations (Mayer 2009). Thus, effectively managing wild boar populations and preventing agricultural crop damages must be a priority. For this, a better understanding of the wild boar mating and breeding behaviour and patterns is inevitable, as their reproductive potential is one of the key factors in their expansion success (Comer and Mayer 2009).

GPS tracking data are a wide spread and feasible means of studying wild boar behaviour and movement. However, a certain level of methodological skills in geospatial data analysis are required, to be able to identify and interpret wild boar movement patterns. This project aims to identify and assess potential mating events by means of GPS data of wild boar and the statistical computing environment "R" (R 2021).

1.2 Research Questions

This project works addresses the topic of wild boar mating patterns and their identification by means of trajectory analysis of fertile males and females. It aims to answer the following research questions:

- Can potential wild boar mating events be inferred from movement patterns of fertile females and males?
- Can the environmental context be used to assess potential mating events?

1.3 Reproductive Biology of Wild Boar

In this section, relevant aspects of wild boar reproductive biology, which is relevant for this study, will be recapped.

1.3.1 Sexual Maturity

The two most important factors in determining, whether a wild boar is fertile, are age and weight. According to Gethoeffer et al. (2007) piglets of 20kg and 8 months have an 80 % chance of having reached sexual maturity. Drimaj et al. (2019) claim that, for males, the body weight is the more important factor to determine, whether a piglet has reached sexual maturity. Accordingly, a pig reaches maturity at a weight of 29 kg (which corresponds to an age of approximately 6 months).

1.3.2 Mating Season

According to Gethoeffer et al. (2007), the main reproductive season for wild boar is from November to April. Gethoeffer et al. (2007) studied wild boar in different regions of Germany (Lower Saxony and Rhineland-Palatinate). Mauget (1972) estimates the mating season to last from November to March. The associated study area is in France.

1.3.3 Social Behaviour

In this subsection, the social behaviour and group dynamics of wild boar are briefly summarized. It is based on Mayer (2009).

While sows usually live in groups consisting of one or several sows and their litters, boars are mostly solitary outside of the mating season. However, occasionally two or more mature males do form social groups. The average group size of wild boars ranges from 3 to 9. Solitary sows are usually observed when they are pregnant and prepare for birth. After giving birth, sows typically remain alone with

their litter until the time of weaning. While males generally disperse after weaning, the females tend to remain with the mother.

1.3.4 Mating Behaviour

In this subsection, the mating behaviour of wild boar is briefly summarized. It is based on Signoret (1970).

The pre-copulatory phase of the mating between wild boar is typically characterized by the female running away and the male persistently chasing after her. In case the female stops, the male may sniff her ano-genital region (Sniffing), nose her flanks (Nosing) or seek naso-nasal contact (Head to Head) with her (see Fig. 1). If the female accepts the male's mating advance, she takes up a mating stance, where she stands still and arches her back. The male will then quickly mount her and copulate.

