Inferring social network centrality from behavioural tests in sheep: A novel method for PLF

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CONTEXT 1/4

PLF systems are developing, supported by frequent breakthroughs in digitalization:

- Sensors
- Communication networks
- Data storage and analysis
- Data visualization
- Automated processes

↘ work hardness
↗ work attractiveness
↗ technical performances

welfare

reproduction

health

nutrition

microchip

Breeders are in search for a compromise between functions, price and number of animals to monitor simultaneously
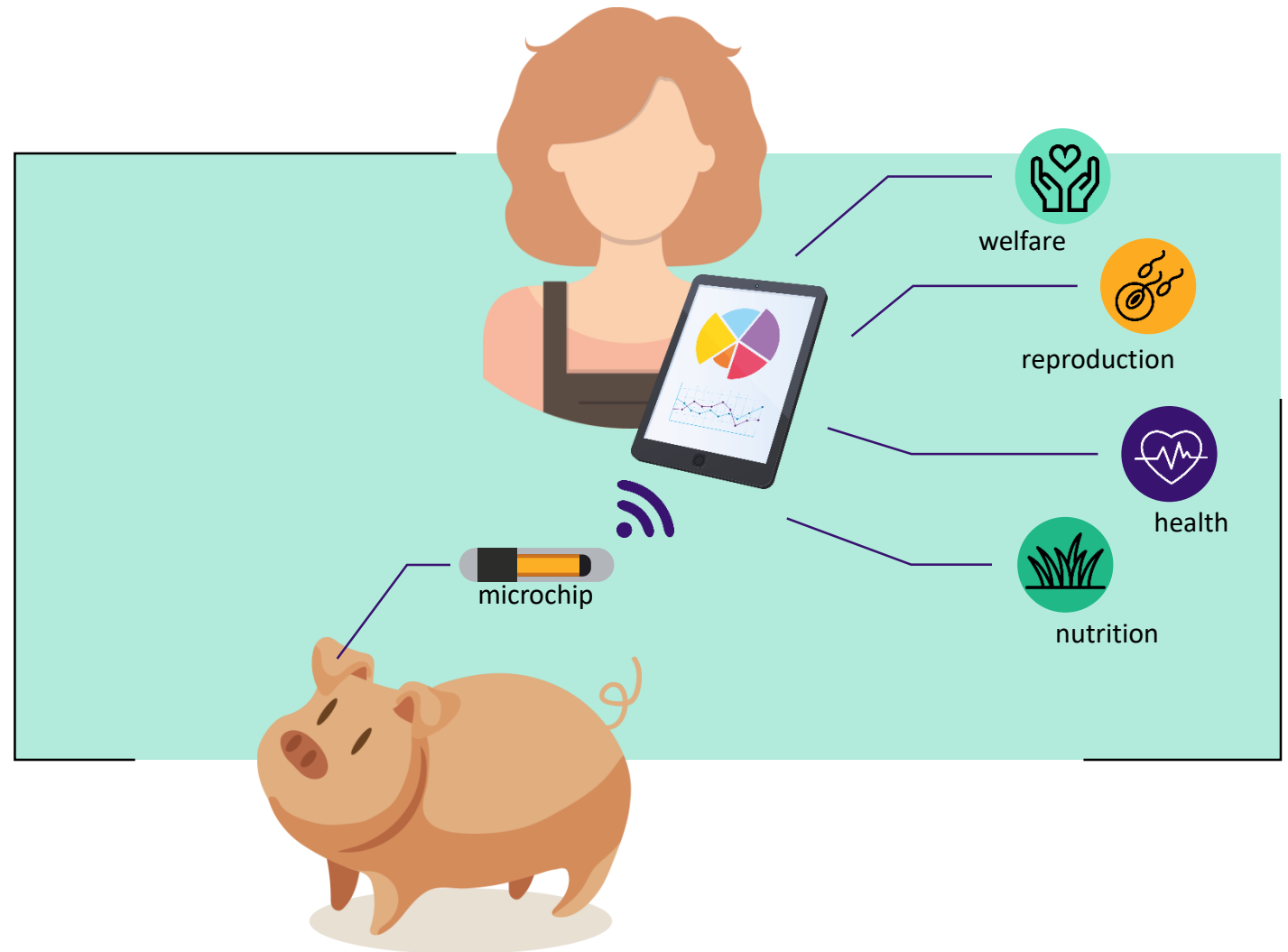
In this context, specific constraints are associated with extensive livestock farming conditions

