

ISSN 2278-2575

Cobra

Vol.-XII Issue -1

January - June 2018



Bi-annual journal of the Chennai Snake Park Trust

Annual subscription : Individual – Rs. 75/- . Institution – Rs.150/-.

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Cover

Dwarf desert agama (*Calotes minor*): a small terrestrial diurnal insectivorous lizard inhabiting the Kutch open sand dune landscape of Gujarat. Also see page 1

Photo: Ravi N. Ardesana

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Sr. No.	Scientific Name	Common Name	Distribution (Gujarat)
1	<i>Calotes ocellatus</i>	Hardwicke's Bloodsucker	North & South
2	<i>Calotes versicolor</i>	Scout's Forest Lizard	South Gujarat (endemic to India)
3	<i>Calotes variegatus</i>	Indian Garden Lizard	Widespread
4	<i>Psammophilus blanfordianus</i>	Blanford's Rock Agama	Barbaric forests of the state (endemic to India)
5	<i>Stigmaphys antennatus</i>	Spray-headed fan-throated lizard	Widespread
6	<i>Tropidurus agilis</i>	Brilliant ground agama	Basal granites in Kachchh district

*This is a species-complex; taxonomic studies are pending (Günther 2015).

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Cover

Desert desert sparrow (Coturnix coturnix) a small bird with a distinctive black and white pattern on its head including the Korb's eye and blue landscape of Gujarat - 10-15 page 1

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**NATURAL HISTORY NOTES ON THE HARDWICKE'S
BLOODSUCKER *CALOTES MINOR* (HARDWICKE & GRAY,
1827) WITH PRELIMINARY REPORT ON THE AGAMIDAE
OF GUJARAT, INDIA**

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Agamids are a family of diurnal, mostly insectivorous lizards inhabiting the old World. Agamids are represented by 489 species over all. . There are 70 species of Agamids occurring in India (Utez et al. 2018). Most species are rare and poorly known and many new species are being described even in the recent times. Six species (Table 1) are reported from Gujarat State (Das 2002; Vyas 2007; Vyas 2011; Srinivasulu et al. 2013a&b; Deepak et al. 2015; Deepak et al. 2016; Joshi et al. 2017).

Table 1. List of Agamid lizards recorded in Gujarat State, India

Sr. No.	Scientific Name	Common English Name	Distribution (Gujarat)
1	<i>Calotes minor</i>	Hardwicke's Bloodsucker	Kutch & Saurashtra
2	<i>Calotes rouxii</i>	Roux's Forest Lizard	South Gujarat (endemic to India)
3*	<i>Calotes versicolor</i>	Indian Garden Lizard	Widespread
4*	<i>Psammophilus blanfordanus</i>	Blanford's Rock Agama	Eastern forests of the state (endemic to India)
5	<i>Sitana spinaecephalus</i>	Spiny-headed fan-throated lizard	Widespread
6	<i>Trapelus agilis</i>	Brilliant ground agama	Banni grasslands in Kachchh district

*This is a species-complex; taxonomic studies are pending (Ganesh 2015).



Hardwicke's Bloodsucker (*Calotes minor*) is one of the smallest Agamid of India (Murthy 2010). *Calotes minor* has been assessed as Data Deficient because it has rarely been seen despite its vast range (Khan & Papenfuss 2016). This species inhabits arid environments such as dry forest and has been collected from hard barren desert and desolate areas. It is a diurnal, crepuscular species and shelters in burrows close to the roots of thorny bushes, and feeds on insects, leaves and flowers. It gives out a brief squeak when caught (Khan 2006). The female is larger than the male and more brilliantly coloured during breeding season (Daniel 2002). Females during the breeding season show a deep black throat; juveniles olive or pinkish brown with dark brown band between eyes. Clutch size is 8-10. When alarmed, they vocalize with a squeak (Das 2002).

Distribution

Calotes minor is widely distributed across the Indo-Gangetic plains, ranging from Bangladesh through the Central and United Provinces of India (Smith 1935) and west to the upper and lower Indus Valleys in Pakistan. Its definite records are from Sindh and Punjab, District Jhang (Mertens 1974, Khan and Mirza 1977). This lizard was recorded from Gujarat, including Bhuj (Khan & Kumar 2010), Gulf of Kachchh (GEER 2014) Samples were collected from Narayan Sarovar in Kutch and Chotila, Wardhwan, Velavar in Saurashtra (Deepak et al. 2015). Instead of Velavar, it might be Velavadar (see fig.7 of Deepak et al. 2015; Vyas 2003), one specimen was collected from Veraval, Junagadh district (now in Gir-Somnath district) in September 1975 by R. C. Sharma (Sharma 1982).

The Saurashtra peninsula is one of the three conspicuous physiographic divisions of the Gujarat state and lies between 20° 30' N to 22° 30' N. latitude and 69° 00' E to 72° 30' E. longitude. The Saurashtra region is structurally a horst bounded by the Gulf of Kachchh fault in the north and by the extension of Narmada-Son fault in the south. Three sides of the region are marked by Gulfs of Khambhat and Kachchh in the east and north respectively, whereas on the west is the Arabian Sea (Shodhganga 2018).

Observations

On April 2004, I had visited Rampara forest (22°31'82" to 22°34'88"N 70°55'54" to 70°58'59"E) which is located in Rajkot district (now in Morbi district) of Saurashtra region of Gujarat. In general, the eco-climate of the forest locality is of semi-arid type (Panchal & Pandey 2004). I observed a lizard (*Calotes*) near

a gate on ground in the short dry grasses along the roadside. It looked different from syntopic agamids *Calotes versicolor* & *Sitana spinaecephalus*. It was much smaller than other Agamids. I photographed it (Image 1) and identified using a field guide (Daniel 2002) to be Hardwicke's Bloodsucker (*Calotes minor*). Till date, this species has not been noted in Rampara Wildlife Sanctuary (Singh & Tatu 1999) and that was the first record of the *Calotes minor* from Rampara Wildlife Sanctuary. On 19 May 2013, Bhavesh Trivedi, Divyarajsinh Parmar and I visited Velavadar National Park (22°00'-22°05'N and 72°00'-72°08'E), Bhavnagar district in Saurashtra peninsula. Biogeographically, the area falls under 4-B Gujarat-Rajwada biotic province in the semi-arid zone (Vyas 2003). At around 09:30 hrs, we had seen three individuals in grassland. All the three were seen at different locations in basking position on the stones along the roadside (Image 2). This species is generally found sitting on stones, but can climb up to a metre on vegetation (Das 2002). The present observations are in support of this view.

Conservation

This species is vulnerable due to increasing anthropogenic activities around its natural habitat (Khan & Kumar 2010; Ardesana et al. 2017) likely has been impacted by conversion of habitat into urbanisation, industries, invasion of *Prosopis* sp., state/national highway network, agricultural purposes and pressures associated with a growing human population and settlement (Editor-Director 2000; Vyas 2002, Vyas 2003; Khan & Papenfuss 2016; Ardesana et al. 2018). Due to this habitat destruction, many of *Herpetofaunal* species are declining very fast and many of them near extinction globally (Cassani et al. 2015; Ardesana et al. 2018). Further research into its habitat and threats and population monitoring are needed (Khan & Papenfuss 2016).



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STATUS OF SEA TURTLES IN THE BUFFER ZONE OF MARAWAH MARINE BIOSPHERE RESERVE, UNITED ARAB EMIRATES

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Introduction

The Marawah Marine Biosphere Reserve is the largest Marine Protected Area in Arabian Gulf, located in the west of Abu Dhabi Island. The total area of the reserve is 4255 sq.km. It was established as a protected area to preserve the natural diversity and quality of its coastal and marine environment. Marawah is home to important marine and coastal ecosystems including sea grass beds, coral reef, salt marsh and mangrove, which support the rich marine biodiversity of the Persian Gulf. The ecological services of this ecosystem include feeding and breeding grounds for marine organisms, benefit to peoples in supporting the livelihood, tourism etc. It has been estimated that around 21 species of Cetaceans and 14 species of reptiles are found to occur in the Arabian/Persian Gulf (EAD, 2007, Baldwin, 2005), making this region a ecological sensitive area. Marine reptiles play a key role in the marine ecosystem and considered as Ecological Indicator of the particular area. The Persian Gulf Sea Snake, *Hydrophis lapemoides* (Gray, 1849), is one of the most abundant sea snakes (Gasperetti, 1988), mostly associated with reef and sea grass ecosystems. The Persian Gulf accommodates the main nesting habitats of hawksbill turtles, as well as for Green turtles to some extent. Marine turtle is one of the valuable natural heritages of United Arab Emirates. According to Miller et al. (2015) the regions around Marawah Island area forms an important foraging area for the green (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). In the recent year, buffer zone of Marawah Biosphere Reserve is heavily affected by the Petroleum based companies and their development activities and vessel movement. Hence, the survey of sea turtle was taken up to know the status, distribution and



abundance of the species, which will enable us to take a holistic view of present status of sea turtle habitats and their population in order to derive management recommendations for the long term conservation of the species.