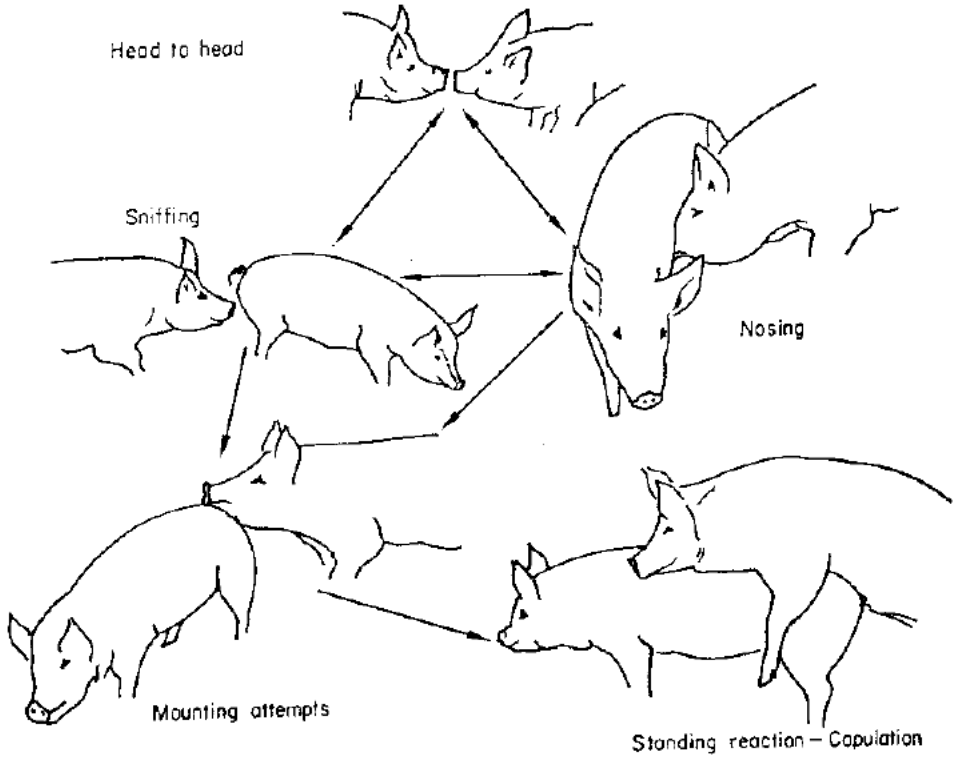

Fig. 1: The individual features of the pre-copulatory phase (Head to Head, Sniffing, Nosing) and the transition to copulation are shown schematically (Signoret 1970).

2. Data and Methods

In this chapter, the used data and tools, the data processing steps, and the modelling procedure applied in this study will be discussed step by step.

2.1 Input Data and Tools

The primary data that were used in this study, are the wild boar location data from 19 wild boars in the area of interest in the Bernese Seeland and the meta data on 46 wild boar that were tracked in the study area (Cantons Aargau and Bern) by the project "Evaluation eines akustischen Wildschwein-Vergrämungssystems" (ZHAW 2021).

The data include timestamp and position for each animal that was tracked between May 2014 and October 2016 with a temporal resolution of 15 minutes. The animals were tracked using a GPS sensor attached to a collar. Since some of the collars had to be replaced, due to the wild boars removing or breaking them, the collar ID, which is also provided in the data set, is not synonymous with the animal name or ID. The meta data on the 46 tracked wild boar include collar IDs, sex, weight and study area per animal.

Additionally, to add the relevant geographic and environmental context, a raster map of the region of interest (Bernese Seeland) was used (CMA 2021).

The data integration and processing, as well as the modelling of the mating patterns were performed in R. Tab. 1 provides a list with the used R packages and an explanation on what they were used for.

Package	**Functionality / Use**
ComputationalMovementAnalysisData	Used to load the required wild boar and wild boar meta data into R
ggplot2	Used to visualize data
dplyr	Used to manipulate tabular data
sf	Used to handle spatial vector data
terra	Used to import raster data
lubridate	Used to handle dates and times
tmap	Used to create thematic maps
gridExtra	Used to arrange graphics

Tab. 1: Overview over the R packages that were used in this project and their functionality.

2.2 Data Processing

In a first step, the data for the 2015/16 mating season were selected, applying the definition of Gethoeffer et al. (2007) (November – April). Subsequently, the location data for all animals were rounded to the next 15 minutes, since the sampling times of the GPS sensors did not precisely coincide. As a result, the positions of the wild boar (represented in the CH1903+ / LV95 coordinate system) were linearly interpolated to the new timestamps.

Next, all wild boar that were studied during the selected mating season were identified. Their names, sexes and weights are listed in Tab. 2. Based on their weights and the findings of Gethoeffer et al. (2007) and Drimaj et al. (2019), it is fair to assume that all the identified animals have reached sexual maturity.

Name	Sex	Weight [kg]
Venus	Female	24.5 – 29.0
Ueli	Male	79.5 – 91.0
Miriam	Female	47.0
Gaby	Female	46.0 – 52.0
Frida	Female	96.0
Evelin	Female	67.0
Caroline	Female	58.0 – 81.5
Amos	Male	46.0

Tab. 2: Sex and weight of the wild boars that were studied during the mating season 2015/16. Note, that the range of the weights is due to the fact, that some boar were weighted several times.

However, not all the aforementioned wild boar are tracked continuously over the duration of the mating season. The periods of tracking for each wild boar during the mating season 2015/16 are illustrated in Fig. 2.

