TYPOLOGICAL CHARACTERISTICS OF SHEEP FARMS IN RELATION TO A POTENTIAL RISK OF CONTAMINATION WITH *NEOSPORA CANINUM* IN THE CENTRAL REGION OF ALGERIA

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Abstract. The aim of this work was to produce a typology of sheep farms in five districts of the central region of Algeria and to identify the elements linked to the contamination with Neospora caninum. It concerned 195 farms and was conducted from March 2016 to March 2018. A multiple correspondence analysis individualized three groups of modalities with a variance between groups of 47%. The results showed that the farming system was extensive with semi-tie-stall housing, the number of sheep was small (<50 heads), the dominant breed was the Ouled Djellal (29.74%) and the sheep lived with the goats (36.92%). The dominant pathologies were parasitic, respiratory and reproductive, and abortions were present at 96%. This survey allowed us to identify breeding practices linked to possible contamination with Neospora caninum, such as cohabitation with goats and the fate of abortions and afterbirths. The presence of dogs was the most important factor (72.30%).

Keywords: typology, sheep, abortions, neosporosis

INTRODUCTION

Sheep farming plays a dominant role in the rural economy in Algeria due to the eating habits of a constantly growing population of around 42 million inhabitants (ONS, 2018). The sheep livestock is estimated at 28.4 million head of sheep (MADR, 2018) and the annual production of red sheep meat is estimated at 3.25 million quintals. Regarding the food availability of red meat, it is 14.4 kg per year per inhabitant.

Despite a large and growing number of sheep, the yield remains low, this mainly due to poor control of breeding management. A large part of the sheep livestock is concentrated in the steppe regions (Aidoud et al, 2006) and the high semi-arid cereal plains (80% of the total number). The dominant farming system is the extensive one, strongly influenced by climatic hazards without adequate health care. The dominant breeds are the "*Ouled Djellal*", "*Hamra*", "*Rembi*" and "*D'men*", the rest are composed of secondary breeds such as the berber breed "*D'man*", "*Barbarine*" and the "*Sidaou-Targuia*" breed (Moula, 2018). The rationing method remains uncertain and depends on the availability of food. The ration generally consists of dry fodder and concentrate. Transhumant herds can benefit from green fodder depending on climatic conditions. In tie- or semi tie-stalls, sheep often live in close proximity of other species such as cattle, goats, horses, poultry and dogs.

This practice of breeding increases the risks associated with the appearance of certain abortive diseases. This is the case with *Neospora caninum* infection, indeed the method of feeding and watering, the proximity to other animals, dogs in particular, and the behaviour of breeders in the event of abortions (management of abortions and afterbirths).

The aim of this study was to produce a typology of sheep farms in five districts of the central region of Algeria. This work is a preliminary step which will allow us to identify the farms presenting a potential risk of neosporosis. This knowledge is essential to define the epidemiology of the pathology in the ovine species, which will allow better management of the disease and the implementation of effective prophylactic actions.

MATERIAL AND METHODS

Study zone

The study area was located between latitudes 43° and 36° North and longitudes 3° and 5° East. It was characterized by a temperate to Sub-Saharan climate with average annual precipitation of 338mm to 830 mm.

Fig. 1. Geographic map showing the study area

Questionnaire

The questionnaire used for this study was semi-structured; the questionnaire was translated from French into the local language (Arabic) by a person fluent in French and Arabic. Open-ended questions allowed the interviewee to direct the discussion to topics they considered to be important. The questionnaire consisted of four parts:

- The first part enabled identification of: the breeder, the attending veterinarian, the concerned district and the legal status of the farm.
- The second part described the zootechnical parameters: the category of the present sheep, the size of the farms, the main breeds exploited, the age classes, the breeding types and the stabulation methods.
- The third part provided information on health parameters: the most frequent pathologies in the breeding and the presence of abortions.

- The fourth part concerned the risk factors linked to the exposure to *Neospora caninum* : the origin of the animals in the farm, the fate of the abortions and the afterbirths, the presence of other domestic animals in the farm and the presence of dogs.

Sampling and data collection

The survey concerned 195 sheep farms chosen at random from each study area. The livestock was distributed over five districts unevenly depending on the importance of sheep farming in each one of them. The study was conducted from March 2016 to March 2018. The data was obtained by personal interviews to avoid misunderstandings.

Statistical analyzes

All statistical analyzes were performed with R software (version 3.5.2). In addition to descriptive statistics, multiple correspondence analysis (MCA) and hierarchical classification (ACH) were carried out to establish a typology.

Table 1

Codes for variables and modalities used in the multiple correspondence analysis (MCA).

