Egyptian Journal of Sheep & Goat Sciences, Vol. 14, No. 1, P: 39 52, April 2019

Feasibility of utilizing advanced reproductive technologies for sheep breeding in Egypt. Part 1. Genetic and nutritional resources.

A.G. Elshazly[1] and C.R. Youngs[1,2]

[1] Iowa State University, Department of Animal Science, 2356B Kildee Hall, 806 Stange Rd, Ames, Iowa 50011-1178 USA

[2]Corresponding author: E-MAIL: cryoungs@iastate.edu; VOICE: 1-515-294-5541; FAX:1-515-294-4471

SUMMARY

Sheep are a valuable livestock species because of their ability to convert forages, as well as feedstuffs not suitable for human consumption, into meat and milk that are important sources of human dietary protein. Sheep are the most abundant ruminant livestock species in Egypt, and great opportunity exists to enhance their productivity though implementation of a genetic improvement program utilizing the advanced reproductive technologies of artificial insemination and embryo transfer. These two reproductive technologies permit the production of more offspring from genetically superior animals in a shorter amount of time than would be possible through conventional breeding. It will be important to match the appropriate breeds of sheep with the proper nutritional and production environments that will enable animals to express their full genetic potential for enhanced production of meat, milk and fiber.

INTRODUCTION

The Arab Republic of Egypt (more commonly known as Egypt) spans the northeastern corner of Africa and the southwestern corner of Asia; its population is estimated at 100 million (World Population Review, 2018), ranking it among the top 15 most populous nations of the world. In 2017, the gross national income (GNI) per capita (Atlas method) was $3,010 (World Bank, 2018a), and its GINI index (a measure of equality of wealth distribution within a country) was 31.8 (World Bank, 2018b). Egypt's 2017 human development index (HDI) rank, which is based on factors such as life expectancy at birth and average years of education of its citizens, is 115 out of 189 countries (United Nations Development Programme, 2018).

Agriculture is important to the economy of Egypt. It contributes approximately 14.5% of the nation's' gross domestic product (GDP) and accounts for approximately 28% of all jobs – including jobs for nearly 45% of all women in the workforce (USAID, 2018). Despite agriculture's importance, food insecurity is a problem in Egypt. Approximately 16% of its citizens have poor access to food (21.3% in rural areas and 8.8% in urban areas), and food insecurity is highest in rural Upper Egypt where 38.7% of the population has poor access to food (World Food Programme, 2018). Recommendations to improve food security for Egyptians include further development of their livestock production systems (Soliman, 2018).

The most abundant animal (excluding avian species) raised for food in Egypt are sheep (FAOSTAT, 2018). As a small ruminant, sheep can convert low-quality roughages into meat and milk for human consumption (in addition to producing fiber and hides). Sheep are well-suited to foraging on marginal grazing lands that are unable to support grazing of larger livestock species such as cattle and buffalo. Therefore, sheep represent a wonderful opportunity for Egypt to increase the production of animal-source foods thereby reducing problems associated with food insecurity.

Sheep production in Egypt:

Sheep are an essential component of Egyptian agriculture, and livestock production accounts for approximately 30% of the country's total agricultural income. Sheep production is being encouraged in Egypt as a means of

improving the daily dietary protein intake of humans. Sheep, therefore, constitute an important component of Egypt's food security plan. In 2017, more than 2.34 million head of sheep produced 72,296 tons of red meat representing approximately 7.4% of all red meat production in Egypt (FAOSTAT, 2018). Average carcass weight was approximately 30.9 kilograms. Total production of sheep milk was 99,322 tons.

Sheep occupy an advanced position within the Egyptian livestock sector because of their suitability to the different agricultural conditions in the country, especially in the reclaimed and desert lands. Sheep are highly efficient in converting non-dense pastures to meat, milk and wool; they also possess the ability to travel long distances during grazing and to withstand harsh environmental conditions. Sheep meat and sheep milk can contribute significantly to the goal of reducing human dietary protein deficiency which is one of the most pressing problems of the country. Thus, sheep are able to produce meat and milk without consuming large quantities of feed concentrates (that are in short supply in Egypt) when compared with large ruminants.

The current number of sheep in Egypt is 5.69 million head, and this number exceeds that of cattle (5.06 million head), goats (4.35 million head), and buffaloes (3.37 million head). Figure 1 shows that the number of sheep (as well as cattle) has been increasing over the past two decades, whereas the number of buffaloes has been decreasing in the past decade. The number of sheep has increased due to their ability to graze and their need for less concentrate, while the number of cattle has increased because of their greater utilization of feeds to produce milk (when compared with buffaloes) especially in F1 Friesian X local crossbreds which now represent the majority of the cattle population (E.I. Shehata, personal communication).

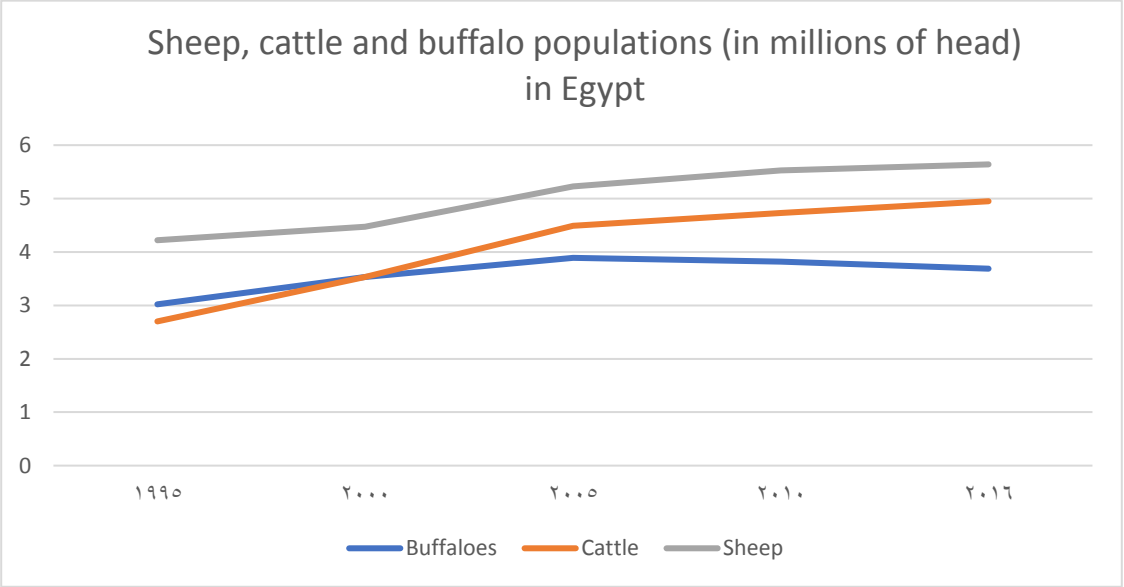

Figure 1. Temporal changes in populations of three major ruminant livestock species in Egypt during the time period 1995 through 2016 (data from FAO).

