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Assessment of Egyptian Local Sheep and Goat Productivity Under the Environmental Conditions of Coastal Zone of Western Desert and Upper Egypt

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Abstract: Livestock plays a significant role in food production, income generation, soil quality, transportation and the overall welfare of communities, especially in developing nations. Sheep and goats are vital sources of food, livelihood and urgent financial needs. Researching livestock practices can help optimize production, enhance productivity, and improve market access, ultimately boosting the economic well-being of developing communities. Research is needed to identify climate-resilient livestock practices, develop drought-resistant breeds, and optimize feed management strategies. By enhancing the resilience of livestock systems, research can help safeguard food security and livelihoods in the face of climate change. Climate change, evidenced by temperature changes and increased extreme weather events, negatively impacts traditional farming systems and livestock production by affecting pastures, feeds, water quality and livestock diseases. Breeds of the Coastal Zone of Western Desert (CZWD) such as the Barki sheep and goat as well as the Saidi breed in Upper Egypt (UE), have adapted to these harsh conditions and are crucial for smallholders. However, there's an information gap regarding these breeds' productivity in smallholder systems. This study utilizes the Twelve Month Monitoring (12MO) survey to estimate the productivity and demographic parameters of these breeds from 2018 to 2020.

1 Introduction

Increasing human population and urbanization are driving a surge in livestock product demand and emphasizing the role of domestic animals in nutrition and food security, especially in developing countries (Gaughan et al 2019, Godde et al 2021). Sheep and goats, particularly, are crucial for livelihood, food, and converting cash assets (Henry et al 2018). However, livestock production in these regions often suffers from low productivity due to limited resources and knowledge. Concurrently, climate change poses

significant threats by altering ecosystem services and thus impacting feed and water availability as well as increasing disease risks (Bagath et al 2019, Cheng et al 2022). Within this context, Egyptian local breeds of sheep and goats have thrived due to their adaptability to tough environmental conditions. Thus, they play an integral role in both the extensive production system in the Coastal Zone of Western Desert (CZWD), which relies on natural resources in addition to the intensive system as in Upper Egypt (UE), which is irrigation-dependent. Despite their importance, there's a noticeable lack of data on the productivity of these breeds because of absent recording systems. This study focuses on assessing the Egyptian local sheep and goat productivity through three consecutive years (2018-2020) under demographic parameters of the CZWD (Matrouh governorate) and Upper Egypt (Assiut governorate).

2 Materials and Methods

2.1 Study Areas

The research covered two agro-ecological zones:
First: CZWD which extends from Alexandria governorate to the Libyan border. This zone possesses an arid Mediterranean climate with an annual rainfall of less than 150 mm and temperature ranges from 8°C to 30°C.
Second: Assuit governorate along the Nile River in Upper Egypt (UE) which experiences hot weather with temperatures ranging from 3°C to above 40°C and negligible rainfall (Galal et al 2005).

Tables 1 and **2** detail the climatic conditions monthly of these regions over 3 years.

2.2 12MO retrospective demographic survey

The 12MO was used to assess demographic parameters and flock/herd productivity. This method recounts all animals by age and gender and records all demographic events over the past year. Surveys were conducted from 2018 to 2020 in Matrouh and Assuit to maximize event recall accuracy. **Table 3** highlights the sample structure. Breeders were chosen based on flock/herd size and number of breeding females. It was intended to survey 25 flocks/herds per location. The targeted breeders' number was achieved in Matrouh but for Assuit the number increased by adding more breeders to the sample due to the small number of animals per flock/herd.

Tables 4 and **5** show the total number of sheep and goat breeders involved in the 12MO survey with the total number of animals included and the average number per herd/flock.

For sheep, a total of 52 breeders (25 in Matrouh and 27 in Assuit) were included in the 12MO survey, and the total number of sheep included in the survey increased each year. For goat the total number of goat breeders included in the 12MO survey varied between 30 and 38 breeders and the total number of goats included in the survey increased by 130% in Matrouh and 35% in Assuit.

