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The Asian Water Monitor, *Varanus salvator*: An Introduction to its Non-Breeding Ethology.

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ABSTRACT.– The Asian Water Monitor (*Varanus salvator*) is a highly adaptable species that lives in close proximity to humans. The present study aims to construct an ethogram of *V. salvator* to obtain a complete record of its behaviours in its natural environment. This ethogram is constructed on the basis of all the exclusive behaviours (39) and behavioural categories (8) documented for 43 individuals from two study sites situated on the outskirts of Kolkata, India. The ethogram reveals that *V. salvator* devotes most of its time to foraging (84.63 minutes, 37.58%) and sluggish movements (50.73 minutes, 22.52%). This study also indicates the activity period of the species and its interaction with anthropogenic disturbances, interestingly showing very less temporal overlap with human activity. These results reflect an overall idea of the non-breeding behaviour of *V. salvator* and highlight the survival strategies of such opportunistic species amidst two highly congested areas.

KEYWORDS. Focal Animal Sampling, Repertoire, Behavioural Pattern, Ethogram, Co-exist

Introduction

An ethological study begins with observing each behaviour of the species exclusively and constructing a repertoire known as an ethogram. An ethogram is a list of exclusive behaviours of the studied animal describing its elementary and functional patterns (Altmann 1974, Lehner 1998). The behaviour of an animal is the link between a species and its environment and plays a crucial role in understanding its evolutionary perspective (Breed and Sanchez 2010). Behavioural understanding deals with systematic field observations merging with prior theoretical knowledge of the species, and quantitative analysis of their ethological pattern. Such *apprehension* is helpful to *understand the* behavioural complexity of species and build conservation measures for them and their habitat (Sutherland 1998).

The Asian water monitor (*Varanus salvator*) has a wide distribution in Tropical Asia and has occupied a large range of habitats (Bennett et al. 2010). *Varanus salvator* is the most widespread species among all varanids (Koch 2007) found in Sri Lanka, northern India, Bangladesh, Burma, Vietnam and Hainan to Peninsular Malaysia and the Indonesian islands (Traeholt 1993; De Lisle 2007). It is one of the largest extant lizards in the world, reaching an average length of 1.5 m (Karunarathna et al. 2017). *Varanus salvator* is known to maintain healthy populations and can very well adapt to human-moulded habitats (Uyeda 2015, 2009; Karunarathna *et al.* 2017; Chatterjee and Bhattaccharya 2014). It is the only monitor that is known to have colonised the marine habitat successfully and is adapted to both freshwater as well as salt water habitats (Traeholt 1993). They are a semi-aquatic and generalist species inhabiting a variety of natural habitats (Gaulke and Horn, 2004). Being a diet generalist provides added ecological plasticity to this species (Karunarathna *et al.* 2017). Ac-