Egyptian sheep breeds are characterized by high fertility rates, an extended breeding season, but low prolificacy (Gabr *et al.*, 2016). The breeds have adapted over time to their local environmental conditions, and sheep are distributed geographically in Upper Egypt, Central and North Upper Egypt, and governorates outside the valley (North and South Sinai, Marsa Matruh, New Valley, Red Sea and Nubaria). The governorates of Gharbia, Matrouh, Sharqiya, Minya and Sohag are among the most densely populated provinces for sheep (Elshennawy, 1995).

Egypt lies predominantly between 22° and 32° N latitude, and 25° and 35° E longitude. Climatic conditions in three of the major sheep-producing regions of Egypt are characterized in Table 1. A visual depiction of regions where sheep are commonly raised is shown in Figure 2.

Table 1. Annual precipitation rate, humidity level, and temperature ranges in three geographical regions of Egypt where the most common breeds of sheep (Rahmani, Ossimi, and Barki) are raised.

	central and northern delta	south delta and central Egypt	northwestern coast and the desert areas
Annual precipitation rate (mm)	100-200	0-80	120-300
Humidity (%)	56-75	48-68	40-80
Temperature range (°C)			
Maximum	18-33	19-37	29-39
Minimum	6-19	5-21	9-18
Most common sheep breed	Rahmani	Ossimi	Barki

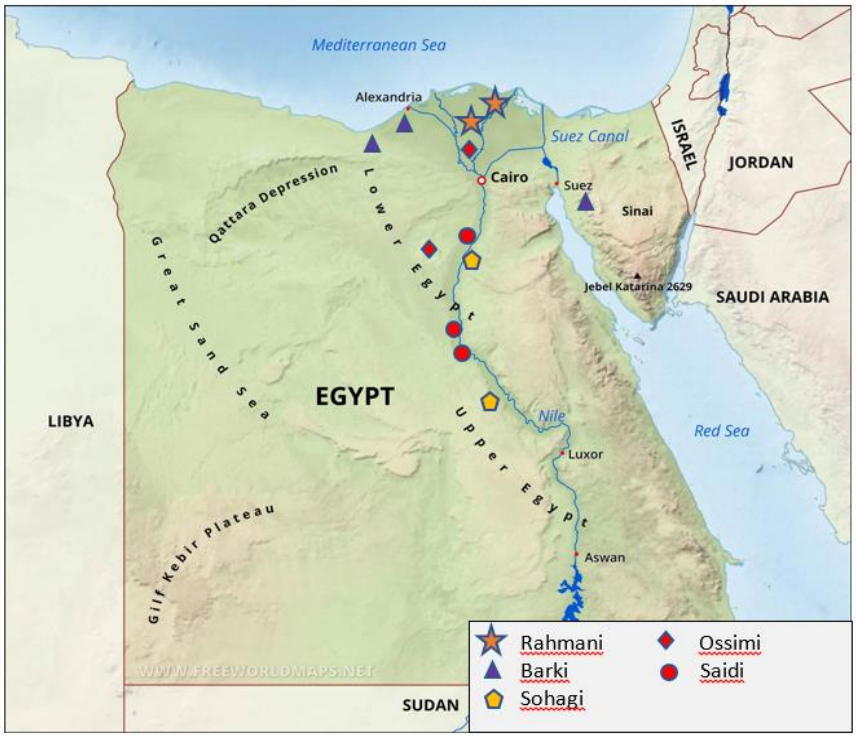

Figure 2. Geographical distribution of a diverse group of local Egyptian breeds of sheep.

Genetic resources for sheep breeding in Egypt

The ability to expand sheep production in Egypt depends on a myriad of factors. However, one of the major factors that determines the upper limit of productivity is the genetic make-up of available sheep breeds. It is therefore important to acquire an understanding of the sheep breed resources present in Egypt and how they can potentially be used to increase the production of meat and milk for human consumption. Both major and minor sheep breeds available in Egypt will be described below.

Major sheep breeds in Egypt

The three main breeds of sheep in Egypt are Rahmani, Ossimi and Barki; these breeds represent approximately 65% of the Egyptian sheep population (Elshennawy, 1995). Rahmani and Barki fat-tailed sheep are considered the predominant breeds in old cultivated lands regions around the Nile River in Egypt (and other middle eastern countries; Galal *et al.*, 2005). Fat-tailed sheep are hardy and adaptable; they successfully scavenge crop byproducts. When feed is ample and parasites are not burdensome, fat-tailed sheep can be impressive in size, growth, and conformation. These breeds are kept mainly for meat production (Abdel-Moneim, 2009; Hashem *et al.*, 2015). Carcass quality is good, with most body fat concentrated in the tail. These breeds are well adapted to local conditions, possess a small to medium frame size, and have a lambing rate ranging from 105% to 130%. Their fleece consists of coarse wool fibers.

The Rahmani is the largest breed, easily identifiable by its red wool and small ears; it is found in the central and northern delta regions. The Ossimi is a slightly smaller breed with white wool, and it is spread throughout the south delta and central Egypt regions. The Barki is the smallest breed; it possesses white wool and a brown neck and is the breed of choice for Bedouins in the desert. The distribution of the Barki breed extends from west of Alexandria to the eastern provinces in Libya, and it has a great ability to graze grass that grows naturally in the desert. These desert sheep are spread along the northwestern coast of Egypt in Matrouh governorate as well as in the desert areas west of the Nile.

Table 2 shows a comparison of the Rahmani, Ossimi, and Barki breeds with respect to various production traits.

Table 2. Comparisons among the Rahmani, Ossimi and Barki breeds of sheep in Egypt‡.

