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The Wildlife week 2015 this year in Tamil Nadu was celebrated in a grant way lead by the Tamil Nadu Forest Department. This was done in collaboration with a variety of stakeholders from through out the State. The programme was inaugurated on 2nd October 2015 at Vidya Karthik Kalyana Mandapam, Thripur. Prior to the event a series of meetings were organized at the office of the Project Tiger Addl. PCCF, Coimbatore by the invitation of Dr. V.T. Kandasamy IFS, inviting all the department staff and NGOs to plan the event. Later the exhibition event was coordinated by DFO C.H. Padama IFS, ACF Vidya and others.

On 2nd October 2015, Tamil Nadu Forest Department celebrated the Wildlife Week at Tiruppur presided by Hans Raj Sharma IAS and the TN Environment and forest minister Sri. M.S.M Anandan inaugurated the event. Cultural events highlighting the importance of wildlife and the need for its conservation was organized. The performers were mainly the students and community people from all over the state. The day-long programme attracted public, school and college students. The entire even was attended by more than 15 thousand people.

Many parallel events were organized for the benefit of the public and also to create awareness among people about wildlife conservation. One such event was stalls by NGOs, forest department staff and welfare boards. Nilgiri Natural History Society, SACON, Keystone Foundation, TRAFFIC India, WWF, Oosai, Wildlife and Nature Conservation Trust, Arulagam, FEO, MPDA, KANS Trust, ZOO and Tiger Reserves, TNFD are some major organizations participated.

ZOO set up a stall highlighting the lesser know fauna and all wildlife conservation related activities carried out by the organization.

Most of the stalls were set on the previous day which was visited by the TN Environment and Forest Minister. The event on the 2nd October started at 8.30 am. The minister along with most of the forest department staff visited the stalls and declared open for the public which was kept until 4.pm. About 5 thousand people visited the stalls and benefited.

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Management of Dystocia in a Four-horned Antelope (*Tetracerus quadricornis*)
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**Introduction**
Dystocia is defined as difficult or abnormal birth (Aiello *et al.*, 2005) wherein the labor is abnormally prolonged. Uterine inertia, inadequate birth canal, fetal oversize, abnormal fetal predisposition in the birth canal, feto-pelvic disproportion, twins, incomplete cervical dilatation and uterine torsion are some of the common causes of dystocia in farm animals (Aiello *et al.*, 2005; Bliss, 1988) leading to dam and neonatal mortality and hence heavy economic losses to dairy animals (Arthur *et al.*, 2000; Thomas, 1990). Causes of dystocia and its management has been widely studied in farm animals but very little is known about dystocia in free living and wild ruminants or zoo animals as cases are either rare or are not diagnosed (Pople *et al.*, 2001).

Four-horned antelope belongs to family cervidae and is found in tropical seasonal forests. It is placed in schedule I in India Wildlife (Protection) Act 1972. It feeds on a variety of plants including grasses, foliage, fruits and a wide variety of shrubs and trees. The gestation period of four-horned antelope is 7.5-8 months although higher gestation length has also been reported in cervids (Jeber *et al.*, 2013). Deer usually gives birth to a single fawn, twins have, however, been also reported (Timmins *et al.*, 2008). Young fawns start taking solid food after two weeks and may start rumination after one month of age (Leslie, 2011).

Considering the paucity of literature on reproductive problems in general in cervidae and probably no report of dystocia in four-horned antelope, the present case is reported.

**Case History**
A four years old female four-horned antelope of Bondla Zoo, Goa was presented with a history of labor since last six hours but failure to deliver the fawn. The animal had already completed the gestation length of 7 months and 25 days. The approximate weight of the doe was 20 kg and temperature, respiration and pulse rate was recorded and found to be 101.0 F°, 18 per min. and 80 per min. respectively. The doe was restless but there were no signs of straining. Per vaginal examination was performed after proper restraining which revealed normal anterior longitudinal presentation, dorso-sacral position and fore limbs were extended in the birth canal. The cervix was completely dilated. The cause of dystocia was tentatively diagnosed as uterine inertia.

**Discussion**
Gestation period is highly variable in deer and it is also not possible to predict the exact time of parturition as the date of breeding is not exactly known (Chan *et al.*, 2009). Therefore, timely placenta. A course of antibiotics (Intacef 500 mg i/m), antihistamine (Anistamin 2 ml i/m), anti-inflammatory (Melonex 2 ml i/m) and B-complex plus liver extract (Bellamyl 2 ml i/m) was given for three days along dextrose 5 % saline on the first day (500 ml i.v). Oral Calcium (Calshakti platina 10 twice daily for 15 days) was also administered. Both the doe and fawn were healthy and doing well (Fig.1-4).

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intervention and veterinary aid on the basis of symptoms of labor is very important for the survival of the fawn. The case under record may be due to old age of the dam as the incidence of dystocia is rare in young does and increases as the age of the animal increases (Jeber et al., 2013). Any form of stress to the dam including human disturbance, sudden change of weather may interrupt the process of parturition (Mosdol, 1999). In the present case the uterine contractions were absent and hence the case may be because of uterine inertia as has also been reported in the past (Audige et al., 2001). The case was relieved by manual traction and resulted in uneventful delivery of the fawn and recovery of the doe.

Acknowledgement
The authors would like to thank to APCCF (Wildlife), Goa Forest Department for providing the necessary facilities to carry out research work.

References


Black-bellied Tern (*Sterna acuticauda*) is an Endangered bird species with a current estimated population size of around 6700-17000 mature individuals globally (BirdLife International 2012). The bird is described as “characteristic of large rivers and marshes” preferring habitats such as the river banks with large sandpits and river islands. Although this species is distributed widely (extending from Pakistan, through Myanmar, Thailand and Indochina), it is scarce throughout its distribution. In India, the species is believed to be a resident on large rivers, extending from Gujarat in the west to Arunachal Pradesh in the east, and Punjab in the north to old Andhra Pradesh in the south. It is winter visitor to Kerala, south India (Grimmett et al. 2011). The species is now rare through its range and hardly any quantitative information is available on its population status in India. In Odisha, it was recorded in Bhitarkanika National Park, Chilika Ramsar sites and Chandaka Wildlife Sanctuary (Tiwari et al. 2002; Gopi and Pandav 2007; Balachandran et al. 2009). Odisha can be considered as a region that could offer long-term survival for the Black-bellied Tern, as three large rivers and several medium sized rivers flow across the state and form several river islands in the eastern part of the state. The Black-bellied Tern was kept under the Near Threatened category and later on shifted to Endangered category in 2012 by IUCN, as the species was rare than it was thought to be. Destruction of breeding habitat, the collection of eggs for food and overfishing are some of the threats reported globally as the reasons for its rapid population decline (BirdLife International 2012).

While carrying out biodiversity survey in different areas of Odisha during 2010 to 2013, I observed Black-bellied Tern from Hirakud Reservoir (21°41′3N. 74′′, 83°40′48.6′′E), Satakiosa Gorge (20°35′51.6′′N, 84°46′45.7′′E) and Mundali (20°27′2.7′′N, 85°44′32.3′′E) in the river Mahanadi; Samal Reservoir (21°4′39.8′′N, 85°9′10.3′′E) in the river Brahmani. These were mostly unprotected areas adjacent to human habitation. Sand extraction for development purpose, rampant fishing and disturbance of breeding habitat by fisherman or local people were seen in these areas. Such disturbances add pressure on this Threatened bird in Odisha.

Conservation and protection of the species is now important due to global population decline. Therefore, strict vigil is required to conserve the Black-bellied Tern breeding habitat, by forest department with the participation of NGOs and local people in the form of patrolling and educating the masses. Special care should be taken, providing safety to nesting areas to prevent damage of eggs by domestic animal and local people. Furthermore, a long-term scientific study and regular monitoring are urgently required to understand the population status of this endangered bird species in Odisha.

**Acknowledgements**

I would like to thank Mr. Tim Inskipp, for his comments in improving the manuscript.

**References**


Melanistic mammals deviate from the recognized colour morph of the type specimen of a species by having a much darker pelage colour and absence or reduction of pelage patterns distinguished by brown or white hairs. There is a paucity of information on melanism in cervids in general and Spotted Deer *Axis axis* in particular. Previous record of melanism in cervids has been reported for White-tailed Deer (*Odocoileus virginianus*) by Wozencraft (1979); Smith *et al.* (1984) and Baccus & Posey (1999).

A melanistic male Spotted Deer or Chital *Axis axis* (Erxleben, 1777) was sighted and photographed (Fig 1) by first author at 12.43 PM on 14th January 2014 in Muthanga Forest Range (Geo-coordinates: N 11.66492, E 76.41034) of Wayanad Wildlife Sanctuary of Kerala state in India. This melanistic colour morph chital was found grazing in the grassland along with two other normal colour males at a distance of approximately 300 m from our vehicle. In this particular month, bachelor herds of 40-50 chital stags were also witnessed. Antler of one normal male was grown but in velvet and another normal male was with two tines of antler in velvet while the antlers of melanistic colour morph chital had just rounded outgrowths (Fig 2). On the same day after 10 minutes’ drive further at 12.55 PM, another melanistic colour morph chital was sighted on the edge of main tourist road (Geo-coordinates: N 11.66579, E 76.38879) hardly 2 km from the Muthanga range office (Fig 3). This individual was in a herd of about 7-8 chital, mostly females. The sex of this melanistic colour morph chital could not be determined because as soon as we spotted this individual, the herd started rushing back into the thick understorey away from our vehicle. Antler was not present in this colour morph chital and pelage was blackish to dark brown in colour.

Colour morph or in some cases complete melanistic chital are rarely seen, though reported in case of White-tailed Deer (Baccus & Posey, 1999). Incidence of melanistic morphs in mammalian populations is generally rare but may vary temporally and spatially. Thus a melanistic morph of Chital is an unusual phenomenon in nature. We can only assume that this morphism may probably serve as an adaptation to the extremes of environmental variation.

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We like to thank Mr. Ravi Singh, SG & CEO of WWF-India for encouragement throughout the study. We are also thankful to Drs. Dipankar Ghose and Sejal Worah for their advices and continuous support. We would like to acknowledge Mr. D. Boominathan for arranging logistics in the field site and Kerala forest department for issuing permission and support in carrying out the study.

**References**


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During my field data collection on Human-Elephant conflict project of WWF-India, I have visited many places by tracking elephants in the O’Valley area of Gudalur forest division of The Nilgiris district. On 4th May 2014 I observed a large fast flying butterfly around Bishop Wood (Bischofia javanica) tree top. Later I confirmed the species identity with the help of experts as the Blue Nawab (Polyura screiber, Godart, 1824).

It is one of the most beautiful butterfly of the family Nymphalidae (Brush-footed butterflies). Polyura screiber measuring 90-100 mm in wing span is a dark brown butterfly with a broadly blue edged, white discal band on the upper side of the wing. Its extremely powerful wings help them remain almost exclusively among the tree tops in tall, thick jungle (Wynter-Blyth, 1957).

The place was a patch of evergreen forest with encroached human settlements within 25m. It was near a small stream with location latitude N11.45577 and long E 076.48900. Earlier sighting reports of this species were also in evergreen forests, during the months of March to May in the south India, around flowering trees, streams and animal droppings (Kehimkar, 2008). Plants such as Mouliava spicata, Rourea sanataloides (Connaracaceae) and Wagatea spicata (Leguminosae) were reported as larval host plants of Blue Nawab (Mathew, 2011).

This butterfly is distributed in Bangladesh, Myanmar and India (Kehimkar, 2008). In India, it is reported from North Kanara, Coorg, The Nilgiris, the Nadgani Ghat, Sholayar and Travancore (Mathew, 2011). This species is protected under Scheduled I of Indian Wildlife Protection Act 1972.

The presence of this species in the last remaining forest patches indicates the importance of these habitats for rare species. Further investigations involving species inventory surveys and host plant abundance evaluations will help in long term conservation planning for such species.

Acknowledgements
I am grateful to Bhoominathan Durairaj (Landscape coordinator, WWF-India, Western Ghats Nilgiris Landscape), Ajai Desai, Mohanraj, N (Project advisers) and Dr. Ashok Kumar for the encouragement and timely advices. I also thank Thejasvi I.F.S. (Divisional Forest Officer, Gudalur Division) for the support and cooperation throughout the study.

References
A Study of Gastrointestinal Parasites in Bonnet Macaque (Macaca radiata) of Pookode, Wayanad, Kerala
C.P. Arjun¹, R. Ravindran² and T. Anoopkumar³

Abstract
Bonnet macaque (Macaca radiata) is an endemic primate restricted to peninsular India. Bonnet macaque is diurnal omnivorous, feeds on a variety of diets such as fruits, leaves, insects, lichens, eggs etc. They are highly adapted to live in the wild and in human settlements and interact with humans than any other wild animal. There is a great chance for spreading zoonosis from monkeys to humans. Similar situation is observed in the Pookode Lake region (N 11.53315, E 076.02567) at southern part of Wayanad district of Kerala. Pookode Lake is one of main tourist attractions in Wayanad and also identified as one of major human-monkey conflict areas of Wayanad. A study on gastrointestinal parasites of monkeys was conducted based on identification of ova of parasites in their faecal sample. Ova of Strongyle sp., Strongyloides sp. and E. vermicularis were identified from the faeces of bonnet macaque.