- Large flocks
- Mobility of the animals
- Geographic isolation: low networks coverage, difficulty of maintenance
- High autonomy / storage capacity
- Environmental constraints

At a larger scale: lack of available digital tools

- Highly diversified
- Irregular / low incomes
- Low density industries
- Mistrust of breeders
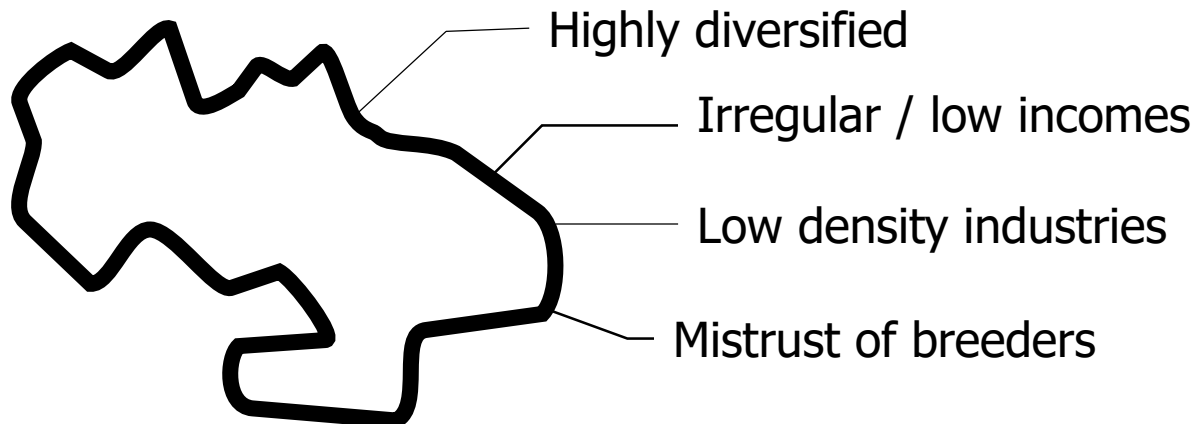
HOWEVER

the demand is real with specific needs:
- Long-term localization and activity
- Land use management
- Welfare management
- Land sharing
- Domestic animals and wildlife interactions

CONTEXT 3/4

"I want to monitor the activity and mobility of my animals."
How many devices do I need?
On which animals?

