EAZA BEST PRACTICE GUIDELINES

North African ostrich *(Struthio c. camelus)*

2025 (1st edition)

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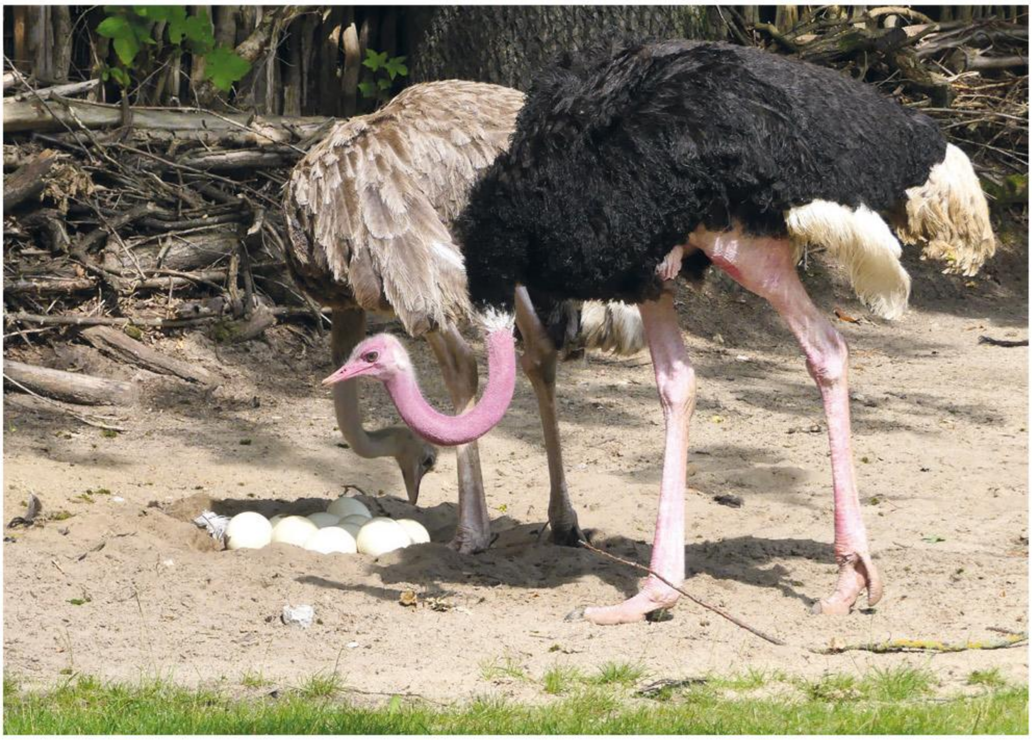

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Preamble

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.

Introduction / Summary

Ostriches have long been kept in many zoological institutions, and zoos have gathered a wealth of experience with their keeping. Ostrich farms exist in many countries, and even if much of what applies to farm husbandry is not transferable to zoo husbandry, the countless sources on the subject can provide valuable information. Experience and information from both sectors have been incorporated in this document.

The North African ostrich (*Struthio camelus camelus*) is a subspecies of the common ostrich (*Struthio camelus*). An ex-situ conservation programme for the North African ostrich was established in 2011 as European Endangered species Programme and is now an EAZA Ex situ Programme (EEP). The zoo population is still relatively small and new findings on keeping these birds are constantly emerging (e.g. on mixed species exhibits); these must be added in the years to come.

The needs of the North African ostrich are broadly similar to those of other ostriches. However, North African ostriches are significantly larger and less tractable than the more widely-kept South African ostriches *(Struthio camelus australis*) or many of the hybrids kept in zoos. The males in particular are dangerous animals, and this must be taken into account when handling these birds. Furthermore, new EEP participants often receive young animals, and young males are much more boisterous than older zoo birds that may well have lived in the same institution for many years.

These Best Practice Guidelines offer advice on keeping North African ostriches, and may also be read as guidance on deciding whether to keep them, with information on planning new accommodation and stock density.

The document consists of two sections. The first describes the principal aspects of taxonomy, biology, distribution, population status, and conservation efforts.

The second section is devoted to zoo husbandry: the design of indoor and outdoor enclosures, feeding, acclimatisation, social structures, breeding, handling, and transport. A final chapter comprises important veterinary information.

Particular attention is given to enclosure design and to the importance of careful acclimatisation procedures; ostriches are very much ‘creatures of habit’, and any change in their routines and surroundings must be carried out gradually and cautiously.

Reproduction and breeding are also dealt with relatively comprehensively, as this topic is of paramount importance for the EEP. Practical experience in this area can also provide important support for species conservation efforts in situ.

Acknowledgements

I would like to thank all those colleagues, both at Hannover Zoo and other institutions, who with their knowledge and practical work have contributed to the compilation of these Best Practice Guidelines. Particular thanks are due to Dr. Pia Krawinkel, who wrote the veterinary chapter.

My warmest thanks, also, to the zoos in Alphen, Gelsenkirchen, Muenster, Paris, Schwerin und Sigean, and of course to Sahara Conservation for their photographs.

CONTENT

1. BIOLOGY

1.1 TAXONOMY

Class	**Aves**
Order	**Struthioniformes**
Suborder	**Struthiones**
Family	**Struthionidae (ostrich)**
Genus	***Struthio***
Species	***Struthio camelus*** (Linnaeus 1785)
Subspecies	*Struthio camelus camelus* (Linnaeus 1758) – North African ostrich, North African red-necked ostrich

Fig. 1 North African ostrich male at his nest at Hannover Zoo

Since 2014, following DEL HOYO ET AL. a distinction has been made between two ostrich species: *Struthio camelus* and the Somali ostrich *Struthio molybdophanes*. Until then the Somali ostrich, native to the Horn of Africa, was listed as a subspecies of *Struthio camelus*. It is classified as 'vulnerable' by the IUCN (BirdLife International 2022).

Within the species *Struthio camelus* three subspecies are defined: the South African ostrich (*Struthio c. australis*), the genetically close Masai ostrich (*Struthio c. massaicus*) and the North African ostrich (*Struthio c. camelus*). A further sub-species, the Arabian ostrich (*Struthio c. syriacus*), which was closest genetically to the North African ostrich, was extirpated in the mid-20th century (FOLCH 1992).

Fig. 2 Female North African ostrich in Souss Massa National Park, south of Agadir, Morocco

1.2 MORPHOLOGY

Ostriches are the largest living birds. CRAMP (1977) and FOLCH (1992) note that male ostriches can reach a height of 2.1 to 2.75 m (9 ft), and females 1.75 to 1.9 m, the North African and the Masai ostrich being larger than the South African ostrich (BROWN ET AL. 1982). Some authors assume that the North African ostrich is the largest of these three subspecies (BERTRAM 1992, ROOTS 2006).

The maximum weight of a fully-grown ostrich is noted by FOLCH (1992) as 100-130 kg (sometimes as much as 150 kg) for males and 90-100 kg for females. JARVIS (2015) estimates that the maximum weight of North African males is less than that of their Masai and South African counterparts. THORNTON ET AL. (1912, cited by SMIT 1963) also mention a maximum height of 2.74 m and weight of 125 kg for the North African ostrich.

A male hatched in Hannover in March 2011 had attained a weight of 133 kg by May 2020, while a female hatched at the same time weighed about 110 kg. In December 2021 the weight of the male was 138 kg, the weight of the female 120 kg. In an upright but relaxed posture, the male's head was 2.2 to

2.3 metres above ground, and the hen's 1.9 to 2 metres; both birds can, of course, stretch significantly higher.

With male North African ostriches the head and the upper neck have only a scant covering of downlike feathers, and the flanks and thighs are naked. The skin is normally pink, turning an intense red during the breeding season – this also applies to the tarsal scutes. The plumage is a glossy black, with a white frill of feathers between the naked part of the neck and the black plumage. The tips of the wing feathers and tail feathers are usually pure white (FOLCH 1992, BROWN ET. AL 1982), although the tail feathers can also be a reddish brown (own observations, JARVIS 2015).

Fig. 3 North African ostrich female at Hannover Zoo

Female birds are much less conspicuously coloured; the naked parts and the plumage are greyish brown, the neck is covered with downlike feathers. Both hens and cocks have pale brown eyes (cf. JARVIS 2015) and a bald patch on the top of the head (cf. SMIT 1963).

Chicks' plumage is spiky at first, reminiscent of a hedgehog. Their backs and wings are clad in beige-brown-black camouflage feathers, and underneath they are sandy grey. Dotted and dashed black lines run along the neck, and the crest is reddish brown (own observations). The actual feathers begin to grow at about three months. Juvenile birds resemble the hen, and male birds develop their black and white plumage in the course of their second year. The adult bird attains its full size at about 12 months, and its full weight later (cf. BROWN ET.AL 1982). In the wild, ostriches reach sexual maturity at three to four years (FOLCH 1992), while this can be markedly earlier in human care (also see 1.6 Reproduction).

Ostriches have exceptionally large eyes (5 cm diameter), protected by a nictitating membrane and the eyelids, which also have bristle feathers resembling long eyelashes (BROWN ET AL. 1982, FOLCH 1992, BEZUIDENHOUT 1999).

Ostriches cannot fly, lacking the carina on the breastbone to which the chest muscles of flying birds are attached. The chest musculature is shorter and they have no clavicle (FOLCH 1992). The pubic bones are, unlike in other flightless birds, fused (FOWLER 1996).

Feathers have no barbicels (hooks), so that the barbules do not hang together; this makes the plumage exceptionally soft and smooth (FOLCH 1992). Lacking uropygial or oil glands, ostrich plumage is not water repellent (FOLCH 1992, GRUMMT 2006).

Ostriches have long legs for running and are the only species of bird with just two toes, originally the third and fourth. When running, the weight is placed on the inner i.e., third toe; the surface area that comes in contact with the ground is sharply reduced, making it possible for these birds to maintain a ground speed of up to 50 k.p.h. and sprint at up to 70 k.p.h.. The stride length is noted as up to 3.5 m (FOLCH 1992) and it is possible that this could be markedly longer for the North African ostrich (cf. Smit 1963). Ostriches have tremendous stamina, according to DRAGESCO-JOFFÉ (1992), and can maintain a speed of around 30 k.p.h. over distances of 40 to 50 km without exerting themselves greatly.

The inner toe has a claw, several centimetres long, which can be a dangerous weapon.

Male ostriches have a phallus, which is often displayed during the courtship display.

Ostrich eggs are very large, but small in relation to the size of the bird's body. They are round to oval, hard-shelled, yellowish directly after laying turning to creamy white. The eggs of the subspecies differ markedly; those of the North African ostrich are particularly smooth-shelled, with very small pores (cf. SCHÖNWETTER 1960). SCHÖNWETTER (1960) notes sizes from 142-175 x 120-145 mm (average: 158.5 x 131; cf. KRAWINKEL 1994). This coincides essentially with our own data. The eggs brought from Morocco were between 136 and 177 mm long with diameters of 120 to 144 mm; average size was 155.9 x 133 mm. The weight of the Moroccan eggs was between 1,300 and 2,125 g, with an average of 1,724 g.

Fig. 4 Egg of a North African ostrich (left) and of a South African ostrich (right); photo taken at Landesmuseum Hannover

1.3 LONGEVITY

FOLCH (1992) mentions a life expectancy of 30 to 40 years, HURXTHAL (1979) estimates the maximum lifespan of ostriches in Nairobi National Park to be around 19 years. In human care ostriches can, according to GRUMMT ET AL. (2006), live for 50 to 60 years. A typical lifespan, however, is less than 30 years, and birds are considered old when they reach the age of 20.

A North African ostrich chick (left) and a hybrid chick at the age of two weeks. Both hatched in June 2021 at Réserve Africaine de Sigean.

Centre: The same ostriches at the age of four months (NAO left).

Below: Heads of the ostriches, four months old, in detail (NAO left).

The adults of the different ostrich (sub)species are easy to distinguish, but not juveniles or chicks. At Réserve Africaine de Sigean in 2021 two chicks, a North African ostrich (NAO) and a hybrid chick hatched within three days, the hybrid ostrich being three days older. Both female chicks were raised by the same 1.3 foster birds.

Obviously, it is not possible to describe the main differences of the subspecies by only looking at two chicks. However, tendencies are discernible. The NAO chick in this case is paler than the hybrid chick, the colour of the feathers is different, as is the colour of the legs, which is more greyish in the hybrid. The NAO grew faster than his hybrid sibling.

At the age of four months a different body shape is visible, the NAO being slimmer than the hybrid and the tail being longer. The head shape is markedly different, with the longer beak of the NAO. At this age the bald patch on the head, a characteristic of the subspecies, is already clearly visible (Antoine Joris, personal communication June and October 2021).

Pictures taken by Antoine Joris, Réserve Africaine de Sigean.

1.4 HABITAT, NUTRITION AND PHYSIOLOGY

In general, one finds ostriches in habitats with an annual rainfall of over 800 mm (*S. c. massaicus*; cf. HURXTHAL 1979) as well as in those with less than 200 mm of rain per year, the latter figure applying to the subspecies *S.c. australis* and *camelus* (BROWN ET AL. 1982).

North African ostriches occur in savannah and in the vast Sahel semi-desert plains. In desert areas they are mainly found in large dry river valleys (wadis or oueds). They cross hyper-arid regions but usually avoid sand dunes (CRAMP 1977, DRAGESCO-JOFFÉ 1992). They are found in highland regions, but above all on plateaux and in wadis (GIAZZI 2006). OSTROWSKI (2000) reports that North African ostriches adapt well to rainfall of 40 to 150 mm per year, but cannot cope in hyper-arid areas with less than 40 mm.

Ostriches prefer open, semi-arid habitats with relatively short grass where enough food is available and the view is clear to see predators in time (FOLCH 1992). According to BROWN ET AL. (1982) *Struthio c. camelus* will also cross dry areas with scrub of up to 3 m high. Especially in desert and semi-desert habitats, ostriches are as a rule nomadic; in search of suitable sources of food they are very mobile and roam over large areas (CRAMP 1977, DRAGESCO-JOFFÉ 1992, FOLCH 1992, GIAZZI 2006).

Fig. 5 Photo taken by John Newby (Sahara Conservation) in the Air Mountains, Niger, in the 1980s. This ostrich population was extirpated in the 1990s during civil unrest.

BROWN ET AL. (1982) assume that ostriches in dry habitats can go without open water for months, while at water sources (and also in human care) they drink copiously and regularly. If no open water is available in the wild, needs can be met from the water content of green plants, particularly succulents (WILLOUGHBY & CADE 1967, SKADHAUGE ET AL. 1984).

Ostriches are often described as omnivorous but in general feed on plants and parts of plants (BROWN ET. AL. 1982 FOLCH 1992). In the wild they are very selective (ROBINSON & SEELEY 1975, WILLIAMS ET AL. 1993, MILTON 1994), preferring dicotyledons, although in principle they can eat all parts of plants, both mono- and dicotyledonous. They pluck grass seed heads, blooms of the composite family, and seedpods of e.g., aloe and acacia. Unlike mammals in the same habitat they uproot the whole plant, thus accessing extra food and water (WILLIAMS ET AL. 1993).

In addition to the aforementioned acacia, cassia species also play a part in nourishing North African ostriches, especially their legumes/pulses and blooms. Other sources of food may be, for instance, *Schouwia thebaica (purpurea)* and *Heliotropium undulatum*, and the fruit of *Citrullus colocynthis* and *Ficus carica*, the roots and leaves of *Crotalaria saharae*, the succulent leaves of *Oxystelma bornouense*, leaves of *Cucumis* and *Maerua crassifolia* (*rigida)* and the shoots of *Mimosa* (CRAMP 1977, DRAESCO-JOFFÉ 1992, OSTROWSKI 2000).

Simply because of their size, ostriches cannot seek out shady, cool microhabitats during the hottest hours of the day; large as they are, however, this is compensated for by mobility and a low evaporation rate (WILLOUGHBY & CADE 1967).

Ostriches are adapted to their hot, arid habitat in multifarious ways. At high temperatures they can cool themselves by spreading their feathers, letting the lightly splayed wings hang and thus expose the naked thorax. Only when this is not enough do they react by breathing faster (panting), without causing respiratory alkalosis (LOUW ET AL. 1969, SCHMIDT-NIELSEN ET AL. 1969). The body temperature can thereby be maintained, but the higher breathing rate causes higher water loss through evaporation. If ostriches are subjected to high temperatures and dehydration they can, like other desert inhabitants, raise their body temperature and thus reduce water loss (CLOUDSLEY-THOMSON & MOHAMED 1967, SCHMIDT-NIELSEN ET AL. 1969, SKADHAUGE & DAWSON 1999).

Ostriches' overall water balance is described by WILLIAMS ET AL. (1993) as "frugal"; it resembles that of large savannah and desert mammals such as antelopes and camels. Unlike mammals, however, ostriches lose the greater part of their water not through evaporation but through the (separate) release of faeces and urine (WITHERS 1983).

Nitrogen is removed, like in other birds, through the excretion of uric acid; compared to the excretion of urea this is per se a water saving procedure. Another is possibly the mucus secreted by ostriches that, in a dehydrated condition, serves instead of water as lubricant for the expulsion of the undissolved uric acid (LOUW ET AL. 1969).

After dehydration phases, ostriches can take in large amounts of water in a short period (COUDSLEY-THOMSON & MOHAMED 1967, WITHERS 1983). DEGEN ET AL. (1994) assume that this water is stored in the bird's glandular stomach and gradually released into the body.

1.5 BEHAVIOUR

Especially SAUER (1966, 1972), HURXTHAL (1979) and BERTRAM (1992) give detailed descriptions of ostrich behaviour in their original habitat.

Ostriches are diurnal. In the wild, according to FOLCH ET AL. (1992), they are most active in the early morning and late afternoon, although activity very much depends on the availability of food. Most of the day they are either standing or walking, feeding, pecking at the ground and watching out for possible predators. During the day, if not incubating, they sit just for a relatively short time for resting or taking a sand bath.

IMMELMANN (1962) and FOLCH (1992) report that during the night, ostriches sit down and rest with their necks raised and eyes closed. Only for short intervals do they sleep with the head and neck stretched on the ground in front of them or to the side. LESKU ET AL. (2011) found that the main part of ostrich sleep is slow-wave sleep. The birds sit motionless with necks held erect and open eyes. Only a smaller part of the sleep is rapid eye movement sleep, characterized by closed eyes and a drooping and swaying head.

According to BERTRAM (1992) ostriches are "loosely gregarious". Adult ostriches might be seen on their own, but are also attracted to others. SAUER (1966) describes a wide variety of social grouping, during and out of the breeding season.

Communication in ostriches mainly is effected by means of visual signals – by posture, wing flapping, flushing of the neck etc. Males show more ritualized social signals, known as displays, than females. Displays are important especially in courtship and in agonistic male-male interactions, but are shown also in anti-predator behaviour (see HURXTHAL 1979).

BERTRAM (1992) defines some of the main ostrich displays as follows:

"Kantling – by males towards females to induce readiness to copulate, and towards other males in agonistic encounters. While squatting, the male waves his quivering spread wings alternately in the air as he rocks from side to side. The same movements are made during copulation itself.

Full threat – by a male just before attacking, and just before copulation. Both wings are raised high above the body, the primaries being well spread.

Wing flagging – by a male in mildly aggressive encounters. Alternate wings are flicked up and down beside the body.

Soliciting – by submissive and possibly receptive females towards males, and by males when showing a nest site to females. Both wings are spread, lowered and quivered intermittently, while the head is held low but jerked up at intervals.

Distraction – by males and females with chicks (or nests near hatching), towards predators including human beings and vehicles. The spread wings are held low and rowed erratically in unison, while the neck waves unpredictably and the bird may periodically collapse."

In general, the posture of the body is important as a social signal. More confident and aggressive birds keep more erect with head and neck high, and the tail raised, whereas submissive individuals hold their head and tail down.

A very conspicuous visual signal is the flushing of the bare parts of the skin at legs and neck of the male ostriches at the beginning of the breeding season. The bright reddish-dark pink signals to females and competing males that the male is in breeding condition and that he is territorial. During courtship or aggression, the skin colour often intensifies for several minutes. This is also the case when the male is booming. With his booming call the male asserts his territory and indicates his readiness to breed. The skin colour becomes even more striking because of the inflated neck. BERTRAM describes the booming as a "deep and powerful mwoo-mwoo-mwoooo". Some authors, like FOLCH (1992), compare it to a lion's roar.

Other acoustic signals in ostriches are less frequent and less conspicuous. These include e.g. hissing, snapping and snorting sounds performed by both sexes.

Young birds make several different noises depending on their mood in different situations. Even before hatching, the chicks make contact calls.

1.6 REPRODUCTION

As described above, it can take three to four years until ostriches reach sexual maturity. Within the EEP until now, males reached sexual maturity at about 36 months at the earliest and one female already at about 28 months.