Production Trait	Rahmani	Ossimi	Barki
birth weight – males (kg)	3.4 - 4.7	3.64	3.5
birth weight – females (kg)	3 -4.2	3.06	2.3
growth rate (gm/day) from birth to weaning	144-172	115-137	120-152
weaning weight (kg) at 3 months	15	14	12
growth rate (gm/day) after weaning	89-169	60-80	120
female age at puberty (days)	270-295	275	347
female body weight at puberty (kg)	21.7-30	32	24-28
mature body weight of rams (kg)	65-75	60-65	50-60
mature body weight of ewes (kg)	50-55	45-50	40-45
fertility rate (%)	95	90-95	88
rate of twin births (%)	25-30	14.3	5
mortality rate at birth (%)	7.7	4.5-7	6.3
mortality rate - birth to 1 month (%)	12.5	10-18	6.3-16.6
mortality rate - birth to weaning (%)	14.6	11.8	16.6
fleece weight (kg)	1.50	1.25	1.1

(‡ adapted from El-Hommosi and El-Hafiz; 1982; Aboul-Naga *et al.*,1982; Aboul-Ela MB; Chemineau P., 1988; Almahdy *et al.* 2000; Galal *et al.*, 2005. Production traits where ranges are not reported indicate a lack of data from publicly available sources.)

Rahmani breed

Origin: The Rahmani breed originated in northern Syria and southern Turkey. The breed was first introduced into Egypt in the 19th century and is named after Rahmania, a village in the Beheira governorate in the north of the Nile delta.

Description: Rahmani sheep are reddish brown in color, with color fading with advancing age. They have a large head with curved nose, and the ear is pendulous or short and disappears in some individuals. Males have large helical horns, but horns are small or absent in females. The neck is short and the body is long. Animals have an oval fatty tail. The abdomen is characterized by very short wool, and below the knee the legs are free of wool. Figure 3 shows a typical ram and ewe of the Rahmani breed.

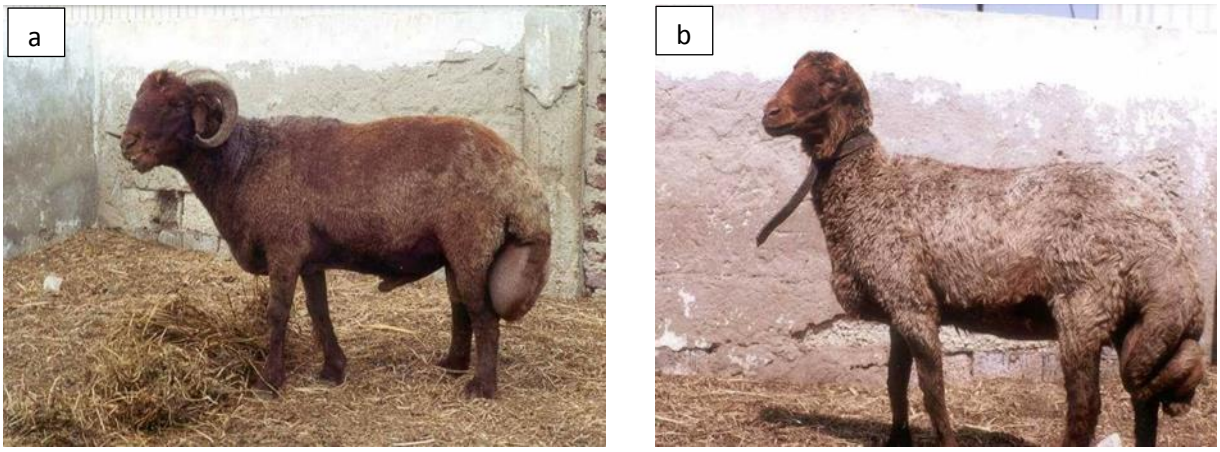

Figure 3. Typical appearance of rams (panel a) and ewes (panel b) of the Rahmani breed (photo credits: http://www.apri-arc.net/photos/1237984517)

Ossimi breed

Origin: The origin of the Ossimi breed is in the Giza Governorate, and the breed is named after Ossim, a village near Cairo in the north of Upper Egypt. The breed is the most popular one among the Nile valley and delta breeds, and the number of Ossimi sheep is expanding at the expense of other breeds. The breed is considered the most productive in middle Egypt, but the least productive in Southern Egypt.

.

Description: Ossimi sheep typically have a white fleece. The head is brown or dark brown (or occasionally black) and has a convex shape. The ear is semi-pendulous. Males possess horns, but horns are absent in females. The neck is short, and the body is long. Animals have an oval or round fatty tail weighing 2.5-4.0% of the animal's body weight. The neck, legs and abdomen usually have minimal wool. Figure 4 shows a typical ram and ewe of the Ossimi breed

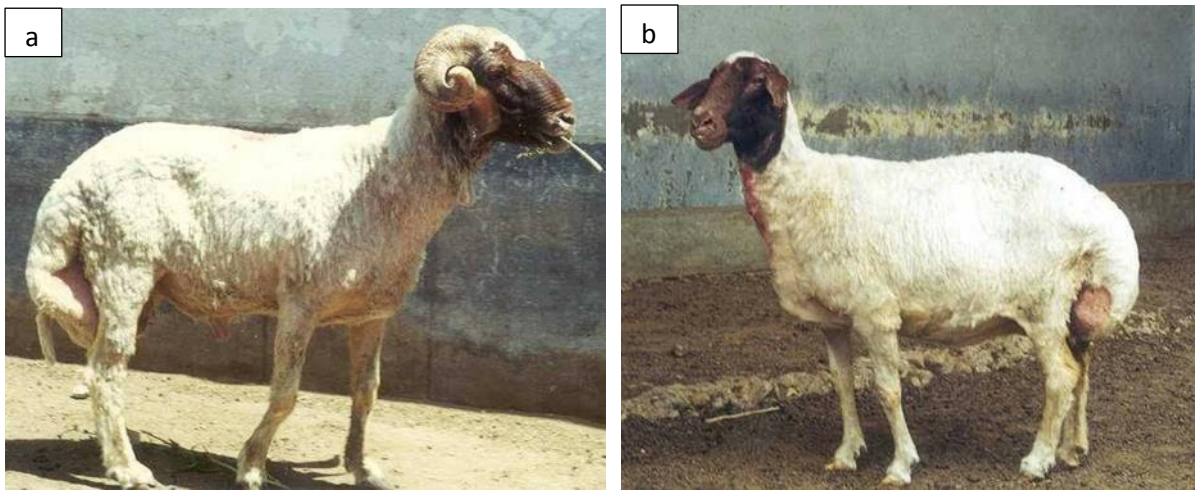

Figure 4. Typical appearance of rams (panel a) and ewes (panel b) of the Ossimi breed (photo credits: http://www.apri-arc.net/photos/1237984518)

Barki (Desert sheep) breed

Origin: The origin of the Barki breed, often referred to as a desert sheep, is in the coastal Mediterranean zone in North Africa. The breed is named after the Libyan province Barka (Cyrenaica).

