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Dairy cattle breeding practices, production and constraints in arid and semi-arid Algerian bioclimatic environments

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ABSTRACT

The present study aims to characterise dairy cattle farms in two Algerian agro-ecological regions; the semi-arid region (SAR) and the arid region (AR). The survey was carried out on 213 farms. Accordingly, more than 40% of farms are characterised by small herds with ≤15 heads/farm and ≤5 dairy cows/herd. SAR farms benefit from both agricultural land types of 1–300 ha (Used Agricultural Area UAA and pastoral area), while the Saharan ones rely on small UAA. Fertility levels were higher in SAR farms where is recorded a fertility index ≤2 in 92.6% and open period ≤90 days postpartum in 68.6% with a mean lactation length exceeding 305 days in 44.6% farms. The average daily milk yield is 15 litres/cow in both regions. It is recommended to implement strategic and reliable farm management to improve herd management, minimise constraints, and maximise production, particularly in the AR.

KEYWORDS

Cattle; breeding; management; performances; limitations

Introduction

In the last few years, Algeria's cattle sector has significantly increased in number and production rates. National policy aims to develop dairy cattle breeding within a strategy of contributing energy and food security to agriculture with sustainability [1]. However, Algeria remains one of the major milk importers in the world [2], and its number of dairy cows, despite massive imports, remains far below the number needed to meet milk requirements. The cattle breeding objective is based on ideal production and reproduction performances (by maximising fertility and fertility rate) under best economic conditions.

Indeed, livestock is restricted to the country's coastal fringe and inland plains, depending on grassland availability favoured by high rainfall, but rare in the south, which represents 80% of the total surface of the country [3]. This makes its production directly dependent on climatic conditions, seasonal variations, and forage resources.

In recent decades, agriculture in the southern region (areas with arid biotopes), which has long been considered traditional, has experienced marked intensification

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processes thanks to the development of irrigated crops through groundwater exploitation via boreholes [4]. This implies the ability to exploit the vast surface in fodder production and face the heat stress that can cause many problems and depress animal productivity [5]. Normally, this implies the improvement of the Saharan cattle farm's production.

The current study aims to describe the dairy cattle farms located in two different Algerian bioclimatic environments: the arid region (AR) of Biskra-Ouled Djellal and the semi-arid region (SAR) of southern Souk Ahras. A descriptive analysis was implemented to extract farming methods, management differences and their effects on performance, costs, needs, and profitability. The study also aims to determine the limitations that hinder the dairy cattle farming development in each region and to deduce the basis for productivity improvement and the development of the milk sector in both regions.

Materials and methods

Study area

The study area is represented by two different bioclimatic conditions:

(1) The southern part of Souk Ahras municipality, characterised by a semi-arid zone with a rainfall of less than 350 mm/year, consisting of plains and pasture [6,7].
(2) Two municipalities Biskra and Ouled Djellal, located in the northeast of the Sahara, are characterised by an arid climate with an average rainfall of 120 to 150 mm/year [8].

Methodology

To collect data on farms' characteristics and herds' management, a survey was conducted, using the Single-Visit Multiple-Subject Diagnostic Survey (SVMSDS) method, validated according to ILCA (1991), and spread over 4 months during the agricultural campaigns 2020–2021 in Biskra-Ouled Djellal and 2021–2022 in Souk Ahras.

The data were collected through structured interviews using a questionnaire, which was developed with the breeders and managers of farms chosen at random and informed of the purpose of the project, taking into account their breeding objectives (dairy information from DSA (Agricultural Services Department), motivation to participate, and ease of access to their farms. The questionnaire consisted of multiple-choice questions that were open-ended and answered on a visual analogue scale. This questionnaire is in five sections: the first deals with the breeder's socio-demographic data; the second attempts to describe the breeding; and the other sections characterise the management of reproduction, feeding, and milk yield.

The collected data aim to describe and compare farms of both regions, highlight the management mode effects on different performances and identify the advantages and limitations that restrain the breeding future in each zone. The English version of the questionnaire and the datasets of the study are available from the corresponding author on reasonable request.

Dairy farms sampling

In order to obtain highly generalisable findings and reliable statistical results, we have determined the typical sample of representative farms which the survey will cover, following the formula of Thompson and Steven [9], for an optimal random sample size:

$$n = \frac{N \times p(1-p)}{[N-1 \times (d^2 + z^2] + p(1-p)]} \quad (1)$$

Knowing that: The reduced deviation corresponds to a confidence level of 95%.

The sampling error = 5%, with N = population size.

So for the AR: $N = 120$ then $n = 92$, and the SAR: $N = 190$ then $n = 121$.

Data analysis

In this study, we used a multi-strategy approach to describe the dairy cattle farms of each region (Biskra-Ouled Djellal and Souk Ahras) and compare them (practices, performances, etc) by combining qualitative and quantitative analysis using the SPSS Statistic 25 software. The quantitative data are represented by their average values ± standard deviation and the qualitative data by their frequency and percentage. The comparison was made using the Chi-square test with a significance level $p < 0.05$.

Figure 1 summarises the chronological sequence of our study process.