The breeding season of ostriches depends on climate, weather conditions and the availability of food. In Niger, for example, egg laying takes place during or after the rainy season (DRAGESCO-JOFFÉ 1992, MAIMOUNATOU IBRAHIM, pers. communication 2019). In the far north of the range, in Southern Morocco, with its winter rain, ostrich hens usually lay between November and March. The start of the laying season depends on food availability after the rains but also on the prevailing temperatures (WIDADE OUBROU, pers. communication 2010).

Observations on the breeding behaviour of *Struthio camelus australis* are found in SAUER & SAUER (1966), SAUER (1972) and JARVIS ET AL. (1985) and of *S. c. massaicus* in HURXTHAL (1979), BERTRAM (1979, 1992) and MAGIGE ET AL. (2009). Important information on their complex breeding behaviour is also provided by the genetic studies of KIMWELE & GRAVES (2003). A description from a zoo is found in BOLWIG (1973). Furthermore, there are, of course, numerous descriptions of the behaviour of ostriches kept on farms, e.g. in DEEMING (1997), DEEMING & BUBIER (1999) and KENNOU SEBEI & BERGAOUI (2009).

Depending on the environmental conditions and population density there are various breeding strategies; both monogamous bonds and complex breeding groups with one male and several hens occur (SAUER & SAUER 1966, FOLCH 1992, MUSHI ET AL. 2008).

Lying down, the males scrape large nest hollows in sandy soil. The dominant or major hen is the first to lay an egg in such a scrape (BERTRAM 1992).

Ostrich hens lay eggs over a period of around two to three weeks (SAUER & SAUER 1966); HURXTHAL (1979) mentions an average of 16 days (11-21), BERTRAM (1992) 23 days (8-33), before incubation starts. In general it is assumed that a female lays every second day at the most. Several hens lay their eggs in the same nest. The number of eggs in the clutch can vary widely depending on habitat and population density; both BERTRAM (1992) and MAGIGE ET AL. (2009) note an average of 26 eggs for the Masai ostrich (15-39 and 20-38 respectively). BERTRAM (1992) assumes that around 11 of the eggs in a clutch are from the major female. In Namibia SAUER & SAUER (1966) describe clutches of between 16 and 23 eggs, of which no more than 8 are from the major hen.

But clutches can also be significantly larger. FOLCH (1992) mentions a nest in Nairobi National Park containing 78 eggs, and in Souss-Massa National Park nests with over 80 eggs have been found (own observations) which, at least in the latter case, could be due to the high population density.

Fig. 6 A male turning and positioning the eggs before proceeding with incubation

However, only about 20 eggs can be incubated (FOLCH 1992, KIMWELE & GRAVES 2003); the others are rolled out and, with larger clutches, form a ring around the nest. BERTRAM (1979, 1992) and HURXTHAL (1979) assume that the major female recognises her own eggs from their appearance and therefore does not roll them out of the nest. Unfortunately, this could not be confirmed in studies by KIMWELE & GRAVES (2003) or MAGIGE (2008).

The unique complexity of ostrich breeding behaviour is shown by the genetic studies of KIMWELE & GRAVES (2003). They establish that most of the eggs in a nest are not fertilised by the breeding male, and that the major hen does not lay exclusively in her own nest but also, as minor hen, in the nests of other males.

Both the male and the major female incubate the eggs. According to FOLCH (1992) the male incubates mainly at night and the better camouflaged hen mainly in the daytime over a markedly longer period.

Average incubation time is around 42 days (SAUER & SAUER 1966, HURXTHAL 1979, BERTRAM 1992). The temperature inside the nest has been measured by SIEGFRIED & FROST (1974) and BERTRAM (1992) at 34 to 36 °C and by BERTRAM & BURGER (1981) at 33 °C, with 42 % humidity (cf. also SWART & RAHN 1988). Both SIEGFRIED & FROST (1974) and BERTRAM & BURGER (1979) note that the temperatures of eggs and the nest are "remarkably constant"; the former ascribe this to the high degree of care by the parents, their relatively constant body temperature, that they move relatively little, and that such large eggs cool down and warm up slowly.

The hatching of the chicks from a clutch can take around four days, after which the nest is immediately abandoned (HURXTHAL 1979).

Accounts of hatching rates of incubated eggs vary widely; Bertram (1992) gives figures of 80, 86 und 100 % for three nests. Data from HURXTHAL (1979) indicates that 100 % hatching rates can be attained by experienced birds. Overall, however, the hatching success of ostriches is low; chicks hatch from just 10 % of the eggs laid – and many chicks die within their first few months (FOLCH 1992).

Hatchlings from several clutches are gradually brought together in large groups, known as crèches, which are led by one or more adults until the next breeding season. Such groups can comprise from 100 to 300 birds (FOLCH 1992).

1.7 DISTRIBUTION

The North African ostrich was originally found across the entire North African Sahara and Sahel regions (DURANT ET AL. 2014). Today it has disappeared from the northern Sahara. In some parts of Morocco and Algeria, ostriches were still common in 1850 but had been exterminated by 1900 (CRAMP 1977, DRAGESCO-JOFFÉ 1992). The last wild ostrich in Tunisia was probably shot in 1887 (KACEM ET AL. 1994). In Libya, too, ostriches disappeared in the course of the 19th century. There were no ostriches left in northern Egypt by the end of the 19th century, although they still occurred in the south of the country up to the 1990s (MANLIUS 2001).

In 1982 BROWN ET AL. delineated an area of distribution from southern Morocco and Mauretania in the west to Ethiopia in the east and as far as South Sudan and northern Uganda in the south. Many of the ostriches had withdrawn to desert regions in the interior and the vicinity of mountain massifs (DRAGESCO-Joffé 1992).

Today, the wild population is estimated as being from a few hundred to at most 1,000 animals (JOHN NEWBY, Sahara Conservation, personal communication 2018). DURANT ET AL. (2014) assume that the North African ostrich no longer occurs in 99.8 % of its original habitat.

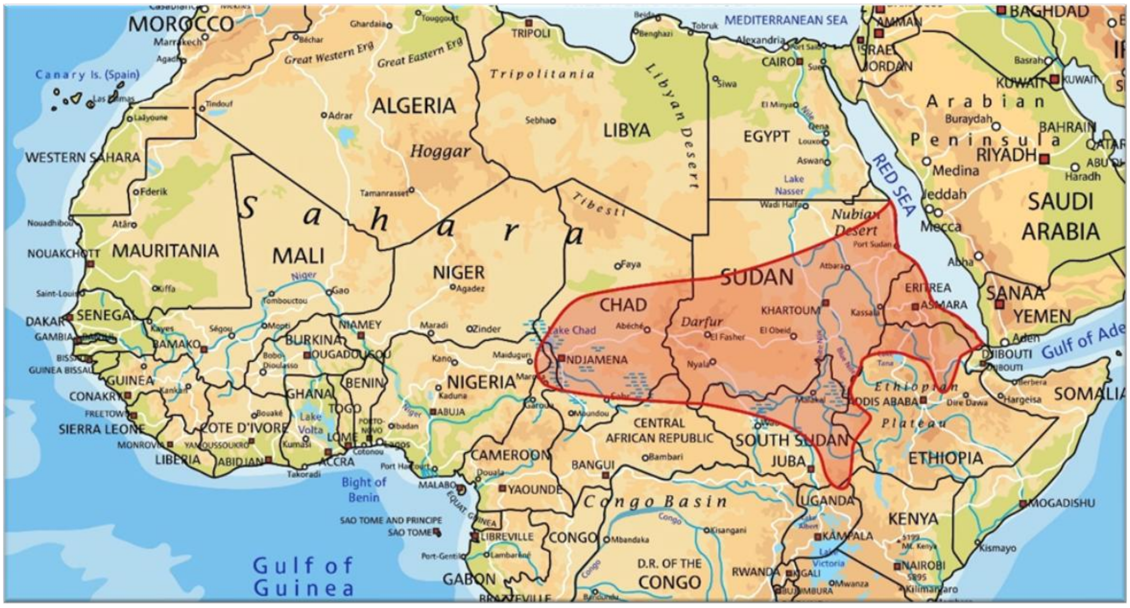


Fig. 7 Maximum area (red), where North African ostriches may still occur. A few birds are also still found In Senegal.

What is probably the largest population of North African ostriches lives in Zakouma National Park in Chad; 241 birds were counted here in 2014 (ANTONÍNOVÁ ET AL. 2014). Their actual numbers within the park were, however, estimated as higher and suitable habitat still exists outside the park (DARREN POTGIETER, Zakouma National Park, personal communication 2015).

In the Sudan, ostriches are assumed to occur solely in national parks; the largest group is probably that in Dinder National Park on the border to Ethiopia. The latest available census is from 2011, when 295 ostriches were counted (YOUSIF 2012).

In Waza National Park in northern Cameroun bordering Nigeria and Chad numbers have fallen dramatically over the last decades; a census in 2007 lists just nine ostriches (FOGUEKEM ET AL. 2010; cf. ESSER & VAN LAVIEREN 1979, SCHOLTE ET AL. 1999).

North African ostriches still occur in the Central African Republic, in Ethiopia and in Uganda (at the border with South Sudan); but accurate figures are not available. Few animals are still found in Senegal (S.M. FALL, Senegal National Parks, personal communication 2018).

Furthermore, ostriches are kept in breeding stations, by private individuals, and in a few zoos in North African and Arabian countries.

1.8 CAUSES OF POPULATION DECLINE / THREATS

The reasons for the birds' disappearance may differ according to region. ROOTS (2006) reports that the ostrich population of Ethiopia – where both the North African and the Somali ostrich are found – declined sharply in the 1970s and 1980s when many ostrich eggs gathered in the wild were not only sold within the country but also exported in their thousands through Djibouti. LAURENT & LAURENT (2002) also describe Djibouti as an important trading centre for animal trophies and products from Ethiopia, Somalia, and Kenya, and that in a single two-hour police raid in 2001, among other finds 200 ostrich eggs were confiscated.

DRAGESCO-JOFFÉ (1992) lays the blame for the disappearance of ostriches from the northwest Lake Chad regions above all on professional hunters, who could make large sums of money from the sale of ostrich bone marrow and fat, to which medical benefits are ascribed.

Ostriches were widespread in West Africa up to the 1970s. Extensive surveys in 2003 and 2004 found no birds left. Reasons for their disappearance lie partly in overgrazing and degradation of their habitat, while theft of eggs from the nest also plays a major role. The main cause of their extinction, however, is seen by THIOLLAY (2006a, 2006b) as extreme hunting by the military, extraction industry personnel, and tourists, with their efficient weaponry and vehicles.

The last major ostrich population in West Africa was to be found in Niger, where 1,600 birds were estimated to be living in the Aïr and Ténére Nature Reserve in the 1990s. Massive poaching in the course of civil war completely eradicated them in this decade (OSTROWSKI ET AL. 2001, GIAZZI ET AL. 2006).

1.9 CONSERVATION MEASURES

In Morocco and Tunisia ostriches have been and continue to be reintroduced in national parks, as they are in Arabian countries, where the North African ostrich acts as 'substitute' for the extinct Arabian ostrich (ENGEL & BRUNSING 1999, ROBINSON & MATTHEE 1999, ROOTS 2006, ZAFAR-UL ISLAM 2008, WOODFINE ET AL. 2012).

In Niger, Sahara Conservation has been working together with the US Association of Zoos and Aquariums (AZA) and local environmental conservation organisations for many years to establish conservation areas, promote environmental education and breed North African ostriches for reintroduction to the wild (www.saharaconservation.org).

In 2011 EAZA, on the initiative of Hannover Zoo, set up a European Endangered Species Programme (EEP) for the North African ostrich to make it better known in Europe and promote its conservation.

1.10 CONSERVATION STATUS

Despite their genetic differences (FREITAG & ROBINSON 1993, MILLER ET AL. 2011) the North African ostrich (*Struthio c. camelus*) and the *Struthio c. australis/massaicus* group are classified as one species. This species, *Struthio camelus,* is assigned by IUCN to the category 'Least Concern' (BIRD LIFE INTERNATIONAL 2018). CITES also distinguishes no subspecies but does list all ostrich populations that occur in countries in which *Struthio c. camelus* was naturally distributed in appendix I, i.e., they have the highest conservation status (CITES 2021).

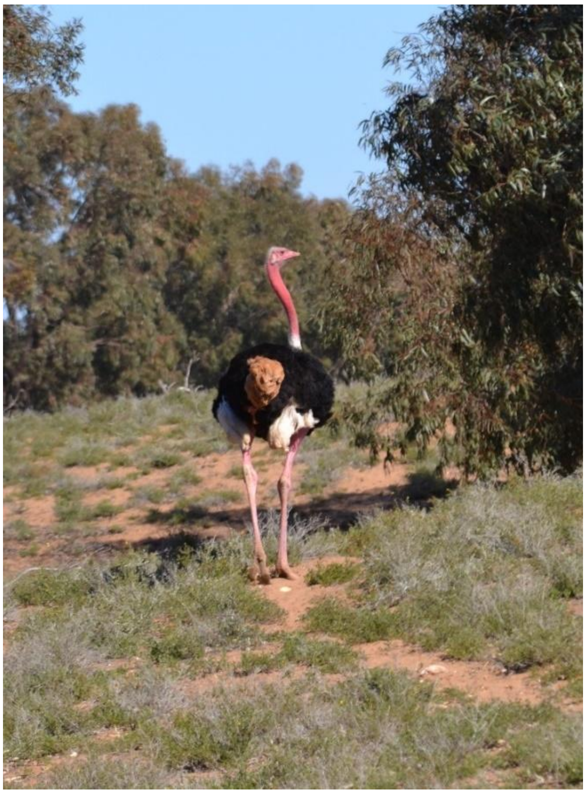


Fig. 8 Male North African ostrich in Souss Massa National Park, Morocco

2. MANAGEMENT IN ZOOS

2.1 ENCLOSURE

2.1.1 General Enclosure Design

The enclosure should give the birds opportunities to express natural behaviour including e.g. running during courtship. Minimum dimensions must always be seen in the context of enclosure structure and considering individual birds living in the enclosure. Younger ostriches usually have a greater need for movement than older birds, and growing ostriches need exercise for normal skeletal growth (TULLY 2016). In general, the outdoor enclosure for a trio of adult, reproductive birds should not be smaller than 1,000 m².

In rectangular enclosures the smallest side should not be too short i.e., not less than approximately 12 m. Acute angles should be avoided to avert the danger of animals becoming trapped. Enclosures with steep slopes are not suitable. A richly-structured enclosure is important, but elements such as large rocks, for example, which could be dangerous for running birds, should be placed with care.

Ostriches live in open landscapes and under natural conditions they spend considerable time watching out for predators. This should be taken into consideration when selecting a suitable enclosure. Of course, in a zoo watching out for predators is not necessary, but nevertheless the birds feel more secure with a clear view of their surroundings. Furthermore, a view into other animal enclosures, e.g. with antelopes, or into visitor areas, offers considerable environmental enrichment.

2.1.2 Boundary

The health and safety of the birds, preventing escape, and the safety of keepers and visitors must be considered when selecting the enclosure boundary.

Ostriches are able to surmount relatively high barriers. Fences should have a height of 1.80 m for adult birds, who reach their full height at approximately one year This height should also apply in a combination of e.g. dry moat, wall and smaller fence. An example from Zoo Hannover is shown in the pictures below (Figs. 9 & 10). In the case of a combination of barriers, the width of the barrier also must be considered. In Hannover it is also 1.80 m.

Figs. 9 & 10

A dry moat at Zoo Hannover with gently sloping side, seen from the visitor area (above) and from the inside of the enclosure (below).

Fences and all other barriers must be clearly visible to the birds. This is especially important after moving birds to a new enclosure, but even if the territory is known to the birds they may be startled by a sudden, unusual noise or movement and start a panic run (cf. HOFFMANN & LAMBRECHTS 2011). Dry moats, e.g. between two enclosures, need additional material at the borders such as rocks, plants or dead wood, to make them visible for the birds from further off. Ostriches can run very fast and must be able to stop in time or to change direction.

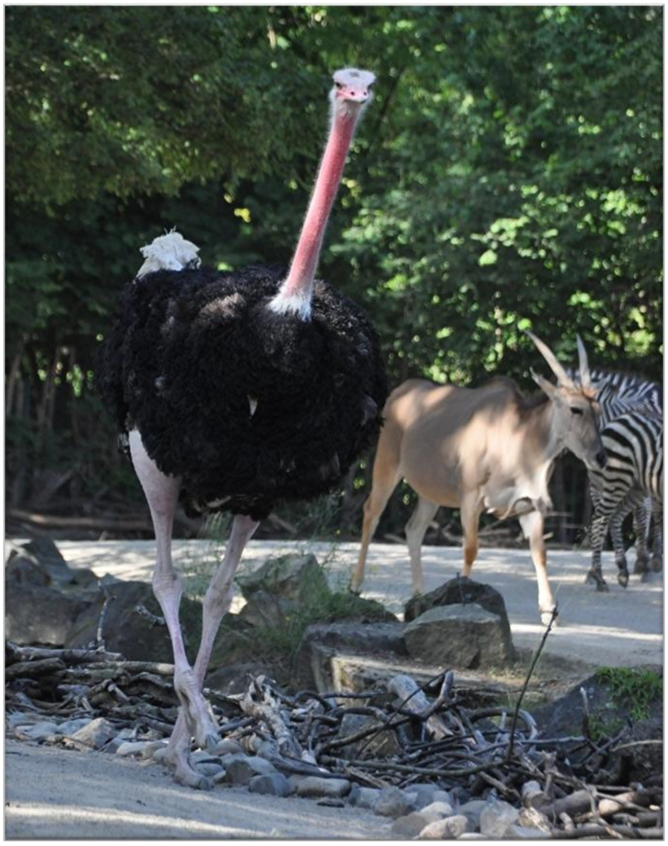


Fig. 11 & 12

Ostrich and eland are situated in two neighbouring enclosures, separated by a conventional dry moat with relatively steep banks. This dry moat caused various accidents because the moat was not sufficiently visible to the ostriches. (Zoo Hannover; photo above: B. Zeller, 2013).

Below, the same dry moat 4 years later. Branches were added to secure the moat, to make the obstacle visible.

If mesh fences are used the mesh size must be such as to prevent the bird's head and legs from being trapped. Also, in the case of other fencing material like metal trelliswork or metal plates, the risk of self-injury must be avoided. No wire ends, nails or other objects should protrude into the enclosure.

Water moats or other water areas are only suitable if ostriches can enter and exit easily on the enclosure side but are not able to exit on the outer site. Many ostriches like to bath and are said to be able to swim.

Fig. 13 Water moat at Avifauna Alphen. Importantly, the lack of obstacles and the gentle slope allow the birds to enter and exit the water easily (photo: Avifauna Alphen).

Electric fencing is problematic for several reasons and should be avoided. Wires are not clearly visible from a distance. They do not stop birds from escaping, but on the contrary can be dangerous if birds get entangled and fall. If necessary, electric fencing should only be used in combination with clearly visible barriers which make the running birds stop in time.

If low barriers are used on the visitor side, it must be ensured that the distance between visitor and animals is wide enough. Ostriches must not be able to reach the visitors. Visitors must not be able to hold small children or dogs within range of the birds. It must be born in mind that ostriches are able to stretch their necks considerably.

2.1.3 Substrate

The enclosure surface must be well drained and free of waterlogging all year round. Birds should not slip nor sink in. Areas of frequent use can be of gravel.

To help abrasion of the claws, smaller concrete surfaces, e.g. in front of the indoor areas are helpful. Stones are necessary to grind the food. If the soil does not contain stones these can easily be added at some points within the enclosure (also see 2.2.2 Feeding).

2.1.4 Furnishings and Maintenance

Sand or dust bathing is essential for plumage care. Sand bathing and preening are the most important types of comfort behaviour described in ostriches (cf. SAMBRAUS 1994). Enclosures must therefore be provided with sand baths. Often a bath is taken by several ostriches at the same time. Accordingly, the bathing areas should be big enough for several animals. The birds do not just squat, they lay down their stretched necks and turn them in the sand. It should also be possible to sand-bath in damp weather. Good drainage is therefore indispensable. As ostriches also like to use sand baths for egg laying, several sand bath areas should be available within an enclosure.

Fig. 14 Sand bathing ostrich at Zoo Hannover (photo: B. Zeller)

The placement of possible nesting sites should be carefully considered. If it is planned to take away the eggs regularly, e.g. to use them for artificial incubation, it might be helpful to offer a nesting site near a gate or fence. Thus, eggs can be taken away without entering the enclosure or having to take the ostriches indoors.

For natural incubation it is important that the birds are disturbed as little as possible. The nesting site therefore should be situated in a relatively quiet area of the enclosure.

North African ostriches, as desert and savanna dwellers, usually do not have the opportunity to seek shade, and even avoid it because they prefer a clear view. However, unusually high temperatures and the lack of shade might cause heat stress. Shade as well as shelter against rain and wind should be provided.

The grass growing within an enclosure is not usually a main feeding source. Nevertheless, grass and herbs that can be plucked by the birds can serve as behavioural enrichment and should be available.

