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A SYNOPSIS OF THE REPTILES OF GUJARAT, WESTERN INDIA

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(with two text-figures)

ABSTRACT.- This paper deals with the reptile fauna of Gujarat State, and is primarily based on a collection made by the author during the Gujarat survey between 1989-1993. Information from earlier collections from Gujarat in the Zoological Survey of India, have also been included, as are data from the literature. To increase the usefulness of the paper, species that have ranges approaching the State have also been included. Altogether, 66 species in 50 genera and 18 families that are known from Gujarat have been dealt with in this report. Keys, diagnostic characters, measurements and distributional notes have been incorporated in the paper. Two squamate species, *Hemidactylus triedrus* and *Lygosoma lineata* are being reported for the first time from Gujarat.

KEY WORDS.- Reptiles, Gujarat, India, systematic list, biodiversity, keys.

INTRODUCTION

The western Indian State of Gujarat, comprising a land area of approximately 200,000 km^2, is situated along the west coast of India (coordinates 20° 01'-27° 07'N; 68° 84'-70° 04'E). The area is bounded by the Arabian Sea in the west, Pakistan in the north, Rajasthan in the north-east, Madhya Pradesh in the south-east and Maharashtra to the south. On the basis of terrain attributes such as geology, ecology and topography, the state of Gujarat can be divided into the following geomorphological divisions:

- North-eastern crystalline hills
- Trappian highlands of south Gujarat
- Rocky tableland of Kachchh and Saurashtra
- Arid and semi-arid plains of north Gujarat
- The Rann of Kachchh
- Alluvial plains of central Gujarat
- Uplands of south Gujarat
- Coastal areas

These diverse ecological conditions promote high levels of biodiversity in the State. The long coastline of Gujarat and other geomorphic divisions, have a distinctive flora and fauna. The annual rainfall and temperature show significant variation from 400-800 mm and 40-50° C, respectively. Forest area comprises 10% of the total land area of Gujarat.

On the Subcontinent, the records of the Asiatic lion (*Panthera leo persica*) and Asian wild ass (*Equus hemionus khur*) are restricted to this state. Among reptiles, *Cyrtodactylus kachhensis kachhensis* and *Hemidactylus porbandarensis* are endemic to Gujarat. About a seventh the reptile fauna of India have been recorded from Gujarat.

Prior to the establishment of the Zoological Survey of India in 1916, little work was carried out on the reptiles of Gujarat. Acharya (1933), Bhaskar (1981), Daniel and Shull (1963), Frazier (1989), Smith (1931, 1935, 1943), Sharma (1981, 1982), Vyas (1989a; 1989b; 1994) and Vyas and Patel (1990), provided data on the fauna. However, information on the fauna is largely limited to notes on anecdotal observations on natural history or checklists.

The present work is an inventory of the reptile fauna of the State of Gujarat. Material for this study was collected by the author between 1989-1993, as well as the older collections preserved in the National Zoological Collection,

Zoological Survey of India (ZSI), Calcutta. Altogether, 66 species belonging to 50 genera and 18 families are being reported. The paper lists current scientific name, diagnostic characters, distribution, measurements and key for the identification of all 66 species of reptiles reported from Gujarat.

MATERIALS AND METHODS

Aquatic forms were collected with cast nets and fishing hooks. Terrestrial and arboreal forms were collected by hand or with forceps. The reptiles reported in this paper have been collected by staff members of the Zoological Survey of India. Specimens were killed using chloroform and fixed in 5% formalin solution. An incision on the abdomen was made in case of large specimens, and small specimens were injected with a 10% formalin solution inside the abdomen, for fixation of viscera. The fixed material along with labels containing data on locality, altitutude, habitat, date of collection and name of collector, were packed and kept in 5% formalin solution. The material was unpacked in the laboratory, washed in water and preserved in 95% ethanol.

Where no material has been mentioned, data on species have been derived from the literature.

SYSTEMATIC ACCOUNT

CLASS: REPTILIA

ORDER: CROCODYLIA

FAMILY: CROCODYLIDAE

GENUS: *Crocodylus* Gronovius, 1763

Crocodylus palustris Lesson, 1834:

Description: Snout broad, without lachrymal ridges, 1-1/3 to 1-1/2 times as long as broad at base. A row of four distinct, sharply raised, post-occipitals, dorsal scutes in 16-17 transverse rows and four, sometimes six longitudinal series of bony plates embedded in skin. Ventrally, skin lacks armour. Fingers webbed at base.

Distribution: This species inhabits rivers, lakes and other large waterbodies throughout the Indian region. According to Vyas (1994), it occurs in all major river systems and large reservoirs of Gujarat State. It also occurs in Nepal, Pakistan, Bangladesh and Sri Lanka.

ORDER: TESTUDINES

SUBORDER: CRYPTODIRA

Key to families:

1. Limb clawless . . . . . Dermochelyidae
1'. Limb clawed . . . . . 2.
2. Shell covered with smooth skin . . . . . Trionychidae
2'. Shell covered with horny skin . . . . . 3.
3. Limbs paddle-shaped . . . . . Chelonidae
3'. Limbs not paddle-shaped . . . . . 4.
4. Limbs flattened, digits webbed . . . . . Bataguridae
4'. Limbs not flattened, digits free . . . . . Testudinidae

FAMILY: DERMOCHELYIDAE

GENUS: *Dermochelys* Blainville, 1816

Dermochelys coriacea (Linnaeus, 1766):

Description: Body and limbs of hatchlings covered with polygonal shields; 6 longitudinal ridges on carapace and 5 on plastron; top and sides of head covered with symmetrical scutes; body covered with smooth skin in adult. Beak on upper jaw with `w' shaped cusp. Limbs paddle-shaped and clawless; forelimbs large. Tail short. Dorsal colour black with pale yellow or white spots; paler below.

Distribution: Gujarat, Goa, Kerala, Tamil Nadu, Andhra Pradesh, Lakshadweep, Andaman and Nicobar Islands. A cosmopolitan species.

FAMILY: CHELONIIDAE

Key to genera:

Four pairs of pleural shields. . . . . *Chelonia*
Five or more pairs of pleural shields . . . . . *Lepidochelys*

GENUS: *Chelonia* Brongniart, 1800

Chelonia mydas (Linnaeus, 1758):

Description: Snout short, upper jaw blunt, decending perpendicularly from nostril without hook; tomium of lower jaw serrated, that of upper jaw with strong vertical ridges on upper surface; forelimbs single-clawed and with large scales. Carapace heart-shaped or oval, with pairs of pleurals. Vertebrals broader than long. Colour marbled olive above, with darker spots or streaks, paler below.

Distribution: Gujarat, Maharashtra, Kerala, Lakshadweep, Tamil Nadu, Andhra Pradesh, Andaman and Nicobar Islands. A cosmopolitan species.

GENUS: *Lepidochelys* Fitzinger, 1843

Lepidochelys olivacea (Eschscholtz, 1829):

Description: Carapace broad, almost heart-shaped, fairly raised, flat topped; posterior marginals serrated; 5-9 pairs of pleurals; 12-14 pairs of marginals; a broad nuchal touching first pleural; five or more coastals; marginals 27, rarely 25. Carapace of juveniles with three distinct keels; inframarginals pores distinct. Head small, triangular; four prefrontal scales on forehead; upper jaw hooked but without ridge. Adult olive-brown above, yellowish below.

Distribution: Gulf of Kachchh in Gujarat. It is also recorded from the coasts of Maharashtra, Goa, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, Andaman and Nicobar Islands. A cosmopolitan species.

FAMILY: TESTUDINIDAE

GENUS: *Geochelone* Fitzinger, 1835

Geochelone elegans (Schoepff, 1792):

Material examined: Banaskantha District. ZSI 25041, near Rasarpur Village, 20 km from Palanpur. 20.9.1993.

Measurements: Carapace length 55 mm, carapace width 52 mm. Shell height 38 mm.

Description: Carapace oblong when viewed from above in adults, to almost round in juveniles. Nuchal absent; all vertebrals, except first, which is as long as broad, are broader than long; 12th marginals united, bridge with a single axillary and inguinal scute on each side. Head moderate in size, its anterior bulging and some-

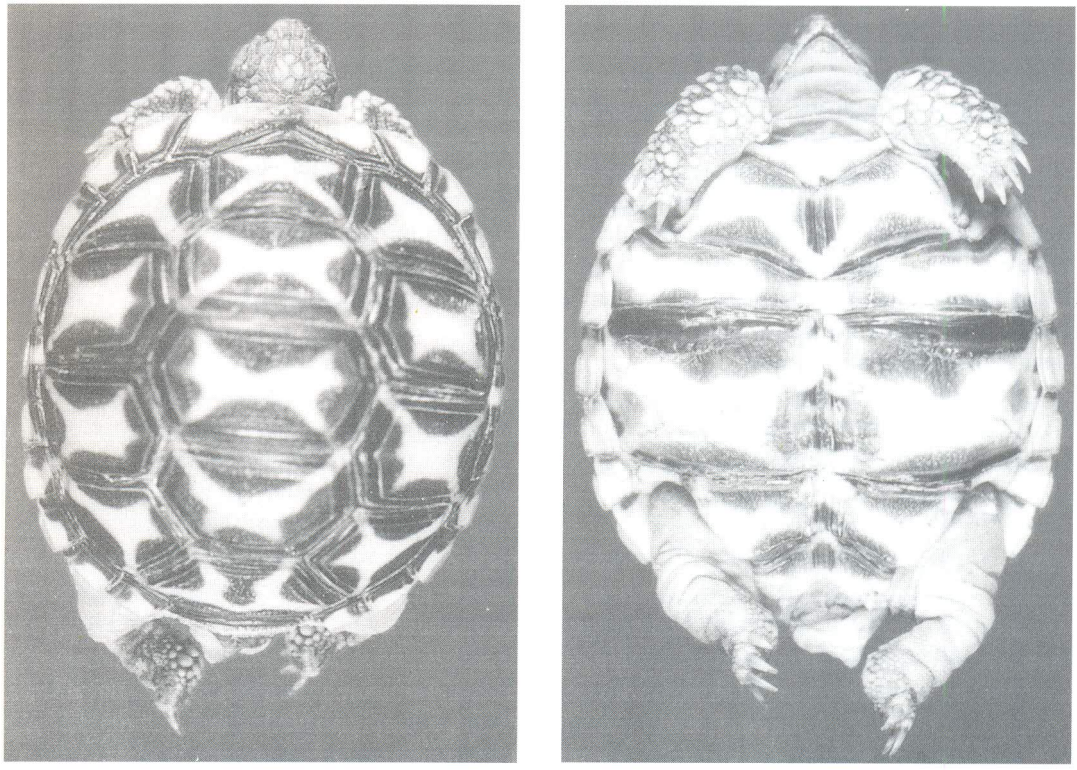

FIGURE 1: *Geochelone elegans* (ZSI 25041) in dorsal (left) and ventral (right) views.

what convex; upper jaw slightly tricuspid. Skin on forehead divided into small irregular shields. Tail moderately long and terminating in a spur-like scute; shell black above, each vertebral and coastal shield with a yellow areola, from which radiate as many as eight streaks, producing a starred pattern which is continuous over marginals to plastron. Heads and limbs yellow, more or less spotted with dark brown or black.

Distribution: Gujarat, found also in other districts, according to reports. Elsewhere- Rajasthan, Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh. Outside India- Pakistan and Sri Lanka.

FAMILY: TRIONYCHIDAE

Key to genera:

Marginal bones absent; no cutaneous plastral flaps; snout long . . . . . *Aspideretes*

Marginal bones present; cutaneous plastral flaps present; snout short . . . . . *Lissemys*

GENUS: *Aspideretes* Gray, 1872

Aspideretes gangeticus (Cuvier, 1824):

Description: Carapace low and oval. Head comparatively large and broad with dorso-laterally situated eye; elongated proboscis. Limbs with three claws. Tail short. Carapace dull olive green with irregular dark reticulation, plastron ivory white. Head greenish, with black longitudinal streak from between eyes and nape; three oblique black streaks on sides; 4-6 eye-like markings on back of juveniles.

Distribution: Gujarat, Punjab, Rajasthan, Orissa, Bihar, Uttar Pradesh. Outside India- Pakistan, Nepal and Sri Lanka.

GENUS: *Lissemys* Smith, 1931

Lissemys punctata punctata (Bonnaterre, 1788):

Material examined: Kachchh District, ZSI 25040, Gudver Nabhoi Forest area, 28. 9. 1993. ZSI 25046, Bachau, 26. 9. 1993. Rajkot District, 1 ex., Rajkot. Coll. D. Sood.

Measurements: Carapace length 60-150 mm; carapace width 55-100 mm; shell depth 35-65 mm.

Description: Carapace broadly oval in adults; circular in juveniles. Head moderately large, snout short, its length less than eye diameter; carapace and plastron covered with skin; callosities finely granulated. Lateral and hind portion of carapace flexible. Plastron with soft semi-circular flaps, which conceal retracted hindlimbs. Plastron with seven callosities. Limbs fully webbed, three clawed. Tail short. Olive-brown above, with numerous black-bordered yellow spots, irregularly arranged, with a light yellow rim.

Distribution: Gujarat, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar West Bengal, Andaman Islands. Outside India- Pakistan, Nepal, Sri Lanka, Bangladesh and Myanmar.

FAMILY: BATAGURIDAE

Key to genera:

Vertebral shield short-sided anteriorly . . . . . *Kachuga*

Vertebral shield short-sided posteriorly . . . . . *Melanochelys*

GENUS: *Kachuga* Gray, 1869

Key to species:

Head patterned with a broad red or orange crescentic band. . . . . *tecta*

Head without crescentic band . . . . . *tentoria*

Kachuga tecta (Bell, in Gray, 1831):

Description: Carapace elevated, oval with a prominent vertebral keel that is spiked especially on third shield, hind margin of carapace not or feebly serrated. Nuchal usually broadest behind. Head moderate, patterned with a broad red crescentic band, snout shorter than orbit, pointed and slightly projecting beyond lower jaw; upper jaw unnotched. Digits fully webbed; limbs with transversely enlarged scales. Colour olive brown above, with a red keel, below pinkish-yellow; each scute with 2-3 black blotches. Head black on top; temporal regions often with a yellow `v'-shaped mark; limbs dark olive, with yellow spots.

Distribution: Gujarat. Elsewhere- Punjab, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Assam, Meghalaya, Arunachal Pradesh. Outside India- Pakistan, Nepal and Bangladesh.

Kachuga tentoria circumdata (Mertens, 1969):

Description: Carapace elevated, oval with distinct vertebral keel that is spiked especially on vertebral 3; vertebral 3 and 4 longer than wide, vertebral 5 wider than long, vertebral 1 longer than wide; plastron truncated anteriorly, notched posteriorly. Head patterned without crescentic band, snout pointed, skin at back of forehead with irregular scales; upper jaw unnotched, vertebral shields short-sided anteriorly. Limbs are with fully and broadly webbed digits and have transversely enlarged scales. Colour olive-brown above with a reddish keel; pink ring along peripheral-marginal juncture, yellowish below with a single black blotch on each scute. Two curved pink bands on middle of forehead; pink broken band behind eye.

Distribution: Gujarat, Madhya Pradesh and Uttar Pradesh.

GENUS: *Melanochelys* Gray, 1869

Melanochelys trijuga (Schweigger, 1814):

Description: Head moderately small, snout shorter than orbit, slightly projecting beyond lower jaw, upper jaw notched at middle. Vertebral shields short-sided posteriorly. Carapace elongated, fairly elevated in adults, depressed in juveniles, tricarinate; posterior marginals feebly serrated; nuchal small, triangular. Head greyish-olive with yellow or pink reticulations which are most prominent on sides.

Distribution: This subspecies is distributed in Gujarat, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh.

ORDER: SQUAMATA

SUBORDER: SAURIA

Key to families:

1. Tongue slender, forked. . . . . Varanidae
1'. Tongue not slender nor forked. . . . . 2.
2. Top of head with symmetrical shield . . . 3.
2'. Top of head without symmetrical shield. . . . . 4.
3. Body not covered with osteodermal plates, femoral pores absent . . . . . Scincidae
3'. Body covered with osteodermal plates, femoral pores present . . . . . Lacertidae
4. Tail prehensive . . . . . Chamaeleonidae
4'. Tail not prehensile. . . . . 5.
5. Dorsal scales imbricate; pupil rounded . . . . . Agamidae
5'. Dorsal scales not imbricate; pupil a narrow slit. . . . . 6.
6. Eyes with movable eyelids; digits dilated . . . . . Gekkonidae
6'. Eyes with movable eyelids; digits not dilated . . . . . Eublepharidae

FAMILY: EUBLEPHARIDAE

GENUS: *Eublepharis* Gray, 1827

Eublepharis fuscus (Börner, 1981):

Description: Eyelid movable, body stout, back with small juxtaposed scales intermixed with enlarged tubercles, limbs short, tail shorter than head and body, swollen at base, eight supralabials, 42 midbody scale rows, males with 10 preanal pores, femoral pores absent.

Distribution: This species (which has been misidentified with *Eublepharus macularius* in the older literature) occurs from Gujarat and Maharashtra to northern Karnataka.

FAMILY: GEKKONIDAE

Key to genera:

1. Eyelids movable . . . . . *Eublepharis*
1'. Eyelids immovable . . . . . 2.
2. Digits strongly dilated . . . . *Hemidactylus*
2'. Digits not dilated . . . . . *Cyrtodactylus*

GENUS: *Cyrtodactylus* Gray, 1827

Cyrtodactylus kachhensis kachhensis (Stoliczka, 1872):

Material examined: Kachchh District, ZSI 25011, near Khatri Talaw, 10 km from Bhuj, 28.9.1993.

Measurements: Snout to vent 35 mm, tail 40 mm.

Description: Head moderately large, depressed, covered with minute granular scales in-

termixed with large tubercles; eye large, ear opening smaller than pupil, a vertical slit. 10 upper labials and 8 lower labials. Body dorsoventrally flattened, with distinct lateral fold; dorsal scales composed of 12 rows of smaller subtriheadral tubercles intermixed with small granular scales; belly covered with large rounded imbricate scales; digits long, slender, not dilated; toes elongate; subdigital lamellae well developed. Tail slightly depressed. A male with 6 preanal pores. Colour grey; dark black spots on back arranged irregularly; cream below.