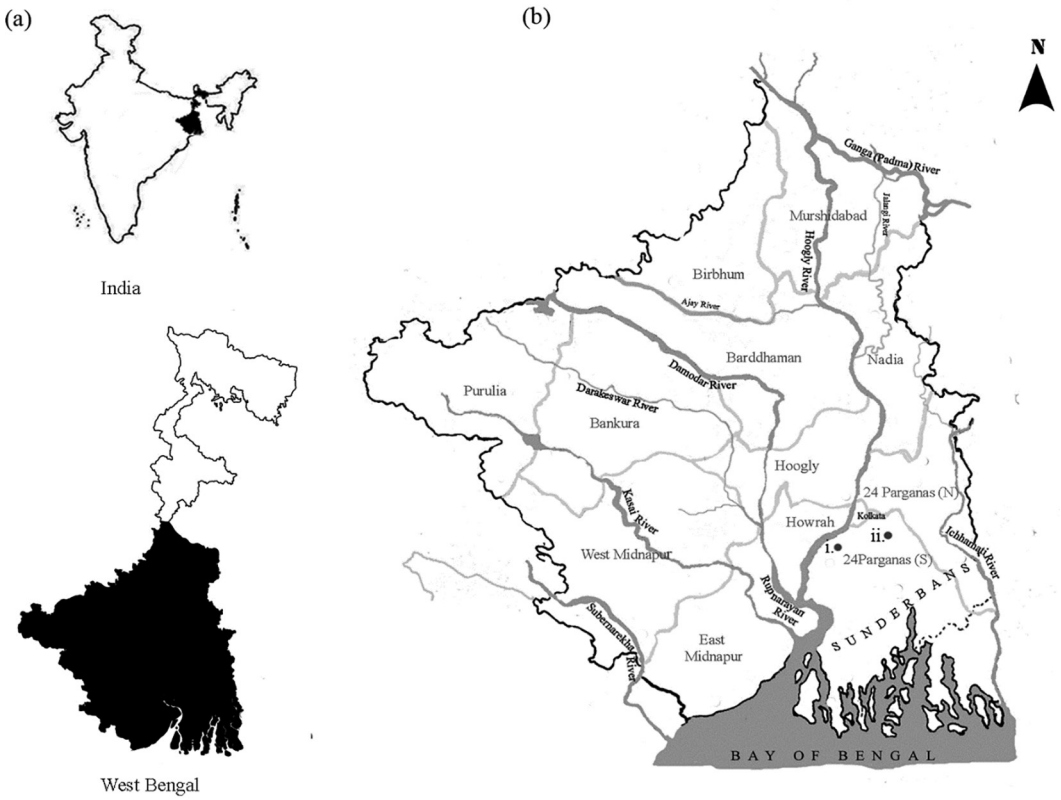

Figure 1. Map showing (a) Location of West Bengal in India. (b) Study locations: i. Budgebudge, ii. CKBS

cording to Carl Traeholt (1993) water monitors are territorial and show area-concentrated foraging behaviour (Traeholt 1997; Gaulke *et al.* 1999; Gaulke and Horn 2004).

The water monitor is the third most heavily traded species in the world (Pernetta 2009) and has been subjected to hunting pressures in the international leather trade due to the demand for their skin. Its meat is eaten and the fat is used in traditional medicine (Uyeda 2009; Bennett *et al.* 2010). Despite such threats, the species is not enlisted as a protected species according to international organizations like IUCN and CITES. IUCN listed *V. salvator* in the category of least concern (LC) whereas the Convention on International Trade in Endangered Species (CITES) trade database included them in Appendix II which comprises species that are not presently threatened with extinction but are at risk unless trade is closely controlled. (Bennet *et al.* 2010; CITES 2020). In India they are included in the highest category of protection i.e., Schedule I, according to the Indian Wildlife Protection Act, 1972 (IWPA, 1972).

Several ethological studies exist on different species of varanids throughout the world but until now a limited number of studies have been conducted on the behaviour of *V. salvator* in their wild habitat (Auffenberg 1994; Uyeda 2015; Chatterjee and Bhattaccharya 2014). The present study aims to describe the non-breeding behaviours of *V. salvator* in its natural habitat (both urban and semi-urbanised settings) in southern part of West Bengal, India and to prepare a detailed ethogram for understanding their behavioural patterns which can lead developing explicit conservation strategies for them in future.

Material and Methods

Study sites. A pilot survey was conducted in different locations on the outskirts of Kolkata city, West Bengal, India. The two sites finalized for the in-depth study are rural areas of Budgebudge (22°24’54’’N; 88°11’20’’E) and Chintamani Kar Bird Sanctuary (CKBS) (22°25’45’’N; 88°24’4’’E) (Fig. 1). Previous studies (Chatterjee and Bhattacharyya 2014;

Chitra 2015) suggested that both the areas comprise a substantial number of *V. salvator* along with its potential habitat. Budgebudge is a village set up with typical elements such as crop field and settlement areas dotted with small wetlands; whereas CKBS is a small sanctuary (0.07 sq km area) with extremely high tree density situated amidst a congested urban system interspersed with small water bodies like a few ponds and a canal (Wildlife Wing, 2020). These study locations were selected due to their differences in conservation practices. CKBS is a bird sanctuary managed and maintained by the state forest department whereas Budgebudge is a village area with the absence of any formal wildlife protection measures (Wildlife Wing, 2020, Chatterjee and Bhattacharyya, 2014). The geological and climatic conditions are similar in both the places as these are situated on the same side of the lower Gangetic alluvial flood plains (Sirohi, 1989). Mean daily temperature varies around 31 ˚C. Summer temperatures cross 42 ˚C and winter temperatures fall up to 12 ˚C. The atmosphere is moist humid (70.8%) throughout the year except in winter, and annual precipitation is moderate (1641.4 mm) (Indian Meteorological Department 2014).