2.3 Estimation of demographic parameters

The study adopted the method by Lesnoff et al (2010) to calculate instantaneous hazard rates for different animal categories. Hazard rates help in estimating the parturition rate, prolificacy rate, mortality rate and disposal rate. These parameters were determined using the 12MO package in R software programming language, core 2022 version 3.5.3.

2.4 Statistical analysis

Data were analyzed using the linear model as follows:

$$Y_{ijk} = \mu + L_i + S_j + e_{ijk},$$

where,

Y_{ijk} is the number of parturitions, number of offspring, total flock/herd, total purchased, total sold, total slaughtered and total dead. μ is the general mean. L_i is the fixed effect of the i^{th} studied locations, (i= 1 to 2), 1=Matrouh and 2= Assuit
S_j is the fixed effect of the j^{th} year of the survey, (j= 1 to 3), 1=2018, 2=2019 and 3=2020. e_{ijk} is the random error which is distributed normally $(0,\sigma_e^2)$.

The interaction between locations and the year of survey was not statistically significant ($p>0.05$), for this reason, it was excluded from the model. The significant effects in the analyses were ($p<0.05$) and ($p<0.01$).

Table 1. Monthly temperature (°C) in the studied areas over the three studied years

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Matrouh	2018	15	16	18	20	23	25	27	27	26	23	20	16	21.2
	Min-Max	13-17	14-19	15-22	17-23	20-26	23-29	24-30	25-30	24-29	21-26	18-22	14-18	
	2019	13	14	15	18	22	25	27	27	25	24	21	17	20.5
	Min-Max	11-16	11-17	13-18	15-21	18-25	22-28	24-30	24-30	23-28	21-26	18-24	15-19	
	2020	13	14	16	18	21	24	26	27	26	24	19	16	20.2
	Min-Max	11-15	12-17	13-19	14-21	18-25	20-28	23-30	24-31	23-30	21-27	17-21	14-19	
Assuit	2018	14	20	24	26	31	33	33	33	30	27	21	15	25.6
	Min-Max	9-20	14-26	18-31	20-33	25-38	27-39	27-39	27-39	24-36	22-33	16-26	11-20	
	2019	14	16	19	24	31	33	33	32	29	27	22	15	24.6
	Min-Max	9-19	11-21	13-25	18-30	24-38	26-40	26-40	26-39	23-36	21-34	17-29	10-22	
	2020	13	16	21	25	30	33	33	33	34	28	19	17	25.2
	Min-Max	7-18	10-22	14-27	18-31	22-37	25-40	26-40	27-40	25-40	22-35	15-25	12-24	

Source: World Weather Online, 2023

Table 2. Monthly rainfall (mm) in the studied areas over the three studied years

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Matrouh	2018	11.7	3.5	0.8	2.6	0.1	0.2	0	0	0	3.7	12.5	27.1	5.2
	2019	1.4	8.1	10.9	4.2	0.1	0.6	0	0	1.6	5.8	0.1	7.8	3.4
	2020	20.1	7.9	47.0	0.4	0	0	0	0	2.2	11.4	29.4	3.6	10.2
Assuit	2018	0.3	1.2	0	0.2	0.9	0	0	0	0	0	0.2	0.1	0.2
	2019	0	0.6	0.1	0.7	0	0	0	0	0	0	0	0	0.1
	2020	0.1	2.1	7.1	0	0.2	0	0	0	0	0	0	0	0.8

Source: World Weather Online, 2023

Table 3. Number of breeders and (%) according to species of animals over the three studied years

Specie	Matrouh			Assuit		
	2018	2019	2020	2018	2019	2020
Sheep	14 (56)	10 (38)	11 (42)	9 (32)	6 (21)	10 (36)
Goat	0 (0)	1 (4)	1 (4)	1 (4)	1 (4)	1 (4)
Sheep & Goat	11 (44)	15 (58)	14 (54)	18 (64)	21 (75)	17 (60)
Total	25	26	26	28	28	28

Table 4. Total number of sheep breeders and animals involved in the study over the three studied years (from 2018 to 2020)

	Total			Matrouh (Barki)			Assuit (Saidi)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Total No. breeders	52	52	52	25	25	25	27	27	27
Total No. animals	1371	1643	1927	753	914	1084	618	729	843
Average No. animals	26	32	37	30	37	43	23	27	31