Variables	Codes	Modalities
Species present in the farm other than sheep	Bvs1	Presence of cattle in the farm
	Bvs0	Absence of cattle in the farm
	Cap1	Presence of goats in the farm
	Cap0	Absence of goats in the farm
	Atr1	Presence of other animals in the farm
	Atr0	Absence of other animals in the farm
Breed	OD1	Presence of the Ouled Djellal breed
	OD0	Absence of the Ouled Djellal breed
	HA1	Presence of the Hamra breed
	HA0	Absence of the Hamra breed
	RB1	Presence of the Rembi breed
	RB0	Absence of the Rembi breed
	NNK1	Presence of the berber (kabyle) breed
	NNK0	Absence of the berber (kabyle) breed
Number of sheep	Efp	Number of sheep < 50 heads
	Efm	Number of sheep between 50 and 100 heads
	Efg	Number of sheep between 100 and 200 heads
	Efh	Number of sheep between 200 and 300 heads
Age	AgA1	Presence of sheep between 0 and 6 months
	AgA0	Absence of sheep between 0 and 6 months
	AgB1	Presence of sheep between 6 and 12 months
	AgB0	Absence of sheep between 6 and 12 months
	AgC1	Presence of sheep between 1 and 4 years
	AgC0	Absence of sheep between 1 and 4 years
	AgD1	Presence of sheep over 4 years

	AgD0	Absence of sheep over 4 years
Farming system	Intf	Intensive farming
	extf	Extensive farming
Stabulation	Entv	Tie-stall
	Lib	Libre
	sEntv	Semi tie-stall
	Tranh	Transhumance
Water source	Pf	Well or borehole water
	Res	Tap water
	RS	Surface water
	ER	Spring water
Origin	Mxt	Mixed breeding (some bought and some born in the breeding)
	NDE	Sheep born in the farm
	ACHT	Sheep bought from the livestock market
Pathologies	GEN	Reproductive diseases
	PRZ	Parasitic diseases
	PMS	Respiratory diseases
	LCM	Musculoskeletal diseases
Abortions	AV1	Presence of abortions in the farms
	AV0	Absence of abortions in the farms
Fate of the abortions	AVJ1	Disposed abortions
	AVJ0	Non disposed abortions
	AVef1	Buried abortions
	AVef0	Not buried abortions
	AVCN1	Abortions given to dogs
	AVCN0	Abortions not given to dogs
Fate of the afterbirths	Afxe1	Buried afterbirths
	Afxe0	Not buried afterbirths
	Afxj1	Disposed afterbirths
	Afxj0	Non disposed afterbirths
	AfxCN1	Afterbirths given to dogs
	AfxCN0	Afterbirths not given to dogs
Presence of dogs	PrCN	Presence of dogs in the farm
	AbCN	Absence of dogs in the farm

RESULTS AND DISCUSSION

Identification of the farms

The farms were distributed in the study area as follows: Bejaia (21.02%), Blida (10.8%), Boumerdès (3.07%), Bouira (21.53%), Djelfa (43.58%). Regarding the legal status, it should be noted that all farms surveyed (100%) consisted of private farms where the breeder was the owner.

Zootechnical characteristics

The survey showed that the majority of farms (60%) adopted an extensive farming system and a semi tie-stall housing (65.64%), this, in cohabitation with goats (36.92%). The majority of farms (75.90%) were mixed (some animals born in the farms and some bought from livestock markets). The most dominant farm size was the small one with <50 heads (50.8%) followed by the intermediate size of 50-100 heads (27.18%), and the large size was 21.8%, meanwhile only 1% exceeded 300 heads of sheep. The Ouled Djellal race was predominant at 29.74%.

Health status

We identified several pathologies with similar frequencies for parasitic, respiratory and reproductive diseases with respective rates of 33.85%, 32.82% and 29.23%. Musculoskeletal problems were only reported in 4.10%. It should be noted that 35.38% of the breeders confirmed the presence of abortions without the cause being defined.

Breeding practices and neosporosis

It is important to study the elements of epidemiology. This to improve knowledge of practices involving the occurrence of diseases and the circulation of pathogens by looking at the relationships between the environment, the host and the parasite.

Among the practices linked to the risk of exposure to *Neospora caninum* in the studied farms, was the cohabitation with other domestic species and in fact most farms were mixed with several animal species. Goats were the most associated with sheep with a percentage of 36.92. Cattle and other species (horses and poultry) were associated with lower percentages of 19.48 and 13.33 respectively. Animal watering could be a source of contamination especially when it comes from surface water, as was the case for 21.53% of farms.

It should be noted that the most important risk factor was the presence of dogs, the definitive host of *neospora caninum,* in the farms. Whether the intention was guarding or leading the herd, dogs were present in the vast majority of farms with a percentage of 72.30%.

There was a risky practice associated with the presence of dogs near sheep, and that was the care of abortions and afterbirths that were either thrown away or given directly to the dogs. The abortions and the afterbirths were either thrown away at 15.94% and 59.42% respectively, or given to the dogs in 43.47% of the cases. In both cases, abortions and afterbirths were available to dogs which perpetuated the parasitic cycle of neospora caninum in case of infection.

