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A Study Of Social And Breeding Behaviour In Ostrich (*Struthio Camelus*) In Captive Environment

Vismaya Vimbi [1], Hyzil J B[2*] Sojomon Mathew[3], Eapen Jacob[4]

[1]*Master Student, Departemnt of Zoology, Government College for Women, Vazhuthacadu, Thycaudu P.O, Trivandrum - 695014, Kerala.*

[2*]*Assistant Professor, Department of Zoology, Government College for Women, Vazhuthacadu, Trivandrum -695104,Kerala.*

[3]*Assistant Professor, department of Zoology Govt. College, Kottayam- 686013, Kerala, India*

[4]*Assistant Professor, Department of Zoology, University College, Thiruvananthapuram-695034, Kerala, India.*

***Corresponding Author** - Hyzil J B*

**Assistant Professor, Department of Zoology, Government College for Women, Vazhuthacadu, Trivandrum -695104,Kerala..*

***E.mail :-** hyzilsyam@gmail.com*

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Abstract

The earth is teeming with a distinct variety of life forms, but many species are being threatened due to human encroachment, habitat degradation, climate change and pollution, putting the earth's magnificent biodiversity at risk. The risk of extinction rises as the gene pool's diversity decreases. Thus, conserving the existing biodiversity based on sustainable development and several conservation strategies like zoological parks plays a key role in providing a home to a wide range of indigenous species and exotic birds in a stress-free environment with high veterinary care. Menagerie plays a role in ex-situ conservation by captive breeding and in-situ conservation by reintroduction into the wild. This research has been conducted to observe the behavioural pattern of *Struthio camelus* that were reared in captive condition. Breeding, mating, aggression, pecking and locomotion patterns were investigated. Predominant reproductive behaviour in the wild and captive are kantling, soliciting and agonistic displays. The number of eggs laid by the females within the clutch, the length of laying period, egg shape, size and colour were noted. The male rooster showed more aggressive behaviour and was disturbed at the sight of visitors producing a hissing sound. The population of the ostrich is declining as they are hunted for their feathers and skin, thus by captive breeding strategies, these species can be re-established in the wild. This research helps in contributing scientific knowledge through observation of animals in their enclosures and increases longevity through improved diet.

Keywords: Zoological Park, Captive breeding, Breeding behaviour, Conservation

INTRODUCTION

Lining up the members of class Aves, systematists have roughly divided 11,000 different living bird species[1]. The behavioural research on birds involves the study of their evolution and natural behaviour, cognitive abilities, social and breeding behaviour, and how their behaviour is influenced by captivity[2].

Origin of flightless birds- Ratite

Classifying the modern flightless birds which belong to subclass Neornithes, superorder Palaeognathae or Ratite and order Struthioniformes include various families: Struthionidae, the ostriches; Rheidae, the rhea; Casuariidae, the cassowaries; Dromaiidae, the emus; and Apterygidae, the kiwis. Additionally, the extinct moas of New Zealand, genus Dinornis (Dinornithidae), and the elephant birds of Madagascar and Africa, genus Aepyornis (Aepyornidae), we're likely closely related and have been classified in different orders or families as well [3]. Although the origins of flightless birds are unknown, Romer suggests that ratites descended from a flying ancestor and lost their ability to fly as their size grew, and that flying was an adaptation for escaping from on-the-ground predators [4]. Taxonomists considered ratite as an example of convergent evolution on southern continents, but as the principle of continental drift progressed into plate tectonics, it became much easier to believe that ratites originated from similar ancestors who were scattered as the continents spread apart. The other bird species, except the tinamous, which are phylogenetically nearest to the ratites and are believed to have evolved from a common ancestor, lack a palaeognathous ("old jaw") palate [3].

Ostrich – The Camel Bird

Ostriches (*Struthio camelus*) largest living ratite without keel bone and native to South Africa [5]. They belong to the family Struthionidae with 5 distinct subspecies including Rednecks (*Struthio camelus massaicus*, *Struthio camelus camelus*), Blue Necks (*Struthio camelus molybdophanes*, *Struthio camelus australis*), and the South African Black Neck (*Struthio camelus domesticus*) [6]. The age, skin color of bare legs, head, and neck, and size and shape of their eggs vary slightly between species [7]

Morphometrics

Ostriches are large and vary in height ranging between 1.7 to 2.7 m tall depending on sex and individual. They can weigh from 63kg to 157kg [8] and adapted for a terrestrial mode of life having long powerful legs and can run at a speed of 60-70 km/hr, covering more than 8 m in a single stride [9]. The head is small, wide and flattened and the bill is straight, short and bluntly rounded at the tip. The gape stretches backwards past the eyes [10] and helps to dissipate excess body heat during the hottest hours of the day. The eyes are wide and have thick, black eyelashes which protect from dust storms. The flattened sternum (breastbone) lacks a keel, which serves as an anchor for flight muscles in other bird species [11]. Ostriches show sexual dimorphism with adult males generally having a grey-colored neck with black and white wing primaries and tail feathers, while female having white to light grey wing primaries and tail feathers, as well as a dull brown to a grey color pattern on their bodies [12]. Males outnumber females in size. The bird appears naked because the head and about two-thirds of the body is sparsely covered with short, hair-like degenerated feathers. There is no secondary shaft or aftershaft on the feathers. There are about 50–60 tail feathers, 16 primary feathers, 4 alula feathers and 20–23 secondary feathers on the wings. The rectrices and wing feathers have been replaced with decorative plumes. The legs are well-developed, naked and pinkish having only two toes, one with a large, strongly clawed third toe (inner) and another generally weaker, clawless fourth (outside) toe. The horn plates on the tarsus of sexually mature males are red, while those of females are black.