Data collection. This study was conducted during the non-breeding period (May–June 2018) of the species. Initially an *ad libitum* survey was performed in the study locations to identify the potential habitats for the Asian Water Monitor. We used opportunistic encounter followed by the Focal Animal Sampling (FAS) method for the in-depth study in which all occurrences of interactions of an individual were recorded without interfering or disturbing their activities (distance of minimum 150 m from the individual) and each exclusive behaviour was noted down with a detailed description of the posture. The length of each sample period for each focal individual and the amount of time during which the individual is in view was recorded (Lehner 1996; Altmann 1974). The amount of time the animal was in sight and the frequency of each sub-behaviours was noted down. While conducting the FAS in an area from a vantage point it was only possible to observe the focal animal when it was within the viewing range of the observer. Therefore, the activity data was taken for those individuals till they were in sight and recorded till the time they moved out of the viewing range of the observer during each time slot. In each time slot the habitats were scanned thoroughly and if any individual were sighted, the observation was conducted for the individual till it was in sight with each behavioural detail along with duration and frequency of each behaviour being noted down. Once chosen, a focal individual was followed to whatever extent possible (till the focal animal was in view) during each sample periods (Altmann, 1974). Binoculars (Nikon; resolution: 8 x 42) were used for enhancing the visibility of the species and occasionally a camera (Model: Canon 700D, Lens: 55-250 mm) was employed to record their different behavioural activities. Later the direct observation notes were cross checked with the video to standardize the technique. Using this data an ethogram was constructed describing their postures and displays and to understand the patterns of behaviour. A repertoire was made consisting of all the behaviours shown by the monitor while it was in sight. These behaviours were assigned to functional categories based on prior studies on lizards (Tracy Langkilde et al., 2003; Carpenter et al., 1970; Done & Heatwole, 1977; Whittier & Martin, 1992; Torr & Shine, 1994; Whittier, 1994).

Observations were made for 43 individuals (N=43) in different developmental stages (juvenile, sub-adult, adult) that were identified from the SVL (Snout to Vent length) of the individual (Amarasinghe *et al.* 2009; Langkilde *et al.* 2003; Torr and Shine 1994). Thirty eight adults, two sub-adults and three juveniles were observed. Data was collected over a period of seven different time slots (each slot comprises 2 hrs.) in a day starting from 06:00 hrs. in the morning to 20:00 hrs. in the evening. In a single field day, a maximum of three time slots were covered to minimise observer fatigue and bias in data collection. Night sampling was not done due to poor availability of light after 20:00 hrs. (Bandyopadhyay *et al.* 2014). Climate data (temperature, humidity and rainfall) were recorded using HTC thermo-hygrometer for the days (for each time slots) when field surveys were conducted. Total 225 minutes and 14 seconds of on-field sighting data during May–June period was documented covering different times of the day to construct a detailed exclusive ethogram (Langkilde *et al.*

2003; Torr and Shine, 1994; Bandyopadhyay *et al.* 2014). An exclusive ethogram is where each behaviour performed by the species is considered as single behavioural type in the ethogram (Lehner 1998). Data collected from the two survey sites were pooled to perform further analysis and construct the ethogram.

Data analysis. Analyses of the number of times each animal performed each behaviour during each time slot yielded quantitative results. The data from each observation period for the two sites were combined. For statistical analysis we have combined behavioural data from all observed animals, treating all instances of a particular behaviour pattern as independent observations (Torr and Shine 1994). This assumption was done due to small sample size for many behaviours and to aid in statistical analysis. The temperature recorded during survey days were grouped into three clusters of < 30 ºC, ≥ 30–40 ºC, and ≥ 34–38 ºC. The number of individuals sighted during each temperature cluster were then analysed in MS Excel, and a regression analysis was performed. Sightings of focal animals during each time slots were then plotted in a graph showing the number of individuals sighted during each of the surveyed time slots.