CONTEXT 4/4

Innovative solution are required to implement PLF paradigms under extensive livestock farming conditions
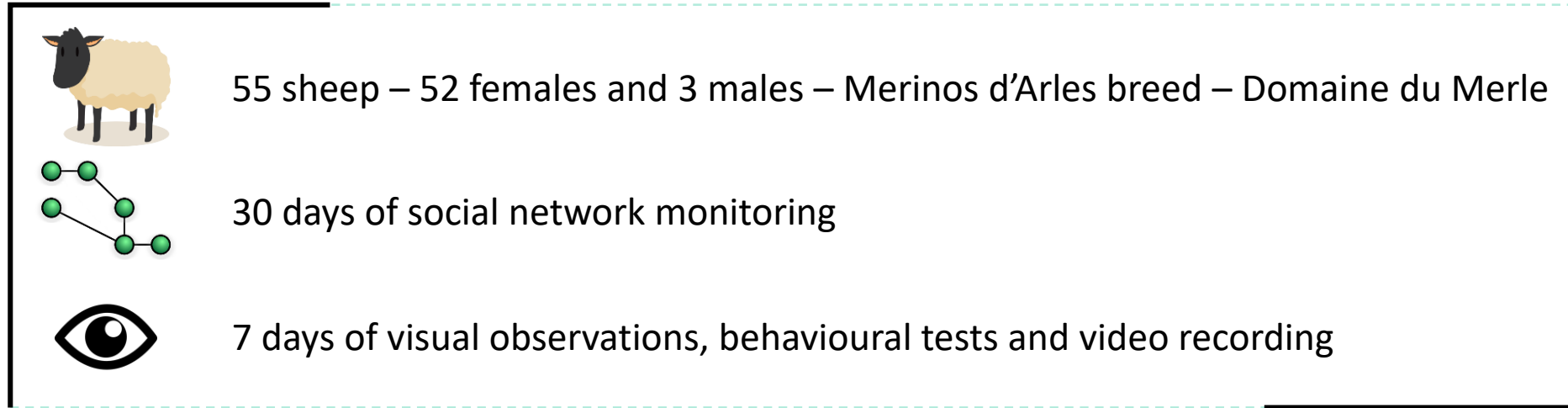

As a compromise between costs and data reliability, a rational choice of **target animals** to equip will improve the implementation of robust and profitable PLF tools

HYPOTHESIS

1. Some individuals are more representative of the mobility of the flock
2. Social Network Analysis can identify these animals as central individuals in the network
3. Simple behavioural observations and tests can identify these animals

METHODS

55 sheep – 52 females and 3 males – Merinos d'Arles breed – Domaine du Merle

30 days of social network monitoring

7 days of visual observations, behavioural tests and video recording

1. Social Network Analysis