Table 5. Total number of goat breeders and animals involved in the study over the three years (2018-2020)

	Total			Matrouh (Barki)			Assuit (Saidi)		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Total No. breeders	30	38	33	11	16	15	19	22	18
Total No. animals	308	496	550	141	272	324	167	224	226
Average No. animals	10	13	17	13	17	22	9	10	13

3 Results and Discussion

3.1 Sheep flock and goat herd composition

The average number of sheep per flock was higher in Matrouh than in Assuit over the three years, which suggests that breeders in the CZWD rely more on sheep as a primary source of income and food security compared to those in UE. However, the average also indicates a notable reduction in sheep per flock in the extensive systems of CZWD due to drought incidence and selling many animals to cope with this shock. Regarding the sheep flock composition, the adult ewes represented the majority (56-68%) of the sheep flock in both zones, followed by young females less than 1 year (20-30%). In Matrouh, adult ewes represented 59-71% of the total flock, followed by young females (19-28%). The same flock composition was found in Assuit, where adult ewes represented 53-65% of the total flock, followed by young females (21-33%). These results indicate that adult ewes are the backbone of the sheep flocks in both zones.

The average number of goats per herd was higher in Matrouh than in Assuit over the three years, indicating that the breeders in the CZWD depend more on goats as a source of family consumption and income compared to UE. The adults represent nearly more than half of the goat herd composition (48-59%) followed by the young replacing females less than 1 year (18-35%). In Matrouh, adults represent 54-67% of the total herd followed by young females (20-33%). For Assuit, the adult goat does represent 40-52% of the total herd followed by young females (16-36%) and young males (19-25%).

3.2 Assessment of some reproductive traits

The main reproductive traits that were estimated included parturition, prolificacy, mortality and disposal rates for both sheep and goats in both zones over the course of the three-year survey. The parturition rate was higher in Matrouh than in Assuit for both sheep and goats throughout the entire survey period. For Barki sheep, the parturition rate ranged from 0.84 to 0.98, which was higher than the parturition rate for Saidi sheep which ranged from 0.74 to 0.76 (as shown in **Table 6**). Similarly, for the goats, the parturition rate (ranging from 0.83 to 0.95) was higher in Barki than the Saidi goats (ranging from 0.75 to 0.82) throughout the three years. This indicates that some Barki ewes and goats may have two parturitions with no seasonal effects on adults during the year. The breeders in CZWD have a strong economic interest in rearing sheep and goats, which are their main source of income in the harsh desert conditions. They specialize in small ruminants breeding and management and therefore, Barki ewes can give birth twice per year in May and October (Galal et al 2005). The difference in feeding strategies may explain the differences in parturition rates observed in the two zones. The Barki breed was selected to be a productive breed under arid conditions, while the Saidi breed was selected for its resistance to feed shortage and high temperatures. The prolificacy rate, as calculated by dividing the number of offspring born by the number of parturitions; for Barki sheep ranged from 1.09 to 1.22, while for Saidi sheep it ranged from 1.29 to 1.41 (**Table 7**). For the Barki goats, the prolificacy rate ranged from 1.45 to 1.72, while for the Saidi goats, it ranged from 1.68 to 1.81. The prolificacy rate for Saidi sheep was higher than for Barki sheep throughout the survey period, and the same trend was observed for goats. It is worth noting that Barki sheep typically have single lambing. In general, the highest mortality rates, all over the year, were observed for young males and females compared to other age and gender classes. In 2018, there was a high mortality rate for young females and males in both sites, which could be attributed to sudden deaths caused by cold nights during winter or high temperatures during summer, as well as weakness due to lack of milk for suckling or illness. The mortality rate for adult ewes and does was relatively low. Deaths of adults could be due to problems during pregnancy or after lambing or kidding. There were some differences regarding young animals, with the mortality rate for young female and male sheep being lower in Matrouh than in Assuit over the three years. This difference is mainly because breeders in Matrouh have more concern about their animals, give them more attention, and usually provide better care to use young females for replacing or selling and young males for selling after weaning or for fattening. While in Assuit, the breeders focus more on large ruminants and off-farm jobs. The mortality rates for adult ewes and does were similar in both sites. Galal et al (2005) reported mortality rates of Barki lambs until weaning as 6.3% to 16.6%, compared to 3-20% for females and 9-32% for males at the same age. The mortality rate of Barki kids from birth to four months was 7.7-9.4%, compared to 3-10% for females and 9-19% for males at the same age. In general, breeders in both sites tend to sell young lambs and kids after weaning or a short period of fattening (**Table 8**). Additionally, small numbers of adult animals are sold for various reasons,