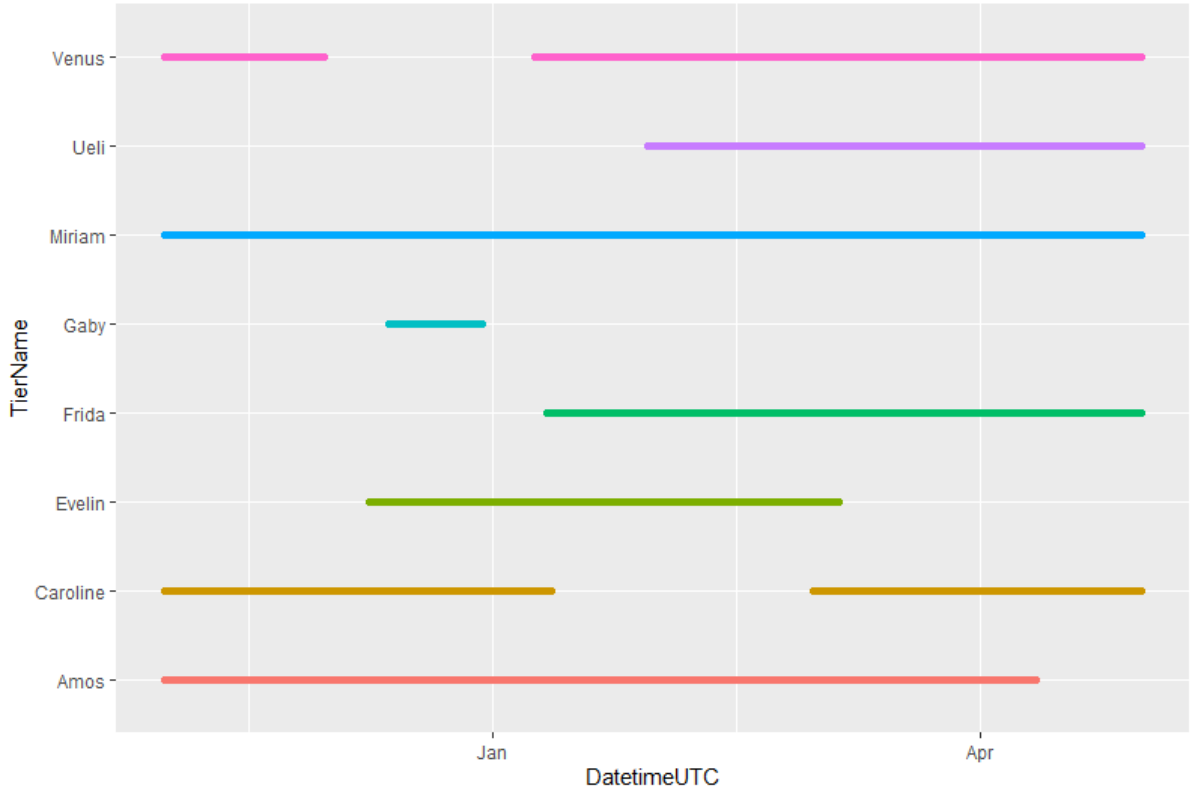

Fig. 2: Periods of tracking during mating season 2015/16 for each wild boar.

2.3 Model Design

To identify potential mating events, some preconditions must be met. Intuitively, for a boar and a sow to be able to mate, they need to physically be at the same location. Therefore, meeting events between male and female animals were identified. For this, the Euclidian distance between all females and males was calculated over the entire mating season. Then, the minimum Euclidian distance that occurred between each male and female was calculated. If the minimum distance was below a predefined threshold, the two individuals were considered to have physically met. When selecting the threshold, one should consider both the temporal resolution of the available data, as well as the positional error of the GPS sensor. The former amounts to 15 minutes in our case. During this time a lot of movement can occur that goes unnoticed by the GPS tracker. The latter may amount to

approximately 2 – 3 meters (Zandbergen and Barbeau 2011) or even up to 12 meters (Du et al. 2018). In this study, a distance threshold of 50 meters was applied, due to the rather coarse temporal resolution of the location data.

It is assumed, that the entire mating procedure as described in subsection 1.3.4, takes some time. Therefore, only events, where the distance fell below the threshold on at least two consecutive times, were considered as meetings. Afterwards, the trajectories of all wild boar were selected and analyzed for each meeting. The following questions were discussed in this analysis:

- When did the meeting occur?
- How much did the male and female move during the meeting?
- How did the male and female move during the meeting? (How fast? In what direction? Who followed who?)
- Were other wild boar nearby? If yes, how did they move?

Selected meetings of interest were then discussed with regards to whether they were likely to have been mating events, failed mating events or unrelated meetings.