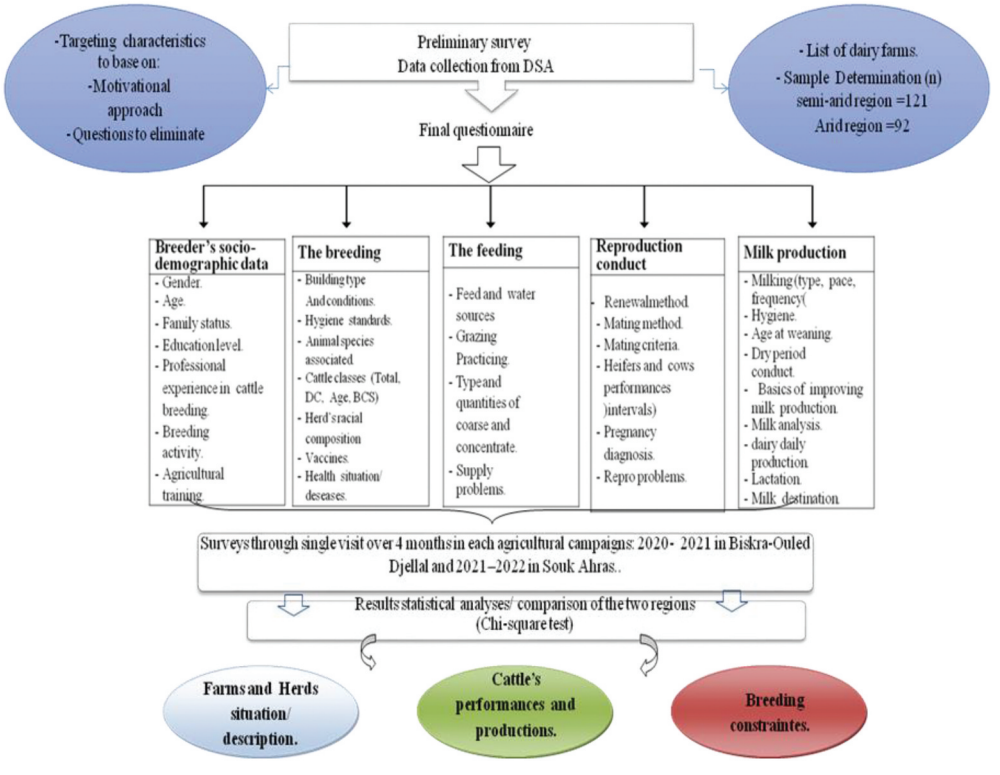

Figure 1. Diagram of dairy cattle characterisation in arid and semi-arid regions.

Results

Socio-economic characteristics

According to socio-economic status results of surveyed dairy cattle breeders, presented in Figure 2, most farms (77%) are managed by farmers (98.6% men) aged from 30 to 60 years, mostly married in both regions, with a significantly ($p < 0.05$) high rate of singles in the SAR of Souk Ahras (14.9%) compared to the AR (5.4%). Further, 40.2% of AR farmers have never received formal education and only 5.4% of them have a university degree. But in the SAR, only 16.5% of farmers have never attended formal education and 78.5% are educated.

The results also provided a high significant difference ($p < 0.001$) in the breeding practice, which represents the main occupation 83.5% of SAR farms, whereas 47.8% of AR's breeders have an auxiliary activity.

Breeding characteristics and conditions

Land potential

Our results, presented in Table 1, reveal that SAR farms benefit from both types of land (used agricultural area (UAA) and pastoral area) with a variety of surfaces that go from 1 to 300 ha. Of those Saharan (AR) farmers ($p < 0.001$) rely on the UAA (in 80.4% of farms) with small surfaces that do not exceed 10 ha in 21.7% of farms. According to their used land surfaces, three groups are represented in Figure 3.

Livestock building/cattle housing

Table 1 shows a high significant difference ($p < 0.001$) that characterises our sample buildings, regarding type, general characteristics and hygiene conditions (cleaning, disinfection, vaccination, etc).

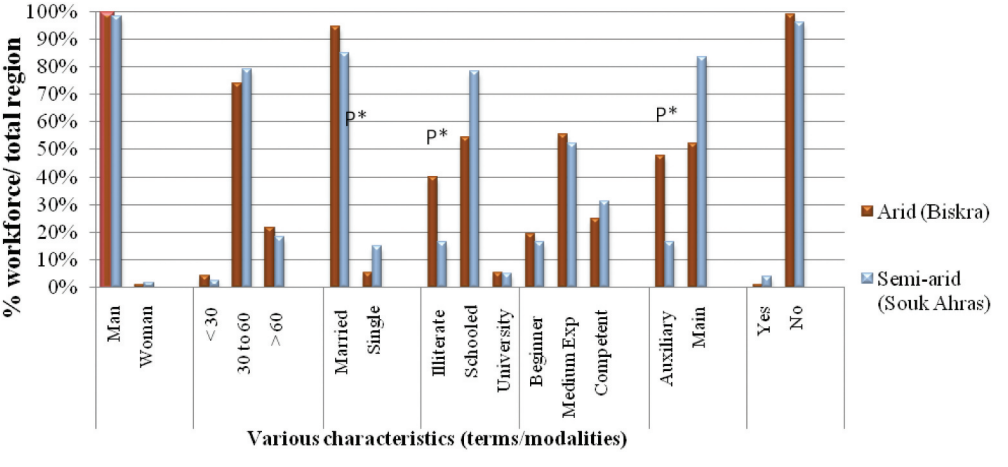

Figure 2. Socio-economic characteristics (breeder's identification) (statistical significance: $p^* < 0.05$).