Geographical distribution and Habitat

Struthio camelus occurs throughout much of Africa between 10˚ and 20˚ north of the equator, south of the Sahara, East Africa, Africa south of the rainforest belt, and much of Asia Minor, but most existing populations are in-game parks [3]. It conjointly inhabits Namibia, southern Angola and Botswana, Mauritania, Mall, Niger, Chad, Sudan, Ethiopia, Kenya, Uganda, Cambia, Southern Rhodesia and Republic of Mozambique. It's regionally extinct in African countries however has been introduced to Australia and Swaziland. Their preferred habitats are vast, treeless and barren regions of Africa, which occur in small groups with the company of the antelopes and zebras. They enjoy the water and often take baths where water sources are available [8]. In northern Africa, it lives in the dry beds of watercourses in broad valley bottoms and desert-savanna plains, rarely above 300 ft. In eastern Africa, it is in savanna; in southern Africa, it is in open grassland with some shrubs [3]. In South-West Africa, ostrich inhabit the semi-desert to the true desert with patches of open, stunted woodland [13]. Open, short grass plains and semi-arid deserts are ideal habitats. They relish the open forest

and stay away from dark woods and tall grass [5]. This characteristic is due to the uric acid content of the urine, which is carried in a mucus-like substance that aids in water loss. Most ostrich densities are found in semi-arid areas, but they can also survive in areas with little vegetation [14].

Longevity within the wild and captivity

In the wild: The ostrich will live for 30 to 50 years, with the average age being 40.

In captivity: They can live for up to 50 years, with some ostrich farmers predicting a lifespan of up to 70 years [15]. Given that ostriches lack teeth, determining their age can be challenging. Due to a lack of other methods, keeping good and proper records for individuals from hatching can aid in age identification. However, there is enough evidence to suggest that feather growth and bone ossification can be used to accurately assess the age of a bird at any given time. Feather production and likely bone ossification for birds of the same age differ significantly due to a wide variety of rearing methods and diet. As a result, these approaches are still in their early stages of development and need further research and attention. [16].

Behaviour of Ostrich

Social organization: An ostrich population is frequently a mixed community of flocks, families, and individuals of all ages, with the composition changing seasonally. In a sequence of ostrich sightings in East Africa, single birds made up 49% of the sightings, two birds made up 35%, and three to five birds made up 16% [3]. Tiny flocks of ostriches (five to ten birds) live in the wild, but larger flocks congregate near water in the dry season or where food is plentiful. Group's stride across the short grass plains, frequently picking food from the ground. The ostrich spends its time sleeping, dust brushing, and preening while it is not eating. The ostrich is often the first animal on the plains to detect a predator because of its exceptional hearing and height, its fleeing flocks also warn other animals of the impending threat. Many rivals are outrun by the ostrich, which can achieve speeds of 39 miles per hour. It only kicks powerfully in self-defence on rare occasions [11]. When a bird approaches another in a submissive pose, with its head lowered and tail down, social interaction between birds of different groups is initiated [17]. The ostrich is nocturnal, but on moonlit nights, it can become active. It squats on the ground to loaf and roost, and it is most productive in the mornings and evenings. Its average walking speed is 4 km/hr, but it can run at a speed of 70 km/hr when alarmed. It is vigilant while feeding and continuously raises its head to look around. The male ostrich's territorial call is a roar that carries far and sounds like a lion's roar. As a communication call, a gentle "booh" is used, and hisses are used in danger displays. The frequency of their behaviour changes with seasons [3].

Breeding and courtship behaviour: Ostriches are seasonal breeders, only reproducing at certain times of the year and the mating season lasts six to eight months. Breeding season begins in March and concludes in August/September in the northern hemisphere. It starts in the southern hemisphere around July/August and lasts until the end of March. The domesticated ostrich is sexually mature at 2-3 years, while the wild ostrich is sexually mature at 4-5 years. The female is sexually mature slightly earlier than the male [9]. Male cock is polygynous in which 80% of ostriches were seen with a single male and 20% engage in a relationship with more than one male ostrich in the breeding season [18]. The "major hen" is the one that shows her family rank to the "minor hens" and their mate. The adult females demonstrate courtship displays by posturing during the early stages of mating. In front of potential mates, they can urinate, defecate, and show off. Young yearlings showed submissive behaviour by lowering head and neck in S-shape. The adult male develops red pigment on their beak, thigh and shin skin [19]. Agonistic displays, chasing, kantling are shown by the male ostrich, which refers to a male's aggressive behaviour toward other male or female cocks, the cock drops to his hocks and fans both wings forward and backwards while hitting his head on each side of his spine respectively. The female displays her precopulatory soliciting behaviour by fluttering her wings and holding them in the forward position and lowering her head with support of her beak. This ends with the faeces of the ostrich to the ground with her elevated tail and neck forward [5]. The male cock mounts on the female. The male stamps his feet on the ground several times just before mounting. Mounting entails the male sitting on the female's right side with a leg on either side. Before intromission repeated thrust of the phallus is often required. During copulation, the male performs a kantling dance that culminates in the male bringing his head forward and emitting a deep harsh grunt. During the 30-60 seconds of mating, the female keeps her head forward and snaps her beak [20].

Egg laying and Nesting behaviour: Shortly after mating, the female begins to lay fertile eggs. The ostrich lays the world's largest egg. Surprisingly, the ostrich egg is one of the smallest in comparison to the bird's size. Measuring, on average, 17-19 cm in length and 14-15 cm in width and weighing up to 1900g. The ostrich egg weighs less than 1% of the female's body weight. The eggs are white to yellowish white in color, with a rough

shiny surface pitted with superficial pores of varying sizes and shapes. The largest eggs were measured in the Masai ostrich of East Africa, while the smallest were found in the arid regions of South Africa's west coast [9]. After the first mating, the first fertilized egg is laid after 10 to 14 days. The first female to lay in a nest becomes the major hen of the male that owns the nest, while others are the minor ones that lay eggs in the same communal nest. The major hen lays a total of 11 eggs at a period of every two days. The male cock also mates with several other females and all of them lay clutches in the same nest; there may be 20 to 30 eggs when the dominant female is ready to begin her 42- to 46-day incubation [11]. Females incubate the eggs during the day, while males incubate them at night. The drab female blends in with the sand, while the black male is almost undetectable in the night, allowing the nest to go undetected [21]. The eggs and chicks are attacked by several predators, including hyenas, jackals, and vultures, resulting in a poor breeding success rate of one chick per incubated nest [3].