Distribution: Gujarat. Elsewhere- Pakistan.

GENUS: *Hemidactylus* Gray, 1825

Key to species:

1. Enlarged dorsal tubercles numerous, strongly keeled, arranged in regular longitudinal series . . . . . 2.
1'. Enlarged dorsal tubercles not numerous, feebly keeled, not regularly by arranged . . . 3.
2. Free distal phalanx of inner digit at least half as dilated portion . . . . . 4.
2'. Free distal phalanx of inner digit not half as long as dilated portion . . . *porbandarensis*
3. Dorsal tubercles large, back with dark cross bars . . . . . *triedrus*
3'. Dorsal tubercles large, back with dark spots . . . . . *brookii*
4. 9-11 lamellae under fourth toe; 10-17 femoral pores on each side . . . . . *leschenaultii*
4'. 11-14 lamellae under fourth toe; 5-7 femoral pores on each side . . . . . *flaviviridis*

Hemidactylus triedrus (Daudin, 1802):

Material examined: Surat District, ZSI 24583, Jamwala, 17.12.1962. Coll. B. Biswas.

Measurements: Snout to vent 55 mm; tail broken.

Description: Head rather large; snout obtusely pointed. 9 (8-10) upper and 7 lower labials; nostril between rostral and small scales. Back with small irregular scales with large triheadral tubercles arranged in 16 (16-18 regular longitudinal rows. Digits with 6 (6-7 lamellae under first and 8-9 (7-10) under fourth toe. Back with olive green and white edged crossbars. Belly white with a reddish tinge.

Distribution: Gujarat, Andhra Pradesh, Kerala, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Pakistan and Sri Lanka.

Hemidactylus brookii Gray, 1845:

Material examined: Banaskantha District, ZSI 25030, Palanpur, 19.9.93. Bhabnagar District, ZSI 24879, Songadh, 21.9.89, Bharuch District, ZSI 24911, Dediapara Forest Rest House, 23.3.92. Jamnagar District, ZSI 24886, Khambalia, 45 km west of Jamnagar town, 2.9.89. ZSI 24884, Sasangir, 15.9.89. ZSI unreg., Willingdon Dam area, 10.9.89. Kheda District. ZSI 24926, Radhanag Village, 28.11.92. ZSI 24928, Nagra Village, 30.11.92. ZSI 24951, Andhera Village 29.11.92, Rajkot District. ZSI 24887, Chotila, ca. 49 km east of Rajkot, 5.9.89. ZSI 24888, Gondal, *ca* 36 km south of Rajkot town, 7.9.89. Vadodara District, ZSI 24899, in and around Baroda town, 29.3.92. Surat District ZSI 23165, Chaodwadi, 8.12.62. Coll. B. Biswas. ZSI 24581, Gamwala, 3, 15 & 17.12.62. Coll. B. Biswas. ZSI 24582, Jasadha, 9.2.58. Coll. B. Biswas. ZSI 24898, Amroli, 4 km from Surat town, 18.73.92. ZSI 24914, Ukai Dam site, Sonegodh, 15.3.92.

Measurements: Snout to vent 22-45 mm, tail 25-53 mm.

Description: Head moderately large, snout obtusely pointed; 8-10 upper and 7-9 lower labials; 5-6 lamellae under first toe and 7-10 under fourth. Back with conical tubercles arranged in a regular series. Colour brown or grey with dark spots, whitish below. Male with 14-24 preano-femoral pores.

Distribution: Throughout the Indian region. Outside India- south-east Asia, southern China, and northern Africa.

Hemidactylus leschenaultii (Duméril & Bibron, 1836):

Material examined: Banaskantha District, ZSI 25036, Hibatpur Forest Nursery 18.9.1993. Surat District, ZSI 24904, Raniamba, Sonegadh, 14.3.1993. The Dang District, ZSI 24892, Mahal, 12.3.1992.

Measurements: Snout to vent 52-56 mm; tail 60-62 mm.

Description: Body stout with lateral folds, upper labials 10-12, lower labials 8-10. Body dorsally covered with fine granules intermixed with small tubercles irregularly scattered. Scales on belly small, rounded, imbricate; 9-11 lamellae under fourth toe, 6-7 under first; 10-17 femoral pores on each side in males. Grey above and white below. Back with conspicuous wavy crossbars. A dark line from eye to ear.

Distribution: Peninsular India, Rajasthan, West Bengal. Outside India- Pakistan and Sri Lanka.

Hemidactylus flaviviridis Rüppel, 1835:

Material examined: Ahmedabad District, ZSI 24922, Dhandhuka, 3.12.1992. Banaskantha District, ZSI 25031 & 25035, Palanpur, 18.9.1993. Dihiguda Village, Radhanpur, 22.9.1993. Bharuch District, ZSI 24912, Dediapara, Forest Rest House, 23.3.1992. Junagad District, ZSI 24890, Willingdon Dam site, 10.9.1989. Rajkot District, ZSI 24877, Kalawad, ca. 5 km W Rajkot, 6.9.1989. Sabarkantha District, ZSI 25003, Vijaynagar, ca. 78 km from Himatnagar. 12.9.1993. Surat District, ZSI 24903, Raniamba, Sonegadh, 14.3.1992, ZSI 24915, Ukai Dam site, 15.3.1993. The Dang District, ZSI 24916, Mahal, 12.3.1992.

Measurements: Snout to vent 50-80 mm; tail 45- 80 mm.

Description. Moderately large house gecko with 12-15 upper and 10-12 lower labials, 7-10 lamellae under first and 11-14 under fourth toe. Tail swollen at base, body greyish above with five indistinct greenish-brown bands edged with white posteriorly. Belly white, scales with minute black dots.

Distribution: This species occurs from the shores of the Red Sea and around the coasts of the Arabian Peninsula and Iran, across northern India to West Bengal and south to the vicinity of Mumbai.

Hemidactylus porbandarensis Sharma, 1981:

Description: Body slender, slightly depressed snout obtusely pointed, longer than distance between eye and ear opening, which is one third of diameter of eye; upper labials 9-11 and lower labials 7-8; mental large, triangular, two times adjacent labials; two pairs postmentals, inner pair two times larger than outer one; rostral broader than high. Back with small irregular scales and with 16-17 longitudinal series of more or less rounded or oval tubercles; flat, rounded imbricate scales below; 5-6 lamellae under first toe and 9-10 under fourth. Tail moderately depressed, verticillate; upper portion covered with round smooth or feebly keeled scales and a series of 6 strongly keeled pointed tubercles. Males with a series of 6 preanal pores.

Distribution: Porbandar, Junagadh District of Gujarat.

FAMILY: AGAMIDAE

Key to genera:

1. Femoral pores absent . . . . . 2.
1'. Femoral pores present . . . . . *Uromastix*
2. Four toes . . . . . *Sitana*
2'. Five toes. . . . . 3.
3. Body not depressed . . . . . *Calotes*
3'. Body depressed . . . . . *Laudakia*

GENUS: *Sitana* Cuvier, 1829

Sitana ponticeriana Cuvier, 1829:

Material examined: Ahmedabad District, ZSI 20221, Ahmedabad, 11.11.1928. Coll. J. J. Asana; ZSI 24946, Koleswar Village, ca. 14 km Ahmedabad Railway Station, 16.12.1992; Banaskantha District: ZSI 25025, Rasarpur Village, 20 km W Palanpur, 20.9.1993; ZSI 25029, Palanpur; 19.9.1993; ZSI 25038, Hibatpur Forest Nursery, 18.9.1993; Bharuch District: ZSI 24896, Kokam Village, Dediapara, 21.3.1922; ZSI 24906, Dediapara; 22.3.1992; ZSI 24919; Natagam Village, Dediapara, 23.3.1992; Junagad District, ZSI 24885, Sasangir, 15.9.1989; Kachchh District; ZSI 6335-8; Kachchh, July, 1872; F. Stoliczka; ZSI 25014, Dagapara Village, 29.9.1993; ZSI 25020, Nakhatrana, ca. 50 km Bhuj, 29.9.1993; Mehsana District; ZSI 24990, Khedwa Forest Nursery, 10 km Mehsana, 1.10.1993; ZSI 24991; Linch Forest Nursery; ZSI 25024, Jagudan Forest Nursery, Mehsana, 2.10.1993; Panchmahal District, ZSI 24901, Dahod, 27.3.1992; ZSI

24908, Lunwada Forest Rest House, Godhra, 25.3.1993; Rajkot District, ZSI 24873, Rajkot, 8.9.1989; Sabarkantha District, ZSI 24981, Khed-brahma, 16.9.1993; ZSI 25010, Dhaliwali, ca. 58 km from Himatnagar, 11.9.1993; Surat District, ZSI 24894, Raniamba, Sonegadh, 16.3.1992; Dangs District, ZSI 24918, Mahal, 13.3.1992.

Measurements: Snout to vent 18-55 mm; tail 25-130 mm.

Description: A small lizard, easily distinguished from other agamids by having four toes. Body compressed, dorsal scales pointing backwards and upwards, strongly keeled, no dorsal crest. Male with gular pouch; tail long. Dorsally light or dark-brown with a series of dark-brown, black-edged rhomboidal spots on back; belly whitish.

Distribution: Nearly the whole of India up to the limit of the Ganga River in the east. Outside India- Sri Lanka and Nepal.

GENUS: *Calotes* Rafinesque, 1815

Key to species:

Scales on side of body pointing backward and upward; no fold in front of shoulder . . . . . *versicolor*

Scales on side of body pointing backward and downward; a fold in front of shoulder . . . . . *rouxii*

Calotes versicolor (Daudin, 1802):

Material examined: Ahmedabad District, ZSI 24947, Kaleswar Village, 16.12.199. Banaskantha District, ZSI 25028, Palanpur, 19.9.1993. Junagad District, ZSI 24870, Verabal 17.9.1989; ZSI 24883, Dared Village, 1.9.1989, Kachchh District, ZSI 25039, Gudkar Navoi Forest, Bhuj, 28.9.1993, ZSI 25043; Bachaw, 16.9.1993. Kheda District, ZSI 24876, Kalwad, ca. 52 km from Rajkot town, 6.9.1989; ZSI 24925, Radhanag Village 28.11.1992. Mehsena District, ZSI 24984, Jagudan Forest Nursery, 2.10.1992. Sabarkantha District, ZSI 25009, Dhalwali, ca. 58 km from Himatnagar, 11.9.1993, ZSI 25032, Forest at Dhenda, Himatnagar, 13.9.1993. Surendra Nagar District, ZSI 24920, Latuda Forest Nursery, 7.12.1992, ZSI 24929, Dhrangodrah, 12.12.1992. Surat District, ZSI 23642, Chhodawadi, 6.12.1962. Coll. B. Biswas. The Dang District, ZSI 24893, Mahal, 12.3.1992. Valsad District, ZSI 24902, Dharampur, 9.3.1992.

Measurements: Snout to vent 24-110 mm; tail 47-250 mm.

Description: Body compressed laterally, head oval, dorsonuchal crest well developed in the male, two distinct spines on each side of head above tympanum, no gular pouch, no fold in front of shoulder. Tail long, rounded. Greyish brown above with dark transverse bars; belly whitish. Juveniles with light dorsolateral stripes which enclose transverse black spots. The species exhibits considerable colour variation.

Distribution: Widely distributed throughout the south Asian region and most of south-east Asia.

Calotes rouxii Duméril & Bibron, 1837:

Description: Head moderately large; forehead concave; head scales unequal; two small separated spines on the back of head; diameter of tympanum half of orbit. Dorsal scales keeled, lower rows pointing backwards and downwards; 50-60 scales round middle of body; gular sac minute, absent in female; a long oblique, curved fold in front of shoulder. Limbs moderate, slender; fourth finger a little longer than third; fourth toe distinctly longer than third. Tail slightly flattened. Colour olive-brown above; a dark band along side of head on to neck; upper part of head, neck and gular pouch red; dark lines radiating from eye; belly brown.

Distribution: Gujarat and western coastal areas from Mumbai to Kerala.

GENUS: *Laudakia* Gray, 1845

Laudakia minor (Hardwicke & Gray, 1827):

Description: Body slightly depressed, but head not depressed; head scale large, unequal strongly keeled two or a group of spines above tympanum. Dorsal scale keeled, imbricate and 48-58 around body. Ventrals smaller and less keeled than dorsals. An oblique fold in front of shoulder. Tail short, rounded. Colour yellow-

ish-brown with three rows of dark brown spots on back and tail base. A white streak on each side of nape.

Distribution: From the valley of the Ganga in Uttar Pradesh, to the Indus Valley in the west Kachchh District in Kathiawar, Gujarat.

GENUS: *Uromastix* Merrem, 1820

Uromastix hardwickii Gray, 1827:

Material examined: Surendra Nagar District, ZSI 24954, 25 km from Muli towards Sara Road, 8. 12. 1992.

Measurements: Snout to vent 125 mm, tail 115 mm.

Description: Body depressed, dorsal scales small, smooth; ventrals slightly larger, smooth; no crest, nostril large; tympanum large, deeply sunk, vertically oval; enlarged scales in each side of jar, parallel to infralabials; skin on neck very loose. Tail thick at base, depressed, cross series of spinose scales on tail. Yellowish-brown with dark spots.

Distribution: Gujarat, Uttar Pradesh, Rajasthan. Outside India- Pakistan.

FAMILY CHAMAELEONIDE

GENUS: *Chamaeleo* Laurenti, 1768

Chamaeleo zeylanicus Laurenti, 1768:

Description: Body compressed laterally. Skull strongly ossified; a casque on top of head. Body covered with granular scales; a prominent canthal and supraorbital crest, the latter continued backwards as a ridge of enlarged tubercles along side of head and then curving upwards to meet parietal crest; no rostral appendages. Eye large, pupil opening a small aperture, tympanum absent; tongue extensile, club-shaped at tip. Forelimbs modified for grasping and digits in two opposed sets, two directed away from and three towards body; number is reversed in arrangement of foot. Tail prehensile. Green, varying in shade from pale green to almost black. Tail often banded.

Distribution: Kachchh (Gujarat). Elsewhere- Indian Peninsula up to the drainage of the Ganga in the east. Outside India- Pakistan and Sri Lanka.

FAMILY: SCINCIDAE

Key to genera:

1. Palatine bones meeting on midline of palate . . . . . 2.
1'. Palatine bones separated at median line of palate . . . . . *Ophiomorus*
2. Pterygoid bones separated, palatal notch reaching towards level of centre of eye . . . . . *Mabuya*
2'. Pterygoid bones not separated, palatal notch not reaching level of centre of eye . . . . . 3.
3. Tympanum not exposed . . . . *Ablepharus*
3'. Tympanum exposed . . . . . *Lygosoma*

GENUS: *Mabuya* Rafinesque, 1815

Key to species:

Fronto-nasal broader than long . . . . *carinata*
Front-nasal not broader than long. . . . . *macularia*

Mabuya carinata (Schneider, 1801):

Material examined: Ahmedabad District, ZSI 24923, Dhanduka, 3.12.1994; ZSI 24938, Ahmedabad, 15.12.1992; ZSI 24938, Rojka Village, 5.12.1992; ZSI 24939, Chharodia Village, Dhanduka, 4. 12. 1992. Sabarkantha District, ZSI 25004, Vijaynagar, ca. 78 km from Himatnagar, 12.9.1993, ZSI 25008, Dhalwali, ca. 58 km from Himatnagar, 11.9.93. Surat District, ZSI 24897, Amroli, 4 km from Surat town, 18.3.1993.

Measurements: Snout to vent 40-95 mm; tail 35-90 mm.

Description: Head shields arranged symmetrically; a single pair of nuchals. Frontonasal broader than long. Dorsal and lateral scales subequal with 3 or 5 distinct keels; 30-34 scales round body. Digits moderately long, with smooth or obtuse keeled lamellae, from 14-18 under fourth toe. Juveniles dark bronze above with yellow lateral band from snout to base of tail. Adult, light bronze above with 4-6 rows of black dots on back. A light band from behind eye to base of tail. Belly white or yellow.

Distribution: Widely distributed in the Indian peninsula, Bengal, Assam. Outside India- Sri Lanka, Nepal and Bangladesh.

Mabuya macularia (Blyth, 1853):

Material examined: Ahmedabad District, ZSI 24940, Chharodia Village, Dhanduka 14.12.1992; ZSI 24949, Koleswar Village, 14 km from Ahmedabad Railway Station 16.12.1992. Banaskantha District, ZSI 25026, Rasarpur Village, 20 km from West of Palanpur, 20.9.1993; ZSI 25027, Palanpur 19.9.1993; ZSI 25037, Hibatpur Forest Nursery 18.9.1993. Bharuch District; ZSI 24895, Kokan Village, Dediapara 2.9.1992. Khambat, 1.12.1992; ZSI 24953, Andhera Village, 29.12.1992. Junagad District, ZSI 24179, Somnath, 15.2.1975. Coll. V. D. Srivastava. Kachchh District, ZSI 24988, Bachaw, 24.9.1993; ZSI 25013, Bhuj, 28.9.1993. ZSI 25018, Degapara, 29.9.1993; ZSI 25019, Nakhatrana, Bhuj 29.9.1993; ZSI 25042, Bachaw 26.9.1993. Kheda District, ZSI 24941, Khedwa Forest Nursery, 1.10.1993. 24985, Jagudan Forest Nursery 2.10.1993; ZSI 24992, Mehsana District, Linch Forest Nursery, 2.10.1993; ZSI 25006, Mehsna, 3.10.1993. Sabarkantha District, ZSI 25007, Dhalwali, ca. 58 km from Himatnagar. 11.9.1993. Surat District; ZSI 19746, Surat, 19. 11. 1917. Coll. T. B. Fletcher. Surendra Nagar District; ZSI 24934, Ramul Forest Nursery, 7. 12. 1992; ZSI 24932, Khareswar Village, 10. 12. 1992; Dang District; ZSI 24917, Mahal, 12. 2. 1993.

Measurements: Snout to vent 28-60 mm; tail 32-90 mm.