Description: Barki sheep are a small to medium-sized breed. They are multi-colored, but usually possess coarse white wool that is softer than wool from Rhamani and Ossimi sheep. They usually have a small black, brown or white head with a straight nose, and the medium-sized ears are semi-pendulous. The males have horns, but horns are absent in females. The Barki has long thin legs (brown or black in color) that allows travel for long distances in search of grass. It has a triangular fatty tail. Figure 5 shows a typical ram and ewe of the Barki breed.

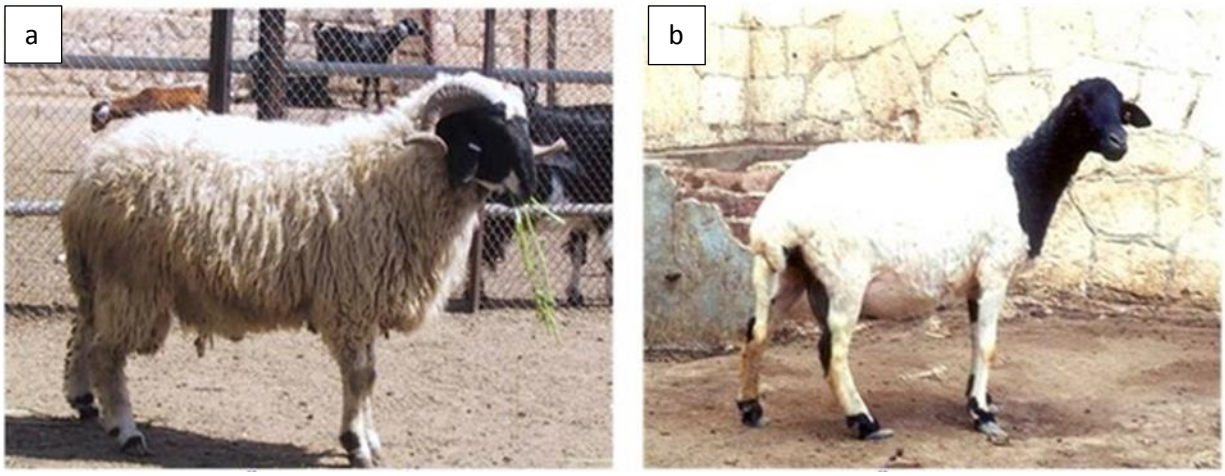

Figure 5. Typical appearance of rams (panel a) and ewes (panel b) of the Barki breed (photo credits: http://www.apri-arc.net/photos/1237984519).

Minor sheep breeds in Egypt:

In addition to the three major breeds of sheep already discussed, there are a number of other breeds which, based on their total number present in Egypt, would be classified by some as minor breeds. These less plentiful breeds (e.g., Abidi, Aboudleik, El-Adely, Fallahi, Farafra, Kanzi, Maenit, Saidi, Sanabawi, and Sohagi), however, do play a vital role in the regions where they are raised because they are well adapted to the local production conditions. Unfortunately, relatively few research studies have been conducted with these minor breeds to fully assess their production characteristics. A brief overview of some of these minor breeds – is provided below.

Saidi sheep

Origin/distribution: The Saidi sheep is found in Upper Egypt, especially in the Assiut governorate.

Description: The body color of Saidi sheep typically is black or dark brown (and sometimes creamy white). Occasionally individuals combine two colors. The head is large and covered with wool. It has a curved nose, and medium ears. The neck is long and has a pulp. In both males and females horns are often absent. The breed has a long cylindrical tail.

Production characteristics: The mature body weight averages 50 kg for rams and 35-40 kg for ewes. Average lamb birth weight ranges from 2.5 to 3.1 kg, and weaning weight averages 13 kg. Daily growth rate from birth to weaning averages 104 gm, and post-weaning daily growth rate averages 88 gm. Fertility rate of ewes ranges from 82 to 92%, and the percentage of twin births is 35%. Typical mortality rate at birth ranges from 4.5 to 7.0%, and mortality rate from birth to weaning is 10.0-18.2%. Figure 6 shows a typical ram and ewe of the Saidi breed.

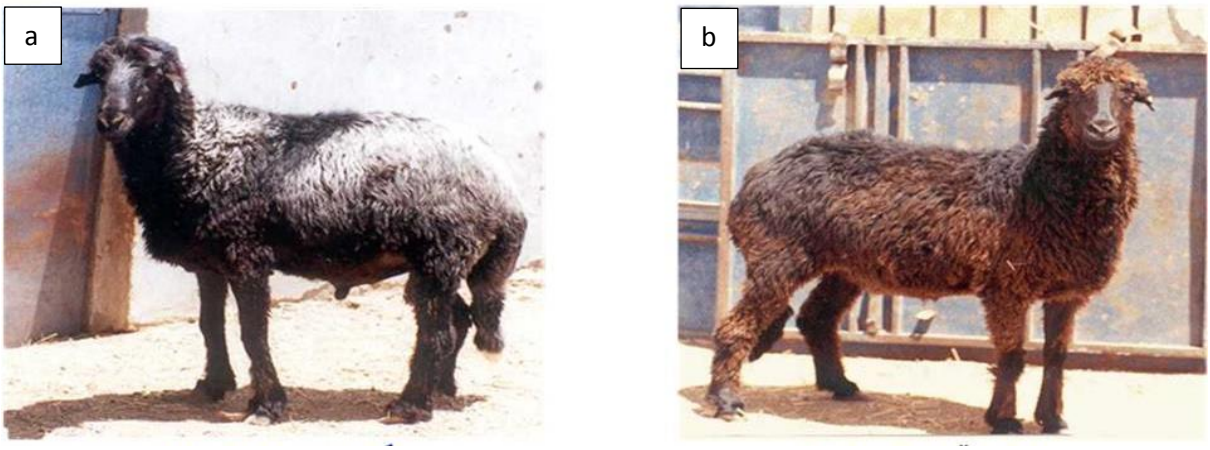

Figure 6. Typical appearance of rams (panel a) and ewes (panel b) of the Saidi breed (photo credits: http://www.apri-arc.net/photos/1237984520).

