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Full Length Research

Breeding practices and selection criteria on livestock farming in the Drâa-Tafilalet region of Morocco

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ABSTRACT: This study aimed to identify breeding practices and selection criteria used by livestock breeders in the Drâa-Tafilalet region in southeastern Morocco. Five sites in the region with three to five rural districts each were selected, within each district, one to eight breeders of each livestock species were interviewed. There were 305 surveys conducted in 21 districts with 60, 105, 71, 21, 35 and 13 breeders of cattle, sheep, goats, camels, chickens and rabbits, respectively. Frequencies were calculated to describe breeding practices and index values were used to examine selection criteria employed by breeders. A total of 74.6% of cattle breeders used natural mating, 16.9% used artificial insemination, and 8.47% used both. However, for other livestock species, natural mating was the only method of mating. In cattle, sheep, goats, camels, chickens and rabbits, the proportion of breeding males from the breeder's own herd was 12.8%, 73.1%, 86.1%, 56.1%, 81.6% and 92.3%, respectively. Breeders who practiced the selection of breeding animals were 74.6%, while the rest used random selection. In the former group, 73.9% selected both males and females, 4.26% selected only males and 21.8% selected only females. In selecting breeding animals, body size ranked first for cattle, sheep, goat, camel, chicken, and rabbit breeders with indices of 0.37, 0.41, 0.43, 0.43, 0.47 and 0.50, respectively for males, and 0.33, 0.34, 0.41, 0.41, 0.44 and 0.50, respectively for females. It was concluded that breeders' existing breeding practices and selection criteria should be considered in order to minimize the failure of genetic improvement programs in livestock production.

Keywords: Camels, controlled mating, livestock species, natural mating, rabbits.

INTRODUCTION

Livestock is the source of income for the local population in the Drâa-Tafilalet region of Morocco. In 2017, the livestock population of the region reached 108,200 cattle (78.4% local type and 21.6% improved type), 1,316,200 sheep, 770,800 goats and 11,498 camels (Annuaire statistique du Maroc, 2018). It is distributed among the five provinces of the region with high proportions of cattle and sheep in Midelt province (32.3% and 35.8%, respectively), goats in Tinghir province (29.5%) and camels in Zagora province (54.6%) (Annuaire statistique du Maroc, 2018). The Drâa-Tafilalet region is rich in indigenous livestock breeds. Some are identified and standardized, while others have not been characterized. The region is even the cradle of some breeds currently very famous nationally and even internationally, such as the D'man sheep breed (Boujenane, 1996). The livestock species of the region play a vital role in ensuring food security. They are a source of milk, meat, hides, cash income, family security and other socio-economic and cultural functions. The Drâa-Tafilalet region is known for its traditional livestock farming, which has been practiced by local people for centuries. Breeders in this region have selected and bred indigenous breeds adapted to local climatic and environmental conditions using traditional breeding practices. Because of this traditional management, relying mainly on poor quality rangelands and little veterinary