- Collar-mounted RF devices to record spatial associations between each individual

→ Number and strength of social relations of each individuals

2. Visual observations and behavioural tests

- Identification of various behavioural traits during undisturbed breeding conditions

→ Individual behavioral profiles influencing collective behavior

METHODS
## *Social Network Analysis*
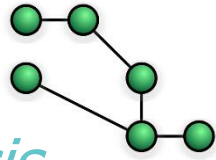
AUTONOMY: 2 months
FREQUENCY: 5 min
RANGE: from 1km to virtually unlimited
COSTS: ≈ 70 €

The "quadrality" of embarked sensors in extensive livestock systems

Social Network based on spatial associations → reflects social closeness
The quality of communication between each collar is interpreted as a relative distance between animals dyads
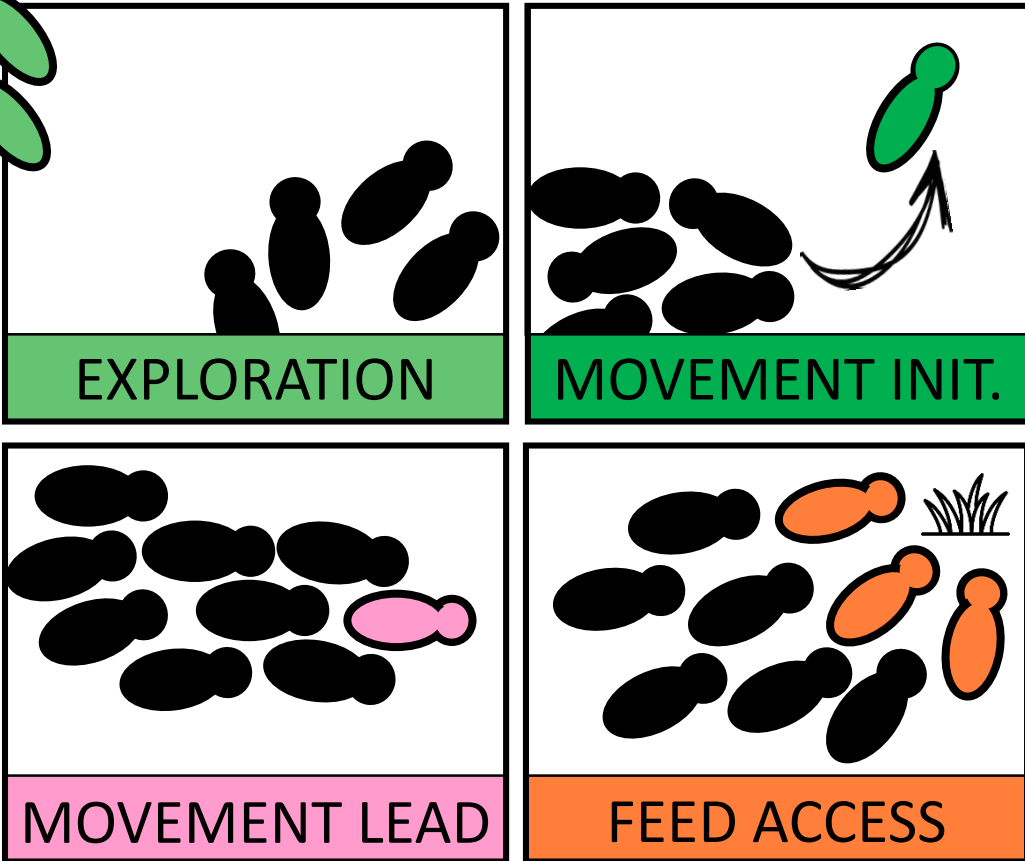