Introduction
Parasites are marvelously well-adapted organisms. Their adaptations are complex since they involve intimate inter-relationship with their host, with which they co-evolved (Barnard & Behenke, 1990). The result is a counter-adaptive arms race between host and parasite with far-reaching consequences on the physiology, ecology and behaviour of both (Jog & Watve, 2005). Parasite richness and prevalence in wild animals can be used as indicators of population and ecosystem health (Teichroeb et al., 2009).

Wild primates can host an incredible diversity of parasites. More than 50 different species of parasites were documented in primates (Nunn & Altizer, 2006). Monkeys are the intermediate host of many parasites which have the potential to be transmitted to humans. Bonnet macaque (Macaca radiata) which is very common in forests of southern India, successfully adapt to almost any kind of environment and they enjoy the intense love and hate relationship with the people (Schlotterhausen, 1999).

A study was undertaken to assess the various parasites affecting the gastrointestinal system of bonnet macaque by microscopical examination of faeces for demonstration of ova of parasites.

Materials and Methods
Faecal samples of bonnet macaque were collected from an area (Fig 1) near Pookode Lake (N 11.53315, E076.02567), which is identified as one of the major man-monkey conflict areas of Wayanad. Examination of faecal samples for parasitic ova was conducted to study gastrointestinal parasitic diversity. They were collected using a scalpel from the ground and stored in collection bottles. They were processed for concentration of ova present in them through sedimentation by centrifugation. Briefly, 5-10g sample was mixed with 12 ml of water in a mortar and triturated with the help of a pestle. The mixture was passed through a sieve to remove coarse debris. The filtrate was collected in a test tube and then centrifuged at 2000 rpm for 2 minutes. The sediment was collected after discarding the supernatant. A drop of the sediment mixed with water was examined using 10X objective of a compound microscope after putting a cover slip. Parasitic ova were detected based on the descriptions provided by Soulsby (1982).

Results and Conclusions
A total of 20 faecal samples of bonnet macaque were collected. Ova of three gastrointestinal parasites were observed viz., Strongyle sp. (4), Strongyloides sp. (2) and Enterobius vermicularis (1). Coop & Holmes (1996) reported that, the gastrointestinal nematodes reduce voluntary food intake, efficiency of food utilization, and increased endogenous loss of protein into the gastrointestinal tract. Hence, the presence of these worms in the gastrointestinal tract definitely affects the general health of the monkey.

Fig 1. Map of study area near Pookode Lake, Wayanad, Kerala

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Ova of Enterobius were reported from bonnet macaque. They were colourless and showed thick shell flattened on one side. Previously, E. maca was reported in Japanese macaque, (Macaca fuscata) (Hasegawa et al., 2012). However, its presence in bonnet macaques from India is not known. Other species seen in primates include E. buckleyi and E. (E.) anthropopithecus in chimpanzee. E. vermicularis is common in human children and transmitted via the faecal-oral route. Humans are the only natural host of E. vermicularis (Panidis et al. 2011). E. gregorii, another human species is morphologically indistinguishable from E. vermicularis except the spicule size (Hasegawa, 1998). There are no reports on the presence of E. gregorii from India.

Acknowledgement
We are grateful to Dr. George Chandy (Director in charge, Centre for Wildlife Studies, CV & AS, Pookode, Wayanad) for the encouragement and support. We also thank the Kerala Forest and Wildlife Department for granting us study permits.

References
Records of Albinism in Spotted Deer *Axis axis* from India: A Review with addition from Pench National Park, Madhya Pradesh

Amit Sayyed¹, Anil Mahabal² and D.P. Shrivastava³

Spotted Deer *Axis axis* (Erxleben, 1777) (Artiodactyla: Cervidae) is most common, wild, visible deer distributed throughout India with substantial population. Its coat colour varies geographically, becoming reddish in southern India (Menon 2003). Further, he has stated that in mammals, the coat colour changes to certain extent due to surrounding environment and ecological conditions and also due to age, sex, nutritional and health status. Menon (2003) has also pointed out that mammals show individual coat or pelage differences and this is particularly so in the case of genetic colour aberrations such as albinism and melanism. Albinism is characterized by absence of melanin pigment resulting in the total white body with pink limbs, snout and ears. Eyes appear red due to blood capillaries visible through colourless tissue. Whereas, in melanism, there is presence of excess amount of melanin pigment resulting in the dark or black coat colour.

### Table 1: Records of albino Spotted Deers from different parts of India

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of colour aberration, No. &amp; Sex (if any)</th>
<th>Locality &amp; Date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Albino-one female</td>
<td>Doon (Dehra Dun), Uttarakhand, November 1931</td>
<td>Atkinson (1932)</td>
</tr>
<tr>
<td>2.</td>
<td>Albino-one adult male</td>
<td>Crawford Market, Mumbai, Maharashtra (for Sale), 1942</td>
<td>Ram Singh (1942)</td>
</tr>
<tr>
<td>7.</td>
<td>Albino-one fawn</td>
<td>Kantarsingh, Labangi section of Pampasar forest range, Satkosia Tiger Reserve, Odisha. 5 June 2014</td>
<td>Pradhan et al. (2014)</td>
</tr>
<tr>
<td>8.</td>
<td>Albino-one young with normal-coloured adult*</td>
<td>Core area, Pench National Park, Madhya Pradesh. 23 January 2015</td>
<td>Observer: 3rd author (DPS)</td>
</tr>
</tbody>
</table>

*Additional records

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The third author (DPS) visited the Pench National Park, Madhya Pradesh on 23rd January, he sighted a young albino Spotted Deer along with a normally coloured adult in the core area of the forest. The young deer was totally white and reddish eyes (Fig 1). A perusal of literature revealed that there are seven previous records of albino Spotted Deer from different parts of India (Table 1) and the present sighting of albino Spotted Deer *A. axis* is an additional record from Pench National Park (22°0’59.82” N; 79°49’46.82’ E), Madhya Pradesh (Table 1). It seems to be a first record from the State.

**References**


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Earthworms of Indian Botanic Garden, Kolkata
Rinku Goswami¹ and Abhik Gupta²

Abstract
The present study was carried out during 2012-2014 at Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah. Out of the total 1805 earthworms collected, 14 species were identified belonging to 7 genera under 3 families and 2 orders. Among these, one species *Metaphire birmanica* is new in this state.

Introduction
Earthworms, belonging to the Phylum Annelida and class Oligochaeta are widely distributed throughout the world but dominant in the temperate and tropical soils. Their population contributes about 80% of total biomass of the soil ecosystem.

Michaelsen (1900) was the first to make comprehensive investigations into earthworm taxonomy based on few morphological characters. His seminal work together with Stephenson’s contribution (Stephenson, 1930) to earthworm systematics published thirty years later, has constituted the backbone of the classical phylogenetic system of earthworms. Later, several contributors studied and developed new systems of oligochaete classification. Studies are being continued till today and now the described earthworm species is approximately 4400 worldwide (Sinha 2009) described in 20 families (Reynolds and Cook, 1993; Blakemore 2010).

At present the Indian earthworm fauna comprises about 590 species placed in 10 families and 69 genera (Julka et.al. 2009). Out of these, 67 species of earthworms are known to occur in West Bengal. Perrier (1872) was first to report of an earthworm species *Perichaeta houlleti* from West Bengal. Later Beddard (1883, 1900, 1902), Michaelsen (1907, 1910), Stephenson (1916, 1917, 1931), Gates (1937, 1945 a,b), Halder and Julka (1967), Julka (1975), Soota and Halder (1977), Halder (1998), Chowdhury and Hazra (2008, 2009), Sharma et.al. (2008), Bandopadhyay et.al. (2008), Biswas et.al. (2008), Chowdhury et.al. (2010), Goswami and Mandal (2014), contributed substantially to the taxonomic studies of earthworm from West Bengal.

To know the present state of earthworm fauna of West Bengal several systematic field surveys are being conducted by different workers. One such study on earthworms was conducted in the unexplored Acharya Jagadish Chandra Bose Indian Botanic Garden to find ecological diversity based on identification and classification of collected earthworms. Out of the total 1805 earthworms collected, 14 species were identified belonging to 7 genera under 3 families and 2 orders. Earthworm species were identified based on their external morphology and internal anatomy and using existing taxonomic keys. Among these, one species *Metaphire birmanica* is new to this state.

MATERIALS AND METHODS
Study Area
The Acharya Jagadish Chandra Bose Indian Botanic Garden (IBG) was chosen as the study area. The garden covers an area of about 273 acres on the west bank of river Ganges (Hooghly) near Howrah. The garden is scientifically planned, and plants of the same group are grown together. Five distinctively different areas in IBG are chosen as per plantation for conducting the present study: each specified for growing cluster of similar types of plants in a specified area.

The study area is characterized by rainy season from June to September. It is situated in the hot moist sub-humid agro-ecological situation having annual rainfall between 1100 to 1500 mm of which 75-80% received during June to September. The mean annual maximum and minimum temperature fluctuates from 40.2° to 10.8° C and relative humidity ranges between 66 to 85%. The soils of this district have been formed from the alluvium deposited by river Ganga and its tributaries.

Earthworm Sampling
Sampling was carried out monthwise for the period of two years from June 2012 to May 2014 for a separate ecological study. Living earthworm samples were collected by digging and hand sorting method. The worms were narcotised in 70% alcohol and then washed and preserved in 10% formalin with proper labelling. The specimens were studied under the Leica EZ4 stereozoom microscope. All the studied specimens are deposited to National Zoological Collection (NZC) of Zoological Survey of India, Kolkata. Registration numbers provided in material examined.

GPS of five habitats

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Following photo plates are showing the external genital organs of earthworms collected from IBG along with two castings.

**SYSTEMATIC ACCOUNT**

**Class:** OLIGOCHAETA  
**Order:** Haplotaxida  
**Family:** Megascolecidae

**Key to genera of the family Megascolecidae of Indian Botanic Garden (IBG)**

1. Nephridia stomate, holonephric; colour usually reddish to violet; gizzard vestigial, in segment v or vi ........................Perionyx  
Nephridia astomate, meronephric; usually brown and slate coloured; gizzard well developed..............2  
2. Gizzard in front of 7/8...........3  
Gizzard behind 7/8 ..........................4  
3. Female pores in xiv, male pores in xviii ............................Lampito  
4. Male pores discharging directly onto body surface...........Amynthas  
Male pores discharging into copulatory pouches opening onto body surface through secondary male pores............................Metaphire

**Genus 1. Amynthas Kinberg, 1867**


**Type Species:** *Amynthas aeruginosus* Kinberg, 1867.

**Distribution:** Oriental and Australasian regions, Oceania

**Key to the species of the genus Amynthas of Indian Botanic Garden (IBG)**

1. Spermathecal pores four pairs in furrows 5/6/7/8/9 ..............2
2. Precitrellar genital markings absent....................A. alexandri

1. **Amynthas alexandri** (Beddard, 1900)


**Diagnosis:** Length 137–178 mm., diameter 4–6 mm., 112–130 segments. Colour dark brown on dorsum. Prostomium rudimentary.

**Type locality:** Probably Kolkata, West Bengal, India.

**Habitat:** Found in several habitats like bamboo, keora and flower garden, waste lands & deciduous forest.

**Materials examined:** 3 exs.: Keora habitat, IBG Howrah; 21.vii.2012; R. Goswami coll; An 4056/1 ZSI. 3 exs.: Flower garden habitat, IBG Howrah; 3.x. 2013; R. Goswami coll; An-SZ54 ZSI. 1 ex.: Keorahabitat, IBG Howrah; 23.vii.2014; R. Goswami coll; An-SZ23 ZSI.

**Distribution:** India: West Bengal – IBG Howrah; Kolkata; Darjeeling and Jalpaiguri districts; Andaman and Nicobar Islands; Assam; Himachal Pradesh; Madhya Pradesh; Maharashtra; Uttar Pradesh.

**Remarks:** This species was earlier known as *Pheretima alexandri*. Sims and Easton (1972) recorded the genus *Pheretima* into six different genera and now the species is known as *Amynthas alexandri*.

**Genus 2. Lampito Kinberg, 1867**


**Habitats:** Soil with abundant organic matter like leaf litter, compost pit and manure heap. Grassland, forest, sewage canal, kitchen drainage.

**Materials examined:** 7exs.: Flower Garden habitat, IBG Howrah; 8.viii. 2012; R. Goswami coll; An 4069/1 ZSI. 2 exs.: Conifer habitat, IBG Howrah; 13.iii.2013; R. Goswami coll; An4155/1 ZSI. 7exs.: Flower garden habitat, IBG Howrah; 19.ii.2014; R. Goswami coll; An-SZ101 ZSI.

**Castings:** Small heaps of threads constricted to small ball like pellets on the surface of soil.

**Distribution:** India; West Bengal- IBG Howrah; Andaman and Nicobar Islands; Andhra Pradesh; Bihar; Gujarat; Karnataka; Kerala; Laccadive and Minicoy Islands; Madhya Pradesh; Maharashtra; Orissa; Rajasthan; Tamil Nadu; Uttar Pradesh.

**Outside India:** Zanzibar, Comoros., Madagascar, Seychelles., Mauritius, Pakistan, China, Maldives, Sri Lanka, Bangladesh, Myanmar (Burma), Thailand, Malay Peninsula, Indonesia, Philippines, Hong kong, New Caledonia.

**Remarks:** Its origin is in India (Western Ghats of South India), but first discovered from Mauritius.

**Economic Importance:** These worms are suitable as waste conditioners. Used as fish bait and also fish and chicken feed. It can control plant parasites.

