EAZA Reptile Taxon Advisory Group

Best Practice Guidelines for the Egyptian tortoise (*Testudo kleinmanni*)

First edition, May 2019
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EAZA Preamble

Right from the very beginning it has been the concern of EAZA and the EEPs to encourage and promote the highest possible standards for husbandry of zoo and aquarium animals. For this reason, quite early on, EAZA developed the “Minimum Standards for the Accommodation and Care of Animals in Zoos and Aquaria”. These standards lay down general principles of animal keeping, to which the members of EAZA feel themselves committed. Above and beyond this, some countries have defined regulatory minimum standards for the keeping of individual species regarding the size and furnishings of enclosures etc., which, according to the opinion of authors, should definitely be fulfilled before allowing such animals to be kept within the area of the jurisdiction of those countries. These minimum standards are intended to determine the borderline of acceptable animal welfare. It is not permitted to fall short of these standards. How difficult it is to determine the standards, however, can be seen in the fact that minimum standards vary from country to country.

Above and beyond this, specialists of the EEPs and TAGs have undertaken the considerable task of laying down guidelines for keeping individual animal species. Whilst some aspects of husbandry reported in the guidelines will define minimum standards, in general, these guidelines are not to be understood as minimum requirements; they represent best practice. As such the EAZA Best Practice Guidelines for keeping animals intend rather to describe the desirable design of enclosures and prerequisites for animal keeping that are, according to the present state of knowledge, considered as being optimal for each species. They intend above all to indicate how enclosures should be designed and what conditions should be fulfilled for the optimal care of individual species.

Citation: De Boer, M., Jansen, L., Stumpel, J., (2019). EAZA Best Practice Guidelines for the Egyptian tortoise (*Testudo kleinmanni*) – *First edition*. European Association of Zoos and Aquaria, Amsterdam, The Netherlands

DOI: 10.61024/BPG2019EgyptianTortoiseEN

Summary

This is the first version of the EAZA Best Practice Guidelines of the Egyptian tortoise, *Testudo kleinmanni*. These guidelines are composed by different sources. Several sources available in literature and experiences of experts in keeping this species have contributed by filling out a questionnaire to obtain these guidelines. The complete literature list can be found at the end of this document.

Although these guidelines provide information about keeping the Egyptian tortoise in captivity, the guidelines also help prevent extinction of this species. This document consists of two sections:

- **Section 1. Biology and field data:** this part reflects the taxonomic information and information about the Egyptian tortoise in its natural habitat (includes behaviour, diet and reproduction);
- **Section 2. Zoo management:** this part includes suggestions about the enclosure, feeding, social structure, breeding, handling, transportation and veterinary problems of the Egyptian tortoise.

These Best Practice Guidelines are for keepers of the Egyptian tortoise who wish to expand their knowledge about this species to take care of the animals in the best possible way. For this reason, it is recommended to consult the guidelines and to contact the TAG-members for any questions or problems.

Acknowledgements

We would like to thank the colleagues and other experts who have contributed to compose these Best Practice Guidelines by sharing their experiences in keeping the Egyptian tortoise, *Testudo kleinmanni*. A special thanks to Matt Goetz (Durrell Wildlife Conservation Trust / Jersey Zoo) for the extensive review and providing additional information.

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Content

Section 1. Biology and field data

1.1 Taxonomy

1.1.1 Order
The Egyptian tortoise, *Testudo kleinmanni*[39], is placed in the order of Testudines[36].

1.1.2 Family
The Egyptian tortoise belongs to the family of Testudinidae[36].

1.1.3 Genus
The genus of the Egyptian tortoise is *Testudo*[36].

1.1.4 Species
The genus *Testudo* consists of five species[38]:
1. *Testudo graeca* (Spur-thighed tortoise);
2. *Testudo hermanni* (Hermann's tortoise);
3. *Testudo horsfieldii* (Horsefield's tortoise);
4. *Testudo kleinmanni* (Egyptian tortoise);
5. *Testudo marginata* (Marginated tortoise).

In 2001, the Egyptian tortoise was split into two different species, *Testudo kleinmanni* and *Testudo werneri.* These species were based on differences in the shell markings and morphology. However, through morphometric analysis, molecular evidence and the normal variation between the populations it was confirmed that *Testudo werneri* should not be treated as a separate species but a synonym of *T. kleinmanni*[3,52].

There is an article available of Joshi (2012) with a detailed description of the phylogenetic status and the sequence divergence of the different species of the Testudinidae family and an article of van der Kuyl, Ballasina, Dekker, Maas, Willemsen & Goudsmit (2002) of the phylogenetic relationships of the different species of the *Testudo* genus.

1.1.5 Subspecies
There is no subspecies for the Egyptian tortoise.

1.1.6 Common names
There are several common names of the Egyptian tortoise (Table 1)[17].

Table 1. Common names of the Egyptian tortoise in Latin, English, French, German, Italian and Spanish (CITES, n.d.).

Scientific name	English	French	German	Italian	Spanish
Testudo kleinmanni	Kleinmann's tortoise, Egytian tortoise	Tortue de Kleinmann, Tortue d'Egypte	Ägyptische Landschildkröte	Testuggine di Kleinmann, Tartaruga egiziana	Tortuga de Plastrón Articulado

1.2 Morphology

1.2.1 Measurements

The Egyptian tortoise, *Testudo kleinmanni*, is the smallest species of the genus *Testudo*[20,31,42] and one of the smallest terrestrial tortoise species of the world[15,27,44,53,54]. The most obvious and distinguishing characteristic of the Egyptian tortoise is the small size[34]. The carapace of the Egyptian tortoise is measured with a vernier caliper[26] (straight carapace length; Fig. 1). The average length of an adult is 100 mm and the weight of an adult is 200 grams[54]. The average weight of the juveniles is 100 grams[31]. Other measurements are given (Table 2).

Table 2. Average carapace length and average and maximum weight of females and males of the Egyptian tortoise.*

	Females	Males
Average carapace length	110 – 125 mm[1] 90 – 127 mm[2] 125 mm[6]	100 – 115 mm[1] 95 mm[5] 100 mm[6] 105 mm[7]
Average weight	300 grams[2] 260 grams[4] 350 grams[6]	150 grams[2] 157 grams[4] 200 grams[6,7]
Maximum weight	350 – 450 grams[3]	160 – 215 grams[3]

**1= Blake& Sherrif & Skelton, 1996; 2= Bruekers, 1995; 3= Dathe, 2003; 4= Grano, 2013; 5= Highfield & Martin, 2001; 6= Mendelssohn & Geffen, 1995; 7= Stettner, 2006.*

Farkas *et al.* (1997) reported a female (Fig. 2) with a carapace length of 144 mm.

Figure 1. Straight line measurements with a vernier caliper (Zwartepoorte, 2015).

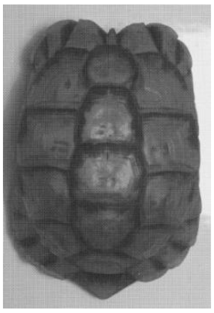


Figure 2. Record-sized female of the Egyptian tortoise (Farkas, Sasvári & Buskirk, 1997).