Table 1. Dairy cattle farms' characteristics and breeding conditions in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Building type	Modern barn	1 (1.1%)	0 (0%)	**0.000**	1(0.5%)
	Shed	16 (17.4%)	57 (47.1%)		73 (34.3%)
	Traditional	25 (27.2%)	64 (52.9%)		89 (41.8%)
	No real Building	50 (54.3%)	0		50 (23.5%)
Building conditions	Bad	16 (17.4%)	11 (9.1%)	**0.000**	27 (12.7%)
	Poor	49 (53.3%)	101 (83.5%)		150 (70.4%)
	Good	9 (9.8%)	9 (7.4%)		18 (8.5%)
	No building	18 (19.6%)	0		18 (8.5%)
Stall type	Hindered	40 (43.5%)	113 (86.9%)	**0.000**	153 (71.8%)
	Free	41 (44.6%)	7 (5.8%)		48 (22.5%)
	Semi restrained	11 (12%)	1 (0.8%)		12 (5.6%)
Ventilation type	natural	100 (92%)	121 (100%)	**1**	213 (100%)
	Mechanical	0	0		0
Litter quality	Clay	49 (53.3%)	11 (9.1%)	**0.000**	60 (28.2%)
	Straw Clay	29 (31.5%)	14 (11.6%)		43 (20.2%)
	Concrete	9 (9.8%)	64 (52.9%)		73 (34.3%)
	Straw Concrete	5 (5.4%)	32 (26.4%)		37 (17.4%)
Compliance with hygiene standards	In the standards	10 (10.9%)	30 (24.8%)	**0.014**	40 (18.8%)
	Moderately within standards	27 (29.3%)	39 (32.2%)		66 (31%)
	Not up to standard	55 (58.8%)	52 (34%)		107 (50.2%)
Animal species associated	Alone	21 (22.8%)	41 (33.9%)	**0.054**	62 (29.1%)
	Small ruminants	71 (77.2%)	77 (63.6%)		148 (69.5%)
	Avian	0	3 (2.5%)		3 (1.4%)
Total workforce class	0–5	19 (20.7%)	22 (18.2%)	**0.96**	41 (19.2%)
	5–15	54 (58.7%)	71 (58.7%)		125 (58.7%)
	15–25	13 (14.1%)	21 (17.4%)		34 (16%)
	25–50	3 (3.3%)	4 (3.3%)		7 (3.3%)
	>50	3 (3.3%)	3 (2.5%)		6 (2.8%)
Dairy Cows class	0–5	45 (48.9%)	52 (43%)	**0.91**	97 (45.5%)
	5–15	40 (43.5%)	60 (49.6%)		100 (46.9%)
	15–25	4 (4.3%)	6 (5%)		10 (4.7%)
	25–50	1 (1.1%)	1 (0.8%)		2 (0.9%)
	>50	2 (2.2%)	2 (1.7%)		4 (1.9%)
Age class (Years)	<5	40 (43.5%)	60 (49.6%)	**0.31**	100 (46.9%)
	05–8	46 (50%)	58 (47.9%)		104 (48.8%)
	08–12	4 (4.3%)	3 (2.5%)		7 (3.3%)
	>12	2 (2.2%)	0		2 (0.9%)
BCS class	2–2.5	11 (12%)	20 (16.5%)	**0.024**	31 (14.6%)
	2.5–3	46 (50%)	76 (62.8%)		122 (57.3%)
	3–3.5	31 (33.7%)	24 (19.8%)		55 (25.8%)
	3.5–4	3 (3.3%)	0		3 (1.4%)
	4–5	1 (1.1%)	1 (0.8%)		2 (0.9%)
Herd's racial composition	Local Cattle	6 (6.5%)	1 (0.8%)	**0.000**	7 (3.3%)
	Local + Crossbred	0	5 (4.1%)		5 (2.3%)
	All breeds	0	1 (0.8%)		3 (0.5%)
	Crossbred	72 (78.3%)	53 (43.8%)		125 (58.7%)
	Crossbred+pure bred	8 (8.7%)	38 (31.4%)		46 (21.6%)
	Purebred	6 (6.5%)	23 (19%)		29 (13.6%)
Water sources	Own source	78 (84.8%)	102 (84.3%)	**1**	180 (84.5%)
	Supply system	14 (15.2%)	19 (15.7%)		33 (15.5%)
Type of land	UAA	74 (80.4%)	37 (30.6%)	**0.000**	111 (52.1%)
	Pastoral area	18 (19.6%)	3 (2.5%)		21 (9.9%)
	Both	0	81 (66.9%)		81 (38%)
Pasture area (ha = hectare)	<25 ha	21 (23%)	92 (76%)	**0.000**	40 (43.5%)
	25-50 ha	8 (9%)	13 (11%)		4 (4.3%)
	>50 ha	15 (16%)	10 (8%)		1 (1.1%)

(*Continued*)

Table 1. (Continued).

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Milk analysis	Yes	25 (27.2%)	81 (66.9%)	**0.000**	106 (49.8%)
	No	67 (72.8%)	40 (33.1%)		107 (50.2%)
Basics of improving milk production	Feed	32 (34.8%)	107 (50.2%)	**0.1**	139 (65.3%)
	Management	4 (4.3%)	2 (1.6%)		6 (2.8%)
	Genetic potential	7 (7.6%)	4 (3.3%)		11 (5.2%)
Type of labor	Family	82 (89.1%)	103 (85.1%)	**0.4**	185 (86.9%)
	Employee	8 (8.7%)	17 (14%)		25 (11.7%)
	Seasonal	2 (2.2%)	1 (0.8%)		3 (1.4%)

BCS: Body Condition Score, UAA: Used Agricultural Area.

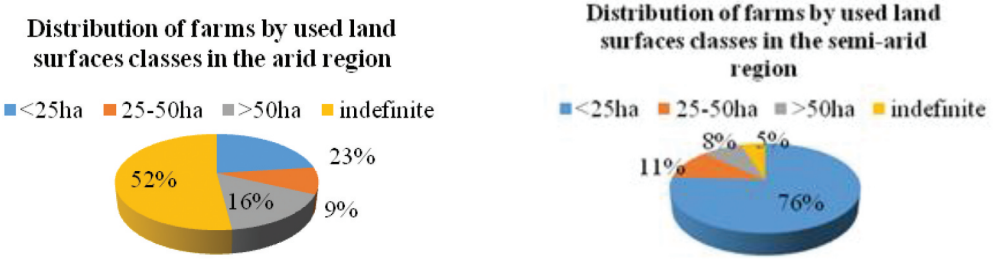

Figure 3. Distribution of dairy farms according to used area classes in the two regions; arid –biskra-ouled djellal – and semi-arid – souk ahras.