Mobile Node

Master Node

either fixed or embarked

RF signal
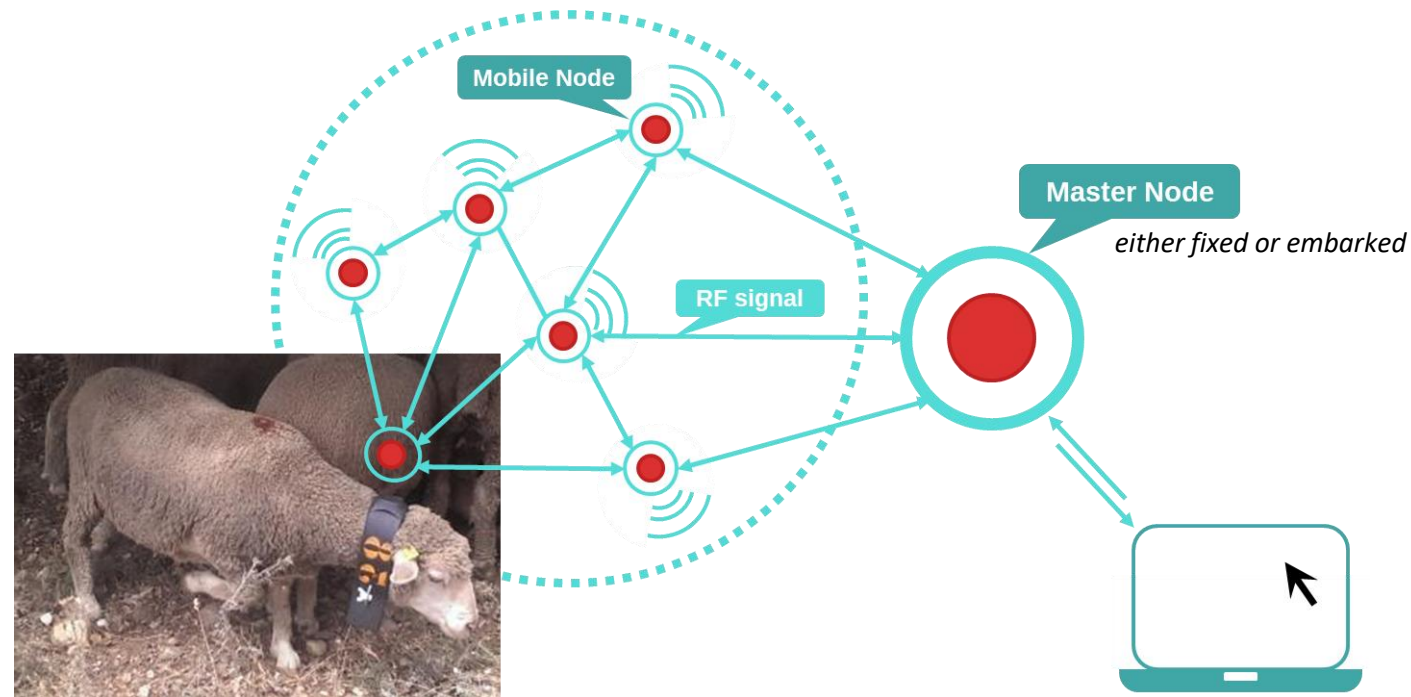
Among parameters of SNA we focused on **centrality**: ↗ connexions (number, strength) = ↗ centrality score
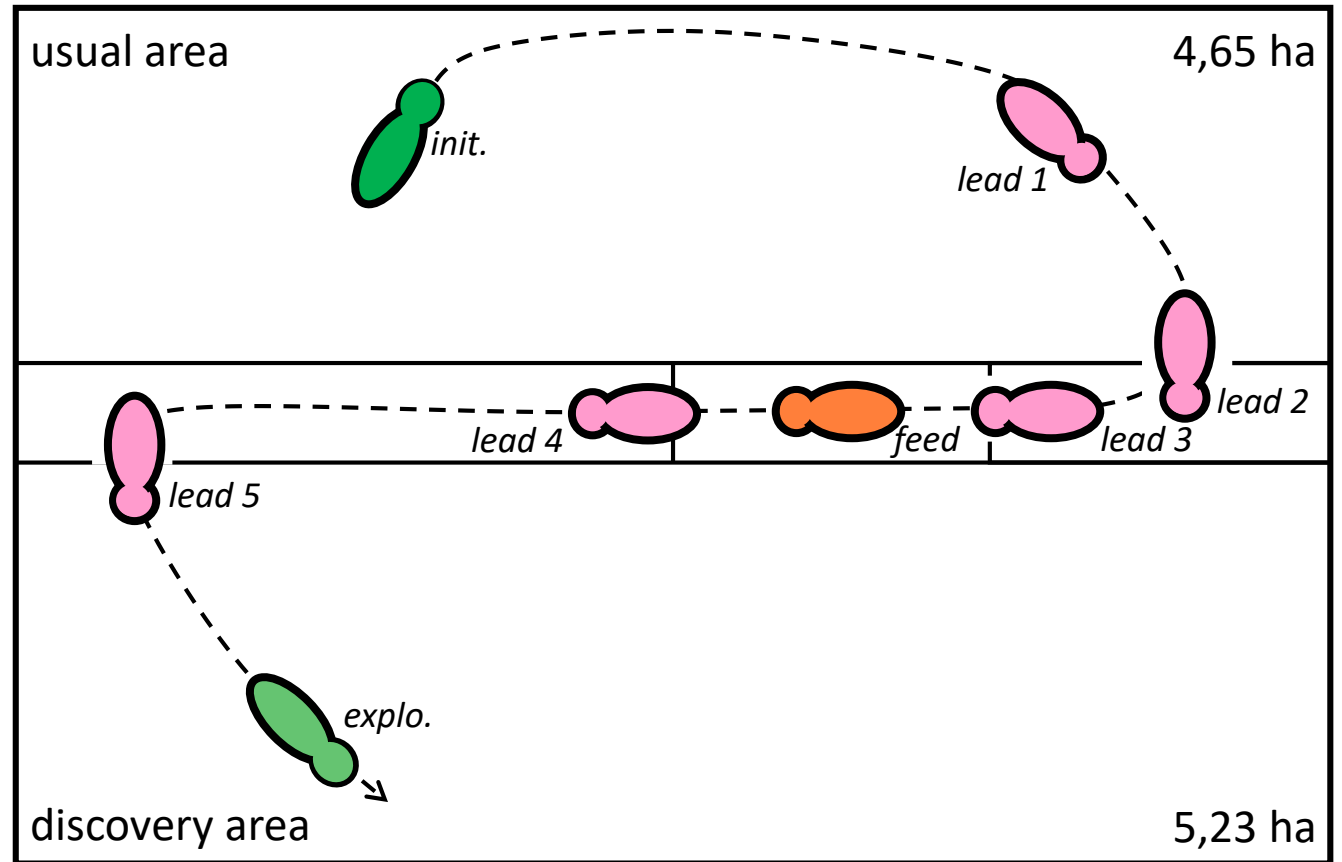**Animals with higher centrality score as "marker" of the movements of a larger group of individuals**