Description: Head small; snout short, not depressed; eye small; frontonasal not broader than long; ear opening oval, slightly smaller than eye. 6 or 7 upper and 7 lower labials. 28-30 scales round middle of body. Dorsal scales 5-7 low keels; lateral scales smooth; 12-17 lamellae under fourth toe. Tail round. Colouration variable. Brown, with or without spots. Flanks dark brown with white spots.

Distribution: Widely distributed throughout India. Outside India- Thailand, Malaysia, Vietnam, Myanmar, Pakistan, Sri Lanka and eastern China.

GENUS: *Ablepharus* Fitzinger, 1823

Ablepharus grayanus Stoliczka, 1872:

Material examined: Kachchh District, ZSI 25015, near Khatri Talaw, 10 km from Bhuj town, 28. 9. 1993.

Measurements: Snout to vent 30 mm; tail- 30 mm.

Description: Size small; snout short, supranasals absent, lower eyelid with large transparent disc; upper composed of three scales; ear-opening absent; 20 scales round middle of body, dorsal scales largest. Limbs short, pentadactyle. Tail with enlarged plates. Body olive-green above with shining metallic lustre. A light stripe from supracilliary edge to tail base. Tail pinkish.

Distribution: Gujarat, Rajasthan. Outside India- Pakistan.

GENUS: *Lygosoma* Hardwicke & Gray, 1827

Key to species:

1. Lower eyelid scaly . . . . . *albopunctata*
1'. Lower eyelid not scaly, with an undivided transparent disc . . . . . 2.
2. Five fingers, five toes . . . . . *punctata*
2'. Four fingers, four toes . . . . . *lineata*

Lygosoma albopunctata Gray, 1846:

Material examined: Kheda District, ZSI 24942, Khambat, 2.12.1992; ZSI 24952, Andhera Village, 29.11.1992; ZSI 20390, Gujarat. Coll. J. J. Asana.

Measurements: Snout to vent 35-45 mm; tail 40-50 mm.

Description: Limbs reduced; body elongated, snake-like. Lower eyelid scaly; nuchal indistinct. Ear opening distinct with 1-2 minute lobules on anterior margin. Tympanum deeply sunk. Body scales subequal or dorsal scales a little larger than laterals, 12-15 lamellae under fourth toe. Tail thick at base. Brownish-red above, each scale with a distinct dark spot, forming longitudinal series. Yellowish-white below.

Distribution: This species is being recorded from Gujarat for the first time. Widely distributed in India, from Kerala, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Bihar, Orissa, Bengal and Assam. Outside India- Nepal.

Lygosoma punctata (Gmelin, 1799):

Material examined: Ahmedabad District, ZSI 24924, Dhanduka, 3.12.1992. Kheda District, ZSI 24927, Radhanag Village, 28.11.1992. Surat District; ZSI 19863, Surat, 2.8.1917. Coll. T. B. Fletcher.

Description: Elongated, snake-like body with five fingers and five toes. Lower eyelid with undivided transparent disc. Body scales smooth, 24-26 scales round middle of body and 62-76 scales down middle of back. Limbs reduced, fourth toe quite longer than third, 11-14 lamellae under fourth toe. Tail thick at base. Colour, brown above, each scale with a dark spot forming a longitudinal series; belly yellowish-white.

Distribution: The whole of India, except the north-east. Outside India- Sri Lanka and Indo-China.

Lygosoma lineata Gray, 1839:

Material examined: Valsad District, ZSI 25047, near Naomibohai Village, 9 km from Dharampur, 10.3.1992.

Measurements: Snout to vent 60 mm; tail 65 mm.

Description: Size smaller but with a relatively more elongated body. Lower eyelid with an undivided transparent disc. 22 scales round middle of body; 106 scales down middle of back. Limbs short, with four fingers and four toes, third and fourth toes subequal; 8 lamellae under fourth toe. Golden brown above with black dots forming prominent longitudinal lines.

Distribution: It is recorded for the first time from Gujarat. Elsewhere- Maharashtra and Karnataka.

GENUS. *Ophiomorus* Duméril & Bibron, 1839.

Ophiomorus tridactylus (Blyth, 1855):

Description: Snout pointed, with angular labial edge; frontonasal large; prefrontals separated; frontonasal broader than long; frontal large, 3-4 supraoculars; parietals narrow, not touching interparietal, lower eyelid with large transparent disc; 6 supralabials, fifth largest; no ear-opening. Body elongated; 22 smooth scales round middle of body. Pale brown or uniform cream dorsally; longitudinal series of brown dots on back sometimes present; a dorsolateral brown stripe on each side from nostril through eye.

Distribution: Katchchh in Gujarat, Rajasthan. Outside India- Pakistan, Afghanistan and Iran.

FAMILY: LACERTIDAE

Key to genera:

Nostril touching first labial . . . . . *Acanthodactylus*

Nostril not touching first labial . . . . . *Ophisops*

GENUS: *Acanthodactylus* Wiegmann, 1834

Acanthodactylus cantoris Günther, 1864:

Description: Snout acuminate, nasal shields swollen, in contact with one another; nostril between two nasals and first labial; fronto-nasal single; prefrontals in contact with one another; frontal long, narrow, with a median groove; 4 supraoculars; interparietal small; no occipital shield; subocular not bordering mouth, separated from it by fifth and sixth supralabials; temporal scales keeled; ear opening with a well marked denticulation upon anterior border, lower eyelid scaly; collar distinct; median dorsal scales large,

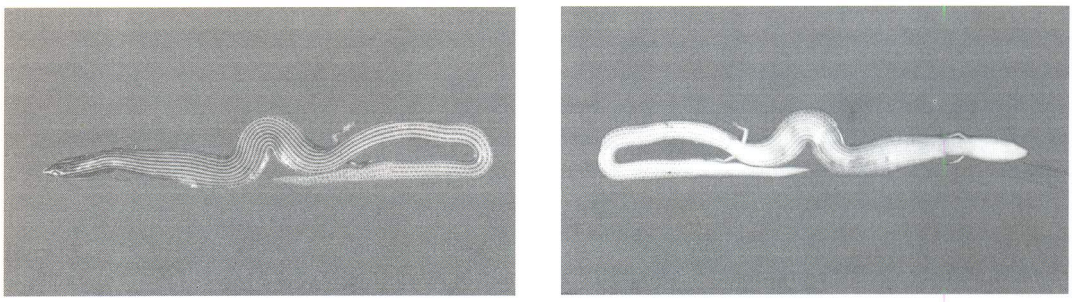

FIGURE 2: *Lygosoma lineata* (ZSI 25047) in dorsal (left) and ventral (right) views.

strongly keeled, imbricate; 26-36 dorsal scales across middle of body; ventral scales in regular longitudinal and transverse series; two large preanal plates, one in front of other. Fourth toe with well-developed lateral denticulation. Subcaudals large. Juveniles with black and white streaks; five white streaks on nape, 4 or 5 on middle of back and 3 at base of tail; a light lateral denticulated streak between ear and terminating at groin; head with black symmetrical markings. Limbs with large round light spots. Lower parts white.

Distribution: Gujarat, Uttar Pradesh, Rajasthan, Haryana and Punjab. Outside India: Pakistan, Iraq, Afghanistan, Iran and Saudi Arabia.

GENUS: *Ophisops* Ménétries, 1832
Key to species:
Upper head-shield smooth . . . . . *microlepis*
Upper head-shield not smooth . . . . . *jerdoni*

Ophisops microlepis Blanford, 1870:

Material examined: Ahmedabad District, ZSI 24948, Koleswar Village, 14 km from Ahmedabad Railway Station 16.12.1992. Jungagad District, ZSI 24881, Dared Village, 1.9.1989; Kachchh District, ZSI 5182-83 & 5186, Kachchh, Coll. F. Stoliczka; ZSI 25017 & 25021, Dagapan Village and Nikhatrana, Bhuj on 29.9.1992, ZSI 25012, near Khatri Talaw, Bhuj 28.9.1993; Rajkot District, ZSI 24874, 8.9.1989. Sabarkantha District, ZSI 24982, Khedbrahma 16.9.1993. Surendra Nagar District, ZSI 24921, Latuda Forest Nursery and ZSI 24936, Ramul Forest Nursery on 7.12.1992, ZSI 24944, Nayaka Dam site, 7.12.1992.

Description: Snout elongate, pointed, upper head shield smooth; nostril between upper and lower nasal; one frontonasal; interparietal long and narrow; temporal scale keeled; tympanic shield large, smooth; dorsal scales rhomboidal, almost equal except outermost rows, in oblique longitudinal series converging towards vertebral line; much smaller than subcaudals; 56 scales round middle of body; ventrals in 6 longitudinal rows; 14 femoral pores on each side, colour olive-green or brown above a light dorso-lateral stripe starts from supraciliary edge and ends at base of tail, bordered above with black spots, a second stripe less distinct, passes along upper lip to base of hindlimb; belly greenish-white.

Distribution: Gujarat Madhya Pradesh, Rajasthan and Bihar.

Ophisops jerdoni Blyth, 1853:

Material examined: Ahmedabad District, ZSI 19823, Ahmedabad, 5.5.1920, Coll. J. Asana; Bhabnagar District, ZSI 24880, Songadh, 30 km from Bhabnagar town, 21.9.1989. Jamnagar District; ZSI 24180-81, Dwarka, 18 & 19.2.1975. Coll. V. D. Srivastava, ZSI 23641, Okha, 16.12.1973, Coll. S. K. Gupta, Kachchh District, ZSI 5184, Kachchh, 1871. Coll. (?); Surat District, ZSI 24580, Jamwali, ZSI unreg., 17.12.1962. Coll. B. Biswas. Surrendra Nagar District, ZSI 24930, Dhrangodrah, 12.12.1992.

Measurements: Snout to vent 18-55 mm; tail 45-130 mm.

Description: Upper head shield strongly keeled, nostril in a large anterior nasal, ear-opening oval a little smaller than eye; gular fold weakly developed, bordered by scales of irregular size; occipital well developed, in contact with interparietal; dorsal scales keeled, imbricate, 28-35 round middle of body; preanal plate large; 7-12 femoral pores on each side. Colour dark olive above and whitish below. Two lemon coloured stripes on flanks which enclose dark transverse bars on middle of back.

Distribution: Gujarat as mentoned in the material. Elsewhere- Rajasthan, Maharashtra, Madhya Pradesh, Andhra Pradesh and Tamil Nadu.

FAMILY: VARANIDAE
GENUS: *Varanus* Merrem, 1820

Varanus bengalensis (Daudin, 1802):

Description: Head long and narrow, covered with small scales, snout pointed and convex at end. Nostril with oblique slit nearer to eye than to tip of snout; scales on crown larger than nuchals; abdominal scales smooth; body scales granular; teeth acute and sharp; tongue long, forked. Limbs strong; digits elongate. Tail long, compressed. Juveniles dark olive above with numer-

ous light spots or ocelli alternating with dark bars and whitish on undersides with dark transverse bars sometimes broken up into spots. Adult brownish or olive with blackish dots on back; lower parts yellow mottled with black.

Distribution: The whole of India. Outside India- Myanmar, Nepal, Pakistan, Iran and southern Uzbekistan.

SUBORDER: SERPENTES

FAMILY: TYPHLOPIDAE

Key to genera:

Nasal suture terminating at edge of preocular. . . . . *Ramphotyphlops*

Nasal suture not terminating at edge of preocular . . . . . *Typhlops*

GENUS: *Ramphotyphlops*Fitzinger, 1943

Ramphotyphlops braminus (Daudin, 1803):

Material examined: Ahmedabad District, ZSI 18712, Ahmedabad, 16.5.1912. Coll. I. Bainbrigge Heycher; ZSI 19204 & 19206, Ahmedabad, 16.6.1920. Coll. J. Asana. Bharuch District, ZSI 24905, Dediapara, 22.3.1992. Junagad District, ZSI 24955, Junagad, 14.2.1975. Coll. V. D. Srivastava. Surendra Nagar District, ZSI 24945, Nayaka Dam site, 7.12.1992.

Measurements: Total length 100-138 mm.

Description: Head bluntly rounded. Eyes indistinct, rostral large, snout rounded; 4 upper labials, last two in contact with ocular. Nasal suture terminating at edge of preocular. Body uniformly cylindrical. Tail very short ending in a small, sharp, stiff point. Scales lightly polished, 20 scales round body. Colour brown or blackish-brown above, lighter below; snout anal region and tip of tail pale.

Distribution: Throughout the Oriental region, Africa, México and New Guinea.

GENUS: *Typhlops*Duméril & Bibron, 1844

Key to species:

Snout rounded . . . . . *porrectus*

Snout pointed . . . . . *acutus*

Typhlops porrectus Stoliczka, 1871:

Description: Snout rounded, strongly projecting; nostril in lateral position; nasal partially divided; ocular and preocular shorter than posterior nasal; eyes indistinct; lower edge of ocular wedged in between third and fourth labials; prefrontal in contact with rostral; tail ending in a five point. 18 scales round body. Colour dorsally blackish-brown, ventral parts paler; anal region cream.

Distribution: Gujarat (Porbandar); Punjab, Uttar Pradesh, Maharashtra, Karnataka, Kerala, Orissa, Bihar, West Bengal. Outside India- Pakistan, Sri Lanka and Myanmar.

Typhlops acutus Duméril & Bibron, 1844:

Material examined: Ahmedabad District, ZSI 19205, Ahmedabad, 16.6.1920. Coll. J. J. Asana.

Description: Snout pointed and hooked, projecting with sharp horizontal edge; nostril inferior; rostral large, covering most of head above. About 30 scales round body. Colour brown above, paler below; each scale paler at centre.

Distribution: Peninsular India, rarer south of latitude 16° N.

FAMILY: BOIDAE

Key to genera:

A supraorbital bone; teeth on premaxilla; head covered with large shields; labials pitted . . . . . *Python.*

No supraorbital bone; no teeth on premaxilla; head covered with small shields; labials not pitted. . . . . *Eryx*

GENUS: *Python* Daudin, 1803

Python molurus (Linnaeus, 1758):

Description: Head flattened with a long snout, neck distinct; head covered with large shields; labials pitted. Nostril large, directed upwards and situated high on snout. Rostral and first two labials with sensory pits. Eyes small, pupil vertical, iris flecked with gold; chin with mental groove. Tail short and prehensile, tapering abruptly. Colour greyish, or yellowish-cream in adults, and in juveniles often a pretty shade of pink. A dark streak from eye to nostril in juveniles; marking sometimes persists in adults. A

conspicuous dark, oblique band from eye to neck. On back of head and nape, a large lance-shaped mark with a pale centre, often fading anteriorly in adults. Body with a series of large, roughly quadrate patches from neck to tail dorsally.

Distribution: Gujarat (no specific records, but likely to occur in the state). Elsewhere- Peninsular India from Sind to Pakistan to Bengal; Sri Lanka.

GENUS: *Eryx* Daudin, 1803.
Key to species:
Mental groove present; tail blunt . . . . . *johnii johnii*
Mental groove absent; tail pointed . . . . . *conicus*

Eryx conicus (Schneider, 1801):

Description: Head slightly distinct from neck. Rostral about two times broader than high; mental groove absent. Nostril slit-like, between two nasals and internasals. Head covered with small obtusely keeled scales, 8-10 scales across forehead between eyes; 10-15 scales round eye. Upper labials 11-13; lower labials 14-17. Body robust; dorsal scales keeled, 40-55 rows. Tail very short and bluntly pointed. Colour yellowish, brownish or greyish above, with a dorsal series of large dark brown, black-edged spots, usually confluent with one another to form a zig-zag stripe; lower parts yellowing or whitish; outer scale-rows with small brown spots.

Distribution: Likely to occur in Gujarat, from where there are at present no confirmed records. The species is distributed from the foothills of the Himalayas to the extreme south of India and from Pakistan in the west to Bengal in the east. Also, Sri Lanka.

Eryx johnii johnii (Russell, 1801):

Material examined: A specimen was observed by the author near the Forest Rest House at Dediapara, Bharuch District on 22.3.1992.

Measurements: Standard length one metre.

Description: Head not distinct from neck; snout broad, wedge-shaped, rostral shield wide and heavy; nostril slit-like, between enlarged nasals; upper labials 9-12, lower labials 13-18; mental groove present; no chin shield; eye small, completely surrounded by 9-12 small scales; pupil vertically elliptical. Body robust, cylindrical, slightly tapering; scale small, smooth. Tail short, blunt, rounded at tip and in general form similar to head. Colour sandy grey or yellowish above, scales edged with dark brown or entirely brown above; uniform or with more or less distinct dark transverse bands; lower parts whitish, spotted with dark brown or almost entirely brown.

Distribution: Gujarat. Elsewhere: Rajasthan, Punjab, Uttar Pradesh and Andhra Pradesh. Outside India- Pakistan.

FAMILY: COLUBRIDAE
Key to subfamilies:
Nostril not valvular . . . . . Colubrinae
Nostril valvular . . . . . Homalopsinae

SUBFAMILY: COLUBRINAE
Key to subfamily:
1. All the teeth solid, not grooved . . . . . 2.
1'. All teeth are not solid, last 2 or 3 maxillary teeth grooved . . . . . 10.
2. Hypapophyses present throughout vertebral column . . . . . 3.
2'. Hypapophyses absent on posterior dorsal vertebrate. . . . . 5.
3. Maxillary teeth equal. . . . . *Xenochrophis*
3'. Maxillary teeth not equal . . . . . 4.
4. Scales in 25-27 rows. . . . *Macropisthodon*
4'. Scales in 15-19 rows . . . . . *Amphiesma*
5. Posterior maxillary teeth longest . . . . . 6.
5'. Posterior maxillary teeth not longest . . . 8.
6. Head elongate, distinct from neck . . . . . 7.
6'. Head short, not distinct from neck . . . . . *Oligodon*
7. Maxillary teeth 13-18. . . . . *Argyrogena*
7'. Maxillary teeth 20-28 . . . . . *Ptyas*
8. All maxillary teeth subequal . . . . . 9.
8'. Some maxillary teeth elongated and fang-like . . . . . *Lycodon*
9. Scales in 19-27 rows. . . . . *Elaphe*
9'. Scales in 13-15 rows . . . . . *Dendrelaphis*
10. Pupil round . . . . . *Psammophis*
10'. Pupil vertical. . . . . *Boiga*

GENUS: *Elaphe* Fitzinger, 1833

Elaphe helena (Daudin, 1803):

Description: Body elongate, cylindrical; head distinct; neck more or less elongate. Teeth solid; anterior maxillary teeth largest; snout twice of eye length; prefrontals twice internasals; loreal slightly longer than high; upper labials 9 or 10; 5th or 6th touching eye; 5th or 7th in contact with temporals. Eye large, pupil round. Scales in 19-27 rows and distinctly keeled on posterior of body and tail, ventrals 217-265 angulate laterally, subcaudals 73-100. Anal single. Colour light or dark-brown above with dark-brown or black cross bars containing white ocelli, prominent anteriorly and laterally. Hind part of body brown above with broad stripe on each side; a black vertical streak below eye and behind it an oblique one; lower parts yellow.

