Temporal variation in movement patterns of invasive raccoon dogs

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Background

Effective monitoring and management of invasive species demands knowledge about their movement pattern in order to direct the actions to the optimal time and place.

Movement patterns varies in time. If animals activity period does not overlap with human activity, encounters will be less likely and observation rate will not reflect the occurrence of animals in an area.

In mammals, males often have a larger space use, movement rate, and a higher dispersal propensity than females. This can slow down invasion rate because the dispersing males does not encounter females. Similar dispersal behaviour between males and females behaviour can give higher expansion rate.

Using a large GPS-dataset on raccoon dog on its invasion front, we studied how movement patterns varied at coarse (season) and fine (diurnal) temporal scale. Specifically, we assessed:

1. Seasonal and diurnal variation in speed and direction of movement
2. Sex-differences in movement patterns
3. Whether movement could be classified into behavioural states related to invasion biology of raccoon dog, and be used to simulate dispersal from source populations

Study area and raccoon dog data

- Northern Sweden, raccoon dog at its invasion front (Fig. 1)
- 55 GPS-collared raccoon dog (30 males, 25 females)
- Individuals followed for on average 196 days
- Variable sampling interval, analyses on two temporal scales:
  - Three hour interval (diurnal and seasonal analyses)
  - Daily mean locations (clustering and simulation)
- Used speed (step length) and turning angle (change in direction between two consequtive steps)
- Used a clustering algorithm to group daily steps into classes
  - Computer-based clustering
  - Simulated raccoon dog movement based on movement states from the clustering procedure

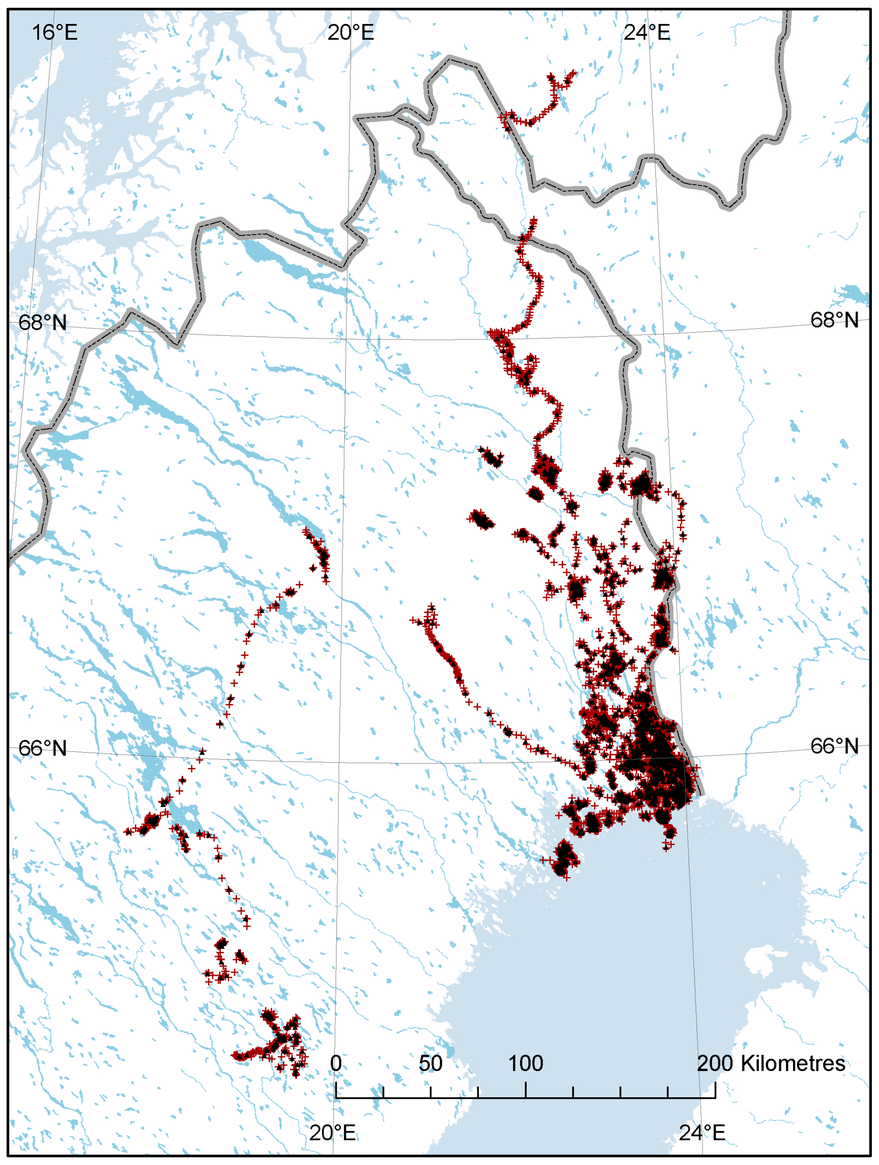

Fig. 1. GPS-locations (red crosses) of raccoon dog in Sweden. Black triangles show daily mean locations.