The plastron of the females are larger than males (Table 3)[34,41,42,44]. This is probably to improve the egg production. The small size of the males could be driven by the accessibility to females and reduced detection by potential predators[41].

Table 3. Mean and maximum Plastron Length (PL) (Macale et al., 2009).

	Juveniles	Females	Males
Mean PL	64.63 mm	108.24 mm	102.53 mm
Maximum PL	98.44 mm	149.54 mm	124.55 mm

There is an article available of Macale, Venchi & Scalici (2011) with a more detailed description of the size variation and the shell shape of the Egyptian tortoise.

The Egyptian tortoise has a rapid juvenile growth phase untill an age of eight to ten years followed by a slow and continuous adult growth phase (Fig. 3)[41].

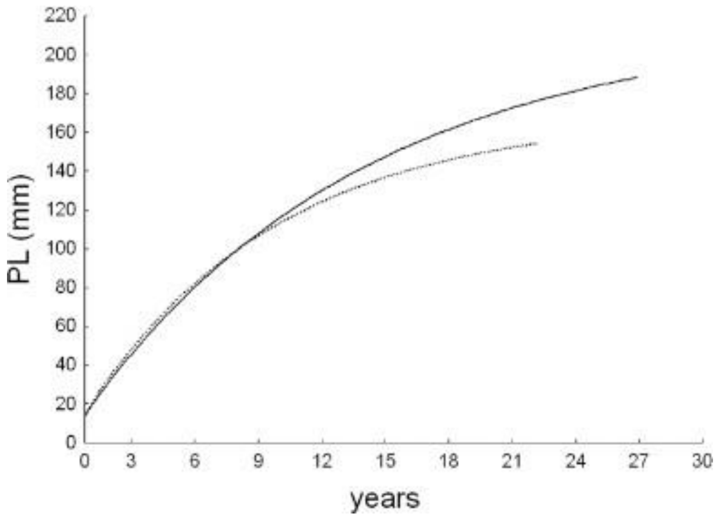
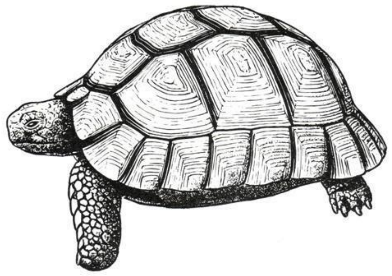
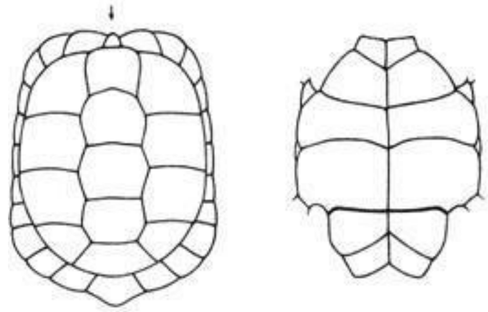
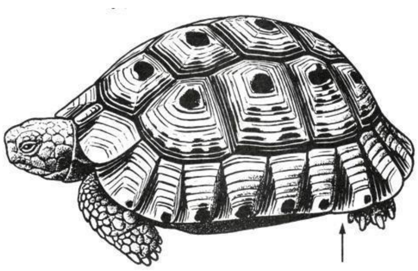
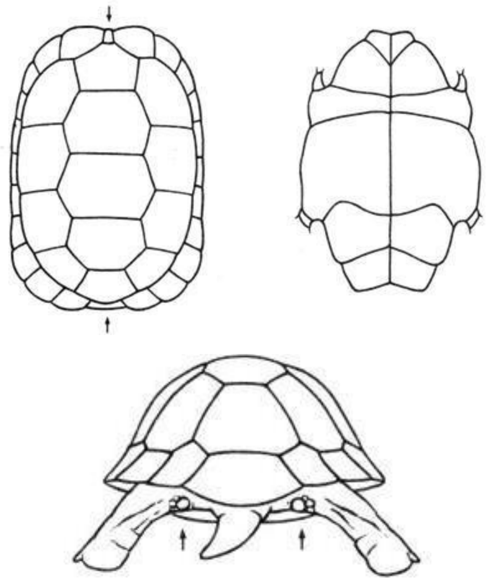
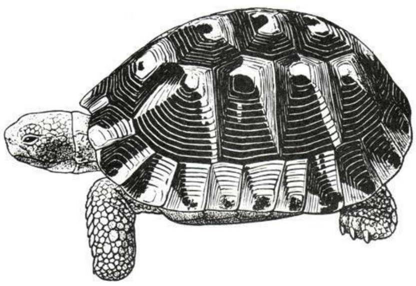
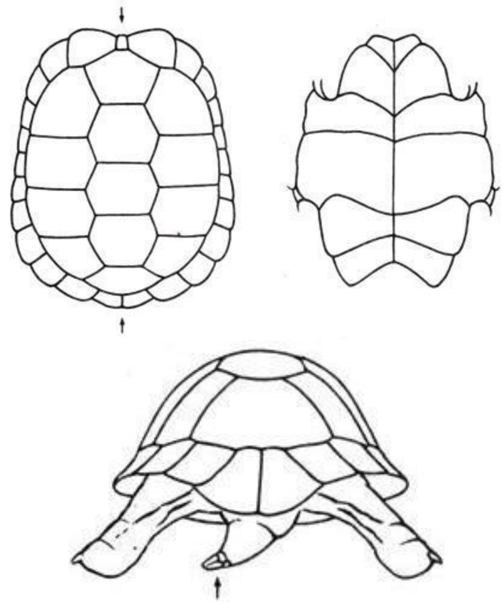


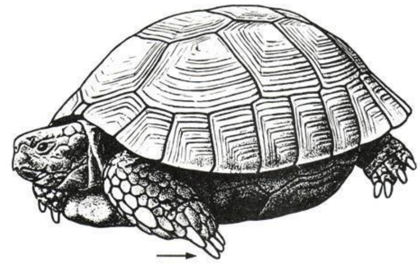
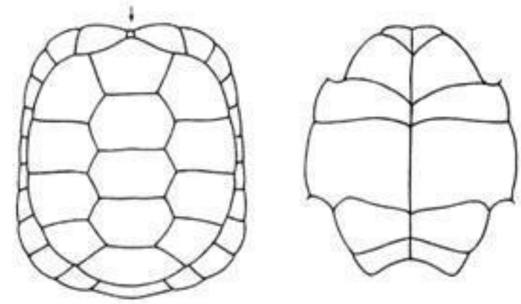
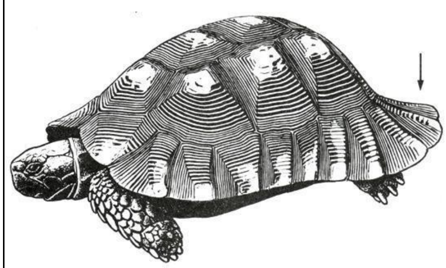
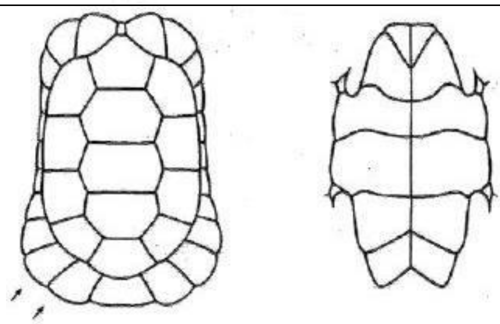
Figure 3. Growth curves of the females (continuous line) and males (dotted line) of the Egyptian tortoise (PL = Plastron Length) (Macale, Scalici & Venchi, 2009).