Table 6. Number of parturition events and parturition hazard rates (h) per animal species and location over the three years (2018-2020)

Specie	Breed	2018			2019			2020		
		No. adult females	No. event	Mean±SE	No. adult females	No. event	Mean±SE	No. adult females	No. event	Mean±SE
Sheep	Barki	535	540	0.98^{a}±0.04	548	503	0.84^{a}±0.03	640	644	0.93^{a}±0.04
	Saidi	399	308	0.76^{b}±0.04	388	339	0.76^{b}±0.04	448	372	0.74^{b}±0.03
Goat	Barki	94	93	0.95^{a}±0.09	154	140	0.83^{a}±0.03	174	180	0.92^{a}±0.07
	Saidi	87	72	0.82^{b}±0.09	96	83	0.79^{b}±0.08	91	81	0.75^{b}±0.07

Means in the same column with the same letter are not significantly different.

Table 7. Number of offspring and prolificacy rate (mean ± se) per breed over the three years (2018-2020)

Species	Breed	2018		2019		2020	
		No. offspring born	Mean±SE	No. offspring born	Mean±SE	No. offspring born	Mean±SE
Sheep	Barki	589	1.09^{b}±0.01	612	1.22^{b}±0.02	751	1.17^{b}±0.02
	Saidi	398	1.29^{a}±0.07	442	1.30^{a}±0.03	524	1.41^{a}±0.03
Goat	Barki	138	1.48^{b}±0.03	203	1.45^{b}±0.04	309	1.72^{b}±0.04
	Saidi	121	1.68^{a}±0.08	150	1.81^{a}±0.07	147	1.81^{a}±0.08

Means in the same column with the same letter are not significantly different.

Table 8. Number of disposal events and disposal hazard rate (h±SE) per species, location, gender and age class over the three years (2018-2020)

Species	Site			2018		2019		2020	
		Gender[1]	Age Class[2]	No. event	H±SE	No. event	H±SE	No. event	H±SE
Sheep	Matrouh	F	Y	262	1.78^{a}±0.11	148	0.90^{b}±0.07	172	0.86^{c}±0.07
			A	89	0.15^{a}±0.02	29	0.05^{c}±0.01	58	0.08^{b}±0.01
		M	Y	361	2.82^{a}±0.15	237	2.07^{b}±0.13	270	1.89^{c}±0.12
			A	5	0.16^{c}±0.07	36	0.88^{b}±0.15	63	1.13^{a}±0.14
	Assuit	F	Y	79	0.83^{a}±0.09	88	0.59^{b}±0.06	78	0.48^{c}±0.06
			A	34	0.08^{b}±0.01	55	0.12^{a}±0.02	79	0.15^{a}±0.02
		M	Y	168	1.97^{a}±0.15	125	1.5^{a}±0.13	150	1.5^{b}±0.12
			A	24	0.64^{b}±0.13	38	0.78^{b}±0.13	67	1.2^{a}±0.15
Goat	Matrouh	F	Y	49	1.8^{a}±0.26	33	0.66^{c}±0.12	80	1.06^{b}±0.12
			A	8	0.08^{a}±0.03	10	0.06^{a}±0.02	5	0.03^{b}±0.01
		M	Y	79	2.75^{a}±0.31	86	2.14^{b}±0.23	115	2.2^{b}±0.21
			A	0	-	9	0.71^{b}±0.24	23	1.2^{a}±0.25
	Assuit	F	Y	17	0.70^{a}±0.17	16	0.41^{b}±0.10	9	0.19^{c}±0.07
			A	13	0.14^{a}±0.04	12	0.11^{b}±0.03	14	0.12^{b}±0.03
		M	Y	23	0.75^{a}±0.16	28	0.68^{b}±0.13	21	0.57^{c}±0.13
			A	8	0.51^{b}±0.18	32	1.5^{a}±0.27	35	1.4^{a}±0.23