Method

Boat based transects methods was used for estimating the abundance of sea turtles during the study period. The study area of was divided into 5.sq.km grid within an area of 100.sq.km in the Buffer zone. A pre-determined transect line was demarcated in the google satellite imagery using Auto-CAD software for survey purpose. In each transect line, the starting point and ending point was geo-tagged. Observers conducted continuous scan for marine species by naked eye and intermittently with binocular during day light hours (0600 to 1830 h). The vessel Sea Falcon 2 (16 meter with 1.8 drift) was used for the survey. The speed of the survey boat was less than 5 knots. During each transect, sea turtle sightings were scored in data sheet. It also contains a brief narrative of behavioral notes, sighting time, species observed, group size, sighting distance and sighting angle. Sea turtle, which could not be identified (due to very short glimpse or very distant spotting or both) during the survey was scored as unidentified turtle. Sea Navmarine binoculars (7x50) was used to observe the species and record the angle. Ocular estimation was done for each sighting in order to measure the sighting distance. Garmin 72 H GPS was used to record the way-points or geographical co-ordinates for each sighting. Canon EOS 650D Digital SLR was used for photography whenever possible.

Results

During the surveys, 106 sightings of sea turtles consisting of four species and one unidentified species were recorded. They are Green sea turtle, Hawksbill sea turtle, Leather back sea turtle and Logger head sea turtle. In total, 210 nautical miles transects were surveyed using the vessel in the Buffer zone of the study area. On an average, overall encounter rate was 0.504 / NM.

Encounter rate

The highest encounter rate was recorded with Green turtle (0.271/NM), followed by hawksbill turtle (0.028/NM). The highest encounter rate of both the turtle species related to the availability of rich shallow sea grass meadows in the study area. Green turtle also appears to be well adapted in the area surrounding the immediate vicinity of the vessel. The encounter rate of logger head (0.004/ NM) and leather back (0.004/NM) were low. The low encounter rate of leather

back and logger head related to heavy disturbances in the study area leads to less availability of bottom dwelling invertebrates. Unidentified turtle was significantly high encounter rate (0.190/NM) (Table: 1).

Table: 1 Percentage of sea turtle sightings in buffer zone of the study area

S.No	Sea turtle species	No.of Sightings	Encounter rate/ Nautical mile
1	Green sea turtle	57	0.271
2	Hawksbill sea turtle	6	0.028
3	Leather back sea turtle	1	0.004
4	Logger head sea turtle	1	0.004
5	Unidentified sea turtle	40	0.190
	Total	106	0.504

A total of 106 sightings of Marine Reptiles were observed in the Buffer zone of the study area. The highest number of sighting was that of Green turtle (57), followed by Hawksbill turtle (6); single sighting each of Leather back and logger head sea turtle were also obtained. The unidentified turtle species were represented by 40 sightings (see Table 1).

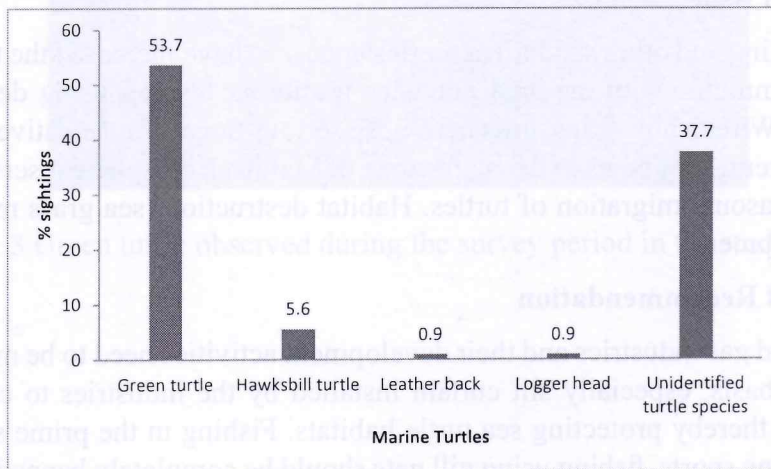


Fig: 1 Relative abundance (in %) of sea turtle sightings observed in buffer zone of study area

Behaviour of Sea turtle

The most frequent behavior observed was 'surfacing' 75%, followed by 'avoiding ship' 18%. A few incidents of 'diving', 'fluke tail' and 'swimming' were observed (Fig: 2). Since, sea turtles are lung breathers and frequently surfacing to water level would be for respiration. Similarly they used to avoid ships to protect them from the propeller, which was also revealed by our observations.

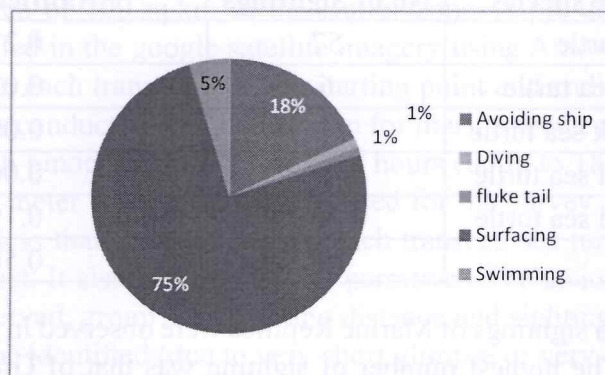


Fig: 2 Percentage of Behaviour of marine Reptiles observed during the survey

Conservation issue

Dredging and other sand fill activities appear to have increased the turbidity. The local communities in the area practices traditional fishing using destructive fishing gear (Wire fishing traps, gills nets, pose serious threats to the native reptiles. Frequent movement of boats in the buffer zone of Marawah biosphere reserve would impact the seasonal migration of turtles. Habitat destruction (sea grass meadows) due to development

Management Recommendation

Oil and gas industries and their development activities need to be monitored on a regular basis, especially silt curtain installed by the industries to check the water quality thereby protecting sea turtle habitats. Fishing in the prime sea turtle habitats, marine sports, fishing using gill nets should be completely banned. Marine traffic should be regulated during migration and nesting season of sea turtle. Outreach programme for students and stake holder should be taken up.

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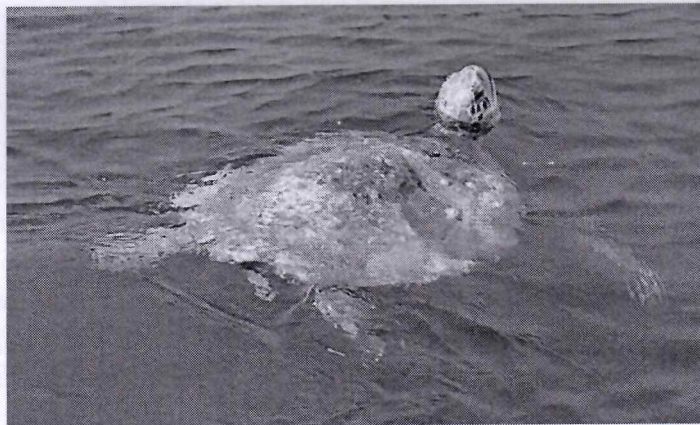


Fig: 3 Green turtle observed during the survey period in the study area

DIURNAL OBSERVATIONS ON THE BEHAVIOUR OF CAPTIVE GHARIALS (*GAVIALIS GANGETICUS*) IN CHENNAI SNAKE PARK

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Introduction

Gharial (*Gavialis gangeticus*) is the oldest representative of the Order Crocodylia and is the only species of the family Gavialidae still surviving (Sahi, 1974). Gharials are listed as an “endangered species” in the IUCN Red Data Book (1975) and are also protected under the Schedule-I of Indian Wildlife Protection Act, 1972 and also the Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Singh, 1986). Its global distribution range is restricted to the Northern Plains ecoregion of south Asia or Indian subcontinent. This region covers the Indus river system, the Ganga, Yamuna, Brahmaputhra and Mahanadi river systems. Extant populations now live in India, Nepal, Bangladesh and Pakistan (very rare) (Daniel, 2002).

Although considerable research work on Gharial (*Gavialis gangeticus*) has been published (see Acharya et al., 2017 and references therein), the topics have been mainly limited to population demography, hatchlings success, habitat use and distribution in natural habitat. Comparatively, very less research has been done on the gharials in captivity (Acharjyo et al., 1996; Bustard & Maharana, 1992). The behaviour of captive gharials differs significantly from those in the wild, notably in the areas of feeding and reproduction. Since ex-situ conservation is important to such critically endangered species, studying this behaviour is vital to maintaining captive populations (Sharma, 2015). This study aims at the improvement of living conditions of captive gharials by observing the behavior of 6 individuals in a common enclosure at Chennai Snake Park, India.

Methods and Materials

Study animals

Behavioural observations were made on six Gharials (*Gavialis gangeticus*) at the Chennai Snake Park, from the period of October 15, 2017 to January 13, 2018. There were 5 females and 1 male at the facility. Each individual were identified based on size, bodily features such as dentition, claws and other peculiarities (e.g. degree of damage of snout that occurred previously due to in-fighting). These differences were used to identify the different individuals during the various sampling sessions. Each Gharial was given a number from 1-6. The male, easily identified by its “ghara” or bulbous structure on its snout and larger size, was named number “1”. One of the smaller females, which had more than half of its lower jaw missing, was named number “2”. Another female, which had less than half of its lower jaw missing, was named number “3”. A female which had a small portion at the tip of the lower jaw missing, was named number “4”. The largest female, which was identified with a missing front tooth, was named number “5”. Another female, which had a missing front tooth in another position, was named number “6”. All 6 individuals were from the same clutch and have been raised together in captivity since hatching.