In a final step, the positions of each meeting couple of interest were mapped onto a background map of the study area in the Bernese Seeland. It was then discussed whether the previous assessment of the meetings could be verified or falsified using the additional environmental information provided by the background map.

3. Results and Discussion

3.1 Meeting Events

A total of 11 meeting events were identified during the mating season 2015/16. Tab. 3 gives and overview of the found events and their assessment. In the following subsections, a few selected meeting events will be studied further.

#	Start	End	Male	Female	Description
1	15.11.2015 18:15	15.11.2015 18:30	Amos	Miriam	Distance less than 10 meters. Hardly any movement. Caroline approaching (less than 500 meters away)
2	14.11.2015 08:45	14.11.2015 17:15	Amos	Caroline	Distance between 20 – 30 meters. Little movement. Amos is moving away from Caroline, as Miriam approaches (approximately 300 meters away)
3	02.02.2016 23:45	03.02.2016 00:30	Ueli	Miriam & Frida	Distance to both below 50 meters. Little movement. Miriam moves away from Ueli towards Frida
4	24.03.2016 20:45	24.03.2016 21:45	Ueli	Caroline	Distance very low at the beginning and the end (approximately 10 meters). Some movement. No other wild boar present
5	08.04.2016 20:45	08.04.2016 21:30	Ueli	Caroline	Distance less than 15 meters. Little movement. No other wild boar present
6	01.02.2016 06:45	01.02.2016 15:15	Ueli	Frida	Distance between 25 – 50 meters. Hardly any movement. Miriam approximately 100 meters away with some movement
7	11.04.2016 00:45	11.04.2016 01:00	Ueli	Frida	Distance less than 50 meters. Hardly any movement. No other wild boar present
8	11.04.2016 23:30	12.04.2016 00:45	Ueli	Frida	Distance less than 50 meters. Hardly any movement. No other wild boar present
9	12.04.2016 20:30	12.04.2016 23:15	Ueli	Frida	Distance less than 50 meters. Little movement. No other wild boar present
10	13.04.2016 07:45	13.04.2016 09:00	Ueli	Frida	Distance less than 40 meters. Hardly any movement. No other boar present
11	28.04.2016 22:30	28.04.2016 23:00	Ueli	Frida	Distance less than 30 meters. Hardly any movement. No other boar present

Tab. 3: Overview over the identified meeting events. Grey shaded events will be studied more in detail below.