Feeding behaviour: The newly hatched ostrich chick is primarily dependent on its yolk sac, which disappears 10-14 days after hatching. The chick does not eat for the first 24-72 hours after hatching. Ostrich chicks imitate the behaviour of their parents or other chicks in pecking objects or selection of food. Since new hatchlings and small chicks have trouble feeding on troughs and are instinctively inclined to peck on the ground, the feed should be strewn on the ground at first. Young birds lack the gastroliths (also known as stomach stones or gizzard stones) and microbes needed to break down and digest fibre. Adult ostriches spend 10% of their time grazing, 20% of their time pecking at soil or pasture, 50% of their time sleeping, and 2% of their time drinking water. The remaining time is spent loitering, socialising, and/or fighting. Ostriches only eat throughout the day and lie down in the afternoon, becoming inactive during the night [22].

Antagonistic behaviour: Ostriches may be aggressive against their partners as well as humans. They try to track down and kick others who aren't in their favour. It is more common at the start of puberty. Males show aggression by fluffing their feathers, raising their wings and tail feathers, and attempting to kick the men [23].

Abnormal behaviour:
Feather pecking: Ostriches pick each other's feathers due to stress, overcrowding, and exhaustion. It occurs more often in winter due to a long time of closure. Toe and face pecking is also a serious problem.
Stargazing: ostrich exhibit peculiar behaviour to lift their heads and position them on their backs regularly and find it difficult to walk, feed and drink. This is due to a lack of thiamine.
Anorexia: When the animals are displeased with feed and water containers or if the water has high chlorine content, they can starve to death or get degraded.
Pica: In chicks, eating faeces is a perfectly acceptable practice since it provides them with microflora, which is essential for digestion. This behaviour can become repetitive in captive animals, resulting in illnesses [24].

Other behaviour: The behaviour of ostriches varies depending on their age and the time of day [25]. Ostriches do activities like yawning and stretching as part of their daily routine [19]. Ostriches are experts at regulating their body temperature by their actions. Ostriches groom themselves by preening their feathers with their beaks while walking, sitting, standing, or even in the rain [26]. During hot weather, the ostriches release heat by panting and by seeking shade [5].

Dietary Requirements
Ostriches are omnivores, but they live mainly on the herbivorous diet. They consume mostly plant matter, but they can also eat the remains of other species leftover from carnivorous predators' feed. They are selective feeders, only eating seed head of grasses and some flowers when provided the chance; otherwise, they will consume a variety of wild leaves and bushes, shrubs, grasses, plant roots, plant seeds, fauna, and sprouts. Tiny bits of meat, such as rats, remains of different species of animals, lizards, small rodents, and frogs, can be found in their carnivorous diet. Locusts and crickets have also been known to be eaten by them. Since access to water in the wild on Africa's dry plains is difficult, Ostriches, like Camels, can go for long periods of time without drinking [27].

Threats to Ostrich
The ostrich was traditionally hunted for meat, eggs, and hide, as well as feathers. A recent trend of increasing the demand for its meat has promoted commercial farming; this has relieved hunting pressure on wild birds, whose status is stable. Today, the ostrich must compete with domestic grazing stock on its native grasslands, but it prospers in reserves. Attempts are being made to re-establish it in its former range [11]. Mechanized

cultivation, overgrazing, poaching, and drought are all factors contributing to ostrich declines around the world [28], [29]. According to 5,000- year-old documents from Mesopotamia and Egypt, the ostrich has influenced human thought, religion, and art since ancient times. The Kalahari bushman's egg is still a precious vessel in which he stores scarce water, and he makes beautiful jewellery for his wife and children out of the shells [3]. In sports, ostriches were first used in amphitheatres in Roman times (around 50 AD), where they were often chosen to battle men. Thousands of livestock were killed as a result of this procedure. Ostriches are currently raced by small humans in competition because of their size. Animal rights campaigners have been outspoken in their opposition to this activity. Ostrich feathers were once considered a fashionable accessory, which led to the establishment of ostrich farms in the nineteenth century. Ostrich leather is known for its strength and has been used in textile production and has a high demand. Ostrich meat is considered a good source of protein, iron, and calcium. There are currently several ostrich farms around the world that breed these birds in the same way that cattle are raised. Ostrich eggs are a valuable food in addition to slaughtering them for beef [30].

Conservation status

In the last 200 years, the wild ostrich population has decreased. The common ostrich is classified as a Least Concern species by the IUCN Red List of Threatened Species, but its population is declining [31]. Most of the remaining birds can be found in game-parks or farms. True wild birds can only be seen in isolated desert areas, but farms and game parks help to keep the population alive [3].

The research was carried out to know about the behavioural pattern of ostriches and helps to understand their cognitive abilities, response to stressors and their breeding pattern. Similar research can be done on other animals and can contribute positively to the science of animal management and animal breeding techniques. Through a greater understanding of the value of behavioural science, we aim to allure more zoological organizations to join, either by funding or undertaking research, or by encouraging the use of their animal collections for behavioural research to both the zoological and academic community.

MATERIALS AND METHODOLOGY

Research Site

The observation was carried out at the Zoological Garden located in the heart of Thiruvananthapuram city. Ever since its establishment in 1859 as the second Zoo in India, the Thiruvananthapuram Zoo has seen a steady progress in the number and variety of its animal collection. It spreads over 36 acres, as part of a 55-acre complex that also houses museums and art galleries.