Acknowledgements

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Results and discussion

1 Seasonal and diurnal patterns of movement

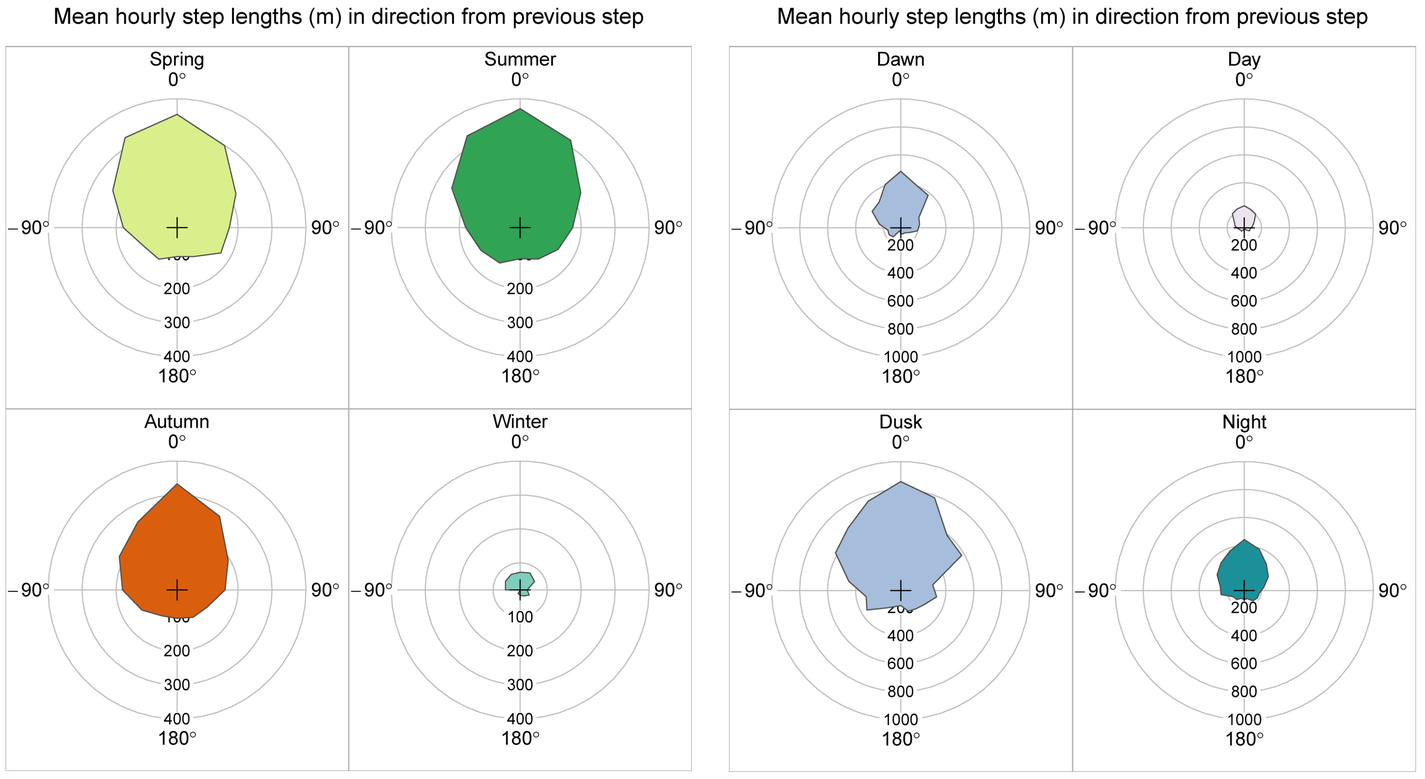


Figure 2. Hourly distance moved (m) and the direction from previous step in relation to a) season and B) light conditions. A turning angle of 0 means that the step continued in the same direction as the previous step.

Movement was faster if it continued in the same direction as previous hour

Short movement rates during winter

Fastest movement during dusk and dawn

Slowest movement during day

2 Sex-differences in movement patterns

No differences between males and females in movement patterns

Temporal pattern of movement did not differ between males and females

Highest speed and more directional movement around sunset

Males and females movement rate is similar

Invasion front is likely to consist of both males and females

This increases the chance of reproduction in new areas.