3.1.1 Meeting Event 2

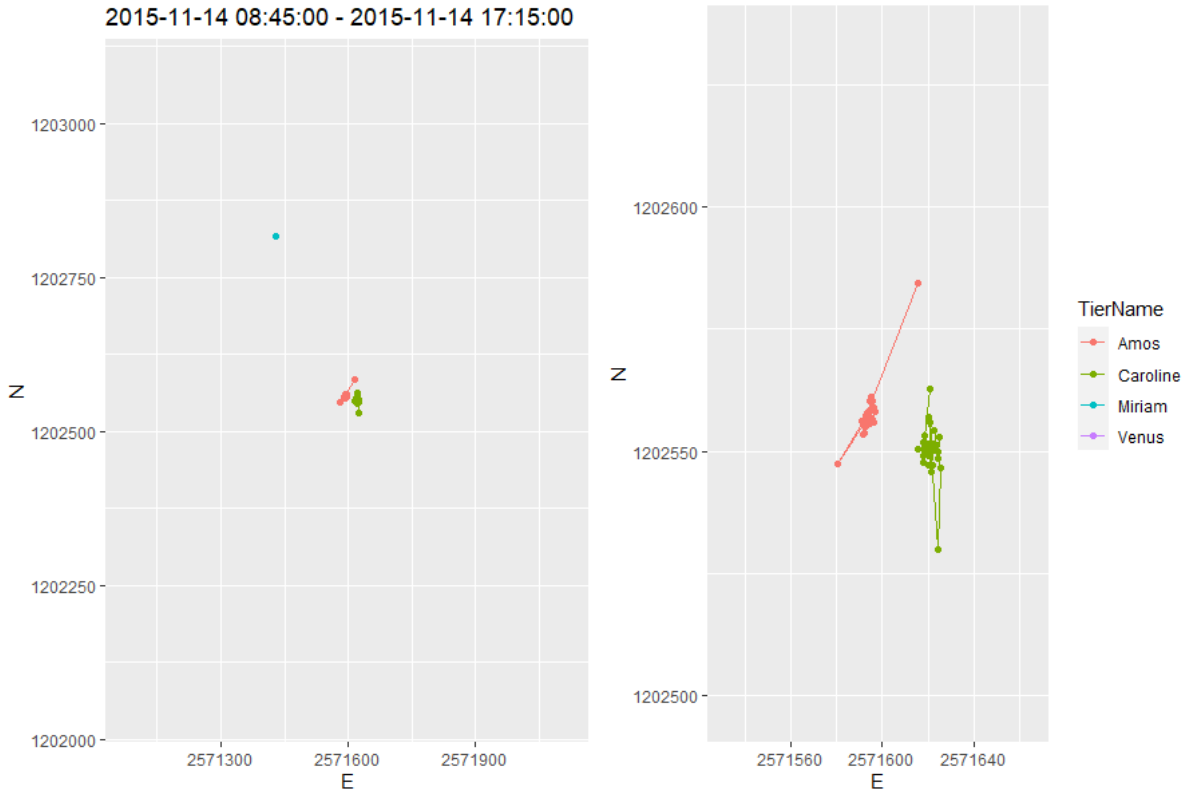

Fig. 3: Trajectories of the wild boar during meeting event 2. Both panels show the same trajectories, but with a different scale.

During meeting event 2 (Fig. 3), Amos and Caroline appear to have been relatively stationary, situated approximately 20 – 30 meters away from each other. The low mobility suggests that they have been resting, rather than attempting to mate. At the last timestamp, Miriam approaches Amos and Caroline, simultaneously Amos moves away from Caroline. It is possible, that Miriam – accidentally or willingly – scared Amos off.

3.1.2 Meeting Event 3

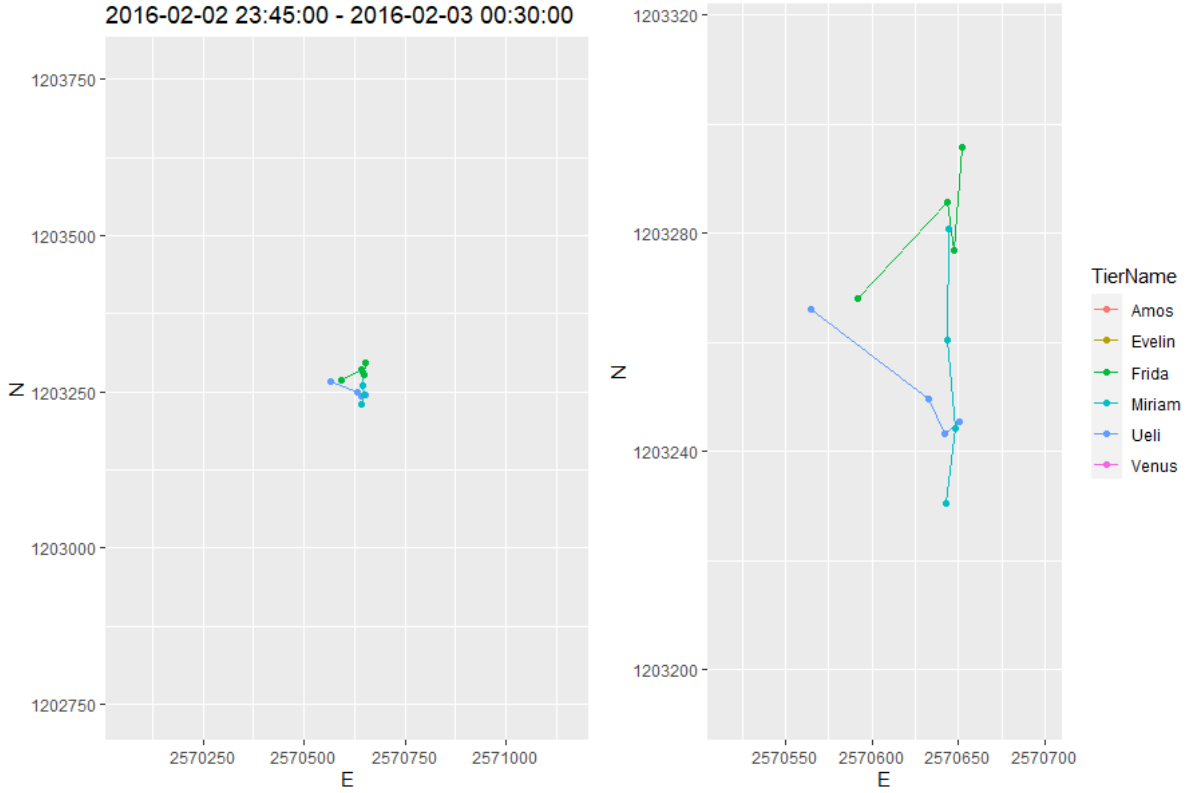

Fig. 4: Trajectories of the wild boar during meeting event 3. Both panels show the same trajectories, but with a different scale.