The Zoo is unique for its breath-taking landscapes and luxuriant growth of vegetation and has a collection of mammals, reptiles and birds in enclosures. The zoo aims to conserve the endemic and endangered species of western ghats and provide education and awareness on nature, support eco-tourism and initiate captive breeding programs.

Study Species: Ostrich (*Struthio camelus*)

The ostrich was selected as the research subject, and its social and breeding habits were studied. Three ostriches were held in captivity, two of which were males and one of which was female. One of the males, who is almost six years old, is placed in a separate enclosure to avoid a battle for the mate. The data was collected from the enclosure, which houses a single male and female ostrich.

The male and female ostriches were born on July 5, 2018, and July 6, 2018, respectively at the Arignar Anna Zoological Park in Vandallor, Chennai, and they were brought to the Thiruvananthapuram Zoo. The male and female ostriches became sexually matured at the age of two and their behavioural changes at the time of breeding and egg-laying behaviour were noted. *Struthio camelus* is the largest living bird and the world's fastest two-legged animal that has two toes and lays the largest egg, which is the largest single cell found on our planet.

Ostrich Enclosure

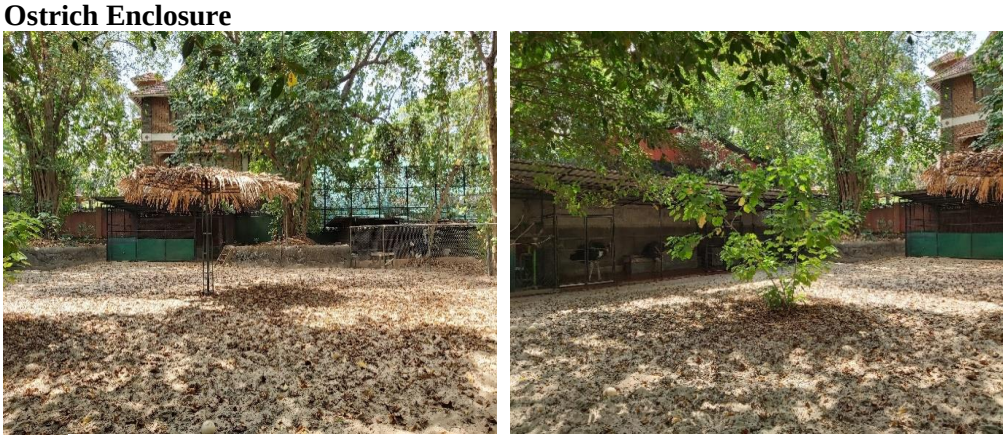


Figure 1. Ostrich enclosure showing their feeding area

The ostrich enclosure was built in 2007 and has an open paddock area of 726.98 sq. m. There are three cubicles in each of the two animal houses, as well as a wooden and concrete feed trough for feeding and drinking. The enclosure is surrounded by high fencing material, and the top of the fence is protected by a protective covering to prevent unintentional injuries and corners of the enclosure are rounded. The area is covered in sandy soil, and there is a small hut built to provide shade. The tropical evergreen tree Kleinhovia hospital L., also known as the guest tree, dominates the landscape around the enclosure (Figure 1.)

Methodology

From January to June 2021, the ostrich's behavioural pattern was observed for six months. The observations were taken from morning 9 am to evening 4pm. With the assistance of zookeeper and curator, information about the ostrich and its growth up to this point was gathered. This information aided in the completion of a more thorough investigation.

Their feeding and non-feeding times were included in the observation period. The observation began one hour before their first feed. All of the ostrich's behaviours were recorded without interfering with their regular activities. With the aid of the zookeeper, a comparison was made between their normal and breeding behaviour and also explained about the list of food items given to the ostrich. It includes the food items and its amount given regularly.

The distinguishing features between the male and female ostriches were identified. Information regarding their enclosure, place of birth, date of birth, age was collected from the Zoo records. The feeding regimen was prepared with the assistance of a veterinarian.

Photographs and videos taken during the observation were used for recording the details and further evaluation. It was helpful for comparison of behavioural patterns of each individual.

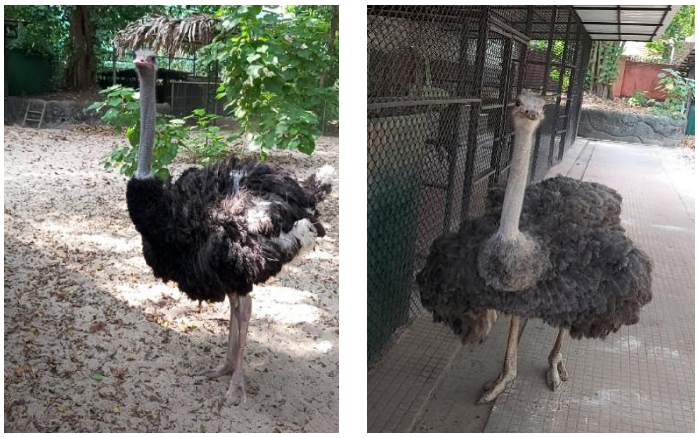
OBSERVATION

Distinguishing the male and female Ostrich

The ostrich, *Struthio camelus*, was observed for three months and was found to prefer sandy areas. Since the ostriches are kept in captivity, only one male is assigned to each female, as male dominance can result in serious injuries. The distinguishing characteristics of the ostriches are given below in the table (Figure 2.)

Table 1: Distinguishing the male and female Ostrich

Characteristics	Male	Female
Height	2m	2m
Colour	Black	Grey
Feathers	Black feathers with white wing primaries & tail feathers	Dull grey feathers with white to light grey wing primaries & tail feathers
Sexual maturity	2-1/2 years	2-1/2 years
Tarsus	Red horn plates	Black horn plates



Male Ostrich Female Ostrich

Figure 2. Representing male and female Ostriches present at Thiruvananthapuram Zoo

Feeding Behaviour

Ostriches feed primarily in the morning and then again later in the evening. They are fed according to a specific diet schedule. Mostly they are provided with plantain banana, spinach, dog biscuit, corn. They only drink a small amount of water, especially during the day. Mostly they put their heads down and show pecking behaviour. They raised their heads only to swallow a food bolus. They usually prefer dry leaves, small grit like materials to peck, that helps in grinding the food. The feeding gets haltered if they get disturbed by any noise or outside influence. Their first meal is at 9.30 a.m., followed by 11 a.m., and the last meal is at 3.30 p.m. Egg supplements were also provided to them as their breeding period progressed. They store the majority of their food in the elastic top part of the gullet when feeding and allow large boluses of food to travel slowly down the neck at intervals.