Distribution: Likely to occur in Gujarat. Known from peninsular India, Rajasthan, Punjab, Uttar Pradesh, Bengal, Assam. Outside India- Pakistan and Sri Lanka.

GENUS: *Ptyas* Fitzinger, 1843

Ptyas mucosus (Linnaeus, 1758):

Material examined: Junagad District, ZSI 24869, Verabal, 17.9.1989.

Measurements: Snout to vent 44 mm; tail 170 mm.

Description: Maxillary teeth 20-28. Head long, distinctly wider than neck, snout bluntly pointed; rostral higher than long; nostril between nasals and first upper labials; 3 loreals, 2 preoculars, 2 postoculars, 8 upper labials, 4th and 5th touching eye; 9 lower labials. Eyes large. Scales 17 rows on middle of body. Body robust, compressed, tapering towards both ends. Tail cylindrical, about one-fourth of total length. Colour olivaceus-brown or dark olive-brown. Scales on posterior irregularly margined with black, forming a reticulate pattern sometimes cross-barred. Lips and ventral scales margined with black. Belly greyish-cream.

Distribution: Throughout the south Asian region. Outside the region- from Afghanistan and Turkestan to southern China and Indo-China.

GENUS: *Argyrogena* Werner, 1924

Argyrogena fasciolatus (Shaw, 1802):

Description: Head distinct from neck. Maxillary teeth 12-14; snout strongly projecting; rostral larger than high; nostril between two nasals; loreal squarish; one large perocular, usually touching frontal; 2 postoculars; posterior genials longer and narrower than anterior; temporals 2 + 3 or 3 + 3; 8 supralabials, 4th and 5th touching eye, 5th highest and touching lower anterior temporal. Scales smoth, 21 or 23 round midbody; ventral 197-225, subcaudals 77-92, anals 2. Body colour light or dark brown in juveniles, ornamented with narrow cross-bars on anterior half of body; posterior part with indistinct dark cross-bars or spots which gradually fade towards tail; head above with light and dark olive, two white spots, one on each side or interparietal suture, lower parts whitish or yellowish.

Distribution: Gujarat and throughout India, except in the north-west. Outside India- The Sri Lankan record needs verification.

GENUS: *Oligodon* Boie, 1817

Key to species:

Hemipenis forked; maxillary teeth 6-7 . . . . . *taeniolatus*

Hemipenis not forked; maxillary teeth 8-11 . . . . . *arnensis*

Oligodon taeniolatus (Jerdon, 1853):

Description: Hemipenis forked, Maxillary teeth 6 or 7 in numbers. Head short not distinct from neck, snout blunt; rostral large; higher than wide and extending posteriorly, almost separating internasals; nostril between nasals; loreal present; one preocular; two postoculars, sometimes three; 7 supralabials, 3rd and 4th touching eye; 7 or 8 lower, labials. Body slender or almost uniform diameter from neck to vent. Dorsal scales in 15 rows at midbody. Colour pattern variable according to locality. Light brown to buff above with narrow black transverse cross-bars or large black spots. There are two black streaks on nape. Ventral whitish, sometimes with lateral spots.

Distribution: Peninsular India, including Gujarat. The range extends from Bihar to south-

ern Pakistan. Outside India- Sri Lanka and Pakistan.

Oligodon arnensis (Shaw, 1802):

Description: Hemipenis not forked; maxillary teeth 8-11 in numbers. Snout short and blunt; nostril in an elongated nasal; rostral large, partly separating internasals; 7 supralabials, 3rd and 4th touching eye, loreal frequently united with prefrontal; 1 preoculars and 2 postoculars; scales in 17 rows. Head depressed. Body cylindrical, short and smooth. Tail short. Colour reddish or greyish-brown with a series black bands; lower parts whitish, sometimes with faint spots.

Distribution: May occur in Gujarat. Elsewhere- throughout India. Outside India- Pakistan, Nepal, Bangladesh and Sri Lanka.

GENUS: *Dendrelaphis* Boulenger, 1890

Dendrelaphis tristis (Daudin, 1803):

Description: Maxillary teeth 17-22, posterior smallest. Head distinct from neck; snout broadly rounded; nostril between two nasals, rostral broader than high; frontal bell-shaped, internasals shorter than prefrontals; loreal elongated twice as long as high; 1 preocular, 2 postoculars, temporal 2 + 2, 9 supralabials, 5th and 6th touching eye. Scales in 15:15:11 rows. Ventrals 163-197, subcaudals 108-145, anals 2. Colour bronze brown or purplish-brown above light greyish, greenish or yellowish below; a buff flank stripe along outer two scale rows, edged with black upper lip and eye margined with yellow.

Distribution: Likely to occur in Gujarat. Elsewhere- throughout India. Outside India- Pakistan and Sri Lanka.

GENUS: *Lycodon* Boie, 1826

Key to species:

Ventrals angulate laterally; 9 supralabials . . . . . *aulicus*

Ventrals not angulate laterally; 8 supralabials . . . . . *striatus*

Lycodon aulicus (Linnaeus, 1758):

Description: Snout more or less spatulate and projecting beyond lower jaw, rostral much broader than high, anterior and posterior nasals subequal; internasals much shorter than prefrontals; loreal in contact with internasal, not touching eye; 1 preocular; 9 supralabials; 3rd, 4th and 5th touching eye; 17 scales at mid body; ventrals 172-214 strongly angulate laterally; subcaudal 57-80; anal 2. Colour brown or greyish-brown above, with 12-19 white crossbars which expand laterally or bifurcate, enclosing triangular patches; a triangular whitish blotch on each side of occiput. Upper lip immaculate white or spotted with brown.

Distribution: Likely to occur in Gujarat. Elsewhere - the whole of southern Asia, including Maldives, Sri Lanka and Nepal, besides Myanmar, Indo-China, south China, the Malay Peninsula, Indonesia and the Philippines.

Lycodon striatus (Shaw, 1802):

Description: Snout projecting beyond lower jaw, rostral much broader than high; anterior nasal usually larger than posterior; internasals much shorter than prefrontrals; loreal in contact with internasal, not touching eye; 1 perocular, 8 supralabials, 3rd, 4th and 5th touching eye;1 scales round midbody, ventrals 165-195 not angulate laterally; caudal 45-58; anal 2. Colour dark brown or black above with 11-18 white or yellowish crossbars on body which divide on sides to enclose triangular spots of body; belly and upper lip white.

Distribution: Likely to occur in Gujarat. Elsewhere- throughout India, westwards up to Iran and Bihar in the the east; Sri Lanka.

GENUS: *Macropisthodon* Boulenger, 1893

Macropisthodon plumbicolor (Cantor, 1839):

Material examined: ZSI 19203 (head only) Ahmedabad, Coll. J. J. Asana.

Description: Head rather broad and short; nostril between two nasals; internasals as long as or nearly as long as prefrontals; loreal united with lower preocular, 2 preocular and 3 or 4 postoculars; 7 supralabials, 3rd and 4th touching eye. 25 scales around body and strongly keeled. Eye moderately large, iris greenish gold. Tail short. Bright green above, white below, with an

indistinct pattern of crossbars on back, belly greyish-white.

Distribution: Throughout India, except the valley of the Ganga and the extreme north. Outside India- Sri Lanka.

GENUS: *Amphiesma* Duméril, Bibron & Duméril, 1854

Amphiesma stolatum (Linnaeus, 1758):

Description: Internasal broadly truncate anteriorly; nostril slightly directed upwards; nasals not touching 2nd upper labials; rostral slightly directed upwards; nasals not touching 2nd upper labials; rostral touching 6 shields; a single anterior temporal; 8 supralabials, 3rd, 4th and 5th touching eye; scales 15-19 rows, strongly keeled, except in outer rows which are smooth. Colour olivaceous-brown. A pair of conspicuous buff stripes covering one whole or two half rows of scales from neck to tip of tail; head olivaceous-brown, whitish yellowish or orange on tips; belly white, with some small scattered black spots.

Distribution: The whole of India. It may occur in the Andaman Islands and Gujarat. Elsewhere- Bangladesh, Sri Lanka, Pakistan, south China and Indo-China.

GENUS: *Xenochrophis* Günther, 1864

Xenochrophis piscator (Schneider, 1799):

Material examined: Junagad District, ZSI 24871, Manderada, 18.9.1989. Kachchh District, ZSI 19207, Kandala, July 1919. Coll. R. B. S. Sewell.

Measurements: Snout to vent 250 mm, tail 95 mm.

Description: Head slightly flattened, distinct from neck; snout bluntly pointed; rostral wider than high; internasals distinctly narrowed anteriorly; nostril between nasals; single large loreal; eye moderate with round pupil; 9 supralabials, 4th and 5th touching eye 6th excluded by lowest postocular. Body stout; scales in 19 rows, more or less distinctly keeled, except in outer one or two rows, which are smooth. Colour yellowish or olivaceous above, with black spots quincuncially arranged; head olive-brown above with two oblique black streaks, one below, other behind eye. Dorsal spots arranged in five series, together forming a chess board pattern. Belly cream.

Distribution: Throughout the south Asian region, from Balochistan to northern Myanmar.

GENUS: *Boiga* Fitzinger, 1826

Boiga trigonata (Schneider, 1802):

Description: Head triangular, much distinct from neck, rather flat; rostral strongly concave below, slightly wider than high; nostril large, between nasals; loreal present; eye large, with vertically elliptical pupil; 1 preocular and 2 postoculars, 8 supralabials, 3rd, 4th and 5th touching eye; scales in 21:21:15 rows. Ground colour yellowish-brown, sandy or fawn, uniform or mottled with darker shades. Dorsally a series of dark Y-shaped marks which meet at centre and resemble arrowheads. Markings fade before or at vent. Head with a pair of lung-shaped brown patches often bordered with black. A narrow dark streak from behind eye to gape. Belly cream.

Distribution: May occur in Gujarat. Elsewhere- the whole of peninsuar India up to Assam in the east. Outside India- Pakistan and Sri Lanka.

GENUS: *Psammophis* Fitzinger, 1826

Key to species:

Anal divided . . . . . *condanarus*

Anal not divided . . . . . *leithi*

Psammophis condanarus (Merrem, 1820):

Description: Upper head sheild not protuberant; nasal incompleted, divided a suture only from nostril to labial; preocular not in contact with frontal; 2 postoculars; 1 anterior and 2 or 3 posterior temporals, 8 or 9 supralabials, 4th and 5th touching eye; 11 lower labials; scales 17:17:13 rows; head oval; pupil round; tail long; anal divided. Dorsum pale olive to brassy, streaked alternately with distinct nut-brown and greenish olive or buff stripes; belly sulphur or primrose yellow.

Distribution: Gujarat (Kachchh). Elsewhere: Maharashtra, Madhya Pradesh, Uttar Pradesh,

Punjab, Bihar, Bengal, Orissa, Andhra Pradesh. Outside India- Pakistan.

Psammophis leithii Günther, 1869:

Description. Maxillary teeth 11-12. Rostral broader than high; internasals half to two-third of prefrontals; frontal long and narrow and in contact with preocular; loreal region concave, loreal twice as long as high; temporals 1 + 2; 8 supralabials 4th and 5th touching eye; 5 lower labals with anterior genials; scales 17:17:13 rows. Colour yellowish-brown above with four dark-brown longitudinal stripes; a dark longitudinal stripe on top of head. Anal not divided.

Distribution: Gujarat (Kachchh). Elsewhere- Jammu and Kashmir, Punjab, Rajasthan, Maharashtra and Uttar Pradesh. Outside India- Pakistan.

SUBFAMILY: HOMAOPSINAE

Key to genera:

Nasal shields in contact with one another . . . . . *Cerberus*

Nasal shields not in contact with one another . . . . . *Gerardia*

GENUS: *Cerberus* Cuvier, 1829

Cerberus rynchops (Schneider, 1799):

Description: Snout broadly rounded; nostril connected by suture first labial; internasal divided by a longitudinal suture; frontal roken into small scales, anterior half distinct; loreal large; 1 preocular, 1 postocular and 2 suboculars. 9-10 supralabials 5th and 6th below eye, 2 or 3 horizontally divided. Scales striated and strongly keeled in 23-25 rows. Head pear-shaped. Eye small, pupil vertical. Tail short rather compressed at base, rapidly tapering to a point. Back grey with numerous black cross bars, which are obscure in fore part but prominent on hind side. Belly pale yellowish with conspicuous black blotches on crossbars.

Distribution: An estuarine species found in Gujarat. Elsewhere- coasts of India and tidal rivers from Sind to Chittagong (Bangladesh) and eastward to northern Australia.

GENUS:*Gerardia* Gray, 1849

Gerardia prevostiana Eydoux & Gervais, 1837:

Description: Nasal separated by internasal; frontal much broader than supraocular; 1 preocular and 2 postoculars; loreal not in contact with internasal. 7 supralabials, 4th touching eye. Dorsal scale subequal. Tail short. Colour dark grey above and cream below.

Distribution: Gujarat. Elsewhere- coasts and tidal rivers of India. Outside India- Sri Lanka, Myanmar, west coast of the Malay Peninsula.

FAMILY: ELAPIDAE

Key to genera:

Maxillary bone extending forward beyond palatine . . . . . *Naja*

Maxillary bone not extending forward beyond palatine . . . . . *Bungarus*

GENUS: *Bungarus* Daudin, 1803

Bungarus caeruleus (Schneider, 1801):

Description: Head flat distinct from neck; snout blunt; rostral slightly wider than high; nostril between nasals; eye small, pupil round; loreal absent; 1 preocular and 2 postoculars; 1 anterior and 2 posterior temporals; 7 supralabials, 3rd and 4th touching eye; 8 lower labials. Body cylindrical; scales in 15 rows on midbody; vertebral scales enlarged and hexagonal. Tail ending in a point. Colour lustrous black or bluish-black above with paired narrow white crossbars, arranged more or less distinctly in pairs, sometimes breaking up into spots in anterior part of body.

Distribution: Likely to occur in Gujarat. Elsewhere- throughout India up to Bengal in the east and Andhra Pradesh in the south. Outside India- Pakistan, Sri Lanka, Nepal and Bangladesh.

GENUS: *Naja* Laurenti, 1768

Naja naja (Linnaeus, 1758):

Material examined: ZSI 23046, Bata, Gujarat, Coll. Unknown. 6.8.1965.

Measurements: Snout to vent, 1200 mm; tail 175 mm.

Description: Maxillary bone extending forward beyond palatine. Head depressed with

short rounded snout; nostril large; pupil round; 1 preocular and 3 postoculars; 7 supralabials; 3rd largest, touching both nasal and eye; 8 lower labials; small triangular shield (cuncate) between 4th and 5th lower labial at oralmargin; scales rows across widest part of hood usually 25 and 13-15 rows anterior to vent. Extremely variable in colouration and markings. The subspecies once recognised on the basis of hood pattern have now been elevated to species status. One of them has a spectacle-like marking on the hood (*Naja naja*). It is yellowish or brownish to black above and whitish-yellow below.

Distribution: Throughout the south Asian region. Outside India- Bangladesh, Nepal, Sri Lanka and Pakistan.

FAMILY: HYDROPHIIDAE

Key to genera:

1. Ventrals distinct throughout and normally entire . . . . . 2.
1'. Ventrals not so distinct throughout and not entire but divided by a median longitudinal furrow. . . . . 3.
2. Mental shield elongate; 3-5 maxillary teeth . . . . . *Enhydrina*
2'. Mental shield normal; 1-18 maxillary teeth . . . . . *Hydrophis*
3. Head very small, body long and slender anteriorly. . . . . *Microcephalophis*
3'. Head not small, body not long and slender anteriorly . . . . . 4.
4. Ventrals well developed . . . . . *Lapemis*
4'. Ventrals not developed, divided by a median longitudinal furrow. . . . . *Pelamis*

GENUS: *Enhydrina* Gray 1849

Enhydrina schistosa (Daudin, 1803):

Description: Head moderate size, slightly distinct from neck; rostral wider than high, with prominent, median downward prolongation giving a beak-like profile; mental elongate; 1 preocular and 1 or 2 postoculars; 4 well differentiated anterior upper labials, last two usually in contact with eye, followed by 3-5 small, wedge-shaped shields; 9 labials. All head shields densely studded with fine tubercles. Body moderately stout, laterally compressed. Iris dull green. Colouration variable; juveniles bluish or bluish-grey with well marked black rings often broadened vertebrally. Bands disappear entirely or partially with age.

Distribution: Likely to occur in Gujarat. Elsewhere- abundant on both coasts of the Indian peninsula. It also occurs in coastal waters from the Persian Gulf to New Guinea.

GENUS: *Microcephalophis* Lesson, 1834

Microcephalophis cantoris (Günther, 1864):

Description: Head very small, elongate; body long and very slender anteriorly, posterior parts very much compressed, its greatest diameter 3-5 times from neck. Snout projecting beyond lower jaw; eye moderate. Rostral large; frontal small; 6 supralabials, 2nd and 3rd in contact with prefrontal 3rd and 4th touching eye. 23-25 scale-rows on neck, 41-48 on thickest part of body; ventral 404-468, entire in slender part divided in thicker part of body. Hemipenis forked near tip and spinose throughout. Dark olive or greyish anteriorly with yellow crossbars. Head black in juveniles, greyish or yellowish-green in adults.

Distribution: West coast of India (Gujarat coast) and on the east coast from Orissa, West Bengal and Bangladesh.