As mentioned above, many ostriches like water. If water areas are present within an enclosure, there should be no steep banks; ostriches should be able to enter and exit easily.

Ostrich enclosures must be cleaned regularly, droppings and feed waste as well as foreign objects removed daily. The birds are very inquisitive and may peck at and swallow anything, including pieces of glass, wires, nails etc.

2.1.5 Indoor Area and Shelters

Depending on available facilities and climatic conditions, it is possible to keep ostriches in closed indoor areas during the night or to offer open shelters which the birds can freely enter and exit at all times. Indoor areas should be placed in such a way that outdoor enclosures can be reached directly without passing through passages. Keepers should be able to enter the indoor area of the ostriches through the building, not just via the outdoor enclosure.

Even shelters which are usually open must have options for taking the birds inside and closing the shelters, if staff must enter the enclosure, in the event of extreme weather, or if sanitary restrictions require it etc.

Options to separate new, ill, or social incompatible birds must always be available. For separated stall units, individual doors should be installed to facilitate management of the separated birds.

Indoor areas should have natural light. They should be well ventilated but draught free.

Additional artificial lighting should be provided where birds have to be kept indoors temporarily. The light regime should be equivalent to 10 to 12 hours of daylight.

The height of the indoor area must be at least 30 cm above the head of the animals (bird in relaxed position and with erect neck). Ostriches can stretch their necks very high. Cables, lamps and other devices must be inaccessible.

The floor must be smooth, dry, non-slip and easy to clean.

Walls or boundaries must be constructed in a way that injuries, e.g. from protruding objects or by being trapped with head or claws, are avoided. As ostrich claws are dangerous weapons, the birds should not be able to kick to the outside.

Whether eye contact between separated birds is positive or not depends on the individual animals and the situation. Separate stall units should be constructed in such a way that eye contact (for standing birds) is possible in principle. Options should be given for closing the upper side of the wall with little effort and thereby preventing birds seeing each other if necessary. Separating walls should have a height of 1.80 m.

Necessary indoor temperatures in winter depend on the age of the birds. For birds older than approximately 4 to 6 months frost-free indoor areas with isolating bedding material are usually sufficient (cf. SCHRADER ET AL. 2009). According to KISTNER & REINER (2004) heating is not even necessary during short periods of -20 °C outside. When indoor areas are heated during winter it should be ensured that the temperature difference between inside and outside is not too high, to avoid respiratory problems.

Chicks, however, need warmth, especially when reared without parent birds. Rearing (brooder) boxes, which are used during the first week and stalls for chicks, at least in Central and Northern Europe, must be heated (see 2.5.2.3 Chick Rearing).

There should be enough trough space or feeding and water points to allow all birds to eat or drink at the same time. Troughs must be placed along the walls, but not directly next to doors, so that they do not hamper the movement of the birds when entering or leaving the indoor areas.

Possible bedding materials are sand, sawdust and straw. For chicks up to four weeks which are kept without parent birds no bedding materials should be used (see 2.5.2.3). After four weeks bedding should be gradually introduced. No bedding should be placed in the direct vicinity of feeding troughs.

Young birds kept without adults tend to feed on anything. Especially in stressful situations like after being moved into a new enclosure, for example, they might overload their stomach with bedding material, which can cause impaction. If the birds eat long-stemmed straw used as bedding it can cause the formation of dangerous bezoars. Therefore, only chopped straw (no longer than 4 cm) should be used at least during the first half year.

Surrounding temperature and precipitation do have an influence on ostrich behaviour. In hot weather ostriches show thermoregulation behaviour as described under 1.4 Habitat. When it rains, on the other hand, ostriches are more often observed sitting down (cf. DEEMING & BUBIER 1999, WÖHR & ERHARD 2005). It might be the case that birds actively seek shelter, but this should not be presupposed. In extreme cases it might be necessary to take the birds indoors if there is a hard frost, to prevent the birds from sitting down in the snow and getting injured by the frost (cf. DEEMING & BUBIER 1999, CLOETE & MALECKI 2011).

2.1.6 Dimensions

Indoor areas for single birds should not be smaller than 8 m². If relatively small stall units are used of e.g. 8 to 10 m² it is helpful if compartments can be connected via sliding doors. Depending on circumstances, the birds can be given more space, can be separated, or birds can be confined to clean an area etc.

When confined for shorter periods e.g., during cold winter weather, a male and females can be kept together or in separate compartments depending on stall dimensions, the characters of the individual birds, hormonal status, age etc.

In Hannover, as an example, during the winter nights the male is kept in an area of 13 m² and one or two females in a neighbouring area of the same size. A third unit is available in case it is necessary to separate the females. Eye contact is possible (see also Fig. 19).

In another institution male and female, when kept together during the night, have 46 m² at their disposal. Sliding doors allow the division of the area into three units if necessary.

2.1.7 Safety / Keeping Requirements

When planning outdoor and indoor enclosures it must be taken into account that especially male ostriches are dangerous animals, even more so during the breeding season. National (working) safety regulations must be followed. It should be possible to take animals indoors and to close the doors without putting the keeper at risk.

As ostriches are also kept as farm animals, in some countries there are regulations or recommendations for ostrich keeping, including minimum dimensions for enclosures and indoor areas, which are equally valid for zoos. This is the case e.g. in Switzerland and Germany. In other countries the requirement is based on the European Council recommendations for ratites kept for farming purposes.

2.2 DIGESTION AND FEEDING

Most of the information about ostrich feeding is derived from studies of farm birds in South Africa. Although several reviews exist (CILLIERS & ANGEL 1999, MIAO ET AL. 2003, COOPER ET AL. 2004, COOPER ET AL. 2005, BRAND & GOUS 2006), the main publications date from the 1990s (SALES 2006). Only ULLREY and ALLEN (1996) give a recommendation for nutrition at zoos. They, however, for practical reasons, recommend the same feeding for ostrich, emu and rhea as well as for different age levels i.e. similarly for growing and adult birds. As there is so little information on the feeding and husbandry of zoo birds on the one hand, and the nutrition of ostriches differs so widely from institution to institution on the other, the information given here can only serve as an orientation.

Adult ostriches are herbivorous (BRAND 2014), and their digestive tract is adapted accordingly. Often, they are described as omnivorous (cf. CRAMP 1977, FOLCH 1992), although examinations of the content of their stomachs do not support this assumption (see chapter 1.4 Habitat). Probably just a very small part of the natural diet consists of animal material.

2.2.1 The Digestive Tract

Ostriches have a rudimentary tongue that lies in the floor of the oral cavity. A long and very extendable oesophagus, opening dorsally to the trachea, is situated on the right side of the neck. A crop is absent.

The oesophagus opens directly into the large, thin-walled glandular stomach (proventriculus). The proventricular glands producing digestive enzymes are restricted to an elongated area of approx. 30 cm lying dorsally and caudally. Distally, the proventriculus opens into the thick-walled muscular stomach or gizzard (ventriculus). Food particles are ground up by ingested stones. The pylorus, the opening from the gizzard to the duodenum, is narrow, so that only small particles may pass through (FOWLER 1996, HUCHZERMEYER 1998, BEZUIDENHOUT 1999).

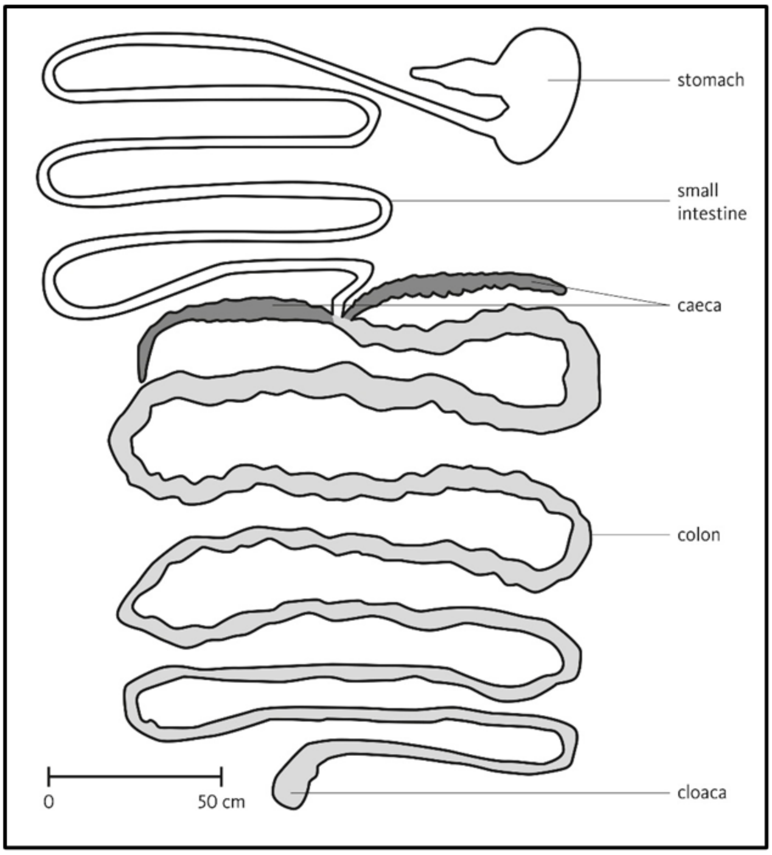


Fig. 15

Graphic illustration of the digestive tract of a young ostrich (body length 80 cm). Redrawn from Stevens and Hume 1995 (Fig. 3.14)

The small intestine, comprising duodenum, jejunum, ileum, is relatively short in comparison to the length of the large intestine and to that of other ratites like emus and rheas (ANGEL ET AL. 1996, MIAO ET AL. 2003). SKADHAUGE ET AL. (1984) examined four wild ostriches and found a duodenum length of 1.5 m and jejunum/ileum lengths from 6 to 8 m. At the junction of ileum and colon open the two large caeca, which could have a length of about 0.9 to 1 m. They have a spiral fold and a sacculated appearance. The colon can have a length of 11 to 16 m (SKADHAUGE ET AL. 1984, BEZUIDENHOUT 1999).

The caeca and the colon form huge chambers in which the microbiological fermentation of plant material takes place and short-chain fatty acids are produced (SKADHAUGE ET AL. 1984, SKADHAUGE & DAWSON 1999, SWART ET AL. 1993a). According to CILLIERS & ANGEL (1999) ostriches are the best post-gastric fibre fermenters among birds.

The ratio of small intestine to colon depends on age. Bezuidenhout (1999) states a ratio of 1:1 in newly hatched chicks and of 1:2 in birds of 6 months, as in adult birds. According to several authors the length of the different parts of the digestive tract in growing birds depends on nutrition; the length of caeca and colon decrease with higher energy content and increase with higher fibre content (CILLIERS & ANGEL 1999, VILJOEN ET AL. 2004). Capacity and gut flora are likewise affected by the fibre content of the diet (BRAND & GOUS 2006).

Passage rates in ostrich are comparable to that of ruminants (CILLIERS & ANGEL 1999). SWART ET AL. (1993a) examined them in ostriches between 5 and 50 kg. They found a variation of the passage time from 21 to 76 h with mean values in the youngest respectively eldest age group of 39 to almost 48 h. FREI ET AL. (2015) report mean digestion times of small particles (2 mm diameter) of 30 to 36 h for birds of 97 to 123 kg.

2.2.2 Feed Ingredients

Fibre digestibility increases with age (ANGEL & CILLIERS 1999, NIZZA & DI MEO 2000). It is approximately 6 % in chicks 3 weeks old, 27 % in birds of 6 weeks and 51 % with 10 weeks. It is more than 60 % in adult birds. The increase is highest up to an age of 17 weeks. The ability to digest fat also increases with age up to an age of about 17 weeks (CILLIERS & ANGEL 1999).

The need for protein is higher in young birds, decreasing with age (BRAND & GOUS 2006, also see Tab. 2). Principal sources of protein in ostrich food are cereals (corn, barley, sorghum, wheat, and oats), alfalfa, soybean meal, animal by-product meals and fermentation by-products (see Tab. 1). According to ANGEL ET AL. (1996) mixtures of protein sources might not supply sufficient methionine or lysine and supplementation is needed to balance the diet.

Tab. 1 Examples for sources of the different food components (from BRAND 2014, adapted)

Energy	**Roughage**	**Protein**	**Minerals**
Maize (corn)	Lucerne hay	Soybean	Feed lime
Barley	Wheat bran	Canola	Di-calcium phosphate
Wheat	Oat bran	Sunflower	Mono-calcium-phosphate
Triticale	Barley hay	Fish meal	Salt
Oats	Oat hay	Sweet lupines	Mineral- and vitamin premix
Brewer’s grain	Oat straw	Peas	
	Wheat straw	Beans	

An important factor for healthy skeletal growth in young ostriches is the ratio of calcium and available (non-phytate) phosphorus. Recommended values usually lie between 2:1 and 3:1 (ANGEL ET AL. 1996, MIAO ET AL. 2003, BRAND 2014, cf. Tab. 2) in growing ostriches. Excessive calcium and phosphorus levels in the diet of ostriches are suspected to have a negative effect on the absorption and utilization of manganese, copper, zinc, and other microminerals (ANGEL ET AL. 1996, MIAO ET AL. 2003), and should be avoided.

Whether additional calcium (in the form of oyster shells e.g.) should be offered to laying females depends on the calcium content of the food and of the number of eggs a hen is laying. If the amount of concentrated food containing the necessary minerals in the diet is very high and the hen is just laying one or two clutches of eggs it might not be necessary. If eggs are constantly removed, ULLREY & ALLEN (1996) recommend offering oyster shell ad libitum to the females, something which is also general practice at Hannover Zoo, for example.

CILLIERS & ANGEL (1999) assume that the intake of soil might represent 1 to 3 % of the total intake of food; this may influence mineral metabolism and should be taken into consideration.

Tab. 2 Comparison of South African commercial guidelines and zoo food

	Brand (2014)[1]					Ullrey & Allen (1996)[4]	Zoo pellets (Mazuri™)[4]	
Age [months]	0-2	2-4,5	4,5-6,5	6,5-10,5	>10.5	all life stages	0-3	>3
product name	Pre-Starter	Starter	Grower	Finisher	Maintenance		Starter	Maintenance
crude protein [%]	19.0	17.0	15.0	12.0	10.0	22.0	17.17	17.34
lysine [%]	1.0	0.9	0.75	0.55	0.3	1.2	0.9	0.97
crude fiber [%]	10.0[2]	10.0[2]	17.5[2]	22.5[2]	30.0[2]	10.0	10.33	17.7
crude fat [%]	2.5	2.5	2.5	2.5	2.0	1.0	2.82	2.55
calcium [%]	1.2-1.5[3]	1.2-1.5[3]	1.0-1.6[3]	0.9-1.8[3]	0.8-1.8[3]	1.6	1.26	1.51
phosphate [%]	0.6	0.6	0.5	0.5	0.5	0.8	0,72	0,62

1) ZA Ostrich Manual: **Minimum** values (if not indicated otherwise) for feed composition, as regulated by law in South Africa.

2) maximum value

3) minimum - maximum

4) Recommended for ostriches, emus and rheas.

Tab. 2 compares values given in commercial guidelines for minimum food composition in South Africa (BRAND 2014) to these from ULLREY & ALLEN (1996) and the values given for commonly used zoo pellets from Mazuri™. The Mazuri values are taken from the bird datasheets 07 and 06 (www.mazurizoofoods.com, last accessed 12 August 2021). The phosphate values were given by Juliette Marshall, senior nutritionist (personal correspondence August 2021), as the datasheets only give the total amounts, not the amount of non-phytate phosphate, available to the birds.

The South African values for protein are minimum values. They are, however, supported by several studies. MAHROSE ET AL. (2015) found the best feed conversion ratio for birds between 2 and 9 weeks for a dietary protein content of 18 % (in comparison to 21 % and 24 %). BRAND ET AL. (2000) report that a dietary protein content of 13 % has no negative affect on growth rate and food conversion in growing ostriches of 4 to 11 months.

According to BRAND ET AL. (2003) minimum values for breeding female ostriches are 8.5 MJ (ME/kg) dry matter and 10.5 % protein. This corresponds with the values given by WILLIAMS et al. (1993) for the average composition of plants selected by free-ranging ostriches in the Namib desert: 11.2 % protein, 35.2 % fibre, 8.87 % dry matter.

In South Africa, different kinds of concentrates are used according to life stage. In contrast, the recommendation of ULLREY & ALLEN (1996) for the feeding at zoos is for all life stages. Mazuri recommends different types of feed for the first 3 months and for older birds. Both recommendations for zoo feeding are for emus and rhea as well as ostriches. This could explain the main differences such as the high protein content of the zoo food.

Assessing the nutritional components of the zoo pellets, it must be considered that ostrich chicks are generally fed ad libitum and, at least at the beginning, almost exclusively on pelleted feed. The feeding of older zoo birds, on the other hand, is usually restricted, and concentrates represent only a fraction of the diet.

In practice, feeding differs from institution to institution. Some ostrich enclosures resemble pasture, other birds are kept in enclosures with very sparse vegetation. Pelleted food of high quality is available, makes the feeding easy and helps to provide the birds with all necessary nutrients. This is especially helpful for the rearing of chicks. Mixed rations, on the other hand, give birds the opportunity to select and are an important tool for occupying them with feeding and consequently for daily behavioural enrichment. Many zoo diets consist of a mixture of different components, with pellets representing just one fraction.

The use of poultry concentrates is not advisable. The bioavailability of amino acids is higher for ostriches, for example, than for domestic fowl (CILLIERS & ANGEL 1999). Due to their high protein content, the use of poultry (chicken and turkey) feeds can cause problems with skeletal growth and obesity (ULLREY & ALLEN 1996, CILLIERS & ANGEL 1999). Coccidiostats may be toxic for ostriches (KORBEL ET AL. 2015).

According to KORBEL ET AL. (2015) the main part of the nutrition of farmed ostriches should consist of roughage. This is even more the case at zoos, where emphasis lies on healthy, long-lived birds, not on fast growth and high egg production rates. Roughage should be constantly available, additional to the roughage the pellets already contain. Lucerne hay, chopped straw and hay, grass or in winter even grass or maize silage can be offered.

Ostriches usually prefer fresh lush dicotyledons and fruits to dry plant material (see chapter 1.4 Habitat). Zoos usually use diverse plants for ostrich feeding.

Examples for suitable plant components of feed are:

- All kinds of green leaves, above all cruciferous vegetables like lettuce, chard, spinach, different kinds of cabbage, as well as carrot leaves, clover etc.
- Slices of turnip, sugar beet, beetroot, carrot etc.
- Tomato, sweet pepper, courgette, cucumber, apple; KORBEL et al (2015) also mention cooked potatoes.

Feed intake depends on many factors such as age and weight of the birds, energy content of the food, season (summer/winter), reproductive status (egg laying or not) etc. (cf. ANGEL ET AL.1996).

Roughage should always be available.

Gizzard Stones

Ostriches need stones to grind feed in the muscular stomach. BRAND (2014) recommends stones of 50 to 75 % of the size of the big toenail. According to JARVIS (2015) the size of the offered stones should be half of the width of the toenail. The stones must always be offered separately from the feed. Suitable stones are of hard material which are not ground too fast and have no sharp edges, such as river gravel.

Water

Clean water should always be available. Water intake depends on age, ambient temperatures, type of feed etc. (ANGEL ET AL. 1996, BRAND 2014). In chicks separated from adult birds a lack of water is obvious when their usually abundant colourless urine becomes whitish (COOPER & HORBÁNCZUK 2004).

2.3 ACCLIMATISATION / ADAPTATION TO A NEW ENVIRONMENT

Ostriches are very set in their ways and habits. Any sudden change in their environment causes stress. They can easily be frightened by e.g. hot air balloons, helicopters or other flying objects (experience within the EEP, cf. HOFFMANN & LAMBRECHTS 2011).

New enclosures i.e. unfamiliar surroundings can cause panic reactions, as can unknown animals in neighbouring enclosures. Stereotypical running patterns as described by HOFFMANN & LAMBRECHTS (2011), might occur.

Most stress symptoms, however, belong to the area of feeding behaviour. Pecking constitutes a major part of ostrich behaviour. Stressed birds peck at anything they find: bedding material, faeces, sand, water, stones, foreign objects. They tend to overload their stomach, and impaction might be the result. This happens especially in young birds but is also seen in adults. Another behavioural disorder described in the literature is pecking at fencing material. Snapping into the air (above head height), at water or sand – with or without ingesting sand – may also be observed (cf. HUCHZERMEYER 1998, SAMBRAUS 1995b). At farms with intensive ostrich keeping, birds sometimes even peck their own feathers or the feathers of other birds (SAMBRAUS 1995a, 1995b, SAMSON 1996, SCHULZ 2004).