Typology
Multiple correspondence analysis

Multiple correspondence analysis, applied to 13 variables with 59 modalities, made it possible to discriminate three selected axes, representing 47% of the total variability. Table 2 shows the statistical link between these variables and the first three axes, such as it is estimated by the analysis of variance.

Degrees of statistical link between the variables and the three first axes.

Variables	Dim 1	Dim 2	Dim 3
Cattle	***	***	-
Goats	***	-	-
Others	***	***	-
OD	***	***	***
Ha	***	***	-
RB	**	**	-
NK	-	-	***
Number of sheep	***	***	***
AGEA	***	***	**
AGEB	***	***	***
AGEC	*	-	***
AGED	***	**	***
Type of breeding	***	-	*
Stabulation	***	***	***
Water source	***	***	***
Origin of animals	***	***	***
Presence of dogs	***	***	***
Pathologies	***	***	***
Presence of AV	***	-	-
Fate of abortions	***	***	***
AVef	***	***	-
AVCN	***	**	-
Fate of afterbirths	***	***	***
Afxj	***	***	-
AfxCN	***	**	-
* $p < 0.05$; **$p < 0,01$; ***$p < 0.001$; –: not significant.			

- Axis number 1 represented 29.01% of the total of the variable. It was positively correlated with pathologies ($r = 0.64$), cohabitation with goats ($r = 0.62$), the stabulation method ($r = 0.63$), the source of water ($r = 0.57$) and the presence of abortions ($r = 0.46$). (Fig. 2)
- Axis number 2 represented 10.28% of the total of the variable. It was positively correlated with the stabulation method ($r = 0.53$), pathologies ($r = 0.36$), the number of animals present in the farm ($r = 0.37$) and the water source ($r = 0,31$). (Fig. 2)
- Axis number 3 represented 7.79% of the total of the variable. It was positively correlated with the source of water ($r = 0.69$), the Berber breed ($r = 0.36$), age ($r = 0.23$) and the number of sheep in the farm ($r = 0.22$). (Fig. 3)
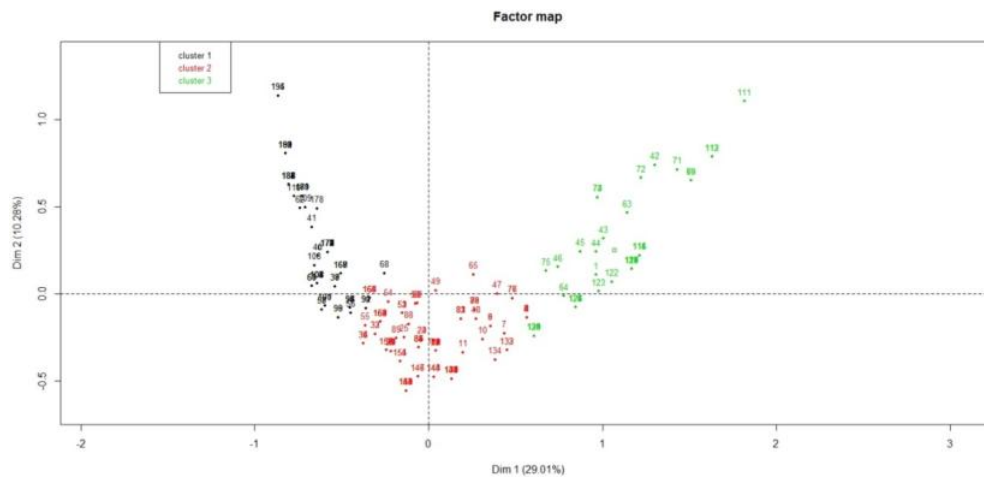
Fig. 2.Graphic representation of the modalities on axes 1 and 2 (see table 1 for significations of the codes)

Fig. 3. Graphic representation of the modalities on axes 2 and 3 (see table 1 for significations of the codes)

Hierarchical classification and description of clusters

The analysis of hierarchical clusters was carried out on all the variables. Three groups (clusters) were retained, conserving a variance between groups of 47% of the total variability. Figure 3 shows the graphic representation of the three clusters.

Fig. 4. Graphic representation of the clusters on axes 1 and 2 (the numbers correspond to the studied farms)

- Cluster 1 (63 farms, 32.3% of the total) was described as sheep farms with a large number of sheep (50.79%), extensive farming system (92.06%), transhumant (28.57%), surface drinking water (46,03%) and the presence of respiratory pathologies (80,95%). It was a group that did not have abortions (93.65%) and the canine species in this group was absent (60.31%).
- Cluster 2 (96 farms, 49.2% of the total) was a group composed of small numbers of sheep (58.33%), semi tie-stalls (77.08%), with the presence of dogs (83.33%) and the most dominant pathology was parasitic (65.62%).
- In cluster 3 (36 farms, 18.5% of the total) the dominant farming system was intensive (100%) in cohabitation with goats (100%), cattle (66.66%) and other domestic animals (58.33%). The dominant breed was the principal breed Djellal (66.66%). In this group the presence of dogs (100%), abortions (94,44%) and reproductive pathologies (100%) dominated.