GENUS: *Hydrophis* Latreille, 1802

Key to species:

8-13 maxillary teeth . . . . . *lapemoides*
14-18 maxillary teeth. . . . . *caerulescens*

Hydrophis lapemoides (Gray, 1849):

Description: Maxillary teeth 8-11. Head and eye moderate. Body robust. Nostrils superior; nasals in contact with one another; 1 preocular and 2 or 3 postoculars; 8 supralabials, 2nd in contact with prefrontal, 3rd and 4th or 3rd-5th touching eye; 4 infralabials in contact with genials; 29-35 scale-rows on neck and 43-51 on thickest part of body; ventrals distinct throughout. Yellowish or whitish in juveniles with 33-43 black bands strongly dilated dorsally; head black with yellow curved mark. Markings become paler with growth, eventually disappearing completely on ventrum.

Distribution: Indian coast; Persian Gulf. May occur along the Gujarat coast.

Hydrophis caerulescens (Shaw, 1802):

Description: 14-18 maxillary teeth behind poison fangs. Head not reduced; anterior parts of body not very slender; posterior parts compressed, greatest diameter of body 2-3 times that of neck; eye moderate; 7-8 supralabials, 2nd in contact with prefrontals 3rd and 4th touching eye. 31-43 scale-rows on neck 38-54 on body, all strongly keeled. 253-334 distinct ventral scales throughout body. Hemipenis forked close to tip. Bluish-grey above, yellowish-white below, with from 40-60 dark bands, about twice as broad as their interspaces on forepart of body. Head black in juveniles, dark grey in adults.

Distribution: Throughout the Indian coast from Gujarat in the western coast, to Bengal in the east. Outside India- Myanmar and the Gulf of Siam.

GENUS: *Lapemis* Gray, 1835

Lapemis curtus (Shaw, 1802):

Material examined: Junagad District, ZSI 22561, Verabal; Jan-Feb. 1964; Col. A. Danial; ZSI 22577, Verabal; Feb.- March, 1970; Coll. A. K. Nagbhusanam; ZSI 22571, Gujarat coast; 12.12.1971; Col. K. V. Surya Rao.

Measurements: Snout to vent 400-750 mm.

Description: Head large, body short; diameter of neck half or more than half greatest body diameter; eye moderate; frontal as long as or shorter than its distance from rostral; 1 preocular and 1 or 2 postoculars; 7 supralabials, 2nd normally in contact with prefrontal. Olive-green, turning up to pale yellow above with 15-55 ill-defined, dark greenish-brown crossbars, the first on nape.

Distribution: Malabar and Coromandel coasts of India, including Visakhapatnam. The species range extends from the Persian Gulf to Indo-Malaya.

GENUS: *Pelamis* Daudin, 1803

Pelamis platurus (Linnaeus, 1766)

Material examined: Junagad District, ZSI 23512, Subash Nagar Beach, Porbandar, Gujarat, 28.8.1992, Coll. K. V. Subba Rao.

Measurements: Snout to vent 40 mm.

Description: Maxillary bone not extending forward as far as palatine, 7-11 maxillary teeth. Head narrow, head shield entire; nasals in contact with one another; frontal large; 1 or 2 preoculars and 2 or 3 postoculars; temporal small, 2 or 3 anterior; 7 or 8 supralabials, 2nd in contact with prefrontal, 4th and 5th below eye; anterior pair of genials distinct and separated by small scales; 49-67 rows of scales on thickest part of body. Colouration variable, usually black above and yellow or brown below.

Distribution: This sea snake is widely distributed globally, being common in the Indo-Australian seas. It is also found in the Bay of Bengal.

FAMILY: VIPERIDAE

Key to genera:

Nostril in a large nasal; lateral scales in straight rows . . . . . *Daboia*

Nostril in a divided nasal; lateral scales in oblique series . . . . . *Echis*

GENUS: *Daboia* Gray, 1842

Daboia russelii (Shaw & Nodder, 1797):

Description: Head rather long, wider than neck; snout bluntly pointed; rostral about twice as high as wide; nostril large, crescent-shaped, in a large nasal shield; supraocular entire; 11 upper labials, separated from eye by three rows of scales; 14 lower labials; head covered with small snales and without any shield; scales strongly keeled and 27-33 at midbody. Body stout and dorso-ventrally flattened, dorsal scales in straight rows. Three longitudinal rows of reddish-brown or dark brown rings with black or black and white edges forming a chainline pattern on back and sides. Head with dark patch behind. A dark streak, margined with white, pink or buff behind eye. A dark stripe from eye to labials.

Distribution: Likely to occur in Gujarat. The typical subspecies occurs throughout India, from the plains to the hills at 3,000 m. Outside India-

Pakistan, Bangladesh and Sri Lanka. Other subspecies are known from south-east Asia.

GENUS: *Echis*, Merrem, 1820

Echis carinata (Schneider, 1801):

Material examined: Junagad District, ZSI 24891, Willingdon Dam site, 10.9.1989. Panchmahal District, ZSI 24907, around Forest Rest House Lunwada, Godrat 25.3.1992. Rajkot District, ZSI 24872, Rajkot, 8.9.89. Surendra Nagar District; ZSI 24933, Khareswar Village, 10.12.1992.

Measurements: Snout to vent 380 mm; tail 45 mm.

Description: Head short, distinctly wider than neck; snout blunt; rostral about twice as wide as high; nostril in divided nasal sheld; eye surrounded by 10-15 small scales exclusive of supraocular; 3-4 scales between nasal and eye; temporal small, keeled, except lowermost row; 10-12 upper labials, 4th usually largest; scales 25-29, 27-37 and 21-27 rows, outermost rows largest. Colour pattern varies considerably in form of dark-edged spots in a vertebral series connected to a light coloured inverted U- or V-shaped flank mark, enclosing a dark area connected to each other and forming a wavy flank line. Whitish below, uniform or spotted with brown.

Distribution: The whole of India south of the Ganga. Outside India-Pakistan and Sri Lanka.

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DOES THE COBRA OBEY THE SNAKE CHARMER'S FLUTE?

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(with four text-figures)

ABSTRACT: Because snakes lack an external ear opening and a tympanic membrane, it is often thought that they are deaf and that the Indian snake charmer's show of cobras swaying to the tune of a flute is fraudulent. However, physiological experiments have proven the snake's inner ear to be responsive to low-frequency airborne sound. To find out whether the snake charmer's cobras do respond to the music, observations were conducted in Agra and Singapore, including an experiment with the snake charmer visually hidden from his snakes. All observations indicated that the snakes did not respond to the music but to touch and vision. It is postulated that the traditional show may have originated with trained snakes and deteriorated later.

KEY WORDS: *Naja naja*, cobra, snakes, hearing, behaviour, snake charmer, flute, India.

INTRODUCTION

Snakes are characterised, among other things, by lacking an external ear opening and tympanic membrane (Smith, 1943), yet some, especially cobras, are famous for dancing to the snake charmer's music (Morris and Morris, 1965: 138-145). Accordingly, the auditory capacity of snakes has become the subject of acute controversy (Parker, 1963: 43-46). No lesser a person than Malcolm Smith (1943) had written "It is difficult to say how much this lack of auditory apparatus has affected their hearing ... but that they can hear very well is indisputable." The opposite has been stated by several authors of books on snakes or on herpetology: "... sounds conducted through the air are not heard by them" (Gharpurey, 1954); "They simply do not hear air-borne sounds, no matter how loud" (Morris and Morris, 1965); "They have little or no sensitivity to airborne vibrations" (Cox, 1991); or "In snakes, seismic vibrations [=not airborne] appear to be transmitted ... to the inner ear" (Zug, 1993). A third attitude is shared by other authors of recent and otherwise impressive texts on snakes or herpetology: the ear and hearing are not mentioned (e.g., Greene, 1997; Pough et al., 1998).

This situation in the literature is surprising, or disappointing, because Wever and Vernon (1960) already presented conclusive evidence from well-controlled physiological experiments, that the inner ear of several colubrid snakes responds to airborne sound. Their conclusions were later confirmed by Hartline and Campbell (1969), who applied a different physiological methodology, for additional species and families. Thus, although cobras were not specifically tested, snakes in general do hear airborne sound when of low frequency, within 100-700 Hz. Moreover, in the lower part of this range the ear of some snakes is more sensitive than that of a cat to the same frequencies (Bellairs, 1969: 383-384). Later, the ear and hearing in snakes were described in detail by Wever (1978); the internal ear is quite normal for squamates and receives sound vibrations through the stapes (middle ear ossicle), which on the outside connects to the quadrate, a thin bony plate functioning (additionally to other tasks) in lieu of tympanic membrane.

Noteworthy is the extreme difficulty with which new information penetrates the literature and displaces erroneous belief. This is conspicuously demonstrated by the Encyclopaedia Bri-

FIGURE 1: The snake man at Agra, July 1970. Most of the Indian cobras in the two baskets have risen and spread their hoods.

FIGURE 2: The snake man forces a cobra to sway with his music by closely waving at it his extended flute.

FIGURE 3: The crucial experiment: the snake man is playing his flute while visually separated from the cobra basket by the blanket partition, and only one cobra raises its head a little, without swaying to the music.

FIGURE 4: Agra, the next day. Nurit and Uri Werner watching the second snake man endeavouring to manage his cobra with a similarly extended flute.

tannica: although under "Sound Reception" hearing in snakes is explained properly (Wever, 1975: 46-47), nevertheless under "Reptilia" it still remains "... unlikely that snakes can hear airborne sounds" (Dowling, 1975: 735).

Thus it seemed desirable to test the widespread belief of zoologists, that the typical Indian snake charmer who displays a rearing cobra swaying to his flute's tune, achieves this show despite the snake's inability to hear the music (Morris and Morris, 1965). A limited opportunity to do so arose when in 1970 I briefly visited India on pilgrimage to the late Beni Charan Mahendra whom I respected as the then leader of Indian herpetology (Werner, 1973).

MATERIAL AND METHODS

In the searing heat of the early afternoon hours of a sunny day in mid-July 1970, in front of the modern Clarks Shiraz hotel in Agra, the penetrating, rasping music of an Indian flute heralded the arrival of a snake man. I obtained from the hotel a light-coloured light blanket and negotiated with the snake man who had settled with his several wicker baskets among the sparse but shady trees opposite the hotel. I declined his offer of staging a fight between a mongoose and a cobra but arranged, at a price, that after a normal musical performance with a group of cobras (serving me as control), he would try to repeat the performance with himself separated and hidden from the snakes by the blanket hung as a screen (experimental phase). We fastened one upper corner of the blanket to a tree trunk, and the other upper corner was held securely by a young volunteer from among the small crowd of local spectators. He looked somewhat wary of the snakes, to which in this role he was much closer than usual. The blanket served initially as a backdrop for photography, and later as a screen between the snake man and his snakes; their basket was to remain in the same place. I took care to position the blanket so that the man's shadow should not fall on it (and show on the other side). In addition to the anonymous spectators, the experiment was to be witnessed by Nurit, Uri and Sharon Werner.

OBSERVATIONS

Control performance.- The snake man was sitting on the ground with folded legs ("Buddha posture"), two of the baskets in front of him. He stretched forwards, extended an arm, and lifted the lid off a basket, uncovering four coiled, tranquil, Indian cobras (*Naja naja*). The other basket contained two or three. Now the man returned the globular flute to his lips, and, appearing to exert himself, with inflated cheeks, resumed playing it, slightly inclined forwards. As he played the music, he was swinging the flute right and left over the snakes, in close proximity. One snake lifted its head a little, slowly followed by another. At this point the man, seeming to lose patience, lightly slapped the heads of the remaining snakes with his hand. Thereupon they all rose, about a quarter of the body length upright, and the skin of the neck spread sideways as a hood, obviously due to the erection of the ribs. With their heads inclined horizontally and directed vaguely at the snake man or at his left fist which he held extended towards them, the snakes were swaying right and left in unison with the flute which, while played, was being waved at them (Fig. 1). Their movements could most of the time be interpreted as dodging the flute. The flute was fit with a metallic extension paralleling its own tube, which seemed not to be involved in the production of music but merely to extend the instrument towards the heads of the snakes (Fig. 2). After the man stopped playing and waving the flute, the snakes gradually relaxed and tended to collapse down. The man put the lids on them.

Experimental performance.- The snake man removed one basket, and with somewhat worried face opened the other and, leaving it in position, went and seated himself behind the screen. With concerned face and obvious effort he now energetically played the flute as if willing the snakes to respond (Fig. 3). Occasionally he inquired for feedback from the audience who, now that the snakes were unsupervised, were standing at a greater distance. They could only disappoint him: only one snake had lifted its head a little over the basket rim and spread a hood, without rising much, in stationary posture. It definitely was not swaying with the music.

Additional observations.- The next day a second snake man came to the same place, equipped with fewer snakes (Fig. 4). His flute appeared identical, with a globular middle section and a similar external extension, and although I could observe him only briefly, I was impressed that his mode of operation was similar.

A few days later I observed another snake charmer performing for tourists in Singapore. The snakes could have been *Naja sumatrana* (see Lim and Lim, 1992: 82-83) but identification was uncertain. This man used a somewhat different flute, with two successive globular sections, and without the artificial extension. Nevertheless his performance, too, was open to the interpretation that the snakes were responding to touch and vision, not the music.

DISCUSSION

As explained in the Introduction, based on experiments with snakes of several other families, the airborne sound of the music should be audible to the cobras if containing low acoustic frequencies. I hesitate how to regard the following narrative quoted by Gadow (1901) from a report by H.E. Reyne of the Department of Public Works, Colombo (my abbreviation): "A snake-charmer came ... in 1854 ... I told him ... [to] catch a cobra that I knew ... at the spot, he played on a small pipe, and after persevering for some time, out came a large cobra from an ant-hill, which I knew it occupied..." (This story was erroneously attributed by Kopstein, 1930, to Gadow himself.)

Unfortunately I was not equipped to record the flute's music for physical sound analysis. Worse, I am neither musically inclined nor musically educated. But only two years earlier, I had concluded a full year of physiologically research on the hearing of lizards in the Auditory Research Laboratories of Princeton University, and had gained ample experience in hearing pure tones of assorted frequencies (Werner, 1972; 1976). On this basis there is no doubt in my mind, that on all the occasions described above, the flute's music contained enough energy at sufficiently low frequencies to be perfectly audible to snakes. Yet the performance of all three snake charmers distinctly impressed me that they were not relying on the musical training of the snakes. The experiment in which the first snake man was visually hidden from his snakes left no doubt in this matter.

Despite the dependence of the sense of hearing of reptiles, like the rest of their physiology, on temperature (Werner, 1972; 1976; Wever, 1978), in the circumstances of these observations the lack of musical response clearly was not due to inadequate temperature.

Cobras are considered to be particularly intelligent snakes both by zoo experts (Ditmars, 1944) and by the snake charmers themselves (Morris and Morris, 1965). Since cobras should be able to hear the relevant music quite well, it is intriguing to speculate how the situation arose, that snake charmers, or some snake charmers, put on a misleading show rather than really train their snakes. One explanation that could perhaps be postulated is that originally, in the remote past, the snakes were indeed being trained, and that in more recent times this art has deteriorated and has been replaced by trickery (at least in the hands of some). To me this seems more plausible than to conceive of the snake charmer's traditional musical show as having originated from the start as a fraud.

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SCRATCHING THE SURFACE OF MIMICRY: SOUND PRODUCTION THROUGH SCALE ABRASION IN SNAKES

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(with five text-figures)

ABSTRACT.- Visual and acoustic aspects of the defensive behaviour of *Dasypeltis scabra* were compared to those of seven sympatric vipers (*Bitis caudalis, Cerastes cerastes, C. gasperettii, C. vipera, Echis carinatus, E. coloratus* and *E. pyramidum*). Cluster analysis of quantitative aspects of the sound produced during scale rubbing revealed *Dasypeltis* to be more similar to *Cerastes* than to *Echis*. Cluster analysis of visual attributes were less conclusive; *Dasypeltis* still clustered with *Cerastes*, but non-coded features suggested a stronger resemblance to *Echis*. We found little similarity between *Dasypeltis* and the specimens of *Bitis caudalis* we examined. Our results support the hypothesis that *Dasypeltis* is a Batesian mimic of both *Cerastes* and *Echis*.

KEY WORDS.- Sound production, defensive display, behaviour, *Dasypeltis, Echis, Cerastes, Bitis*.

INTRODUCTION

The growing literature on the behavioural ecology of reptiles contains numerous references to mimicry in snakes, particularly Batesian mimicry (Pough, 1988a,b). The body inflation, head triangulation, and sound production of defensive *Heterodon* (Young and Lalor, 1998) are frequently interpreted as Batesian mimicry of local crotalids. Kardong (1980) argued that *Pituophis melanoleucus* was a Batesian mimic of *Crotalus viridis*, although many of the presumed similarities may reflect shared strategies for crypsis (Sweet, 1985). Acoustic Batesian mimicry may exist in the defensive "cloacal pops" produced by *Micruroides euryxanthus* and *Gyalopion canum* (Young et al., 1999b). A number of African colubrids exhibit defensive head triangulation which is frequently cited as a form of Batesian mimicry with various viperids (Werner and Frankenberg, 1982; Werner, 1983). The most frequently cited, and most heavily debated, example of Batesian mimicry in snakes involves the brightly coloured annular patterns found on coral snakes and a variety of new world colubrids (e.g., Dunn, 1954; Brattstrom, 1955; Gehlbach, 1972; Grobman, 1978; Greene and McDiarmid, 1981; Pough, 1988a,b; Roze, 1996).

Logistical limitations have prevented detailed experimental analyses of these proposed mimetic systems. Furthermore, the behavioural repertoires exhibited by some snakes make analyses of mimicry difficult. *Ptyas mucosus* is often cited as a mimic of *Ophiophagus hannah* (e.g., Soderberg, 1973), and while both produce acoustically similar defensive "growls," the rest of their defensive behaviours are distinct (Young et al., 1999c). This project was undertaken to explore what is perhaps the most complex suite of potential mimicry in snakes, defensive sound production through scale abrasion. The harmless, indeed nearly edentulous, African colubrid *Dasypeltis* has a prominent defensive display. Upon provocation these snakes will inflate their body slightly, triangulate their head, position their body into distinctive C-shaped coils, then rapidly move the body segments transversely. This movement causes contact between specialized scales which results in an audible sound (Gans and Richmond, 1957; Gans, 1961). Similar behaviour is seen in two groups of sympatric African vipers, the saw-scaled vipers (*Echis*) and

the horned desert vipers (*Cerastes*) that have similar, but distinctive, specialized scales (Gans and Baic, 1974). This mimetic complex is often expanded to include the South African horned adder (*Bitis caudalis*), the hiss of which is said to resemble the sound produced by (sympatric) *Dasypeltis* during scale abrasion (Spawls and Branch, 1995).