Housing

The gharial enclosure has a roughly oval-shaped pool, cemented on its edges. The pool, with a spread area of 27 m², covers major parts of the left and middle portions of the enclosure. The depth at its greatest is 2 m. Sand banks, comprising a total area of 140 m², surround the pool on all sides. The sand banks are used by the gharials to bask upon. An observer, standing on the path outside the enclosure can see that a short stone wall has been built starting from the left side of the pool, going along the end of the pool furthest from the observer and to the right side. This wall prevents sand from a major part of the sand banks from falling into the pool. The gharial enclosure also has a few trees, climbers and shrubs. 3 trees, a few shrubs and some creepers can be seen on the left side of the enclosure. On the side of the pool furthest away from the observer, 3 more trees can be seen, 1 of which is overgrown with creepers. More creepers can be seen growing along the sand bank on the this side. None of the gharials were ever observed here. 3 palm trees can be seen on the right side of the pool, which the gharials use to bask under. A patch of grass can also be seen on the extreme right of the enclosure, along with a few plants, 3 more trees and a tree stump.

Recording Behaviour

The behaviour of the Gharials was recorded using a time-constrained behavioural sampling method (see Altmann 1974). All 6 gharials were observed at the same time for a specified period of time. It was possible to record, in most cases, all the behaviours of the group since gharials and reptiles in general, do not show the much higher levels of activity shown by mammals and birds.

During each sampling session, 1-4 observers were physically present outside the enclosure and recorded the observations. Observations were made by naked eye, except when binoculars (Olympus 8x40) were used to observe minor differences in dentition to identify certain female gharials. Photographs were taken using a Canon SX 240 digital camera.

All observations were made during the day because scoring nocturnal observations were impractical in the facility. Observations were for 8 hours i.e., from 0930 hrs to 1730 hrs or 4 hours i.e., from 0930 hrs to 1330hrs or from 1330 hrs to 1730 hrs. When 8 hour sampling periods were undertaken, the sampling period was divided into 2 shifts: 0930 hrs to 1330hrs and from 1330 hrs to 1730 hrs and each shift was covered by different observer(s).

To facilitate comparison of behaviour at different parts of the sampling periods, the sampling period was divided into 4 parts. 0930 hrs to 1130 hrs was classified as “morning”, 1130 hrs to 1330 hrs was classified as “forenoon”, 1330 hrs to 1530 hrs was classified as “afternoon” and 1530 hrs to 1730 hrs was classified as “evening”.

Results

Based on the data collected about the basking habit of the 6 studied captive gharials, the following was observed. With regards to total basking (where the entire body of the gharial is exposed to the sun), the male gharial 1 spent significantly longer time basking than any of the females. Among the females, gharial 5 showed the longest total basking hours and gharial 4, the shortest. It was also noticed that the gharials with damaged jaws (2,3 and 4) all had roughly similar total basking hours.

When partial basking (only a part of the body is exposed to sunlight and the remaining is in the water or shade) was considered, gharial 6 was seen to have clocked the highest number of hours. Most of the females (Except gharial

4) showed relatively high duration of partial basking. Also, the female gharials seemed to indulge longer in partial basking (except 4), than total basking, a stark contrast to the male gharial 1, whose total basking hours largely exceeded partial basking hours. Gharial 4 was odd in the fact that it spent almost the same amount of time partial and total basking.

Resting time was maximum in gharial 4, and least in gharial 1 (= male). Otherwise, gharials 2,3 and 6 seemed to have spent almost similar amounts of time resting. All the gharials spent most of their time resting daily.

Table 1: Time duration details of scoring behavioural data of captive gharials.

Gharial	Hours spent total basking	Hours spent partial basking	Hours spent resting	Vocalization frequency
Gharial 1	18.73	9.78	79.93	510
Gharial 2	7.7	12.88	87.47	14
Gharial 3	7.68	12.08	88.74	31
Gharial 4	7.05	6.7	94.35	10
Gharial 5	11.68	13.1	83.8	27
Gharial 6	4.63	15.52	88.45	7

Vocalization was most prominently seen in gharial 1. Over the observation period, gharial 1 was found to have vocalized 510 times. These were partly in response to visitors at the park. The female gharials (Fig. 5) showed much less frequencies of vocalization. Gharial 3 showed the most vocalization among females, and gharial 6, the least. It is important to note, in this case, that having damaged jaws did not affect the ability of the individual gharial to vocalize.

Table 2: Activity patterns (%) of the various gharials

Activity	Gharial1	Gharial2	Gharial3	Gharial4	Gharial5	Gharial6
Partial Basking	8.87%	11.68%	10.96%	6.08%	11.88%	14.08%
Total Basking	16.99%	6.98%	6.97%	6.39%	10.59%	4.2%
Locomotion	1.73%	1.99%	1.58%	1.96%	1.52%	1.5%
Resting	72.5%	79.34%	80.49%	85.58%	76%	80.23%

Diurnal patterns of all 6 gharials came out to be nearly similar. Salient features of the diurnal pattern include:

All the gharials spent the largest amount of their time (72-85%) resting. Gharial 1 spent the least amount of time resting while Gharial 4 rested the most. Gharial 1 showed the highest total basking, which overtook its time spent partial basking. Gharials 2,3,5 and 6 spent more of their time partial basking than total basking. Gharial 4 on the other hand was shown to have spent almost equal amounts of time partial and total basking.

Percentage of time spent moving was always between 1-2% only. It was the activity that was least taken up for all gharials. Gharial 2 spent comparatively more time on locomotion (almost 2%) than the other gharials.

Table 3: Locomotion patterns of captive gharials across the various parts of the day

Individual	Part of day	Morning	Forenoon	Afternoon	Evening
Gharial 1	Water to shade	2	6	5	7
	Water to sun	1	2	-	-
	Shade to water	2	10	7	12
	Sun to water	2	5	-	-
	Shade to sun	2	3	1	-
	Sun to shade	2	2	1	-
	Within water	19	40	92	55
	Within sun	3	9	10	-
	Within shade	6	5	10	2
	Gharial 2	Water to shade	3	3	7
Water to sun		1	1	-	-
Shade to water		4	3	2	2
Sun to water		2	1	-	-
Shade to sun		3	2	5	-
Sun to shade		3	2	1	-
Within water		71	95	48	41
Within sun		5	7	7	-
Within shade		5	4	20	8
Gharial 3	Water to shade	4	3	3	4
	Water to sun	3	1	-	-
	Shade to water	4	6	2	1
	Sun to water	1	3	3	-
	Shade to sun	1	1	1	-

	Sun to shade	1	1	1	-
	Within water	15	73	63	50
	Within sun	4	-	8	-
	Within shade	5	5	14	2
Gharial 4	Water to shade	2	4	5	5
	Water to sun	2	2	-	-
	Shade to water	5	7	6	2
	Sun to water	3	1	-	-
	Shade to sun	3	-	1	-
	Sun to shade	3	1	-	-
	Within water	40	53	70	53
	Within sun	1	2	4	-
	Within shade	9	-	4	8
Gharial 5	Water to shade	1	1	6	1
	Water to sun	-	2	2	-
	Shade to water	2	1	1	1
	Sun to water	3	2	-	-
	Shade to sun	5	2	2	-
	Sun to shade	1	3	2	-
	Within water	54	66	43	13
	Within sun	9	-	7	-
	Within shade	2	8	7	3
Gharial 6	Water to shade	3	7	6	3
	Water to sun	2	3	-	-
	Shade to water	1	2	2	2
	Sun to water	-	4	-	-
	Shade to sun	3	3	3	-
	Sun to shade	2	2	1	-
	Within water	28	65	47	3
	Within sun	4	5	9	-
	Within shade	4	3	17	11

of 6 individuals housed at Chennai Snake Park Trust, which used gharial habitat groups and 3 adult females. The results provided data on nesting, locomotion, feeding, and agonistic behaviour between the various individuals.

Locomotion Patterns

Most of the locomotion to and from sunny areas (for all 6 gharials, in fact) is usually observed in the morning (9.30am-11.30am) and forenoon (11.30am-1.30am) slots, as there is less sunlight in the afternoon (1.30pm-3.30pm), and none by evening (3.30pm-5.30pm). Gharial 1 showed maximum movement within water, particularly during the afternoon. Its water movement was limited in the mornings. Gharial 1 moved from shade to water (and vice versa) the most in the evenings.

Gharial 2 shows the maximum frequency (and consequently duration) of movement of all 6 studied gharials. Unlike Gharial 1, Gharial 2 seemed to prefer water movement in the earlier part of the day, especially during the forenoon, and its water movement would gradually reduce afterwards as the day went by. It also showed significant amount of movement within shady areas during the afternoon.

Gharial 3 showed high levels of water movement before and after noon which did not reduce considerably even as the day progressed towards evening. Like Gharial 1, Gharial 3 does not show much movement within water during the mornings. Again, it showed elevated levels of movement within shade during the afternoons. Strangely there are no instances of gharial 3 moving within sunlit areas during the forenoon period.

Gharial 4 showed peak water movement during the afternoon and water movement frequency was the constant but lesser during forenoon and evenings. Least water movement is seen during morning time. Differing from gharials 2 and 3, gharial 4 shows marked movement within shade mostly during the morning and evenings (as opposed to the afternoons). It is also noticed that there is no recorded movement within shade or from shade to sun during forenoons.