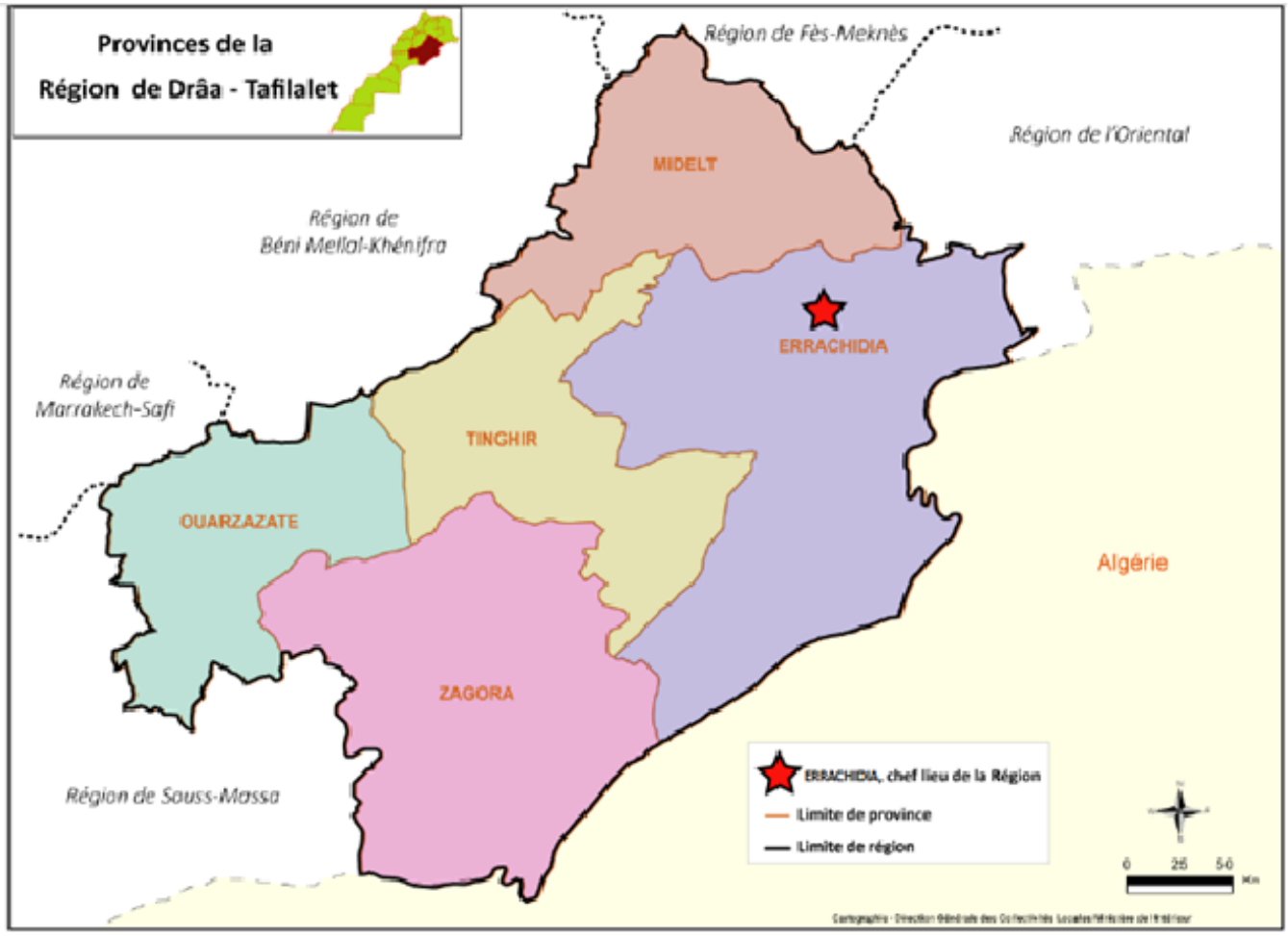

Figure 1. Delimitation of the Drâa-Tafilalet region.

care, the indigenous livestock generally observed a low average productivity. To improve their production performance, crossbreeding programs with exotic breeds have been conducted (Boujenane, 2002). Due to this strategy, the local gene pool is eroding, and some indigenous breeds are in danger of extinction. In Morocco, this approach has decreased dramatically the proportion of indigenous-type cattle over the last four decades, varying from more than 95% of the overall population in 1975 to 40% in 2018 (MAPMDREF, 2018). There is a dearth of information on how the Moroccan breeders breed and select their animals in order to preserve them from extinction and to improve their performance.

To develop sustainable breeding programs that benefit local human populations, it is essential to conduct this study in order to identify the traditional breeding practices and skills of Drâa-Tafilalet breeders and the selection criteria they use to select animals with desirable traits. The lack of such knowledge/record leads to unrealistic breeding goals when designing livestock genetic improvement programs, which can have a detrimental effect on the future of indigenous breeds.

MATERIAL AND METHODS

Study site

The study took place in the Drâa-Tafilalet region of southeastern Morocco (Figure 1). The region covers an overall area of 88,975 km^2, which represents 12.5% of the national territory. It is known not only for its semi-desert climate and lack of rainfall, but also for the lack of water resources and the phenomenon of desertification. It is characterized by very hot summers (40°C) and harsh winters whose temperature varies between -7°C and -1°C. The average annual rainfall in the region is marked by its strong spatiotemporal irregularity, ranging from 300 mm in the High Atlas Mountains, 200 mm in the valleys, 120 mm on the plateau of Ouarzazate to 60 mm in Zagora. The

Table 1. Number of surveys conducted by site and livestock species.

Site	Breeders of						Total
	Cattle	Sheep	Goats	Camels	Chickens	Rabbits	
Z1	15	21	22	0	6	1	65
Z2	19	24	8	0	10	4	65
Z9	12	22	12	7	10	5	68
Z15	14	22	14	3	8	3	64
Z17	0	16	15	11	1	0	43
Total	60	105	71	21	35	13	305
%	19.7	34.4	23.3	6.88	11.5	4.26	100

rainy periods are spread between September and May and the number of rainy days varies from 30 to 40 days per year (Anonymous, 2018).

Sampling method, number and distribution of surveys

Five pilot sites designed as Z1, Z2, Z9, Z15 and Z17 were identified in the Drâa-Tafilalet region, representing mountain oases, intermediate oases and plain oases, in order to conduct a study on livestock production. These sites are located in the provinces of Tinghir, Midelt, Errachidia, Ouarzazate and Zagora, respectively, and cover 24 districts (3 to 6 districts per site). In each site, 3 to 5 rural districts were selected based on the number of cattle, sheep, goats and camels. In each district, one to eight farmers of each livestock species were randomly selected and interviewed. Depending on the main livestock species owned by the breeder, the interviewer completed the species-specific questionnaire. At the end, a survey on 305 farmers was conducted in 21 districts, of which 21.3%, 21.3%, 22.3%, 21.0% and 14.1% were conducted in sites Z1, Z2, Z9, Z15 and Z17, respectively, with 19.7%, 34.4%, 23.3%, 6.88%, 11.5% and 4.26% of cattle, sheep, goat, camel, chicken and rabbit breeders, respectively (Table 1). The field surveys were conducted between April 1 and 8, 2021 in sites Z2 and Z9 and between May 25 and June 4, 2021 in sites Z1, Z15, and Z17. Subsequently, focus discussion groups of 12 to 15 people in each pilot site were organized. These groups included men and women with a good knowledge of the area's livestock and animal genetic resources, representatives of livestock associations and cooperatives, as well as managers and technicians from the administrations involved in the study. Meetings were held to discuss the results obtained from the present study and details or missing information on topics not covered in the surveys as well as to gain a deeper understanding of the topics discussed during structure interviews.

Data analysis

The Chi-square test was used to test the assumption of equal proportion between the qualitative variables (origin of mating males, duration of use of mating males, selection practice…) and the differences were declared significant at $p \leq 0.05$. In addition, for data involving a ranking (selection criteria), an overall ranking was determined using an index calculated according to the formula:

$$Index = \frac{Sum\ of\ (3 * f_1 + 2 * f_2 + 1 * f_3) \text{ for an individual reason or criterion}}{Sum\ of\ (3 * f_1 + 2 * f_2 + 1 * f_3) \text{ for overall reasons or criteria}}$$

Where f_1, f_2 and f_3 are percentages of breeders who granted rank 1, rank 2 and rank 3, respectively. The higher the index, the better.