Activities

During the day, the ostriches are active and spend the majority of their time foraging. They have excellent peripheral vision and are keen observers. They will lift their heads and stand for long periods of time while concentrating on a single object. They are vigilant, even while feeding.

The positive activities like preening, foraging, normal locomotion, breeding, and dustbathing are observed. They normally relax by sitting mainly in the afternoon for a very short time period. While laying down, they do sand bathing and take care of their feathers.

At the sight of visitors, they make a hissing sound, giving a message to stay away. On rare occasions, ostriches will give a powerful kick for self-defence. They remain motionless for a long time, watching the animal in the adjacent enclosure. They are easily startled and flee quickly inside the enclosure even though there is just a minor disturbance.

Ostriches urinate or defecate mostly after their feed and while pecking. Micturition and defecation are separate acts; usually one follows the other almost immediately. The male ostrich protrudes their penis from the floor of the proctodeum on defecation.

Breeding Behaviour

The male and female ostrich attained sexual maturity when they were 2-1/2 years old. Their breeding behaviour started in the month of January. They had shown courtship displays like cock kantling, soliciting, wing swinging and pacing. The male cock becomes more aggressive during the breeding period. Booming sound is produced by the male ostrich during the mating season.

In this period, the male develops red flush beak and pinkish red colour in their thigh and shin skin. The male shows more aggressive behaviour compared to the female, they stand tall with tail erect, make a hissing sound and flap their wings and feathers are puffed up. At this period, they show aggressiveness, even to the zoo keeper, who came to feed them.

They make courtship displays during the mating phase, with the female holding her head down and the male putting his left foot next to her and mounting with his right foot on her back while crouching. The phallus or penis then reaches the female's cloaca after the male cock gently falls on her back. After penetration, the male rolls rhythmically from side to side, vibrating his wings. Consumption usually follows the male's rhythmic

grunting or groaning, snapping of the beak, and partially inflating the upper lip, while the female snaps her beak and shakes her head. On ejaculation, the male produces a guttural sound. Either or both partners get up after one minute of complete copulation.
Shortly after mating, the female began to lay the eggs. By the 28th of January, the female ostrich had laid her first egg. The egg had a cream shade, nearly 15 cm long, and weighed 1.5 kg. The intervals between egg laying were also noted. Before laying their eggs, they displayed courtship behaviour. A total of ten eggs were laid by the female ostrich at irregular intervals. The ostriches left their eggs unattended for two weeks, and the majority of the eggs were rejected because they were infertile. Just three eggs remained after they nearly destroyed a total of seven eggs. Parental care was also observed at this period, with the eggs being rolled and nesting behaviour being observed mostly at night.

RESULTS

The daily activities of the ostriches were observed. The ostriches were more active during the morning, followed by evening and afternoon. The two ostriches had attained sexual maturity, when they were 2-1/2 years old. So, their breeding and egg laying period were included in the observation. The behavioural repertoire in ostriches is explained below:

Feeding behaviour

The diet plan was devised with the aid of a veterinarian. Plantain bananas, cavendish bananas (robusta), spinach, dog feed, cattle feed, and eggs were provided as part of their feeding routine. The feeding time is 9.30 am, 11am and 3.30pm. Since feeding is part of their everyday routine, they moved to the feeding site and waited for their food, sometimes showing pecking behaviour and beginning to make hissing sounds when their food arrived. They showed continuous feeding for an hour in the morning and half an hour at 11 a.m. and 3.30 p.m. The time they were seen drinking was in the morning, and they only drank a small amount of water. (Figure 3.)

Table 2: Daily feed schedule of Ostrich:

Time of feed	Spinach	Plantain banana	Dog feed	Cattle feed	Boiled egg	Cavendish banana	Corn
9.30 am	10 kg	2kg	500g	2.5kg	2	-	-
11am	2.5kg	500kg	-	1kg	2	-	-
3.30pm	2.5kg	-	-	1.5kg	-	500g	500g

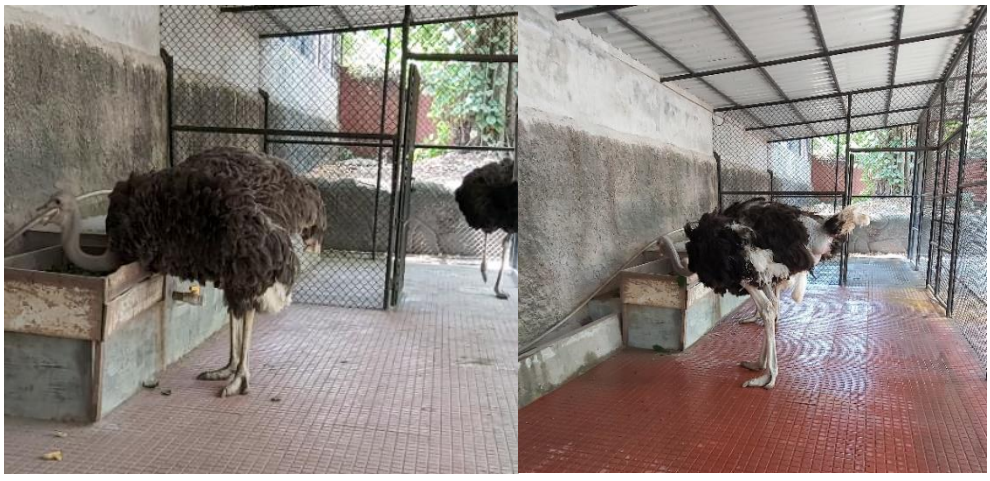


Figure 3. Feeding behaviour of female and male Ostrich

Breeding behaviour

The ostriches displayed monogamous association socially, as the male and female were with each other and moved in the same direction more than 95% of the time. The courtship displays were shown by the ostriches.