**Genus 3. Metaphire Sims & Easton, 1972**


**Type species:** *Rhodopis javanica* Kinberg, 1867.

**Distribution:** Oriental region from Japan southwards through the Indo–Australasian.

**Key to the species of the genus *Metaphire* of IBG**

1. Male pores on segment xx..............................*M. anomala*
   Male pores on segment xviii.............................2
2. Spermathecal pores 4 pairs located in furrows 5/6/7/8/9;
   Genital markings paired on equators of segments xvii and xix..............................*M. posthuma*
   Spermathecal pores 3 pairs.............................3
3. Spermathecal pores in furrows 5/6/7/8;
   Genital markings absent..............................*M. birmanica*
   Spermathecal pores in furrows 6/7/8/9. Invaginated spermathecal pores recognizable internally by the presence of stalked glands. Genital markings small, within copulatory pouches..............................*M. houlleti*
   Genital markings 2 pairs across 17/18 and 18/19 ........................................*M. peguana*

**3. Metaphire anomala** (Michaelsen, 1907)


**Diagnosis:** Length 102–151 mm., diameter 5–5.5 mm., 127–130 segments. Colour light, reddish on dorsum. Prostomium epilobic, tongue open. Clitellum annular. Female pore single, median, presetal, on xiv. Spermathecal pores absent (athecal morphs). Genital markings paired, discoidal papillae, on setal arcs of xviii–xxii, sometimes on xvii and xxiii, occasionally on xxiv (one of the marking either on left or right side on xvii, xxiii, xxiv may be lacking).

**Type locality:** Botanical Garden, IBG Howrah near Kolkata, West Bengal, India.

**Materials examined:** 1ex.: Flower garden habitat, IBG Howrah; 4.xii. 2013; R. Goswamicoll; An-SZ92 ZSI.

**Distribution:** India; West Bengal: IBG Howrah; Kolkata; Himachal Pradesh, Madhya Pradesh.

**Outside India:** Myanmar (Burma), Thailand, Vietnam, China.

**Remarks:** This species is not common in India. In west Bengal A morph of anomala group (Gates, 1972) is found in and around IBG of Howrah.

**4. Metaphire birmanica** (Rosa, 1888)


**Habitat:** Flower garden, grass lawn, bamboo habitat, paddy field, soil with manure, under the stone and forest of hills. Prefers to stay in the deep clay.

**Materials examined:** 4exs.: Flower garden habitat, IBG Howrah, 21.xi.2012; R. Goswami coll; An4114/1 ZSI. 5exs.: Flower garden habitat, IBG Howrah; 11.xi.2013; R. Goswamicoll; An-SZ75 ZSI.

**Type locality:** Bhamo, Myanmar (Burma).

**Distribution:** India, West Bengal: IBG Howrah, Kolkata, Himachal Pradesh, Uttar Pradesh.

**Outside India:** Myanmar (Burma).

**Remarks:** Regeneration of tail region is possible.

**5. Metaphire houlleti** (Perrier, 1872)


**Type locality:** Kolkata, West Bengal, India.

**Materials examined:** 1ex.: Flower Garden habitat, IBG Howrah; 15.x.2012; R.Goswami coll; An4107/1 ZSI. 1ex.: Keora habitat, IBG Howrah; 19.ix.2013; R.Goswami coll; An-SZ28 ZSI.

**Habitats:** Garden soils, marshy soil, soil with stones, rotten and wet leaves of bamboo, under logs, deciduous forest.

**Distribution:** India: West Bengal–IBG Howrah, Kolkata, Jalpaiguri; Andaman.

**Remarks:** This is a very rare species in India and reported to occur only from Kolkata and Howrah. Originated in Myanmar.

7. *Metaphire posthuma* (Vaillant, 1868)


**Diagnosis:** Length 75–140mm., diameter 4.5–5 mm., 100–113 segments. Colour light to dark grey, brown. Prostomium epilobic, tongue open. Combined male and prostatic pores paired, minute and invaginated on xviii. Female pore single on xiv. Spermathecal pores minute, superficial in furrows 5/6/7/8/9. Genital markings paired, circular papillae with centres slightly median to male pore lines on setal arcs of xvii and xix, rarely xx.

**Type locality:** Java, Indonesia.

**Material examined:** 1ex.: Bamboo habitat, IBG Howrah; 21.vii.2012; R. Goswami coll; An4039/1 ZSI. 16exs.: Conifer habitat, IBG Howrah; 29.viii. 2013; R. Goswamicoll; An-SZ160 ZSI.

**Habitats:** Garden soil, deciduous forest, banana groves.

**Distribution:** India: West Bengal–IBG Howrah, Kolkata, Jalpaiguri; Andaman.

**Remarks:** Lowland tropical species. According to Gates (1972) *houlleti* species has seven morphs. In West Bengal, recorded species shows H morph, larger Hp morph and smaller Hp morph.

6. *Metaphire peggana* (Rosa, 1890)


**Material examined:** 14exs.: Conifer habitat, IBG Howrah; 21.vii.2012; R. Goswami coll; An4054/1 ZSI. 16exs.: Bamboo habitat, IBG Howrah; 29.viii. 2013; R. Goswamicoll; An-SZ5 ZSI.

**Habitats:** Garden soil, deciduous forest, banana groves.

**Distribution:** India: West Bengal–IBG Howrah, Kolkata, Jalpaiguri; Andaman.

**Outside India:** Indonesia, Malay Peninsula, Myanmar, Thailand, Vietnam.

**Remarks:** This is a very rare species in India and reported to occur only from Kolkata and Howrah. Originated in Myanmar.

**Castings:** Small spheroidal pellets (Gates, 1930) are deposited on the soil (photo plate attached).
Outside India: Bangladesh, China, Christmas Island, Indonesia, Malaysia, Myanmar, New Hebrides, Pakistan, Philippines, Seychelles, Taiwan, Tinian, Thailand, Santa Cruz, U.S.A., Vietnam.

Remarks: These worms are very active. When touched during collection it coils immediately. Abundant in India as well as in West Bengal. Their population is highest in IBG.

Genus 4. *Perionyx* Perrier, 1872


Diagnosis: Pericaetine, setae numerous. Clitellum annular, setae retained. Combined male and prostatic pores paired, on xviii; female pore unpaired.

Type species: *Perionyx excavatus* Perrier, 1872.

Distribution: India, Myanmar, possibly Malaysia and Sri Lanka.

Key to the species of the genus *Perionyx* of IBG

1. Last pair of hearts in xii ..............................2

   Last pair of hearts in xiii ..............................3

2. Male pores transverse slits on slightly raised, transversely elliptical white areas, near mid ventral line, penial setae with spines. *P. excavatus*

   3. Male genital field with elongated penes................

      ..............................*P. simlaensis*.

8. *Perionyx excavatus* Perrier, 1872


Type locality: Ho Chi Minh City, Vietnam.

Habitats: Found mainly in moist sites with rich organic soil like manure and compost heaps, sewage sludge, at the edge of ponds, kitchen drainage and under earth’s crust.

Casting: Small slender stick like formation on top of the soil.

Economic Importance: As the rate of reproductive growth is very high, this species is used for vermicomposting, waste management and food for fish and chicken.

Materials examined: 2exs.: Conifer habitat, IBG Howrah; 21.vii.2012; R. Goswami coll; An4055/1 ZSI.7exs.: Keora habitat, IBG Howrah; 14.v.2013; R. Goswami coll; An-SZ2 ZSI. 2exs.: Flower garden habitat, IBG Howrah; 19.iii.2014; R. Goswami coll; An-SZ111 ZSI.

Distribution: India: West Bengal: IBG Howrah, Burdwan, Kolkata, Darjeeling; Andaman, Arunachal Pradesh, Assam; Himachal Pradesh; Karnataka; Tamil Nadu.

Outside India: Comoro, Dominica, Hawaii, Taiwan, Fiji, Indonesia, Malaysia, Malay Peninsula, Myanmar, Mauritius, Philippines, Samoa, South Africa, Sri Lanka.

Remarks: Endemic species and prefers a temperature range from 21° C -27° C. Cannot withstand low temperature.

9. *Perionyx simlaensis* (Michaelsen, 1907)


Diagnosis: Length 85–155 mm., diameter 3–5 mm., 139–175 segments. Colour violet red dorsally, grey ventrally. Prostomium epilobic, tongue open. Combined male and prostatic pores minute, paired, on xviii, each pore at the base of an elongate and medially grooved pene, arising from the centre of a somewhat spherical to ovoidal cushion – like large porophore, both porophores located in a broad transverse depression. Spermathecal pores paired in furrows 7/8/9.

Type locality: Dharampur, Shimla Hills, Himachal Pradesh.
Habitat: Moist place with high organic matter, bank of streams, ponds, lakes and sewage canals.

Materials examined: 5exs.: Bamboo habitat, IBG Howrah; 4.xii.2013; R. Goswami coll., An4237/1 ZSI. 8exs.: Keora habitat, IBG Howrah; 19.ii.2014; R. Goswami coll., An4252/1 ZSI.

Distribution: India: West Bengal: IBG Howrah, Himachal Pradesh; Uttar Pradesh.

Remarks: This species is endemic to Himachal Pradesh and first found in Shimla.

Family: OCTOCHAETIDAE

Key to the genera of the family Octochaetidae of IBG

1. Oesophagus with a single gizzard........................................2
2. Oesophagus with two gizzards.............................................4
3. Discrete calciferous glands present........................................3
4. Calciferous glands one pair, each gland trilobed with one vertical lobe in each of segments xv, xvi and xvii............................Dichogaster

Genus 5. Dichogaster Beddard, 1888

1888. Dichogaster Beddard, Q. Jlmicrosc. sci., 29: 251. (Type species, probably Dichogaster damonis Beddard, 1888)

Diagnosis: Lumbricine. Dorsal pores present. Clitellum, intersegmental furrows obliterated, dorsalpores occluded, setae retained. Male pores paired, in seminal grooves, on xvii at A lines; prostatic pores paired, minute, at the ends of seminal grooves on xvii and xix at A. Female pore unpaired on xiv. Spermathecal pores paired in furrows 7/8/9, at A. Genital markings absent.

Type species: Dichogaster damonis Beddard, 1888.

Distribution: India: West Bengal: IBG Howrah, Kolkata, Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Goa, Gujrat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh.

Outside India: Madagascar and its adjacent islands, Germany, Pakistan, China, Japan, Sri Lanka, Bangladesh, Malay Peninsula, Myanmar, Indonesia, Philippines, Vietnam, Hainan island, Australia, some islands in the Pacific Ocean, USA, South Africa, Cape Verde Island, Comoro Island, West Indies (Haiti, Jamaica, Dominican Republic, Trinidad), Mexico, Panama, Colombia, French Guiana, Brazil, Argentina, Bolivia, Venezuela.

Remarks: It is originated probably from West Africa and transported throughout in India.

Genus 6. Eutyphoeus Michaelsen, 1900

1900. Eutyphoeus Michaelsen, Tierrech, 10: 322.


Type locality: Bergedorf, Hamburg, Germany.

Habitat: Found in various habitats. Top soil which has high organic matter, compost pits, human drainage canals, rotten tannery.

Castings: Small round pellets heaps on soil surface.

Economic Importance: Useful as waste conditioner.

Materials examined: 2exs.: Flower garden habitat, IBG Howrah; 27.ix.2012; R. Goswami coll., An4085/1 ZSI. 1ex.: Flower garden habitat, IBG Howrah; 3.x.2013; R. Goswami coll., An-SZ52 ZSI.

Distribution: India: West Bengal: IBG Howrah, Kolkata, Andaman & Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh.

Remarks: The genus is represented in IBG by only one species Dichogaster bolaui.
superficial in 7/8. Female pores minute, on xiv. Male pores paired, just posterior to prostatic pores, on xvii; seminal grooves absent.

**Habitat:** Open areas under grass, flower garden and less visible in shade where grass does not grow.

**Castings:** Anal ejection forms a mud tower on soil surface, which has a central internal passage and at the top the tower is either open or covered (photo plate attached).

**Type species:** *Typhoeus orientalis* Beddard, 1883.

**Distribution:** India (from Myanmar border to the gangetic plain and west through the Himalaya, and Orissa), Bangladesh, Myanmar, Nepal, Pakistan, Vietnam.

**Key to the species of the genus Eutyphoeus of IBG**

1. Holandric ..................................................2
2. Metandric ..................................................3

2. Penial setae present...........Eutyphoeus incommodus
3. Penes short, annular ...........Eutyphoeus orientalis
Penes elongate and tubular...........Eutyphoeus waltoni

**11. Eutyphoeus incommodus** (Beddard, 1901)

**Diagnosis:** Length 42–147 mm., diameter 4-6 mm., 92–189 segments. Prostomium combined pro/epilobic. Lumbricine setae. Male pores paired. Female pores paired. Spermathecal pores paired. Genital markings paired.

**Type locality:** Kolkata, West Bengal, India.

**Materials examined:** 2exs.: GBThabitat, IBG Howrah; 19.xii.2012; R. Goswami coll, An4136/1 ZSI.
1ex.: Coniferhabitat, IBG Howrah; 13.3.2013; R. Goswami coll, An-SZ40 ZSI.

**Habitat:** Recorded from pasture soils (Soota, 1970). It occurs from June to September, during monsoon season.

**Castings:** Deposits slender thread form tower like casts.

**Distribution:** India: West Bengal-IBG Howrah, Kolkata, Bihar, Uttar Pradesh.

**Outside India:** Bangladesh.

**Remarks:** Species is abundant in Uttar Pradesh.

**12. Eutyphoeus orientalis** (Beddard, 1833)

**Diagnosis:** Length 130-250 mm., 5-10 mm., 130-217 segments, Clitellum xiv –xvi. Prostomium pro/ tanylobic. Genital markings paired, segmental. Spermathecal pores small. Female pore single, on left side. Male pores discharge into paired vestibula (bivestibulate) opening onto the body surface through circular to transversely elliptical or slit-like apertures in ab. Penes short and annular, each pennis on the roof of a deep vestibulum.