Cattle herd

According to both regions' results, reported in Table 1, dairy cattle farming, which is associated in the majority of farms with small ruminant breeding, is characterised by small herds of under 15 heads/farm in more than 75% of farms and only 6% have >25 heads. There is an average of 13.2 ± 9.4 head/farm in AR and 7.9 ± 4.6 head/farm in SAR, with 6.8 ± 3 DC (Dairy Cow) per herd.

More than 48% have cows of 5–8 years old, and a BCS (Body Condition Score) between 2.5 and 3.5 is estimated in 83% of farms.

In both regions, the three types of cattle are present, with statistically very different percentages ($p < 0.001$); crossbred cattle represent the largest part with a rate of 82.6% in AR and 59.5% in SAR. Contrary to purebreds which are more exploited in the SAR (43.7%) the local cattle, which are the least exploited, are more used in the AR (6.5%).

Breeding practices and management

Feeding practices

As Table 2 shows, whether green or dry, fodder is the roughage of all farms, supplemented always by 4–18 kg/cow/day with an average of 8 kg/c/d (kg/Cow/Day) of concentrate, which is basically the rich special dairy cow concentrate, called 'DC', in the SAR, when (with a high significant difference $p < 0.001$) it is the bran and the mixtures in most AR farms.

Table 2. Comparison of feeding practices in dairy cattle farms in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Watering frequency	1/Day	17 (18.5%)	10 (8.3%)	**0.000**	27 (12.7%)
	+1/Day	26 (28.3%)	73 (60.3%)		99 (46.5%)
	Ad libitum	49 (53.2%)	38 (31.4%)		87 (40.8%)
Grazing Practice	Yes	39 (42.4%)	116 (95.9%)	**0.000**	155 (72.8%)
	No	53 (57.6%)	5 (4.1%)		58 (27.2%)
Coarse food	Green forage	3 (3.3%)	2 (1.7%)	**0.669**	5 (2.3%)
	Dry forage	14 (15.2%)	16 (13.2%)		30 (14.1%)
	Green + Dry forage	75 (81.5%)	103 (85.1%)		178 (83.6%)
Type of concentrate	Bran	35 (38%)	28(23.3%)	**0.000**	63 (29.7%)
	DC(Special DC)	5 (5.4%)	33 (27.5%)		38 (17.9%)
	Mixtures	42 (45.7%)	22 (18.3%)		64 (30.2%)
	Whole mixtures (DC+ Mixtures)	10 (10.9%)	37 (30.8%)		47 (22.2%)
Individual daily quantity of concentrate (Kg)	0-4	0	2 (1.7%)	**0.054**	2 (0.9%)
	4-8	33 (35.9%)	29 (24%)		62 (29.1%)
	8-12	52 (56.5%)	69 (57%)		121 (56.8%)
	12-16	7 (7.6%)	19 (15.7%)		26 (12.2%)
	16-20	0	2 (1.7%)		2 (0.9%)
Type of add-on if it exists	MVS (Mineral Vitamin Supplement)	8 (8.7%)	0	**0.002**	8 (3.8%)
	Stones	0	4 (3.3%)		4 (1.9%)
	MVS + Stones	0	1 (0.8%)		1 (0.5%)

Regarding watering, animals in 53.3% of Biskra-Ouled Djellal's farms (AR) farms are freely watered. In Souk Ahras, most farmers control watering by more than one time/day frequency.

Reproduction management

As Table 3 shows, natural mating is the most common mode of reproduction in both regions.

Unlike the AR, where farmers practise self-renewal and purchase cows, 48.8% of SAR farmers renew their herds randomly.

Concerning pregnancy diagnosis, in the majority of SAR farms, it is based on the absence of heat within 45 days post insemination. In AR, diagnosis is made starting at 45 and 90 days in 41.3% and 25% of farms, respectively, using mostly rectal palpation (examination).

Dairy production practices [**Table 4**]

Manual milking was observed in the majority of AR farms, but it is mechanical in almost all SAR farms.

The control of drying-off is very significantly different ($p < 0.001$) between the two studied regions in terms of duration and mode. About 50% of AR farmers practise a long drying period (of more than 60 days), whereas 37% of them do not manage any proper drying period. On the other hand, in the majority of SAR farms, the dry period is physiological (gradually throughout 45–60 days).

Table 3. Reproduction management of dairy cattle farms in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Renewal of the herd method	Purchase of cows	39 (42.4%)	22 (18.2%)	**0.000**	61 (28.6%)
	Self-renewal	34 (37%)	34 (28.1%)		68 (31.9%)
	Imported heifers	0	6 (5%)		6 (2.8%)
	No particular strategy	19 (20.7%)	59 (48.8%)		79 (36.6%)
Criteria for heifers mating	Weight	6 (6.5%)	8 (6.6%)	**0.000**	14 (6.6%)
	Age	30 (32.6%)	65 (53.7%)		95 (44.6%)
	Heat appearance	45 (48.9%)	15 (12.4%)		60 (28.2%)
	No particular strategy	11 (12%)	12 (9.9%)		23 (10.8%)
Mating method	Natural projection	81 (88%)	97 (80.2%)	**0.2**	178 (83.6%)
	Natural P and/or artificial insemination	7 (7.6%)	12 (9.1%)		18 (8.5%)
	Artificial insemination	4 (4.8%)	13 (10.7%)		17 (8%)
Time of pregnancy diagnosis	<45D	31 (33.7%)	110 (90.9%)	**0.000**	141 (66.2%)
	45-90D	38 (41.3%)	7 (5.8%)		45 (21.1%)
(D= day)	>90D	23 (25%)	4 (3.3%)		27 (12.7%)
Means of pregnancy diagnosis	Heats cessation	32 (34.8%)	112 (92.6%)	**0.000**	144 (67.6%)
	Cessation + rectal search	36 (39.1%)	5 (4.1%)		41 (19.2%)
	Ultrasound	11 (12%)	1 (0.8%)		12 (5.6%)
	Rectal search	13 (14.1%)	3 (2.5%)		16 (7.5%)