RESULTS AND DISCUSSION

Mating systems

Natural mating is the most common method of reproduction in the region. In cattle, 74.6% of breeders used natural mating, 16.9% used artificial insemination (AI) and 8.47% used both methods to obtain a pregnancy. Among the breeders who practiced AI, 80% were located in the Z2 site and 20% in the Z15 site where improved-type cows were mostly found. Heat detection was performed by the bull, and cows in heat were usually bred several times during each estrus period. In contrast, when the bull was absent, heat detection was performed by the breeders and each cow was bred once or twice during the estrus period. In other livestock species, natural mating was the only breeding method that was applied. Godadaw *et al.* (2014) and Zewdu *et al.* (2018) revealed that almost 12.5% and 6.70%, respectively of cattle breeders in Northern Amhara and East Gojjam Zone in Ethiopia practiced AI.

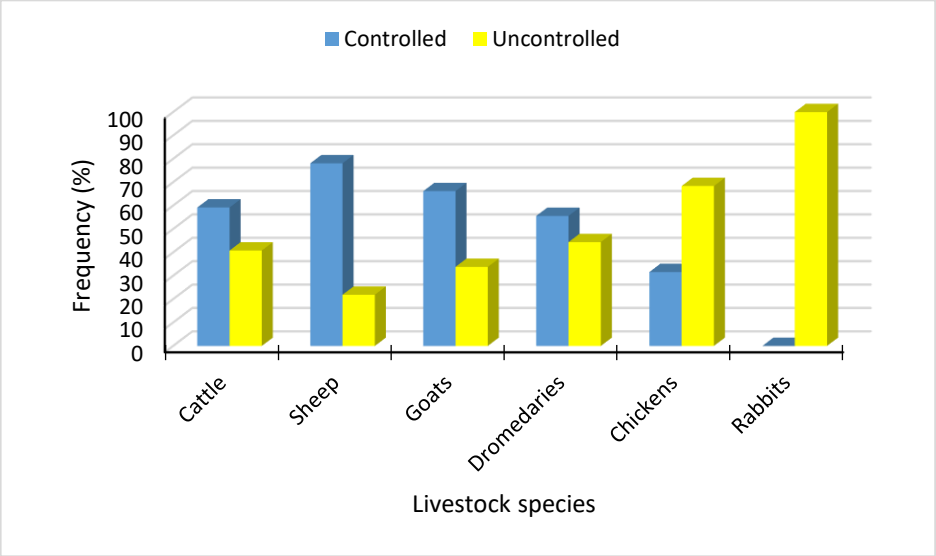

Figure 2. Frequency distribution of natural mating practiced by breeders of the different livestock species.

Among the breeders who practiced natural mating, 40.8% cattle; 21.9% sheep; 33.8% goat and 44.4% camel breeders applied uncontrolled or random mating (Figure 2), because they were either unaware (40.4%), did not have their own mating males (15.5%) or the herds were mixed on rangelands (36.5%), which meant that one breeder's male could mate with another breeder's female. In herds where breeding was uncontrolled, owners reported that they were unable to identify the sire of newborn. However, those who practiced controlled mating did so to maintain the genetic purity of their breed or to produce the type of offspring they desired. The methods of controlled mating included the selection of mating males, and the separation of males and females to coincide with the favorable season for parturition. In addition, the high proportion of cattle breeders who practiced uncontrolled mating could be as result or due to lack of bulls in the visited farms due to small size of the herd (1-5 cows), and the acceptance of any male as long as the cow is bred. According to Chenyambuga and Lekule (2014) and Zewdu *et al.* (2018), several goat and cattle farmers practice uncontrolled mating system because it is easier and cheaper.

However, for chickens, random mating represented 68.4%. In fact, due to scavenging system of production, a breeder's hen was often mated with his neighbors' roosters. Random mating was the only method used in rabbit breeding because the breeding males and females were mixed, and any male could mate with any female.

In case of natural mating, males are either permanently present with females, introduced when the cow is in heat or during the sexual season of sheep, goats and camels. In cattle, 12.2% of breeders reported that bulls were permanently with the cows and 87.8% reported that they were introduced at the estrus time. In sheep, goats and camels, 79.8%, 97.1% and 82.3% of the breeders, respectively reported that males were permanently with females all year round, while the others reported that males were introduced during mating periods. In poultry and rabbits, males and females were together all the time.

Cattle breeders reported that there was no structured season for mating; cows were presented to bulls when they were in heat. This explains the distribution of calving throughout the year and results in births at different periods of the year. However, many breeders observed that most cows were bred between March and July when they were in good body condition and calved between December and March. These findings are similar to those of Ndebele *et al.* (2007) who noted that there is no strict season for cow mating in Zimbabwe, while Godadaw *et al.* (2014) reported that mating is seasonal in Ethiopia. For other livestock species, the timing of mating is determined by the sexual season, as the seasonality of mating is also seen in the distribution of parturition, except for D'man ewes that usually lamb twice in 14 to 16 months.

With the exception of cattle breeders, a considerable proportion of sheep, goat, camel, chicken and rabbit breeders had their own mating males (Figure 3). For cattle, 63.8% of breeders stated that mating bulls came from neighbors, 12.8% from their own herd, 2.13% from the souk (rural market), while 21.3% came from various other origins. According to Zewdu *et al.* (2018), 52.9% of farmers in the study districts of Ethiopia relied on bulls from neighbors and 40% on their own home-bred bulls, whereas Zaw Win *et al.* (2019) stated that 86.7% of farmers in the central dry zone of Myanmar used a bull