**Type locality:** Kolkata, West Bengal, India.

**Materials examined:** 3exs.: Bamboo habitat, IBG Howrah; 30.vi.2012; R. Goswami coll, An4038/1 ZSI.
1ex.: GBThabitat, IBG Howrah; 19.9.2013; R. Goswami coll, An-SZ40 ZSI.

**Habitat:** From pasture soils (Soota, 1970).

**Castings:** Deposits slender thread form tower like casts.

**Distribution:** India: West Bengal-IBG Howrah, Kolkata, Bihar, Uttar Pradesh.

**Outside India:** Bangladesh.

**Remarks:** Species is abundant in Uttar Pradesh.

**13. Eutyphoeus waltoni** Michaelsen, 1907
1907. *Eutyphoeus waltoni* (in part) Michaelsen, Jb. hamb. wiss. Anst., 24: 179. (Type loc. – Mainpuri, Uttar Pradesh, India; types in Zoological Survey Of India, Kolkata)

**Diagnosis:** Length 53–230 mm, diameter 4–8 mm., segments 115–201. Prostomium pro-or tanylobic. Clitellum annular. Male pores at ac opening onto the body surface through circular apertures or transverse slits, discharge into deep, well–like paired vestibula
(bivestibulate). Peneelongated, tubular, 1 mm. long. Female pore single on the left side of xiv. Genital markings paired.

**Type locality:** Mainpur, Uttar Pradesh, India.

**Material examined:** 1ex.: Flower garden habitat, IBG Howrah; 19.9.2013; R. Goswami coll, An-SZ35 ZSI. Sexs.: Flower garden habitat, IBG Howrah; 23.vii.2014; R. Goswami coll, An-SZ152 ZSI.

**Habitat:** Garden, flower bed, cultivated land.

**Castings:** Threaded tower like cast. This species gives large castings among *Eutyphoeus* genus in Bengal and Bihar (Roy, 1958).

**Distribution:** India: West Bengal-IBG Howrah, Kolkata, Bihar, Gujarat, Himachal Pradesh, Madhya Pradesh, Punjab, Uttar Pradesh.

**Outside India:** Bangladesh.

**Remarks:** This species has bioluminescence.

**Order MONILIGASTRIDA**

**Family MONILIGASTRIDAE**

**Genus 7. Drawida Michaelsen 1900**


1900. *Drawida* Michaelsen, *Das Tierreich*, Berlin, 10: 114


**Diagnosis:** Male pores paired at or near inter segmental furrow 10/11; female pores paired, at or just posterior to inter segmental furrow 11/12; spermathecal pores paired, at or close to 7/8. Clitellum in x – xiii.

**Type species:** *Moniligaster barwelli* Beddard, 1886.

**Distribution:** India, Borneo, China, Indo–China, Japan, Java, Korea, Malay Peninsula, Manchuria, Myanmar, Nepal, Philippines, Siberia, Sri Lanka (?), Sumatra, Thailand.

**Remarks:** The family is represented in West Bengal by a single genus *Drawida* and a single species *D. nepalensis*.

14. *Drawida nepalensis* Michaelsen 1907


**Type locality:** Gowchar near Kathmandu, Nepal.


**Habitat:** Cultivation field, soils rich with organic nutrient like bamboo leaf litter, flower gardens, forests.

**Distribution:** India: West Bengal: IBG Howrah, Kolkata, Andaman & Nicobar Islands; Arunachal Pradesh; Assam; Bihar; Himachal Pradesh; Jammu & Kashmir; Meghalaya; Sikkim; Uttar Pradesh.

**Outside India:** Bangladesh, Indonesia, Myanmar, Nepal, Pakistan.

**Remarks:** This species is useful in vermiculture.

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Introduction
Reptiles comprise a highly diverse class of approximately 9,300 species (Reptile Database 2011) in four distinct taxonomic orders: Crocodylia (crocodiles), Testudines (turtles), Rhyonocephalia (tuataras), and Squamata. The order Squamata is comprised of three distinct suborders: Sauria (lizards), Serpentes (snakes), and Amphisbaenida (worm lizards). Traits shared by reptiles include skin covered in keratinous scales, lungs for respiration, and having an ectothermic ("cold-blooded") metabolism. Most also have four limbs (are "tetrapods") and lay shelled eggs. Reptiles are an ancient lineage with ancestors dating back more than 300 million years, but 30% of all reptile species are now estimated to be "threatened" or worse (IUCN 2010), due to factors that include habitat loss, exploitation, and ecological interference (e.g., introduced species or disease).

Reptiles have been historically linked to amphibians due to their ectothermic metabolism, with the field of herpetology devoted to their shared study, and the term "herptiles" (or "herpetofauna") often used to describe species in zoological collections. This is somewhat unfortunate, as amphibians and reptiles are distinct biologically and taxonomically, and they are not the only ectothermic vertebrates; fish are ectothermic as well, possibly confusing the uninformed. However, one of the most prestigious scientific societies devoted to the study of reptiles and amphibians, the American Society of Ichthyologists and Herpetologists (ASIH), actually includes the study of fishes as well, and there are numerous other societies devoted solely to the study of herpetology.

Reptiles also have been historically exhibited in zoos in sparse and minimal conditions (as were many other species) due to their ability to survive on fewer resources, as well as due to the "biological ignorance" of early facilities and keepers who simply did not know what is now well known by professional and well-educated zoo and aquarium staff. The last few decades have seen continued improvement in the exhibitry of many species, with elaborate naturalistic settings and even mixed-species exhibits providing visitors a more wellrounded and educational experience. This chapter includes the basic general care guidelines for most reptile species, with provisions to account for their ectothermic metabolism, as it is probably the single most important "limiting factor" (as it limits success if not provided for) to be considered by new keepers. The unique care considerations necessitated by reptile thermoregulatory behavior (thermoregulation) cannot be overlooked. This chapter will also briefly discuss the skills and tools needed for a keeper to properly and safely maintain venomous species in captivity.

After studying this chapter the reader will understand

- that the unique behavior and physiology of reptiles affects the housing, feeding, and reproduction of these animals in the zoo and aquarium environment.
- the best practices for daily care, handling, housing, and transport of reptiles.
- the need for specific tools, enclosures, and training to work with certain dangerous reptile species.
- the key habitat and environmental requirements of reptiles—particularly temperature and lighting, but also the availability of water and proper substrate.
- the principal issues involved in medical management of reptiles.
- the need for conservation and continued research into threatened species.

General Characteristics of the Taxa
The order Crocodylia is comprised of alligators, caimans, crocodiles, and gharials, and includes the largest living reptile, the saltwater crocodile (Crocodylus porosus) at 7 m (23 ft.) and 1500 kg (3300 lbs.) or more. Most of the 24 species in this order are tropical in distribution, with both the American and Chinese alligators (Alligator mississippiensis and Alligator sinensis) extending their ranges into temperate regions. Crocodilians are well-adapted for a semiaquatic existence, with elongate heads, throat valves (so they can open their mouths underwater to grab prey), valved nostrils, elongate heads, throat valves (so they can remain submerged during hunting, webbed digits, and literally flattened tails for efficient swimming. They are also the only reptiles with four-chambered hearts, which allow them to bypass the lungs while submerged (as they are not being used) so that blood can be sent elsewhere. The crocodilian's heart is also more efficient than that of other reptiles, allowing crocodilians to reach greater sizes and, along with higher levels of hemoglobin in the blood, allowing them to remain submerged for relatively long

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periods. Crocodilians tend to be apex predators in their environments, with some species considered "generalists" (alligators and caimans have broad snouts and blunt teeth) and other "specialists" (gharials have very thin snouts and thin sharp teeth to catch fish). They have very powerful jaws with muscles biased for closing pressure (but relatively weaker opening strength), and some species can feed on relatively large prey items, which they dismember before swallowing. Their teeth can be replaced constantly throughout their life span by teeth growing in the sockets below, and all species are carnivorous. Most species will bask to aid thermoregulation, and all species lay eggs in covered nest sites. Although widely distributed, crocodilians face significant conservation pressure due to humans, with half of all species probably suffering population losses in the wild.

The order Testudines is comprised of turtles and tortoises, and is noteworthy because of the unique bony shell, incorporating the skeleton, that allows most species to withdraw entirely within it and offers protection from predation. The shell comprises two parts, the dorsal carapace and the ventral plastron. The bone of the shell in most species is covered by keratinous plates known as scutes. The carapace and plastron are fused together, with an anterior opening for the head and forelimbs, and a posterior opening for the hindlimbs and tail. Shell morphology differs among the 13 families and 300-plus species, with some species having a heavy, thick shell and others having a thin, flexible shell. Some aquatic species will exhibit a greatly reduced plastron coupled with a heavily fortified carapace, and others will exhibit one or two plastral hinges that allow them to completely close the plastron against the carapace after withdrawing. A few species even exhibit hinged carapaces. Another trait unique to testudines is the absence of teeth. Instead, they have keratinous sheaths that cover the jaws. These horny (hardened) sheaths can be quite sharp in carnivorous species, while in herbivorous species they maybe serrated. Limb morphology also varies among testudines, with larger terrestrial forms (tortoises) exhibiting "elephantine" clubbed feet to better support their weight, while semiaquatic terrestrial species (terrapins, softshell turtles) exhibit significant webbing of the digits and streamlined shells for swimming. Sea turtles have evolved paddle-like limbs for efficient underwater propulsion, as they spend their entire lives at sea (except for the females). All species lay eggs, usually in secluded nests. Testudines are widely distributed in many different habitats including deserts, grasslands, forests, remote islands, fresh water, and the ocean. However, they also face significant conservation pressure, with more than 50% of the species considered threatened due to human behavior. The term "tortoise" usually refers to a terrestrial, herbivorous turtle with a heavy shell, although the use of this term varies with locality. The term
"terrapin" usually means a semiaquatic omnivorous turtle with webbed feet and a streamlined shell from freshwater or brackish environments in North America. Technically, they are all simply turtles.

The order Rynchocephalia is comprised of only two species of tuataras (Sphenodon sp.), odd lizardlike "living fossils" endemic only to New Zealand and rarely exhibited outside of that region. They are actually found only on 32 offshore islands, with a small population only recently reintroduced onto the mainland in 2005 (Zealandia 2008). Although they superficially resemble lizards, they are part of a distinct evolutionary lineage that flourished some 200 million years ago, of which they are the only living remnants. Their unique characteristics include two rows of teeth in the upper jaw, functional hearing without external ears, primitive spine and rib bones, and the ability to remain active at temperatures usually too low for other terrestrial reptiles (they are actually intolerant of the higher temperatures used by many other reptile species for proper thermoregulation). They also have a very slow reproductive rate, probably due to the harsh cooler climate they inhabit; they lay eggs and are the only reptiles without a copulatory organ. They have been considered endangered for over a century due to relatively small populations on the various islands, where they seem to thrive only in the absence of mammalian predators. Introduced rats have posed a continued threat to some populations, but efforts at eliminating rats from these islands have met with some success.

The order Squamata comprises the lizards, snakes, and amphisbaenians in three suborders and accounts for almost 96% of all reptile species, with more than 5,400 species of lizards, 3,300 species of snakes, and 181 species of amphisbaenians (Reptile Database 2011). With such a large number of species distributed in so many diverse habitats, this order’s morphological diversity is also extensive, probably because most lizards are under 30 cm (lt.f.) in length, which allows them to take advantage of the many ecological niches available to smaller animals. This fact is coupled with the environment being able to support many smaller animals rather than fewer large ones, and smaller animals not being able to move as far, thus encouraging specialization in smaller geographic areas (Bauer 1998,126). Snake diversity is probably due to similar abilities, coupled with the success of limbless locomotion and the evolution of venom to subdue prey. Most lizards have four limbs with five clawed digits on each, eyelids, external ears, and a relatively long tail, although exceptions to each trait exist. Snakes lack each of those traits, although a few primitive species do have remnants of the pelvic girdle and limbs. Snakes do have unique adaptations to a limbless lifestyle, such as a higher number of ribs (more than 400 in some species) due to a lengthening of the body (with a relatively short tail) and a highly flexible skull that enables many species to consume relatively large prey items whole and consequently feed less often than similarly-sized lizards. All snakes are carnivorous, whereas there are numerous herbivorous and omnivorous lizards. Further differences include a single functional lung in most snakes, an extendable trachea (protrusible windpipe) to aid respiration when swallowing prey in most snakes, autotomy (tail loss and regrowth as a predator defense) in many lizards, greater thermoregulatory activity in many lizards, and specialized ventral scales in snakes to aid locomotion. Lizards and snakes both exhibit hemipenes, paired eversible structures within the cloaca (a shared terminal pouch for the digestive, urinary, and reproductive tracts) in males used for internal fertilization of the female; oviparity (egg laying) is their primary mode of reproduction, although viviparity (giving birth to live young) is not uncommon in both suborders. Both lizards and snakes exhibit a well-developed vomeronasal organ (also known as Jacobson's organ), an auxiliary olfactory sense organ which is probably well known by the tongue flicking in many snakes and some lizards, especially varanids (monitor lizards). Lizards and snakes both also exhibit a cyclic pattern of skin shedding (ecdysis), with snakes usually shedding their skin in one piece (rare in lizards). Also, while a quarter of all snake species are known to be venomous, only two lizard species are venomous: the beaded lizard (Heloderma suspectum) and the Gila monster (Heloderma suspectum), with the venomous apparatus in each species located in the lower jaw, quite differently from snakes.