Behaviour shown by male Ostrich

The male cock initiated monotonous booming sound, kantling displays by wing flapping and agonistic displays- a sign of aggressiveness by producing a hissing sound. The male develops red flush beak and pinkish red colour in their thigh and shin skin.

Behaviour shown by female Ostrich

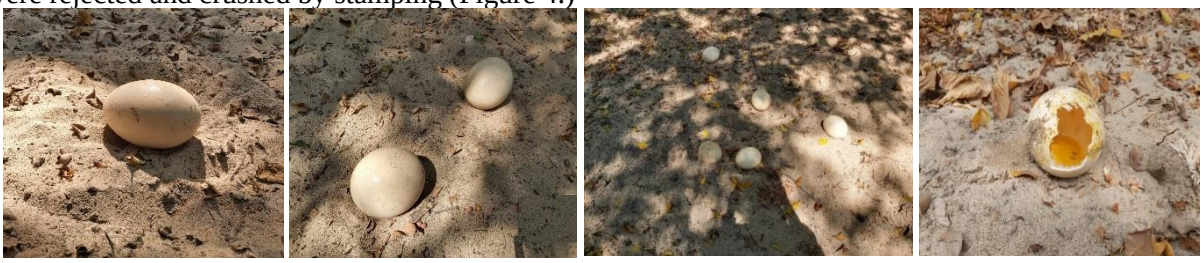
The female hen showed soliciting behaviour by flapping her wings forward and backward and holding her head toward the ground. The female emits a clucking sound by snapping her beak and vibrating the feathers in sequence (fluttering), expressing her willingness to breed.

Copulation time was observed in the afternoon, and it took approximately 60-90 seconds to complete. After two days of mating, the female hen started to lay eggs. The egg laying period is mentioned in the given table and one egg was laid on each day.

(Date/Month) Egg laying	28/1	4/2	7/2	11/2	21/2	1/3	9/3	14/3	17/3	20/4
Time Period (days)		6	2	3	9	7	7	4	2	33
Viability of egg	R	R	R	R	R	R	R	S	S	S

R- Ruptured S- Survived

The eggs are laid at irregular intervals, as shown by this observation. Just three of the ten eggs laid by the female ostrich survived. The eggs laid were left unattended for two weeks before showing signs of parental care, such as rolling the eggs and nesting behaviour. However, since the majority of eggs were infertile, they were rejected and crushed by stamping (Figure 4.)



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Aggressive behaviour

During the breeding season, the male ostrich became more aggressive. At the site of visitors, the ostriches snap their beak repeatedly and produce a hissing sound, signalling them to stay away. (Figure 5.) The ostriches stand upright with tails erect and swinging their wings. They have very sensitive ears and are keen observers, and during the egg-laying period, they are more alert, to protect the egg from predators.

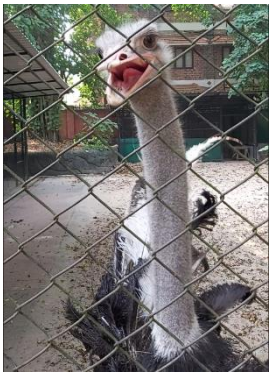

Figure 5. Aggressive behaviour

Resting behaviour

Resting was mostly seen in the afternoon. The two most common resting behaviours shown by the ostriches are standing (94%) and sitting (5%). No sleeping posture was spotted during the observation period. They remain inactive during the night time. (Figure 6.,7.)

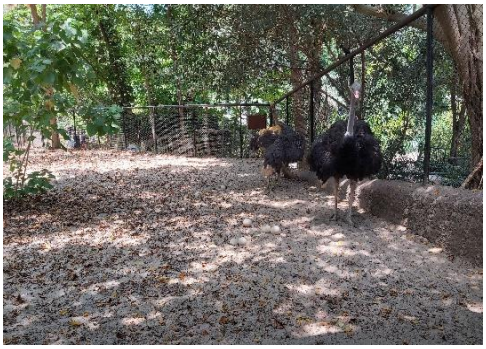

Figure 6. Resting in the shade

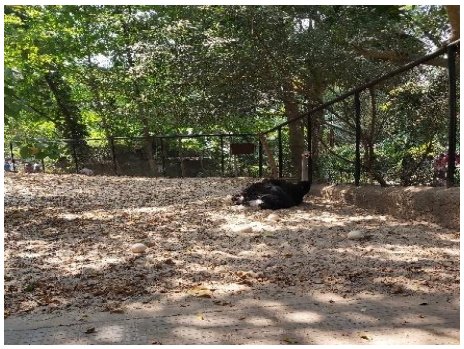

Figure 7. Sitting behaviour of male Ostrich

Locomotion behaviour

During the observation period, the ostrich spent most of the time foraging. Locomotive behaviour is more prompt during morning, followed by evening. They mainly walk by pecking (90%) and run (3%) when startled by any sound.

Grooming activity

Grooming activities are carried out to remove foreign contaminants such as leaves and soil trapped in their feathers. This was mainly performed in the afternoon. They also beat their wings, to dissipate heat from their body.

DISCUSSION AND CONCLUSION

The study of ostriches (*Struthio camelus*) in captivity revealed information about their territorial, locomotive, breeding, resting, and egg-laying behaviour. Observation of animal behaviour is crucial in determining the animal's health [32]. Understanding their behaviour and the important stimuli that followed courtship and mating allows breeding programs in captivity to be more successful. Nowadays, zoos play an important role in providing suitable enclosures for the animals after studying their life in the wild. The zoo provides a stress-free atmosphere with excellent veterinary care and allows the animals to display their normal behaviour.