1.2.2 General description

The differences between the Egyptian tortoise, *Testudo kleinmanni,* and other *Testudo* species are clearly demonstrable (Table 4).

Table 4. Similar species of the Egyptian tortoise, Testudo kleinmanni (CITES, n.d.).

Name	Picture	Characteristics
Testudo kleinmanni		
Testudo graeca		
Testudo hermanni		

Testudo horsfieldii		
Testudo marginata		

Carapace

The carapace of the Egyptian tortoise is moderately[17,54] domed[53,56] with the highest point clearly behind the middle of the carapace[53]. The carapace is oval shaped[17,53,54] which is deeply notched in the nuchal region[40,54]. The carapace is usually yellow or straw-coloured.

Plastron

The plastron is completely yellow[49], pale straw-coloured[34,53], greenish yellow[40] or generally brown-yellow with only two black or brown 'V-shaped' triangular spots on the abdominal shields and the narrow ends pointing backwards [14,15,20,34,40,44]. However, these spots may also be missing. The plastron has rarely no ventral markings[44]. The triangular markings are distinct features that distinguish *Testudo kleinmanni* from other, similar species. There are Egyptian tortoises with entirely unmarked plastrons, but this is atypical for these tortoises (Fig. 4)[34].

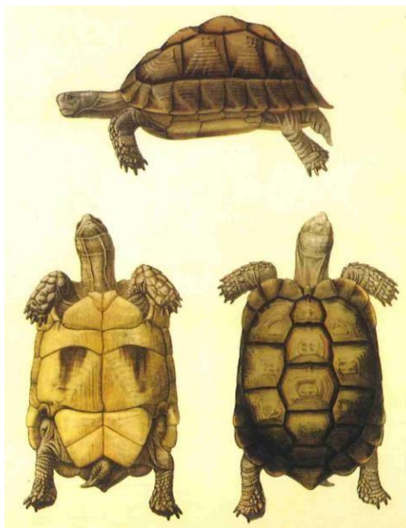


Figure 4. The characteristics of the Egyptian tortoise, Testudo kleinmanni (Devaux, 1997).

The posterior or rear part of the plastron (xiphiplastron) is moveable in both sexes of the Egyptian tortoise[15,20,40,49,53]. The scales on the front limbs are quite large and usually divided into three rows[15,44,49,54]. The supracaudal shield of the Egyptian tortoise is not divided[40].

Head, limbs and tail

The head of the tortoise is moderate in size with a non-protruding snout and an upper jaw which is weakly hooked and brown-coloured. The colour of the head is yellowish brown[56] or ivory to pale yellow[34]. Most Egyptian tortoises have a marking on top of their head which is black[14].

The colour of the limbs is ivory, pale yellow[34] or yellowish brown[56].
The Egyptian tortoise lacks conical scales (spores) on the relatively thin thighs. The large scales on the strong front limbs, which usually consist of three or four rows, are also a distinguishing feature[15,34,40,53,56]. Both front limbs and hind limbs have five claws[49,53].
The tail scute (supracaudal) is often not divided, but tortoises with a divided tail scute exist[15].
Egyptian tortoises have no nail on the tip of their tail[54]. The tails of the males is thicker and longer than those of females[18,53,56].

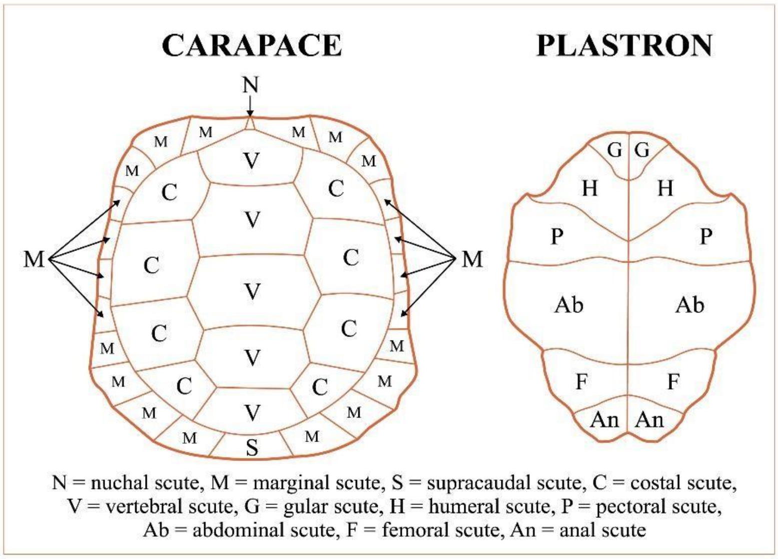


Figure 5: General description of the carapacial and plastral scules of a tortoise, source: Shutterstock.

Juveniles
Hatchling Egyptian tortoise differ from older individuals by their colouring. Hatchlings have a brown-spotted pattern on the carapace which is lost during the course of a few months[27].

There is an article available of Delfino, Chesi and Fritz (2009) with a more detailed description of shell morphology of the Egyptian tortoise. There is also an article available of Saber & Kamal (2010) with a detailed description of the species' respiratory organs.

1.3 Physiology
There are not many data available on the normal physiology of the Egyptian tortoise. They body temperature is dependent on the environmental temperature (see paragraphs 1.5.2 and 2.1.4).

1.4 Longevity
The estimated maximum lifespan of Egyptian tortoises in captivity is 26.29 years for females and 22.18 years for males, based on 248 animals[41]. There is no data available of the maximum lifespan is of the Egyptian tortoise in the wild. However, based on knowledge about similar *Testudo* species, the assumption can be made that the maximum longevity of *Testudo kleinmanni* is much longer.

A common method for determining the age of a young tortoise is counting the shell growth rings of the animal. The shell growth rings of the females of the Egyptian tortoise are more visible, larger and easier to distinguish, because the females have a larger carapace. The carapace of male Egyptian tortoises are smaller, so the rings are closer together, shorter and more difficult to distinguish. When adults become older and larger, it is more difficult to determine the age of the tortoise. Most of the individuals with a carapace length below 90 mm (75 per cent) exhibit a shell growth ring per year. Counting the shell growth rings is relatively reliable for determining the age of a tortoise with an age of five years or younger and the threshold age of an animal for a reduced reliability is around the age of six. The growth shell rings may stop or become unreadable when growth slows down and when tortoises become mature. This means that counting rings of the Egyptian tortoise is a reliable method for animals with an age of five years or younger or with a carapace length below 90 mm. This method is unreliable for larger and sexually mature Egyptian tortoises[7] and for captive-raised individuals which have not experienced very regular annual climatic variation.