Finally, amphisbaenians, or worm lizards, are specialized for a fossorial (underground) lifestyle, with heavy skulls to aid in burrowing, recessed mouths, reduced or absent eyes, shorter tails, loose skin, and ringlike skin scalation to aid in traction underground. Most species appear to be oviparous, although little is known of many species due to their fossorial lifestyles, with some known from only a single specimen. The family Bipedidae contains the only three species that possess forelimbs, with all other species limbless. Amphibiaenians are efficient predators with muscular jaws that can deliver a powerful bite, with some species able to tear flesh from prey too large to be swallowed whole. They tend to be restricted to tropical regions, and are rarely exhibited in zoos.

Orientation to the Keeping and Husbandry of Reptiles
Reptiles occupy a tremendous variety of habitats: tropical to temperate (some even arctic, as in the European viper [Vipera berus]), arboreal/terrestrial/fossorial/aquatic (many freshwater and some marine), desert/savanna/forest/montane (many in isolated island populations), and some even trogloidyic (living deep in subterranean caves). Reptiles share ectothermic metabolism with amphibians and fish, and with invertebrates for that matter, but they tend to exhibit more active thermoregulatory behavior, actively and quickly seeking proper temperatures for their metabolic needs, driven by digestion or reproduction. Some species are "passive conformers," living in environments or microclimates that vary little in temperature (e.g., caves), but the majority are either heliothermal (basking in the sun to absorb heat),
thigmothermic (lying on warm surfaces to absorb heat), or both, depending on environmental conditions. Whether a reptile is diurnal or nocturnal often determines its mode of thermoregulation. Keepers should make use of microenvironments and the opportunity to offer variable temperatures (and humidity) to captive reptiles so that they can choose the environment that best suits their needs.

Keepers must know their species’ origins in order to design proper care regimens and habitats. Proper species identification is important, as an animal’s natural history and behavior should be used to shape its captive conditions. Especially to the untrained or inexperienced eye, many species may look similar to others that are closely related but come from distinctly different habitats or environments. Basing husbandry on incorrect environmental parameters can greatly stress certain species and can even lead to death. For example, many people think of chameleons, especially the “true chameleons” of the subfamily Chamaeleoninae, as creatures living in dense tropical rain forests subject to high humidity and rainfall. However, many species within this taxon live not in rainforests but in quite arid climates, and continuous moisture at consistently warm temperatures would be harmful to them. Similarly, keeping cave geckos of the genus Goniurosaurus in the same manner as leopard geckos of the genus Eublepharis (very common in the pet trade) would be a mistake, even though they appear very similar in morphology and belong to the same subfamily (Eublepharinae). Goniurosaurus sp. originate from Asian subtropical forests with high humidity, and they are usually stressed by higher temperatures and lack of consistent moisture. Eublepharis sp. originate from Middle Eastern deserts with greater temperature swings and, of course, drier habitats. Leopard geckos are known to be less “delicate,” but this is probably due to the fact that they have adapted to greater environmental extremes and can tolerate less precise conditions in captivity.

Species common to the pet trade (sometimes referred to as "domesticated") often make interesting exhibit animals, especially if kept in naturalistic enclosures meant to mimic their original environment. These species can also provide clues to husbandry that can be extrapolated towards husbandry methods for less common species. In the example above, leopard geckos can be kept in an enclosure setup meant to mimic a desert escarpment, where they would shelter under rocks and in crevices underground during extremes of heat or cold. These underground or subsurface areas will usually retain moisture, which the geckos need to prevent dessication. Keepers and experienced hobbyists have known for quite some time that if these animals are kept completely dry, they will have difficulty shedding and may possibly suffer a lack of appetite, probably due to stress from dehydration; so they provide them with areas of moisture (dampened sand beneath a large flat rock, for example). One could use this example to judge the needs of other species from arid climates, such as other lizard species and snakes that shelter in similar microclimates but other distinct geographic areas. In fact, many reptile species from arid climates will dig their own tunnels to access such subsurface moisture. It also typically follows that “generalists” tend to fare better in captivity than “specialists,” as the generalists can adapt to change more easily, exhibiting less stress. However, captive zoo and aquarium conservation programs may require facilities to keep species with challenging needs that can be met with appropriate research and attention to detail. Such research must include learning about the environmental parameters of microclimates or ecological niches the animals inhabit, as well as about available food items they consume throughout the year. Also, seeking previous successful husbandry methods or new ideas from other experienced keepers can greatly aid a new keeper when he or she is faced with caring for a potentially challenging species.

Not only must keepers pursue such background information to be successful, they must also learn and acquire the attitude and skills necessary to work with certain dangerous species such as large crocodilians and venomous snakes. Proper mentoring and training is a must, and dangerous species should never be underestimated or taken for granted, no matter the level of experience and training accrued by the keeper. Training for working with venomous snakes is usually a graduated process, with inexperienced keepers learning from observation of more experienced personnel. This is followed by work with nonlethal species, so that the keeper can learn how to use the tools required as well as how the animals may respond to being manipulated by them. This continues with progressively more “challenging” or “difficult” species, and the training may go on for some time, especially as the various venomous snake species exhibit diverse behavior and capabilities. Approximately 25% of snakes (more than 700 species) are considered venomous, with more than 30% of those (approximately 250 species) considered to possess venom of medical significance to humans.

The Zoo and Aquarium Environment
Reptile keepers must consider a variety of environmental factors to ensure proper captive conditions, but three are usually considered most important: temperature, lighting, and humidity. These factors may vary significantly throughout an exhibit, especially if it is large enough, but each species will have "preferred target levels" of each factor. Keepers will need to compare natural conditions to the artificial or captive conditions the exhibit can provide and ask: "Can the proper conditions required of this species be accomplished in captivity, or at least closely mimicked?" Although many species can tolerate less than optimal conditions, keepers need their charges to thrive, not just survive.

Temperature
Temperature is of course important for ectotherms, as proper environmental temperature will allow these species to carry out essential metabolic processes
such as digestion, reproduction, immune response, and basic muscle activity to allow movement. They cannot generate metabolic heat themselves, so they rely on the environmental heat around them, which can vary significantly even over short distances (e.g., from sun to shade) and is naturally provided by the sun. In captivity, keepers will usually use artificial light sources or substrate heat emitters for indoor exhibits. Lighting fixtures work well for heliothermic species, as they would normally bask in the sun to warm themselves; however, the type of light fixture and bulb used will be important. Fixtures and bulbs will become very hot, so the animals should not be able to come into contact with them as serious burns could result. Fixtures should be constructed of ceramic, as plastic will degrade with heat over time. Fixtures and bulbs should also not be able to be contacted by any water (including water sprayed by keepers), because of the risk of electrocution and also because hot glass bulbs will shatter when quickly cooled by water. Standard incandescent PAR bulbs can be used to transmit heat, as their shape provides a focus to transmitted heat and light. However, keepers should be aware there are two basic types: flood and spot. Floodlight bulbs have a wider light spread and spread heat over a wider area; this may be necessary in smaller exhibits or with species that do not bask in higher temperatures. Spotlight bulbs have a narrower light spread, concentrating heat and light into a narrow beam; they can be useful in larger exhibits where the basking areas are some distance from the light fixture, but they have very little temperature range in smaller exhibits and can burn animals quickly as they try to bask. Some light bulbs, such as some self-ballasted mercury vapor bulbs, emit not only heat but also useful light spectrums (such as UV-B), to be discussed in the next paragraph. Thigmothermic species rely on heat absorbed from the substrate they are on, and this can be provided by overhead lighting sources or substrate heating sources. Various heat pads, tapes, and cables can be placed to warm the substrate, but must be closely monitored to ensure that they do not cause the substrate to become too warm as burns can result. Keepers should strive to measure heat regularly with thermometers (digital infrared models can be quite useful) at designed basking sites both before and after their installation, so that animals are not harmed by incorrect temperatures. They should also strive to provide a gradient of heat throughout the exhibit, so that the animals can choose the thermal environment they need. An exhibit with a proper temperature gradient may have not just a warm and a cool zone but several warm zones of various temperatures, as well as multiple cool zones. This is admittedly difficult in smaller enclosures, and that is why keepers must be aware of the animals’ natural thermal range and seek to provide as much of it as possible. Keepers must also remember that temperature will vary throughout the day in the natural environment, typically dropping at night; mimicking this variance may benefit their animals or even be required.

Light
In Earth’s biosphere light and heat are linked, and in captive conditions they can be linked as well, but the quality of artificial light can be quite different from one source to another. Natural sunlight is considered to be “full-spectrum” light, and includes visible light, infrared (IR), and ultraviolet (UV) wavelengths. Artificial light that contains all the wavelengths of visible light is also considered full-spectrum light even though it may not include much IR, which has a longer wavelength than visible light and registers as heat, or UV, which is important to many reptiles. Many vertebrates use UV light as a catalyst for vitamin D formation in the skin, but there are three different wavelengths of UV to consider. UV-A, the longest of the UV wavelengths, is beneficial to many diurnal reptiles as it may drive activity levels and social behavior, and is often emitted by many full-spectrum bulbs. It also passes through normal glass, such as windows or skylights. UV-B is of even greater importance, as it is needed to synthesize vitamin D in the skin, and vitamin D is needed to metabolize calcium for proper bone growth. Without proper exposure to UV-B, many species may suffer from metabolic bone disease (MBD), in which the affected animal’s skeleton is weak due to a lack of metabolized calcium, even if calcium is provided in the diet, as without vitamin D it cannot be metabolized properly. UV-B is usually not found in common full-spectrum lamps or typical PAR spot and floodlamps, and it also cannot pass through regular window glass. It can, however, be provided by specialized lamps, both incandescent and florescent. Keepers should determine the appropriate exhibit lighting needs for each species, which may consist of a combination of lamp types. UV-C is the shortest of the UV wavelengths, and the most dangerous, as it quickly damages living cells. It is usually filtered out by the atmosphere’s ozone layer and is not found in typical light bulbs. Keepers should note that both UV-A and UV-B can cause damage to human skin (and the DNA within the skin cells) with sufficient exposure, and they should therefore limit their exposure to these light sources. The animals should also be given the opportunity to remove themselves from exposure. Not all species, including most snakes or nocturnal species, require such high-quality full-spectrum light. Photoperiods should ideally follow those the animals would experience in the wild.

Humidity and Water
Atmospheric moisture can be provided through the use of moving water features and intermittent spraying or misting, combined with a reduction in ventilation. However, keepers should take care to allow sufficient ventilation and periodic drying to prevent mold growth in the exhibit. Exhibits should be equipped with sufficient drains so that any substrate does not become constantly saturated if exposed to continued water inputs. Ventilation can also be controlled to maintain humidity at desired levels, and the use of a hygrometer (which measures humidity), either analog or digital, is recommended. A variety of substrates may be used (soil, sand,
gravel, etc.) as long as they are not harmful to the animals, especially if ingested, and as long as they do not present a drainage problem. Live plants can be used for many reptile species, except for certain herbivores which may eat them, and the plants can increase humidity in the exhibit as well through transpiration (plant respiration). Water sources must remain clean, with smaller nonmoving pools periodically drained and flushed when fouled, and moving water features or larger pools treated appropriately with mechanical, chemical, and biological filtration, which must be regularly maintained so that water quality does not suffer or degrade. Keepers should also be aware that not all species will drink from water dishes or pools. Many lizards (including chameleons) will only drink from falling water as they normally drink during rains, or from water droplets as they would when covered with morning dew. Some species also drink very slowly, so the keeper should ensure water is provided for them over a period of time, and leaving misters running for several minutes or more might be necessary.

**Enclosures**

Reptiles are generally less active than similarly-sized endotherms, and therefore can often be housed in smaller enclosures. Enclosure materials resistant to water are preferred because they will not degrade when exposed to water used to clean or to maintain humidity. Most exhibit or enclosure shells are constructed of some combination of concrete, plastic, fiberglass and glass, with glass preferred over clear plastics for exhibit windows as it resists scratches. Glass aquariums can be used to house smaller species away from exhibits. Ventilation openings should of course be screened to prevent escape, and keepers should periodically inspect them, as their integrity may be compromised with age. Snakes and some lizards are excellent at using relatively small openings to escape, so enclosures should be designed or implemented with this in mind. Holding areas and vestibules should be designed with possible escape in mind, with secure secondary barriers, and with clutter kept to a minimum to facilitate recapture. Weapons may also be considered in case recapture is not a possibility and the animal has to be destroyed; however, further discussion about the specifics of such usage is beyond the scope of this chapter.