Results

Behaviours were assigned to four functional categories based on prior studies on lizards (Carpenter *et al.* 1970; Greenberg 1977a; Whittier and Martin 1992; Torr and Shine 1994; Whittier 1994; Langkilde *et al.* 2003). Each behaviour were further broken down into exclusive behaviours (Lehner 1996) in the ethograms for time budgeting and to reflect detailed behaviours of *V. salvator*.

Ethogram

A total of 39 exclusive behaviours of *V. salvator* were observed and identified. According to their elements of behaviour, the observed 39 behaviours are clustered into eight behavioural categories. i.e., foraging, feeding, movement, sluggish movements, resting, basking, alert, and interaction. Furthermore, these behaviours were assigned to four functional categories (exploratory, maintenance, escape and social). The detailed repertoire of each exclusive behaviours and their behavioural and functional categories are described in Table 1.

Functional category I: Exploratory

Behavioural category I: Foraging

Exclusive Behaviour I: Swimming

Exploring for potential prey. Swift locomotion in water bodies for exploration of prey using the two pairs of limbs and the long tail accompanied by tongue flicks and head turns. They forage in the deepest part of the water bodies i.e., in the centre, mostly searching for fish as well as along its banks covered with submerged vegetation in search of small invertebrates and amphibians.

Exclusive Behaviour II: Crawl

A lateral undulatory gait, wherein the body flexes sideways while walking. An investigative search for food (Treaholt 1993). A swift forward movement of the body on land with two pairs of limbs and the tail in contact with the surface. Foraging walk is accompanied by constant tongue flicking and looking sideways trying to locate prey using their specialized tongue.

Exclusive Behaviour III: Tongue flick

Tongue is specialized to sense the environment and helps in locating prey. Unlike snakes, monitors lack a slit in-between the upper and the lower jaw through which the tongue could make its way out easily, therefore they have to open their mouth to expose their bi-forked tongue. During 'tongue flicking' the tongue

Table 1.

Functional Category	Behavioural Category	Exclusive Behaviour / Elemental Category
Functional Category	Behavioural Category	Exclusive Behaviour / Elemental Category

droops down close to the ground before it is retracted back inside. The rate of tongue flicking is seen to vary from being as rapid as two flicks a second to as slow as one flick per 2 seconds or more. While foraging in water most of the times the tongue touches the water and then goes under the water surface.

Exclusive Behaviour IV: Head turn in movement

Swaying its neck and head sideways to have a 180° view while crawling or swimming; on turning its head and neck 90° left or right, the monitor's upper body (from head to neck) looks like alphabet 'C'.

Exclusive Behaviour V: Motionless head turn at rest

Turning its head sideways or gazing straight while the body stays still on ground or in water showing very limited movement.

Exclusive Behaviour VI: Head and neck raise

At times the monitor stops the foraging walk or swim and fully stretches its neck and turns its head from left or right to have a better view of its surroundings, giving the neck and the head a telescopic appearance.

Exclusive Behaviour VII: Dip

Individuals dipped their snout inside water while foraging for food in water, or from the bank. While on the bank they dipped their snout inside the water to search for food.

Exclusive Behaviour VIII: Sudden stall

Continuous foraging walk or swim is interrupted by sudden stalling for a few minutes and then the tongue flicking and walk/swim continues.

Exclusive Behaviour IX: Climbing

Going up a tree using two pairs of limbs accompanied by the hook shaped nails and the long tail with occasional tongue flicks, in search for food.

Exclusive Behaviour X: Dive

Leap into the air such that all four limbs leave the substrate and landing or plunging in water with a heavy splash usually from a tree or some other elevated surface, followed by a quick swim.

Exclusive Behaviour XI: Underwater Dive

While diving in the pond, the whole body goes underwater instantly. The animal resurfaces in a while.

Functional category II: Maintenance

Behavioural category I: Feeding

Exclusive Behaviour I: Grab

Rapid forward movement of the head in order to grasp the food using the jaws. The food is held horizontally in the jaws in order to get grip.

Exclusive Behaviour II: Jerk

Shaking the head sideways while grabbing the food in the jaws in order to kill the prey completely.

Exclusive Behaviour III: Swallow

Engulfing the entire food (anterior part first) by directing the head upwards followed by stretching and nodding of the neck.