1.5 Zoogeography and ecology

1.5.1 Distribution

The limited range of the Egyptian tortoises lies within the Mediterranean Basin[6,54] from Libya through northwestern Egypt (North Coast and North Sinai) to the Negev Desert in Israel (figure 6). Egyptian tortoises are usually observed within 60 km or sometimes within 80 or 100 km from the Mediterranean sea[22,44,53]. Further inland the climate becomes too dry for this species[54,56].

Until several years ago, the Egyptian tortoise's range occupied an area over 120.000 km^2 [31,45]. In 2003 this area did not exceed 16.600 km^2.. Due to severe pressures and several threats the species has been eradicated from large areas in Egypt[11].

Figure 6. The distribution of the Egyptian tortoise. Yellow = unknown, false or dubious distribution; orange = confirmed range (Devaux, 1997).

1.5.2 Habitat

The Egyptian tortoise inhabits desert and semi-desert habitats. The environment of this species is dominated by extreme climatic conditions. Sandy areas with sparse vegetation is inhabited, where the animals are confronted with high temperatures[15,29,30,31,54,58]. During the hot and dry season (June to September), the vegetation is completely dry and water is almost unavailable[20].

The characteristics of the habitat of the Egyptian tortoise is without any trees or bushes, and is dominated by shrubs of the species *Artemisia monosperma*. Furthermore there are sandstone areas and a sparsely vegetated steppe landscape[49,50].

An article by Schneider & Schneider (2008) is available listing several shrubs occurring in the habitat of the Egyptian tortoise in Libya.

The climate in this area is strongly influenced by the Mediterranean Sea. The seasons are very distinct, with relatively wet and cool winters and dry and hot summers[16,49,53]. Rainfall occurs in the winter and averages 200 mm per year, but can be as little as 50mm[16,49] (figure 7).

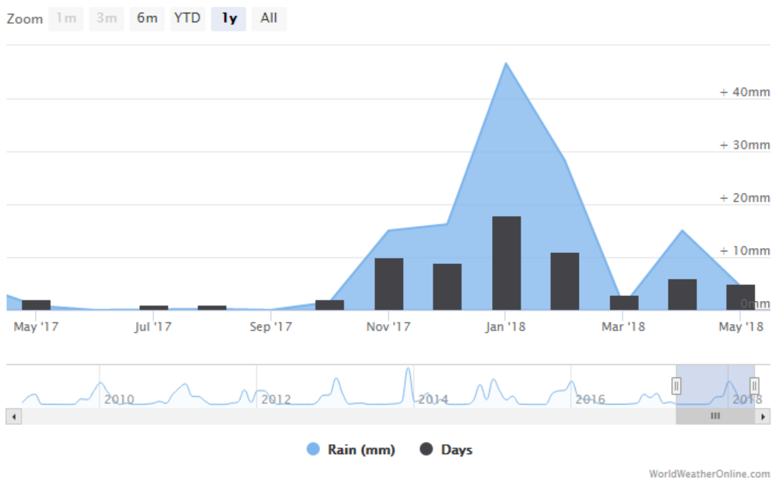


Figure 7. Precipitation chart of El' Arish (Sinai, Egypt).

The mean air temperature in the habitat of the Egyptian tortoise is 25°C with the mean minimum temperature of 16°C in the winter and the mean maximum temperature of 33°C in the summer (especially in July). In the winter, sub-zero temperatures may occur but they are rare in this area. In summer, temperatures can reach 40°C and the soil surface can be around 60°C[44]. The differences of the temperature between day and night is 8 to 10°C[53].

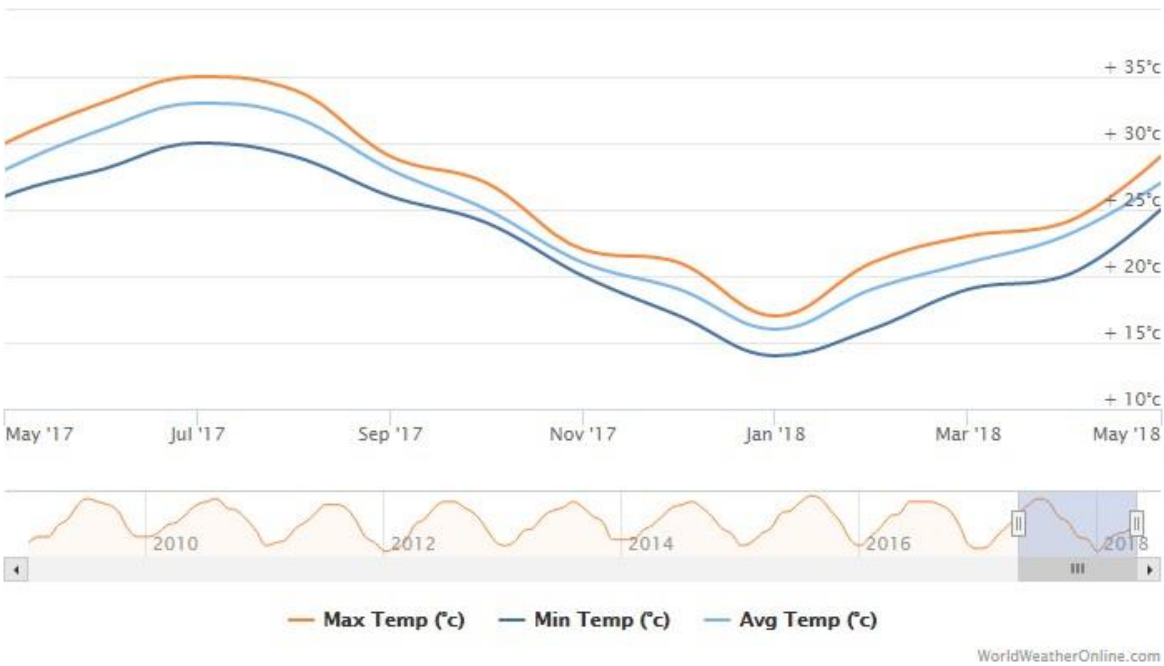


Figure 8. Temperature chart of El' Arish (Sinai, Egypt).

1.5.3 Population density

By the end of 1990, the Egyptian tortoise appeared to be virtually and technically extinct in Egypt, but in 2000 a small population of the Egyptian tortoise was found in North Sinai (in the Zaranik Protected Area)[58] with a density of about four to five tortoises per km^2 [56]. These low densities do not constitute a viable population and there is no suitable habitat for these animals[11,50,56,58].

The distribution and the status of the Egyptian tortoise in Libya is unclear and there are no published data[16,50,56]. Because of the ongoing conflict among rival factions seeking control of the territory and oil of Libya, research on population density and distribution is almost impossible.