Many reptile species are cryptic or more comfortable when shelter is present, but providing shelter and materials that allow cryptic species to “blend in” may make it difficult for the public to view the animals. Many keepers would prefer an exhibit that is easy to work in, but such an exhibit may not look appealing, whereas a lushly planted exhibit may look very nice to the public, but be difficult for the keepers to work in. Keepers must weigh the needs of the animals against the needs of the visitors who would like to observe the species on display. Often a compromise can be struck in which the shelter in which the animals hide is presented in such a way as to allow visual observation. For example, a small hollow log can be cut lengthwise and placed against the exhibit glass so that the sheltering species can be seen. Materials can also be used in such a way as to allow the public to view cryptic species, especially if exhibit signage explains the animal's capabilities and morphology. For example, lizards that perch on vertical small trees can be highlighted in an exhibit if the trees are near the viewing window and signage explains where visitors should look. However, exhibit material should never present a way for the reptile to escape, or compromise the keeper's ability to work safely with it in the enclosure. For example, a sectioned slab of a log used by the reptile on exhibit to hide should be positioned carefully. If it is too close to the door of the exhibit, the keeper might have to move it every time the exhibit is serviced or entered. Conversely, if it is too distant from the door, the keeper might leverage his or her position to check on the species sheltering under it, and might be unable to react properly if the animal attempts to escape through the open exhibit access door (which may happen in smaller exhibits) during inspection of the shelter. In larger exhibits, keepers can close the access doors after they enter. Arboreal species will require branching and even large tree limbs, but they should be kept away from the keeper access doors so that keeper can safely open the doors without startling the animal and can maintain an appropriate distance from it. Also, one must evaluate whether the exhibit design is flexible enough to accommodate changing needs such as seasonal reproduction: whether eggs can be laid on exhibit in removable or easily accessible nesting areas that enable the keepers to take them out of the exhibit easily. Not having to remove certain animals from exhibits for reproductive purposes frees up resources and space for other species that may require it, and certain species may even continue to allow juveniles to inhabit the same space.

**Dangerous species and tool use**

Many species present a risk to keepers when kept in captivity, including crocodilians, large lizards (e.g., monitor lizards) and nonvenomous snakes (e.g., large boas and pythons), and venomous snakes. Crocodilians and large lizards can inflict significant bites and can also strike with their tails, causing wounds or knocking keepers off-balance. Large lizards may also have very sharp claws used to inflict deep wounds. Large boas and pythons are famous for their ability to constrict, and they can indeed kill humans in that way, but they also have multiple rows of large teeth that can inflict serious wounds. Large species should never be worked alone, and keepers who work with them should be well trained. Dangerous species can and should be shifted off exhibit if the exhibit needs to be serviced for cleaning or maintenance. Some species can be trained for this purpose, but others may need to be tempted with food to move from an exhibit to a holding cage, and keepers may have to be patient.

Certain species can be moved with tools such as snake hooks or tongs, and crocodilians can be pushed with long blunt wooden poles if necessary. Keepers...
should always use caution with tools and should be well-versed and experienced in their usage. While snake hooks rarely pose a danger to the animal, they require practice to use properly, as the keeper must balance the animal on one or two of them, and the animal may not want to remain balanced. Certain snakes, such as arboreal boas, pythons, and vipers tend to remain on hooks (though they may try to climb the hooks), while other species, like some colubrids (racers, boomsangs, etc.), may never feel comfortable while on them, thus requiring the keeper to work quickly. Heavy-bodied species also present a challenge, as the hooks tend to be narrow, causing the animal discomfort. Keepers might also find these heavier species uncomfortable to work with, since holding their weight away from one’s body requires more effort and endurance, particularly in the arms. Tongs can be used with lizards as well as snakes, but can cause injury to the animal if not used properly. They consist of two opposing metal segments at the end of a pole that collapse together when the handle at the other end is squeezed, but because the two metal lengths are joined at a pivot joint, they can pinch, and they can also present a crush problem, especially to moderately sized snakes and their many thin ribs. Keepers may be tempted to “tail” certain species—grasping the animal’s tail while keeping the rest of the body, especially the head, away from them—but the author considers this risky, as the tail may be injured or may slip from the keeper’s grasp.

Venomous snakes present a unique problem, because their bite can initially cause little physical damage, but the venom can cause significant tissue damage, and in many species may be enough to cause death. Venomous snakes should be remotely shifted between enclosures using cable-actuated or levered shift doors whenever possible. Even the most experienced keeper can be bitten, and it only takes one “bad” bite to end a life. Shifting is not always possible, so keepers may need to move the animals using tools and should therefore be well trained and experienced before working with venomous species. They should also never work these animals alone. Clear acrylic tubes can be used to restrain snakes that cannot be restrained “freehand” without risk. The keeper guides the snake partly into the tube and then restrains its posterior half against the tube, preventing it from crawling through or backing out. Sometimes a snake will resist entering even a clear tube, but it can be placed into a large open container, such as a large plastic trash can, with the tube above it and slide over it as it tries to crawl out of the can. With the snake trapped in the tube, the keeper or veterinarian can draw blood, inject medicines, or do a close visual inspection. The tube may also have small openings or slits cut into it to allow wound treatment through the tube and near the dangerous head region. If the facility has a large collection of variously sized snakes, multiple tubes of various sizes may be needed, but tubing should only be performed by highly trained keepers.

If venomous snakes are to be removed from a secure enclosure or exhibit and placed into temporary quarters, such temporary housing must still be appropriately secured. Keepers will commonly use large plastic trash cans for temporary placement, and these cans usually come with snap-on lids. However, these lids are not secure enough on their own and should be taped to the can body with strongly adhesive duct tape. Coloured identification tags or cards (usually red) should always be used with venomous species, both on the exhibit and on temporary enclosures, so that all keepers know which animals are present in a given enclosure. Many zoos will assign a tag to a particular animal, and that tag will follow the animal wherever it goes within the zoo.

Finally, provisions should exist for the possibility of a venomous bite sustained by a keeper. Appropriate speciesspecific antivenin should be on hand so that it can travel with the keeper to the hospital if a bite is sustained. Not all bites result in envenomation or will warrant antivenin treatment, but if they do, the antivenin must be administered in a hospital setting as it may itself cause a serious reaction. Local hospitals should be trained in venomous bite treatment and be prepared to accept a bite victim, with a medical liaison trusted by the zoological facility to treat the victim accordingly. As one might imagine, this requires significant advance planning. Antivenin must be stored properly in a dedicated refrigeration unit and must be kept current, as it loses effectiveness over time. Zoo staff should be trained to respond to a venomous bite accordingly, and snakebite alarms should be placed throughout the zoo and tested regularly, so that their activation alerts other staff members. Keeper response to a possible venomous bite should be practiced, with regular drills used to ensure that all staff members know their particular roles, which will vary by institution. Trained staff members should make every effort to secure the animal if possible after a bite, so as not to compound the situation with an escape. Holding areas and vestibules should also be designed and constructed with escape in mind. Floors should be kept clear of clutter, doors and windows should seal tightly, walls should be solid, and drains should be securely screened.

Feeding and Nutrition
As reptiles are ectothermic, they require only about 10% of the dietary energy intake of similarly-sized endotherms. Because of this, they require less food, and this is what allows many species to occur in habitats of lower productivity in nature, or to occur in higher numbers in areas of greater productivity. Being an ectotherm is not necessarily a handicap when compared to an endotherm in different environments. However, keepers may overlook the importance of this difference, and as a consequence, overfeeding and obesity occur. Weight and body condition should be monitored and recorded regularly, especially for juveniles but also for erratic or periodic feeders like some snakes, and adjustments made as necessary. Species fed ad libitum, especially in group settings, should be closely monitored, as should dominant individuals that may consume a disproportionate amount of food, as gut distention can result in death. Temperature should also be monitored regularly, as digestion is
compromised when temperature drops below a certain threshold (usually a species-dependent one). Below this threshold, food cannot be digested, and if allowed to remain in the gut it can cause illness and death.

Certain species can be shifted into holding quarters to feed and to allow keepers to service their exhibits; this is especially useful and warranted for dangerous species. If species are fed while on exhibit, care must be taken to ensure that the substrate does not present a risk of accidental ingestion. Feeding tongs or forceps can be used with many species, especially carnivores, but care must be taken so that the animal does not injure its mouth on the forceps or tongs when lunging for food items. The tongs or forceps should also be long enough so that the keeper’s hand and fingers are not at risk of being accidentally bitten, but not so long as to be unwieldy; the keeper should be able to move them quickly. Certain carnivores and insectivores may exhibit feeding responses only for live or moving prey items; a keeper can use forceps or tongs to mimic movement in prekilled prey items, but he or she should take care that the animal does not injure its mouth when attempting to feed on the grasped food. Juvenile snakes and sick or injured species may also need to be “teased” with food to elicit a feeding response, and this entails slowly moving the food items near the animal’s head or along the jaws, causing the animal to reflexively bite at the food. Once it has bitten the food, the animal will often continue reflexively to swallow it.

Live food items commonly used for carnivorous reptiles in zoos and aquariums include various species of crickets, fruit flies, beetle larvae (e.g., mealworms, superworms), cockroaches, earthworms, and moth larvae (silkworms, waxworms). Prekilled food items, usually for larger species, include various species of rodents (usually commercialized mice and rats), rabbits, birds (usually domestic chickens), fish, and even domestic pigs. The size of the prey item, of course, is determined by the size of the animal feeding on it, usually corresponding to the size of its head. Snakes can and will proportionally feed on relatively larger single prey items, due to their skull and jaw morphology. Certain prey species can be cultured on site, but feasibility will depend on the zoo or aquarium’s needs, and it may be more convenient and efficient to procure food animals from commercial vendors. Keepers should still familiarize themselves with how to culture various species, in case the need arises.

Herbivorous and omnivorous species will feed on many commercially available fresh green vegetables, including various lettuces, endive, kale, collar greens, mustard greens, dandelion, and spinach. They will also consume various fruits and vegetables, including apples, grapes, various berries, pears, papaya, mangos, melons, carrots, squash, sweet potatoes, corn, peas, and beans. A number of commercially produced dry pelleted foods produced by various companies, usually for the pet trade, can be used by zoos to supplement a diet of fresh produce.

While keepers should research the nutritional profiles of a diet before deciding on supplementation, certain diets will ultimately require that additional substances be added. Vitamins and minerals are common supplements, especially to carnivorous diets, as prey items may be deficient in one or another. Commercially produced insects tend to have a poor calcium-to-phosphorus ratio, basically being very low in calcium. Keepers can “gut load” the prey species before offering them to the reptile, by feeding them a diet rich in vitamins and minerals, and they can also “dust” them with a vitamin and mineral powder. Insects prepared in this manner should be fed to reptiles immediately, as the dusted material will wear off and ingested material will be passed with subsequent digestion. Feeding reptiles with tongs will ensure that they receive the proper amount of supplemented prey items. Snakes rarely need supplementation as they are usually fed whole prey, and omnivorous reptiles should be given a varied diet so that deficiencies are minimized. Herbivores can also be fed varied diets to minimize the need for supplementation, and keepers should remember that more is not always better, as oversupplementation can be just as harmful as undersupplementation. Keepers should also remember that water is important for proper digestion in many species, especially to those that are fed dry prepared diets, but that not all species will drink from standing water.

Behavior
Many reptile species do not exhibit easily identifiable behaviors such as those for submission, aggression, injury, and illness. Keepers must learn to look for subtle actions in many species, as they will not often act like cobras that spread their hoods when threatened. Many species will become habituated to their keeper’s presence, in effect tolerating it, but that does not mean that they are without stress, and they may lash out unexpectedly as a result. This lack of identifiable clues is especially problematic in cases of illness or injury. If there are no identifiable behavioral changes, what does the keeper look for? Most often, keepers will look for changes in feeding behavior, but changes in thermoregulatory behavior (such as extensive or limited time spent basking by a heliothermic species) or a lack of response to stimuli (such as not moving when prodded lightly by the keeper) may mean that the animal’s health is compromised. In fact, if it is determined that the animal is suffering from an illness, the keeper may be able to aid the animal by providing additional sources of variable heat, as many species will spend more time basking to increase their internal body temperature and system metabolism, thus boosting their immune response. In effect, this may also provide an inhospitable environment for pathogenic organisms, in much the same way as a fever would for a mammal.

Aggressive behavior by these animals, toward both conspecifics and keepers, is to be avoided, and...
keepers must learn and note its causes. It can be due to various factors including territoriality, reproduction, hunger, and defense. Reproductive changes in behavior are often seasonal in most species; they tend to coincide with egg laying or birthing in females and the exclusion of competition in males. The author once cared for a large male green iguana (Iguana iguana) at the Buffalo Zoo that was usually a wonderful nonaggressive animal, often basking in the middle of the exhibit for the public to view, and presenting little difficulty when the enclosure needed servicing. In fact, the iguana would often slowly approach the service door and present its throat for a good scratch from the keeper staff. However, usually around April, it would become belligerent when approached, often bobbing its head and puffing itself up to become larger, and occasionally gaping and hissing and even attempting to bite. This behavior, of course, was driven by reproductive hormones and their subsequent effect on behavior in many males, and it lasted for about a month. Some species also become overly excited at feeding times, and in their rush to feed they become problematic. Keepers can alter feeding schedules and locations so that the reptiles do not become fixated on a particular time and location, although the need for this depends on the species. For example, a group of medium-sized tortoises do not pose much of a threat, but a group of larger monitor lizards might.

The potential for enrichment exists for many ectothermic species, although their response to it may be more tempered than that of endotherms. Food is still the most common form of enrichment, although it does not have to be the only one used. When it is used, food can simply be presented differently to the animals (e.g., given whole instead of cut up, or live instead of prekilled) or presented in such a manner as to challenge the animals and cause them to spend extra time trying to consume it (e.g., strawberries hung by strings for tortoises, or live fish placed into an exhibit for aquatic reptile species). Other reptiles can be trained, like mammals and birds, using operant conditioning, usually consisting of target training and desensitization. For example, a large tortoise may reach a weight of 135 kg (300 lbs.) or more and present a challenge to keepers if they want to move it within an exhibit or off the exhibit. Rather than have people lift the tortoise, the keepers could employ target training to have it follow a brightly colored foam ball on the end of a stick. The keepers could then use the ball to move the animal wherever they wanted, within reason and of course with patience. Keepers should remember that enrichment may not be warranted or practical for all species, including "sit and wait" predators (e.g., many boas, pythons, and vipers) that are not "bored" by sitting in one position for a period of time, since that is simply what they do.