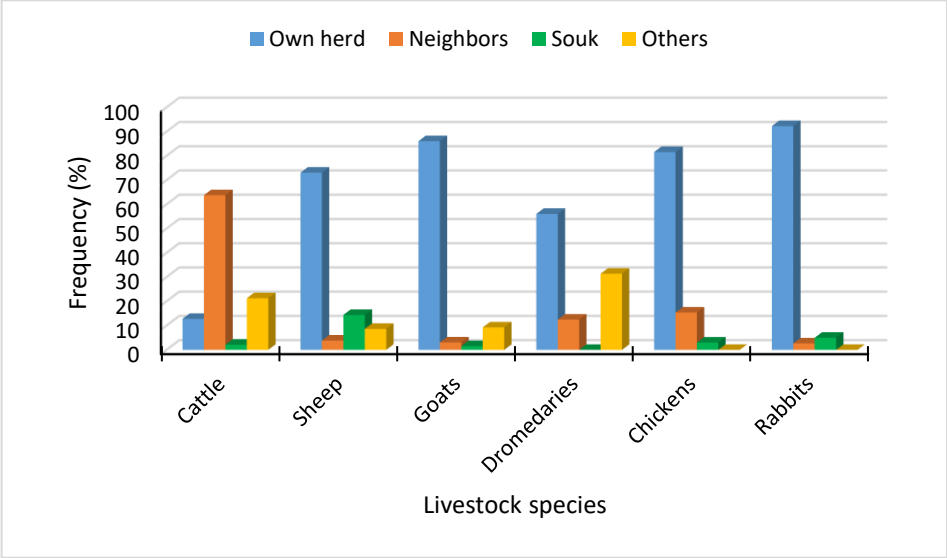

Figure 3. Frequency distribution of the origin of mating males according to the livestock species.

from outside the household for mating. On the other hand, the proportions of mating males from the breeder's own herd represented 73.1% in sheep, 86.1% in goats, 56.1% in camels, 81.6% in chickens and 92.3% in rabbits. Other origins of males were neighbors, souk or a combination of these different sources. Similar to this report, Getachew *et al.* (2010), Nigussie *et al.* (2013) and Gebreyesus *et al.* (2013) reported similar origins for rams and bucks, while Asefa *et al.* (2015) and Abebe *et al.* (2020) revealed that about 47.8% and 46.2% of the smallholder farmers had their own breeding bucks and rams. Moreover, there is a difference in the origin of males according to the size of herds of different major species. Breeders with small herds rely less on their own herds for mating males and more on other sources, while the reverse is true for large herd sizes. Nevertheless, some breeders with large herds relied on neighbors for mating males. This indicates that the origin of breeding males depends partly on the own herd and the quality of males in it compared to males from other sources. Furthermore, the fact that mating males are largely from the breeder's own herd and from neighboring herds indicates that genetic relationships between animals in the herd or between animals in herds of the same district are potentially close and inbreeding is high. Ngowi *et al.* (2008) and Godadaw *et al.* (2014) stated that stud bulls have similar origins to those observed in the present study.

In cattle, 75.9% of breeders used improved-type bulls or crossbred bulls for mating, while 24.1% used indigenous-type bulls. This shows the willingness of breeders to replace the indigenous-type with the improved-type. Among camels, 44.4% of breeders used Guerzni males, 16.7% used Marmouri males, the rest percentage had no preference. Sheep breeders used rams of the breed they raised (D'man, Siroua or Timahdite), except for 12.6% of breeders who crossed the D'man ewes with the Ouled Jalal rams in the Z2 site or with Sardi rams in Z17 site.

The duration of use of males differs according to the livestock species (Figure 4). The majority of bulls (65.6%), rams (73.8%) and bucks (36.4%) were used for 1 to 2 years, while 66.7% of male dromedaries were used for more than 4 years. Thus, a large proportion of breeders kept mating males for a long time, with the risk that these males mate with their own daughters, resulting in high inbreeding within the herds. Therefore, it is recommended that available bulls be exchanged between breeders after three years of use, and rams and bucks after two years. This strategy could reduce the negative effects associated with inbreeding. According to Abebe *et al.* (2020), the average duration in which a particular ram stayed within the flock for breeding purposes is about 2.26 years.

Selection management

Selection is the operation that consists of choosing, based on a certain number of criteria, males and females that will be used for mating in order to improve the performance of offspring. Out of all the breeders, 74.6% practiced selection, while the rest did not; the animals used for mating were chosen randomly. The Chi-square test showed that the proportions differed ($p<0.05$) according to the livestock species. In fact, sheep breeders practiced selection more than those of other species, and cattle breeders selected less (Figure 5). The latter result might be related to the fact that many cattle breeders did not own bulls and accepted any male to breed their cows. The

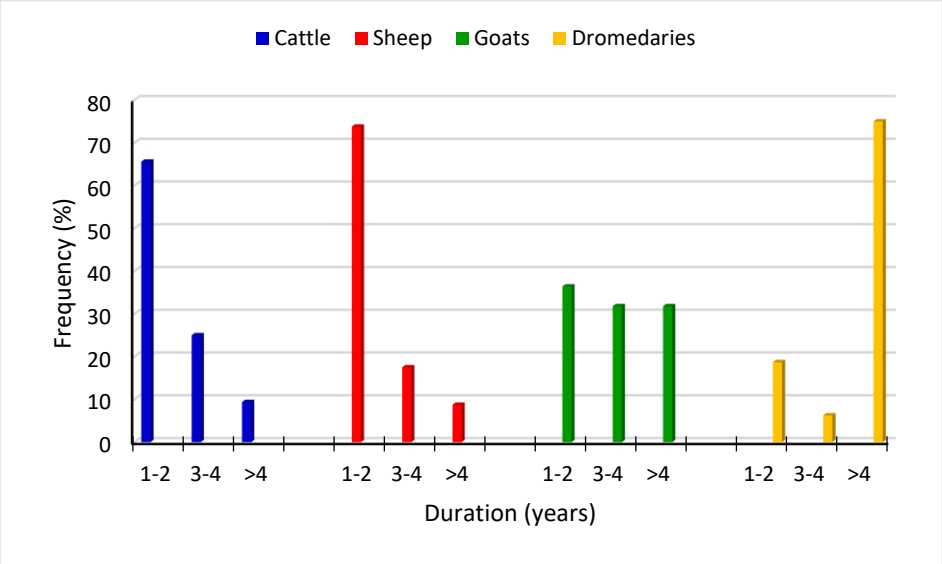

Figure 4. Frequency distribution of the duration of use of mating males of different livestock species.