Much like gharial 3, gharial 5 also shows higher water movement in the earlier part of the day, which reduces in the afternoon, and quite significantly so in the evening. Also, movement within sunlit areas has not occurred during forenoons. Here, the next most frequent movement (to movement within water) is movement within sunny areas, especially during the mornings. Movement within shade occurred more often during forenoons and afternoons, and less during mornings and evenings. Another feature is the lack of migration to sunny areas from water during the morning hours.

Gharial 6 showed comparatively very low evening water movements. Movement in water is highest during the forenoons (similar to 2,3 and 5). Movement within shady area is prominent in the afternoon (Similar to 2 and 3), but it also showed a higher incidence of movement within shade during evenings compared to gharials 2 and 3. Movement within sunny areas is pronounced in the afternoons. No movement from sun to water was seen in the mornings.

Potential Breeding Behaviour

All six individuals showed some potential breeding behaviours towards mid-December which continued into early January. There was a marked increase in agonistic behaviour during this period, both among the females, and between the male and females as well. The gharials would often nudge or push each other with their snouts and limbs, and became more competitive for food and basking spots. They also climbed and lay on top of each other on multiple occasions, both on land and in water. Jaw slapping was exhibited by all the gharials, and here, it was interesting to note that the damage to the jaws in gharials 2, 3 and 4, did not inhibit this behaviour; but was considerably weak in gharials 2 and 3 due to the mentioned damage. The gharials would also blow bubbles from just below the surface of the water, for a short duration of time. This was prominently seen in the male, but quite common among the females as well. Unexplained huddling of the gharials (3-4 of them at a time) within the water was observed twice, and on one such instance, the male was involved. There were also stray occurrences where one of the females would suddenly run or swim quickly (splashing in the water) for no clear reason.

Discussion

Gharial is one of the most critically endangered of the crocodylians (Thorbjarnarson, 1992). Most studies on gharials have been performed on wild populations, with comparatively less research done on gharials in captivity. Since *ex situ* conservation is important to such critically endangered species, studying their captive behaviour and recognizing how it deviates from wild behaviour is vital to maintaining captive populations. This study aimed to obtain a better understanding of the ecology of captive gharials (*Gavialis gangeticus*), in order to improve their living conditions. This was done by observing the diurnal behaviour of 6 individuals housed at Chennai Snake Park Trust, which included 1 adult male and 5 adult females. The results provided data on basking, locomotion, feeding, and agonistic behaviour between the various individuals.

Basking

Crocodylians are ectotherms, which means they depend on external heat sources to regulate their body temperature (Lang 1987). Solar radiation is an important source of heat, especially for larger animals which are relatively independent of ambient air temperatures (Spotila et al. 1972; Smith 1979). Crocodylians gape by opening their mouths for long periods, and this behaviour may function to cool the head while basking (Lang 1987). However, crocodylians with weight ranging from 30-1000 kg are simple ectotherms in which endogenous heat production, changes in regional blood flow and mouth gaping are insignificant influences on core temperature (Grigg and Seebacher, 2000), and gharials fall under this weight range (GCA 2009). Bouts of activity are powered by anaerobic metabolism, after which a long recovery period is needed (Coulson 1984). The results of this study are consistent with the above statements, as time spent on basking constitutes a large part of the total activity of the gharials, second only to resting.

Gharials often bask in groups, though each individual may have a preferred spot that it defends (GCA 2009). Even under captive conditions, in an enclosure much smaller than their wild habitat, the male (gharial 1) and one of the females (gharial 4) showed marked preference to specific basking spots that they would vigorously defend from the other individuals. Thermoregulation entails hours of heat-seeking or avoidance during most days, contributing to an overall impression of inactivity (Lang 1987).

Resting

Inactivity itself is an important behavioural response. Just because an animal is not moving does not mean it is not vigilant (Regal 1978). It is consequently difficult to know the extent to which animals are truly “active” or “sedentary” (Bennett 1982). The gharial is one of the longest and largest of all living crocodylians (Maskey, and Percival, 1994), and larger crocodiles have lower metabolic rates (Lang 1987). This study shows results in accordance with the above statement, as it is evident from the activity pie-charts that all six individuals spend majority of their time resting during the day.

Communication and Vocalization

Communication takes place whenever a signal is emitted by one individual and leads to changing behaviour of another individual (Wiley 1983). While the efficiency of visual signals is restricted to relatively short distances, acoustic signals

are able to perform over long distances since sound propagation works fast and efficient in air or water (Pough 2001). Crocodylians by contrast use vocalizations in a broader variety of contexts for long-range and short-range communication (Pough 2001, Vergne et al. 2009). Another type of acoustic message, barely perceptible to humans, is the subaudible vibrations, referred to sometimes as 'infrasound' (Lang 1989).

The gharial relies heavily on hisses and snorts when communicating both in and out of the water. Male gharials develop a conspicuous bulb-like structure (the ghara) on the end of their slender snouts, and this appears to change hissing exhalations into buzzing sounds as air resonates in the enlarged nasal cavity (Lang 1989). As seen in the table attached to Fig.5, gharial 1 (the only male in the enclosure) vocalized much more than any of the other individuals. This may be because the ghara amplifies the sound produced by the individual, rather than the female gharials not vocalising. However, male crocodylians produce significantly more vocalizations during the courtship and mating period, and in dominance displays (Lang 1989).

Locomotion

All extant crocodiles brace their bodies against mechanical loading and during movement, in a mechanism referred to as the 'eusuchian-type' bracing system. Differences in the configuration of the paravertebral shield and the length of the lateral epaxial muscles in the cranial half of the tail between *Gavialis gangeticus* and other extant crocodiles correlate with the former's apparent inability to high-walk at large sizes (>approx. 50 kg). These characteristics also possibly affect their capacity to gallop (Salisbury and Frey, 2004). Gharials' bodies are well adapted for swimming, with powerful tails, streamlined bodies, and highly webbed back feet. They swim with their limbs tucked in against their body, using their strong tail to propel them forward (GCA 2009). It can clearly be seen in the results that the percentage of movement within water greatly exceeds all other types of movement, in all six gharials. Movement from water to land and land to water were consistently low for all gharials, which indicates that such movements were performed only to shuttle from the basking or resting site to the water, to cool off. This is supported by Lang (1987) - movement from water to land and vice-versa is again part of a thermoregulatory mechanism, as water serves alternately as a heat source as well as a heat sink.



Caveats and Conclusion

As the observation period was between 9:30 AM to 5:30 PM, one of the limitations was that the nocturnal activities could not be recorded, which could give a better all-round picture of the ethogram. The sample population had five females and only one male, which made it impossible to observe male-male conflict and territorial behaviour.

The study provided a wholesome diurnal activity pattern of the captive gharial and gave a better understanding of its ethology. Previous studies mainly dealt with gharial ethology in the wild. Results from this study can be used to understand the behaviour of individuals living in captivity, and to design and manage future captive rearing and breeding projects.

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A PRELIMINARY STUDY ON THE BEHAVIOUR OF BLANFORD'S ROCK AGAMA (*PSAMMOPHILUS* CF. *BLANFORDANUS*) IN CAPTIVITY

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Introduction

Understanding the behavior of a species can be fundamental to effectively conserve that species. Captive facilities like zoos aim to create awareness, carry out research and conserve species particularly the threatened ones (Russo, 2013, Ward 2016). But yet, it is surprising that the contribution made to Conservation biology in the last two decades by Animal behavior in captivity as well as in the wild is negligible, because of lack of research works in that regard (Sutherland, 1998). Until recently, it has been felt that the gap between these two aspects is still not bridged and accounts little in solving the biodiversity crisis, as evidenced by joint meeting with members of behavior and conservation societies (Caro, 2007). Nevertheless, behavioral studies of animals in captivity ensures an understanding of the human impact on the natural habits of animals by studying their response to human presence, retain the population of species, promote “cultural skills” in the animals, and induce behavioral manipulations, if necessary (Sutherland, 1998) and subsequent restoring or rehabilitation in the wild (Caro, 2007).

While such aspects have received some attention in larger animals like mammals and even birds, not much is known about reptilian taxa. In reptiles, postures and positions are described for only certain aspects of behavior like fighting and courtship (Carpenter, 1961, 1962, 1969; Kastle, 1963, 1967; Carpenter and Blanc, 1969; Ferguson, 1970) and understood fully for only a few species (Carpenter, 1962; Gorman, 1968; Jenssen, 1970b, 1971; Ferguson, 1971a; Purdue and Carpenter, 1972a, b). It is only recent that the entire set of behavioral postures and positions are being researched upon (Kastle, 1967; Brattstrom, 1971). There are many studies on behavior and activity pattern of lizards in the wild. For example,

studies on mating behavior was done by Noble and Teale (1930) and Noble and Bradley (1933), but literature on Indian lizards is even more scanty.

In India, with over 200 species of lizards, some like the chameleon, the monitor lizard and other such require conservation measures (Daniel, 2002). One such species is the exclusively rock-dwelling Blanford's Rock Agama (*Psammophilus blanfordanus*). Studies on this species include field studies in its natural habitats (Venugopal, 2010; Chandra et al., 2005, Chandramouli and Baskaran, 2010) and other aspects like liver histopathology (Parida et al., 2013), embryonic development (Jee et al., 2016), male reproductive organs like epididymis and testis (Singh et al., 2016). Works were also done on a closely related species, *Psammophilus dorsalis*, including aspects such as thermoregulation (Veeranagoudar et al., 2010), escape response (Sreekar and Quader, 2013), reproductive mechanisms (Srinivas et al., 1995), and so on. The necessity for undertaking this study is to assess the behavior of the lizards under captive conditions in a terrarium set-up, with the provisions of a replicated natural habitat. We aim to study its intra-specific interactions in captivity and the spatial resource use pattern across the entire day experiencing dynamic temperature and humidity regimes. As such, we expect to shed light on the behavioral profile of these lizards in captivity.