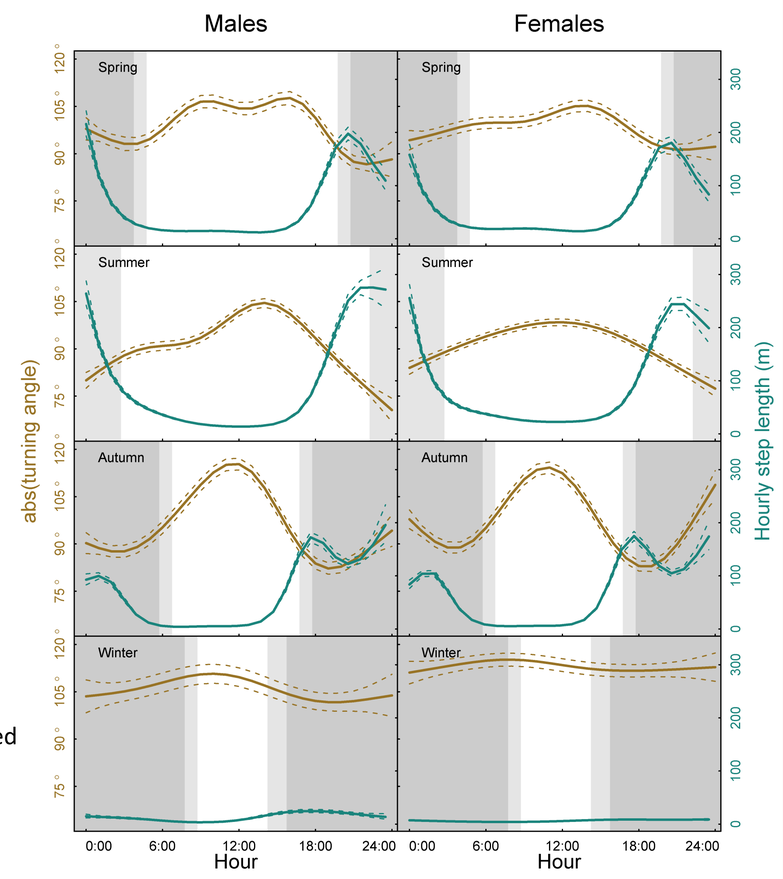
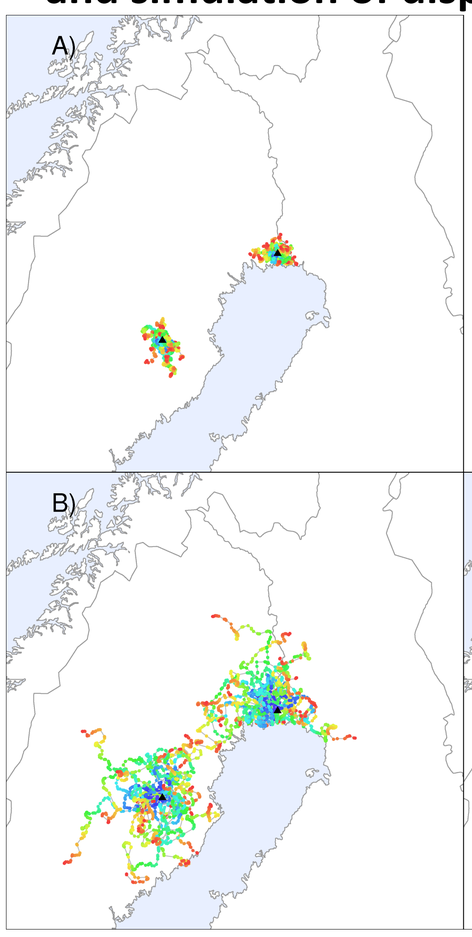


Figure 3. Hourly distance moved (m) and the direction from previous step during the 24 hour period for male and female raccoon dog. A turning angle of 0 means that the step continued in the same direction as the previous step, 180 is a complete tuning back. Dark and light gray shading indicates the mean hours of night and twilight at the centre of the study area, whereas white is daylight period.

3 Classification of movement states and simulation of dispersal



Movement patterns allowed us to separate between three movement states (Fig. 4):

1. Dispersal (long daily step and low turning angle, **D**)
2. Settled (long daily step and high turning angle, **S**)
3. Winter sleep/non-moving (short daily step and high turning angle, **NM**)

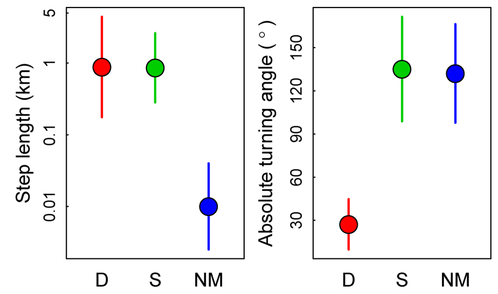


Fig. 4. Step lengths and turning angles of daily movement describing different states. D = dispersal, S = settled, and NM = non-moving.

We simulated state-specific movement with two starting points; Haparanda and Lycksele (Fig. 5).

Dispersing raccoon dog can reach very far in short time, and cross each others paths frequently.

Fig. 5. Simulated movement paths for 150 days based on state-specific step length and turning angle. A) settled individual, B) dispersing individuals, C) 50% fastest dispersal individuals (daily step lengths > 1 km). Colours indicates time from start of dispersal (blue is start, red is end).