Exclusive Behaviour IV: Gape

After engulfing food, the monitor let its mouth wide open to take in air. If the food is dry or bigger in size it takes more time to engulf and hence becomes difficult to pass through the throat. This might be the reason behind the high oxygen demand post swallowing the food (Hicks *et al.* 2000), engulfing the food might sometimes be followed by wide opening of the mouth to take in air.

Exclusive Behaviour V: Wipe

Wiping or encircling the mouth with tongue after the food is down the throat.

Exclusive Behaviour VI: Drinking

The snout is placed in water while the monitor sips water using its tongue.

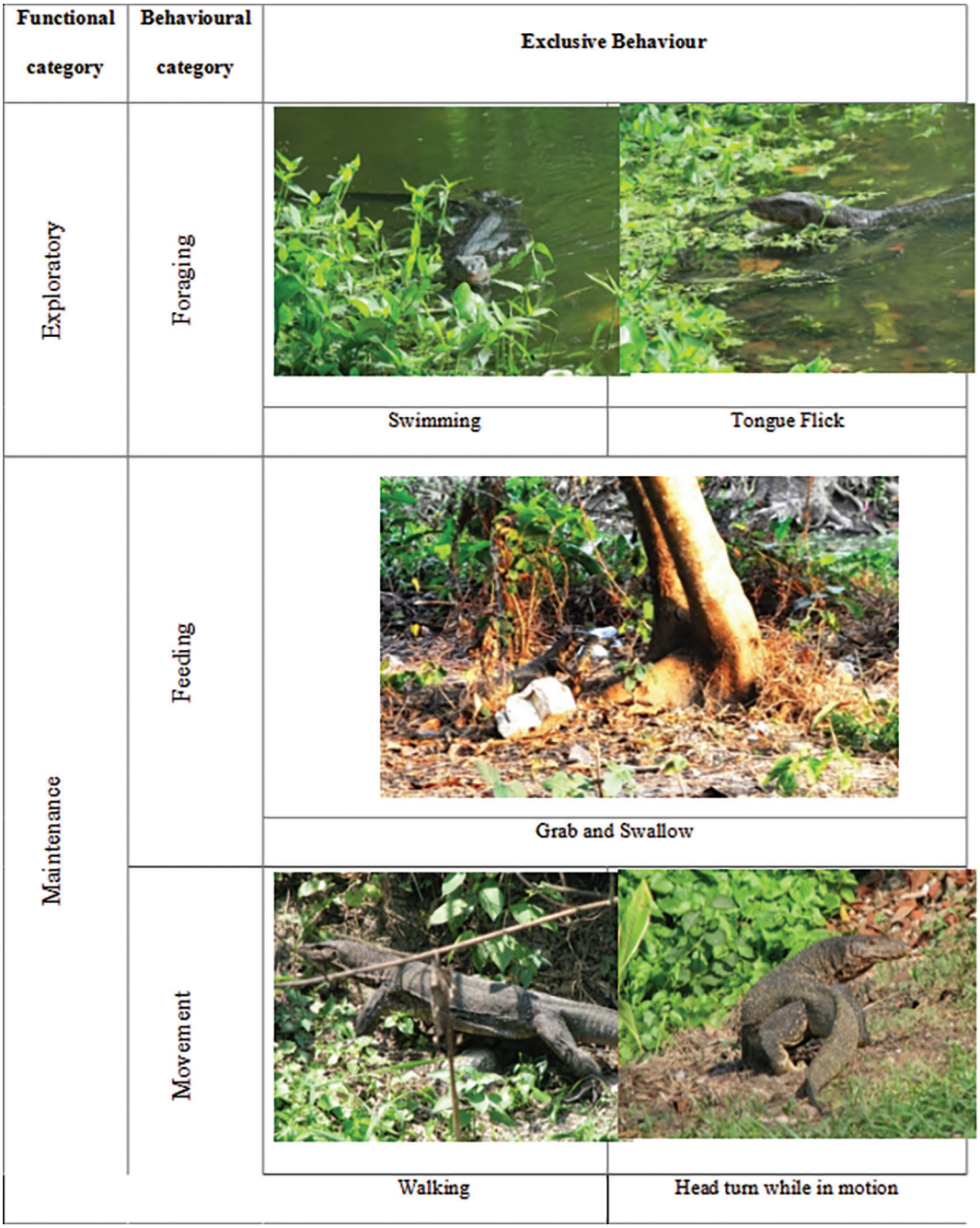

Figure 2. Behavioural patterns of the Asian Water Monitor

Behavioural category II: Movement

Exclusive Behaviour I: Walk

A swift forward movement of the body on land without tongue flicking. The hind limbs land 3–4 cm away from the fore limbs. Walking is a wavelike movement of the body and the body forms both the crest and trough in a single crawl.