Table 4. Dairy production practices between arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Milking type	Manual	59 (64.1%)	29 (24%)	**0.000**	88 (41.3%)
	Milking robots	33 (35.9%)	92 (76%)		125 (68.7%)
Milking Pace and Frequency	Morning	5 (5.4%)	14 (11.6%)	**0.009**	19 (8.9%)
	Morning+evening	82 (89.1%)	107 (88.4%)		189 (88.7%)
	Evening	5 (5.4%)	0		5 (2.3%)
Milking hygiene	Bad	7 (7.6%)	7 (5.8%)	**0.68**	14 (6.6%)
	Poor	53 (57.6%)	63 (52.1%)		116 (54.5%)
	Poor to good	23 (25%)	39 (32.2%)		62 (29.1%)
	Good	9 (9.8%)	12 (9.9%)		21 (9.9%)
Age at weaning of calves (M=months)	<1M	1 (1.1%)	4 (3.3%)	**0.25**	5 (2.3%)
	<3M	2 (2.3%)	11 (9%)		13 (6.1%)
	>3M	59 (64.1%)	104 (85.9%)		46 (76.5%)
Duration of dry period (M=months)	<45M	2 (2.2%)	12 (9.9%)	**0.000**	14 (6.6%)
	45-60M	44 (47.8%)	79 (65.3%)		123 (57.7%)
	>60M	46 (50%)	30 (24.8%)		76 (35.7%)
Drying-off method	Brutal	13 (14.1%)	1 (0.8%)	**0.000**	14 (6.6%)
	Progressive	45 (48.9%)	88 (72.7%)		133 (62.4%)
	Not practiced	34 (37%)	32 (26.4%)		66 (31%)
Milk destination	Dairies	18 (19.6%)	102 (84.3%)	**0.000**	120 (56.3%)
	Private Points (Pp	40 (34.5%)	7 (5.8%)		47 (22.1%)
	Pp +self-consumption	5 (5.4%)	1 (0.8%)		6 (2.8%)
	Self-consumption	29 (31.5%)	1 1(9.1%)		40 (18.8%)

Performances

Reproduction performance

Age at mating and 1st calving. According to Table 5, it was found that, based on heat detection, most of AR farmers inseminate their heifers at the age of 12–15 months. Unlike the SAR farmers, who prefer to inseminate them at an age of >15 months.

Table 5. Reproductive performances (heifers/cows) in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Heifers average age at mating (Months)	<12	8 (8.7%)	6 (5%)	**0.000**	14 (6.6%)
	12-15	67 (72.8%)	28 (23.1%)		95 (44.6%)
	>15	17 (18.5%)	64 (52.9%)		81 (38%)
Age at first calving (Months)	<24	8 (8.7%)	11 (9.1%)	**0.000**	19 (8.9%)
	24-30	75 (81.5%)	71 (58.7%)		146 (68.5%)
	>30	9 (9.8%)	16 (13.2%)		25 (11.7%)
Inter calving interval (Day)	<365	18 (19.6%)	74 (61.2%)	**0.000**	92 (43.2%)
	365-400	46 (50%)	32 (26.4%)		78 (36.6%)
	>400	28 (30.4%)	15 (12.4%)		43 (20.2%)
Calving-first insemination interval (Day)	<60	20 (21.7%)	46 (38%)	**0.001**	66 (31%)
	60-90	63 (68.5%)	52 (43%)		115 (54%)
	>90	9 (9.8%)	23 (19%)		32 (15%)
Calving-fertilization interval (Day)	<60	8 (8.7%)	26 (21.5%)	**0.033**	34 (16%)
	60-90	54 (58.7%)	57 (47.1%)		111 (52.1%)
	>90	30 (32.6%)	38 (31.4%)		68 (31.9%)
Number of inseminations for fertilization	<3I	83 (90.2%)	116 (95.9%)	**0.16**	189 (93.4%)
	≥3I	9 (9.80%)	5 (4.1%)		14 (6.6%)

Indeed, the majority of farms in both regions have an interval of B-1stC (Birth – 1st Calving) of 24–30 months.

Waiting period, days open and number of inseminations. Results show that most AR farms have an interval calving first insemination (waiting period) >60 days with average C-FI intervals (Calving-Fertilization Interval) of 60–90 days and >90 days in respectively 58.7% and 32.6% of farms, with a success rate at first insemination of about 3.3%. Moreover, for fertilisation 71.7% of farms require ≥2 inseminations, of which 9.8% require ≥3.

In SAR, fertilisation occurs in the 60 days postpartum in 21.5% of farms and in the 60–90 days postpartum in 47.1%, with an average C-FI exceeding 100 days in + 58% of farms. Besides that, 92.6% of farms require ≤2 inseminations for cows' fertilisation.

Indeed, the calving–calving interval (C-CI) is >400 days in 30.4% and 12.4% of arid and semi-arid farms respectively.