Farafra Oasis sheep

Origin/distribution: The Farafra sheep (or Farafra Oasis sheep) is a native breed commonly found in the El-Farafra Oasis of the western desert of Egypt where there is a lack of rainfall and average temperature is between 39.5°C and 11°C. It may have originated by crossing Ossimi sheep with desert sheep such as the Barki.

Description: The Farafra breed has a white fleece with a brown face. Males and females are typically polled. The breed has a long cylindrical tail.

Production characteristics: The mature body weight averages 45-50 kg for rams and 35-40 kg for ewes. Average lamb birth weight ranges is 2.5 kg, and weaning weight averages 15 kg. Fertility rate of ewes averages 90%, and the percentage of twin births ranges from 30% to 60%. Figure 7 shows a typical ram and ewe of the Farafra breed.

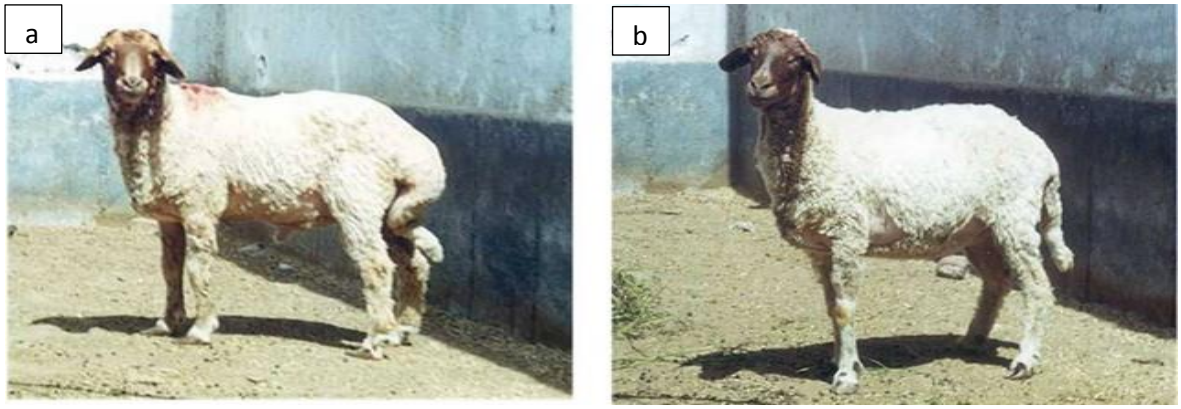

Figure 7. Typical appearance of rams (panel a) and ewes (panel b) of the Farafra breed (photo credits: http://www.apri-arc.net/photos/1237984521).

Fallahi sheep

Comparatively little is known about the Falahi breed of sheep. It is likely a result of mating Ossimi and Rahmani sheep with local breeds. The average ewe body weight is 45 kg, and rams are heavier. The head size is medium, and rams have medium-sized twisted and triangular horns. The medium-sized ear is semi-pendulous. The body color usually is brown (but sometimes black), and some animals exhibit overlapping colors.

Sohagi sheep

The Sohagi breed is found in southern Egypt in the governorate of Sohag. Body weight averages 60 kg for rams and 40 kg for ewes. It has a long neck and legs. The head is small, usually dark brown in color, but sometimes

Sohagi ram	Sohagi ewe
	

Figure 8. Typical appearance of a ram (left photo) and a ewe (right photo) of the Sohagi breed. Photo credits: https://www.tahrirnews.com/Story/306270/

creamy with black rings around the eyes. The rams often have horns.

El-Adely sheep

The breed was developed by Adel Said in his farm, and the name of the breed "El-Adely" was derived from the name of its founder (Mourad, 2008). The El-Adely sheep was developed from mating of selected local sheep with selected Ossimi sheep, followed by genetic selection for many generations. Inbreeding was also used to fix some favorable genes in the base flock. Two strains were produced from this breed – a high ovulation rate strain (HORS) and high milk yield strain (HMYS) for higher meat and milk production, respectively (Kayali *et al.* 2012).

Kanzi (or Dershawy) sheep

This breed is spread in the Red Sea, Halayeb and Shalatin areas. The body weight of ewes averages 40 kg. It has long legs covered with short hair plus a long head and convex nose (especially in rams). It has a cylindrical fatty tail, horns are small or often absent, and fleece color typically is dark brown or black.

Maenit sheep

This breed is the smallest sheep breed in the Red Sea, Halayeb and Shalatin regions (body weight of ewes averages 35 kg). The body is covered with short creamy hair, and it possesses a cylindrical tail.

Aboudleik sheep

This breed is one of the largest breed in the Red Sea, Halayeb and Shalatin areas. The body weight of ewes averages 45 kg. The body is covered with short hair, and the breed exhibits long legs covered with short hair. Animals have a long head and convex nose (the latter especially in rams), and ears are small (or nearly absent). Horns are small and can be absent, and animals possess a cylindrical tail. The color of the wool usually is dark cream or dark brown.

Risk status of sheep breeds in Egypt

The Domestic Animal Diversity Information System (DAD-IS) of the Food and Agriculture Organization (FAO) of the United Nations is an important source of information regarding livestock breed diversity. Breeds may be categorized as local breeds (found in only one country), regional transboundary breeds (found in two or more neighboring countries), or international transboundary

Figure 9. Typical appearance of ewes of the Kanzi (left photo), Maenit (middle photo) and Aboudleik (right photo) ewes. Photo credits: http://www.vercon.sci.eg/indexUI/uploaded/sheep/Image/sh3.gif

breeds (found in numerous countries in more than one region of the world). Of the 807 local livestock breeds in Africa listed in the DAD-IS database, 31 breeds are at risk of extinction, 71 breeds are not at risk, and the risk status of the remaining 705 breeds is unknown (FAO, 2019a). These data stress the need for better characterization of local sheep breeds in Egypt. Accurately assessing and monitoring the risk status of any breed is possible only when population sizes are known. Unfortunately, this information is often lacking for breeds of sheep in Egypt (as evidenced by the lack of data for many of the 12 breeds of sheep in Egypt that are listed in the DAD-IS database; FAO, 2019b).