Despite the frequent citations of the work by Gans and his colleagues, this mimetic system has received very little attention. Ideally, field observations of predators interacting with these species could be combined with a variety of experimental manipulations of this system to detail the extent and form of mimicry among these snakes. Unfortunately, the scarcity of some of these species, and the logistical difficulties of making these observations in the wild, nearly preclude this approach. The goals of the present study are more modest. By analyzing these species we hope to compare the relative similarities of the acoustic and visual components of their defensive behaviour. In this way we hope to identify which components of the defensive display of *Dasypeltis*, if any, may represent Batesian mimicry of one, or more, of these viperid snakes.

MATERIALS AND METHODS

Scale rubbing was investigated in four genera of snakes (Table 1). Most of the snakes were maintained at Lafayette College under a 12:12 photoperiod, a temperature range of 29 - 32°C, and a diet of pre-killed mice. Audio and video recordings of the defensive behaviour were taken in three locations: the venomous snake room at the Centre for Herpetology, Madras Crocodile Bank Trust, India; a working room in the department of Herpetology at the Houston Zoo; and an experimental room at Lafayette College. In each case the recordings were taken while the animals were at their normal temperatures.

The same recording protocol was used in the three locations. Loose sand was removed from the animal's skin, and each specimen was placed onto a clean, dry recording platform. This plexiglass platform was 50.8 x 30.5 cm with 10 cm walls around it, and allowed for continual viewing of the animal. A ruler and digital timer were located in one corner of the platform. Individual specimens were placed on the recording platform and their defensive behaviour evoked by the investigator. A video record of the defensive behaviour was obtained using a Video 8 camera (Sony) mounted 100 cm above the recording platform. An audio record of the behaviour was obtained with an ND 757B (ElectraVoice) microphone (frequency response 50-22,000 Hz) located 40 cm from the snake's body. At the Centre for Herpetology, the sounds were recorded on a Fostex X-18 recorder (frequency response 50-12,000 Hz), at the Houston Zoo a TCD-D8 DAT recorder (Sony) was used, and at Lafayette College the sounds were routed through a P511 amplifier (GRASS Instruments) into the data acquisition system. The amplitude of the sounds were determined using a 840029 Digital Sound Meter (SPER Scientific) positioned approximately 40 cm from the animal's body. Upon completion of the recordings, the snout-vent length (SVL) of the specimen was determined.

All recorded sounds were converted to digital signals using an Instrunet Analog/Digital converter (GW Instruments) and a Power Macintosh 6400 (Apple Computer). Acoustic analyses were conducted using the SoundScope software package (GW Instruments) and the WLFDAP 1.0 (Zola Technologies, Atlanta, GA) digital filtration software. Sonogram and power spectrum analyses (with a sampling rate of 44.1 kHz, a Fast Fourier Transformation (FFT) using 2048 points, and a 59 Hz filter) were used to identify the minimum, dominant, and maximum frequencies. The minimum and maximum frequencies were defined based on amplitude decrease from the dominant frequency. The velocity of scale rubbing was calculated using the scale bar and digital timer on the video image. Multiple bouts of sound production were quantified from every specimen. Statistical analyses of the quantitative data set were performed using SYSTAT™ software.

To illustrate the morphology of the lateral body scales, portions of the integument were removed from the mid-body of specimens of *Dasypeltis scabra, Echis carinatus* and *Cerastes*

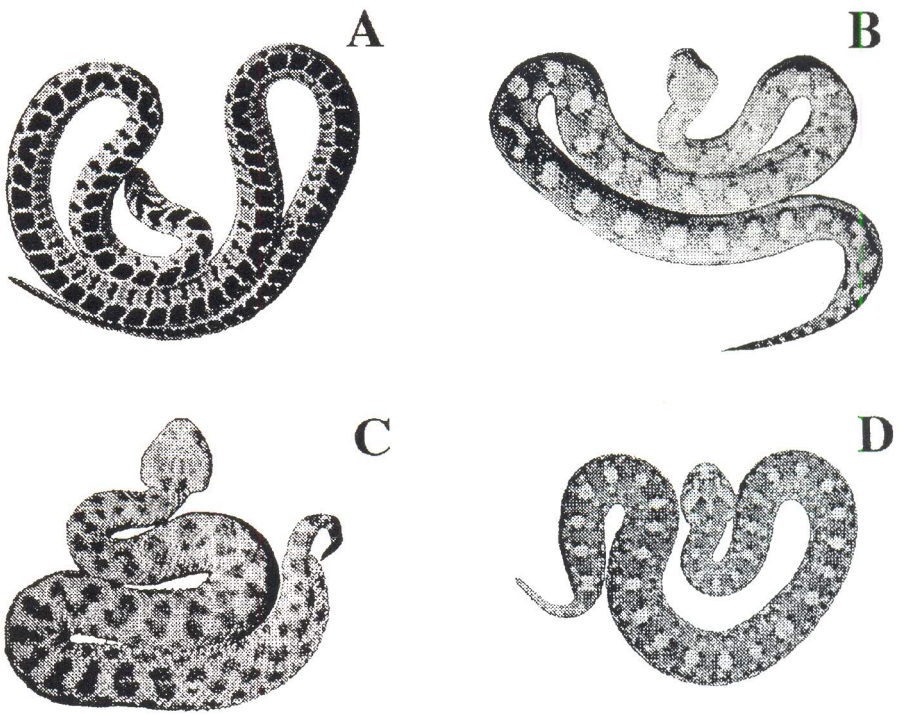

FIGURE 1: Dorsal images from photographs of four species during defensive displays. A- *Dasypeltis scabra*, B- *Echis coloratus*, C- *Cerastes cerastes*, D- *Bitis caudalis*. Note the distinct C-shaped coils in *Dasypeltis* and *Echis*, the triangular shape adopted by *Cerastes*, and the very loose coil formed by *Bitis*.

cerastes from the private collection of BAY. Skin samples were dehydrated through an ethanol series and critical point dried. They were sputter coated with 300Å of gold and examined using an ISI Super 3A scanning electron microscope at 15kV.

RESULTS

Defensive behaviour.- The four genera exhibited distinctive defensive behaviour; little interspecific variation was observed within *Echis* and *Cerastes*, so only generic level descriptions will be provided. *Dasypeltis*, even long-term captives, reacted quickly to the slightest provocation. The body was inflated and the head triangulated in a way that produced a distinctive gape to the lower jaw (Young et al., 1999a). The body was arranged into elongate horizontal coils the ends of which extended far beyond the head to form a loose, C-shaped body posture (Fig. 1A). Once in this posture, the adjacent body segments were moved transversely against one another to produce an audible sound; movement could take place in either direction. The specimens showed little inclination to retreat and often advanced toward the investigators while launching repeated strikes. These defensive behaviour continued unabated throughout the data collection interval and often persisted after the snake was returned to its cage.

Echis, like *Dasypeltis*, was quick to respond to the slightest provocation. The body was slightly inflated and positioned into tight, C-shaped coils (Fig. 1B). The terminal ends of the coils typically extended in front of the head. Sound was produced by sliding the opposing body coils past one another. *Echis* showed little inclination to retreat or advance, but did launch repeated strikes. Once initiated, these defensive behaviour were continued as long as the researcher was in close proximity, and, on occasion, were continued after the specimen was returned to its cage.

The defensive behaviour of *Cerastes* was characterized by crypsis and fleeing. Normally direct tactile stimulation was required to invoke

TABLE 1: Data on the 31 specimens analyzed for this study. The specimens examined at the Centre for Herpetology were collected locally; however, the geographic origin of most of the other specimens was not known.

Species	N	Size (cm)	Source	Data Collection
Dasypeltis scabra	2	62 - 69	Commercial	Lafayette
Dasypeltis scabra	2	52 - 83	Oklahoma City Zoo	Lafayette
Dasypeltis scabra	1	64	Houston Zoo	Houston Zoo
Bitis caudalis	3	27 - 40	Houston Zoo	Houston Zoo
Echis carinatus	10	22 - 32	wild	Centre for Herpetology
Echis coloratus	2	67 - 68	Kentucky Reptile Museum	Lafayette
Echis pyramidium	1	33	Commercial	Lafayette
Cerastes cerastes	1	49	Commercial	Lafayette
Cerastes cerastes	1	57	Kentucky Reptile Museum	Lafayette
Cerastes cerastes	1	56	Houston Zoo	Houston Zoo
Cerastes gasperetti	1	58	Houston Zoo	Houston Zoo
Cerastes gasperetti	2	44 - 55	Reptile Gardens	Lafayette
Cerastes vipera	4	26 - 35	Commercial	Lafayette

the defensive behaviour, and frequently the specimens had to be first lifted completely free of their sand substrate. Little body inflation was observed during the defensive behaviour. The body was positioned into two or three horizontal coils, the ends of which generally did not extend cranially past the head; when viewed from above, the animals typically appeared almost triangular rather than C-shaped (Fig. 1C). Like *Echis* and *Dasypeltis*, species of *Cerastes* produced sound by abrading the scales on adjacent body segments. *Cerastes*, however, tended to produce sound only while locomoting. Invariably this locomotion was directed backward, that is away from both the investigator and the snake's line of sight. When stimulated in their cages, the specimens would frequently abruptly terminate the defensive sound production and begin to bury themselves in the sand. Despite the continual stimulation required to maintain the defensive behaviour, only one defensive strike was observed.

The specimens of *Bitis* exhibited little defensive behaviour other than a continued attempt to flee. There was only modest body inflation and no distinct body posturing, although the animals would on occasion adopt a loose coil (Fig. 1D). Despite strong provocation, only a few defensive hisses were recorded, all produced with the mouth closed. Only one defensive strike was observed from these specimens.

Visual aspects of the defensive display.- In general appearance, *Dasypeltis* was more similar to the species of *Echis* we examined than it was to either the species of *Bitis* or *Cerastes*. This resemblance is based on three main attributes (Fig. 1); the relatively narrow body in *Dasypeltis* and *Echis*, in contrast to the stout body of *Bitis* and *Cerastes*; the smaller head width in *Echis* and *Dasypeltis* (even with flaring) than in *Bitis* or *Cerastes*; and the prominence of the dorsal patterning in the scalation which was distinct in *Dasypeltis* and *Echis* and more variable and muted in the *Bitis* and *Cerastes*. During scale abrasion, when adjacent segments of dorsal patterning are moved past one another, the prominent dorsal pattern of *Dasypeltis* (and to a lesser degree *Echis*) produced a visually striking effect.

Setting aside the specimens of *Bitis*, which never exhibited body movements similar to those of the scale abrading species, data for the velocity of scale abrasion (defined as the transverse movement of one body coil against an adjacent body coil) were calculated for every specimen. Differences in the length of video record, body position, and inclination to scale rub resulted in differing numbers of quantified scale rubbing episodes. In light of the small sample

TABLE 2: Summary of the scale abrasion velocity data by species.

	Velocity of Scale Abrasion					
Species	Episodes Quantified	Mean Velocity in cm/sec	Velocity Range	s.d.	Mean SVL	Mean Velocity in SVL/min
Dasypeltis scabra	41	4.31	1.76 - 7.69	1.89	66	3.92
Cerastes cerastes	17	3.09	1.13 - 6.54	1.66	53.8	3.45
Cerastes gasperetti	13	7.09	4.98 - 8.40	1.01	51	8.34
Cerastes vipera	31	2.83	0.91 - 4.45	0.70	29.6	5.74
Echis carinatus	89	2.40	1.07 - 3.97	0.67	27.3	5.27
Echis coloratus	8	3.56	3.17 - 4.14	0.29	67.6	3.16
Echis pyramidium	6	1.20	1.10 - 1.27	0.07	33	2.18

sizes for some species and the inherent variation produced by recording data in three locations, the data were pooled for each species (Table 2). While there were variations in the velocity of scale abrasion, only *C. gasperettii* was significantly different (F-ratio = 8.70, P = 0.026). While larger species had higher velocities of scale abrasion (Fig. 2), the relationship is not significant; reanalysis after removal of *Cerastes* produces only slight changes and still yielded non-significant results.

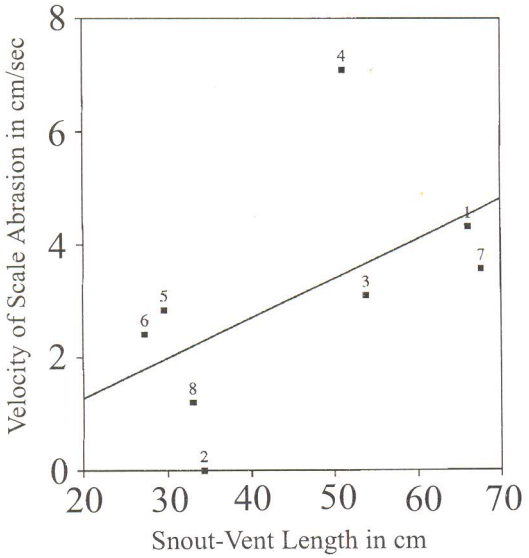

FIGURE 2: Velocity of scale abrasion as a function of snout-vent length. Note how the species fall into two groups. Key to species: 1- *Dasypeltis scabra*; 2- *Bitis caudalis*; 3- *Cerastes cerastes*; 4- *Cerastes gasparetti*; 5- *Cerastes vipera*; 6- *Echis carinatus*; 7- *Echis coloratus*; and 8- *Echis pyramidum*.

Morphology of scale abrasion.- All the specimens examined, with the exception of *Bitis caudalis*, shared the same epidermal specialization. On the lateral surface of the body there are multiple scale rows that deflect caudoventrally approximately 40° from the long axis of the body (Fig. 3A). The keels of these scales are sculptured in species-specific patterns involving differences in the height of the keel, extent of keel fragmentation into individual sawtooth-like projections, and the relative smoothness of the keel surface (Fig. 3B-D).

Acoustics of the defensive display.- Pooling the data for each species, and discarding recordings where the acoustics were compromised, produced the summary results given in Table 3. The minimum frequency of sounds produced by *Bitis caudalis* and *Echis pyramidum* were significantly higher (F-ratio = 34.21, P = 0.001) than the other species. In *B. caudalis* and *E. coloratus* the dominant frequency of the defensive sound was significantly higher (F-ratio = 11.21, P = 0.015) than in the other species. The maximum frequency in the defensive sounds of *Cerastes cerastes* and *B. caudalis* was significantly higher (F-ratio = 38.17, P = 0.001) than in the other species. There was a significant difference (F-ratio = 30.926, P = 0.001) in the amplitudes of the sounds produced, with *Dasypeltis, B. caudalis, C. cerastes* and *C. vipera* representing the low amplitude species. The minimum, dominant, and maximum frequencies all decreased with body size, but none significantly. The amplitude of the sound had no significant relationship with body size.

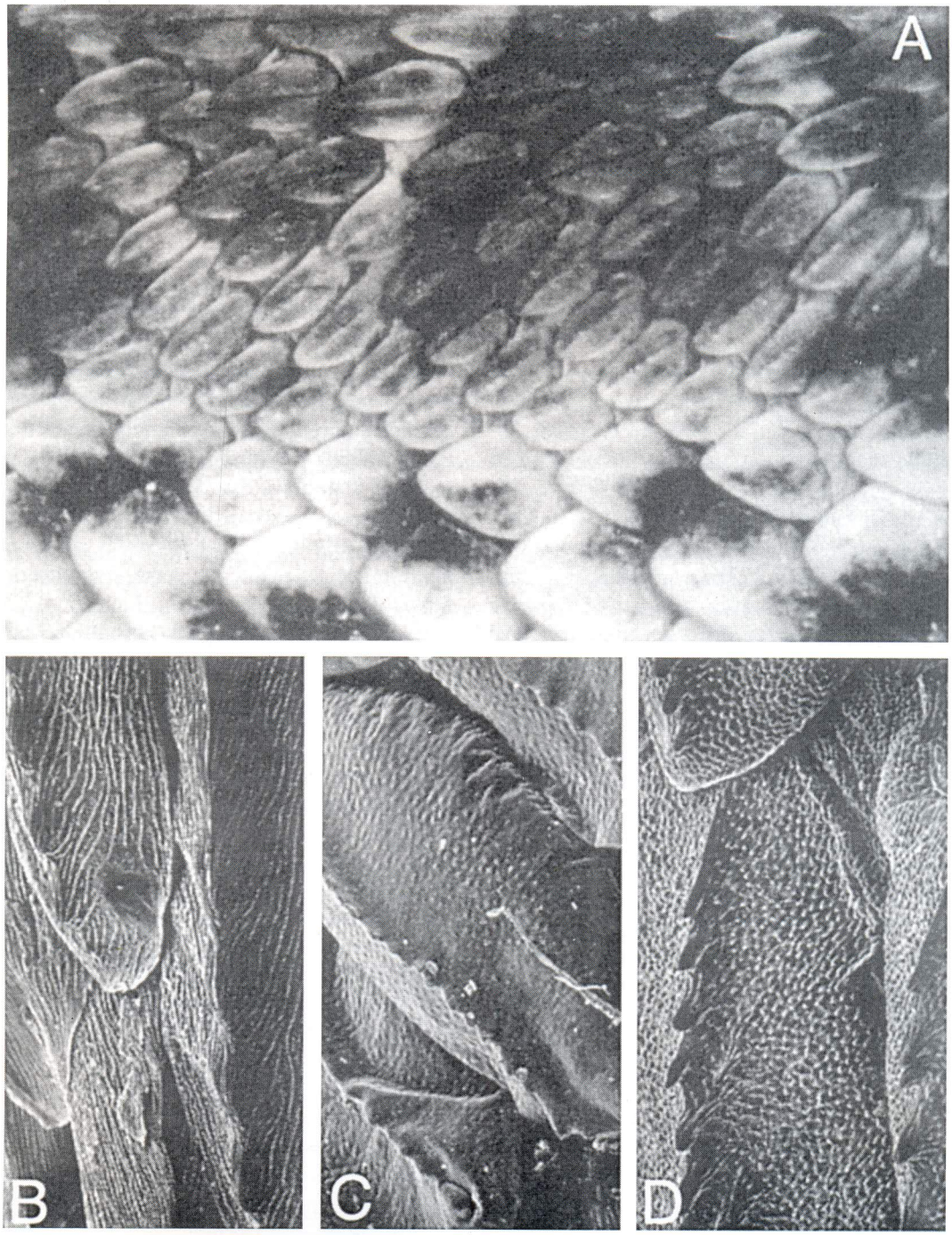

FIGURE 3: Morphology of scale abrasion. A- Low magnification of *Echis carinatus* showing the multiple scale rows deflecting away from the long axis of the body; B- *Dasypeltis scabra* (x 75); C- *Cerastes cerastes* (x 75); and D- *Echis carinatus* (x 72). Note the variation in the morphology of the specialized keel in these species.