METHODS 👁

Visual tests & observations

Tests and observations were repeated twice a day

Observations and tests

Field plots & daily route

EXPLORATION

MOVEMENT INIT.

MOVEMENT LEAD

FEED ACCESS

usual area   4,65 ha

init.

lead 1

lead 2

lead 4   *feed*   *lead 3*

lead 5

explo.

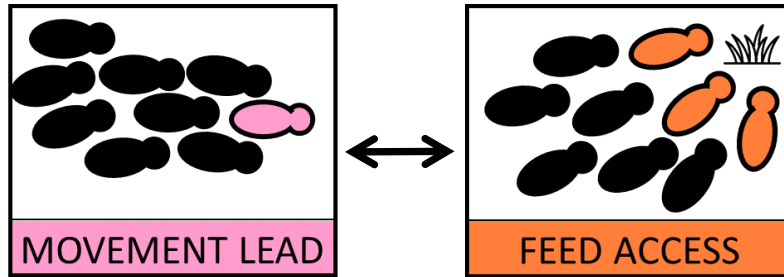discovery area   5,23 ha

Observations and behavioural tests accessible for on-farm application
Each animal was scored for each trait to establish their behavioural profiles
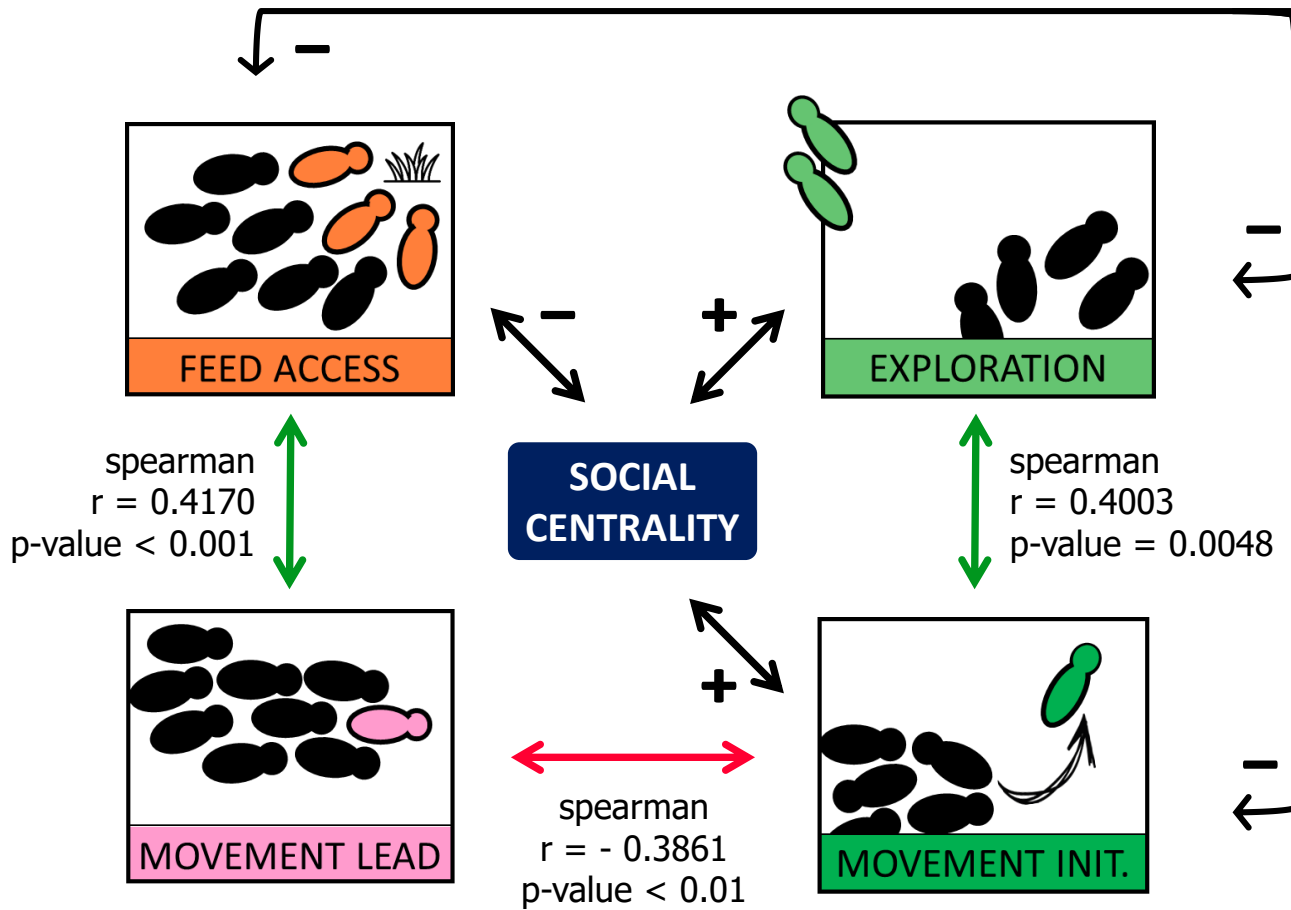
RESULTS