Exclusive Behaviour II: Slow motion

Unrushed movement or gentle forward movement of the body at a pace far slower than that of the normal walk. Hind limbs lands 4–8 cm away from the fore limbs.

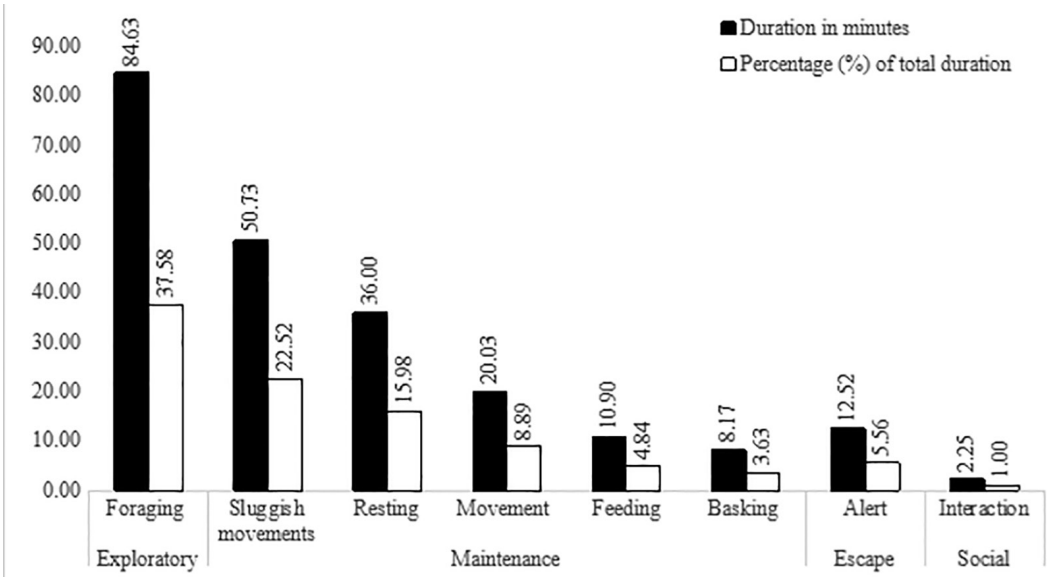

Figure 3. Duration of different behavioural activities of *Varanus salvator*

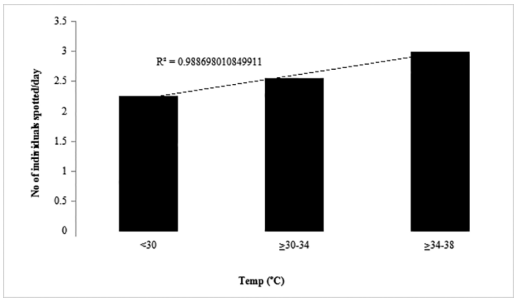

Figure 4. Number of individuals observed in different temperature intervals.

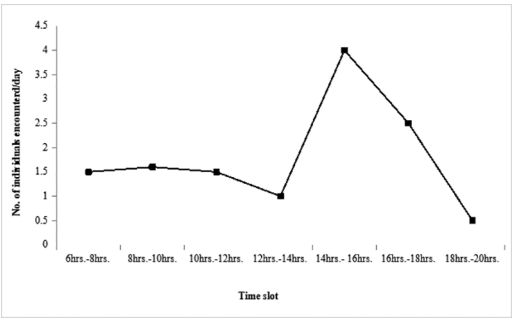

Figure 5. Activity of *Varanus salvator* spotted in different periods of a day.

Exclusive Behaviour III: Run

While escaping from anthropogenic disturbances or on coming in very close proximity to humans, monitors increase their pace of walking and move fast by raising the body off the ground. While running only certain part of their tail stays in contact with the ground surface.