In recent decades, there has been purposeful introgression of genes from exotic sheep breeds into local sheep breeds in an attempt to improve animal productivity. However, there has also been a limited and indiscriminate introgression of some exotic sheep genetics into local Egyptian sheep breeds because some exotic breed males sold for slaughter were not actually harvested but instead were purchased by sheep farmers and used as breeding sires for crossbreeding.

It is important that attention be paid to maintaining the diversity of sheep breeds in Egypt. If well-adapted local breeds become extinct, there may be an irreplaceable loss of unique and valuable genes that could hinder future sheep breeding efforts, particularly in the wake of climate change and diseases resistance. Breed conservation programs should be initiated and maintained, and such programs could be greatly enhanced by the use of assisted reproductive technologies (i.e., artificial insemination and embryo transfer).

Nutritional resources to support sheep breeding in Egypt

The geographical distribution of a diverse group of Egyptian breeds of sheep was shown in Figure 2. Close inspection of that figure reveals that some breeds are prevalent near a major source of water whereas other breeds are located in the desert. The nutritional resources available in those two different regions are quite different not only in terms of abundance but also with respect to nutritional (relative feed) value.

The availability of feed resources has a direct influence on the type of management system employed by sheep farmers. The most commonly utilized breeding system is an “open” system where rams co-mingle continuously with ewes; it is common for smallholder sheep farmers to send non-pregnant females to stay with shepherded flocks having rams until conception (and pay a breeding fee). In larger farms, two management systems applied for sheep production are: 1) a once-per year (annual) lambing system ; breeding from May 15 until August 15 (lambing mid-October to mid-January); lambs weaned at approximately 4 months of age, and 2) an accelerated mating system (three mating seasons every two years; 35-day mating seasons start May 15, January 15, and September 15; lambs weaned at approximately 2 months of age. In both systems, market lambs are sold at approximately 6 months of age (Aboul-Naga and Aboul-Ela, 1987). Shehata (2006) also described four different sheep production systems based on size of flock and available inputs: 1) village system, 2) new reclaimed areas system, 3) commercial flock system, and 4) rain-fed lands systems.

A major problem facing most sheep farmers is lack of feed. Although Egypt is capable of producing some of its own feed grains, it must import large quantities of grain because less than 3% of its land is arable (World Bank, 2019). Figure 10 provides an overview of available sheep nutritional resources.

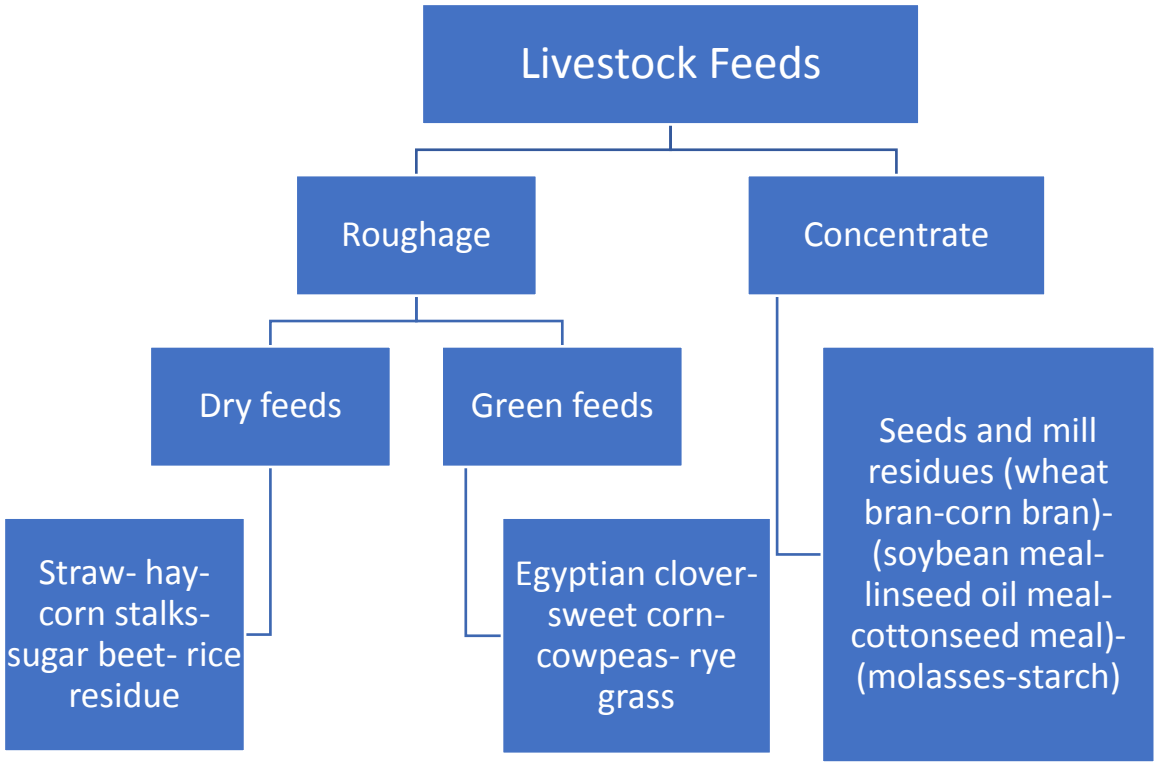

Figure 10. Overview of nutritional resources available for sheep production in Egypt (Dr. Abdelaziz Elhais, personal communication).

The sheep feeding system varies with changes in availability of green fodder. During the summer, green feed is scarce and concentrate feeding is common. Sheep are brought from the Western Desert to the Delta to graze crop residues, ditches and any other forage or fodder that can be found. Egyptian farmers are adept at utilizing feed resources. Common feedstuffs include the corn plant, wheat and barley straw, and pelleted feeds. During the late pregnancy and lactation periods ewes are supplemented with a pelleted concentrate mixture, starting with 0.5 kg/hd/day and increasing to 0.750 kg/hd/day. (The two weeks before the start of the breeding season, ewes undergo flushing by receiving 0.25 kg of concentrate.) The concentrate pelleted diet contains 68% ground corn, 15% wheat bran, 15% decorticated cottonseed meal, 1.5% calcium carbonate, and 0.5 % salt. A mineral and vitamin mixture is also provided.