Dairy production

As Table 6 shows, there is no significant difference ($p > 0.05$) between the two regions' dairy production. A milk yield level of 15–25 L/C/D (Litre/Cow/Day) is registered in most farms with an overall average of 15 ±4 litres. This level reaches +35 L/C/D in spring with an average of 20 ±5 litres.

There is a high significant difference between regions in terms of lactation length, which is below 305 days in almost all AR farms, and 305–350 days in the rest. Nevertheless, 7.4% of SAR farms benefit from an extended lactation period of >350 days, 37.2% of 305–350 days and 55.4% from a duration of less than 305 days.

It was also found that regardless of the region, farmers are divided into two groups (50% each): those who keep their cows for more than 10 years and those who prefer to renew them before their 10th year.

Table 6. Cattle dairy production in arid and semi-arid regions.

Variables	Terms	Arid (Biskra-Ouled Djellal)	Semi-arid (Souk Ahras)	Chi2 (sig)	Total
Daily average quantity of milk	<10L	14 (15.2%)	18 (14.9%)	**1**	32 (15%)
	10-25L	74 (80.4%)	97 (80.2%)		171 (80.3%)
	>25L	4 (4.3%)	6 (5%)		10 (4.7%)
Quantity at Peak	<10L	0	2 (1.7%)	**0.026**	2 (0.9%)
	10-15L	12 (13%)	7 (5.80%)		19 (8.9%)
	15-20L	29 (31.5%)	35 (28.9%)		64 (30%)
	20-25L	29 (31.5%)	29 (24%)		58 (27.2%)
	25-30L	10 (10.9%)	24 (19.8%)		34 (16%)
	>30L	12 (13%)	24 (19.8%)		36 (16.9%)
Lactation period (length "Day")	<305	90 (97.8%)	67 (55.4%)	**0.000**	157 (73.7%)
	305-350	2 (2.2%)	45 (37.2%)		47 (22.1%)
	>350	0	9 (7.4%)		9 (4.2%)
Cow's productivity duration (Years)	<5	2 (2.2%)	3 (2.5%)	**0.015**	5 (2.3%)
	<10	60 (65.2%)	55 (45.5%)		115 (54%)
	>10	30 (32.6%)	61 (50.4%)		91 (42.7%)

Breeding situation

Figure 4 exhibits the presence of multiple pathologies, principally mastitis, followed by digestive and respiratory pathologies in the AR region. The SAR farms suffer much more from reproductive pathologies (in 19.8% of farms), mainly obstetrical ones, principally placental retention; digestive pathologies come in the 2nd place. Food is the major limitation (price and availability), in addition to the lack of water, tracks, inseminators, and a harsh climate in AR.

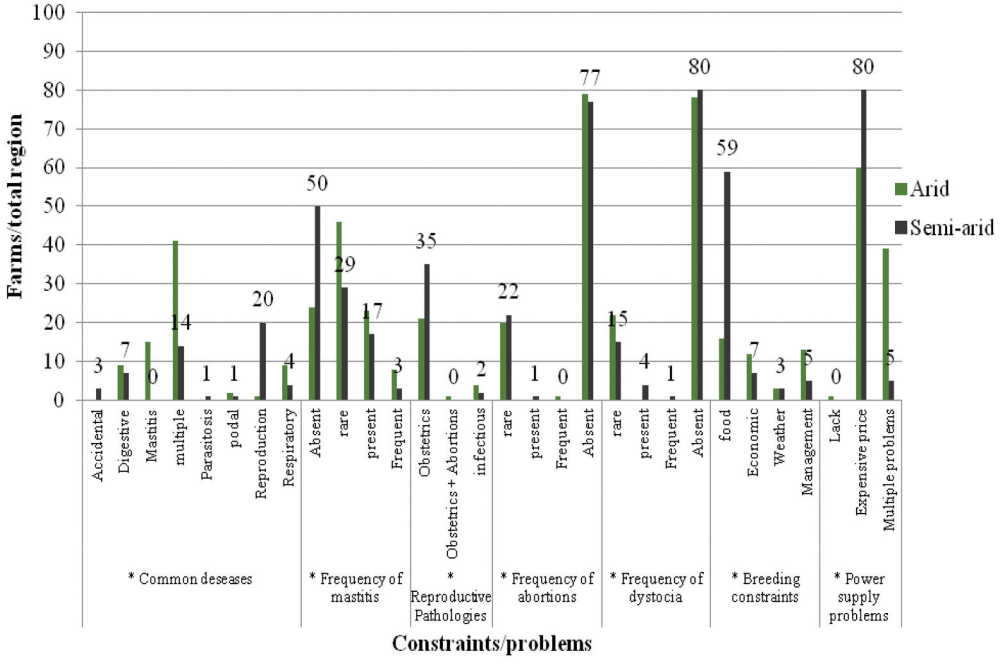

Figure 4. Major problems of dairy cattle farming in arid and semi-arid regions.

Discussion

Socio-economic characteristics

Most farms are managed by middle-aged farmers; since younger individuals avoid this occupation because of its harsh conditions and low social status. A training level that may be judged low and insufficient, especially in AR, may lead to poor livestock management and negatively affect practices and development (the adoption of new technologies and work techniques in the agricultural sector, the use of artificial insemination, etc.) [10,11]. Furthermore, these results are close to those obtained in sub-humid regions and SAR in Algeria (Relizane) [12], Tunisia [13] and Senegal [14]. Because Biskra is a date palm and greenhouse cultivation region [15], many breeders in this AR have an auxiliary occupation (agro-breeders).