- **Movement lead strongly interacted with the sequence of observation**
  → Animals with a privileged access to feed led the previous passage sequence

- **The exploration and initiation traits were positively correlated**
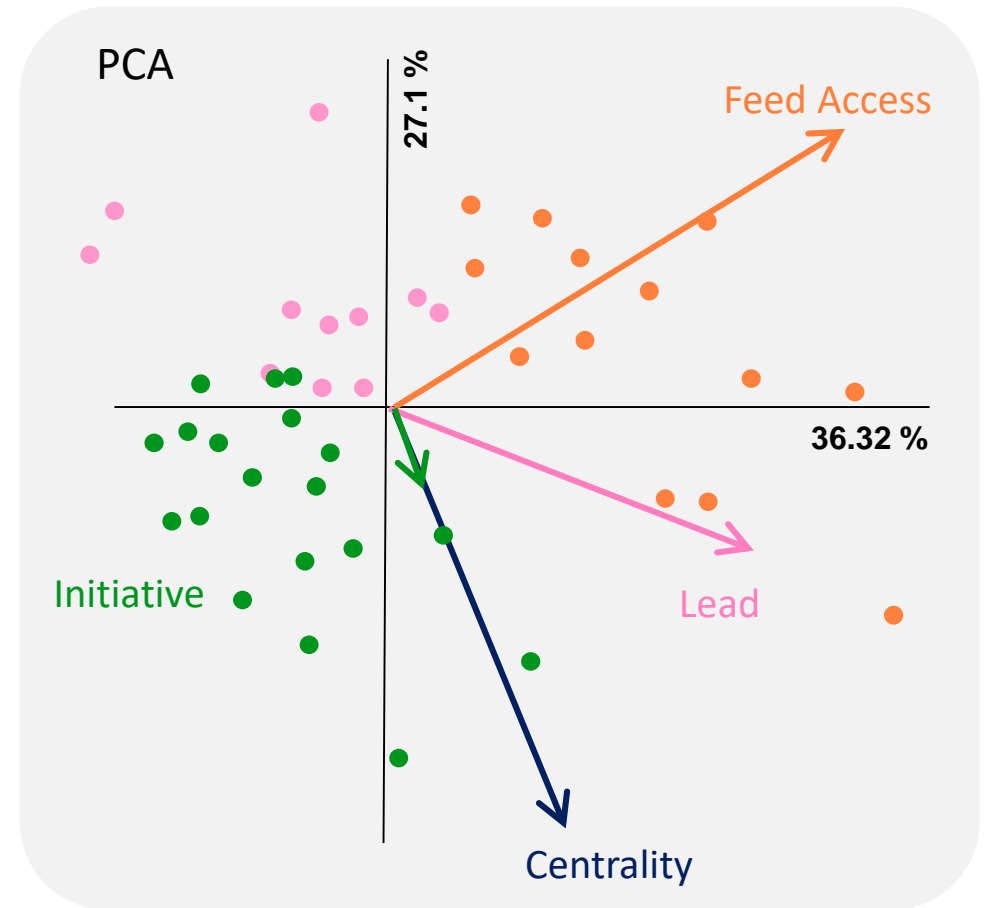 → These two variables can be merged as an "initiative score"
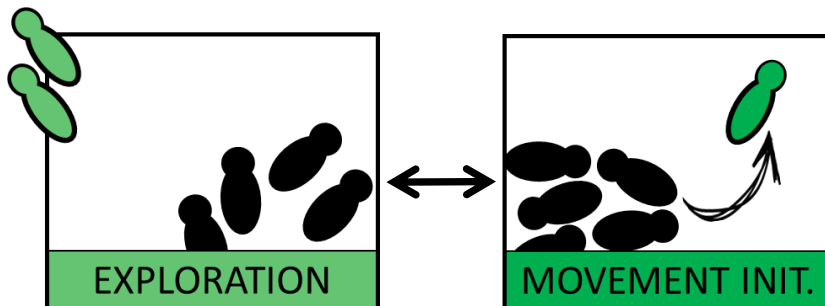
RESULTS

Best model (glm) using stepwise regression (backward):

$$Centrality \sim 0.46 + 0.37 \left(\frac{Initiative\ score}{Feed\ access} \right)$$

Individuals with a less privileged access to feed are more central and have more impact on the movements of the flock and conversely...

DISCUSSION

Social centrality in a flock of sheep can be inferred from the individual knowledge of the behavioural traits of feed access and initiative score
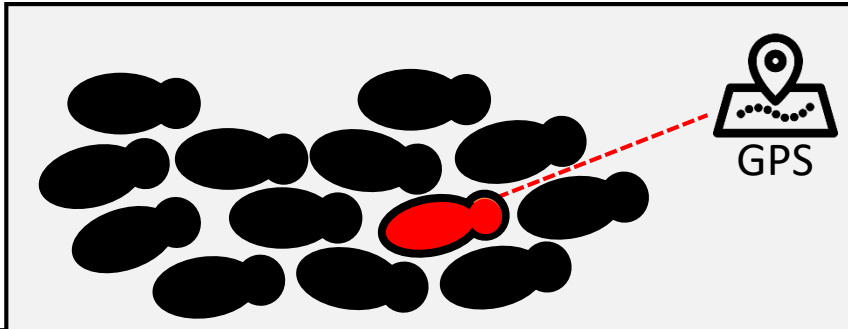
These individuals, that **play a role in the movement of groups** of animals, can be considered as **markers for the mobility of the flock and identified using simple behavioural tests**

CENTRAL INDIV.

Targeting individuals to rationalize costs of equipment and maximize the relevance of the information obtained fits directly into the main principles of PLF especially applied to extensive breeding conditions where **the principles of parsimony, frugality and robustness have to be put forward**
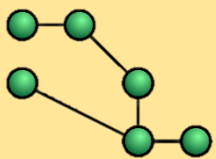
Using the appropriate tools, **SNA** is a powerful methodology to explore **animal behaviour at the individual and collective levels to promote innovative management practices**

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