If the ostriches' surroundings must be changed the transition should be as gentle as possible. If closed indoor areas are used the birds should have the opportunity to acclimatise indoors first, to adapt to the new surroundings, noises, keepers, management etc. In a second step, the birds can become accustomed to the outdoor environment in a relatively small intermediate enclosure. Fences could be closed to some extent to reduce stressful external stimuli. If possible, birds should be able to see into the actual (future) outdoor enclosure. Once they are let into the larger outdoor enclosure, ways to escape into the intermediate enclosure or indoors should be open. Birds must have the opportunity to be well acquainted with the new enclosure, borders, obstacles etc. before other animals are added.

Feed could be brought from the previous institution and be mixed with the new feed. The period of gradual feed transition should last approximately two weeks.

2.4 SOCIAL STRUCTURE

2.4.1 Basic Social Structure

Ostriches are social animals and should not generally be kept as solitary specimens. This is especially important with young birds.

In general, adult ostriches are kept in groups of one male and one to four females, whereby the number of females can be higher.

Whether it is better to keep two females or three or even more depends on the individual case. Some females get along very well and, in some instances, even share incubation. In other cases, a second female might only be a disruptive factor during the incubation phase. If females are chased away during incubation, it might be helpful to have two "minor" females and consequently a two-by-two constellation.

The age of the individual birds is important for the formation of a group; ideally, immature birds should be kept with other immatures or with adult females.

The keeping of sexually mature males with immature females is problematic. It should be considered only when the enclosure is very large, the formation of two groups is possible and birds can keep their distance. There should be a sexually mature female as partner animal for the male as well as other immature birds as companions for the immature female.

2.4.2 Keeping more than one Sexually Mature Male

There is very little experience yet in keeping several sexually mature North African ostrich males together. Until now only one institution within the EEP, the Réserve Africain de Sigean in Southern France, is keeping adult males together in one enclosure.

Whether it is possible to keep two or more males together in one enclosure will depend on the available space, but also on whether the birds have to be taken indoors, for example at night. Difficulties are likely to arise in this case. At Réserve Africain de Sigean a group of five to seven males is kept in a 15-hectare open field enclosure. The birds are never indoors at night. Each male defends its own small territory during the breeding season. Even though there are four females in the enclosure the males do not fight over them. In another 14-hectare enclosure 15.5 hybrid ostriches are kept all year round with no aggression between the males.

For farm environments, open shelters with two entrances are usually recommended so that in case of aggression the birds can more easily leave the shelter.

Minimum dimensions for outdoor enclosures for several males exist either as recommendations or in mandatory form, for farmed birds (Council of Europe 1997) as well as for farmed and zoo birds (e.g. in Switzerland [TSchV 2008] or in Germany [BMEL 2019]).

These minimum dimensions, however, are problematic, above all because they are based on experiences with generally more docile farm ostriches.

2.4.3 Changing Group Structure

During the breeding season male ostriches are territorial and particularly aggressive. A change in the group structure such as adding new group members or the removal of the male should therefore take place outside the breeding season.

Generally, ostriches react very sensitively to a change of environment. Hence, acclimatisation should take place gradually and carefully. The birds must be kept under close observation to detect aggression but also abnormal behaviour (excessive intake of food, water, substrate, bedding etc., feather pecking, stereotypical behaviour; see 2.3 Acclimatisation) as early as possible.

Before adult birds are brought together, standard practice is to get them used to their new surroundings, indoors and outdoors. Before a bird joins the group in the outdoor enclosure it can be kept in an adjacent enclosure within sight of the other birds. Thus, the behaviour of the birds towards each other can be assessed and they have a chance to get to know each other. Often, however, especially with young ostriches, this is difficult because birds kept alone try to get to the other birds and even injure themselves at the separating fence. In this situation, birds must be kept without eye contact initially or be introduced directly, to the least aggressive animal(s) of the group first.

Before adding ostriches to a group (or ostriches to other species) new animals should have the chance to become acquainted with the outdoor enclosure, to learn where its boundaries and obstacles are and where the way to the enclosure entry or back indoors is, in case flight is necessary.

When introducing new hens, they should be introduced to other hens first before adding the male to the group.

2.4.4 Sharing an Enclosure with other Species

Within their natural environment, ostriches are often seen in the company of groups of other animal species, and at zoos mixed species exhibits are also possible. Which species can be kept together with ostriches depends on the respective species but above all on the available space. It must always be considered that during the breeding season ostrich males are territorial and will defend their territory by any possible means.

Fig. 16 North African ostrich (with foster chicks) at Zoo Muenster with *Tragelaphus oryx*

Fig. 17 Mixed species exhibit at Zoom Erlebniswelt Gelsenkirchen with *Tragelaphus oryx, Antidorcas marsupialis* and *Equus burchelli boehm*i (photo: ZOOM Erlebniswelt)

So far zoos have not had much experience with the keeping of North African ostrich together with other species. Tab. 3 shows the species kept together by the EEP partners. Research on ostriches in mixed species exhibits until now has been carried out by CHAIWAN & PLOWMAN in 2013 and KEETMAN & SCHAPIRA in 2014. Exhibits with North African ostriches were not included.

Institution	Encl. size [m²]	*S. c. camelus*	Other animals within the enclosure	Remark
Hannover	1,050	1.1	none	
Alphen	1,500	1.1	1.1 *Balearica r. gibbericeps* , 0.0.8 *Numida meleagris*	
Jerez	1,800	1.1	2.5 *Gazella dorcas neglecta* , 7.7 *Numida meleagris*	
Hamburg	1,832	1.1	1.1 *Phacochoerus africanus* , 1.4 *Equus quagga chapmani*	ostrich eggs have to be removed, to avoid destruction by *Phacochoerus*
Kronberg	2,485 (+ 150 pre-encl.)	1.1	*Numida meleagris* (just temporarily)	
Tabernas	3,800	1.1	2.4 *Tragelaphus spekii gratus* , 1.0 *Giraffa camelopardalis* , 1.4 *Tragelaphus strepsiceros* , 2.1 *Eudorcas thomsonii* , 0.0.4 *Balearica regulorum* , 1.2 *Kobus leche*	only before the onset of sexual maturity of the male ostrich
Paris	9,592: main encl. 823: pre-encl. 817: isolation encl. 1 994: isolation encl. 2 1,397: pool	1.1	3.10 *Giraffa camelopardalis* , 3.7 *Tragelaphus strepsiceros* , 2.2 *Balearica pavonina* , 1.0 *Leptoptilos crumenifer* , 0.3 *Struthio camelus spec.*	
Muenster	10,000	1.2	0.2 *Struthio camelus australis*, 1.4. *Kobus defassa,* 1.4 *Tragelaphus oryx,* 1.4 *Equus burchellii boehmi,* 1.8 *Antidorcas marsupialis,* 1.5 *Connochaetes taurinus*	
Paignton	12,788	1.1	1.2 *Equus zebra hartmannae*	
Gelsen-kirchen	22,000 + 5,000	1.1	1.6 *Equus guaggua boehmi* , 1.2 *Ceratotherium simum* , 1.9 *Tragelaphus oryx* , 2.3 *Tragelaphus strepsiceros* , 8.0 *Antidorcas marsupialis* , 2.3 *Hippotragus niger* , 1.0 *Leptoptilos crumenifer*	the rhinos are not able to leave the 5,000 m² area, but the other animals enter
Sigean	159,300	4.0	28 *Connochaetes taurinus* , 53 *Antidorcas marsupialis* , 6 *Syncerus caffer* , 75 *Kobus leche* , 11 *Oryx gemsbok* , 0.4 *Struthio camelus sp.*	ostriches are never locked indoors
Sigean	12,400	3.1	0.26 *Ovis aries musimon*	ostriches are never locked indoors

Tab. 3 Examples of institutions holding North African ostriches as of June 2020

2.4.5 Introduction of New Species

Ideally, introductions should take place outside the breeding season (see above).

Prior to an introduction, if possible the different species should be kept in adjacent enclosures so that animals can get used to each other. If both enclosures are very large it might be necessary to feed the different species beside the separating fence so that they have to come close to each other.

Fig. 18

Introduction of North African ostriches and scimitar-horned oryx at the fence of an acclimatisation enclosure in Ouadi Rimé - Ouadi Achim Wildlife Reserve in Chad (photo: Sahara Conservation)

Before introducing new species, ostriches must be used to each other. They have to be well adapted to the enclosure (see 2.3 Acclimatisation) and know the possible escape routes. Situations where the ostriches are easily cornered by other species must be avoided. Whether the introductions take place step by step – e.g. smaller or more docile antelope species first, then bigger or more aggressive ones, then zebras etc. – or all species are brought together at the same time depends on the size of the enclosure, the different characters of the animals etc. When the different animal species are brought together within the enclosure, there should be abundant feed in several feeding sites, so that the animals are occupied with eating and not very much interested in new arrivals. Keepers should observe the introductions carefully and be prepared to intervene (by opening doors to create escape routes or by separating animals).

2.5 BREEDING

The breeding of ostriches is relatively easy – although not all animals are compatible; some females will ignore a certain male even if it is the only male available. These females might have bred successfully with other males before. Another female, on the other hand, might accept this male directly (experience within the EEP, cf. CLOETE & MALECKI 2011).

Breeding management is feasible. If natural incubation is intended, it is possible to remove eggs until weather conditions are suitable. Eggs can be taken away for artificial incubation or to prevent incubation. If breeding is not intended eggs can be replaced by dummy eggs or can be prevented from developing, for example by vigorous shaking. The advantage is that after a while the hen stops laying and birds have the opportunity to express their natural breeding behaviour.

SWAN & SICOURI (1999) describe sperm storage in ostriches (also see BEZUIDENHOUT ET AL. 1995). They assume that fertile eggs can be laid for at least five to eight days after copulation. MALECKI ET AL. (2004) report that fertile eggs are laid for almost four weeks after separation of the two sexes.

2.5.1 Mating

In the wild, if population density allows male ostriches usually cover several females and females are covered by different males. At a zoo, single stable breeding groups are the rule. Which male:female ratio is advisable depends on the individual situation (see 2.4.1 Basic Social Structure).

Especially in the male, the start of the breeding season is indicated by a change of behaviour and appearance. The male usually becomes more aggressive towards keepers and the colouring of the bare parts of the skin, especially of the neck, intensifies. The male asserts his territory by standing at the enclosure boundaries and making his booming calls. At the same time, he is signalling to the females that he is available. The male is also busy with preparing one or more nesting sites, scratching depressions into the sand and offering them to the females.

Courtship display might be visible, but the mating itself might not necessarily be so. It sometimes happens very quickly without much courtship behaviour prior to copulation.

The breeding season of North African ostriches in their natural environment mainly depends on the availability of food and consequently takes place during or after the rainy season. HICKS-ALLDREDGE (1996; cf. TULLY 2016) describe ostriches as dependent on photoperiod and that in the United States the breeding season of the (farm) ostriches starts when daylight increases. LAMBRECHTS (2014) reports the same for the South African Black (hybrid ostrich race) in South Africa. In the EEP ostriches, however, it is not necessarily the case that their behaviour is influenced by daylight. The first- and second-generation ostriches in some institutions start to lay as early as December (or even the end of November), just like their ancestors in Morocco.

2.5.2 Egg Laying and Incubation

Hens usually lay into the scrape prepared by the male or even at a nesting site offered by the staff. Healthy, well-nourished females can achieve a very regular laying pattern. They might lay every second day and even within a fixed time window during the day.

If the eggs are not removed the hen/hens might lay for about two to three weeks until incubation starts (see 1.6 REPRODUCTION). Young females might lay their eggs anywhere, indoors or outdoors, or even lose them when running. These eggs, when undamaged, can be placed at a nesting site chosen by the zoo staff. The ostriches will accept it as their nesting site or the clutch they like to complete.

2.5.2.1 Natural Incubation

So far there has been just one example of a naturally incubating North African ostrich pair in a zoo environment, due to the fact that the EEP is relatively young. The first successful natural incubation happened in 2024 at Réserve Africaine de Sigean.

In other institutions natural incubation might not have been attempted or birds might have been inexperienced. Nevertheless, there have been cases of natural incubation by other ostriches or hybrids, on farms as well as in zoos.

In general, natural incubation might be difficult in Central and Northern Europe due to the climatic conditions. On the other hand, zoos in Sweden and Denmark have succeeded in natural incubation. The zoo in Schwerin in Northern Germany is another example of a zoo where natural incubation works successfully. At some zoos e.g. Zoo Muenster, Zoo Basel or Zoo Schwerin, natural incubation was also carried out indoors.


Figs. 19 & 20 Different nesting situations at Zoo Schwerin, Germany. The hybrid ostriches, in different years, successfully incubated indoors (left) as well as under the shelter in the outdoor enclosure (right; photos: Zoo Schwerin).

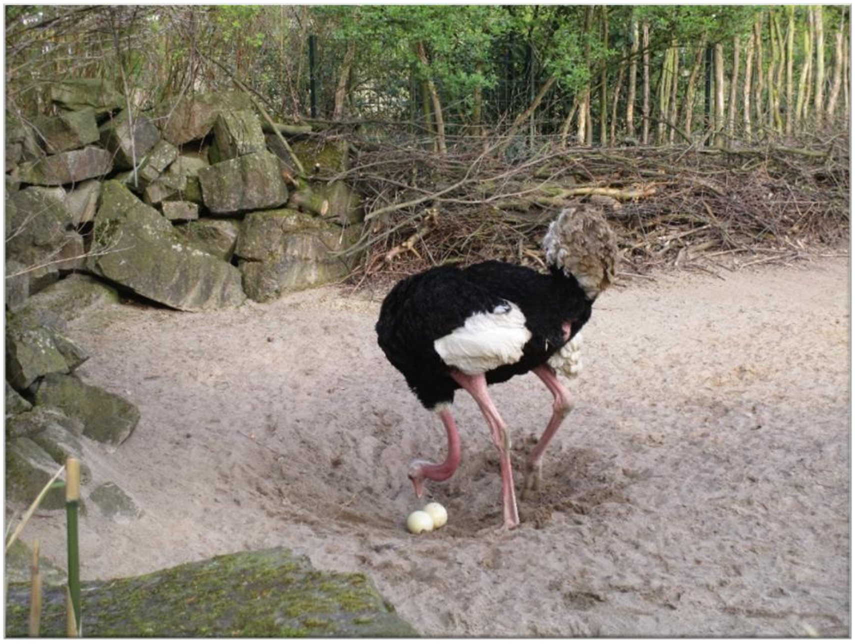


Fig. 21 Nesting site at Zoo Hannover

The primary requirement for successful natural incubation is a suitable nesting site. The nesting site must be a sufficiently large, dry and well drained sandy area. An example from Hannover is: nesting depression of ca. 130 cm diameter, surrounding flat, sandy area ca. 300 cm (should not be less than 250 cm). The birds should have the chance to scrape deeply into the sand. When a nesting site is chosen by the birds there must still be other areas where sand bathing can take place. Often the male scrapes several hollows in the sand to offer them to the female as nesting sites. The final choice of site where the incubation takes place can be influenced by placing one or several eggs there. These eggs can either be laid shortly before by one of the females and still be intact or an “artificial” egg, which can easily be prepared by emptying eggs, filling the shell with sand and closing them with silicone. To get the right weight a mixture of different sand types is recommended. Especially when the females are in their first laying season it is common that they lay their eggs anywhere and that these have to be placed in the nest by the keepers.

When choosing nesting sites, aspects like potential disturbance of the incubating birds, protection from inclement weather and the feasibility of feeding the birds should be considered.

Usually, the male and the dominant female incubate the eggs. In trios it also happens that two females share the incubation.

Female ostriches at a zoo might carry on laying as long as their eggs are removed. German farmers report that ostrich hens stop laying in autumn without any change in management, which coincides with the stimulation by “gonadotropin hormones during increasing photoperiod” described by HICKS-ALLDREDGE (1996) or, in this situation, the decreasing stimulation. But this is not necessarily the case. To stop the hen laying eggs it might be necessary to let her complete her clutch and incubate. A seasonal feeding with less energy content in autumn and early winter might be helpful, too, to prevent the hen from indeterminate laying. At the end of winter the feeding can be changed again to more energy rich food to stimulate laying and improve egg quality.

The separation of the male might also end the laying. For farm birds the stimulus of the presence of the male is described (MALECKI ET AL. 2004).

2.5.2.2 Rearing after Natural Incubation

Ostriches that lead chicks should be able to seek out a sheltered area. A feeding place close to the nest has the advantage that one parent can always be near the chicks to protect them from predators such as crows during hatching and as long as they cannot follow their parents. Soon after hatching, chicks should be able to watch adult birds feeding and drinking. It should be possible to set up temporary feeding places for the chicks where, separately from the adult birds, they can be fed starter pellets, finely chopped leaves, herbs and roughage etc. Long-stemmed feed items should not be offered to chicks, as they can cause bezoars (see also 2.5.4 Rearing after Artificial Incubation, Feed and Water).

2.5.2.3 Artificial Incubation

Natural incubation is always preferable to artificial incubation. Ostriches should have the opportunity to express natural behaviour and chicks should have the chance to grow with their parent birds or other adult ostriches. In this recently-founded and small EEP however, artificial incubation, which can show very good results due to the immense experience there is in the ostrich farming business, might be a suitable option for a good reproduction rate and relatively fast population growth. The experience gained in zoos might on the other hand be of considerable value for the ongoing efforts to reproduce ostriches in range countries for reintroduction purposes. For these reasons, we give a relatively detailed description of artificial incubation.

Egg Collection and Cleaning

Egg collection should take place soon after laying. Eggs should be collected with clean hands or with a paper towel. Dirty eggs can be cleaned with a paper towel or a soft brush. Massaging dirt into the egg pores is to be avoided. Very dirty eggs can be washed carefully with warm water. The water should be lukewarm; in any case it must be warmer than the egg. If the water is too cold, the pores shrink and draw water and pathogens into the egg (DEEMING 1997, BRAND 2014). Washing is possible under slowly running water (KISTNER & REINER 2004, BRAND 2014) or in a bath. In the second case, the egg should not be completely submerged in the water. Disinfection is possible but usually not necessary. Eggs should not be dried with a towel or other materials but air-dried.

Egg Storage

It is helpful to set several eggs in the incubator at the same time. The development of the eggs/embryos can be compared, and the chicks will hatch within a short period of time. Eggs may be stored for at least two days and can be stored for about 10 to 14 days. Hatchability already starts to decline after seven days and in ostrich farming setting eggs after that period is not common. At a zoo, however, where just a small number of eggs are laid, a longer storage time of about 10 days is advisable. Before storage, eggs should be labelled by pencil with number and laying date. After candling the air chamber should be marked.

Eggs should be stored in a clean, well-ventilated room. Recommendations for storage temperatures lie between 15 and 18 or up to 20 °C. For storage longer than seven days, sometimes lower temperatures of 12 °C are recommended. Brand (2014) recommends temperatures of 15 to 20 °C with a relative humidity of 75 to 80 %. There should be no wide temperature fluctuations and the temperature should never exceed 25 °C, even for brief periods. During storage, eggs can be placed either horizontally or in an upright (tilted) position with the air chamber at the top.

After two days, eggs should be turned. Eggs lying horizontally are turned through 180°. The turning direction is to be changed daily.

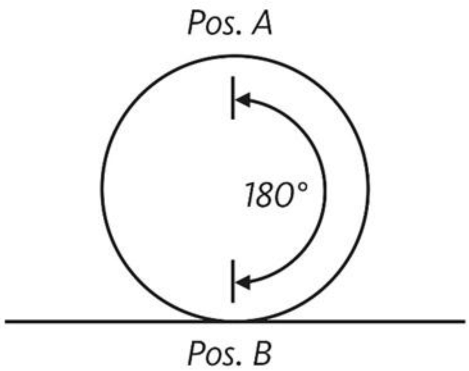


Fig. 22 Turning of eggs stored horizontally.
Redrawn after Kreibich & Sommer 1994

Eggs in an upright position are moved as in the incubator: they usually stand at a 45° angle from the vertical direction and are tilted through 90°.

When transport over long distances is necessary, eggs should be left unmoved afterwards to stabilise for approximately 12 hours.

12 to 24 hours before setting the eggs, the room temperature should be raised to an intermediate temperature between storage and incubation temperature to avoid condensation on the egg surface.

Incubation

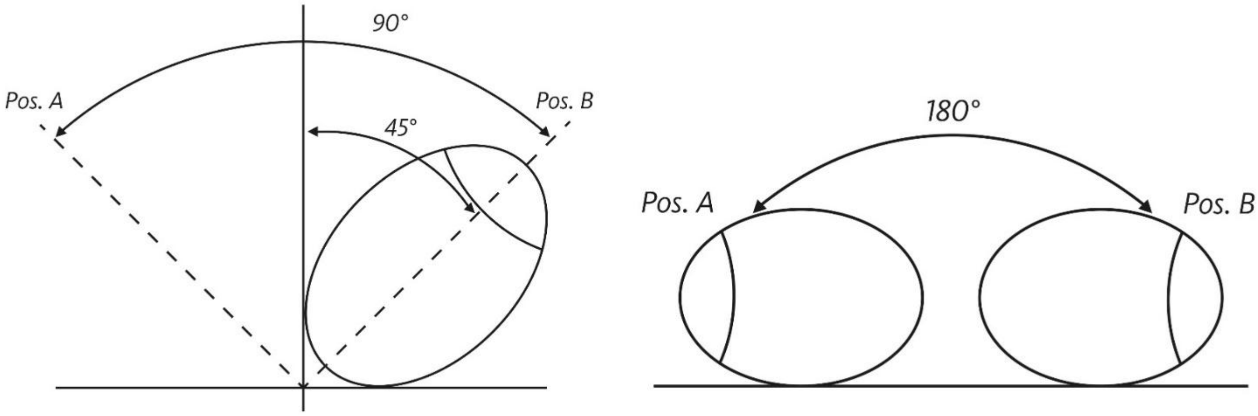
Incubators should have a good ventilation system and be situated in a well-ventilated room.