Breeding characteristics and conditions

Livestock building/cattle housing

Concerning type, general characteristics and hygiene conditions (cleaning, disinfection, vaccination, etc.) buildings in SAR remain poor, but are of a better standard than those in AR. In general, no structure resembles a recognisable cowshed. This situation had a significant effect on farm performance since the cowshed is a major factor in dairy farms [16], and can also promote many diseases especially mastitis which is directly related to rearing and milking conditions, and hygienic characteristics [17], as the results revealed.

Land potential

Our results reveal that SAR farms benefit from both types of land, but those in Sahara (AR) rely on the UAA with small surfaces. This significant difference is owing to the moderate rainfall in SAR [6] that offers pasture lands to exploit. The AR breeders are able to exploit their own lands thanks to boreholes [4]. Previous studies in Algeria also indicate different agricultural land surfaces; Meskini et al. [12] recorded an average of 8 ha/farm in the SAR, Relizane and Boukhechem et al. [18] reported an average of 42.7 ± 101 ha in the northern zone. In Tunisia, Amamou et al. [19] recorded an agricultural area of more than 50 ha in only 10% of the studied farms, 20% had 10–50 ha and 70% <10 ha.

Cattle herd

Most dairy cattle farms in both studied regions are characterised by small herds of less than 15 heads/farm with an average of 13.2 head/farm in AR and 7.9 ± 4.6 head/farm in SAR, and 6.8 ± 3 DC (Dairy Cow) per herd. Close averages of 14 heads/farm, 8 head/farm and 10.4 DC/herd were recorded, in humid and semi-arid regions; respectively in Tizi Ouzou [20], in Constantine [17], in Mascara and at different locations in Algeria [21]. Close percentages are recorded also in Tunisia [19] where 65% of the exploitations have <10DC and 6% with >50 cows. In both regions, crossbred cattle represent the largest part, nevertheless, other studies have reported that imported purebred farms are the most frequently encountered [21,22].

Breeding practices and management

Feeding practices

It should be noted that feeding practices were not adopted according to the recommendations because farmers did not use the scientific guide/standard calculation of nutritional needs. Fodder is the roughage of all farms, always supplemented by a concentrate based on the availability of dates wheat, bran and mixtures in AR farms. As in other Algerian SAR, as noted in Setif and Mila [22], grazing is the major type of feed in the SAR farms, unlike AR where many farmers do not practice it, owing to the lack of pasture and aridity. Therefore, the SAR farms' ration is considered richer, thanks to the beneficial effects of grazing on the health and welfare of cows [23].

Reproduction management

Controlling reproduction is a cardinal element in the livestock economy. In fact, late fertilisation and low fertility increase charges and losses [24]. Natural mating is the most common mode of reproduction in both regions (because of the lack/absence of inseminators in the AR, but for religious and traditional reasons in the SAR where farmers prefer using their own bulls). These results are in concordance with those observed in arid regions of M'zab Valley in the central Algerian Sahara [25], in Senegal [14] and in the semi-arid region of Setif [26].

Unlike the AR, where farmers practise self-renewal and purchase cows, 48.8% of SAR farmers renew their herds randomly, i.e. without any particular strategy and depending on availability, in contrast, 84% of Relizane' dairy farmers raise heifers for replacement [12]. Pregnancy diagnosis in cows is very important from an economic and management standpoint. It minimises the inter-insemination interval and reduces open days, so it is necessary to identify as soon as possible the non-pregnant cows [27]. The test is the absence of heat in the majority of SAR farms and rectal palpation (examination) in AR. Both methods are less specific and less sensitive, which can affect performances and should be improved by the application of more accurate methods and more precise techniques, particularly the ultrasonography. This method can detect pregnancy up to 15 days earlier than rectal palpation with high sensitivities and specificities when performed between 21 and 35 days after insemination [28].

Dairy production practices

Milking conditions (milkers' hands, udder health status and hygiene score, milking machine) are mediocre in almost all studied farms. Manual milking was observed in the majority of SAR farms; probably because the small size of the herds causes farmers to think that manual milking is appropriate, since the milk is being produced for domestic consumption – not sale or barter as a surplus product. This agrees with reports of Foughali et al. [17] and Dassou et al. [14] in respectively Constantine (Algeria) and Senegal. But in the SAR ($p < 0.001$), where dairies (marketing) represent the principal destination of produced milk, there is a pronounced need to use milking machines for their advantages.

It is notable that a part of the milk produced is always reserved for calves' consumption until late weaning (>3 months), which seems to be a general rule in the majority of

the two regions' farms. Generally, breeders prefer late weaning. Indeed, Abdelli et al. [3] reported that in Medea the weaning age is >3 months in most of the studied farms, Boukhecham et al. [18] reported an average of 4.12 ± 1.29 months in northern Algeria, and even in Ethiopia, Mengistu et al. [29] reported an average of 9.27 ± 2.22 months. This sounds beneficial for calves' health since late weaning facilitates a more gradual change in ruminal and intestinal microbiota, so it could explain the negative effects of early weaning [30]. Furthermore, beneficial effects on growth and later consumption are associated with this method [31].

Performances reproduction performance age at mating and first calving

Breeding heifers for replacement in dairy farms incurs substantial financial costs because nutritional and managerial demands increase during the non-productive period, i.e. from birth to calving. These variables serve as estimations of the costs required to achieve profitability. The longer the non-productive period, the greater the costs, including expenses for feed, treatments, and other necessities [32]. It was found that most AR farmers inseminate their heifers at the age of 12–15 months. The SAR farmers prefer to inseminate them at an age >15 months. Our results are close to those of Mohamed-Brahmi et al. [13] who recorded an average age at first mating of about 15 ± 3.5 months, but lower than that reported by Benidir et al. [33] who found that most of all Setif' breeders raise their heifers until 20 months for first conception service; then the age at first calving is about 29 months. At El Taref sub-humid region, Attia et al. [5] reported that the average age at first service is 24 months.