**Reproduction**

Sexual dimorphism between the sexes varies greatly in reptiles and is not always obvious (e.g., in many lizard species including monitor lizards, Varanus sp.). This is especially true with young animals. Keepers often use secondary sex characteristics such as behavior, relative size, colour, and shape and size of the tail (if males have hemipenes, the tail may be larger) to identify the different sexes. A keeper can also use a reptile-specific ball-tipped probe to search the animal’s cloaca for hemipenes in squamates (the probe can be inserted further into the cloaca if hemipenes are present), although it must be done carefully to avoid injury to the delicate tissue. X-rays and ultrasounds can also be used in some species to identify specific sex organs. Some species have specific morphological differences between the sexes, such as the longer forelimb claws some male terrapins (Trachemys [Chrysemys] sp.) use to stroke the female’s neck during courtship, or the throat dewlaps many male iguanids (such as Anolis sp. [Chrysemys] sp.) use in territorial visual displays. Young tend to resemble adults in morphology and diet, although behavior may change with maturation, and keepers should remember that young venomous snakes still possess venom.

Reproductive behavior is usually stimulated via external environmental cues such as light, temperature, humidity, rainfall, and food availability. Behavioral cues driven by the environment (e.g., calls or vocalizations in some geckos, male posturing or displays in many lizard species) can cause further stimulation in some species. Even many tropical regions experience climatic variability, in which animals have evolved to time their reproductive behavior so that their young stand a better chance of survival, or so that the females have adequate resources to produce viable eggs and young. By controlling the environmental parameters in zoo and aquarium exhibits, keepers can control reproduction in many species. For example, many temperate species require a period of cooling before their gametes will mature and become viable within the male and female. These reptiles experience this cooling period in the wild, but do not experience it in captivity unless keepers manipulate the environment. Keepers can subject their animals to a controlled period of cooling to induce successful breeding, but must first account for their health. Reptiles should not be cooled when they are stressed or ill or have recently been fed. Their cooled environment should not promote desiccation; they may be offered water during cooling. Often, light schedules should be changed in concert with ambient temperatures, as the reptiles might respond best to multiple cues.

The laying of external eggs (oviparity) is the most common strategy in reptiles, although live birthing (viviparity or vivipary) is also widespread, probably due to the presence of egg predators or harsh environmental conditions (i.e., cold temperatures) inhibiting egg incubation. Temperature sex determination (TSD) is widespread in crocodilians, turtles, and many lizards. With TSD, the temperature in which the egg develops determines the embryo’s sex, and this may enable keepers to predetermine the sex of a clutch (or of a certain percentage of it). This could be of importance to certain conservation efforts, as females maybe considered more “valuable” because a single male...
can fertilize multiple females. Parthenogenesis is also found in a few species of lizards (e.g., whiptails, some gekkos, and even Komodo dragons [Varanus komodoensis]) as well as snakes (blindsnakes and boas); it is the asexual reproduction process in females that results in female offspring in the majority of examples. Parthenogenesis, which is considered odd and rare for vertebrates, has the practical aspect of not needing a male for reproduction. Egg incubation conditions vary in the natural environment, mirroring local conditions usually at the microclimatic level, as eggs are usually buried or hidden, with temperature and moisture around the eggs the most important factors. Keepers should attempt to mimic the natural microclimates for temperature and moisture, and should take care when moving eggs so as not to rotate them as many birds do, since that can kill the developing reptile embryos. Keepers can mark eggs lightly on their dorsal surfaces for reference, and common incubation mediums include moistened vermiculite, perlite, sand, and paper towels. An incubator may be needed to ensure consistent temperature; some models have alarms for temperature problems. Keepers should also provide proper egg deposition sites within zoo enclosures to prevent females from "holding" their eggs too long, which can lead to egg binding or dystocia ("difficult birth") and a need for surgical intervention.

**Transportation**

Reptiles are moved between facilities or institutions as needed for various management strategies, including North America's Association of Zoos and Aquariums (AZA) or similar breeding programs. The goals for proper and efficient transport are to limit stress, reduce time in transit, limit exposure to extreme temperatures, and prevent dessication (especially in some delicate species). Under International Air Transport Association (IATA) guidelines, containers should be insulated to protect from temperature extremes and should be ventilated, clearly labeled, and shock-absorbent (i.e., cushioned). They also need to be secure, especially for dangerous species, with multiple layers of confinement. Moisture requirements for reptiles are modest for most species, unlike in the case of amphibians, although juveniles of some delicate reptile species (small lizards and snakes) will dessicate quickly without a dampened substrate. Larger crocodilians usually require custom-built crates that are just large enough to hold an animal but do not allow it to turn within the crate; this ensures that the animal's head stays at the labeled "head end" of the crate, and keepers are not surprised or endangered when it is allowed to exit. Venomous snakes should be explicitly labeled, with at least three confinement layers, and keepers should never open such containers without proper backup and tools. The final exterior crate for venomous snakes must be completely secure; wooden crates are often screwed shut. Snakes are often bagged, but because many venomous species can bite through the bag material, the bag should be placed in a rigid (usually plastic) secondary container that is properly ventilated. Keepers should refer to the proper IATA guidelines for particular species, as well as to chapter 23 in this volume.

**Veterinary Care**

Signs of illness in reptiles include reduced or absent feeding response, regurgitation, odd fecal consistency, odd skin colour or texture, odd posture, increase in basking behavior (or the opposite), localized swelling or bloating, gaping of the mouth, trembling, and reduction in normal reflexive behavior. Common diagnostic techniques include fecal/blood/tissue exams, radiography, ultrasound, and endoscopy. Certain diagnostics, specifically fecal exams, should be performed regularly. Diseases are often dietary, environmental, genetic, or infectious, with the infectious agents including bacteria, viruses, fungi, and parasites (with both internal and external possibilities). Keepers should be well versed in disease possibilities and specific symptoms, so that veterinary personnel can be notified properly. The importance of quarantine cannot be overemphasized as a means to prevent transmissible diseases from moving from new arrivals to infect the rest of the zoo or aquarium's collection. Not all health problems are the result of infectious disease, however, as difficulties with ecdysis are commonly encountered as a result of environmental factors such as humidity. Severity will depend on the species involved and the extent of the problem. Shed skin that adheres to the ocular scales of snakes ("eyecaps") can ultimately lead to blindness if allowed to continue over time, so keepers should make every effort to ensure that snakes do not retain the eyecaps after shedding. Stuck eyecaps can be loosened with gentle streams of water, but keepers should take care not to simply pull them off, especially if they are dry and tightly adhered, as it can damage the underlying delicate tissue of the eye. Adhered shed on digits can constrict over time, especially in growing juveniles, and impede proper blood circulation, so keepers should periodically inspect the digits for these tissue ringlets.

Specific commonly encountered diseases include infectious stomatitis ("mouth rot"), respiratory infections, metabolic bone disease (MBD), vitamin A deficiency, Cryptosporidium, salmonellosis, ectoparasites (mites and ticks), endoparasites (pentastome "worms" and nematode roundworms), and a host of other bacterial and viral diseases. Infectious stomatitis and respiratory infections are usually the result of stress from inappropriate temperatures, overcrowding, and poor nutrition. MBD is usually the result of improper calcium-to-phosphorus ratios and lack of exposure to UV-B light. Cryptosporidium is a highly contagious disease passed via fecal contamination that infects the stomach and intestines, preventing digestion; it is quite problematic due to a lack of effective treatment options. Salmonellosis is usually only a problem for keepers; it appears that Salmonella sp. bacteria occur normally in the gastrointestinal tracts of many
Zoological facilities and management organizations have partnered with various local, national, and international organizations to protect terrestrial and semiaquatic turtles in Asia, sea turtles worldwide, and crocodilians in South America, Asia, and Australia. Only their continued efforts will prevent further losses as humans continue to negatively affect the global and local environments needed by reptiles.

**Summary**

Reptiles share an ectothermic lifestyle with amphibians but do not rely on environmental water to the same degree because their scaled exteriors minimize dessication. With more than 9,000 species in four distinct orders, their morphological diversity is significant and is reflected by the diversity of their habitats. Reptiles tend to be active thermoregulators and not simple thermoconformers; providing appropriate and various microclimates in captivity can be vital to their success, with heat and light being vital to most species. Keepers must be familiar not only with the natural history of the species in their care, but also with the unique tools used in their husbandry, including snake hooks and tongs. Keepers of venomous and large dangerous species need to account for the unique challenges posed by their charges, and must learn how to properly care for them while remaining safe themselves. Keepers must also account for reptiles' ectothermic metabolism in management of the planning and implementation of their diet, reproduction, transport, and veterinary care. Finally, keepers should always remember why they are caring for the various reptile species in captivity, as these animals will serve as ambassadors of education and conservation, and in some cases as the founders of future generations both in captivity and in the wild.

**Conservation and Research**

Three of the four reptile orders (Crocodylia, Testudines, and Rhynchocephalia) are at great risk of continued loss of numbers, species, and populations due to human influence. The reasons include habitat loss (e.g., through climate change), overcollection (overharvesting), introduction of nonnative species (which either consume natives or outcompete them), introduction and spread of foreign diseases, accidental bycatch in commercial fisheries (e.g., sea turtles), and pollution. Island populations have been and continue to be at great risk due to their naturally low population numbers, their inability to relocate on their own, and their lack of evolved responses to foreign predators. Zoological institutions and their larger management organizations play a vital role in fostering education and research within the zoos and aquariums (ex situ) and in the natural environments of the reptiles themselves (in situ). Zoos and aquariums also preserve populations of species and their unique genetic biology, acting as reservoirs for future breeding and reintroduction plans. Keepers should share the information they derive from their work, including dietary information and reproductive successes, so that collectively their efforts help the zoological community meet its goal of conservation.

**References**


LOCATION
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DESCRIPTION
The foremost criteria for Glacier Run was to replace the zoo's popular but outdated pinniped and polar bear exhibits with safe, innovative, state-of-the-art exhibits that would provide optimum space and resources for animals and keeper staff along with special experiences for visitors.

When visitors arrive at Glacier Run, they get an immediate sense of place - a town on the edge of the Arctic wilderness where residents have learned to live in balance with nature. Modelled after the town of Churchill in Canada, Glacier Run features seals and sea lions, a rescued grizzly bear family and three polar bears. The Arctic-themed mining boom town includes the bear exhibits and features an old mining quarry now flooded with water, a fishery and warehouse dock, a bridge above the town which is affectionately called 'the bear walk' where bears look down upon guests, an old Ford truck where bears climb into the truck bed while guests are in the cab, a gift shop, a classroom and an advancing glacier that has destroyed a road in the town. The 300 seat Seal and Sea Lion amphitheater overlooks the 409,000 liter (108,000 gallon) pinniped pool. When guests aren’t enjoying the many poolside views, they are likely experiencing up close and personal views of the bears and pinnipeds during one of the several daily training demonstrations.

Animals are daily rotated through the various exhibit spaces. This unpredictability closely mimics what the animals would experience in nature and helps to keep them more engaged, active and inquisitive, thus more enriched in their zoo home. While at Glacier Run, visitors have the opportunity to interact with zookeepers to learn about current challenges to Arctic environments and animals, and to discover how incremental changes in human everyday activities and behaviours can make a difference for our planet and these species.

SIZE
Space Allocation for the Glacier Run facilities for bears and pinnipeds: Entire facility: 14570 m² Entry plaza: 650 m² Visitor viewing space: 1550 m² Animal display enclosures: 1460 m² Animal holding areas: 700 m² Staff working areas: 610 m²

OPENING DATE: 26 April 2011

PLANTS
Glacier Run is modelled to look like being situated on the tundra between the ocean and the boreal forest. Boulders covered with simulated lichens, scrub shrubbery and short grasses recreate the look and feel of the tundra. Various evergreens and short willows cultivated to resemble the growing patterns formed by the harsh winds of the arctic are creating the background looking like the boreal forest.
Before construction, many of the evergreen trees were moved to various places on campus to preserve them. Plants were placed specially to simulate the tundra region, with marshy ornamental grasses and heavy evergreen backgrounds.

**FEATURES DEDICATED TO ANIMALS**

The outdoor Glacier Run exhibit provides numerous experiences for bears. They may choose to swim and dive in the 333,000 liter (88,000-gallon) pool, relax in the grassy areas with mulch and dirt dig pits, or climb down to explore either of two moats.

All the animals utilize some form of enrichment on a daily basis. A variety of enrichment items are utilized including imitation icebergs, large kong (hard rubber) toys, boomer balls, puzzle balls, cardboard boxes, jolly balls, larger enrichment items, food frozen in ice blocks, cubed ice in buckets, ice maker in Bear Alley, areas with mulch and dirt for variety of textures, cut browse for bears, and a shower in the holding pen.

The new facilities were designed to allow bears to rotate through two exhibits, seven bedrooms, bridge transfer and under-town tunnel to help further enrichment efforts. The bears are rotated through these spaces several times daily on a "consistently inconsistent" basis. An overhead transfer between the Glacier and Bear Alley exhibits is regularly accessible to the bears. They appear to appreciate the ability to look directly down on our visitors. Four sets of stairs and a simulated conveyor ramp add an aerobic element to their day. Each animal is also given time off public exhibit during the day. Doors are left open to allow animals to choose to leave public spaces.