Methodology

We observed the behavioral profiles of Indian rock agama *Psammophilus blanfordanus* maintained in captivity in the Chennai Snake Park (13.0039° N, 80.2387° E) over a period of 20 days, extending from 7th to 29th May 2017. There were six adults, four males and two females. We conducted this ethological survey in the summer month with an average temperature of 34.9°C (30.9°C-39.5°C) and average humidity of 44.5% (26%-63%). Activities were scored at different times of the day, by Time-Constrained Sampling method (Martin & Bateson, 1993; Lehner, 1996). Data collection of all activities was taken on a 2-hour duration basis. We (as a group of four) divided the time period of observation as morning (8.30am-10.30am), forenoon (11.00am-1.00pm), afternoon (1.30pm-3.30pm), and evening (3.30pm-5.30pm) and came to the spot for observation during these hours. A threshold distance of 90 cm was maintained outside the terrarium. In each of the four time periods as mentioned above, a total duration of 25 hours of observation, amounting to 100 hours duration in all was taken. For better understanding, the duration of activities which exceeded more than a minute were expressed in minutes and the duration of activities which exceeded more than an hour were expressed in hours.

Terrarium

The terrarium was a large glass-fronted enclosure with dimensions 6ft X 9ft X 6ft and was provided with two lateral openings of dimensions 1 ft X 0.3 ft covered by mesh top. Sand with small rock mix of about 2 inches thickness was provided as a substratum. Around 15 medium-sized (1 foot) rocks were kept inside the terrarium. Some of the rocks were aggregated towards the middle of the enclosure forming crevices. A log of wood was also provided. In addition; a mud-pot heating element and a water dish were also provided.

Recording of Activities

Duration of an activity followed by the frequency or the number of occurrences, represented within brackets, was recorded. Along with the activities, the temperature and humidity for every 2-hour duration of study were recorded. Each time period of observation was conducted by two of us. While one of us observed the lizards and narrated, the other wrote the duration and frequency of activities. The total sum of all the activities subtracted from the total duration of observation (ie. 2 hours) gave the total resting time for a given time period of study. The temperature and humidity values were recorded by a Digital Hygrothermometer. Photographic documentation of certain activities were taken using Honor 6X handset from outside the enclosure. We used the stopwatch facility in mobile phones to note the time period of activities. Changes in position of body part of the lizard without involving total displacement of the lizard from one place to another was noted as movement. Up and down movement of the head was scored as head-bobbing and lifting up of the tail was scored as tail raising. A voluntary reflex to get rid of particulates was defined as scratching. Change of place or displacement of the lizard from one place to another was scored as locomotion. Active pursuing or following of lizards among one another was scored as chasing. Any vertical displacement of the animal from one place to another was scored as climbing. Inactive state of the animal when present in shade is defined as resting. Resting in sun-lit area was scored as basking and resting inside the water was scored as resting in water. If a part of the body was exposed to sunlight with the rest of it lying in shade, it was noted down as partial basking.

Study Species

The Blanford's Rock Agama *Psammophilus blanfordanus* (Stoliczka, 1871) also called Indian Rock Lizard and Peninsular Dwarf Rock Agama, is found in rocky habitats of Indian peninsula (Kumar et al., 2002) and elevated hilly regions up to 1829 meters elevation (Daniel, 2002), mainly along the Western Ghats and Eastern Ghats (Smith 1935; Sharma 1976; Ishwar et al., 2001; Sanyal and Dasgupta 1990; Vyas, 2000; Srinivasulu et al. 2006; Venugopal 2010). The species is also common in the vicinity of Bengaluru (Daniel, 2002). It is an agile, thermophilic (sun-loving) lizard, and a close relative of its sister species, Peninsular Rock Agama (*Psammophilus dorsalis*) (see Smith, 1935) and is distinguished by a deeper anti-humeral fold, larger scales on the body from 80-100 round the middle, dorsals being distinctly keeled and imbricate (Smith, 1935), and presence of a fold in the skin of throat (Daniel, 2002). It is a common, social, diurnal, rock-dwelling (rupicolous), agamid feeding primarily upon insects (Daniel, 2002; Radder et al., 2005), rarely on other lizards (Aruna et al., 1993; Sreekar et al., 2010), etc. and categorized as a Least Concerned species by IUCN. It has also been observed that the lizard has arboreal habits and is found on large tree trunks (Ranabijuli, 2011). Adult males are larger than females with distinct scarlet red and black color of the head (Smith, 1935). Females are comparatively smaller with cryptic dull grey or olive brown coloration (Radder et al., 2005).

Psammophilus blanfordanus shows social behavior. Social hierarchy in these animals is established by a 'Peck order' whereby the dominant male occupies the most elevated spot with the maximum perch height. The perch height occupied by males is higher than that of females with the possibility of variation during breeding season (Radder et al., 2005). *Psammophilus blanfordanus* shows the following behavior in the wild: 1) Territoriality (Pianka and Vitt, 2003), 2) Mating Behavior (Pianka and Vitt, 2003), 3) Interspecific behavior like feeding and undergoing predation, 4) Intraspecific behavior involving visual signals, chemical signals, and tactile communication (Pianka and Vitt, 2003). Among these, visual signals and response is the most highly developed, as indicated in case of *Psammophilus dorsalis* (Sreekar and Quader, 2013). As with the case for agamid lizards generally, they are diurnal and have high cone cell density in their eyes, and are capable of detecting and discriminating colors and even UV light (Pianka and Vitt, 2003).

Results

The set of activities that were observed out of 100 hours included resting (89 hours), in-water resting (18 hours), basking (2 hours), tail raising (~2 hours), partial basking (~2 hours), movement (~30 min), locomotion (15 min), climbing (12 min), head bobbing (9 min), feeding (3 min), scratching (~2 min), chasing (46 sec), drinking (37 sec), biting (6 sec), dewlap display (3 sec), and excretion (1 sec). Highest activity was recorded at temperature and humidity level of 33.1°C and 48% respectively (48 min) while lowest activity recorded was at 35.3°C and 38% temperature and humidity level respectively (6 sec). Major activities except for resting (outside and inside water) include basking, tail raising and partial basking (Refer Fig.1). Minor activities include biting, dewlap display, excretion (Refer Fig.2). Because of varying temperature and humidity levels, we segregated the time period of observation into morning, forenoon, afternoon and evening hours.

The morning duration activities of lizards (8.30 am-10.30 am) were characterized by average temperature and humidity levels of 33.4°C and 48% respectively. Except for resting (inside and outside water), the most observed activities during this time period of observation included basking (46 min), tail raising (20 min), and movement (11 min). The occasionally occurring activities were locomotion (3.2 min), head bobbing (~3 min), and feeding (~2 min). The rarely occurring activities included scratching (33 sec), climbing (29 sec), chasing (8 sec), drinking (5 sec), and excretion (1 sec). The total duration of activities was 1 hour 42 minutes (Refer Fig.3).

The forenoon duration activities of lizards (11.00 am-1.00 pm) were characterized by average temperature and humidity levels of 35.6°C and 40% respectively. Except for resting (inside and outside water), the most observed activities during this time period of observation included partial basking (1 hour 40 min), basking (1 hour), and tail raising (17 min). The occasionally occurring activities were feeding (7 min), movements (6 min), locomotion (3 min), climbing (2 min) and head bobbing (~2 min). Rarely observed activities include scratching (34 sec), drinking (9 sec), and chasing (9 sec). Total duration of activities was 3 hours 18 minutes (Refer Fig.4).

The afternoon duration activities of lizards (1.30 pm-3.30 pm) were characterized by average temperature and humidity levels of 35.9°C and 43% respectively. Except for resting (inside and outside water), the most observed activities during this time period of observation included basking (35 min), tail

raising (25 min), climbing (10 min), and partial basking (10 min). The occasionally occurring activities were movement (~6 min), locomotion (3 min), head bobbing (2 min). The rarely occurring activities included scratching (22 sec), feeding (15 sec), drinking (13 sec), chasing (12 sec) and biting (2 sec). Total duration of activities was 1 hour 54 minutes (Refer Fig.5).

The evening duration activities of lizards (3.30 pm-5.30 pm) were characterized by average temperature and humidity levels of 34.8°C and 45% respectively. Except for resting (inside and outside water), the most observed activities during this time period of observation included tail raising (36 min), and movement (7 min). The occasionally occurring activities included locomotion (~5 min), head bobbing (2 min) and feeding (44 sec). The rarely occurring activities included climbing (30 sec), chasing (17 sec), drinking (10 sec), scratching (8 sec), biting (4 sec) and dewlap display (3 sec). Total duration of activities was 52 minutes (Refer Fig.6).

Basking was highest in forenoon (1 hr) followed by morning and afternoon hours; it was not observed in the evening. Partial basking was highest in forenoon (1 hr 40 min) followed by afternoon hours; it was not observed during morning and evening. Tail raising was highest in the evening hours (36 min) followed by afternoon, morning and forenoon. Movement was observed throughout the observation period. It was highest in the morning hours (11 min) followed by evening, forenoon and afternoon hours. Locomotion was highest in the evening hours (~5 min) followed by morning, forenoon and afternoon hours. Head bobbing was highest in the morning hours (~3 min) followed by forenoon, afternoon and evening hours.