TABLE 3: Summary of the acoustic properties of the defensive sounds produced by the eight species. Frequency values are in Hertz, amplitude values are in Decibels (RMS, SPL). Data are presented in the form of means (standard deviations).

	Summary of Defensive Sound Production				
Species	Episodes Quantified	Minimum Frequency	Dominant Frequency	Maximum Frequency	Mean Amplitude
Dasypeltis scabra	15	324 (77)	1002 (274)	6374 (302)	54.2 (3.2)
Bitis caudalis	8	567 (72)	2065 (417)	10802 (273)	55.4 (3.4)
Cerastes cerastes	12	353 (81)	563 (34)	11183 (1088)	52.1 (3.7)
Cerastes gasperetti	15	364 (108)	788 (103)	3923 (463)	59.2 (4.2)
Cerastes vipera	14	289 (96)	1088 (209)	6228 (1120)	49.5 (6.4)
Echis carinatus	15	254 (44)	1728 (336)	6846 (930)	62.5 (5.6)
Echis coloratus	7	224(45)	2729 (133)	4622 (178)	63.4 (2.3)
Echis pyramidium	5	764 (56)	1628 (386)	6141 (215)	64.5 (1.7)

All of the sounds analyzed had a simple acoustic structure. There was no evidence of distinct harmonics, no frequency modulation, and no distinct amplitude modulation (Fig. 4). In many of the sounds the dominant frequency had an amplitude only slightly above the other frequencies.

Clustering of species by defensive behaviour.- Cluster analysis (k-means) for visual stimuli were performed using the size and velocity data. Additional analyses were performed after adding coded data for body width, head width, and dorsal patterning; these subsequent analyses gave similar results but were less robust and so will not be detailed herein. The best division of the species (Size: F-ratio = 40.24, P = 0.001; Velocity: F-ratio = 6.99, P = 0.038) resulted in two clusters. The first consisted of *Dasypeltis, Cerastes cerastes, C. gasperettii* and *Echis coloratus*; the second cluster consisted of *C. vipera, E. carinatus, E. pryamidum* and *Bitis caudalis* (this division is evident horizontally in Fig. 2).

Cluster analysis was also performed on the acoustic data set, following normalization. Initial analyses used all three frequency measures as well as amplitude, ultimately the maximum frequency was eliminated from the analysis due to its lower robustness. A separation into four clusters produced the best results (Minimum fre-

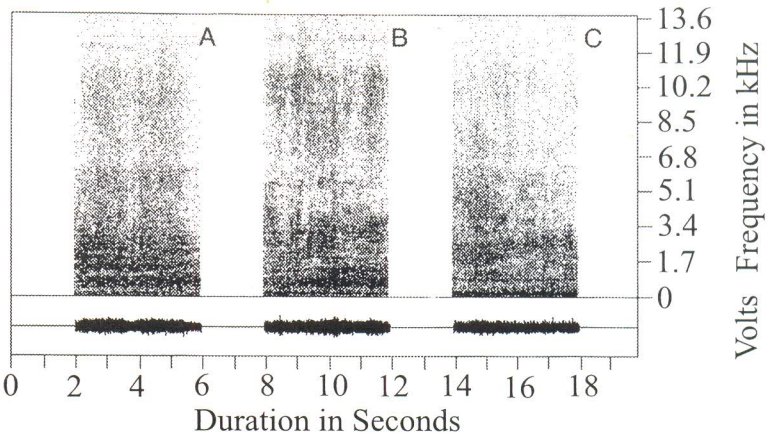

FIGURE 4: Sonogram of scale abrasion. A- *Dasypeltis scabra*; B- *Cerastes cerastes*; and C- *Echis coloratus*. Y-axis is frequency in kHz, X- axis is time. Note the similarity in amplitude of these signals, and the overall acoustic similarity and simplicity of the sounds.

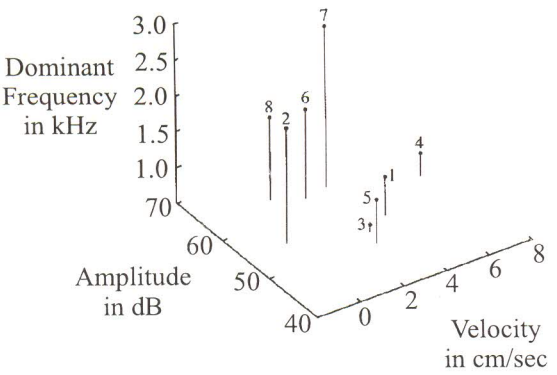

FIGURE 5: Cluster analysis (k-means) of the eight species. Data have been normalized to enhance cluster resolution. There is significant separation between four cluster composed of (1- *Dasypeltis scabra*; 3- *Cerastes cerastes*; 4- *Cerastes gasparettii*; 5- *Cerastes vipera*), (6- *Echis carinatus*; 7- *Echis coloratus*), (8 - *Echis pyramidum*) and (2- *Bitis caudalis*).

quency: F-ratio = 80.13, P = 0.00; Dominant frequency: F-ratio = 6.28, P = 0.048; Amplitude: F-ratio = 4.41, P = 0.093). The largest cluster (Fig. 5) contained *Dasypeltis*, *Cerastes cerastes, C. gasperettii* and *C. vipera*, the second cluster consisted of *Echis carinatus* and *E. coloratus,* the third and fourth clusters consisted of *E. pyramidum* and *Bitis caudalis* (respectively). A final analysis was performed using the entire data set (following normalization) this combined analysis yielded the same clustering as the acoustic data set (Fig. 5).

DISCUSSION

There are limitations to this type of study that must be borne in mind. Logistical limitations resulted in the exclusion from our data set of several species within this potential mimetic complex, including species from each genus examined. Conversely, the relative ease of data collection from wild caught specimens led us to include *Echis carinatus* even though it is not sympatric with *Dasypeltis*. An additional limitation stemmed from our inclusion of long-term captive animals within the data set. Most of these long-term captives exhibited prominent defensive displays, suggesting no real captive bias, although this was not the case for *Bitis caudalis*.

Our observations of the defensive behaviour of *Dasypeltis* are in good agreement with the previous literature, especially the detailed description offered by Gans and Richmond (1957) who noted the visually striking effect produced by the rapid scale abrasion movements of *Dasypeltis*. Our descriptions of the defensive sequence in *Echis* are also in good agreement with the literature (e.g., Leviton et al., 1992). Our analyses of *Cerastes* indicates that the defensive body posture is different from that of *Echis* and *Dasypeltis* in that prominent, C-shaped coils are rarely formed. This is contrary to the literature on *Cerastes* (e.g., Spawls and Branch, 1995; Schleich et al., 1996), although the illustrations in these works agree with our description and Fig. 1. While the specimens of *Bitis caudalis* we examined exhibited slight body inflation, would hiss, and, at least on one occasion, struck defensively, no distinct body posturing was observed. Accounts in the literature describe this species as forming "C-shaped coils" (e.g., Broadley, 1983; Spawls and Branch, 1995), but also note that the defensive behaviour tends to fade with captivity. Our examination of the morphology of the scales used for sound production agrees with earlier descriptions (Gans and Richmond, 1957; Gans, 1961), and Gans and Biac (1974) have described the interspecific variation in the morphology of these scales.

Despite the differences in their acoustic properties (Table 3), all of the defensive sounds examined have the structure of a generalized, broad-band warning call. All of the sounds were acoustically simple, and while of a lower frequency range, are acoustically similar to other previously described defensive sounds of snakes whether of epidermal or respiratory origin (Young, 1997). Gans and Richmond (1957) put forth the very reasonable hypothesis that during scale abrasion the respiratory system acts as a resonating chamber to amplify the sound. Unfortunately, in subsequent work by other authors this hypothesized function has been presented as

established fact. The lungs of *Dasypeltis, Cerastes* and *Echis* are each roughly 80% of the SVL (Wallach, 1998), yet in our study there was no significant relationship between body size and the amplitude of the scale abrasion sound. We were able to monitor amplitude during periods of scale abrasion in *E. coloratus* when the specimen exhibited clear cycles of body deflation and inflation, there was no pattern of amplitude change to correspond to changes in body diameter. This study does not disprove the hypothesis that the respiratory system acts as a resonator during scale abrasion, but it does suggest a more cautious approach to the idea.

Our data suggest that *Dasypeltis* is a better acoustic mimic of *Cerastes* than it is of *Echis*. That distinction must be tempered by the recognition that all three groups are producing acoustically simple, broad-band sounds. For the velocity of scale abrasion, which was the only real visual data set we had, *Dasypeltis* also clustered with *Cerastes*, although *E. coloratus* was included within the cluster. Our own impressions, based on dorsal patterns, body size, posture, and behaviour, were that *Dasypeltis* bears a stronger visual similarity to *Echis* than it does to *Cerastes*. Given that other species within these genera were not available to study, and that geographic variation in some of these traits has been described (Sternfeld, 1913; Gans, 1961), pushing these comparisons further seems unjustified. We do not find strong support for Batesian mimicry between *Dasypeltis* and *Bitis caudalis*, but this may reflect the influence of captivity on the specimens of *B. caudalis* we examined.

The defensive behaviour we observed in *Dasypeltis* bore both visual and acoustic similarities to those of *Cerastes* and *Echis*. As such, this study supports the hypothesis that *Dasypeltis* is a Batesian mimic of a group of sympatric vipers (e.g., Gans, 1961). To test this hypothesis more rigorously would require identification of the suite of potential predators, their respective sensitivities to visual and acoustic stimuli, and their response to these snakes in the natural environment. While logistically daunting, only a study of this type could show whether the similarity of the particular defensive behaviour was strong enough to serve as Batesian mimicry for a particular predator (see Mappes and Alatalo, 1997).

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Comments on the grass lizards (Lacertidae: *Takydromus*) of Vietnam and Myanmar

(with two text-figures)

According to Bobrov (1995) and Nguyen and Ho (1996), two species of grass lizards are known to occur in Vietnam: *Takydromus sexlineatus* and *T. wolteri*, which are also reported to occur in sympatry (Darevsky et al., 1986). Ziegler et al. (1998) were able to record for the first time a representative of the subgenus *Platyplacopus* for Vietnam: *T. kuehnei*, which proved to be a new subspecies after comparisons were made with the Chinese populations (Ziegler and Bischoff, in press). Moreover, Ziegler and Bischoff (in press; see also Ziegler et al., 1998) demonstrated that some of the Vietnamese records of *T. wolteri* were based on misidentified *T. kuehnei* and also *T. sexlineatus*, and therefore the occurrence of the otherwise strictly Palearctic *T. wolteri* in northern Vietnam must be seriously doubted. *T. kuehnei* has been found only in northern Vietnam, while *T. sexlineatus* is distributed all over the country (see Bobrov, 1995; Nguyen and Ho, 1996), and is assigned by most authors (Dao, 1979; Darevsky et al., 1986; Bobrov, 1992; Bobrov, 1995; Zhao and Adler, 1993) to the subspecies *ocellatus*. As was already mentioned by Ziegler et al. (1998), Bourret recorded in his unpublished manuscript "Les lézards de l'Indochine" (1942-1947) not only *T. sexlineatus ocellatus* for the entire "Indochine française", but also the nominotypic subspecies for South Vietnam ("Cochinchine"). If sympatry of *T. sexlineatus ocellatus* and *T. s. sexlineatus* is established, their subspecific status would be no longer tenable.

In the course of our investigation on Vietnamese *Takydromus* material, it turned out that all specimens of *T. sexlineatus ocellatus* from Vietnam had partially regenerated tails which, in addition, were relatively short in the specimens from northern Vietnam - from the south only ZFMK 38316 was accessible to us. The same was true for specimens of *T. sexlineatus ocellatus* from Hainan, whereas the specimens from southern continental China clearly showed longer and unregenerated tails (Table 1). Externally, in most cases hardly discernible, regenerated tails- characterized by smaller, more

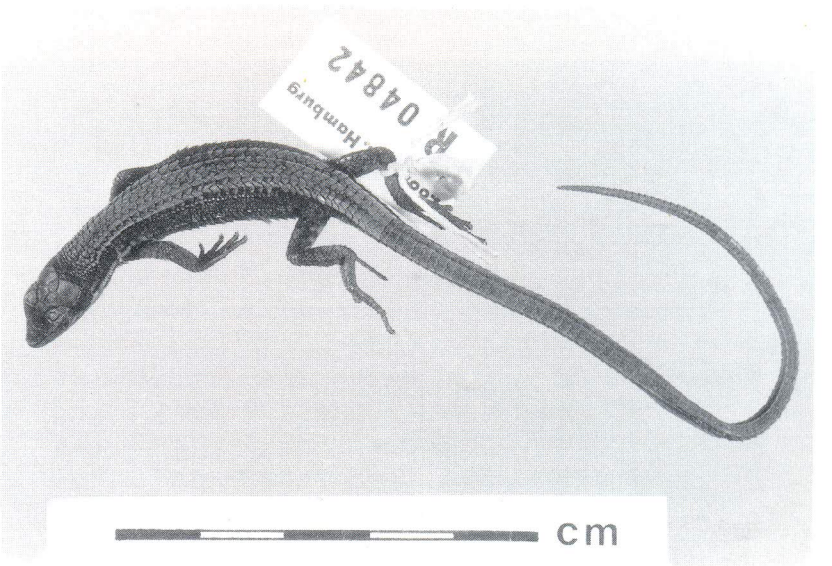

FIGURE 1: Dorsal view of the questionable *Takydromus* specimen, ZMH R04842 (SVL 47 mm, TL 108 mm) from Myanmar. Photo: J. Köhler.

weakly keeled scales with different colouration-were further examined by x-ray, to verify the cartilaginous cord that replaces the vertebral column.

In view of the fact that the tail in *Takydromus sexlineatus* can be five times longer than the snout-vent length (see Boulenger, 1921) and has an important locomotory function, the short tails caused by an obviously high autotomy readiness in *T. sexlineatus* from northern Vietnam and from Hainan are remarkable, because, on account of the long tail in *T. sexlineatus*, the shift of the centre of gravity behind the body towards the tail base is normally advantageous for locomotion in specific habitat, viz. high grasslands (De Rooij, 1915; Smith, 1935; Hauschild, 1986; Arnold, 1997). Therefore, the question arises whether these specimens with obviously shorter tails are possibly adapted to other habitat structures. According to Bobrov (1992), *T. sexlineatus ocellatus* in southern Vietnam inhabits "places with abundant grass cover and sunshine-plantings, light forests or grasslands. The highest abundance of *T. s. ocellatus* are marked in young *Hevea* plantings". Both MTKD specimens (37908-9) were, according to the information given on their labels, collected in the open countryside at Cuc Phuong National Park in northern Vietnam, whereas ZFMK 70352 was collected at bushy wayside vegetation in cultural landscape (J. Hnizdo, in litt.). Also, both specimens from Hainan were not found in high grasslands, the otherwise typical habitat for *T. sexlineatus*: ZFMK 61732 was collected in 700-800 m above msl in a clearing with sparse vegetation and isolated tufts of grass; and ZFMK 61754 at a relatively open *Hevea* plantation with sparse undergrowth at the edge of the forest (P. Heimes, pers. comm.).

The autotomy-induced, shorter tails of specimens from northern Vietnam and Hainan are most probably caused by predation, and the reasons for this obviously higher autotomy readiness are of great biological interest. Arnold (1984; 1988) assigned species with reduced tail autotomy to three groups, the third group of which (species with specialized locomotion in dense vegetation) fits well with *Takydromus sexlineatus*. Apart from individual differences in the autotomy ability (e. g., temperature, embryonic development) according to Arnold (1988), only "interspecific variation in the readiness with which the tail is shed" is known. Therefore, the case of infraspecific variation in autotomy readiness mentioned herein raises most interesting questions: if the populations of North Vietnam and Hainan are adapted to other biotope structures than "typical" for *T. sexlineatus* and

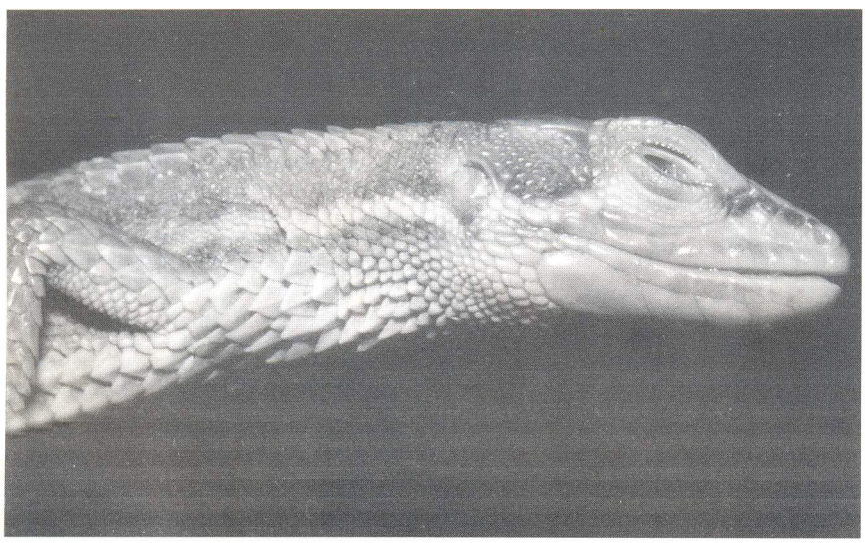

FIGURE 2: Lateral view of the head of ZMH R04842. Photo: T. Ziegler.