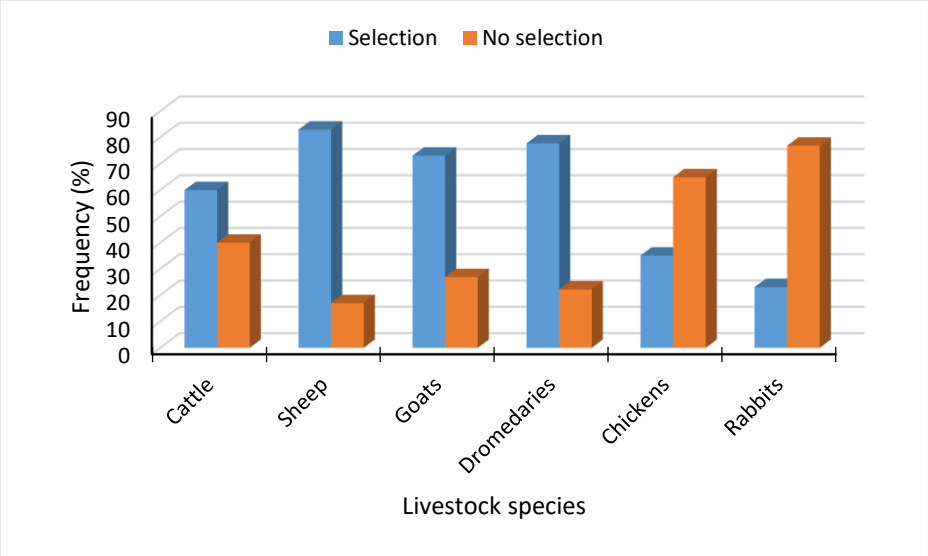

Figure 5. Frequency distribution of selection practice in herds by livestock species.

percentage of cattle breeders practicing selection (60%) is similar to the percentage reported by Zewdu *et al.* (2018), who reported that about 55.1% of the respondents selected bulls to mate their cows in East Gojjam zone, Ethiopia. Moreover, depending on the livestock species, the practice of selection differs ($p<0.05$) for both sexes. For cattle breeders, 45.6% selected both males and females, while 54.4% selected females only (Figure 6). None of the breeders selected males only, as they were often sold at a young age and not kept for breeding. Among camel breeders, 85.7% selected both males and females and 14.3% selected males only. Among sheep breeders, 3.45% of breeders selected only males, 18.4% only females and 78.2% both males and females. Among goat breeders, these frequencies were 6.12%, 10.2% and 83.7%, respectively. In chickens, 76.9% of breeders selected both males and females and 23.1% selected females only. In rabbits, 75% of breeders selected both sexes and 25% selected males only. These results showed that a high proportion of breeders were aware of

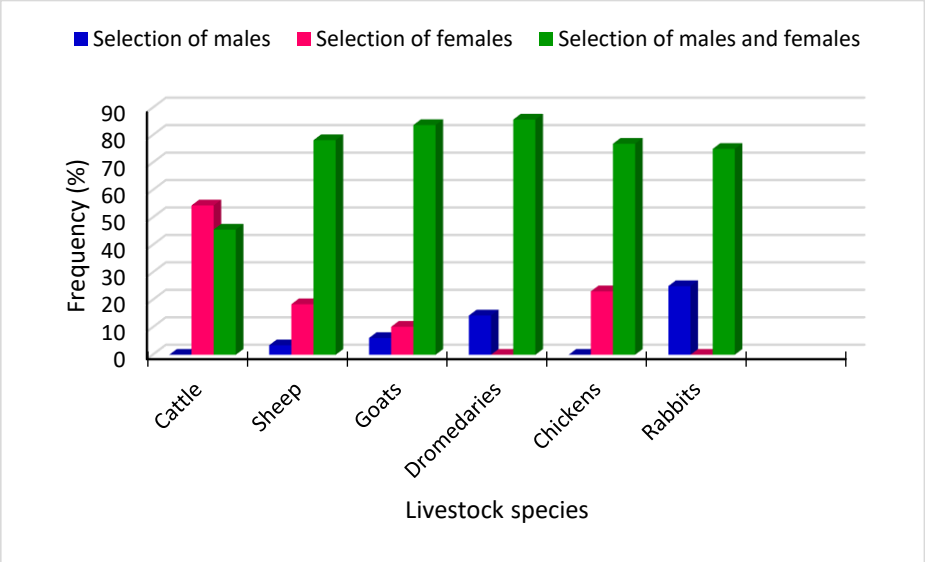

Figure 6. Frequency distribution of selection practice in both sexes according to livestock species.

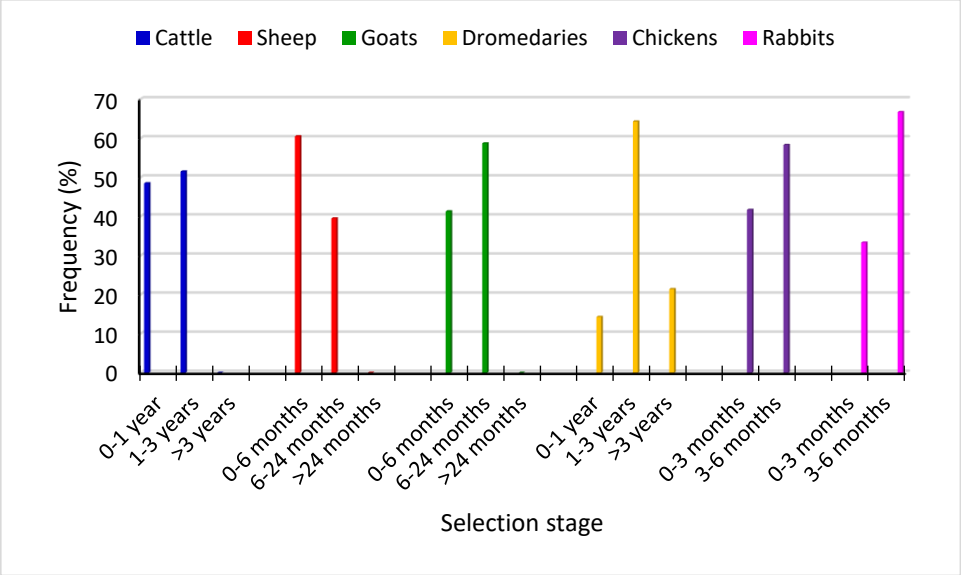

Figure 7. Frequency distribution of the selection stages of the breeding stock by livestock species.