**FEATURES DEDICATED TO KEEPERS:**

The buildings and exhibit areas are constructed with solid, reinforced, cast-in-place concrete walls and include steel mesh surfaces that allow protected keeper access to the bears for training. Additional mesh doors are installed at key points in the keeper hallway to allow portions of the area to be closed off in the event of an animal escape. All bear doors are triple-locked and keeper hallway doors are double-locked. Keeper spaces have containment pockets with emergency telephones located in both the bear and pinniped holding hallways. Keepers also carry 2-way radios.

Electronic sensors are installed on each keeper and bear door. This system shows via a lighted panel in the keeper work area when a door is open. The buildings and all outdoor animal spaces have a system of video cameras that allows the remote monitoring and recording of the animals in all parts of the facility, including the maternity den. The Louisville Zoo's policy is to have two trained staff present and active in the shifting of all dangerous animals.

The central holding facility for multiple species (2 bear species and 3 pinniped species) allows more time for keeper/animal engagement (currently about 7 hours per day), which in turn builds relationships and allows more time for the study of animal behavior and for creating new enrichment activities. Keepers have a long list of enrichment foods and manipulative items that are used, documented and evaluated as to effectiveness.
FEATURES DEDICATED TO VISITORS:
Most guests enter Glacier Run through a large Guest Services hub that provides food service, picnic tables, a playground, family restrooms, a gift/sundries kiosk and the Calistoga Splash Park, all built prior to the pinniped and bear facilities. A town sign welcomes visitors to Glacier Run, the “Polar Bear Haven of the World” - modeled after Churchill, Canada. Guests walk up the winding, landscaped path to the edge of ‘town’ where they encounter a large 409,000 liter (108,000-gallon) pool with seals and sea lions, a shaded amphitheater for 3 daily keeper presentations, and multiple above-ground and underwater viewing areas along the surrounding walkway. Interpreters and heavy theming engage the visitors on their upward path into the ‘town’, or down a path to underwater viewing and into the ‘mine office’. The lower level features a massive 2-story window for underwater viewing of bears.

An old pickup truck ‘parked’ by the loading dock has its cab in the public space and its bed in the bear space. Guests can hop inside and look out the back window for super close-up views and the unexpected thrill of feeling movement caused by bears that use the truck bed as a play feature, as an ice machine overhead periodically dumps ice into the truck bed. On ‘Main Street’, visitors often see the bears rambling along an old mine track that serves as an overhead footbridge connecting the two sides of the ‘town’, which are the two exhibit spaces. This safely provides the impression of bears moving through town just as they do in Churchill.

Multiple viewing vantage points and elevations around the edge of the exhibit let visitors get nose-to-nose with the bears as they swim or walk up close to the windows. On the far side of ‘town’, the ‘old road’ has been destroyed by the ‘receding glacier’. This overlook provides one more chance to see the bears as they climb and play on the sections of ‘broken road’. Guests can purchase a memento of
their time in Glacier Run at the Gypsy’s General Store.

The Glacier Run Community Center and Town Hall is actually a multi-purpose space that includes a foyer with multiple large viewing windows, a classroom with a large viewing window into the Glacier exhibit, restrooms, replicas of Inuit art, and other artifacts and biofacts. When not in use by students, the space is open to the public or available for meetings and after-hours rental.

Bear Alley includes one of two garage doors that roll up to reveal a mesh barrier where guests get up-close views as keepers safely train the bears through operant conditioning as a second keeper interprets the session. Keepers also spend several hours a day answering guests’ questions while observing the behavior of the bears.

INTERPRETATION
The very nature of the exhibit design is based on the idea of humans learning to live in balance with wildlife and adjusting to changing dynamics in the Arctic. Glacier Run provides an immersive, context-dependent, themed experience. The arctic town setting is designed to increase a sense of place, comprehension and emotional connectedness. Dramatic illustrations of melting glaciers plus the co-existence of grizzly bears, scavenging polar bears and people in town reinforce the storyline - learning to live in harmony with nature and the effects of climate change.

With the rotation of grizzly bears, the zoo discusses human habitat overlap with polar bears and their evolutionary history and future, as polar bears move more inland as a result of climate change. In the truck cab, visitors can experience unexpected nose-to-nose views and a “bumpy ride” courtesy of the bears. They may be surprised to see bears walking across the bridge overhead. Strategic positioning of exhibit spaces helps convey natural predator/prey relationships. Polar bear alert signs, historical photos, canoes, cultural artefacts and a local radio show give visitors a sense of life on the tundra. The Community Center and Classroom feature Inuit artefacts and original artwork. Traditional window banners, themed storyboards and flat screen TVs present animal facts, rescue stories, conservation messages, compelling images of the arctic (courtesy of Polar Bear International), and explain how incremental changes in our behaviour can positively affect climate change and thus make a difference for these arctic regions and species. Seven formal daily training presentations (3 pinniped, 4 bear) plus the daily presence of interpreters and keepers provide details on animal behaviours, enrichment, rotation, histories, the arctic ecosystem, and conservation issues.

MANAGEMENT
To mimic the wild, the Glacier Run animal management program is built around the idea of being consistently inconsistent and allowing the animals to have some level of control over their environment. The complexity of the facility allows the animals to make choices throughout their day, including the option to be off or on exhibit. Abundant enrichment opportunities provide mental stimulation, and daily training builds trust between keepers and animals. These elements reduce unnecessary habituation, prevent or decrease abnormal repetitive behaviours and allow for close and careful monitoring of physical health.
The exhibit and holding areas were designed using guidelines from the Marine Mammal Protection Act and the Manitoba Standards. The main exhibits and off-exhibit holding areas exceed these standards and two of these areas also include pools in the event an animal is unable to go into the exhibit. Skylights were built in the bear holding areas to provide natural light. The bear exhibits and holding area form a complete loop for rotating the bears in several different directions for management purposes. Each exhibit and holding area has bear access from two locations. An overhead transfer between the Glacier and Bear Alley exhibits is regularly accessible to the bears.

The water features in the bear exhibits provide for the health and well-being of the animals. The bear pool has a shallow shelf that encompasses half of the surface area. The bears, especially the grizzlies, enjoy using this area. The pool then drops to a depth of over 4.3 meters (14 feet), affording them the opportunity to swim and dive. The state-of-the-art aquatic life support systems include a reverse osmosis plant which minimizes the loss of salt water. This system also utilizes the 16°C (60°F) chilled water to cool the ozone generators.

All of the bears are trained to transfer through a holding area with a built-in scale where accurate weights are regularly obtained. There is a mesh training wall in each of the bear exhibits. Keeper training demonstrations are moved from area to area and from bear to bear so as to appear random to the animals and to discourage their anticipation.

Modifications include changes to animal shift door to create “howdy panels” to give bears visual access to other bears and keepers. The animal shift door into Bear Alley was modified with a mesh panel to allow keepers greater visual access during the introduction of a cub to Bear Alley.

**RESEARCH**

PGAV Destinations and The Marketing Workshop, Inc. conducted qualitative research in 2005 to help guide the design and process. The "From Knowledge to Narrative" workshop was conducted in 2007 to formulate interpretive objectives, key messages, etc. Applied Research and Education Center (AREC) at Indiana University Southeast performed online surveys in April 2011, post-opening surveys in October 2011, and visitor behaviour tracking in October 2011. Expanded curriculum offerings in the science behind global warming are made possible by a NSF grant.

**CONSERVATION**

The Louisville Zoo participates in AZA conservation initiatives, programs and studies with regard to the conservation and well-being of the bears. In a collaborative effort with U.S. Fish and Wildlife Service’s Alaska Region, the Coordinator of the Polar Bear Species Survival Plan (SSP), and Polar Bears International, it was determined that Louisville Zoo’s new Glacier Run bear habitat was the best placement option for a rescued Alaskan polar bear cub who brings more genetic diversity to the captive population.

The zoo collaborates and provides funds for its in situ conservation partner, Polar Bears International. Off-site conservation education included several “Tundra Connections,” live links between local environmental magnet schools and PBI scientists in Churchill, regional distribution of 500,000 arctic themed Backyard Action Hero activity books to schools, podcasts, blogs, over 30 “Bears About Town” public outreach events regionally and 249 school outreaches for over 14,000 students.

For better water conservation, all sand filter backwash water is reclaimed to dirty water basins, processed through additional filters and returned to the pool. There is also a reverse osmosis system to remove rain water from the salt water pools to help prevent salt water from going to the storm sewers. Constructing the holding building below ground allows for natural convection cooling. This provides the air conditioning system a -7°C (20 degree Fahrenheit) cooling advantage in the summertime, minimizing the conflict of these systems working overtime to reduce the humidity created by the large volumes of water in the holding pools. The entire back wall in the former polar bear exhibit was maintained and used as a retaining wall. The steep grades and utilizing the exaction of the old exhibit saved tons of CO₂ that would have been needed to fuel earth-moving equipment. All chillers, HVAC and lighting systems were specified to meet the highest level of energy efficient operations available.
Taracad Narayanan Ananthakrishnan (b. 15 December 1925), renowned Indian entomologist and insect ecologist, is no more. He passed away in New Jersey (U.S.A.) at 2.30 PM on Friday, 7 August 2015, leaving behind Menaka Ananthakrishnan, Ramdas, Pushpa, Nisha, Arjun, Ranee, Aparna, and Ashwini, besides several of us — his doctoral students. Influenced by M.S. Mani, master of Indian entomology of the 1940s, Ananthakrishnan made great strides studying Indian insects from the 1950s. Ananthakrishnan’s journey with thrips commenced in mid-1940s. He first looked at the feeding behaviour, population dynamics, and reproductive biology of *Arrhenothrips ramakrishnae*, a thrips described by Joseph Douglas Hood, an American entomologist, based on the materials supplied by Ramakrishna from India, in the early decades of the 20th century.

Approximately until the mid-1970s, with generous funding under the PL—480 scheme, he could travel the length and breadth of India and collect Thysanoptera and describe them. In essence, during these 30-odd years, working in Loyola College, Madras, Ananthakrishnan made immense advances collecting and describing scores of Indian Thysanoptera, which incidentally brought to light their importance in agriculture, horticulture, and forestry.

Between 1950 and 1980, Ananthakrishnan had unravelled 396 new nominal taxa of Thysanoptera, which included 76 new taxa of the genus group and 320 new taxa of the species group. With the experience of collecting and analyzing hundreds of Indian Thysanoptera, Ananthakrishnan was impressed with phenotypic variations he saw in their populations. His interest into the ecology and evolution of animals was gradually evolving and the most opportune moment came in the 1970s, when the University Grants Commission (New Delhi) launched a textbook-writing scheme, which he utilized to write the *General Animal Ecology* with T.R. Viswanathan. This book was, and continues to be, one of those fine books on animal ecology, which was (and is) highly suitable for use by undergraduate and postgraduate students of biology. This book uniquely incorporated ecological details of Indian animals.

He served as the Director of Zoological Survey of India and in 1980 formed the Entomology Research Institute at Loyola College, Chennai. The Entomology Research Institute was established by him with a singular purpose of understanding and explaining the chemical and molecular ecology of insect—plant interactions. He also served as the Co-chair of the IUCN SSC South Asian Invertebrate Specialist Group. An admirable trait in him was his thorough knowledge of animals — from the Protozoa to Mammalia and from their classification to their physiology. He was a born teacher who had the innate skill to teach effectively and inspirationally, be it general zoology or entomology or the ecology of insect—plant interactions - Extract from Anantanarayanan Raman Note.
ZOO’s PRINT Publication Guidelines

We welcome articles from the conservation community of all SAARC countries, including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka and other tropical countries if relevant to SAARC countries’ problems and potential.

**Type** — Articles of semi-scientific or technical nature. News, notes, announcements of interest to conservation community and personal opinion pieces.

**Feature articles** — articles of a conjectural nature — opinions, theoretical, subjective.

**Case reports**: case studies or notes, short factual reports and descriptions.

**News and announcements** — short items of news or announcements of interest to zoo and wildlife community.

**Cartoons, puzzles, crossword and stories**

**Subject matter**: Captive breeding, (wild) animal husbandry and management, wildlife management, field notes, conservation biology, population dynamics, population genetics, conservation education and interpretation, wild animal welfare, conservation of flora, natural history and history of zoos. Articles on rare breeds of domestic animals are also considered.

**Source**: Zoos, breeding facilities, holding facilities, rescue centres, research institutes, wildlife departments, wildlife protected areas, bioparks, conservation centres, botanic gardens, museums, universities, etc. Individuals interested in conservation with information and opinions to share can submit articles ZOOS’ PRINT magazine.

**Manuscript requirements**

Articles should be typed into a Word format and emailed to zooreach@zooreach.org. Avoid indents, all caps or any other fancy typesetting. You may send photos, illustrations, tables.

Articles which should contain citations should follow this guideline: a bibliography organized alphabetically and containing all details referred in the following style: surname, initial(s), year, title of the article, name of journal, volume, number, pages.

**Editorial details**

Articles will be edited without consultation unless previously requested by the authors in writing. Authors should inform editors if the article has been published or submitted elsewhere for publication.

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ZOOS’ PRINT magazine is informal and newsy as opposed to a scientific publication. ZOOS’ PRINT magazine sometimes includes semi-scientific and technical articles which are reviewed only for factual errors, not peer-reviewed.

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