Eggs are usually set vertically, that is, tilted at an angle of 45° to the vertical.

Incubation temperatures should be between 35.5 and 37.2 °C. Temperature is the most critical incubation parameter and determines the duration of the incubation period, which should last about

42 days. The temperature should be set some hours before the eggs are put into the incubator. Temperature fluctuations should not exceed 0.5 °C.

Eggs should be turned at least 3 times during the day if turned by hand. In Hannover they were turned automatically, 10 times daily. Egg "turning" means that the eggs are tilted through 90° from a 45° angle in one direction to a 45° angle in the other direction.



Figs. 23 & 24 Vertical and horizontal egg turning during incubation. Redrawn after BRAND 2014.

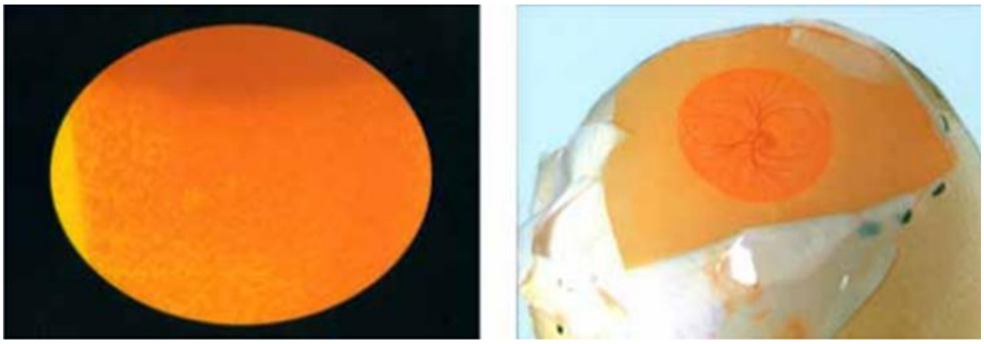
If incubators are used where eggs have to be turned by hand, BRAND (2014) recommends incubating for the first two to three weeks in a horizontal position, turning through an angle of 180°, point to point (see Fig. 24). During weeks three to five they should be put in an upright position and turned through 90° as described above.

Recommended humidity lies between 20 and 30 %. In Hannover mean values were between 22 and 24 % with a fluctuation between 18 and 38 %. Temperature and humidity as well as proper automatic turning should be checked twice daily.

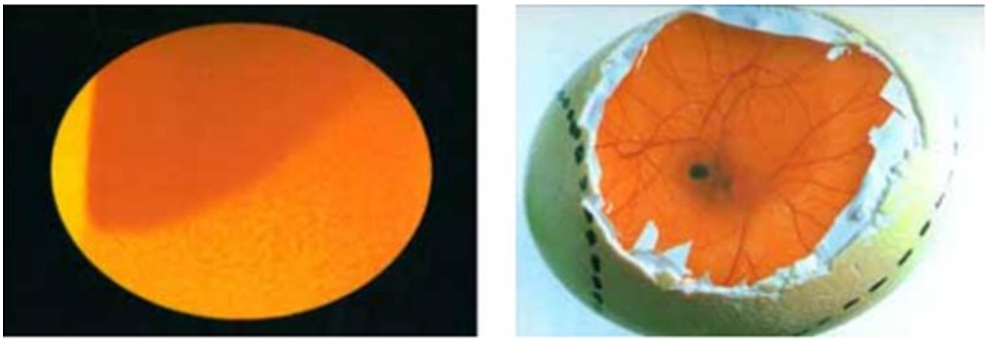
Daily cooling of the egg is not necessary, although, depending on the incubator and the number of eggs set, it may be necessary to open the doors once (or even twice) a day for better ventilation of the incubator. If for any reason there has been a power cut for a certain time, the incubator should also be ventilated to provide oxygen. A few hours of cooling do not affect the embryo. As ostrich eggs are very big it takes some time to cool down the inner part.

Incubation Monitoring

Weight loss should be monitored as well as the development of the embryo/chick itself. An egg should lose 13 to 15 % moisture until about day 39. If eggs lose more than 18 to 20 % or less than 10 % of their initial weight, the chicks are less likely to hatch. Insufficient water loss results in oedema, and oedematous chicks usually need assistance to hatch. To control the weight loss of the eggs, the weight should be noted when setting the eggs, subsequently once a week and again at day 38 or 39 before moving the eggs to the hatcher (or hatching compartment of the incubator). During the weekly check eggs should also be candled. Infertile eggs or eggs where development has stopped should be taken out of the incubator for sanitary reasons. To determine, just by candling, if an embryo has died or not is relatively difficult and requires some experience. Notes should be made to help in assessing the embryonic development. An intensive egg smell (often intensifying when eggs are taken out of the incubator) is an indication of rotting eggs and these eggs should be removed immediately.



Day 7



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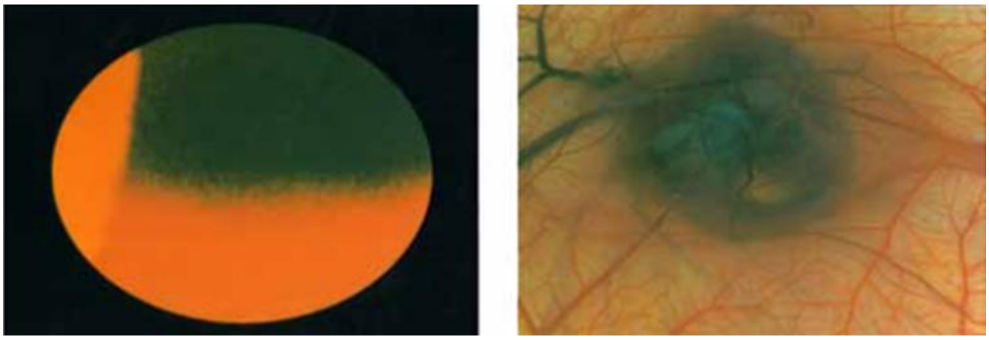

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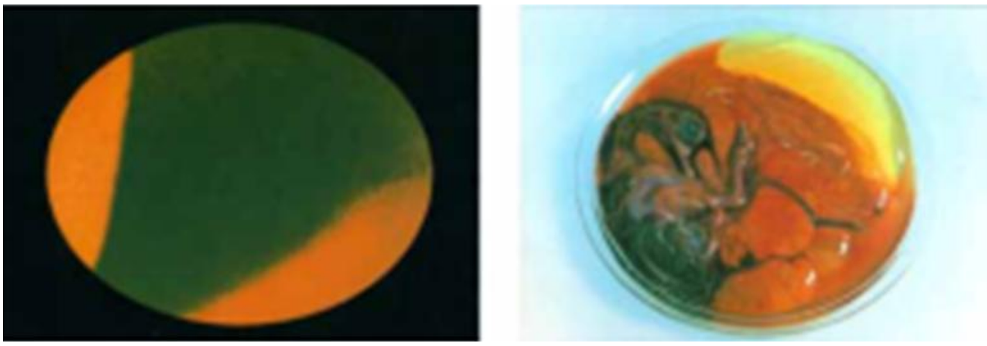

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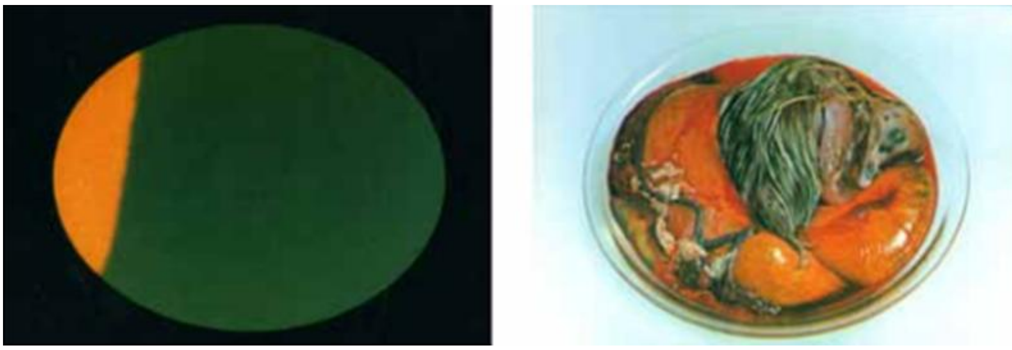
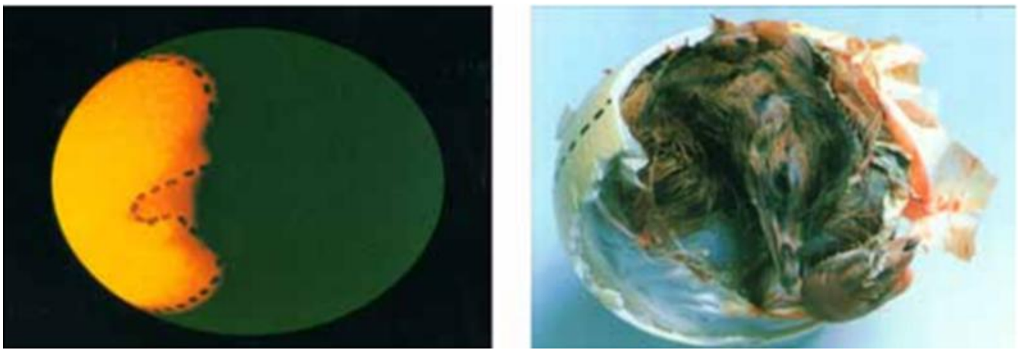


Day 35



Day 39

Fig. 25 Embryonic Development, photos taken from Jarvis 2015

Hatching

In a farming environment, very often all eggs are moved to the hatcher at the same time. At the zoo, where the number of eggs is usually small, eggs should be transferred individually when internal pipping, that is the entry of the beak into the air chamber, takes place. Starting on day 38 or 39, eggs should be candled twice daily. Normally the edge of the air chamber can be seen as a smooth line. The internal pipping may appear as a clear depression in the edge of the air chamber, that is, an expansion of the air chamber, or as a dark shadow entering the previously clear air chamber (see Fig. 25). At this point, the eggs must be moved to the hatcher.

Hatchers usually operate at a temperature about 0.5 °C lower than that of the incubator (in Hannover: 36 instead of 36.6 °C). Humidity is always higher than in the incubator but varies considerably, lying between 30 and 70 %. The high humidity helps to keep the egg membranes soft when the egg is open. Dry membranes can become very hard and make the hatching process even more difficult.

Eggs should be set in horizontal position and not turned any more. After 24 to 36 hours the chick will have consumed the oxygen of the air chamber. During this time the chick should have managed external pipping, that is the opening of the shell. If this is not the case, an opening (of approximately 2 cm diameter) should be made into the shell over the air chamber. Afterwards the chick should be left for another 24 hours until, if necessary, further assisted. Regular monitoring, however, is necessary, because a chick may also move away from the air chamber. If no progress is visible after the aforementioned 24 hours, the shell may be removed gradually, piece by piece, with the utmost care. If fresh blood is visible i.e. the membrane still has visibly active vessels, the process must be stopped and the hatching assistance continued at a later point in time.

If no internal pipping is taking place, it can be due to the malposition of the chick. The head in this case is not turned into the right direction, and the chick therefore unable to penetrate the air chamber. In this case, the shell must be removed very cautiously from the air cell in the direction to where the beak is presumed to lie, but without harming the inner shell membrane.

Incubation time for ostriches is approximately 42 days, but is heavily dependent on incubation temperature; variations between 39 and 47 days are possible. At Hannover Zoo in 2011, for example, chicks hatched between day 40 and 43. Tables with notes on the hatching progress are very helpful for the monitoring of future hatching phases. They make it easier to determine if no more progress is to be expected and hatching help is necessary.

After hatching the chick remains in the hatcher until it is completely dry and the feathers become fluffy. The surface within the hatcher should be non-slip to prevent leg spraddling. Stabilisation of very weak, oedematous chicks might be necessary and can be effected with a ring made e.g. of a twisted towel. Before removing the chick, the navel has to be checked, perhaps disinfected, the weight can be noted, and the chick can be tagged e.g. with a cable tie. If this method is used, the ties have to be checked regularly to avoid chafing or ingrowth.

For descriptions on incubation and hatching refer to STEWART (1996), DEEMING (1997), KISTNER & REINER (2004), SMITH (2007), HANSET (2013) or BRAND (2014). DEEMING & AR (1999) as well as COOPER (2001) published reviews of scientific reports. Numerous authors have examined egg characteristics (GONZALES ET AL. 1999, MUSHI ET AL. 2008 e.g.), pre-incubation conditions (WILSON ET AL. 1997, SAHAN ET AL. 2003a, HASSAN ET AL. 2005, MALECKI ET AL. 2005, BRAND ET AL. 2007, BRAND ET AL. 2011, BRAND 2012), and incubation parameters (e.g. CHRISTENSEN ET AL 1996, VAN SCHALKWYK ET AL. 2000, SAHAN ET AL. 2003B, HASSAN ET AL. 2004). These studies may be referred to for further details.

2.5.2.4 Rearing after Artificial Incubation

Brooder Boxes

After the chicks are completely dry and a thorough check-up has been carried out, the chicks are transferred to brooder boxes where they spend their first three to five days. These brooder boxes should be placed in light, well ventilated but draught free and warm rooms. The box used at Hannover Zoo is 120 cm deep and 280 cm wide. Inside, two partitions can be inserted to create smaller spaces if just a single or a few chicks are kept in the box. The sides should be at least 60 cm high.

Heat sources are heat mats or heat lamps. The flooring must be non-slip but also relatively easy to clean. If the heating is from above the flooring material can be a well insulating rubber mat. If the floor is heated a carpet-like material can be used, but birds must not be able to pull fibres out. The floor temperature directly under the lamp should be about 30 to 34 °C, the box air temperature not lower than 22 °C.

If spot lamps are used it must be ensured that birds which are relatively immobile stay near the lamp. If necessary, the area of the box should be reduced. UV light may be used for short intervals.

The floor of the box must be cleaned daily.

During the first two days it is usually not necessary to feed the birds or offer water; during this time they are supplied with nutrients from the yolk, which is retracted during hatching. The yolk is normally resorbed by day 10 to 14 (DEEMING 1995, cf. DEEMING ET AL. 1996, DZOMA ET AL. 2001, MUSHI ET AL. 2004). Depending on the state – stronger or weaker – in which the chicks hatch, they will start moving sooner or later. When they start pecking at the ground, food and water should be offered, so that the pecking gets positive results and the birds learn to find food. Water should be fresh and lukewarm. Probiotics, which help the birds develop a healthy enteric flora, can be added to the water. At the beginning, it might be difficult for the chicks to find the water. Little stones, pieces of oyster shell or small pieces of green leaves can be put into the water to make it visible and interesting. At first, small amounts of pelleted feed are scattered on the ground until the chicks find the troughs. Starter pellets might even be broken into smaller pieces. A person might play with the fingers in the feeding trough to attract the chicks to the feed and “teach” them to take it.

Formerly it was believed that fasting was necessary for yolk resorption (cf. BRAND & OLIVIER 2011). Studies on the effect of feeding and watering on yolk sac resorption show contradictory results (DZOMA & DORRESTEIN 2001). The studies from NOY & SKLAN (2001) respectively NOY ET AL. (2001) on poultry suggest that the feed intake is stimulated by the secretion of yolk to the small intestine and digestion enhanced. This is assumed to be the case in ostriches as well. However, it should not lead to forced feeding. Just try to motivate chicks by simulating pecking movements etc. Chicks may need some time to recover from the hatching process and to get mobile, even more so if they hatch with oedema.

When the chicks are able to move, hence able to get back to the heat source, and find water and feeding troughs easily, they can be transferred to the stalls. If other chicks are still in the box they can stay a day longer, and if there are already other chicks in the stall they can be transferred earlier. Young birds should never be kept alone. If just one chick hatches, consider employing a chicken or rabbit as a companion animal (cf. HUCHZERMEYER 1998).

Stalls

During the first three months ostrich chicks which are raised without parent birds are very sensitive. They should be raised in light and clean stalls. Temperature fluctuations should be avoided as well as stressful situations, like sudden noise e.g.

For about the first 5 weeks no bedding material should be used. Ostrich chicks make no distinction between feed and bedding; they peck at anything.

The floor should be well insulated e.g. covered with rubber mats. For the usually small groups which are kept in zoos heat lamps can be used as a heat source. Naturally, every bird must be able to find a place under the lamps. The floor temperature should be about 30°C at the beginning and about 25 °C in week four. The room temperature should range from 23 to 21 °C in week two and three and be about 20 °C in week four. Temperature reductions should be made very gradually. Open beaks and spread wings indicate that the temperature is too high for the chicks. If the birds climb on top of one another, it might indicate that the temperature is too low. For growing chicks, it is possible to provide warmer rooms or heated areas only during the night.

If the birds have no access to direct sunlight, consider the use of UV light.

The floor must be cleaned daily, and the surface must be non-slip. Running chicks can easily slip on their own faeces.

Feed and Water

Feed, in the form of e.g. ostrich starter pellets, and water should always be available. Young birds peck at the droppings of adults to obtain the necessary fibre-digesting microbes (cf. BRAND 2014). If the chicks are reared without parent birds, probiotics added to the feed might help the bird develop a healthy enteric flora. If no medical products are available, yoghurt might be a surrogate. VIDEVAL ET AL. (2023) assume that feeding the chicks with the fresh faeces of adult birds is not only helpful for the development of the chicks' intestinal flora but leads to better growth of the animals and lower susceptibility to intestinal diseases.

Feed and water should be offered in troughs placed along the walls. The birds should not be able to overturn the bowls. As ostriches drink with a scooping movement the water troughs need an adequate surface area. If water bowls are relatively big and the birds can step into them, make sure that smaller birds are also able to leave the bowls, e.g. by putting a stepping stone into it. During the first five weeks it might even be better to take the water troughs out of the stalls during the night. Feed and water troughs must be cleaned regularly.

Starting in week one small round stones, the diameter approximately half the width of the toenail, should be offered once a week. Stones should never be offered with the feed, since the birds might overload their stomach with them. Seashells or limestone grit are no substitute for stones because they are ground or dissolved too fast. They also contain calcium, which might unbalance the calcium:phosphorus ratio of the feed (DEEMING 1996). The stones could be scattered on the ground, which as a positive side effect animates the birds to move.

The first bits of fresh green, at the beginning no bigger than 1 to 2 cm, can also be given to the birds. The amount should be increased very slowly, and the texture of the faeces must be observed, to ensure that the amount of green food is not too high.

TULLY (2016) points out that many chicks have diarrhoea when the yolk sack is resorbed and the chicks start eating well, at 8 to 12 days of age. If the chicks are alert and active, no treatment is needed. Diarrhoea also occurs after a sudden change in diet, for which he recommends the administration of probiotics.

Starting in week four, small amounts of rough fodder like chopped hay can be added to the feed.

Rearing

After week five bedding material can be introduced (sand, sawdust, straw). If straw is used it must be chopped. Chopped straw should ideally be used for the first six months, but at least for the first three months. The bedding material must be introduced carefully. At the beginning the material can be put in just a smaller area of the stall. The area around the feeding troughs should always be free from bedding material. When introducing the bedding, the behaviour of the birds must be monitored closely. The chicks peck at anything, they might not make a distinction between feed and bedding. If they ingest long fibre straw dangerous bezoars might occur.

Chicks do not like to be left alone. When the group is small frequent contact with humans is necessary.

The feet and leg posture of the ostriches must be observed attentively. Rolled toes should be corrected as soon as possible. If cable ties or other bands are used for marking, these must be checked regularly, as ostriches grow very fast.

During week two, if the weather is appropriate, with temperatures around 20 °C, the chicks can go into an outdoor enclosure. At the beginning, they should go out only for a few hours. After three weeks and with appropriate temperatures, chicks can stay outside the whole day.

Ideally, their first outside enclosure has a brick or concrete floor. If the chicks are kept on grass from the start the grass must be cut short and must not be wet from rain or morning dew. Chicks should never go outside when hungry. Before letting the chicks outside, the enclosure must be checked and thoroughly cleaned of all kinds of foreign objects which could be swallowed. As mentioned before, ostriches eat anything: screws, nails, wire, shards etc.

Young ostriches should never get drenched, but especially during the first three to four months this is crucial. In the event of heavy or steady rain, chicks must be taken indoors.