During meeting event 3 (Fig. 4), Ueli is moving towards south-east, Miriam is moving towards north and Frida towards north-east. All boars are moving rather slowly (although short running bursts cannot be detected due to the coarse temporal resolution). Both Miriam and Frida seem to be moving away from Ueli. This meeting event may represent a rejected mating advance from Ueli.

3.1.3 Meeting Event 4

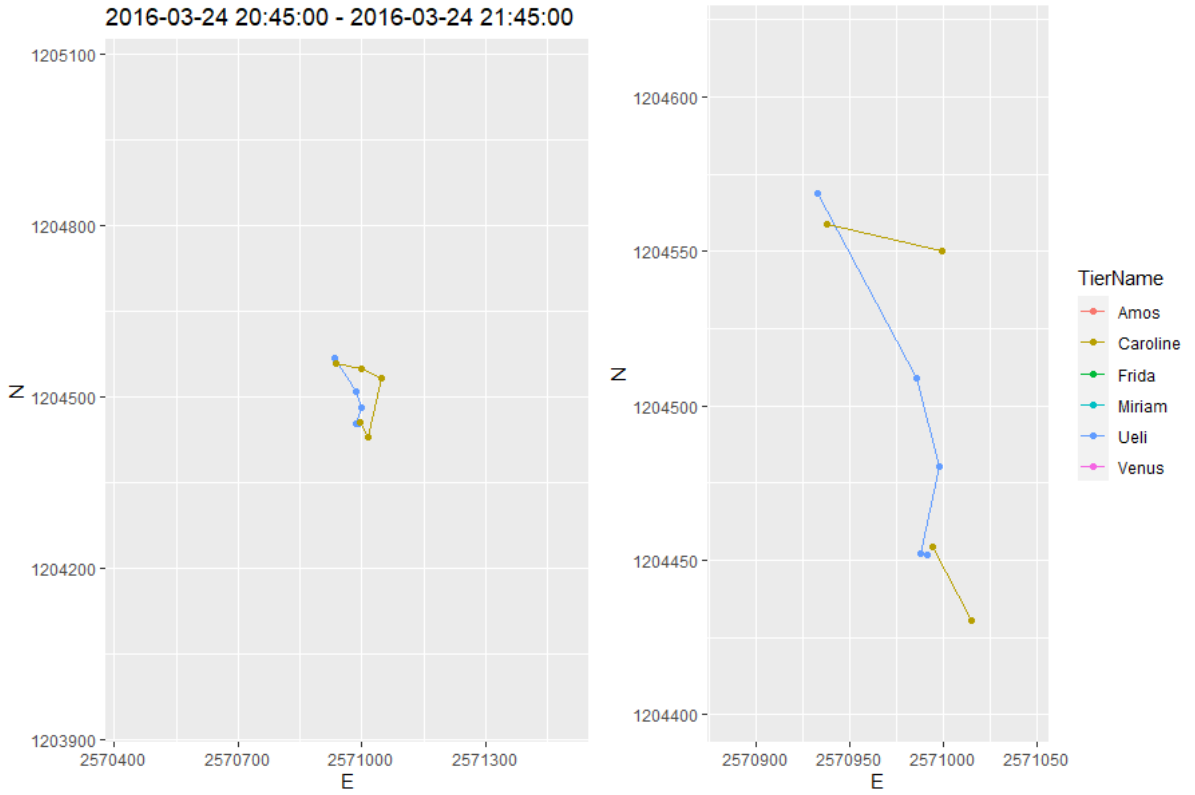

Fig. 5: Trajectories of the wild boar during meeting event 4. Both panels show the same trajectories, but with a different scale.

During meeting event 4 (Fig. 5), Ueli (moving from north to south) and Caroline get very close at the beginning and especially at the end (less than 10 meters). This may represent a playful chase, as it was described in subsection 1.3.4. There is a high chance that Ueli's mating advance was successful. The proximity of the two at the beginning, as well as the end of the event and the low speed of the wild boar during the event, indicate that the meeting was friendly and neither animal felt threatened by the other.