Exclusive Behaviour IV: Floating

It implies swift locomotion in water or swimming which does not involve foraging. The spindle shaped body aids in efficient movement through water while the tail helps in steering or changing direction. While floating, only the head remains above water surface and portions of dorsal part of the body and the tail is visible.

Exclusive Behaviour V: Head turn while in motion

Swaying the head right and left to have a view of the surroundings while the monitor is either floating or walking.

Exclusive Behaviour VI: Leap

Jump into the air from a tree trunk or some other substrate towards the ground such that all four feet leave the substrate.

Behavioural category III: Sluggish or restricted movements

The behavioural category sluggish or restricted movements deals with lazy unenergetic behaviours showing hardly any or very little motion and almost no locomotion.

Exclusive Behaviour I: Stand still

Stalling or showing no or very little movement for a considerable time. The lower part of the body i.e., from the neck up to the tail is in contact with the surface, while the neck is above the ground (but not fully stretched) and the monitor is gazing in a particular direction for quite some time (may extend up to 15 minutes) in the stand-still position.

Exclusive Behaviour II: Throat expansion

Motionless stalling is accompanied by gazing in a particular direction and expanding and contracting the throat at regular intervals; may be followed by a few tongue flicks.

Exclusive Behaviour III: Yawn

Throat expansion sometimes followed by a yawn i.e., opening the mouth wide and exposing the region inside the mouth. Individuals show such activity as a sign of being tired and wanting to rest. Mostly seen in the afternoon.

Exclusive Behaviour IV: Jaw licking

A yawn is followed by licking the upper and lower jaw using tongue. Just after a yawn the individual wipes its mouth and starts walking. After this the individual is not seen to be very active and either goes for basking or rests.

Exclusive Behaviour V: Scrape

Rubbing the mouth to a hard surface (for e.g., tree trunk or any solid substratum). Mostly observed in juveniles.

Exclusive Behaviour VI: Head raise

Raising the head lateral to the body to some height.

Behavioural category IV: Resting

Exclusive Behaviour I: Lie flat

The whole body is kept in contact with the surface while the monitor is lying motionless under the shade with the forelimbs directed backwards tucked close to the body and hind limbs placed sideways. The body looks even more bulky and D shaped. A monitor can rest for hours at a stretch lying in the same position with eyes open (lack of eyelids) while the nictitating membrane covers the eyes at times and opens again like a high-speed shutter of the camera.

Exclusive Behaviour VII: Watching around

Looking sideways by turning the head and neck while resting.

Behavioural category V: Basking

Exclusive Behaviour I: Bask flat

A monitor lying in the open with the dorsoventrally flattened body against the substrate with all the body parts touching the surface and often sunbathing (on the ground or on the trunk of trees) in this position.

Exclusive Behaviour II: Head and neck stretch

Basking while stretching the neck and moving the head upwards.

Exclusive Behaviour III: Head rest

Head and neck stretch are followed by head rest wherein the monitor resumes lying in a flat position while being under the sun.

Exclusive Behaviour IV: Repositioning

While basking the monitor changes its position frequently so that every part of the body is exposed to the sunlight equally.

Functional category III: Escape

Behavioural category I: Alert

Exclusive Behaviour I: Halt

On land or in water continuous walk/swim is interrupted by pausing for a few seconds/minutes to observe their surroundings before continuing the walk.

Exclusive Behaviour II: Flee

On coming in close proximity to humans (or other disturbances), monitors increase their pace and move fast or change the direction of their crawl by raising the body off the ground and creating heavy thumping sound. Sometime the run is not continuous; it runs a certain distance, pausing to look behind in order to keep an eye on the individual.

Functional category IV: Social

Behavioural category I: Interaction

Exclusive Behaviour I: Chase away

Smaller sized individuals of *V. salvator* are chased by the dominant and larger ones.

Exclusive Behaviour I: Submissive

A thrust of the body in water when chased by another individual of larger size, followed by the one that submits to the interaction getting displaced from that area. This involves direct one on one interaction.