If younger and older ostrich chicks are kept together the age difference should ideally not be more than two weeks. If the difference is wider, it must be ensured that the younger birds get enough feed and the older birds do not trample on the younger ones.

In- or outdoors, it is very important that chicks have sufficient room for exercise. It is essential for normal bone (especially leg) growth and for good digestion. Lack of exercise in growing birds, together with imbalanced nutrition, can lead to a variety of leg deformities (Tully 2016).

Ostrich chicks kept without parent birds are relatively easily distressed. When changes of environment are necessary – move from brooder boxes to stalls, from smaller stalls in one area to bigger ones in another – the transition should be as smooth as possible. Abrupt changes must be avoided e.g. feeding troughs from the old surroundings can be taken to the new place for the first time to give some continuity. Surroundings, feed and staff in charge should never change at the same time.

Figs. 26, 27 & 28

Examples from Zoo Hannover:
The chicks (hatched in early spring) have their first exercise area in a closed, roofed yard with a carpet-like material covering the floor (left). The material of the flooring must not allow the chicks to pull fibres. The same material is also used in the brooder boxes.

A paved yard (right) is ideal as a first exercise area outdoors.

Straw must be introduced carefully. For the first months it should be chopped short (left).

If any change of environment, group structure, or feeding, has taken place chicks must be closely observed. Possible stress symptoms are that single chicks keep away from the group or that the whole group huddles together, that they are inactive, that necks are retracted (not stretched) with the head at body level, and that the chicks look hunched. Trilling, changes in faecal consistency, changes in feeding behaviour and excessive intake of bedding material, sand, stones, water or faeces are other symptoms. According to TULLY (2016) for the first two weeks after movement to a new environment for the chicks the risk of impaction is high, independently of a change in substrate or diet.

Contact with humans should be offered frequently as desertion stress has a negative impact on the welfare and the health of the chicks (HUCHZERMEYER 1998). Radios, for instance, might partly substitute for human voices.

A special kind of behaviour can be seen in younger birds. Chicks and, less frequently, older ostriches are often observed to be dancing or waltzing (twirling around, making pirouettes). At a zoo the birds dance when they go from the indoor area into the outdoor enclosure for example, but they also make turning movements after a short stressful event: a loud noise, a short moment of restraint by the keeper etc. It seems that the dancing just shows that the birds are very excited due to a change of environment or a special event, which is sometimes negative but not necessarily so. (cf. HUCHZERMEYER 1998).

Imprinting

The EEP ostriches until now (with just one exemption) are all hand reared or reared in a group of peer birds. However, no indication of false sexual imprinting has been observed. Birds react towards (known) humans with courtship behaviour. Males kantle – fall down, alternately moving both wings up and down, meanwhile swaying the neck from side to side. In some cases this might also be a threat display by a territorial male towards an intruder, as described for wild ostriches by HURXTHAL (1997). In females, the soliciting exhibited – wings spread, held low and intermittent small quivering movements with the head held low – is more obviously part of courtship behaviour. Until now, no cases have been reported that these ostriches show the described behaviour only to humans and not towards other ostriches, or do not mate with other ostriches.

2.5.3 Foster Rearing

Foster rearing is possible. The adoption of chicks by males and females is common practice in South Africa. However, foster rearing should be tried only with experienced parent birds that have chicks of their own. The fostered chicks should be of the same age or a little younger. Ideally, they should be slightly smaller than the pair's own chicks, but never bigger. Usually, chicks are given to the foster parents at the age of 7 to 14 days. After taking the new chicks the parent birds should not have more than 10 to 15 chicks, so that one bird is able to gather all the chicks under their wings at the same time.

In any case it is necessary to introduce the chicks with the utmost caution, because it is always possible that the intended parents do not accept the new chicks but peck at them, kick them or throw them into the air (cf. DEEMING 1999, WANG ET AL. 2012, ENGELBRECHT 2014).

2.5.4 Population Management

The North African ostrich EEP was established in 2011. It is still small; as of December 2024 the EEP comprised 50 birds, kept in 14 European institutions. Aim of the EEP is to expand and to maintain a physically healthy and genetic diverse population.

The EEP was founded from two egg imports from Souss Massa National Park (SMNP) south of Agadir in Morocco. Within the National Park the North African ostriches live in a fenced area of around 2,000 hectares. The founders of the park population had been brought from Chad in 1996. In 1999 there were 10 birds (ENGEL & BRUNSING 1999), and by 2011 there was an estimated population of around 150 birds, reproducing regularly (M. EL BEKKAY, W. OUBROU, SMNP, pers. communication 2011).

Subspecies purity of the ostriches from Morocco was ascertained through genetic testing at the Smithsonian Conservation Biology Institute (FLEISCHER 2011) and the Institut Pluridisciplinaire Hubert Curien (GACHOT-NEVEU 2010) in Strasburg.

In 2011, 24 eggs from one clutch were imported, of which 14 chicks grew to adulthood. A genetics laboratory in Gelsenkirchen (Labor für Abstammungsbegutachtung, OLEK 2011) carried out a microsatellite analysis. With the help of Prof. Dr. Radespiel from the University of Veterinary Medicine in Hannover assumptions regarding the potential founders were made based on the genetic analysis. Five founders were identified – one male and four females – and the first breeding trios were established according to these findings.

In 2011 eggs were taken from a clutch of 42 eggs. Due to the number of eggs in the clutch, the growth rate of the clutch and the assumption that each hen lays every second day, it was inferred that at least 8 females had contributed to the clutch. In 2017 eggs were taken from a clutch of 75 eggs. In this case we assumed that at least 12 females had laid eggs in the clutch.

In 2017 only five chicks hatched, of which four grew to maturity. The same genetic analysis was conducted as in 2011. These birds have the same parents; and it was ascertained that the sire was identical with the sire of the 2011 import and the dam identical with one of the founders as determined in 2011. Thus, the number of founders was not increased by this import.

Due to the low number of founders a further import from a range country is desirable.

2.6 INDIVIDUAL IDENTIFICATION AND SEXING

2.6.1 Individual Identification

Newly hatched chicks can easily be marked with cable ties of different colours, fastened directly above the foot (at the lower end of the tarsometatarsus). These cable ties, however, must be checked regularly, because the birds grow very fast and the ties can grow in. With some experience one need not handle the bird to check the tie; it is plain that the tie has become inflexible and does not fall down on the foot. On older birds, which cannot be handled as easily as small chicks, elastic bands with hook and loop fastener (Velcro®), normally employed for marking cows, can be attached to the tibiotarsus. It is not necessary to check these bands so often. Nevertheless, in growing birds they can only be used for a certain time, until handling becomes too stressful for birds and keepers. Naturally, every bird should be marked with an identification microchip (transponder) as soon as possible.

2.6.2 Sexing

It is easy to determine the sex of ostriches more than two years old because of their very different appearance. In ostriches however, as in other birds, the males are homogametic, with two identical sex chromosomes (ZZ) and the females are heterogametic with two different sex chromosomes (ZW; see YAZDI ET AL. 2020). Therefore, a female with a non-functioning ovary could have black plumage and look like a male (KREIBICH & SOMMER 1994, HUCHZERMEYER 1998).

The sex of young ostriches can be determined by gen laboratories.

With some experience it is possible to determine the sex of young ostriches while they are defecating and the larger phallus or the smaller clitoris is visible. When ostriches are some weeks old, with great caution, it is also possible to perform a cloacal examination (vent sexing; cf. GANDINI & KEFFEN 1985, KREIBICH & SOMMER 1994). One person, standing or sitting, places the ostrich on its back. The examining person introduces a lubricated finger, depending on the size of the bird the little or the index finger, into the cloaca. Meanwhile the thumb of the other hand, placed cranially, slightly presses ventrally onto the cloaca. With a turning movement of the lubricated finger and a gentle cranial pulling the cloaca is everted. The clitoris and the phallus of ostriches look relatively similar. The phallus is slightly longer, conical in form, reddish and appears more swollen than the clitoris. The clitoris is light pink and laterally compressed. When sexing just one or a small number of chicks, it is difficult for an inexperienced person to see a difference. However, if examining a male and a female chick of the same age at the same time the difference is obvious.

Cloacal prolapse is a possible risk of this technique, which should be minimized by very careful manipulation of the bird.

Figs. 29 & 30 Sex determination of a female ostrich (left) and a male (right), both at six weeks old. The keeper is squatting on his knees, the birds are placed on their back. The 2nd person is introducing the lubricated little finger into the cloaca.

2.7 BEHAVIOURAL ENRICHMENT

The most important aspect with regard to enrichment is a well-designed enclosure, with different types of substrate, the essential sand bath, insolated areas as well as shade, perhaps shallow water areas etc. Birds should have a good view of their surroundings, e.g. the neighbouring enclosure or the visitor areas.

Another important aspect is feeding. Birds should spend considerable time feeding, they should have the opportunity to pluck grass and perhaps seeds, herbs, leaves etc. If this is not possible they should be fed a high amount of roughage.

Branches, foliated bamboo sprouts, *Rubus* sprouts, maize plants etc. can be strewn on the ground or fixed to the fence. Attractive food can be frozen into ice blocs and placed (e.g. hung) in the enclosure. Halved pumpkins, melons or big courgettes may be offered.

Some institutions report that their ostriches enjoy water. If no open water is available, a lawn sprinkler or a water hose may be provided.

Indoors it is possible to work with metal feeding baskets that the bird have to reach out for. The basket can be filled with plant material which has to be plucked out of the basket. It must be ensured, however, that the birds do not trap their heads.

Suspended objects e.g. chains that are visually attractive might be used, as well as plastic bottles with a small hole; the birds have to peck at them to make seeds fall out of the bottle.

Ostriches are often described as curious and inquisitive, but above all, especially adult ostriches are very set in their ways and suspicious of novelty. For the introduction of new items great patience and caution is necessary. Indoors, if possible, new items can be fastened in neighbouring boxes, so that they can be inspected from a safe distance first, before being introduced into the box used by the ostriches.

2.8 HANDLING AND TRANSPORT

The handling of fully grown ostriches is difficult and can be dangerous for birds and humans. It should happen only when absolutely necessary and only be carried out by experienced personnel. The handling of birds during the breeding season, especially of the males, should be avoided.

Ostriches defend themselves by kicking forward. They are not able to kick backwards. Therefore they should always be approached from behind or from the side (cf. HOFFMANN & LAMBRECHTS 2011). Usually, birds are more docile when blindfolded or hooded (cf. PERELMANN 1999, TULLY 2009). One blindfolding technique is to grasp the neck, pull it down and pull a hood over the head of the bird. A second option is to draw a big dark sock without a toe or a cut-off sweater sleeve over one forearm. The handler offers the bird feed in the open hand of the same arm; and while the bird is eating, the handler grabs the beak and pulls the sock or sleeve over the head of the bird with the other free hand. If socks or sleeves are used, make sure that the nostrils of the birds are free so that the bird’s breathing is not impaired. In both situations, the person blindfolding the bird must be very careful.

Fig. 31

A young ostrich female blindfolded with a sock. Beak and nostrils are free, so that breathing is not impaired.

To lead an adult North African ostrich at least two people, preferably three, are necessary. Some ostrich farmers as well as KORBEL ET AL. (2015; cf. WOTTON & HEWITT 1999) recommend leading birds backwards, so that they have to concentrate on walking and are less able to kick. Two people should grasp the breast of the bird with one arm, and with the free hand at wing or tail lead the bird in the right direction. Birds should never be held by a single wing or leg.

If possible, juvenile birds (TULLY 2016 refers to birds from four months to one year old) should be slowly and calmly herded. Young birds, especially, are easily distressed, but not only these but also older birds might just squat down. If they do it is rarely possible to encourage the birds to get up again for some time.

Small chicks up to approximately two months can be picked up and carried with one hand stabilizing the body from below and the other hand on the back. The legs should dangle free. Older chicks can be picked up from the sitting position by grasping both lower legs and holding them next to the body of the ostrich (DEEMING 1996). The birds can be held under one arm or should at least be held to the body of the handler (see Fig. 32).

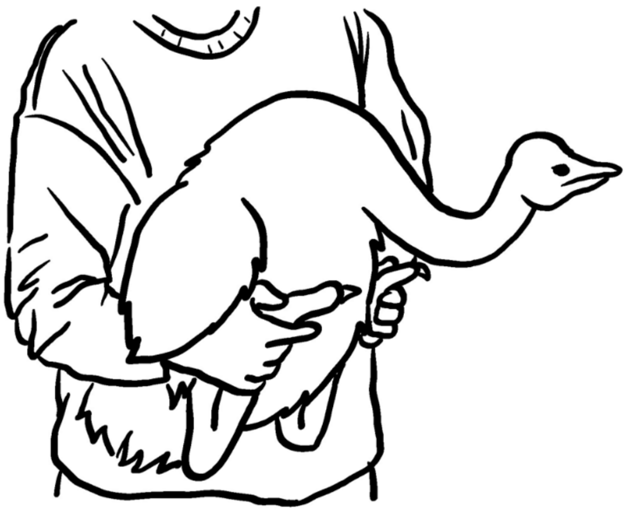


Fig. 32

Holding a chick of up to about 5 kg in weight. The bird is picked up from the sitting position.

In general one should try to entice the birds forward with a bucket of feed e.g. pellets or cereals rather than driving them.

It is feasible to transport ostriches in special crates (see IATA live animal regulations), but usually they are moved in trailers. These can be e.g. modified horse trailers without horizontal poles, a closed back etc. or special animal transport trailers with several compartments.

During transport the birds should not have too much space, so that they are not thrown around the trailer. Ostriches easily lose their footing when the vehicle is accelerating, braking, or taking a curve (cf. KORBEL ET AL. 2015). According to some authors the space requirement for an adult bird is 1 m², in other cases a minimum space of 1.5 m² is required (see IATA live animal regulations 2021). KORBEL ET AL. (2015) recommend a width of 0.7 m and a length of 1.2 m, so that the animals are not able to turn and are supported at the sides. Sufficient space for the birds to sit down is essential. The trailer must be sufficiently high so that the birds are able to stand upright. It should be closed but sufficiently ventilated.

The ramp should not be too steep i.e. with a gradient of no more than approximately 20 to 25° (cf. MITCHELL 1999, KORBEL ET AL. 2015) and be non-slip. There should be no high steps nor gaps at the bottom or the top of the ramp.

Inside the trailer or compartment there must be no sharp edges, trip hazards or protruding installations which could pose an injury risk. Neither should there be holes where heads or toes could be trapped. The floor must be non-slip. A metal floor with straw is usually not sufficient. Special rubber mats (see photos below) covered with straw, sawdust or wood shavings should be used.

Figs. 33 & 34 When transporting ostriches, a non-slip floor is crucial. The photos show examples of rubber mats, fixed on a trailer or loose, to be used below the bedding material (photo right: Réserve Africaine de Sigean).

MITCHELL (1999) recommends using chopped straw as bedding, while WOTTON & HEWITT (1999) argue that no chopped straw should be used, because the birds might ingest it and this could result in impaction. Distressed birds, however, might eat anything, including long straw, and this can lead to even more dangerous bezoars. Hence, on the question of bedding material consider what the birds are used to, how long the move will be and how old the birds are. The younger the birds and the longer the move the bigger is the risk of ingesting bedding material.

One option to get a bird onto a trailer is leading the blindfolded bird onto it as described above. The sides of the ramp must be secured with large panels or railings while the bird is led onto the trailer. The blindfold material must be removed once the bird is on the trailer.

If it is not possible to handle the bird, a short raceway can be built, to drive the bird onto the trailer. The way, however, has to be short, so that the ostrich is not able to gain speed. The sides must be high enough so that the bird is not able to jump them, also when standing on the trailer ramp. The side panels of the raceway must be closed to avert any trapping of the toes. If the trailer does not have a door and is closed by the ramp only, the trailer has first to be shut with a large panel until the ramp is lifted.

Whether adult ostriches should be transported as a group, which might reduce stress, or in individual compartments, is a matter of debate.

We recommend always transporting adult males in individual compartments. Whether adult females should be moved as a group or in individual compartments depends on the character of the birds and on their management prior to transport. The decision should be made case by case. Birds younger than 12 months and raised together should always be transported in groups. Separated birds should be able to see each other (KORBEL ET AL. 2015).

It is possible to transfer ostrich chicks reared by humans (after artificial incubation) when a few days old. The smaller the chicks, the easier and less stressful a move from one place to the other. However, this rarely happens in a zoo environment. For the transfer of older ostriches, reared by parent birds or humans, there is probably no ideal transfer age. Until now, moves have been carried out when the birds were at least four to five months old. Subadult ostriches react extremely sensitively to changes and are more relaxed in the company of other ostriches. If possible, the birds should be moved accompanied by other birds, in the same compartment when raised together or in neighbouring compartments when from different institutions.

2.9 VETERINARY: CONSIDERATIONS FOR HEALTH AND WELFARE

Ostriches have anatomical peculiarities that are important for their medical care. Furthermore, their size, strength and the usually wild behaviour, especially of North African ostriches, are major factors in the veterinary care of these birds and present specific challenges in diagnosis and treatment.

2.9.1 Anatomy / Physiology / Diagnostics

Diagnostic procedure

The first step is observing a bird from a distance, considering the posture of the body and especially that of the head. Eyes, ears, and nostrils should be clear and free of discharges. The neck should be flexible, and evenly slender without bulges. The plumage should be complete, with no bare patches, and clean (a healthy ostrich preens its feathers regularly). The bare limbs should be checked for skin irregularities and blemishes, and the length of the toenails should be noted; nail overgrowth may indicate a musculoskeletal disorder.
The bird is then studied in motion to detect possible lameness.
Its surroundings must also be included in the general examination. Assessment of the droppings (faeces, urine) could indicate the need for further tests. Dropped feathers should be examined for pathological changes and parasites.
North African ostriches do not usually cooperate with hands-on examination. Further examinations are usually only possible with trained birds, and because they are dangerous and unpredictable any contact must be protected (by restraint, grid). Sometimes it is possible to blindfold ostriches with a hood (see animal transport) to make them slightly more tractable.
For more intensive examinations sedation or anaesthesia are necessary.

Anatomical features

Ostriches have no crop and no gallbladder. The male has a very pronounced phallus (for sperm transport only). These are the only birds with two toes (3rd and 4th) and a two-part patella (proximal and distal patella; WEISSENGRUBER ET AL. 2003, CHADWICK ET AL. 2014).

Physiological parameters

Heart rate: adults 28-36/min (LOUW ET AL. 1969), chicks 80-164/min (VAN HEERDEN ET AL. 1991)

Respiratory rate: 5/min (HUCHZERMEYER 1998), 6-12/min (FOWLER 1996, SIEGAL-WILLOT 2007), in hot weather/under stress up to 60/min (FOWLER 1996), chicks 12-60/min (VAN HEERDEN & KEFFEN 1991)

Body temperature: 39 °C (38-40 °C; SKADHAUGE & DAWSON1999), 37.8-38.9 °C (HUCHZERMEYER 1998)

Gastrointestinal passage time (depending on age, body size and especially on the type of food): with easily digestible foods the gastrointestinal passage takes 6 hours (TULLY 1996), with high fibre content it takes up to 36-48 hours (SMITH 2003) or even up to 76 hours (SWART ET AL. 1993).

Stomach contractions: 2-3/min (HUCHZERMEYER 1998)

The positions of the single organs in the coelomic cavity are shown in Figure 35, the skeletal features in Figure 36.