3.1.4 Meeting Event 6

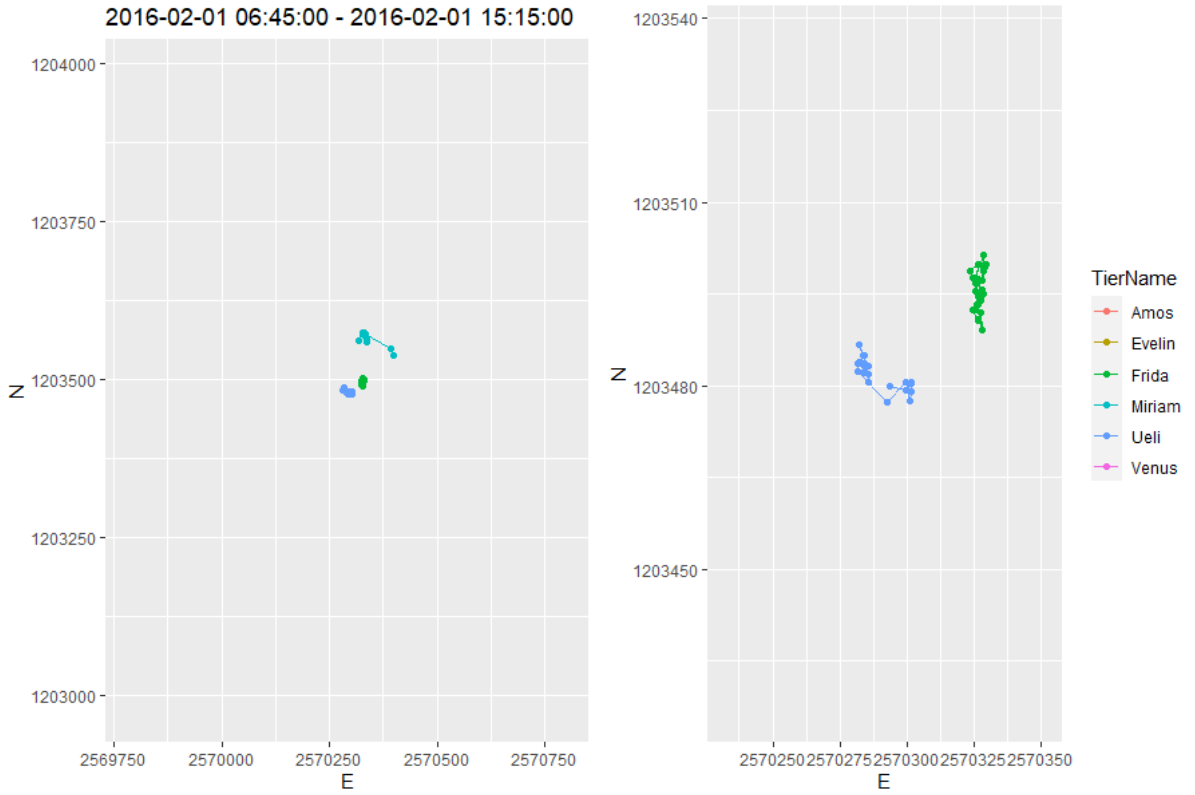

Fig. 6: Trajectories of the wild boar during meeting event 6. Both panels show the same trajectories, but with a different scale.

During meeting event 6 (Fig. 6), both Ueli and Frida were close to each other (25 – 50 meters) the entire time. Neither boar seemed to be moving significantly over the length of the meeting event. This suggests that the boar may have been resting, rather than mating. Miriam, who was a bit further away (approximately 100 meters) appears to be more active but does not seem to be interested in either Ueli or Frida.

3.2 Contextualization

Finally, the selected meeting events of interest (2, 3, 4 and 6) were put into a geographic and environmental context. The locations of the male and female wild boar that met during each event were plotted as a convex hull over a background raster map of the study region (Fig. 7).