Behavioural pattern

Quantification of each behavioural category of the Asian Water Monitor reflects that in a day they devote most of their time (76.08% of the total activity duration) to three activities, foraging (84.63 mins, 37.58%), sluggish movements (50.73 mins, 22.52%) and resting (36 mins, 15.98%). Here all activities including resting or sleeping have been considered a behaviour.

Regardless of a massive time spent foraging, very little effort is transformed into feeding (10.9 mins, 4.84%). The monitors are very curious animals and hence remain alert (12.52 mins, 5.56%) mostly due to anthropogenic disturbances such as eye contact or sudden encounter with villagers while bathing in the pond. Basking (8.17 mins, 3.63%) is another common behaviour practiced by *V. salvator*, particularly in the late afternoon for a very limited period of time (Fig. 3). The duration of basking might be less but the sighting frequency is maximum in the afternoon. It is very evident from Fig. 5 that the sighting frequency of the monitor lizards are quite considerable throughout the morning i.e., 6 am–10 am, decreasing very steeply from 12 pm–2 pm and then peaking between 2 pm–4 pm, followed by a gradual drop in activity. It can be inferred from this figure that late afternoon is the best time for foraging since the monitors in the study sites are coexisting with humans. Human activity is low in late afternoon (2pm to 4pm) and increases between 12 pm – 2 pm and in the evening, when human activities like bathing, washing etc. increase. The period between 2 pm–4 pm is the time when the villagers show least activity and this is the time when the monitor lizards are the most active. Therefore, the monitor's activity time does not coincide with human activity time or shows very little overlap. Comparing daily temperature with the activity of monitor lizards (Fig. 4) showed a positive correlation (r = 0.988). Though it is not possible to draw any conclusions from this relation, given the limited sampling, the trend of increase in activity with temperature can be studied further. As the study was conducted in the non-breeding season of the animal, no mating behaviours were documented.

Discussion

Preparing an ethogram is an introductory process for any kind of behavioural study. This study clearly reveals all the behaviours observed during the study tenure (total 39 exclusive behaviours clustered into eight behavioural categories and four functional categories) of *V. salvator* during their non-breeding period. The repertoire (along with the pictures) was an effort to describe every aspect of each behaviour of *V. salvator* observed during the brief study period in its wild habitat, which actually helps to understand their overall activity and resource utilization regime.

Among all the behaviours, the monitor lizards devote maximum activity time to foraging (84.63 minute, 37.58%). Their feeding behaviour reflects that these monitors are active hunters and swallow the prey entirely. Along with fishes, rat, and aquatic invertebrates, *V. salvator* was also found to hunt snakes for food. Sighting frequency followed by different behavioural activities of monitor lizards are maximum in the afternoon in both the study areas. Budgebudge area is a village, densely populated by human where anthropological activity is less in the afternoon as compared to mornings and evenings. Meanwhile, CKBS is situated just beside a broad metallic road where the frequency of cars passing by this area is less in the afternoon. The study also highlights the fact that the activity of *V. salvator* increases with increase in atmospheric temperature.

This ethogram clearly depicts the overall behavioural patterns of the species in its non-breeding period and the reasons behind their survival in a highly congested human habitat. It is to be noted that observations made on field might be altered by the presence of the observer or interactions such as eye contact between the animal and the observer. Also, we note the incomplete nature of the present ethogram since we undoubtedly failed to document all the behaviour exhibited by *V. salvator* during the non-breeding period. Though the study primarily aimed at understand the behavioural differences in the

two sites having different characteristics, there were no significant differences observed and it is difficult to draw any conclusion from the limited sample size (observation time of each behaviour) and time. Hence, the behaviour data from both the sites were pooled for consistency in the statistical analysis. With a larger sample size and a greater input of time one can draw concluding results on the differences in behaviour amongst the two sites and also amongst different age groups in *V. salvator*.

Eating snakes (both venomous and non-venomous) in the villages and controlling their population enhances the credibility of monitors in front of the local villagers, because according to the popular belief venomous snake is more harmful to human rather than monitor lizards. This positive existence value helps them co-exist with the humans in these localities. Apart from increasing the activity in the afternoon, it separates its niche from humans and avoids any serious conflicts. This study was conducted under a time constraint, but still gives a wholesome idea about their behaviour during the non-breeding season and the reason behind their sustainability in these highly populated human altered ecosystems.

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