1.5.4 Conservation status

Since November 1994, the Egyptian tortoise, *Testudo kleinmanni*, is included in the list of species regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I. In the Red List of Threatened Species IUCN, this species is rated as 'Critically Endangered' (Fig. 9).

Figure 9. Status of the Egyptian tortoise, Testudo kleinmanni (IUCN, 2003).

The status of the Egyptian tortoise has changed during the past years (Table 5)[36].

Table 5. Status of the Egyptian tortoise, Testudo kleinmanni (IUCN, 2003).

Year	Status
1982	Indeterminate (I)
1986	Indeterminate (I)
1988	Vulnerable (V)
1990	Vulnerable (V)
1994	Vulnerable (V)
1996	Endangered (EN)
2001	Critically Endangered (CR)

In 1997, 300 Egyptian tortoises from Libya were seized from the pet trade. These animals were transferred to Tortoise Care Egypt with the expectation of creating a conservation program for this species[2].
In October 2005, at the Naples airport in Italy, a suitcase arrived with the incredible content of 274 Egyptian tortoises. The animals were seized by the agents of the State Forestry Corps and were entrusted to the care of the reptiles department of the Bioparco Foundation of Rome[31].
In November 2007, 370 Egyptian tortoises were illegally imported from Libya to Italy, packed in suitcases. The animals were seized by the authorities at the airport. Unfortunately, these tortoises all died due to stomatitis and rhinitis after the confiscation in Italy[43].

Since the year 2000, breeding programs of the European Studbook Foundation (ESF) and the European Association of Zoos and Aquaria (EAZA) have been founded. In North Sinai, in the Zaranik

Protected Area, a project has been established for recovering the Egyptian tortoise. Linking the ex-situ breeding programs to the in-situ project forms the base for the recovery and conservation in Egypt of the Egyptian tortoise.
The aim for the near future in Israel and Libya is to establish measures for the recovery programmes for the Egyptian tortoise. With the involvement of the locals in the habitat of the tortoise, the Egyptian government and the assurance colonies of the ESF- and EAZA EEP-studbooks, the basis has been laid for a successful and feasible future recovery of this critically endangered species[58].

1.5.5 Threats

Habitat destruction, intensive commercial collection for the pet trade and overgrazing by goats and sheep (Fig. 10 & Fig. 11) are the three main factors for the disappearance of the Egyptian tortoise throughout their range[5,10,11,16,28,44,50,53,54,56,57,58].

Figure 10. Intact habitat of the Egyptian tortoise (Mendelssohn & Geffen, 1995).

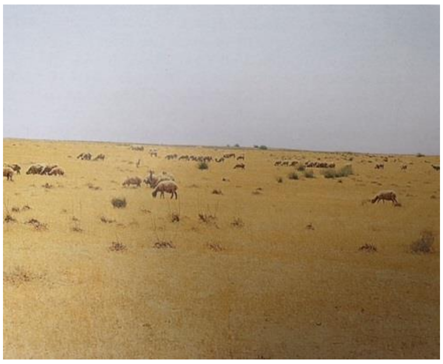


Figure 11. Overgrazed habitat of the Egyptian tortoise (Mendelssohn & Geffen, 1995).

During the first half of the twentieth century, a lot of Egyptian tortoises were collected from areas of Egypt for the pet trade in Europe. The trade continued until the seventies when the Egyptian tortoise was extirpated from large areas of the North Egyptian coast[11].
The market in Cairo (Saiyyida Aisha market) is a centre for the illegal pet trade[33,56].

1.6 Diet and feeding behaviour

1.6.1 Food preference

Annuals, which grow exuberantly after the first rainy periods in Autumn, are the main and major food item for the Egyptian tortoise[11,15,29]. *Artemisia monosperma* serves as food[27,47,56], as do grasses [56]. A dry matter laboratory analysis of some plants eaten by this species can be found in Table 6.

Table 6. Dry matter laboratory analysis, Rank & Kaufman (2012)

Analysis/Plant	*Artemisia monosperma*	*Astragalus kahiricus*	*Cardus australis*	*Convovulus lanatus*	*Cutandia memphitica*	*Neurada procumbens*	*Plantago albicans*	*Stipagrostis scoparia*
% Crude Protein	16.7	25.1	23.6	15.3	14.2	21.4	14.8	7.3
% Adjusted Crude Protein	16.7	25.1	23.6	15.3	14.2	21.4	14.8	7.3
% Acid Detergent Fiber	16.9	23.0	26.1	33.3	33.1	39.1	52.8	43.2
% Neutral Detergent Fiber	22.6	26.9	35.8	50.1	54.5	64.3	64.3	73.5
% Non-Fibrous Carbohydrate (NFC)	43.0	39.0	30.5	25.4	23.8	9.7	16.3	13.5
% Water-Soluble Carbohydrate (WSC)	12.4	10.5	5.6	8.0	13.7	3.1	3.8	4.3
% Crude Fat	9.5	4.3	6.1	4.5	3.2	3.9	1.8	1.8
% Total Digestible Nutrients (TDN)	77	69	68	62	59	58	55	52
Relative Feed Value	312	246	178	117	108	85	69	70
% Ca	1.55	1.91	5.84	2.24	0.98	2.99	3.78	1.31
% P	0.25	0.19	0.18	0.19	0.25	0.28	0.15	0.12
% Mg	0.27	0.28	0.47	0.40	0.20	0.40	0.43	0.18
% K	2.72	2.57	2.10	1.80	1.40	2.13	1.37	0.83
% Na	0.20	0.12	0.38	0.06	0.08	0.03	0.08	0.09
PPM Fe	880.0	1020.0	1600.0	1610.0	1270.0	1300.0	5380.0	2200.0
PPM Zn	42.0	23.0	63.0	29.0	41.0	41.0	47.0	26.0
PPM Cu	22.0	19.0	36.0	16.0	17.0	21.0	40.0	22.0
PPM Mn	83.0	74.0	85.0	80.0	49.0	87.0	128.0	59.0
PPM Mo	1.5	1.0	1.7	0.7	0.9	0.9	0.4	0.6

1.6.2 Feeding and drinking

The Egyptian tortoise is enable to eliminate almost dry uric acid so water loss is minimized[53]. Dew formation in the arid habitat of the Egyptian tortoise may serve a s a source of water[50]. Egyptian tortoises feed intensely when ambient temperatures range from 20°C to 24°C on sunny spring and winter days. From April onwards, vegetation becomes scarce and tortoises become less active and are forced to rely on stored reserves.

1.7 Reproduction

Egyptian tortoises can store sperm for long periods, as has been described in other chelonian species. They produce multiple clutches each year[30].

1.7.1 Sexual maturity

Sexual maturity of the Egyptian tortoise in captivity is reached at a minimum age of five years[7,23]. Females on average mature later than males[41]. Maturity data from the wild are deficient.

1.7.2 Seasonality of cycling

In the wild, multiple clutches of eggs are laid in early-late Spring[54].