When green fodder is available, well-managed ewes are typically fed 6 - 9 kg beerseem clover (*Trifolium alexandrinum*, a high moisture feedstuff) daily and are supplemented with 0.25-0.50 kg of hay in the morning and 0.25 kg of concentrate feed in the evening. When green fodder availability is limited, ewes are typically fed 4.5 kg of berseem clover daily and are supplemented with 0.250 kg of manufactured feed or barley (or a mixture of rice bran, maize, wheat bran, and germ). When there is no green fodder available (e.g., in the summer months), ewes are fed 1.5 kg derris (dried beerseem clover; if it is available), or 1 kg of chopped sorghum (green maize forage) in addition to manufactured feed or grain. It is also possible to fed them 0.5 kg derris + 0.5 kg hay + 0.75 kg gm concentrate feed (Dr. Adbelaziz

Elhais, personal communication). It should be recognized, however, that many farmers do not follow these feeding strategies, especially when the market price of slaughter lambs is low.

The valley breeds, Ossimi and Rahmani, are raised mainly on smallholder farms with 2-5 small ruminants and 1-2 large ruminants (cattle and buffaloes). Agriculture in this sector is characterized by a very intensive cropping system, fragmented landholdings (95 percent of the farms have less than 2 kirats, and an economy that is moving rapidly from subsistence to non-subsistence. Traditionally, livestock activities revolved around the utilization of berseem (Egyptian) clover (*Trifolium alexandrinum*), which is in relative abundance from October to May. Summer fodder crops have been introduced on a relatively moderate scale.

In the northwestern coastal strip where the Barki breed is raised, sheep owners live in communities along the coast and their sheep graze along the coastal strip (up to 20 km to the south) during the rainy season (October through April). Rainfall (100-200 mm annually) is meager and erratic, and natural vegetation is generally poor but varies according to the amount of rainfall. Sheep are managed either by the owner or by hired shepherds at the rate of one shepherd for every 150 sheep. Smaller flocks (owned by different people) frequently are combined into larger flocks as a single grazing flock for easier animal management. The grazing unit ranges from 300 to 500 mature ewes plus young sheep and the breeding males (Elshennawy, 1995).

Many of the sheep owners have orchards of figs, olives and almonds; they also grow barley. The sheep holdings under this system are much bigger than those in the valley, and owners have sheep flocks up to 2,000 head (which does not include their goats and camels). Sheep do not require much water during grazing, but in dry years they are confined near wells and water collection points.

During the dry months, especially in the region adjacent to the Nile delta, larger flocks move eastward and southward to the Nile delta and valley to access crop stubble and other available feed resources for grazing. Rice, wheat, and barley straw (the latter in desert areas when rainfall occurs) is also used during the summer months.

Egyptian sheep development program

Historically, Egyptian sheep farmers selected rams for heavier body weights, presence of horns and certain color patterns (e.g., dark red or brown head and neck in the Barki). Limited genetic selection has been practiced for ewe reproductive rate (Elshennawy, 1995).

Between 1974 and 1996, the Egyptian Ministry of Agriculture conducted a crossbreeding program (The Egyptian-Finnsheep Breeding Project) with the aim of improving the productivity of Rahmani and Ossimi sheep breeds through crossing with the highly prolific Finnsheep. Results of this project, however, showed little economic benefit from crossbreeding with Finnsheep to produce a ¼-Finn ¾-local breed genotype (Elshennawy, 1995). However, crossbreeding must not be overlooked as a vitally important tool to enhance productivity of sheep in Egypt. For example, crossbreeding with the Awassi breed has been recommended (Shehata, 2006). Other non-native breeds should also be evaluated to determine how best to enhance productivity of F_1 crossbred sheep.

Egyptian sheep researchers have recommended crossbreeding among the three local fat-tailed breeds (Rahmani, Ossimi, Barki) in commercial flocks for fattening purposes to capture breed complementarity and hybrid vigor (heterosis). They also suggested crossbreeding with outside breeds, but only if the exotic breed is adapted to the desert (because non-adapted exotic breeds [e.g., the Finn] have been tried in the past and have failed to be productive in the challenging desert environment). Crossbreeding of local Egyptian breeds should be performed with improved breeds characterized by a moderate reproductive or productive efficiency level; such exotic breeds should originate in an environment similar to that of the local breeds (Marai *et al.*, 2009). In semi-intensive production systems where sheep are fed harvested feeds (and do not rely on grazing), it is possible that productive breeds which are not

adapted to desert conditions could make an important contribution.

At present, there is no national comprehensive sheep breeding program in Egypt. The lack of such a program represents a tremendous opportunity for the Egyptian sheep industry. Although development of a national sheep genetic improvement program may seem like a large and insurmountable task, government research institutes and universities can provide leadership in such an effort. Adoption of a standardized record keeping system for sheep flocks managed by research institutes and universities could provide an opportunity to perform genetic evaluations and subsequently identify genetic superior rams and ewes.

Once genetically superior rams and ewes have been identified, assisted reproductive technologies (i.e., artificial insemination and embryo transfer) could be utilized to more rapidly propagate the superior genetics. Use of these reproductive technologies would also permit the much-needed across-flock genetic ties that are integral for comprehensive and accurate genetic evaluations. Although these reproductive biotechnologies would not be practical to use under field conditions (at the farmer level), they could be used under controlled experimental conditions to breed rams that are subsequently sold to smallholder farmers for use in crossbreeding with their locally adapted sheep.

Incorporation of artificial insemination (AI) and embryo transfer (ET) into the sheep breeding programs at government research institutes and universities would constitute an important first step in the transformation of Egypt's sheep industry. Although the technical expertise to incorporate AI and ET into sheep breeding programs already exists to a certain extent in Egypt, it is likely that additional financial investment in technical training and equipment purchases will be needed to accelerate the pace at which these technologies can be more widely adopted.