The statistical link with the group variable was highly significant (p <0.001) for all of the following variables : numbers of sheep, breeds, stabulation method, water source, pathologies, origin of animals, age, presence of dogs and presence of abortions.

Zootechnical characteristics:

Most of the herds in the study area were mixed herds, including several animal species, majorly sheep and goats (36.92%). Indeed, goats are used for their meat, milk and hair (Hafid, 2006; Boulakhras, 2018) as well as for self-consumption and the management of sheep herds in pasture (Moula et al, 2017). This extensive sedentary sheep-goat production system (32.2%) was commonly adopted in all regions of Algeria with a majority of semi tie-stall housing (65.64%). The same observation was made in the region of Kabylie (Kardjadj et al, 2016; Saidani et al, 2019). Yabrir et al (2015) who conducted a typology of sheep farming in the steppe zone of central Algeria (Djelfa region) noted a reorientation of breeding practices from a transhumant type to a semi tie-stall sedentary stabulation in closed or semi open barns. On the other hand, the

size classes (small, medium and large) were observed in our study with a majority of small farms (50.8%), the other classes were presented at 27.18% and 21.03% respectively. Only 1.03% exceeded 300 heads and were classified as very large numbers of sheep. The three classes (small, medium and large breeders) were also observed by Kanoun-Meguellati and Yakhlef (2008) in the region of Djelfa. Racial diversity was observed in the study area with, however, a predominance of the Ouled Djellal breed (29.74%) which is classed as one of the main breeds. Djaout et al (2017) made the same findings in the tell and steppe region.

Health status

In terms of health, 32.3% of the farms surveyed presented mainly respiratory pathologies. This was also observed by Saidani et al (2019) which is consistent with the dominant extensive farming system. In group 3 we observed the presence of abortions at 94.44%, this is compatible with a poor control of breeding management that is anarchic and random.

Breeding practices and neosporosis

In the cycle of neospora caninum the dog represents the definitive host; its presence is often associated with neosporosis, which has been demonstrated in cattle (McAllister, 2016) and sheep (How et al, 2012). In our study, this was particularly shown in clusters 2 and 3 (67.7%), where the presence of dogs was reported concomitantly with the abortions (Moreno et al 2012; Gonzales et al 2014; Gharekhani et al 2016). Foods contaminated with sporulated dog oocysts are the most likely virulent materials to contaminate intermediate hosts, and a few hundred viable oocysts could be sufficient to induce an abortion (Sarrazin, 2009).

Certain practices increased the risk of exposure to the parasite and the maintenance of its cycle such as the handling of afterbirths, especially when they were thrown away, as shown in cluster 3. This was consistent with observations made in Algeria in cattle breeding (Ghalmi et al, 2011) where dogs infected cattle through contaminated food or drinking water, and cattle infected dogs via contaminated abortions (abortions and afterbirths). A similar observation was reported in Brazil (Guimares et al, 2004), showing a correlation between seropositivity to *Neospora caninum* in farm dogs and a high seroprevalence of neosporosis in cattle.

This was shown by the typology of our breedings. In fact, axis 2 opposed risky practices (presence of goats, dogs, fate of abortions and afterbirths) to those associated with the absence of abortions (absence of dogs and animals susceptible to infection) (figure 3). It should be noted that in farms where dogs had free access to animals and afterbirths, all the elements of the cycle were present for a maximum of contamination of sheep and dogs. On farms where dogs were absent, the cycle cannot be complete and the level of contamination of animals should be lower (Ghalmi et al, 2007).

CONCLUSIONS

This first stage of the study was based on sheep farming practices in the central region of Algeria, and made it possible to set up a typology by identifying the elements necessary to describe the breeding behaviour in the study area and identify the farms most sensitive to the parasite *Neospora caninum*.

Our study showed a practice based mainly on an extensive farming system without technical mastery of the management of breeding and a random health monitoring. The analysis of the responses to the questionnaires allowed us to identify certain aspects of the functioning of the farms. The typology made it possible to identify groups with different breeding behaviour and practices that would increase the risk of contact with the agent of neosporosis (*Neospora caninum*). Much work must be done towards breeders to make them aware of the importance of mastering breeding techniques in order to prevent health problems such as neosporosis. In the absence of treatment, adopting an intensive farming system with rigorous sanitary monitoring could prevent economic loss due to the proliferation of the parasite.

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