1.7.3 Oviposition, clutch size and incubation

The Egyptian tortoises mate in winter and early spring[20,30,54]. The breeding period in the wild lasts from March until the end of June[15,24,30] in which each female produces two to three clutches. Each clutch consists of one to four eggs[15,23,30,44,54]. The eggs of the Egyptian tortoise are relatively large (20 to 22 mm wide and 25 to 28 mm long[44]) and the size of the eggs can reach a size of 28% of the body length of the female[54]. The rear part of the plastron of the Egyptian tortoise is flexible which is an advantage when laying relatively large eggs[44].

Females lay their eggs in a sandy substrate at a depth of about 3-5cm which are dug in the shade of a (small) shrub facing east or south[20,30,34,44]. The temperatures inside the nests ranged from 24.3°C to 38.2°C during incubation[54]. The estimated between-clutch period is between 20 and 30 days[30,54].

1.8 Behaviour

1.8.1 Activity

The environmental temperature has a strong influence on the activities of the Egyptian tortoise, because the activity of this tortoise decreases when the ambient temperatures rise above a certain level[29].

Both in the wild and in captivity, the active period of the Egyptian tortoise is about two hours in the morning and in the late afternoon to avoid the high mid-day temperatures[6,49].
Egyptian tortoises are most active when the environmental temperature is between 20°C and 24°C on otherwise hot days[44]. These temperatures commonly occur during spring and winter days[29,44]. There are three factors which may promote activity during winter months[29]: the increased availability of annual plants and the decrease in activity of potential predators. In addition, their small body size allows them to reach optimal activity temperatures quickly through short-time basking.

Figure 12. An Egyptian tortoise underneath a shrub (Rank & Kaufman, 2012).

The main factors for stimulating the aestivation period of the Egyptian tortoise are the withering of the food plants and the rising of environmental temperatures. During the summer months the activity of the tortoises decreases and they retreat into rodent burrows[2,16,20,23,27,29,54,58].
During the active season, inactive tortoises hide under small shrubs (Fig. 12) [29,47,58].

1.8.2 Predation

Brown necked raven (*Corvus ruficollis*) prey on the Egyptian tortoises[11,20,44,54]. These raven and the crow (*Corvus corone*) generally prey on immature Egyptian tortoises but also on adults[44]. Other potential predators of the Egyptian tortoise are birds of prey, the desert monitor (*Varanus griseus*)[11,16,45,54], striped hyenas, wolf[54].The desert red fox (*Vulpes rüppelli* and *Vulpes vulpes*) preys only on young tortoises[44,54]. Dogs[11,20,47] and rats can also prey on Egyptian tortoises[20,47].

1.8.3 Sexual behaviour

Egyptian tortoises are not very aggressive during mating. Sexual behaviour consists of knocks by the male on the posterior part of the carapace of the female causing her to stop. This is followed by climbing on the back of the female and pushing his tail beneath hers[30]. At the same time the male utters a series of rasping and high pitched calls, which resemble the sound of a pigeon[30,44] .

Section 2. Zoo management

2.1 Enclosure

2.1.1 Dimensions

Testudo kleinmanni proved to be a very active tortoise in captivity. In particular males during the active periods (spring and autumn) are very busy walking and examining their environment. With this respect they need a lot of spaces. For one adult couple the minimum size for an enclosure is to be recommended of 2,0 m^2. Juveniles can be housed in size enclosures to the adults relative to their body size. Stock densities for juveniles can be relatively high if basic requirements are met.

Figures 13 & 14, two examples of enclosures, Bristol Zoo (left) and Rotterdam Zoo (right).

2.1.2 Substrate

Different suitable substrates can be used. Mixtures of dry sand, loam and/or coconut fibre soil can be used. Care should be taken that the animals cannot accidentally or intentionally ingest soil particles, as this can lead to impaction.

Figure 15, example of substrate Rotterdam Zoo

Care should be taken that the substrate is never completely dry. Especially in winter, the substrate is moistened regularly. In summer, the substrate can be left to dry in the more exposed areas, but in the hides where the animals are resting it should still be kept moist to simulate the environmental microhabitats (in rodent burrows) in nature[53].

2.1.3 Furnishings

Structures that provide shelter should be used as Egyptian tortoises like to rest under objects such as live or dried plants or pieces of wood. These can also serve as visual barriers between animals.

2.1.4 Lighting and temperature

The daily and annual daylight period should be adjusted to the circumstances of the region of origin[23,27]. In particular, UVA and UVB radiation is necessary for the Egyptian tortoise[23].

During the year, the photoperiod ranges between 10 and 14 hours a day (figure 16) .

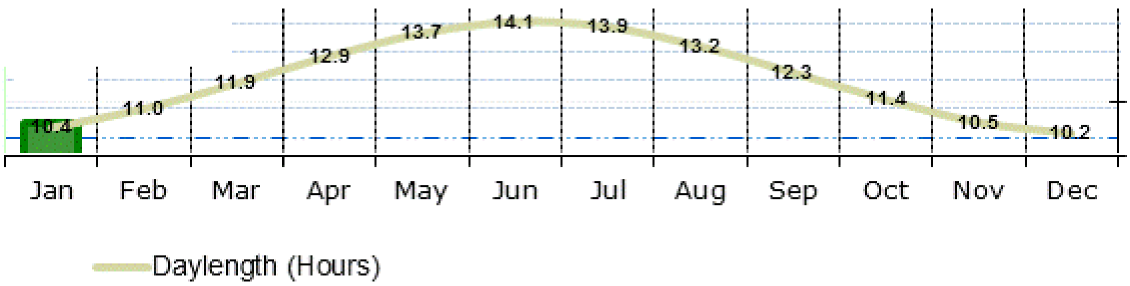


Figure 16. Day length in El Arish, Sinai, Egypt.

UV-B radiation is essential for vitamin D3 synthesis as part of a reptile's calcium metabolism and immune function. Baines et al. [12] give details on the theory and practice of provisioning UV radiation for amphibians and reptiles in captivity. This paper also includes a detailed description of UVI measurements, the "Ferguson Zones" and the "zoning" of an enclosure including methods for appropriate light and UV-B radiation levels and can be easily found through e.g. Google Scholar or Researchgate.net. Looking at the microhabitat preferences and the thermoregulatory behaviour of the species, and applying these to the concept of Ferguson et al. (2010) the Egyptian tortoise would be considered a "partial or open-sun basker" within Ferguson Zone 3. The resulting recommendation would be two options: either to provide *T. kleinmanni* with a uniform Ultraviolet Index (UVI) of 1.0-2.6 throughout the enclosure (also termed the "shade method" in Baines et al., 2016). Alternatively, to provide no UV-B radiation throughout most of the enclosure but a higher UVI of 2.9-7.4 at the basking area (i.e. the "sunbeam method" following Baines et al., 2016).
Suggested lamp types for the enclosure of the Egyptian tortoise are metal halide, halogen or T5-HO fluorescent UV-B[12].

It is a common error in Egyptian tortoise husbandry to employ temperatures which are too high. Seasonal and daily temperature fluctuations should resemble those in the wild in order to achieve the best successes in the keeping and breeding of this species (see 1.5.2., Figure 7 temperature chart of El' Arish (Sinai, Egypt).