It is notable that our breeders manage the rearing of their heifers correctly; by minimising costs and age at first calving. In addition, a lower age at first calving is associated with better udder health, increased daily milk production, improved reproductive performance, and increased calving probability [34,35].

Waiting period, days open and number of inseminations

The fertility evaluation results reveal that a significant number of farms in two regions have waiting periods (calving to first insemination interval) exceeding 60 days, which contradicts recommended practices [36]. This result is close to the finding of Yahimi et al. [37] that 67% of farmers achieve the first insemination in >70 days after calving. Moreover, for fertilization, 71.7% of farms require ≥2 inseminations of which 9.8% require ≥3, rate higher than that recorded by Mouffok et al. [38].

There are too low fertility traits and consequently the calving interval is prolonged particularly in farms in the arid region. According to Hanzen [39], when the inter-calving interval (ICI) is more than the threshold of 400 days in 30% of cows, this indicates serious infertility in the herd, which can be explained by bad heat detection (a crucial element in dairy breeding) leading to prolonged waiting and reproduction periods and then to multiple losses: milk, calves, feed, veterinary expenses [36]. The effects of the hot climate may also depress fertility rates [40].

In SAR, fertilisation occurs in the 60 days postpartum in 21.5% of farms and in 60–90 days postpartum in 47.1%. The same results are recorded in a similar SAR [41], but Haou et al. [42] and Hammami et al. [43] found an average C-FI exceeding 100 days in more

than 58% of farms. Besides, most farms require ≤2 inseminations to get fertilisation. These results mean a rate of success at first insemination of 35.5%. On the other hand, Mouffok et al. [38] reported a rate of 64%.

Indeed, the calving–calving interval result is similar to that of North-eastern Algeria [41] and better than elsewhere. Other studies have reported higher percentages and intervals; an interval of >500 days [13] and 422.4 ± 88.7 days [26] in Algeria, 453 days in Tunisia [43]. Haou et al. [42] reported 400 days interval in 39.7% of studied farms. Abdelli et al. [3] found an average interval of 420 days in almost 83% of the studied farms. But, Semara [44] found a mean interval of 351 ± 43 days between successive parturitions.

Dairy production

A milk yield level of 15–25 L/C/D is registered in most farms with an overall average of 15 ±4 litres. This level reaches +35 L/C/D in spring with an average of 20 ±5 litres, thanks to the availability of feed resources and suitable climate in both regions, because milk production is negatively affected by extreme temperature and humidity indices [45].

These findings, which illustrate farms' practices and animals' welfare status that directly affect milk production [46], are very similar to those in other studies whether in Algeria or Morocco. Belkheir et al. [47] and Si-Tayeb et al. [20] reported an average of respectively 14.5 Kg/C/D and 15 ± 5 L/C/D in Tizi Ouzou. Boukhecham et al. [18] noted an average of 14.3 ± 4.77 Kg/C/D in northern Algeria. Srairi et al. [48] reported an average of 14 Kg/C/D in Morocco. In Constantine and El Taref, lower levels are recorded, 5–15 L/C/D in 77.1% and 5–10 L/C/D in 78.9%, respectively for Constantine [17] and El Taref farms [5]. Moreover, our results are clearly superior to those recorded in the arid zones of Africa, where Adamou Karimou et al. [49] found an average of 2.7 ± 1.4 L/C/D for a lactation period of 7.2 ± 2.8 months in the Diffa region in Niger. In Ethiopia, Mengistu et al. [29] reported an average of 2 L/C/D.

Breeding situation

Firstly, all studied herds benefit from the state vaccination program, and the veterinarian is present just in case of pathologies, which remain the principal reason for culling. Despite the absence of abortions and dystocia (or rarity if present) in most farms, and even if some breeders reported no disease, multiple pathologies exist, principally mastitis, followed by digestive and respiratory pathologies in the AR region. This can be explained by heat load which usually favours those health problems [50]. SAR farms suffer much more from reproductive pathologies, mainly obstetrical ones. Our results agree with those of Constantine where mastitis, foot diseases, dystocia and neonatal diarrhoea are the most frequent diseases [51]. On the other hand, in Setif and Mila the dominant pathologies are foot and mouth disease and pasteurellosis [22].

Farmers in both regions report that food, which represents the major factor of breeding development, is the principal limitation (price and availability), in addition to the lack of water, tracks, inseminators, and harsh climate in AR. All these hinder large-scale exploitation, limit production rates, and dairy cattle breeding. Guerrera has encountered the same problems in the Algerian Sahara [52].

Conclusion

The paper has analysed the functioning of dairy cattle farms and their development limitations in the Souk Ahras and Biskra-Ouled Djellal regions of eastern Algeria (Semi-arid and Arid, respectively). Results revealed that the majority of farms are small, with family labour, poor building quality (in terms of construction and hygiene), random feed intake, haphazard breeding management, and poor land and genetic resource exploitation, particularly in arid regions. As a result, poor performance and low profitability are observed. Nevertheless, we believe that breeding situations can be improved by implementing new management techniques and strategies, reducing constraints, and increasing state assistance in order to achieve objectives (maximum production with sound economic management).

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Disclosure statement

No potential conflict of interest was reported by the authors.

Author's contribution

K. Deghnouche conceived and designed the study. H. Eulmi collected data. H. Eulmi and D.E. Gherissi analysed the data, wrote and corrected the paper. All authors read and approved the manuscript.

Ethical statement

All procedures performed in this study involving experimental animals were in accordance with the ethical standards of the national and international guidelines.

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