the interest of selection for performance improvement. In addition, a significant proportion of the breeders was aware that an effective improvement required selection of both males and females. Nevertheless, breeders knew that males have more influence on the destiny of the herd through the control of the breeding system. Indeed, keeping high merit males could overtime contribute to improve herd performance. Edea *et al.* (2012) reported that 79.7% and 94.7% of sheep farmers in Ethiopia select breeding males and females, respectively, whereas Berhanu *et al.* (2012) and Zergaw *et al.* (2016) found that about 86.4% of goat breeders select breeding males and 71.6% select breeding females.

Selection of animals does not take place at the time of mating, but begins at a young age (Figure 7). In cattle, 48.5% of breeders selected replacement animals at less than one year of age and 51.5% at 1-3 years of age. In sheep, the selection stage was birth - 6 months (60.5%)

and 6-24 months (39.5%), while in goats: birth - 6 months (41.3%) and 6-24 months (58.7%). In dromedaries, selection was carried out at three stages: 14.3% at age 0-1 year, 64.3% at age 1-3 years and 21.4% at age over 3 years. In chickens and rabbits, selection took place at age 0-3 months for 41.7% and 33.3%, respectively for the rest it took place between 3 and 6 months. Marshall *et al.* (2016) reported that selection of breeding males in Somalia took place at 68 (24–120) months for camels, 27 (24–36) months for cattle, 9 (2–24) months for sheep and 16 (1–24) months for goats, indicating that there is no age for selection, but rather selection occurs at opportune times prior to the animal reaching breeding age. Edea *et al.* (2012) stated that ram lambs are selected on average at 7.45 months of age and ewe lambs at 4.44 months old in western and south-western Ethiopia.

Selection criteria

Cattle breeders selected their males on body size, dairy performance of dam, fertility/libido, offspring quality, coat color and temperament. The corresponding indexes were 0.37, 0.19, 0.16, 0.12, 0.10 and 0.06, respectively (Table 2). The primary goal of male selection is to improve conformation and growth performance of offspring. At the souk, buyers prefer males with good conformation, balanced physical posture and attractive color. Breeders reported that female selection took place based on estimated milk production potential. For this, breeders selected on body size (0.33), milk yield (0.22), coat color (0.13), udder size (0.10) and dam performance (0.06).

Furthermore, although the primary objective of cattle is milk production, body conformation traits are used first to select the best milk producers. Cow color is an important selection criterion for breeders, with an index of 0.13. Indeed, the breeders appreciated the black-and-white coats that indicate that the cow has improved blood (Holstein) and is therefore able to produce more milk. They also attached great importance to reproduction of cows, which had an index of 0.07. Breeders aim for cows that can be fertilized 2 to 3 months post-calving and to give birth and wean a calf annually. Breeders placed less importance on temperament when selecting bulls and cows. The cow's docility at milking and any other aspect of behavior were considered unimportant. Based on indigenous knowledge, navel size, udder size, pelvis width, teat size, neck size and shape, height at withers, body length and dewlap size were the first eight ranked traits used as major selection criteria of cattle in Northern Amhara, Ethiopia (Godadaw *et al.,* 2014), while teat size, udder size and pelvic width were the major selection criteria of dairy cows in Gechi district, Ethiopia (Bulcha *et al.,* 2022). In East Gojjam Zone, Ethiopia, the selection of female animals took place by considering expected milk production potential based on body conformation and the performance history of their ancestors (Zewdu *et al.,* 2018). While in South Ethiopia, the selection was based on length of the teat, well-structured udder, prominent milk veins and presence of thin skin among the cattle (Banerjee *et al.,* 2014).

For the selection of breeding rams, the body size was ranked first (0.41), fertility/libido (0.14), then growth rate and fleece color (0.12) (Table 3). For cultural reasons, D'man breeders looked for white rams, as they hope this trait will be passed on to offspring. Some breeders of the Siroua breed preferred white animals that are easily sold at the souk at relatively high prices, while others appreciated animals with black fleece whose wool is sold at three times the price of white wool. The main selection criteria for ewes were body size (0.34), prolificacy (0.19), dam performance (0.10), growth and fleece color (0.08). The objectives behind these selection criteria were mainly to improve the weight and growth of the lambs. Prolificacy was most valued by D'man breeders because flocks were kept indoors in oases, but not desired by nomadic breeders of Siroua and Timahdite breeds that were raised on rangelands. Adaptation was also cited as a criterion for ram selection since it appears to be a sought-after quality in the grazing breeds, which explains the strict use of Siroua and Timahdite rams for mating. Apart from the breeders of the Siroua breed for whom wool production was an interesting selection criterion, those of the D'man and Timahdite breeds did not give importance to this trait. For the breeders, horning and milk production were less important in the selection of rams and ewes, respectively. D'man breeders looked for hornless rams, which is a breed characteristic, while Siroua and Timahdite breeders wanted horned males. Ewe selection on milk production was not very important to breeders, perhaps because they were unaware of its importance for lambs' growth. In comparison with reports on sheep selection criteria used by breeders in different regions, results are in general agreement with those of the present study. These selection criteria included: body conformation, coat color, growth, mating ability and tail shape and size (Getachew *et al.,* 2010), large body size, red or brown fleece color, and long, broad, curled tail (Edea *et al.,* 2012), appearance and/or conformation (Abera *et al.,* 2014), body size and appearance (Taye *et al.,* 2016), body size and coat color (Abebe *et al.,* 2020).