It is important to keep the basking area surface temperature around 35°C to allow optimal thermoregulation. During summer, daytime ambient temperature should be 28-30°C and night-time ambient temperature 20-25°C. During winter, daytime ambient temperatures can be between 20-25°C and night-time ambient temperatures should be significantly lower (10-15°C).

Outdoor housing may only be possible in Mediterranean countries.

2.1.5 Humidity

The relative humidity (RH) ranges from 29% to 89%. The substrate should never be completely dry in the whole enclosure (see paragraph 2.1.2). This is achieved by creating microhabitats within the terrarium, with hide (sleeping) places that are slightly humid, and drier (but not desiccated) spots under the basking lamp. A humidifier on a timer is required to raise humidity in the enclosure at night and in the morning.

2.2 Feeding

The diet of the tortoises is geared towards a low protein, high fibre and high calcium intake[34]. Correct feeding (quality and time) is important for Egyptian tortoises. Do not feed the tortoises too much or too little and always feed the tortoises a varied high-fibre, low-protein vegetable diet. Fruits and animal matter should be avoided[45].

2.2.1 Basic diet

Various food items can be used. Most recommended are various wild herbaceous plants (e.g. dandelion, *Plantago* spp., thistles, clover, *Brassica* spp.) and chicory, endive, romaine and other leafy greens. Mixing the fresh greens with tortoise hay pellets or chopped hay for additional fibre to aid

digestion is hugely recommended.
Online resources (e.g. online search for 'tortoise edible plant lists') list other potential food items.

While some people state that the Egyptian tortoise does not need to be fed every day, this may lead to stress as the animals start searching for food when they are hungry.

Juvenile tortoises receive the same diet as adults.

Supplements should be used to enrich the diet with calcium and vitamins. Various brands can be used depending on local availability and roughly 1% of dry matter diet should consist of calcium. Cuttlefish bone (sepia) is a good calcium source.

Figure 17: example of endive mixed with tortoise hay pellets (left) and dandelion leafs (right)

Food should be provided in a shallow bowl or on an otherwise clean surface, to avoid ingestion of substrate particles which may lead to impaction.

Food quantity is not very important if the nutritional value of the food is appropriate: in their natural environment, these tortoises always have access to (fibre-rich) food.

2.2.2 Water

Water is offered in a small shallow dish/bowl and should be available at all times.

2.3 Enclosure dynamics

2.3.1 Social structure

The optimal group composition is one with a sex ratio in favour of females: the most stress-free ratio would be 1 male to 2-3 females. An inverse sex ratio may lead to stress due to continuous mating attempts by the males, and due to competition between males. Aggression between *Testudo kleinmanni* is rare and single-sex groups are therefore possible.

2.3.2 Sharing enclosure with other species

Egyptian tortoises are a tolerant species and generally unaffected by non-aggressive calm species that share the same environmental requirements. Examples are *Uromastyx* spp., *Xenagama* spp., *Cordylus* spp, *Agama* spp., *Gerrhosaurus* spp.
Housing *Testudo kleinmanni* with other tortoise species is generally unadvisable because of inter-male aggression and the chance of hybridisation.

2.4 Breeding

The sexes do not usually have to be separated outside of the breeding season, but this may be necessary if continuous mating attempts from the male appear to stress the female.

2.4.1 Mating

Like described in paragraph 1.8.4, mating behaviour in captivity equals that in the wild: Egyptian tortoises are not very aggressive during mating. Sexual behaviour consist of knocks by the male on the posterior part of the carapace of the female causing her to stop. This is followed by climbing on the back of the female and pushing his tail beneath hers[30]. At the same time the male utters a series of rasping and high pitched calls, which resemble the sound of a pigeon[30,44] .

2.4.2 Egg laying and incubation

Egg laying

A gravid Egyptian tortoise female becomes more active, actively searches for a suitable place to lay her eggs and starts digging with her hind limbs[53]. Once she has found a suitable place, she will lay one to four eggs in the nest. In captivity, eggs are laid between January and July.
A suitable substrate for laying eggs is warm (e.g. 25-30°C), slightly moist (such that the substrate does not cave in, but not wet) and deep enough (>8 cm). The substrate should have a consistency that allows digging a hole, i.e. it should not collapse. A place near the basking spot is usually preferred.
A female may lay multiple clutches per season.

Eggs

The eggs of the Egyptian tortoise are round and often slightly flattened. The eggs have a length of 28-32 mm and a width of 21-26 mm[14,20,27,30,34].

Incubation

Artificial incubation is needed to achieve good hatching results. Preferable, the eggs should not be turned during incubation, as this can lead to embryonic death.

Incubation substrate needs to be dry at an elevated relative air humidity (70-95%). This can be achieved by placing a water bowl inside the incubator. Hatching takes place after approximately 80-120 days, and lower temperatures lead to longer incubation periods.

Constant incubation temperatures ranging from 26-34°C can be used. Higher temperatures (32-34°C) yield mostly female hatchlings whereas lower temperatures will yield mostly males.

2.4.3 Birth/Hatching

Hatching may take a few days, during which time the hatching tortoise should not be disturbed. Disturbance may lead to the hatchling leaving the egg shell with a large yolk sac still present.

Juveniles are left in the incubator on wet paper tissues until the shell has completely unfolded, the yolk sac has been absorbed and the umbilical opening has closed. It is safe to put them after yolk sac absorption on regular substrate as used for the adult animals.

Figure 18. Egyptian tortoise hatching (Zwartepoorte, 2015).

2.4.4 Population management

An EAZA EEP studbook (EAZA Ex-situ Programme) for the Egyptian tortoise, *Testudo kleinmanni,* is managed through ZIMS for Studbooks.

An EAZA Quick Population Assessment has been done in June 2018.

Currently, only very few individuals in the population seem to be breeding. This is causing the population to be demographically very instable and for genetic diversity to be lost rapidly. It is difficult to determine exactly what the best strategy is moving forward for this population without a detailed discussion on the exact issues and opportunities.

There is a large amount of unknown ancestry in the population. The percentage ancestry known of the population may be improved through research in cooperation with institutions and possibly by creating pedigree assumptions.

It is necessary to reduce the number of unsexed individuals to optimise population management.

Existing Conservation Actions (*source: RCP Species Sheet, will be published in 2019*)

The species is protected by Egyptian law (though not implemented at all times), but not in Libya. However, recent information suggests that the Libyan Environment General Authority and local academics show interest for tortoise conservation in Libya, and that they are looking forward to cooperating with the Egyptian based TortoiseCare program. TortoiseCare will continue to seek funding for future activities for the conservation of the species, and particularly for the development of a species action plan that takes into consideration the conservation needs on a global level, including both Egypt and Libya. The limited data available suggest that the geographically isolated subpopulation from Tripolitania might be taxonomically distinct. It is essential that local subpopulations are not mixed in any circumstances, including possible breeding projects, whether in or ex situ. The use of captive or confiscated stock of unknown origins or parentage in conservation programs should be discouraged at all times for the same reasons. Data for uses and harvest levels are largely known for Egypt only where monitoring is continuing. No data are available for Libya.