CONCLUSIONS

A variety of different sheep breeds exist within Egypt, and the locales in which these breeds are raised is largely a function of available nutritional resources. There is a strong need to increase production of meat and milk from sheep in Egypt, and propagation of the most productive animals in each of the different sheep-rearing environments (e.g., desert and river valley) can be facilitated by use of the two major reproductive biotechnologies of artificial insemination and embryo transfer.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the technical assistance of Prof. Dr. Sherif A. Gabr and Prof. Dr. Abdelaziz Elhais (both from Tanta University in Tanta, Egypt), as well as Prof. Dr. Tarek A. Mahmoud and Dr. Abdelaziz M. Sakr (both of the Animal Production Research Institute in Cairo, Egypt).

Partial financial support of this work by the United States Department of Agriculture (USDA) multi-state research project W-3171 "Germ Cell and Embryo Development and Manipulation for the Improvement of Livestock" is gratefully acknowledged.

REFERENCES

Abdel-Moneim, A.Y. 2009. Body and carcass characteristics of Ossimi, Barki and Rahmani ram lambs raised under intensive production system. Egypt. J. Sheep Goat Sci., 4: 1-16.

Aboul-Ela M.B., and Chemineau P. 1988. Seasonality of reproductive activity in native sheep and goat breeds and their crosses with introduced breeds. In: (Aboul-Naga AM, Ed.) Small Ruminants Research and Development in the Near East. Proceedings of a workshop held in Egypt, Cairo, 2-4 November1988. International Development Research Center, Ottawa, Ontario, Canada. pp.74-87.

Aboul-Naga, A. M., and M. B. Aboul-Ela. 1987. Performance of subtropical Egyptian sheep breeds, European breeds and their crosses. I. Egyptian sheep breeds. World Rev. Anim. Prod. 23:75−82.

Aboul-Naga, A.M, F. Siwdan, T.H. Shalaby, and A. Abbas. 1982. Growth and puberty performance in early weaned Rahmani ewe lambs. Proc. 6th Int. Conf. Animal & Poultry

Production, Zagazig, Egypt, September 21-23, pp. 201-215.

Almahdy, H., Tess, M. W., El-Tawil, E., Shehata, E., & Mansour, H. 2000. Evaluation of Egyptian sheep production systems: II. Breeding objectives for purebred and composite breeds. Journal of Animal Science 78 (2): 288-295. doi: 10.2527/2000.782288x

El-Hommosi, F.F., and G.E. El-Hafiz. 1982. Reproductive performance of Ossimi and Saidi sheep under two pubertal planes of nutrition. Assiut Veterinary Journal 10(19):61-66.

Elshennawy M. 1995. Sheep development program in Egypt. In: (Gabiña D., Ed.). Strategies for Sheep and Goat Breeding . Zaragoza : CIHEAM, 1995. p. 27-32. (Cahiers Options Méditerranéennes; n. 11). Meeting of the joint FAO/CIHEAM Network on Sheep and Goats, Subnetwork on Animal Resources, 1995/03/26-28, Sidi-Thabet (Tunisia). http://om.ciheam.org/om/pdf/c11/96605538.pdf

FAO, 2019a. Domestic animal diversity information system (DAD-IS). Downloaded January 27, 2019 from http://www.fao.org/dad-is/en/

FAO. 2019b. Breed data sheep for sheep in Egypt. Downloaded January 27, 2019 from http://www.fao.org/dad-is/browse-by-country-and-species/en/

FAOSTAT. 2018. Live animals. Downloaded December 5, 2018 from http://www.fao.org/faostat/en/#data/QA

Gabr, A.A., N.A. Shalaby and M.E. Ahmed. 2016. Effect of ewe born type, growth rate and weight at conception on the ewe subsequent productivity of Rahmani sheep. Asian J. Anim. Vet. Adv., 11: 732-736.

Galal, S., F. Abdel-Rasoul, M. R. Anous, and I. Shaat. 2005. On station characterization of small ruminant breeds in Egypt. In: (Iniguez, L.C.,Ed) Characterization of Small Ruminant Breeds in West Asia and North Africa, Vol. 2, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, pp: 141-193.

Hashem, N.M., K.M. El-Azrak, A.N.M. Nour El-Din, T.A. Taha and M.H. Salem., 2015. Effect of GnRH treatment on ovarian activity and reproductive performance of low-prolific Rahmani ewes. Theriogenology 83(2):192-198.

Kayali, I., Rashed, M., & Anous, M. 2012. Molecular genetic fingerprinting for new selected Egyptian sheep strains in relation to Ossimi breed. Egyptian Journal of Genetics and Cytology, 41(2):297-310. doi:10.21608/ejgc.2012.10543.

Marai, I. F. M., A. H. Daader, and L. B. Bahgatal. 2009. Performance traits of purebred Ossimi and Rahmani lambs and their crosses with Finnsheep born under two accelerated mating systems. Archives Animal Breeding, 52(5):497-511, doi:10.5194/aab-52-497-2009.

Maryland Small Ruminant Page, www.sheepandgoat.com/egypt?lightbox=i220c0.

Mourad, M. (2008). El-Adely: A new sheep breed in Egypt. Animal Science Reporter, Vol 2, Issue 3.

Shehata, E.I. 2006. Production systems of small ruminants in Egypt. Egyptian Journal of Sheep, Goat and Desert Animals Sciences 1(1):37-44.

Soliman, M. 2018. Food security in Egypt. Downloaded December 5, 2018 from www.njf.nu/assets/490/7-Food-security-in-Egypt.pdf

United Nations Development Programme, 2018. Human Development Report 2018. UNDP, New York, p. 199. Downloaded December 5, 2018 from http://www.hdr.undp.org/en/countries/profiles/EGY

United States Agency for International development (USAID). 2018. Agriculture and food security. Downloaded December 5, 2018 from https://www.usaid.gov/egypt/agriculture-and-food-security

Word Bank. 2018a. Egypt GNI per capiat, Atlas method (current US$). Downloaded December 5, 2018 from

https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=EG

World Bank. 2018b. GINI index (World Bank estimate). Downloaded December 5, 2018 from https://data.worldbank.org/indicator/SI.POV.GINI?locations=EG

World Bank. 2019. Arable land (% of land area). Downloaded January 27, 2019 from https://data.worldbank.org/indicator/AG.LND.ARBL.ZS?locations=EG

World Food Programme, 2018. WFP Egypt country brief. Downloaded December 5, 2018 from http://www1.wfp.org/countries/egypt

World Population Review. 2018. Egypt population 2018. Downloaded December 5, 2018 from http://worldpopulationreview.com/countries/egypt-population/

\