The indexes of the main selection criteria for male goats, namely body size, coat color, fertility/libido, growth rate and horning were 0.43, 0.15, 0.12, 0.07 and 0.07, respectively (Table 4). Coat color was an important criterion among nomadic breeders who considered the black population to be best suited to pastoral conditions, as the black pigment helps goats warm up quickly during cold periods and nights than those with other colors. On the other hand, breeders of the Drâa breed did not prefer color, as the animals are often multicolored: brown, white, gray and spotted. The only condition is not to have males

Table 2. Ranking of the main selection criteria for male and female cattle (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Body size	54.5	28.6	0	0.37	1	47.4	25.0	8.33	0.33	1
Dam performance	18.2	23.8	15.0	0.19	2	2.63	8.33	13.9	0.06	6
Quality of offspring	13.6	4.76	20.0	0.12	4	0	2.78	11.1	0.03	8
Fertility/Libido	4.55	28.6	25.0	0.16	3	0	0	0	0	-
Coat color	9.09	4.76	25.0	0.10	5	10.5	22.2	0	0.13	3
Temperament	0	9.52	15.0	0.06	6	0	5.56	16.7	0.05	7
Milk production	0	0	0	0	-	28.9	13.9	19.4	0.22	2
Udder size	0	0	0	0	-	5.26	16.7	13.9	0.10	4
Reproduction	0	0	0	0	-	5.26	5.56	16.7	0.07	5

Table 3. Ranking of the main selection criteria for male and female sheep (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Body size	68.1	16.4	7.46	0.41	1	54.6	16.3	10.6	0.34	1
Dam performance	2.78	5.48	5.97	0.04	8	9.30	9.30	12.9	0.10	3
Quality of offspring	5.56	4.11	10.4	0.06	5	1.16	10.5	16.5	0.07	7
Fertility/Libido	11.1	15.1	22.4	0.14	2	0	0	0	0	-
Fleece color	6.64	15.1	20.9	0.12	3	6.98	10.5	5.88	0.08	4
Growth	5.56	17.8	17.9	0.12	3	1.16	13.9	14.1	0.08	4
Milk production	0	0	0	0	-	0	4.65	8.24	0.03	8
Udder size	0	0	0	0	-	3.49	0	0	0.02	9
Reproduction	0	0	0	0	-	4.65	10.5	11.8	0.08	4
Prolificacy	0	0	0	0	-	18.6	19.8	17.6	0.19	2
Adaptation	0	9.59	8.96	0.05	6	0	0	0	0	-
Wool	0	11.0	5.97	0.05	6	0	4.65	2.35	0.02	9
Horning	0	5.48	0	0.02	9	0	0	0	0	-

of entirely black color. Breeders considered horning, since those of the Drâa breed selected goats without horns, while the breeders of the rangelands opted for horned goats, because the large horns rolled up, in full view, were considered as a prestige, and had a high market value. In the pastoral production system, a greater importance was given to the traits of adaptation to climatic stress, lack of food, walking and resistance to diseases than in the mixed agricultural-livestock system. This may be because in the pastoral system the breeders are dealing with hostile production environments. Therefore, adaptive traits must be considered when defining selection objectives. However, instead of selecting directly on adaptation, which is a very broad term, the most practical and efficient way for selection is to focus on production and reproduction traits in the presence of environmental stress, thus allowing animals to be selected under stress. Besides body size, which had an index equal to 0.41, goats were selected mainly on milk production (0.17), coat color (0.11), prolificacy (0.09) and reproduction (0.06). Thus, breeders wished to have large and well-conformed goats, regularly giving birth to more than one kid and producing enough milk for proper suckling of kids and for self-consumption. Bernahu *et al.* (2012) reported that goat breeders of South Omo zone select bucks on body size, coat color, horning and dam performance, whereas does are selected on a short kidding interval, good maternal ability, large body size and prolificacy of the dam. For males and females in Oromia, Ethiopia, Asefa *et al.* (2015) found appearance to be the first ranking selection criteria. According to Zergaw *et al.* (2016), males are selected on growth rate, body size and disease resistance, whereas females are chosen on body conformation, prolificacy and frequency of kidding.

Table 4. Ranking of the main selection criteria for male and female goats (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Body size	72.7	15.9	7.14	0.43	1	69.6	15.2	6.82	0.41	1
Dam performance	0	9.09	19.0	0.06	6	0	8.70	9.09	0.04	7
Quality of offspring	0	6.82	4.76	0.03	8	0	6.52	2.27	0.02	8
Fertility/Libido	6.82	22.7	7.14	0.12	3	0	0	0	0	-
Color	11.4	22.7	11.9	0.15	2	10.9	10.9	11.4	0.11	3
Growth	2.27	9.09	16.7	0.07	4	2.17	6.52	11.4	0.05	6
Milk production	0	0	0	0	-	10.9	21.7	27.3	0.17	2
Reproduction	0	0	0	0	-	0	13.0	9.09	0.06	5
Prolificacy	0	0	0	0	-	4.35	13.0	15.9	0.09	4
Adaptation	6.82	2.27	14.3	0.06	6	2.17	0	0	0.01	10
Hair	0	0	0	0	-	0	0	2.27	0.001	11
Horning	0	11.4	19.0	0.07	4	0	4.35	4.45	0.02	8