Feeding occurred throughout the observation period, but mostly towards forenoon hours and rarely in the afternoon hours. Drinking was also common throughout the observation period, but mostly in the afternoon sessions. Chasing and scratching were also distributed throughout the observation period. Climbing onto walls and tree logs were common throughout the observation period, but mostly observed in afternoon session. Biting was rarely observed in late afternoon and evening sessions, while excretion and dewlap display were the rarest of all, with single occurrence in morning and evening sessions respectively. The duration of activities was highest in the forenoon (3h 18 min vs. 1h 54 min in the afternoon, 1h 42 min in the morning and 52 min in the evening), and inactivity increases towards evening time (52 min). Although activities occur, most of the time is spent in resting, that happened frequently in water too.

Discussions

In *Psammophilus blanfordanus*, postures and actions are the most important stimuli as suggested in case of most diurnal lizard species (Brattstrom, 1974). Under captivity, the Blanford's Rock Agama showed similarities in certain aspects of behavior as already mentioned by earlier workers. Basking was seen to occur mostly in the morning and forenoon sessions as suggested by Parida and Mukherjee (2014). Resting usually occurs in shady areas and rocky crevices in the afternoon due to increased heat preceded by basking in the morning hours as similar to *Psammophilus dorsalis* (Radder et al., 2005). Resting inside water can be attributed to lower body temperature as suggested in case of *P.dorsalis* (Veeranagoudar et al., 2010) or it may be related to water uptake through the skin similar to *Moloch horridus* (Sherbrooke, 1993; Withers, 1993). As with other activities like head-bobbing, which is considered as most observed activity in case of sister species *Psammophilus dorsalis*, (Radder et al., 2006) our findings are similar in that context.

Tail raising behavior in *P.blanfordanus* doesn't seem to have a role in courtship interactions as suggested in case of Phrynosomatid lizards (Martins, 1991, 1993), and confirmed in case of *Psammophilus dorsalis* (Radder et al., 2006), but instead might have a role in male-male interactions. No occurrence of mating and reproductive behaviour was observed during the study period. Some of the lizards in the enclosure were more active than others and performed frequent 'push-ups' as previously suggested in case of captive iguanid lizard genera *Callisaurus*, *Cophosaurus* and *Holbrookia* by Clarke (1963). The lizards were shy and would run away so we could not have a closer look on them as previously described (Radder et al., 2005). Dominant males in captivity prefer to establish greater perch heights, similar to that in the wild (Kumar et al., 2002). Territories, in the usual sense of term, do not apply to captive lizards because of less scope of competition for food and hence space. Biting was a rare activity because individuals were mostly submissive when confronted by a displaying dominant male. Head bobbing also occurs frequently before and after locomotion (personal observation).

An ideal terrarium for lizards in general has been described (Conant and Collins, 1998). The terrarium for *P.blanfordanus* consisted of 2 inches of sandy dry soil and small rock mix, with pebbles and larger rocks to maintain an arid habitat. This is because a rocky habitat was necessary for the survival of this species (Das 2002, Daniel, 2002). Next, a log of wood with concave-side facing down was arranged to make a good shelter and a shallow mud-pot with water up to brim was

kept as suggested (Conant and Collins, 1998). In addition, water was sprayed inside the enclosure to help the lizards in maintaining an optimum body temperature as far as possible.

To the best of our knowledge, behavioral studies of Indian Rock Lizard (*Psammophilus cf. blanfordanus*) in captive conditions are very scarce. As such, we believe that these captive lizards behave similarly when compared in the wild, as resting predominates total duration of activities drastically (personal observation). This may be attributed to smaller body size which is suggested to have higher heating rates as suggested generally in case of high altitude lizards (Carrascal et al., 1992). The activity patterns are mostly influenced by temperature and humidity levels. They require a suitable temperature and humidity range (Present study: 31.5°C-36.7°C & 33%-49% respectively) within which they show highest activity (personal observation). Inactivity is seen to increase after rapid feeding bouts (personal observation). High temperature of substratum may also be a reason for inactivity, because of which the lizards may have been resting inside water for longer durations, which is a rare occurrence in the wild (Rao et al., 2015). Certain activities like head bobbing, tail raising, etc. may serve more than one purpose but it is difficult for us to interpret (personal observation); so further studies are required on aspects such as circadian rhythm (body clock), roosting behavior at night, behavior of juvenile lizards and similar studies across other seasons.

Activity pattern of captive *Psammophilus blanfordanus* in 100 hours
Except Resting (outside or inside water)

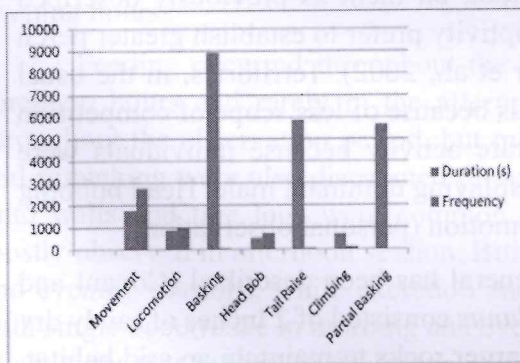


Fig.1: Major Activities

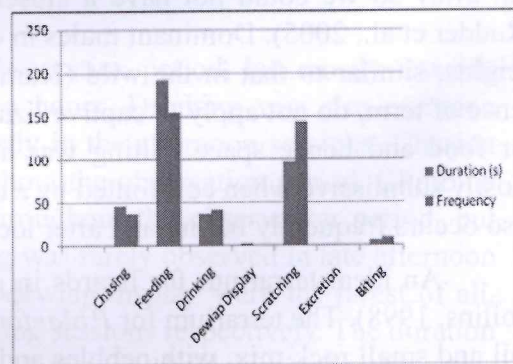


Fig.2: Minor Activities

Activity patterns of captive *Psammophilus blanfordanus* during various time slots except Resting (outside or inside water)

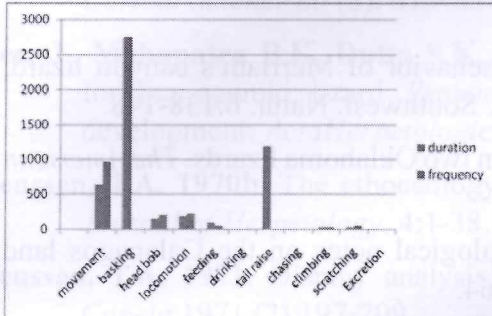


Fig.3: 8.30 AM-10.30 AM

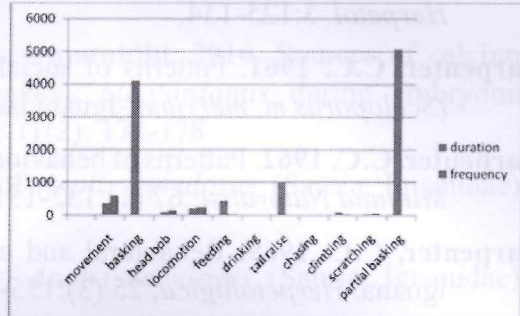


Fig.4: 11.00 AM-1.00 PM

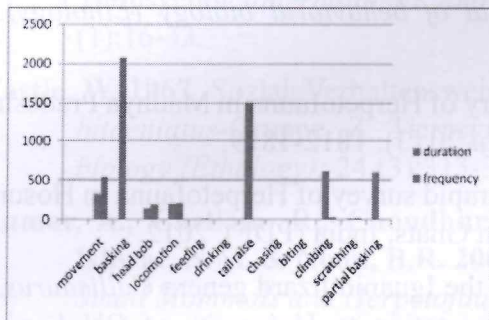


Fig.5: 1.30 PM-3.30 PM

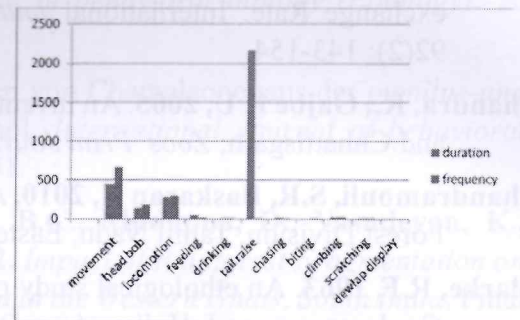


Fig.6: 3.30 PM-5.30 PM

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FEEDING BEHAVIOUR OF STAR TORTOISES (*GEOCHELONE ELEGANS*), WITH SPECIAL REFERENCE TO VEGETABLE COLOUR

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Introduction

The Importance of nutrition and feeding regime of animals have not received enough recognition in ex situ conservation biology. However, the captive breeding of an animal is possible only when the nutritional requirements of the animal are met. Effective habitat management requires an evaluation of nutritional resources (Ofstedal, et al. 1996). The study of animals in a captive condition will help in a better way to conserve them in their very own habitat or the wild. While better known groups like birds and mammals have received enough attention on this regard, other lesser life forms have not. In particular reptiles are not the easiest of animals to use in various types of studies. If such experiments reveal much about the life history of the animals in its natural surrounding is still a question (Bellairs, 1969). The major pursuit for reptiles is food and temperature. Food-specific characteristics are very important to animals, so one of the big challenges in captivity is to provide the near natural diet of the species (Young et al., 2014).