The majority of the behaviours shown by captive ostriches are identical to those of wild ostriches. The key distinction is in the time and mode of display of the conduct. Ostriches in captivity have limited habitat, while wild ostriches live in open grasslands and semi-arid regions of central and southern Africa and S.W. Asia [5]. The captive ostriches have attained sexual maturity at the age of two, while the wild ostriches became sexually mature at four to five years old [9]. Mostly the ostriches are seen in nomadic groups of 5-50 birds and move along with the other grazing animals like zebra and antelope [33] while the captive ostriches are only two in number, so they cannot exhibit much of their territorial behaviour.

The male cock showed more aggressive behaviour compared to the female and produced hissing sound and snapped their beak continuously. In the wild, the ostriches form polygamous groups, the male mate with more than one female while the captive ostriches showed a monogamous association. According to Dr M.M. Shanawany & Dr John Dingle breeding only occurs during particular seasons of the year and it varies with altitude and latitude. In the northern hemisphere, breeding season begins in March and ends around August/September while in the southern hemisphere, it begins around July/August and finishes by the end of March [9]. In the captive ostriches, there is a slight variation in the breeding season; it began in January and by the end of January, the egg-laying period started. The female hen laid ten eggs but the eggs were left unattended for almost 2 weeks and very little parental care was observed. The rolling of the eggs was noticed and even showed nesting behaviour in between the egg-laying period. According to Dr M.M. Shanawany & Dr John Dingle in the wild, the eggs are deposited every other day, virtually without exception, in clutches of 20-24 eggs. After a seven-to-ten-day break from laying, the hen resumes laying and begins a new clutch. High-producing females lay between 80 and 100 eggs throughout the mating season, with up to 167 consecutive eggs observed without an apparent off-season[9]. However, it was the first time the ostriches were bred after

reaching sexual maturity in captivity, and they had an erratic egg-laying pattern, with the majority of the eggs being infertile and so being rejected. Nearly seven eggs were crushed by stamping at a later time, leaving only three eggs. Other factors like inheritance, age, environment, nutrition, health, psychological factors can affect the egg productivity and length of the egg laying period.

The most prominent behaviour shown by the captive ostriches are walking, pecking which are more active in the morning. The captive ostriches showed cognitive abilities as they learned the place and time for their feed. Resting behaviour like standing, sitting have been observed mostly in the afternoon.

The main difference from the wild ostriches is in their feeding habits. The wild ostriches follow an omnivorous diet and consume plant roots, wild shrubs, herbs and left over remains of animals. The captive ostriches are provided with a highly nutritious diet on a regular basis. Predation pressure on wild ostriches is high, while pressure on captive ostriches is low.

By understanding these behavioural patterns, better animal husbandry techniques can be developed and increase the longevity of the captive animals.

The major findings and recommendations

1. The size of the enclosure can be increased so that they get more space for walking and they are fast runners as they sprint in short bursts up to 70km/hr.
2. Wild ostriches mainly prefer open semi-arid regions, hence more sandy soil must be provided so that they can do dust-bathing.
3. Planting long grass sprouts and adding low shrubs helps the animal to peck and graze throughout the day in the enclosure and also provide an aesthetic feel.
4. Incorporating pebbles into the enclosure promotes a natural part of an ostrich's behaviour: they swallow the pebbles to aid in the digestion of their food, but caution must be exercised to ensure that they do not become ill, eating too many could result in serious health problems.
5. Artificial incubation of the eggs can be carried out for successful production of offspring.
6. With a few simple changes, a sustainable and environmentally friendly zoo can be built. Solar power plants, biogas plants, mulching old browse, and the use of water tanks can all contribute to a more sustainable climate.

REFERENCES

[1] T. Allinson, Ed., *State of the world's birds: taking the pulse of the planet*. Cambridge: Birdlife, 2018.
[2] K. Herrmann and K. Jayne, Eds., "Behavioral Research on Captive Animals: Scientific and Ethical Concerns," in *Animal Experimentation: Working Towards a Paradigm Change*, BRILL, 2019, pp. 517–547. doi: 10.1163/9789004391192_022.
[3] B. Grzimek, J. A. Jackson, W. J. Bock, D. Olendorf, and M. Hutchins, *Grzimek's animal life encyclopedia*, Second ed. Detroit (Mich.): Thomson Gale, 2003.
[4] A. N. Shukla and R. Tyagi, *Encyclopaedia of Birds (Set)*, Illustrated., vol. 2. Anmol Publications Pvt Ltd, 2001.
[5] N. Mukhtar, Gazala, and M. W. Mirza, "Understanding of Social and Mating Behaviour of Ostrich (Struthio camelus)," *J World Poult Res*, vol. 7, no. 2, pp. 72–78, 2017.
[6] Dr. C. Inbaraj, Dr. V. Arul, and V. Brindha, "Breeding management of ostrich at captive condition," *J. Entomol. Zool. Stud.*, vol. 8, no. 2, pp. 1949–1950, 2020.
[7] R. G. Cooper, "Handling, Incubation, and Hatchability of Ostrich (Struthio camelus var. domesticus) Eggs: A Review," *J. Appl. Poult. Res.*, vol. 10, no. 3, pp. 262–273, Oct. 2001, doi: 10.1093/japr/10.3.262.
[8] E. Murrells, "Husbandry Guidelines for Ostrich Struthio camelus (Aves: Struthionidae)," *West. Syd. Inst. TAFE Richmond*, pp. 1–77, 2017.
[9] M. M. Shanawany and J. Dingle, *Ostrich production systems*. in FAO animal production and health paper, no. 144. Rome: Food and Agriculture Organization of the United Nations, 1999.
[10] A. Rutgers, A. Rutgers, and K. A. Norris, Eds., *Encyclopaedia of aviculture*. London: Blandford P, 1970.
[11] L. E. Likoff, Ed., *The encyclopedia of birds*. New York: Facts On File, 20.
[12] Y. P. Mbaya, A. Tijani, and C. Okoye L., "Behavioural Pattern of Ostrich (Struthio camelus- L) in Captivity and Perception of People on Rearing of the Bird Case Study: Sanda Kyarimi Park, Maiduguri, Borno State, Nigeria," *Acad. Open Zool. Res. J.*, vol. 1, no. 1, pp. 1–9, 2015.
[13] K. Donegan, "'Struthio camelus,'" *Univ. Mich. Mus. Zool.*, pp. 10–15, 2002.
[14] A. Levy, B. Perelman, M. V. Grevenbroek, C. V. Creveld, R. Agbaria, and R. Yagil, "Effect of water restriction on renal function in ostriches *(Struthio camelus)*," *Avian Pathol.*, vol. 19, no. 2, pp. 385–393, Apr. 1990, doi: 10.1080/03079459008418688.