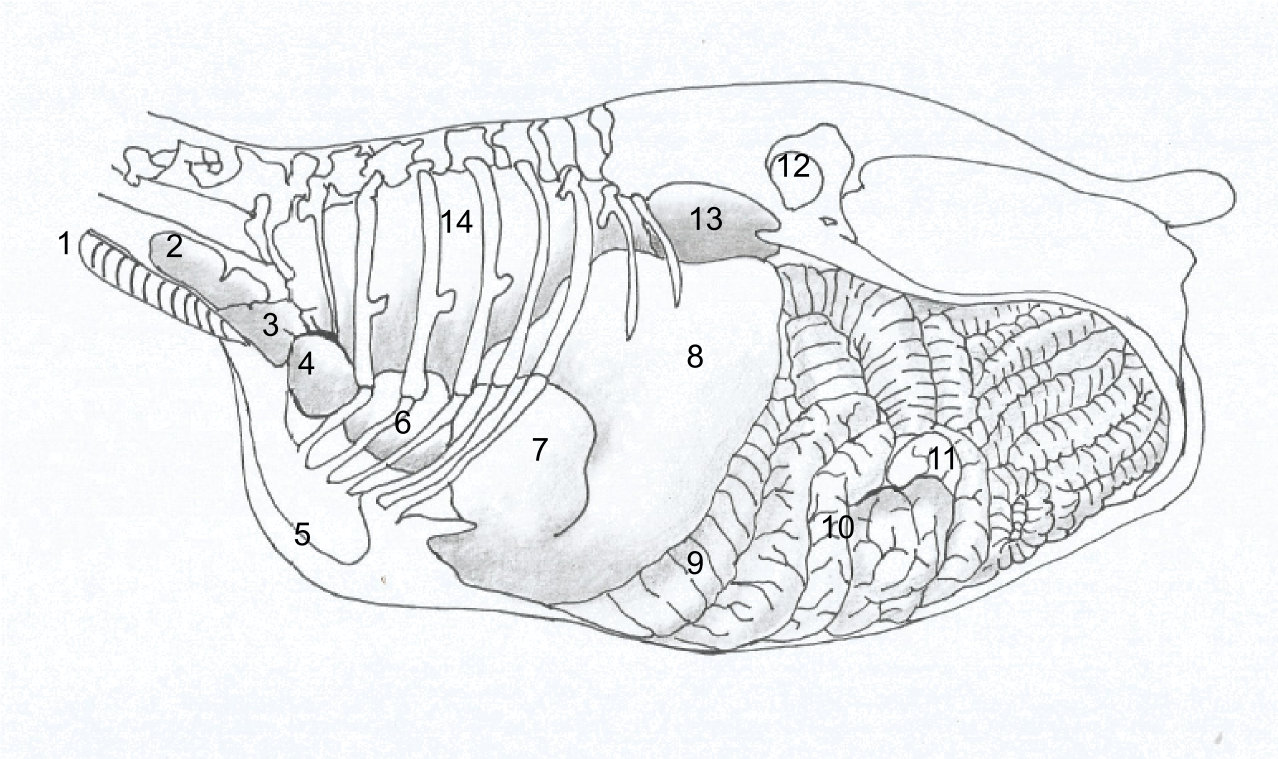


Fig. 35 In-situ position of the organs (left lateral view of the body)
1 – trachea; 2 – thymus; 3 – thyroid gland; 4 – heart; 5 – sternum; 6 – liver (left lobes); 7 – muscular stomach; 8 – glandular stomach; 9 – left caecum; 10 – duodenum; 11 – ileum; 12 – acetabulum; 13 – kidney (left cranial lobe); 14 – lung

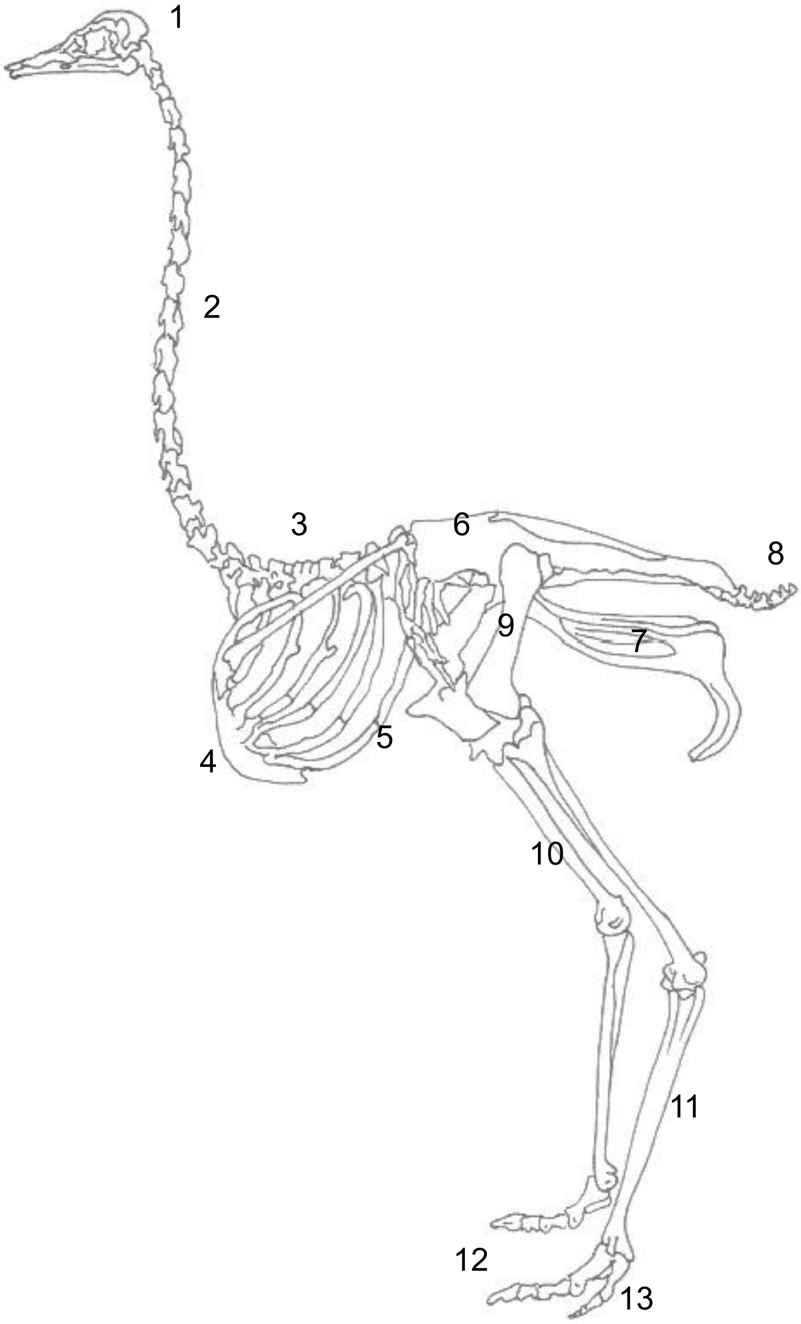


Fig. 36 Skeleton of an ostrich
1 – skull; 2 – cervical spine; 3 – thoracic vertebrae; 4 – sternum; 5 – ribs; 6 – os ileum; 7 – os ischii; 8 – pygostyle; 9 – femur; 10 – tibiotarsus; 11 – tarsometatarsus; 12 – third toe; 13 – fourth toe

Blood sampling / reference values

The best place to take blood samples from chicks is from the right jugular or the medial metatarsal vein, in subadults and adults is the ulnar or jugular vein (PERELMAN 1999).
It is not advisable to use EDTA as an anticoagulant. Lithium heparin (FUDGE 1996) or citrate (PERELMAN 1999) are preferable.

Tab. 4 Haematologic and biochemistry reference values in healthy adult ostriches (FUDGE 1995)*

	SI Unit	**Range**
Haematocrit	l/l	41-57
Leukocytes	G/l	10-24
Heterophilic	%	58-89
Lymphocytes	%	12-41
Monocytes	%	0-4
Eosinophils	%	0-2
Basophils	%	0-2
Glucose	mmol/l	9.1-18.3
Aspartate transaminase (AST)	U/l	226-547
Lactic dehydrogenase (LDH)	U/l	408-1236
Creatine kinase (CK)	U/l	800-6600
Cholesterol	mmol/l	1.0-4.4
Bile acid	µmol/l	2-30
Uric acid	µmol/l	60-870
Creatinine	µmol/l	8.8-61.9
Calcium	mmol/l	2.0-3.4
Phosphorous	mmol/l	0.9-2.5

*Please note that some values indicate muscle cell damage due to physical or chemical restraint.

Radiography

The best way to X-ray the coelomic cavity of an adult ostrich is in a standing position from the right side. If using cassettes (at least 35 x 43 cm in size), three pictures are needed to cover the whole abdomen.
For gastrointestinal contrast studies, feed should be withdrawn 16 hours previously and 7-10 ml/kg barium sulphate-solution administered orally (WAGNER ET AL. 2001).
Depending on age, habituation, and the location of the organ to be examined, it may be possible to X-ray ostrich chicks without sedation. However, sedation is recommended for resistant or larger chicks.
Calmer adult ostriches could be blindfolded for the procedure with a sock over the eyes and manually restrained. The X-ray plates can be fixed in the desired position. X-ray aprons and gloves must be worn to minimize radiation exposure.

Ultrasonography

The acoustic fields for a sonography are found around the featherless regions, so plucking is not necessary. The following organs can be imaged without being disturbed by the air sacs: heart including the large vessels, glandular and muscular stomach, intestines, liver, and kidneys as well as a structure equivalent to the bladder. An inactive ovary cannot be portrayed (WAGNER ET AL. 2001). In a productive hen, the reproductive tract including the associated follicles can be seen in a standing position by transcutaneous ultrasonography behind the thigh at the ventrolateral featherless part of the abdomen (HICKS-ALLDREDGE 1996, WAGNER ET AL. 2001, BRONNENBERG & TAVERNE 2003, SIEGAL-WILLOT 2008).

Anaesthesia management

If possible, birds should be fasted 12 to 14 hours before anaesthesia and water withdrawn 4 hours before anaesthesia. Common complications during initiation and recovery are trauma, injuries, and fractures (SIEGAL-WILLOT 2008). For a quieter waking phase KREEGER & ARNEMO (2018) recommend giving 1 mg/kg diazepam IV after termination of the procedure; others administer 0.2 to 0.3 mg/kg diazepam IV or 1 to 2 mg/kg azaperon IM (BEZUIDENHOUT 1999). If possible, the waking phase should happen in a dark, quiet room. Vitamin E/selenium administration is recommended as myopathy prophylaxis (CORNICK-SEAHORN 1996).

Anaesthesia monitoring

Heart rate during anaesthesia may rise to 45-80/min and respiratory rate to 25-40/min (SIEGAL-WILLOT 2008).
The probe for pulse oximetry can be placed on the wing, tongue, or tibiotarsal region (SIEGAL-WILLOT 2008) or cloaca.
Due to the high risk of hyperthermia a temperature monitor is necessary and can be inserted in the cloaca (reference value: 38-40 °C; BEZUIDENHOUT 1999).
Intubation is easy since the glottis is large; the tube size depends on age (4-18 mm in diameter; CORNICK-SEAHORN 1996).
Other complications which may occur (SIEGAL-WILLOT 2008) are:

- hypothermia (especially in young ostriches)
- regurgitation
- neuropathy
- myopathies (treat with infusions of bicarbonate or dextrose, corticosteroids, Vitamin E/selenium, calcium, antibiotics and flunixin)
- tracheal cramps
- apnoea (treat with 5 mg/kg doxapram IV)
- pre-stomach contractions
- bradycardia
- uncontrolled movements (treat with 0.02-0.05 mg/kg butorphanol IV or 0.2 mg/kg ketamine IV)
- hypertension
- hypotension (treat with Ringer, lactated Ringer or NaCl infusions)

2.9.2 Anaesthetics

There is no hard and fast rule for sedation or anaesthesia in ostriches. In many cases, the huge data series found in the literature show significant variations in anaesthesia protocols. The use of any protocol requires particular attention to avoid e.g. injury due to far too shallow anaesthesia depth or perioperative complications due to too deep anaesthesia. The method to be used must be chosen individually according to age, health status, experience and possibilities (Table 5). After induction by various injectable anaesthetics, maintenance with using inhalants (e.g. isoflurane) via face mask or endotracheal tube can be necessary.

Tab. 5 Selected methods for sedation an anaesthesia in ostriches

Active substance / substances	Dosis	Antidote	Remarks	References
medetomidine	0.05-0.5 mg/kg med			KUMMROW 2015
medetomidine + butorphanol	0.05-0.5 mg/kg med + 0.1-0.2 mg/kg but			KUMMROW 2015
medetomidine + ketamin	8-10 mg TD med + 160 mg TD ket	atipamezole	standing sedation	BERTELSEN 2018
medetomidine + ketamine + midazolam	0,12 mg/kg med + 3,5 mg/kg ket + 0,15 mg/kg mid	atipamezole		ZIMS 2024
Immobilon® (etorphine/acepromazine) + xylazine + ketamine	TD: 1.8 ml Imm (= 4,05 mg eto + 18 mg ace) + 137.5 mg xyl + 30 mg ket	revivon + atipamezole		KRAWINKEL 1995
tiletamine/zolazepam	2.0-10.0 mg/kg 4,0 mg/kg			JENSEN 1989 ZIMS 2024

TD: total dosis

2.9.3 Diseases

2.9.3.1 Infectious Diseases

Infectious diseases are responsible for many losses in all age groups, but chicks and young birds up to five years of age are particularly vulnerable. Ostriches are susceptible to many diseases which are also prevalent in domestic poultry, so special attention must be paid to hygiene.

BACTERIA

Salmonella

Transmission:	directly through contact with clinically inconspicuous carrier animals and their faeces, or indirectly through contaminated objects, stables or leftovers, vertical infection via faeces-contaminated eggs and transovarian infection of the embryo
Epidemiology:	ubiquitous
Clinics:	no typical clinical signs – otherwise apathy and diarrhoea, sudden deaths, mostly septicaemic in young birds with profuse watery green diarrhoea, incubation period 2 to 5 days
Post mortem:	chicks with omphalitis, enlargement of the liver and spleen and general vascular congestion, enteritis in advanced cases
Diagnosis:	enrichment and subsequent bacteriological cultivation
Therapy:	isolation of the chicks, suppression of the symptoms with quinolones, thereby reducing the mortality rate (but they remain chronic carriers!), 0.02% nitrofurazone in food or after antibiogram
Prevention:	routine screening by means of PCR examination of a cloacal swab, regular microbiological examinations of brooding equipment, food and soil samples
References:	GYLSTORFF & GRIMM 1987, SCHALLER 1995, SHANE & TULLY 1996, HUCHZERMEYER 1998, HUCHZERMEYER 1999

Pathogen colibacillosis, E. coli

Agent:	opportunistic pathogen, few serotypes are primarily pathogenic, *E. coli* is a regular component of the physiological intestinal flora in birds
Transmission:	via drinking water with increased *E. coli* content, transmission of the pathogen through faecal contamination of eggshells and deficiencies in hygiene management, resulting in congenital omphalitis
Clinics:	affected animals apathetic, refuse food and water, in case of omphalitis enlarged yolk sac (highly viscous, often also foul-smelling exudate), also *E. coli* associated peritonitis usually after ingestion of foreign bodies, after penetration of the glandular stomach, fibrinous exudate and chronic cases due to the adhesion of the peritoneum to the serosa of the intestines, after septicaemia also airsacculitis
Post mortem:	enlargement of spleen and liver as well as generalized venous congestion
Diagnosis:	cultivation of the pathogen
Therapy:	antibiotics according to antibiogram

Prevention: drinking water may be supplemented with chlorine additives of 1-2 ppm and the germ status can be checked by regular bacteriological tests

References: SHIVAPRASAD 1993, SHANE & TULLY 1996, HUCHZERMEYER 1998

Pseudomonas sp., Klebsiella sp., Proteus sp. and Citrobacter sp.

Epidemiology: increased embryonic mortality, neonatal deaths, and reduced vitality of chicks

Diagnosis: isolation and identification of the pathogens is usually from samples of the yolk sac, whereas the detection of *E. coli* by means of cloacal swabs is non-specific

Therapy: antibiotic treatment after antibiogram, chicks often remain carriers

Prevention: careful handling of hatching eggs, appropriate breeding hygiene and decontamination of the hatching apparatus and chick enclosure are the most important preventive measures

References: SHANE & TULLY 1996, HUCHZERMEYER 1998

Mycobacterium avium (Serovar 1, 2, 4-28)

Transmission: infected ratites serve as carrier animals, excreting the organisms via their faeces; poultry and wild birds are the reservoir of this pathogen; contaminated clothing, equipment and transporters can spread the infection; mycobacteria can remain viable for more than 12 months in the soil of the drains

Epidemiology: uncontrolled access of new birds, uncontrolled movement of people, and deficiencies in biosecurity may encourage the spread of the pathogen, often flock problems

Clinic: cachexia hardly recognizable in ostriches, possibly prolapse of the terminal intestinal tract, local granulomatous conjunctivitis, cloaca, phallus, also generalized gastrointestinal tract, liver

Post mortem: characteristic granulomas can be found on the pleura, the mesentery, the intestinal serosa and the peritoneum, besides often splenomegaly and hepatopathy, granulomas in the bone marrow of the tibiotarsus

Diagnosis: detection of acid-resistant sticks in faeces (CAVE: also apathogenic mycobacteria) or different body tissues, which by means of biopsy or post mortem, enriched specimen in sputofluol and visible by means of Ziehl-Neelsen staining, also direct detection of mycobacteria

Therapy: unsuccessful

Prevention: investigation of newly acquired animals during quarantine, biosecurity measures

References: BURGER 1976, HUCHZERMEYER 1994, 1998, SCHALLER 1995, SHANE & TULLY 1996, DONELEY ET AL. 1999, GARCIA ET AL. 2001, COOPER 2005, KELLY ET AL. 2013

Chlamydia psittaci

Transmission: systemic disease in avian species, transmission via acutely diseased birds or latent carriers via oral intake of faeces or contaminated food or water, zoonosis

Epidemiology: wild birds, ratites and other species can also intermittently shed pathogens without clinical symptoms

Clinical:	short period of apathy, eye discharge before death, mostly deaths without clinical signs
Post mortem:	severe splenomegaly, hepatomegaly, sometimes peritonitis, pericarditis and subepicardial haemorrhagia, single animals with fibrinous airsacculitis, pulmonary congestion
Diagnosis:	PCR of triple swab (conjunctiva, choana, cloaca)
Therapy:	doxycycline (orally low half-life, IM injection might cause muscle necrosis), 0.4 g/kg food tetracyclines
Prevention:	biosecurity, new additions only with 8 weeks quarantine, determine the AK-titre every 30 days
References:	PERICARD ET AL. 1991, KÖSTERS ET AL. 1995, SHANE & TULLY 1996

Pathogenic Clostridium perfringens (part of the physiological intestinal flora), C. colium

Transmission:	multiplication with toxin formation after sudden change of diet, use of anthelmintics, other stress- and disease-related factors; spore-forming rod-shaped, durable in contaminated soils
Epidemiology:	abrupt change of diet/food, periods of famine, stress
Clinic:	acute deaths within 48 hours, high mortality rate, short periods with anorexia, apathy
Post mortem:	mild hyperaemia to pronounced pseudomembranous enteritis, focal hepatic necrosis
Diagnosis:	isolation and anaerobic cultivation
Treatment:	zinc bacitracin in drinking water (0.4 g/l) or 0.03 g/kg feed, ampicillin (0.1-0.2 g/ l drinking water)
Prevention:	elimination of management and diet-related predisposing factors
References:	SHANE & TULLY 1996

Coryza contagiosa (Haemophilus sp.)