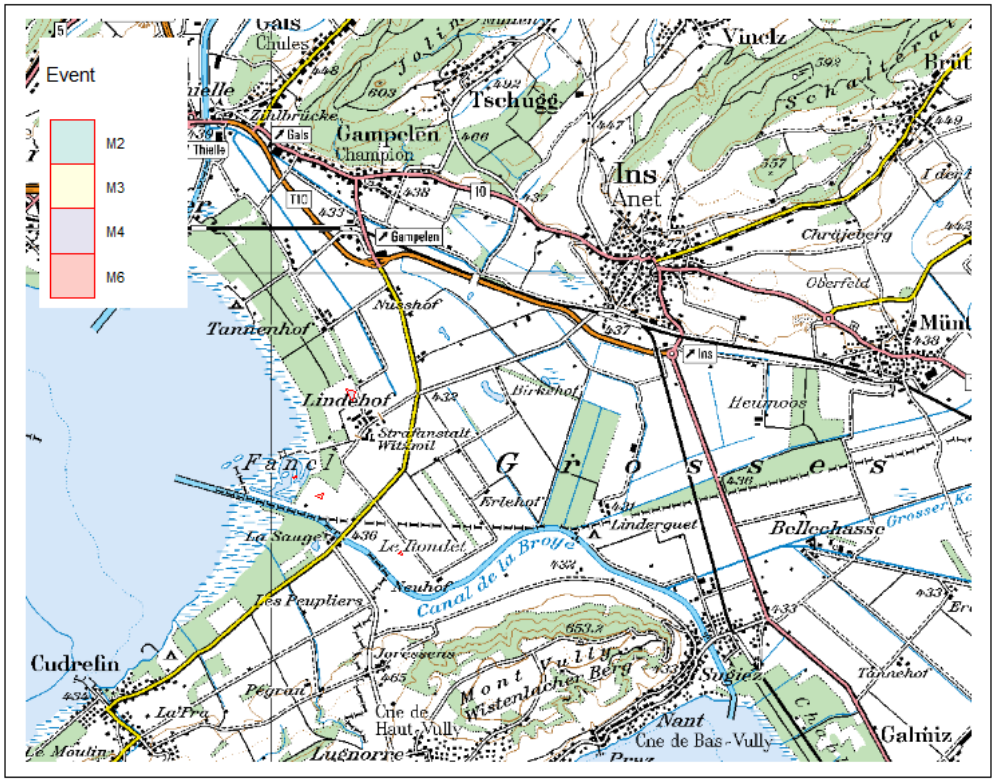

Fig. 7: Convex hulls of the meeting events (M2, M3, M4 and M6) over a background map of the study region. The convex hulls are very small and therefore barely visible. A zoomed-in extract of the map can be found in the Annex.

All four meeting events are relatively close to each other. They all occurred in fields near water (or in case of meeting 6: in the water) and in some distance to the villages (not counting the few houses of the "Lindehof"). This is expected, as there are fewer disturbances and more safe spots for the wild boar away from civilization. What is more, the waters provide them with drinking and wallowing opportunities. Considering the little movement that occurred during meeting event 6 and the location of the event at the shore of the lake, it is highly likely that said event was in fact a wallowing event, rather than a mating event.

3.3 Limitations and Shortcomings of the Approach

This modelling approach exhibits several methodological limitations and shortcomings. In this section, I will focus on and briefly discuss three main issues:

1) Validation: The results of this study are ultimately speculative and cannot be verified without additional data. To validate this approach and to apply it to a more relevant context, reliable and high-quality data such as footage from camera traps (or similar) are required.
2) Temporal resolution: To be able to capture more nuanced movement patterns, a higher temporal resolution of the input data is needed. It may even be possible, although unlikely, to miss a quick meeting between two wild boar – with or without mating – altogether.
3) Untracked wild boar: While our tracked wild boar can be studied to some precision, the untracked wild boar that are present in the area cannot. The interaction between tracked and untracked animals (such as mating or fighting) go unnoticed or – worse – may lead to misinterpretation of the behaviour of the tracked wild boar. It is therefore essential, to track as many animals as possible in your region of interest.

4. Conclusion and Outlook

Using a combination of movement and environmental context data to identify potential mating events, showed some promising results. Several events could be identified for the mating season 2015/16, along with a promising amount of information, allowing us to assess the likelihood of an event being a mating event (such as the presence of other boars, speed or direction of movement or information on the physical surroundings). However, the approach does exhibit a few weaknesses such as the lack of validation, the temporal resolution or the incomplete tracking of the wild boar population.

Applying this approach in a study design that enables the validation of the approach is key in going forward with this method. You are always going to want to have a better resolution and you will hardly be able to track a complete wild boar population over an elongated time period. But the lack of validation options is an issue, which could – and should – be improved by design in the future.

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Annex – Zoom of Thematic Map Extract

Zoomed in extract of the thematic map including the convex hulls of the four studied meeting events.