Conservation measures are going on in Egypt but not yet in Libya. More research is needed also in Egypt, such as a systematic search and identification of habitat pockets where tortoises might still exist. Protected areas exist in Egypt and demands for more are raised. The motives for establishing new protected areas especially for this species are not entirely clear as it is already effectively extinct in Egypt. Reintroduction projects have been currently stalled in Egypt. It may occur in Kouf National Park in NE Libya where one specimen was found 20 years ago. Other Libyan reserves in areas of tortoise activity are non-existent. Protected areas would greatly enhance the survival prospects of the entire species if trade can be stopped.

Census status on May, 9 2019: 112-100-42. 65 wild born animals, 23 unknown and 166 captive born.

2.5 Behavioural enrichment

Egyptian tortoises should be kept in an enclosure that resembles their natural habitat. Therefore, there is no use of behavioural enrichment other than making them search for their food items by distributing these in various places.

2.6 Handling

Figure 19, handling a small tortoise

2.6.1 Individual identification and sexing

Egyptian tortoises can be identified with smallest microchip transponders available on the market (in one of the rear legs or in the pectoral musculature), photos of individual animals, and markings on the carapaces with paint, a permanent marker or nail polish. Males have longer and thicker tails than females. Males often (but not always) have a concave plastron and are generally smaller in size than females. The shape of the caudal edge of the anal scutes (plastron) is different between males and females (see figure 20).

Figure 20, left an adult female, right an adult male. Photo by Job Stumpel

2.6.2 General handling

It is advisable to regularly weigh and measure tortoises (see paragraph 1.2.1) to monitor growth trends and for health reasons.

2.6.3 Transportation

Egyptian tortoises may be transported in an insulated box with adequate aeration. Containers used to transport animals by air should comply with the Live Animal Regulations (43rd edition) of the International Air Transport Association (IATA)[35].

The animals should be individually packed in cloth bags of appropriate size and the remaining crate space suitably cushioned with a material that allows enough airflow through the crate, e.g. shredded paper. Transport temperatures should ideally be maintained between 20°C and 25°C. For short periods, temperature minima and maxima of 15°C and 30°C respectively will be tolerated; an extended time at those temperatures or any further diversion up or down might result in the death of animals.

When shipping commercially by plane, extra precautions need to be considered. Airlines will usually ship live animals in a heated cargo hold; the pilots will be advised on the appropriate temperature the hold will need to be kept in and will engage the hold heating during pre-flight checks. However, the cockpit usually has no thermometer or any continuous influence over the hold heating which means that the cockpit might not be aware of a possible malfunction of the hold heating; in any case, there would not be anything that could be done during the flight to rectify a fault. Therefore, to make sure the animals survive a possible heating failure in the hold, longer shipments by plane, e.g. commercial trans-Atlantic flights, should only be undertaken when outside ambient temperatures on the ground during loading of the crates onto the airplane are >24°C. Monitoring commercial shipments by plane through temperature data loggers enclosed in shipping crates (Goetz et al., unpublished data) indicate that hold temperatures drop by about 1°C/h at cruising altitude if the hold heating is not functioning as intended. Therefore, if the animal crate is loaded at 25°C air temperature, a critical minimum temperature in the transport boxes might only be reached after >10h flight time.

2.6.4. Safety

Salmonella spp. carriage appears to be highly prevalent in reptiles. Reptiles should be considered to be nonclinical carriers of Salmonella spp. The organism is intermittently or continuously shed in their feces and, if ingested by humans, may result in a potentially serious illness.

- Always wash your hands thoroughly after handling tortoises, including equipment. Beware of cross-contamination.
- Very young, the elderly, pregnant women, and the immunocompromised should be extra careful handling or touching tortoises or their environment. These groups have a higher chance of serious illness from Salmonella spp.

2.7 Veterinary considerations for health and welfare

The health of Egyptian tortoises in captivity is, amongst others, dependent on the diet and on the environment of a tortoise[47]. The health of the Egyptian tortoise can be improved by providing optimal veterinary care and diet.
It is very important to prevent cross-infection from other tortoise species.

Herpes viruses
One of the most important and dangerous viruses found in the Egyptian tortoise are herpes viruses[43]. The symptoms include swollen eyes, respiratory distress and oropharyhgeal plaques/stomatitis.
It is possible to detect herpes viruses from the tongue of a clinically ill Egyptian tortoise by virus isolation and Polymerase Chain Reaction (PCR)[43] or by performing antibody assays in clinically healthy carrier individuals.

All animals must be checked for herpes viruses. Positive animals should be considered highly contagious. Make sure negative and positive animals are not able to interact. Rearing of the offspring of positive animals should be done in isolation, away from positive and negative animals. They must be tested as soon as the size of the animal permits.

Metabolic bone disease (MBD)
The Egyptian tortoise, like other chelonian species, is susceptible to metabolic bone disease (MBD)[47,51], mainly through an inappropriate diet (low calcium/high phosphorus) and inadequate UVB exposure. Signs include a depressed shell shape, low bone density (soft shells), weakness, egg retention, constipation and others.

Mycoplasma
Mycoplasma is a bacteria-like organism that can cause upper-respiratory infections in tortoises. Signs include lethargy, weight loss, nasal discharge and failure to thrive. Diagnosis can be made by PCR testing of an oropharyngeal swab and treatment of the disease is possible. Treated animals do not lose the infection but will become asymptomatic carriers. Stress or suboptimal conditions induce the development of clinical disease.

All animals must be checked for mycoplasma. Positive animals should be considered highly contagious. Make sure negative and positive animals are not able to interact. Rearing of the offspring of positive animals should be done in isolation, away from positive and negative animals. They must be tested as soon as the size of the animal permits.

Other veterinary problems
Nematode infections can lead to problems in tortoises. Eggs of the oxyurids genus *Tachygonetria* in the faeces of the Egyptian tortoise are a common finding in *Testudo* species, but they do not lead to problems unless present in very large numbers. Flagellates, amoebae and coccidia are other single-cellular parasites that can lead to disease. Ciliates of the genera *Nyctotherus* and *Balantidium* are often found in herbivorous reptile faeces and considered part of normal intestinal flora.

Almost all reptiles can be found positive for *Salmonella* species, which is not often a problem but it can lead to zoonotic infection.

An article by Eshar, Gancz, Avni-Magen, King & Beaufrère (2014) is available with a detailed description of hematologic, plasma biochemistry and acid-base analysis of the Egyptian tortoise.

2.8 Recommended research

It is recommended to revisit the population of the Egyptian tortoise in the wild to determine the status of this species better[41]. The local Bedouin community is involved in field research by patrolling for wildlife collectors and collecting scientific data. Their participation is vital to the conservation and study of the Egyptian tortoise. But because of the ongoing conflict among rival factions in Libya and the unstable situation in the Egyptian North Sinai, proper research is almost impossible at this moment (2019). The EEP Coordinator is planning to visit local researchers in Egypt to get an good understanding of the situation in the field.

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