Transmission:	by clinically infected or recovered carrier animals, indirectly via clothing and objects
Epidemiology:	due to frequent arrivals of new animals; the pathogen is unstable, can survive only 24 hours without a host, climate with high humidity
Clinic:	increased tear flow, seropurulent exudate from nares, later severe sinusitis
Post mortem:	seropurulent sinusitis
Diagnosis:	PCR, pathogen culture
Therapy:	suppression of symptoms by trimenthoprim-sulfonamides, penicillin-dihydrostreptomycin
Prevention:	biosecurity measures, quarantine of new additions
References:	SHANE & TULLY 1996

VIRUSES

Avian influenza virus

Agent:	in ostriches several types H7N1, H5N9, H9N2, H5N2, H7N1, H5N2 (pathogenicity is determined by the virus type)
Transmission:	widespread in wild birds, indirectly via contamination
Epidemiology:	not all serotypes have the same pathogenicity, young birds are more susceptible than older ones
Clinic:	ostriches between 5 days and 2 months: respiratory disorders, pungent green coloured urine, morbidity 100 %, mortality 80 %
Post mortem:	multifocal necrosis sites in the liver, splenomegaly, nephrosis, fibrinous airsacculitis, congestion of the proximal duodenum
Diagnosis:	tracheal and cloacal swab, PCR, virus culture, proof of serum antibodies
Therapy:	notifiable animal diseases, therapy and vaccination prohibited in many countries (e.g. Germany)
Prevention:	wild bird avoidance, quarantine
References:	SHANE & TULLY 1996, HUCHZERMEYER 1998, JØRGENSEN ET AL. 1998, COOPER ET AL. 2004, HOWERTH ET AL. 2012, ISMAIL ET AL. 2014, ABOLNIK ET AL. 2016, KIM ET AL. 2016

Newcastle disease

Agent:	Paramyxovirus type 1
Transmission:	aerogenic over long distances, indirectly via contaminated objects; poultry, wild and migratory birds are a reservoir
Clinic:	velogenic form, morbidity and mortality 50 %, initially mild enteritis, sudden onset of neurological abnormalities: torticollis, incoordination and inability to stand, death after 3-4 days
Post mortem:	no specific macroscopic changes in acute death, oedema, neuronal degeneration and perivascular lymphocytic accumulation in the brain
Diagnosis:	virus cultivation, PCR, antibody detection in surviving birds after 10 days
Therapy:	vaccination for ostriches not possible, self-healings occur
Prevention:	adult ostriches become resistant with age
References:	GYLSTORFF & GRIMM 1987, KALETA & BALDAUF 1988, HUCHZERMEYER 1996, SHANE & TULLY 1996, VERWOERD ET AL. 1997B, JØRGENSEN ET AL. 1998, ALEXANDER 2000, COOPER ET AL. 2004

Haemorrhagic enteritis ("chick fading syndrome")

Agent:	Adenovirus
Transmission:	transovarial or horizontal through/via infected chicks, may be latently infected up to reproductive ability
Clinic:	in chicks up to 2 months: acute deaths, apathy, anorexia, grey chalky diarrhoea, mortality up to 90 %
Post mortem:	multifocal enteritis, fibrinous airsacculitis, pulmonary oedema, hepatitis, lymphoid depletion of the spleen
Diagnosis:	Isolation of pathogens (especially from liver)
Therapy:	only symptomatic
Prevention:	biosecurity measures
References:	SHANE & TULLY 1996, RAINE ET AL. 1997, EISENBERG ET AL. 2003

Infectious bursal disease (Gumboro disease)

Agent:	birnavirus
Transmission:	probably by direct contact between infected poultry and ostriches, resistant to environmental factors, active up to 90 days in soil
Clinic:	apathy, anorexia, diarrhoea for 3-4 days, inability to stand and head tremor
Post mortem:	macroscopically unspecific: Enteritis, congestion lung, airsacculitis due to secondary infection, histology shows high-grade atrophy with pathognomonic lesions of the bursa
Diagnosis:	PCR, cell cultures
Therapy:	none
Prevention:	biosecurity measures
References:	SHANE & TULLY 1996

Avian poxvirus

Transmission:	by mosquito species, also horizontal transmission by contact
Epidemiology:	so far only in South Africa, Israel, and USA
Clinic:	distinctions from 2nd week of life, cutaneous form proliferative lesions of the eyelids and nostrils (5 mm - 2 cm), diphtheroid form tracheitis, stomatitis, beak breathing with marked dyspnoea, anorexia, dehydration
Post mortem:	characteristic diphtheroid lesions; histology: characteristic intracytoplasmic inclusion bodies
Diagnosis:	histopathological changes (inclusion bodies), virus culture
Therapy:	supporting topical antibacterial therapy, self-healing occurs
Prevention:	vaccination not allowed in some countries
References:	GYLSTORFF & GRIMM 1987, PERELMAN ET AL. 1988, SHANE & TULLY 1996, TULLY 2009, SHIVAPRASAD ET AL. 2002, COOPER 2005

Pathogen viral enteritis caused by adeno- and coronaviruses

Transmission:	clinically inconspicuous reservoir animals, via various environmental factors, rapid transmission in a herd
Clinic:	apathy, anorexia, diarrhoea and dehydration, final severe muscle tremor
Post mortem:	severe dehydration, enteritis (hyperaemia of the jejunum)
Therapy:	supportive therapy
References:	SHANE & TULLY 1996

Borna disease

Transmission:	probably via insects
Epidemiology:	high mortality in Israel
Clinic:	paresis, paralysis within 4-8 days, death due to dehydration
Post mortem:	macroscopically no pathognomonic lesions, neuronal degeneration and lymphocytic perivascular accumulation in the brain
Diagnosis:	ELISA from brain tissue

initially: serum with antibodies from recovered animals as a therapeutic experiment, fluid replacement

References	SHANE & TULLY 1996, HUCHZERMEYER 1998, COOPER ET AL. 2004

FUNGAL DISEASES

Aspergillosis

Agent:	*Aspergillus fumigatus*
Transmission:	chicks: if the chick is exposed to the fungal spores during hatching, penetration through the shell is possible; adult animals: sporadic due to insufficient air movement, high stocking density, dusty food
Clinic:	anorexia, growth retardation, dyspnoea (white mucus), deaths 2 days after hatching or within the first 2 weeks of life, in adults dyspnoea, cyanosis, poor physical condition, including symptomless sudden deaths
Post mortem:	1-2 mm large yellow to greenish granulomas in lungs and air sacs, pneumonia
Therapy:	poor treatment success, possibly 10 mg/kg 7d ketoconazole, 610 mg/kg itraconazole
Prevention:	monitoring of hygiene (samples with Sabouraud medium), disinfection with 35 g/m^3 potassium permanganate
References:	MARHOLDT 1979, GYLSTORFF & GRIMM 1987, PERELMAN & KUTTIN 1992, SHANE & TULLY 1996, HUCHZERMEYER 1999, SMITH 2003, YOKOTA ET AL. 2004, COOPER 2005, TULLY 2009

Zygomycosis

Agent:	*Basida* ssp., *Mucor* ssp., *Rhizopus* ssp. (*Rhizopus oryzae*)
Transmission:	uptake by contaminated food, opportunistic infection in immunosuppressed animals
Epidemiology:	incubation period 5-10 days
Clinic:	inflammation of the muscle and glandular stomach, stomach constipation, apathy, anorexia, weight loss
Post mortem:	multifocal ulcerations of the mucosa of the distal oesophagus, glandular stomach, muscle stomach, rare focal stomatitis
Diagnosis:	fungal hyphae in histology, fungal cultivation (Sabouraud agar), often bacterial companion germs
Therapy:	fluid substitution, broad-spectrum antibiotics, metronidazole
References:	PERELMAN & KUTTIN 1992, SHANE & TULLY 1996

Candidiasis

Agent:	*C. albicans*, *C. mucor*
Transmission:	common in immunosuppression, incorrect feeding, long-term antibiotic therapy
Clinic:	anorexia, apathy, weight loss, stomatitis with white lesions, beak deformation due to necrosis
Post mortem:	focal stomatitis, inflammation of the mucosa, oesophagus, glandular stomach, in severe cases also pseudomembranous stomatitis, pharyngitis
Diagnosis:	fungal isolation and identification, histological examination of a scab of the affected beak cavity
Therapy:	5-20 mg/kg ketoconazole or nystatin (100,000 IU/300 g bw), no antibiotic, substitution of copper sulphate (0.5 g/l) via drinking water
References:	WALLACH & BOEVER 1983, BRUNNING & EMIL 1986, SHANE & TULLY 1996

Pathogen megabacteriosis

Agent:	*Macrorhabdus ornithogaster*
Epidemiology:	triggered by supporting factors
Clinic:	infection of the koilin layer of the glandular and muscular stomach, high mortality rate in chicks
Diagnosis:	detection in the koilin layer
Therapy:	amphotericin B (in ostriches difficult to administer)
References:	HUCHZERMEYER 1994, 1998, SHANE & TULLY 1996

Tab. 6 PARASITES

	name	clinic	remarks	diagnosis	therapy	References
Protozoa	*Cryptosporidium* sp.	infects bursa, rectum, pancreas, cloacal prolapse in male ostriches	specific for ostriches, especially young	oocysts in the faeces or histopathology of the affected tissues	surgical purse-string stitch in cloacal prolapse	HUCHERZERMEYER 1998, MEIRELES ET AL. 2006, NEMEC & LUKESOVA 2012
	Entamoeba struthionis		apathogen			NEMEC & LUKESOVA 2012
	Eimeria	young bird diarrhoea, general disturbance			10 mg /kg oral trimethoprim sulphate bid 5 days	JENSEN ET AL. 1992
	Histomonas meleagridis	typhlohepatitis, juvenile deaths, lethargy, inappetence, cyanosis, yellowish stinking diarrhoea	infection via chickens, also possible indirect transmission via *Heterakis gallinarum*	postmortem, characteristic liver and appendix abnormalities	50 mg/kg dimetridazole (toxic with continuous use), 0.006% ronidzaole in drinking water 14 days, 50 mg/kg dimetridazole drinking water 10 days, 50 mg/kg metronidazole drinking water 10 days	GYLSTORFF & GRIMM 1987, JENSEN ET AL. 1992, HUCHERZERMEYER 1998, MASSI ET AL. 1995
Trematoda	*Philophtalamus gralli*	in the conjunctiva	intermediate host water snail, often in association with galliformes and anseriformes birds		apply 5% carbamate powder in conjunctival sac, 5% carbaryl solution as a spray	GREVE & HARRISON 1980, JENSEN ET AL. 1992, SMITH 2003
Cestoda	*Houttuynia struthionis*	anaemia and poor condition in food deficits	chicks from 3 weeks, may persist for life, high pathogenicity,	proglottids in faeces	130 mg/kg resorantel,	SMIT 1963, JENSEN ET AL. 1992, CRAIG &

			intermediate host unknown (possibly insects)		15 (25) mg/kg fenbendazol, 100 mg/kg niclosamid, 7.5 mg praziquantel	DIAMOND 1996, HUCHERZERMEYER 1998, SMITH 2003, COOPER 2005, NEMEC & LUKESOVA 2012
Nematoda	*Libyostrongylus douglassii*	worms live in the glands of the proventriculus, inflammation of the mucosa, digestive problems, food decomposes in the stomach, anorexia, poor general well-being, deaths possible	enteritis in chronic parasite infestation, tapeworm 60-120 cm long	detection of eggs in faeces, infectious larva after 60 h	15 (-45) mg/kg fenbendzole, 5 mg/kg oxfendazole, 7.5 mg/kg levamisole, 200 µg/kg Ivermectin	KON 1962, SMIT 1960, JENSEN ET AL. 1992, BARTON & SEWARD 1993, CRAIG & DAIMOND 1996, HUCHERZERMEYER 1994, 1998, EDERLI & OLIVEIRA 2009
	Versternema struthionis	infested air sacs and fascia	clinically inapparent			SMITH 2003
	Paroncherca struthionis	lungs	clinically inapparent			SMITH 2003, HUCHZERMEYER 1994
	Struthiofilaria megalocephala	abdominal cavity	clinically inapparent			HUCHZERMEYER 1994, CRAIG & DIAMOND 1996, SMITH 2003
Ecto-parasites	*Struthiolipeuris struthionis*	feed on feathers shafts, feathers, and scales, itching			200 µg/kg Ivermectin 3x every 4 weeks, malathion, carbamyl	SMIT 1963, JENSEN ET AL. 1992, HUCHERZERMEYER 1998

	Struthiobosca struthionis	bloodsuckers	strictly host-specific			BEZZEL & PRINZINGER 1990, HUCHZERMEYER 1998
	Gabucinia spp.	live in the feather shafts, feather destruction				HUCHERZERMEYER 1998

2.9.3.2 Non-infectious Diseases

Yolk sac persistency

Absorption time after hatching is within 7-10 days (JENSEN ET AL. 1992, HUCHZERMEYER 1998) up to 2 weeks (GUITTIN 1987, DZOMA & DORRESTEIN 2001) or longer; absorption takes place only under optimal conditions (no stress, good environmental conditions).
Omphalitis is a very common cause of death at the age of 2 to 3 weeks (DEEMING ET AL. 1996, DZOMA & DORRESTEIN 2001), often associated with *E. coli*, *Pseudomonas* spp., *Staphylococcus* spp., *Proteus* spp. and *Streptococcus* spp. (DEEMING 1995, SHANE & TULLY 1996, DZOMA & DORRESTEIN 2001, SHIVAPRASAD 2003, TULLY 2009).
It is caused by poor breeding hygiene (DEEMING 1996, VERWOERD ET AL. 1999), umbilical infections after hatching, more rarely by retrograde infections from the intestine (VERWOERD ET AL. 1997A).
A persistent yolk sac can be palpated or seen by ultrasound (BLUE-MCLENDON & HOMCO 1995).
Therapy: conservative therapy with parenteral antibiotics does not usually work, surgical removal is necessary. It should be noted that the umbilical intestinal canal (ductus vitellinus) including the vessels must be well closed. Alternatively, the infected yolk sac can be punctured through the navel or in the navel region with a large syringe and emptied, followed by local instillation of an antibiotic solution (KENNY & CAMBRE 1992).

Tibiotarsal rotation and twisted tarsometatarsal bones / Slipped tendons

In ostriches affected by skeletal deformities, often dislocation of the gastrocnemic tendon of distal tibiotarsus and proximal tibiotarsus can be seen.
Birds can no longer stand safely; legs are exposed laterally. Chicks are particularly affected, but also juveniles and subadult ostriches (BEZUIDENHOUT ET AL. 1994, HUCHZERMEYER 1994, 1998, SPEER 1996, SAMSON 1997).
The exact cause is not known, multifactorial causation is discussed:

- genetic predisposition
- malnutrition (poor mineralization of bones due to insufficient nutrition, too high protein content; BEZUIDENHOUT ET AL. 1994, 1996, HUCHZERMEYER 1994, 1998, SAMSON 1997)
- unsuitable substrate (STEWART 1994)
- deficiencies of manganese, copper, biotin and choline may cause chondrodystrophy of the distal tibiotarsus and proximal tarsometatarsus, as in chickens and turkeys, which may cause deformation of the ankle (BEZUIDENHOUT ET AL. 1994, 1996, HUCHZERMEYER 1994, 1998, SAMSON 1997)
- trauma: damage to the lateral parts of the distal growth zone of the bone due to traumatic causes (BEZUIDENHOUT ET AL. 1994, HUCHZERMEYER 1994, 1998, SAMSON 1997); young ratites have an exceptionally large cartilage growth zone in the long tubular bones of the legs (REECE & BUTLER 1984), which can easily be physically damaged by slipping or stumbling (BLACK 1995, DICK & DEEMING 1996)
- rapid movements with a sudden change of direction or during “waltzing” can also cause dislocation (PERELMAN 1991)

Twisted or "rolled" toes

Twisted toes can be observed in up to 25 % of individuals in a hatching group (DICK & DEEMING 1996, DEEMING ET AL. 1996), often occur up to 2 weeks of age (KOCAN & CRAWFORD 1994). They are caused by instability of the interphalangeal joints and usually lead to medial rotation of the 3rd toe (DEEMING ET AL. 1996).
Many causes are discussed: incorrect feeding, incorrect incubation, unsuitable ground, lack of movement and genetic disposition.
Riboflavin deficiency has not been identified as a cause in ostriches (GILSLEIDER 1994) but is seen as a cause with subsequent diarrhoea and delayed growth by WALLACH AND BOEVER (1983). A deficiency of B-complex vitamins is also discussed as a cause (DUNN 1995, DEEMING ET AL. 1996).
Therapy: Correction with tape bandage, spontaneous healing at an age of up to 4 weeks occasionally occurs (DICK & DEEMING 1996, SAMSON 1997).

Stomach stasis

The food is not transported further by the stomach, contractions cease, the proventriculus remains full. Various factors such as poor condition, suboptimal temperatures, damage to the mucosa due to swallowed foreign bodies or behavioural problems can cause stasis. The birds are retarded in development, can no longer stand and die after a short time. Diagnostically, during auscultation, a lack of gastric peristalsis is revealed. For treatment, the causes must be eliminated and liquid food with a high energy content given. To stimulate stomach contraction, 0.1 mg/kg metroclopramide IV (HUCHZERMEYER 1998, SHAKESPEARE 1996) can be given.

Stomach overload/impaction

Impaction is an accumulation of food or foreign bodies in the proventriculus that blocks the opening of the stomach so that the food is not transported further into the intestinal tract. The birds are disoriented and may show abnormal picking behaviour. Other non-specific symptoms include weight loss, lethargy, dehydration, and decreased excretion rate (WALLACH & BOEVER 1983, YÜKSEK ET AL. 2002, SAMSON 1997, SHWALUK & FINLEY 1995). The impaction is often associated with an accumulation of sand. It is possible to palpate the full stomach or x-ray the body cavity (WALLACH & BOEVER 1983).
Ostriches are usually affected until about 6 months of age, stress can be considered as one of the causes (YÜKSEK ET AL. 2002, NAGARAJAN ET AL. 2011, SAMSON 1997, SHWALUK & FINLEY 1995). Lack of grit, inflammation due to candida or scarring may cause stomach clogging (SENK & MISOVIC 1974, BURGER 1976, GYLSTORFF & GRIMM 1987).
Conservative treatment with antibiotics should be initiated: (10 mg/ kg amoxicillin/clavulanic acid IM 5 days), 10 mg/kg metamizole IM for 5 days, B vitamins and 100-400 ml paraffin oil twice daily every 2nd day (YÜKSEK ET AL. 2002).
Therapeutically, a gastric lavage can be tried, surgically, an oesophagotomy or gastrotomy can be used to remove the stomach contents.
Excessive sand intake may cause accumulation of sand in the intestine and may be treated with 0.5-1 g/kg oil or 0-1 ml/kg oil orally to relieve the blockage (HUCHZERMEYER 1998, SHAKESPEARE 1996, SAMSON 1997, SHWALUK & FINLEY1995).

Feeding problems

Obesity due to excessive feeding also may cause sudden deaths due to aortic rupture. (MITCHINSON & KEYMER 1977, HUCHZERMEYER 1999, COOPER 2005); the latter is possibly associated by copper deficiency (SMITH 2003).
Deficiencies of calcium and phosphorous lead to developmental disorders of the bones, spontaneous fractures (COOPER & GIMBI1994) or deformations of the beak (HUCHZERMEYER 1998).
Hypovitaminosis B leads to reduced growth, crusty changes in the eyelids and beak angles (FOGGIN 1992, HUCHZERMEYER 1999, COOPER 2005).

Myopathy

There are different forms of myopathies in ostriches.
In degenerative myopathy, birds can no longer get up or only with difficulty, and die relatively fast (SPEER 1996).
Vitamin E/selenium deficiency can cause muscle degeneration ("white muscle disease") (WALLACH & BOEVER 1983, VAN HEERDEN ET AL 1983). When birds are no longer able to stand up independently and remain prone for a long time therapy can be tried with 300 IU Vit. E, a minimum of 50 IU/kg of food should be fed (WALLACH & BOEVER 1983).
Furazolidone poisoning might also be a cause of myopathies (SPEER 1996).
Myopathy is commonly observed at high temperatures, after exceptional exertion (stress, capture myopathy) and during the awakening phase of anaesthesia (RAATH ET AL. 1992, CORNICK-SEAHORN 1996).
Therapy is by long-term sedation with probe feeding, muscle relaxants, corticosteroids, and antibiotics.
You may also need to support the ostrich with loops while standing and carry out physiotherapy (SMITH 2005, SIEGAL-WILLOTT 2007).

Traumata / injuries

Various injuries can occur, often to the head, neck and limbs, due to ostriches' hectic escape behaviour.
Superficial wounds usually heal without complications, in some cases further treatment is necessary depending on the extent.
Birds in panic may run against fences or other obstacles and break their limbs. Fractures of the long bones have a poor prognosis and orthopaedic treatment should only be considered in young chicks up to 3 months of age.
Fractures of the thigh bone hardly ever heal as it is pneumatised and only has a thin cortex and epiphysis (CRABILL & HONNAS 1996).
Wing fractures can occur, especially when inexperienced staff handle adult birds. A splint may be taped to the fractured wing and the wing taped to the body (TULLY 2009).

Fig. 37

Male ostrich with wing bandage
(photo: Réserve Africaine de Sigean)

Prolapse of the phallus

Prolapse of the phallus of adult males may occur at the end of the breeding season, in birds weakened by other diseases or under extreme weather conditions, especially in cold weather (HICKS-ALLDREDGE 1996, HUCHZERMEYER 1998, 1999). Breeding birds should be separated from the females, possible injuries cleaned and treated. If weather conditions are the cause, birds should be kept at consistently warm temperatures. If this is not effective, shrinking the oedematous tissue of the phallus can be tried by applying dimethyl sulphoxide or terramycin powder (HUCHZERMEYER 1999) or alternatively cold or iced water. The cloaca can be temporarily secured by a purse-string suture.

Fig. 38

Male ostrich with phallus prolapse
(photo: Réserve Africaine de Sigean)

Poisoning

- Furane overdoses: hyperexcitation, head tremor, incoordination, exitus
- Antibiotics like lincomycin, dynamulin, streptomycin and colistin may have toxic effects.
- Overdoses of anti-coccidal substances such as ionophores cause paralysis of the extremities.
- Thiabendazole: neurological symptoms
- An overdose of selenium can cause mortality in young ostriches.
- Furanocoumarins (plants of the family Umbilliferae): cause photosensitivity, often weeks later: weeping eyes, conjunctivitis, erythema on the scalp, eyelids, beak, desquamation of the skin on the legs.
- Anticoagulants (pest control): haemorrhagic syndrome in ostriches, therapy with 5 mg/kg Vitamin K parenteral over several days
- Mycotoxins such as aflatoxin**,** ochratoxin**,** zearalenone (intake from food)
- Zinc (uptake via foreign bodies, drinking water) acute to chronic: enteritis, typhlitis, pancreatic atrophy! (liver: normal 54.3 µg/g, toxic 375-441 µg/g)

References: JENSEN ET AL. 1992, SHIVAPRASAD 1993, HUCHZERMEYER 1994, 1998, DEEMING 1999, KINDER ET AL. 1995, CARREIRA ET AL. 2011

Other veterinary issues

There are several other veterinary problems that exceed the scope of this document. Diseases of the female reproductive organs occur but are difficult to diagnose without anaesthesia. Recurring cloacal prolapse can occur in adult females when trying to expel a retained egg (experience within the zoo community, HUCHZERMEYER 1998). Tumours and stabilized coelomitis are occasionally seen in older females (A. JORIS, Réserver Africaine de Sigean, pers. communication 2024).

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