Especially in tortoises and turtles “The shelled reptiles” (Knight, 1969) studies have been carried out on their feeding behaviour, food preferences and factors which play a major role in feeding. The nutritional status of the wild (herbivorous) tortoises may depend more on the availability of plant species (Ofstedal et al., 1996).

According to Knight (1969) “though tortoises are probably short sighted, they can see well and distinguish color –yellow and red seem to be more attractive. Sight is used in finding and choosing food. Sense of smell is excellent which is used in conjunction with sight when feeding.” However, there is little evidence to

point out if foraging efforts are influenced by color or vision in Indian species. Food sensory characteristics and an animal's preferences are important when designing a species' husbandry (Young et al., 2015). There is an underlying expectation that the animal would choose what was best for them both in wild and in captivity (Ofstedal et al., 1996).

In a study on the food preferences of *Chelonoidis denticulata* based on their assessment of color in choosing their food, the results suggest that they had a preference for red; this type of information should be taken into account when designing enrichment for captive tortoises (Young et al., 2014). Another study on Herman's tortoises revealed that these animals can discriminate between various colors be it natural or artificial and preference over yellow was quite striking than other colors, which could in turn give us quite an insight on the nutrient requirements of the tortoises (Fasola, 2010). In juvenile leopard tortoises, vision is most acute in red and orange wavelengths, which may explain their attraction to foods such as tomatoes, cherries and watermelon and other red colored feed (Cunningham et al., 2010).

The main objectives of this study is to learn whether color of the food influences the preferences or aids in choosing the particular food, to note the difference(if any) between the food preferences of young and mature star tortoises and the quantity of preferred food taken by the individuals.

Materials & Methods

The study was carried out at Chennai Snake Park (13.0039° N, 80.2387° E), during the summer (May and June) which was considered to be the hottest months of the year in southern parts of India. The study was carried out for a certain duration of about 15 days from 21st May to 11th June. The temperature and the humidity values of the study area at this particular time varied around (36.0°C-39.7°C & 34% - 40%) during the day time when the study sample was collected. The star tortoises were observed with naked eye in a captive condition. Six individuals, 3 adults and 3 sub adults were observed for the study. The enclosure of the star tortoises measured about 4 m x 3.5m, with an area of around 120sq.ft. It consists of around 3 retreats or hiding places, one cement slab, a water trough etc .The sex of the individuals was not scored separately for this study.

Study Species

The star tortoises (*Geochelone elegans*) are land tortoises which are almost entirely herbivorous, feeding mainly on grass, fruits, flowers etc with star patterns on both the carapace and plastron with a pattern of dark brown or black on yellow or beige. The captive specimens thrive well on soft vegetables of various kinds. The shell in the adults is elongated and the juveniles have a rounded shell. They belong to scrub forests, edges of deserts, agricultural fields, and forests of teak, grasslands or thorn scrub type of habitats. They are restricted to dry regions of north western India, south eastern and southern parts of India. They are also present in extreme eastern Pakistan and north eastern Sri Lanka. Their nesting season coincides with the monsoon (Das, 2002). The star tortoises are categorized under the status “vulnerable” as they are exploited remarkably as live specimens for pet trade, slaughtered for their shells and loss of their scrub habitat by the Indian Wildlife act schedule IV (Das, 1985).

The sampling method used was the all occurrence sampling . The tortoises were fed every alternative day, during which time the observations were made. The temperature and humidity of the enclosure was noted down with the help of a digital thermo hygrometer. A variety of human consumption grade fresh vegetables and greens were purchased from the market which included greens, cabbage, carrot, tomato, radish or beetroot. The last two were never given together. The feed was weighed with the help of a weighing machine and the weights of the feed were noted separately after it was chopped into small pieces to facilitate feeding. Then the cut and weighed pieces of vegetables were spread on a A4 sheet to note down the area occupied or the visible quantity of each variety of feed. Then the vegetables, greens etc are mixed together in a tub and introduced into the tortoise enclosure on the feeding area which is a small cement slab. The time is noted from the moment the first individual approaches the feed till the last individual leaves after feeding. After this, a time of about 30minutes was taken to check if any individual comes again for feeding in which event the observation continued. Every time the tortoise picked up a food item by its mouth that respective name of the vegetable was noted. Special mentions were made when a tortoise was clearly observed to search and choose a particular vegetable. The time was noted as each individual approaches the food and leaves after feeding respectively. In one trial the vegetables were not mixed but kept separately to get a clear view of their preferred food. Photos were taken to record any special or remarkable events.

Table 1. Nutrient profiles of vegetables offered as feed during the study (Highfield 1990).

VEG.	PROTEIN (g)	FIBRE (g)	FAT (g)	CALCIUM (mg)	POTASSIUM (mg)	VITAMIN A (IU)
GREENS	8.00	1.0	2.00	1130	80.00	-
CABBAGE	1.30	0.80	0.20	49.00	29.00	130.00
CARROT	1.10	1.00	0.20	37.00	36.00	1100.00
TOMATO	1.10	0.50	0.20	13.00	00.27	900.00
BEETROOT	1.61	2.80	0.17	16.00	325.00	33.00
RADISH	0.70	1.60	0.10	25.00	233.00	7.00

Results

Six different types of feed were offered to the tortoises during the study period. The number of samples or trials were 10 (n=10). The average weight (in grams) of the different types of feed which was offered to the tortoises were, Cabbage (382.14) > greens (435.71) > followed by carrot (292.85) > tomato (265.42) > radish (153.57) > beetroot (85). The Amount of feed offered to the star tortoises based on the area occupied by spread out pieces on an A4 sheet were cabbage (1-4.5 pg) > Greens (2-5pg) > carrot (0.5-2pg) > tomato (0.5-1pg) > radish (0.5-1pg) > beetroot (0.5pg).

The Range of time taken by each of the individual from the time they approached the feed and left the area after feeding were, adult 1(33min-1hr 20min), adult 2(20min-50min), adult 3(0-1hr 25min), sub adult 1(11min-42min), sub adult 2(0-50min) and sub adult 3(0-35min). The total bulk or the quantity of feed eaten by each individual during this study were, adult 1(742 pieces), adult 2(507 pieces), adult 3(547 pieces), sub adult 1(220pieces), sub adult 2(273), sub adult 3(115). The frequency with which each type of feed was chosen in a random manner by a particular individual was, adults (Greens-575, Cabbage-437, carrot-271, tomato-88, radish-13, beetroot-2) and sub adults (Greens- 98, Cabbage-155, carrot-115, tomato-54, radish-6, beetroot-0).

Among the six types of feed offered to the star tortoises the most utilized ones were, Tomatoes > Carrots > Cabbage > Greens > Radish > Beetroot. The percentages of chosen feeding instances of the most preferred feed of the tortoises were adults (tomatoes 78.7%, carrots 37.1%, and cabbage 12.77%) and sub adults

(tomatoes 66.03%, carrot 33.13%, and cabbage 8.82%). In case of the tomatoes, the chosen entries were remarkably high than the random entries. Radish and beetroot were never observed to be chosen over and eaten even a single time. There were almost no chosen intakes for beetroot and radish as against their random intakes. The random intake of greens were, disproportionately high when compared to its chosen or preferred intake, particularly by adults. The chosen intakes for tomatoes were disproportionately higher, than the random intakes especially in sub adults (51.42%).

The difference in the consumption of most preferred feed tomato and carrot taken by the adults and sub adults respectively was: Tomatoes (12.67% higher in adults) followed by carrots (3.97% higher in adults). On the whole difference between the adult and the sub adult feeding pattern was that the bulk quantity eaten by the adults (1796) was understandably more when compared to the sub adults (608).

Table 2. Frequency of feed (no of pieces) eaten by the tortoises during the study period.

FOOD	ADULT 1	ADULT 2	ADULT 3	SUB ADULT 1	SUB ADULT 2	SUB ADULT 3
GREENS	305	125	153	25	52	24
CABBAGE	193	156	152	28	98	44
CARROT	154	102	175	95	39	38
TOMATO	85	122	59	68	84	7
BEETROOT	2	0	0	0	0	0
RADDISH	3	2	8	4	0	2

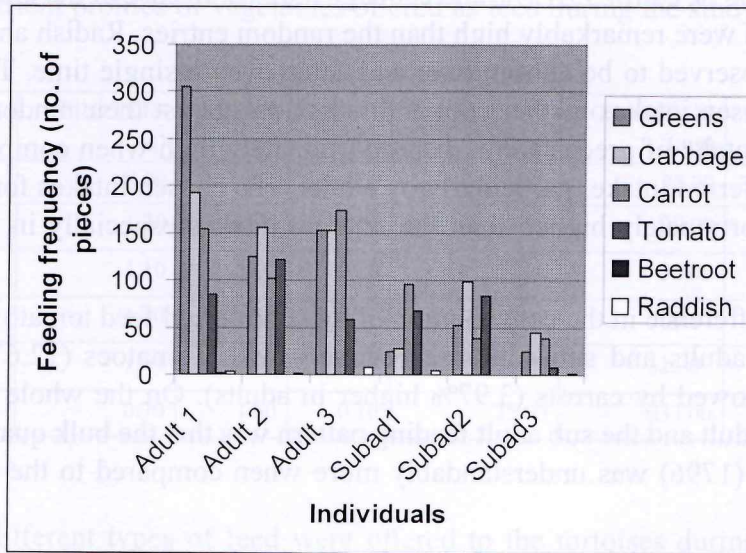


Fig. 1. Colour coded graph depicting consumption of various coloured vegetables by different individuals of the tortoises.