[1]*Gender:* F: Female, M: Male, [2]*Age class:* A: Adult (more than 1 year), Y: Young (less than 1 year). Means in the same row with the same letters are not significantly different

such as aged animals or reproductive failure. Disposal rates, as calculated average number of selling and slaughtering events, for both species were higher in Matrouh than in Assuit, except for adult males, as breeders tend to keep very few reproductive males. This strategy of selling young and non-reproductive animals may reflect the breeders' efforts to cope with environmental challenges such as drought or feed shortage by maintaining only healthy and productive animals in their flocks and herds. Moreover, the selling of young animals provides an opportunity for the breeders to obtain cash quickly for purchasing feedstuffs and drugs to maintain their animals' health and productivity. The disposal hazard rate for young Barki sheep females (less than 1 year) over the three years (1.78, 0.90 and 0.86, respectively) was higher compared to Saidi sheep in Assuit (0.83, 0.59 and 0.48, respectively). Similarly, the disposal rate for young (less than 1 year) Barki males over the three years (2.82, 2.07 and 1.89, respectively) in Matrouh was higher compared to Saidi sheep in Assuit (1.97, 1.5 and 1.5, respectively). The majority of young males are sold by breeders in both sites, while some young females are kept for replacement. For goats, the disposal rate for young Barki females in the three years (1.8, 0.66 and 1.06, respectively) in Matrouh was higher compared to Saidi goats in Assuit (0.70, 0.41 and 0.19, respectively). Similarly, the disposal rate for young Barki males (less than 1 year) over the three years (2.75, 2.14 and 2.2, respectively) in Matrouh was higher compared to Saidi goat in Assuit (0.75, 0.68 and 0.57, respectively). The majority of young kids are sold by breeders in both sites, while some young females are kept for replacement. Breeders tend to sell young animals, especially males, for both species in both sites, to purchase feedstuffs and drugs to maintain good animal health and numbers of females. The selling rates for young females and males were higher in Matrouh than in Assuit, possibly due to the high demand for Barki lambs among consumers because they have a leaner carcass. Breeders in both zones also sell young animals for urgent cash needs. The breeders in Matrouh and Assuit sell more young animals after weaning, especially males because they are forced to dispose of the majority of the young to have the cash to purchase needs of their family and feed and drugs for animals' needs and to allow adult females to be mated for another parturition. This observation agrees with many authors who stated that, in general, livestock producers have adopted and applied mechanisms to adapt to climate change and the most practiced adaptation strategy was reducing livestock numbers by marketing and selling animals due to poor natural grazing and feed shortage (Zhang et al 2017, Henry et al 2018, Rahut and Ali 2018, Abazinab et al 2022, Habte et al 2022). Breeders in UE tend to keep some young animals as cash reserve and to purchase feedstuffs, while those in CZWD are forced to sell the young animals to decrease the size of their flocks/herds to have money to pay feedstuffs traders, which is in agreement with Wang (2011) who found that breeders with higher levels of debt need to sell livestock for cash to pay off loans or interest. Factors such as drought incidence in CZWD and high prices of feedstuffs in UE contribute to increasing disposal rates, as breeders are forced to sell or slaughter the majority of the young animals and part of the adult animals. Alary et al (2014) indicated that breeders in Matrouh usually sell young and sub-adult sheep and goats first to face drought and cover their family needs, maintaining their reproductive animals to ensure restocking after the shock. WFP (2019) explained that a reduction of livestock numbers in times of climate shock with a lower number of more productive animals leads to more efficient production to help compensate for crop failures, loss of income or additional expenses.

Tables 9 and **10** showed the effect of location and year of study on total flock/herd, total purchased, total sold, total slaughtered and total dead. There was a highly significant effect ($p<0.01$) for location on the number of parturitions, number of offspring born, total flock and herd and total numbers of sheep and goats sold. For sheep, there was a high significant effect ($p<0.01$) for location on total numbers of slaughtered animals also year has a high significant effect ($p<0.01$) on total flock and total numbers of dead animals while it was significant ($p<0.05$) on total numbers of slaughtered animals. For the goats, there was a significant effect of location on the total number of purchased animals, while there was no effect of year on dependent variables.