[15] M. Jimenez II and M. G. Jiménez, "The Ostrich (Struthio camelus)," The Ostrich (Struthio camelus). [Online]. Available: http://www.damisela.com/zoo/ave/ratities/avestruz/indexe.htm
[16] World Ostrich Association, "Factors Influencing Meat Quality." [Online]. Available: http://world-ostrich.org/standards/ostrich-meat-quality/
[17] R. G. Cooper, Kh. M. A. Mahrose, J. O. Horbańczuk, R. Villegas-Vizcaíno, S. Kennou Sebei, and A. E. Faki Mohammed, "The wild ostrich (Struthio camelus): a review," *Trop. Anim. Health Prod.*, vol. 41, no. 8, pp. 1669–1678, Dec. 2009, doi: 10.1007/s11250-009-9364-1.
[18] B. C. R. Bertram, *The Ostrich Communal Nesting System:* Princeton University Press, 1992. doi: 10.1515/9781400863143.
[19] E. G. Franz Sauer and E. M. Sauer, "SOCIAL BEHAVIOUR OF THE SOUTH AFRICAN OSTRICH, *STRUTHIO CAMELUS AUSTRALIS*," *Ostrich*, vol. 37, no. sup1, pp. 183–191, Jan. 1966, doi: 10.1080/00306525.1966.9639797.
[20] E. G. F. Sauer, "Aberrant sexual behaviour in the South African ostrich," *Auk*, vol. 89, no. 4, pp. 717–737, 1972.
[21] L. Nell, *The Garden Route and Little Karoo*. Cape Town: Struik Publishers, 2003.
[22] T. S. Brand, P. D. Carstens, and L. C. Hoffman, "The effect of dietary energy concentrations on production variables of ostrich chicks (*Struthio camelus* var. *domesticus*)," *Br. Poult. Sci.*, vol. 55, no. 5, pp. 610–618, Sep. 2014, doi: 10.1080/00071668.2014.956286.
[23] D. L. Brassó, B. Béri, and I. Komlósi, "Studies on Ostrich (Struthio Camelus) - Review," *Acta Agrar. Debreceniensis*, no. 1, pp. 15–22, May 2020, doi: 10.34101/actaagrar/1/3772.
[24] J. Samson, "Behavioral problems of farmed ostriches in Canada," *Can. Vet. J. Rev. Veterinaire Can.*, vol. 37, no. 7, pp. 412–414, Jul. 1996.
[25] M. F. Amado, D. B. Xavier, V. Boere, C. Torres-Pereira, C. McManus, and F. E. M. Bernal, "Behaviour of captive Ostrich chicks from 10 days to 5 months of age," *Rev. Bras. Zootec.*, vol. 40, no. 7, pp. 1613–1618, Jul. 2011, doi: 10.1590/S1516-35982011000700029.
[26] D. G. Menon, D. C. Bennett, and K. M. Cheng, "Understanding the Behavior of Domestic Emus: A Means to Improve Their Management and Welfare—Major Behaviors and Activity Time Budgets of Adult Emus," *J. Anim.*, vol. 2014, pp. 1–8, Nov. 2014, doi: 10.1155/2014/938327.
[27] A. Bradford, "Ostrich Facts: The World's Largest Bird." [Online]. Available: http://www.livescience.com/27433-ostriches.html
[28] Higher Council of Environmental and Natural Resources, "Socio-economic baseline survey in Dinder National Park Report 2001," Khartoum, Sudan, 2001a.
[29] Higher Council of Environmental and Natural Resources, "Ecological Base-line Survey in Dinder National Park," Dinder National Park, Khartoum, Sudan, 2001b.
[30] J. Murchie, "Struthio camelus, The Common Ostrich. http://tolweb.org/treehouses/?treehouse_id=4734#AboutThisPage." [Online]. Available: http://tolweb.org/treehouses/?treehouse_id=4734#AboutThisPage
[31] "¬ Wild welfare (2021). Care for Us- Common Ostrich (Struthio camelus). [online]. Available at: https://wildwelfare.org/wp-content/uploads/Common-Ostrich.pdf." [Online]. Available: https://wildwelfare.org/wp-content/uploads/Common-Ostrich.pdf
[32] R. K. Mohapatra, S. Panda, and U. R. Acharya, "Study on activity pattern and incidence of stereotypic behavior in captive tigers," *J. Vet. Behav.*, vol. 9, no. 4, pp. 172–176, Jul. 2014, doi: 10.1016/j.jveb.2014.04.003.
[33] R. G. Cooper, J. O. Horbańczuk, R. Villegas-Vizcaíno, S. Kennou Sebei, A. E. Faki Mohammed, and K. M. A. Mahrose, "Wild ostrich (Struthio camelus) ecology and physiology," *Trop. Anim. Health Prod.*, vol. 42, no. 3, pp. 363–373, Mar. 2010, doi: 10.1007/s11250-009-9428-2.