Discussion

Many studies regarding food preferences and the factors (like color vision, nutritional requirements) influencing a tortoise to choose its food have been carried out. In leopard tortoises, vision is the most acute in red and orange wavelengths, which may explain their attraction to foods such as tomatoes, cherries and watermelon (Cunningham et al., 2010). In this study it was visibly noted that the tortoises preferred the tomatoes and then secondarily preferred the carrots, both of which are reddish. Both the adults and sub adults had a striking affinity towards the red tomatoes. *Chelonoidis denticulata* chose their food mainly based on color and had a preference for red (Young et al. 2014). In this study tomatoes were preferred more than other colored vegetables (green and white). Food items of many kinds are much liked by tortoises with sliced tomatoes high on the list (Knight, 1964). However the present study reveals beetroot, though red in color was the least preferred among the offered vegetables as evidenced by the least number of intake, though offered in a similar quantity. It is noteworthy to mention that the fibre content of the two least preferred vegetables (beetroot and radish) were high (1.6-2.80g) compared to the other offered vegetables (0.5-1.0g) that were eaten (table



1). Greens that were the staple food for the adults have very high protein, calcium and fat content compared to the other vegetables (table 1). Apart from the very low potassium content, tomatoes do not contain any unusual nutritional characterization (table 1). It is known that the tomatoes have very high water content compared to the offered vegetables. Perhaps this maybe the reason for the tomatoes being preferred so much.

Color vision and discrimination could be related to the need of locating food resources (e.g. flowers and fruits) from great distances or in closed habitats (Costantini et al., 2005; Blazquez & Rodriguez-Estrella 2007). The nutritional status of the wild tortoises may depend more on the availability of plant species (Ofstedal, et al., 1996). Star tortoises are inclined to a vegetarian diet, feeding on succulents like *Cissus quadrangularis*, fallen fruits, grass and similar vegetation (Daniel, 2002). In the wild, star tortoises are known to feed on grass, fruits, flowers and sometimes on snails, bird droppings etc (Das, 1985). There is an underlying expectation that the animal would choose what was best for them both in wild and in captivity (Ofstedal et al., 1996). Most of the naturally available food of the tortoises could not be offered in a captive condition for practical reasons. The diet which was followed for the star tortoises, grown in a captive condition, in Bulgaria was fresh greens, leafy greens, ground carrots, cucumbers, green lettuce etc (Ivanchev et al., 2012). Carrots, leafy greens etc also formed the bulk of diet given to the star tortoises in this study. The young start feeding greedily on same food as the adult (Daniel, 2002). In this study the sub adults were seen to eat and preferred the same feed which was chosen by the adults, though the quantity was, understandably, less compared to the adults. Many tortoises went directly to a piece of tomato present among other foods, this maybe the evidence of selection by scent (Knight, 1964). This was observed in this case also, when the feed was kept mixed the tortoises, be it adults or sub adults were seen to dig out the tomato pieces, ignoring the other feed around.

This is a preliminary work conducted for a short time span. Longer hours of observation will give a better picture of the concerned aspect. Inclusion of more variety of vegetables and fruits of varied colour and nutritional content will give us a better understanding about the feeding and the associated factors. Replicating such observations across seasons will give a holistic picture of the topic.

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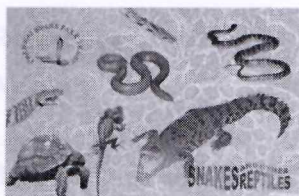
RANDOM HARVEST

Second species of pig-nosed frog from Western Ghats

After the discovery in 2003 of the Indian pig-nosed frog (*Nasikabatrachus sahyadrensis*) from Idukki hills of Kerala state, a second species of this genus has now been discovered. In an article published by Jagat Janani and others in vol. 34 of the journal 'Alytes' the new species *Nasikabatrachus bhupathyi* has been described. This frog inhabits the eastern, rain-shadow belt of the Western Ghats, contrary to *N. sahyadrensis* and also differs in aspects of body form and colouration. This species is named after a herpetologist Late Dr. S. Bhupathy. It is also a burrowing species and is known to occur in the foothills of Western Ghats along Srivilliputhur Wildlife Sanctuary in Viridunagar district of Tamil Nadu.

-- Editorial

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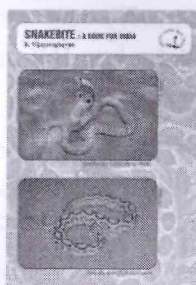
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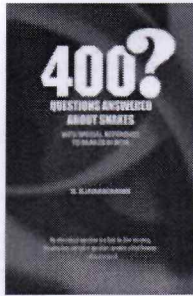
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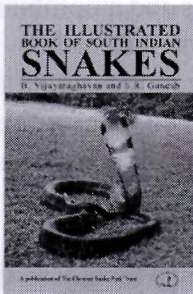


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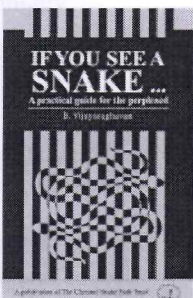


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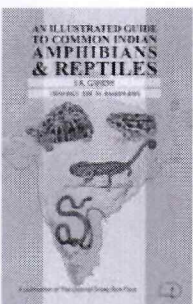


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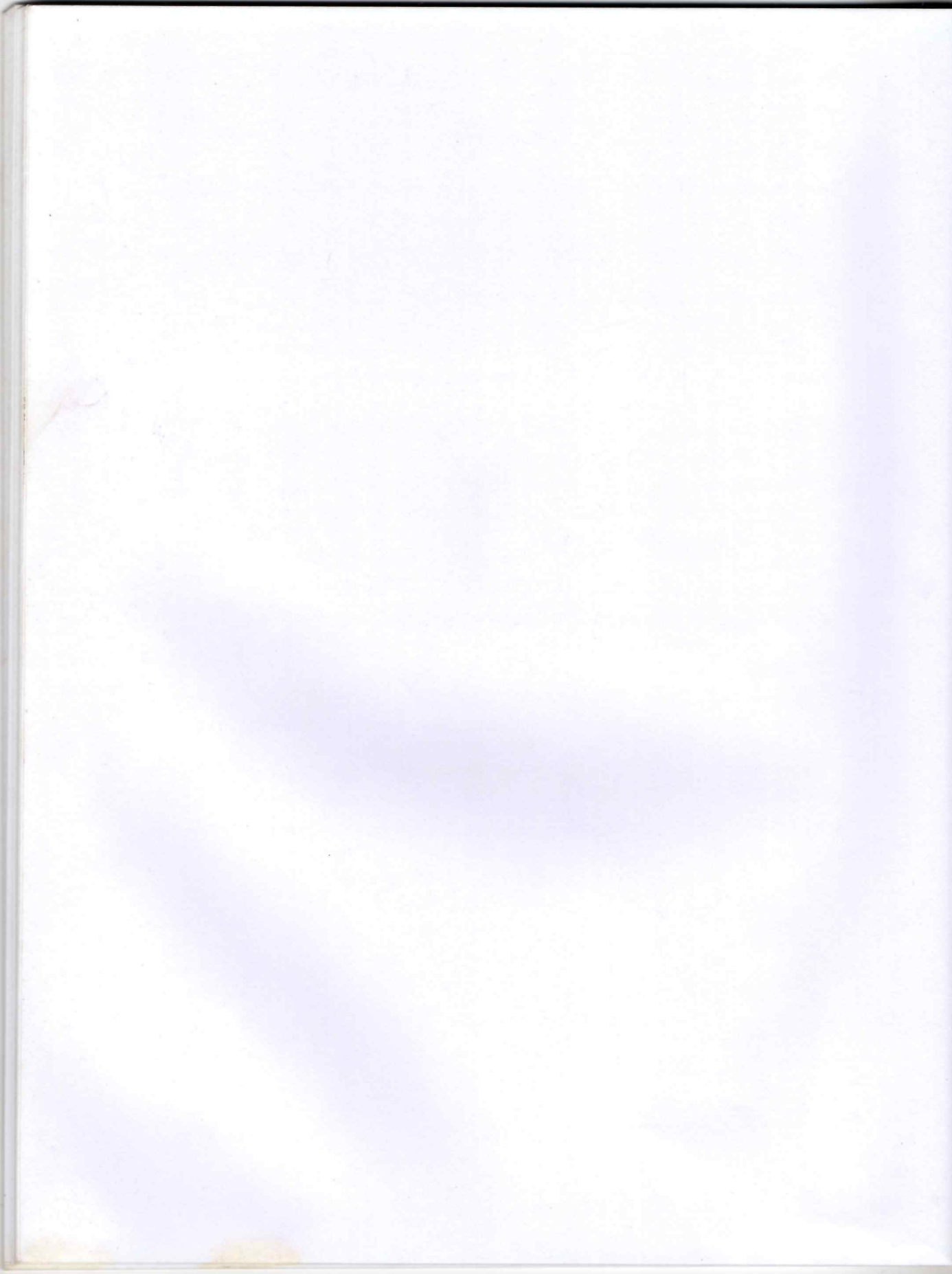
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