Table 9. LSM±SE of total flock, total animals purchased, total animals sold, total animals slaughtered and total animals dead of sheep for two locations and over the three years

	Location		Year		
	Matrouh	**Assuit**	**2018**	**2019**	**2020**
Total flock	36.7^{a}±2.17	27.0^{b}±1.33	26.6^{b}±1.83	31.8^{ab}±2.17	37.2^{a}±2.53
Total purchased	1.7^{a}±0.51	1.4^{a}±0.33	1.6^{a}±0.37	1.5^{a}±0.54	1.5^{a}±0.61
Total sold	20.9^{a}±1.54	11.5^{b}±1.07	18.1^{a}±2.14	16.8^{a}±1.25	13.7^{a}±1.65
Total slaughtered	2.1^{a}±0.22	0.68^{b}±0.12	1.8^{a}±0.26	1.0^{b}±0.20	1.4^{ab}±0.23
Total dead	3.0^{a}±0.35	2.6^{a}±0.39	4.3^{a}±0.48	2.1^{b}±0.38	1.9^{b}±0.42

Means in the same row with the same letter are not significantly different.

Table 10. LSM±SE of total herd, total animals purchased, total animals sold, total animals slaughtered and total animals dead of goat for two locations and over the three years

	Location		Year		
	Matrouh	**Assuit**	**2018**	**2019**	**2020**
Total herd	10.0^{a}±0.84	4.6^{b}±0.28	6.9^{a}±0.73	7.0^{a}±0.78	7.9^{a}±0.90
Total purchased	0.92^{a}±0.41	0.18^{b}±0.07	0.4^{a}±0.13	0.9^{a}±0.50	0.3^{a}±0.14
Total sold	9.8^{a}±1.19	2.9^{b}±0.40	4.9^{b}±1.21	6.1^{ab}±0.83	7.9^{a}±1.19
Total slaughtered	0.6^{a}±0.14	0.5^{a}±0.21	0.87^{a}±0.31	0.39^{a}±0.12	0.53^{a}±0.23
Total dead	0.94^{a}±0.24	1.1^{a}±0.25	1.3^{a}±0.38	0.6^{a}±0.23	1.1^{a}±0.29

Means in the same row with the same letter are not significantly different

4 Conclusion

Breeders in Matrouh (CZWD), heavily rely on sheep and goat breeding as their primary source of income. This indicates the essential role of livestock in ensuring food and economic security. The results underscore the vulnerability of these agroecological zones to climate shocks such as droughts. The significant decrease in sheep per flock in CZWD due to drought incidence and the subsequent selling of many animals to cope with this shock is a pressing concern. The breeders in Assuit consider small ruminants as a secondary activity with more focus on large ruminants and off-farm jobs as their primary source of income. The difference in demographic parameters between the two regions may be influenced by several factors, including the breeders' expertise in animal management, feeding strategies, and the inherent characteristics of the local breeds. The results indicate also that breeders often face economic pressures, leading them to sell young animals to meet immediate cash needs, purchase feed, or pay off debts. Reducing livestock numbers, especially after a climate shock like drought, seems to be a prevalent adaptation strategy among breeders.

The study suggests the following recommendations to enhance small ruminants' production systems in the studied zones: first, breeders in both zones could benefit from training programs focused on advanced breeding and management practices to better manage their animals. Second, implement a system where breeders can provide feedback about the 12MO method, for continuous refinement and improvement of data collection techniques. Third, introduction and cross-breeding with improved breeds can enhance productivity. It is essential to consider breeds that are productive and adapted to local conditions. Fourth, raise consumer awareness about the quality and benefits of consuming products from local breeds like Barki and Saidi; This can fetch better prices for breeders and motivate them to invest more in their animals. Fifth, encouraging breeders, especially in UE, to diversify their income sources can reduce their vulnerability during adverse climatic events.

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