Table 5. Ranking of the main selection criteria for male and female camels (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Body size	64.3	28.6	7.69	0.43	1	50.0	25.0	25.0	0.37	1
Dam performance	14.3	7.14	23.1	0.13	3	25.0	0	0	0.12	3
Quality of offspring	7.14	0	23.1	0.07	5	8.33	33.3	8.33	0.08	4
Fertility/Libido	14.3	35.7	0	0.19	2	0	0	0	0	-
Color	0	28.6	23.1	0.13	3	0	0	0	0	-
Growth	0	0	0	0	-	0	0	8.33	0.01	7
Temperament	0	0	23.1	0.04	6	8.33	0	8.33	0.05	6
Milk production	0	0	0	0	-	8.33	41.7	8.33	0.19	2
Udder size	0	0	0	0	-	0	0	41.7	0.07	5

The first selection criterion for male and female dromedaries was body size. This criterion had an index of 0.43 for males and 0.41 for females (Table 5). Breeders considered that the larger the size, the better the dromedary. The second selection criterion for males was fertility/libido that had an index of 0.19. The breeding male must be fertile and have a high libido allowing him to breed all the females of the herd. Since the majority of the breeding stock came from the breeder's own herd, the males must come from the best dams (high milk production, regular calving and developed maternal ability) and had one of the colors most appreciated by the breeders (white, red or black). Besides body size, females were selected on milk production (0.19), dam performance (0.12), quality of their offspring (0.08) and size of the udder (0.07). Indeed, milk production is valued in camels because it ensures good growth of the calf and provides milk for self-consumption. Nevertheless, temperament was slightly considered when selecting males and females for breeding. Somali pastoralists used good body conformation, coat color (the white is the most desired), high milk yields of dams and sisters, and ancestors' performance as the top selection criteria for males (Marshall *et al.,* 2016).

Roosters were selected primarily on body size (0.47) and plumage color (0.28) (Table 6). Breeders favor males of large size and good conformation in the hope of producing good quality chicks. Similarly, they choose males with a red-and-black plumage, a distinctive sign of the indigenous strain that is highly valued at the time of sale. Hens, like roosters, were selected first on body size, which had an index of 0.44, but also on egg production (0.22), egg size (0.18), feathers color (0.07) and disease resistance (0.01). Eggs were a source of protein and money for households. It is obvious that hens that lay more eggs with a larger size are selected for breeding. However,

Table 6. Ranking of the main selection criteria for male and female chickens (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Plumage color	18.2	55.6	0	0.28	2	0	7.69	25.0	0.07	4
Body size	81.8	11.1	14.3	0.47	1	78.6	15.4	0	0.44	1
Disease resistance	0	33.3	28.6	0.16	3	0	0	8.33	0.01	5
Growth	0	0	42.9	0.07	4	0	0	0	0	-
Fertility	0	0	14.3	0.02	5	0	0	0	0	-
Egg production	0	0	0	0	-	14.3	53.8	25.0	0.22	2
Size of eggs	0	0	0	0	-	7.14	23.1	41.7	0.18	3

Table 7. Ranking of the main selection criteria for male and female rabbits (the highest index is the best criterion).

Selection criteria	Percent of breeders (%)									
	Males					Females				
	1	2	3	Index	Rank	1	2	3	Index	Rank
Coat color	0	66.7	0	0.22	2	0	50.0	0	0.17	2
Body size	100	0	0	0.50	1	100	0	0	0.50	1
Dam performance	0	33.3	50.0	0.19	3	0	0	50.0	0.08	4
Disease resistance	0	0	50.0	0.08	4	0	0	0	0	-
Prolificacy	0	0	0	0	-	0	50.0	0	0.17	2
Growth	0	0	0	0	-	0	0	50.0	0.08	4

the color of the hen's feathers was less important. Indeed, chicken flocks are very often composed of hens of different colors with some red-and-black roosters. Consistent with the current study, Fitsum (2017) revealed that the selection criteria used in Central zone of Tigray, Ethiopia for selection of breeding hens were egg size, plumage color, broodiness, disease resistance and hatchability, while those used for selection of roosters were egg number of the dam, comb type, plumage color and disease resistance. Similarly, Melak *et al.* (2021) reported that most of the breeders select their breeding hens on health, egg production and age, while their breeding roosters on body size, disease resistance and color plumage. Likewise, selection for cockerels was based on big body size, faster growth rate and disease resistance, whereas selection criteria for pullets were egg production of dam, big body size, disease resistance, good mothering ability and faster growth rate (Okeno *et al.,* 2011).

The main selection criteria for male rabbits were, in descending order, body size, coat color, dam performance and disease resistance. Their indexes were 0.50, 0.22, 0.19 and 0.08, respectively (Table 7). Similarly, female rabbits were selected first on body size (0.50), prolificacy (0.17), color (0.17), growth (0.08) and dam performance (0.08). The objective of raising rabbits is the production of meat for self-consumption, but also for the sale of excess animals to generate income for the household. It is obvious that breeders want to improve body size and growth, but also prolificacy in order to benefit from large litters. Coat color was also a selection criterion that was taken into consideration, as black-and-white colored rabbits were the most appreciated. Disease resistance was also cited as a selection criterion since rabbits were often disseminated by different diseases.

Conclusion

It was found that breeders in Drâa-Tafilalet practiced mostly traditional and extensive breeding techniques. The breeding method is still dominated by natural mating. The majority of smallholders in the study region, especially cattle owners, did not keep mating males due to small herd sizes. They practiced controlled breeding system. Most bulls, rams and bucks were used for one to two years, while male dromedaries were used for more than four years. The majority of breeders practiced selection and selected both males and females. Animals might be selected at any age before breeding age. Across all livestock species, the majority of breeders put more emphasis on morphological characteristics in selecting breeding males and females. Therefore, the breeders' existing breeding practices and selection criteria should be considered in any genetic improvement program intended to be implemented in the study region in order to minimize failure and guarantee success.

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CONFLICTS OF INTEREST

The author declares that there is no conflict of interest.

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