TABLE 1: Snout-vent lengths (SVL), total tail lengths (TL), regenerated parts of tail (R) and SVL: TL ratios of the investigated specimens of *Takydromus sexlineatus ocellatus*. MTKD: Staatliches Museum für Tierkunde Dresden; SMF: Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt a. M.; ZFMK: Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn. All measurements in mm.

	SVL	TL	R	SVL:TL
MTKD 37908 (male) Vietnam, Ninh Binh Province, Cuc Phuong	54	40	23	1.35
MTKD 37909 (male) Vietnam, Ninh Binh Province, Cuc Phuong	57	169	55	0.34
ZFMK 70347 (female) Vietnam, Nghe An Province, Tan Ky	47	106	tail tip	0.44
ZFMK 70348 (female) Vietnam, Nghe An Province, Tan Ky	57	85	52	0.67
ZFMK 70349 (male) Vietnam, Thanh Hoa Province, Quan Hoa	53	144	60	0.37
ZFMK 70350 (male) Vietnam, Thanh Hoa Province, Quan Hoa	55	117	96	0.47
ZFMK 70351 (female) Vietnam, Nghe An Province, Ky Son	49	140	68	0.35
ZFMK 70352 (male) Vietnam, Nghe An Province, W Tuong Duong	43	117	56	0.37
ZFMK 38316 (male) Vietnam, Kon Tum Province, Buen Loi	65	268	65	0.24
ZFMK 61732 (male) China, Hainan, Wuzhishan	52	131	89	0.40
ZFMK 61754 (female) China, Hainan, Nada	50	97	65	0.52
SMF 11878 (male) China, Guangxi-Zhuang Province, Nanning	49	214	-	0.23
SMF 11879 (female) China, Guangdong Province, Canton	55	227	-	0.24

are therefore autotomizing their tails easier and more often, this would indicate an important infraspecific evolutionary divergence, which, in the case of a beginning speciation process, would certainly be of greater significance ("selection target") than possibly correlated subtle morphometric differences (see, Böhme, 1978). The only secondarily (i. e., due to regeneration) relatively shorter tails of the populations of northern Vietnam and Hainan could nonetheless indicate a beginning speciation process, i. e., a subspecific differentiation in *T. sexlineatus*. Field studies at further geographical sites and investigation of more material are needed to test the hypothesis.

During our examination of preserved *Takydromus* material, we further found a specimen in the Zoologisches Museum, Universität Hamburg (ZMH), labelled as *Takydromus sexlineatus* from Rangoon (= Yangon, Myanmar) (ZMH R04842, leg. 6. VIII. 1906, Schwinghammer, ded. 12. X. 1906). For Myanmar, the taxa, *Takydromus* (*T.*) *khasiensis*, *T.* (*T.*) *s. sexlineatus* and *T.* (*T.*) *sexlineatus ocellatus* are currently known (Smith, 1935; Bischoff, 1992; Arnold, 1997). However, the above mentioned specimen (Fig. 1, 2) was not assignable to any of these forms. According to the key provided in Arnold (1997), it rather fits *Takydromus* (*T.*) *tachydromoides*, which is restricted to Japan (and perhaps South Korea). Also first comparisons with specimens of *T. tachydromoides* from Japan (ZFMK 7050, 8378-8386, 8970-8972, 22548, 22549, 26519, and 26520) did not contradict such an identification. Because all documents such as receipt books or catalogues have been destroyed in Hamburg during World War II, only the above-mentioned information on the label of the original jar (old number 3060) is left (J. Hallermann, in litt.). Although erroneous locality data seem to be the most plausible explanation in this case, we would not like to rule out the possibility of an overlooked *tachydromoides*-like *Takydromus* taxon in Myanmar and urge resident herpetologists to draw their attention in the course of field studies and on preserved material. Should such a form be discovered in the future, it would most likely not be conspecific with the Japanese form.

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Status of sea turtles along the Pondicherry coast, India

Pondicherry is a small town in the eastern coast of India. It has a coastline of about 15 km, although only 11 km comprise sandy beaches suitable for nesting sea turtles. In other areas, boulders have been placed along the beaches to avoid erosion. Many works regarding sea turtle nestings have been done in the neighbouring areas, such as Madras (Valliappan and Whitaker, 1974; Silas and Rajagopalan, 1984; Abraham, 1989), but no record exists on sea turtle nesting on the Pondicherry coast. A survey was undertaken during the months of December-April in 1998. Along the Pondicherry coast, there are nine coastal villages: Kanagasettikulam, Chinnakalapet, Periakalapet, Periyaveerampatinam, Chinnaveerampatinam, Nallavaadu, Pannithittu, Narambai and Moorthikuppam. A questionnaire was prepared and the fishermen living in the coastal villages where interviewed, during the months of December and January for collecting secondary information on sea turtle nesting.

The villagers reported seeing over 100 nests annually 10 years before, but in recent years, the number of nestings has reduced considerably. According to the villagers, sea turtle nests were not seen in the beaches other than Nallavaadu and Pannithittu for the past three years. Based on this information, the beaches of Nallavaadu and Pannithittu were patrolled every night from January to April. Other villages were visited once a week and villagers were asked to collect information on nests. During the entire season, only five nests were recorded, all belonging to the olive ridleys (*Lepidochelys olivacea*). Nesting occurred only in the beaches of Nallavaadu and Pannithittu. The beach stretch of the Nallavaadu and Pannithittu is about 3.5 km long, of which only 0.5 km is inhabited by fishermen. The other villages are located in close proximity to each other, and almost the entire area of beach utilized by fishermen, including huts, kattamarans (fishing vessels), fish markets, etc. This appears to be the primary reason for the preference of turtles to nest on the beaches of Nallavadu and Pannithittu were there is minimal disturbance.

During the survey, the number of dead turtles washed ashore was 54. The trawlers operating in these areas are suspected to be responsible for the mortality. Fishermen working in the trawlers also confirmed this. The secondary information collected from the villagers revealed that almost all nests are collected for sale in the fish markets of Pondicherry. This year, of five nests collected, three were relocated and two were incubated in pots.

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A note on reproduction in *Polypedates leucomystax* (Gravenhorst, 1829)

Polypedates leucomystax (Gravenhorst, 1829) is a widely distributed species, being recorded from India to south-east Asia (Dutta, 1997). Within this range, it inhabits disturbed areas, as well as evergreen forests, and is generally seen on low vegetation, up to an elevation of 300 m above msl. A study was conducted on the reproduction of this species from April 1997 to May 1998 at Guwahati (91° 36'-49'E; 26° 06'-09'N), Mayeng Reserve Forest (91° 21'-32'E; 25° 48'-55'N) and Garbhanga Reserve Forest (91° 37'-49'E; 25° 55'-26° 05'N), in Assam State, north-eastern India, and the reproductive behaviour of 16 pairs noted.

The breeding season of *Polypedates leucomystax* extended between April to August. Deuti and Bharati Goswami (1995) reported it to last for a month in the state of West Bengal, further west of our study sites. However, amplexus in April and early May continued for a longer duration than in the peak period of June and July (Table 1).

Amplexus was initiated with a female approaching a calling male, performing sinistral movements and jumping onto the male. On contact, the male mounted the female, commencing axillary amplexus. The time spent in amplexus showed considerable variation.

Egg deposition and formation of foam nest was observed in a variety of microhabitats (Table 1), all in proximity of temporary or permanent water bodies. Before laying, both the sexes oriented themselves with the hindlimbs remaining free. The males start secreting a sticky substance, which was followed by secretion by the female. Only the females took part in construction of the foam nest, as reported in *Polypedates maculatus* by Mallick and Mallick (1982). Eggs were laid in batches of 12-16, egg-laying taking about 15 minutes (Table 1). Foam nests were constructed in moist, shady locations, such as bushes, grass blades or at the base of herbs in wa-

TABLE 1: Data on reproduction in *Polypedates leucomystax* in Assam State, north-eastern India.

Sl.	Date	Duration of call	Height from substrate	Minimum distance of calling mate	Duration of amplexus	Nest site	Duration of nest construction	Number of eggs
1	22.4.97	1 h 22 min	fence/0.67 m	> 20 m	5 h 12 min	ground	15 min 32 sec	13
2	12.5.97	2 h 05 min	fence/0.65 m	> 15 m	4 h 10 min	grass	12 min 45 sec	12
3	14.5.97	1 h 16 min	bush/0.8 m	> 10 m	3 h 30 min	ground	13 min	13
4	7.6.97	1 h 53 min	shrub/1.2 m	> 10 m	3 h 45 min	grass	14 min 12 sec	13
5	8.6.97	1 h 47 min	shrub/0.37 m	1.7 m	3 h 25 min	grass	12 min 30 sec	16
6	13.6.97	1 h 30 min	fence/0.75 m	2.5 m	3 h 45 min	bush	12 min 50 sec	12
7	22.6.97	1 h 55 min	bush/0.95 m	1.8 m	3 h 05 min	grass	26 min	13
8	24.6.97	1 h 50 min	shrub/1.5 m	3.0 m	3 h 55 min	ground	14 min 8 sec	16
9	5.7.97	1 h 50 min	shrub/1.5 m	2.1 m	3 h 30 min	bush	18 min 3 sec	12
10	19.7.97	1 h 55 min	shrub/1.6 m	2.8 m	3 h 50 min	ground	16 min 15 sec	12
11	20.7.97	2 h	fence/0.54 m	3.2 m	3 h 20 min	ground	15 min 50 sec	15
12	3.8.97	1 h 25 min	shrub/1.3 m	> 10 m	4 h 12 min	ground	26 min 18 sec	13
13	25.8.97	1 h 30 min	fence/0.70 m	1.8 m	4 h 25 min	ground	12 min	12
14	19.4.98	3 h 40 min	concrete slab/0.42 m	0.75 m	49 h 03 min	grass	16 min 32 sec	14
15	26.4.98	4 h 12 min	concrete slab/0.42 m	1.2 m	10 h 40 min	grass	14 min 20 sec	15
16	26.4.98	5 h 50 min	concrete slab/0.42 m	1.2 m	6 h 00 min	base of herb	13 min	12

terlogged areas, similar to the microhabitats for nests of *P. maculatus* reported by Mallick et al. (1980).

The nest came in contact with water on the second day. Hatching occurred on the third or fourth day after laying, during which the foam started dissolving in water, and the tadpoles swam free.

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Duration of meiosis and spermiogenesis in *Limnonectes limnocharis*

(with one text-figure)

The duration of meiosis and spermiogenesis in *Limnonectes limnocharis* was estimated autoradiographically by following the progression of labelled spermatocytes from the onset of meiosis till the formation of radioactive spermatozoa. A total of 34 mature males were collected in June from Duillya, Howrah, West Bengal, eastern India. Following a 3-day acclimatization in a glass aquarium, each was injected intraperitoneally with 5 (μCi of 3 H- thymidine (sp. act. 9.00 mCi/mM; Bhaba Atomic Research Centre, Trombay, Mumbai, India). The testes of frogs, killed at intervals covering a period from 0.33 d. to 20.00 d. postinjection, were collected. Both histological and squash preparations were made, stained with delafied haematoxylin and 2% aceto-orcein respectively, autoradiographed with Kodak AR-10 stripping film (Ghosal et al., 1993) and the most advanced radioactive stages were recorded (Table 1). Specific activity of 3H is low enough not to inflict radiation injury, nor any alteration in the meiotic cycle.

Vertebrate spermatocytes, unlike mitotic cells, lack a G2 period (Heller and Clermont 1963). The present investigation reiterates the same event since the first frog killed as early as 0.33 d.p.i. displayed radioactivity overlying leptotene. The leptotene remained "hot" until 1.50 days. In the specimen sacrificed at 2.00 d.p.i., zygotene was the most advanced labelled stage. Due to the absence of G2, the duration of leptotene appeared neither less than 1.75 d., nor more than 2.00 days. At 2.42 d.p.i. pachytene appeared radioactive for the first time. Zygotene duration is thus very short, and never exceeds

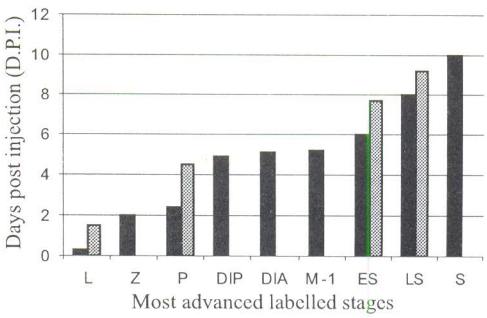

FIGURE 1: Histogram showing individual duration of meiotic and spermiogenetic stages in *Limnonectes limnocharis.* The top of each light column indicates the time of first appearance of radioactivity in any stage; that of dark column indicates that the labelling continued until that period, over the same stage.

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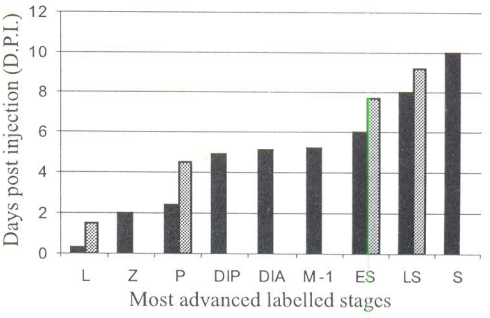

FIGURE 1: Histogram showing individual duration of meiotic and spermiogenetic stages in *Limnonectes limnocharis.* The top of each light column indicates the time of first appearance of radioactivity in any stage; that of dark column indicates that the labelling continued until that period, over the same stage.

TABLE 1: Most advanced labelled stages of meiosis and spermiogenesis detected at intervals following 3H-thymidine injection into *Limnonectes limnocharis*. The number in paranthesis refers to the serial number of frog sacrificed.

Most advanced label detected initially at days post injection	Label detected initially at days post injection	Continued to remain labelled in later tests at days following post injection
Leptotene	0.33 (1)*	1.25 (2), 1.50 (3)
Zygotene	2.00 (4)	
Pachytene	2.42 (5)	3.00 (6), 3.25 (7), 3.50 (8), 4.00 (9), 4.25 (10), 4.50 (11)
Diplotene	4.92 (12)	
Diakinesis	5.08 (13)	
Metaphase-1	5.20 (14)	
Early spermatids	6.00 (15)	6.33 (16), 6.75 (17), 7.00 (18), 7.50 (19), 7.75 (20)
Late spermatids	8.04 (21)	8.75 (22), 9.25 (23)
Spermatozoa	10.00 (24)	10.50 (25), 11.00 (26), 11.50 (27), 12.00 (28), 12.75 (29), 13.25 (30), 14.00 (31), 16.00 (32), 19.00 (33), 20.00 (34)

TABLE 2: Duration (in days) of individual stages of meiosis and spermiogenesis in a few vertebrates as interpreted from the data of respective authors.

Animals	Lepto.	Zygo.	Pachy.	Diplo.	Spermio to genesis Meta-II	Total	Reference
Fish							
Colisa fasciata	0.45	0.10	1.98	0.81	6.01	9.68	Sinha et al., 1979
Channa punctatus	0.45	0.12	2.15	0.80	8.33	11.25	Sinha et al., 1983
Amphibian							
Limnonectes limnocharis	1.75	0.92	2.50	0.40	4.01	10.00	Present investigation
Polypedates maculatus	1.88	0.40	4.72	0.66	9.82	17.25	Ghosal et al., 1981
Reptile							
Calotes versicolor	1.66	0.55	2.60	0.50	13.50	18.00	Ghosal & Bandyopadhyay, 1983
Bird							
Columba livia	2.80	0.40	5.40	0.60	17.00	26.00	Joardar & Ghosal, 1977
Mammals							
Canis familiaris	4.33	0.80	15.61	1.22	22.16	42.15	Ghosal et al., 1983
Homo sapiens	5.7	2.6	13.5	2.5	23.8	48.0	Heller & Clermont, 1963

0.92 day (2.42-1.50). The pachytene stage, which was observed labelled for the first time at 2.42 d.p.i., continued to remain radioactive up to 4.50 days, while labelled deplotenes were detected at 4.92 d.p.i. It is apparent that between 1.50 and 2.00 d. postinjection, zygotene reached the pachytene stage and also that these pachytenes were converted to diplotenes between 4.50 and 4.92 d.p.i. Therefore, the duration of pachytene would neither exceed (4.92-2.00 =) 2.92 days, nor fall short of (4.50-2.42 =) 2.08 days. One may conclude that: a), the pachytene duration ranges between 2.08 and 2.92 or b), the pachytene duration is 2.50 (0.42 days). Hence, pachytene has a relatively longer duration. Diakinesis was found labelled initially at 5.08 d.p.i. and metaphase-I is very short, but also that the succession of these stages is incredibly rapid. The total duration of these stages appears to be under a day.

Labelled early spermatids with its characteristic circular outline were detected as early as 6.00 d.p.i. Spermatids representing various stages of spermiogenesis were labelled until 9.25 d.p.i. Spermatozoa that had yet been unlabelled appeared "hot" at 10.00 d.p.i. and continued to remain the most advanced radioactive elements later. The duration of spermiogenesis could be

neither under (9.25-6.00 =) 3.25 days, nor over (10.00-5.20 =) 4.80 days. The meiosis and spermiogenesis were presumed to have been completed between 9.25 and 10.00 days (Fig. 1).

It is interesting to note that individual durations of zygotene, diplotene, diakinesis and metaphases are exceedingly short among the vertebrates (Table 2). Moreover, a comparative profile of the duration of stages indicates a tendency for the expansion of these durations concurrent with vertebrate evolution. For example, the leptotene, conspicuous for a brief duration in fishes, being as short as 0.45 d. in *Channa punctatus* (Sinha et al., 1983), extends for 5.7 days in man (Heller and Clermont, 1963). In fact, the pachytene has a longer span in vertebrates (Ghosal 1998), the pachytene has a longer span, next being leptotene (Chaudhuri and Ghosal, 1997). Spermiogenesis almost invariably overspans pachytene. The tendency for elongation of the duration of these stages is manifested when the combined duration of meiosis and spermiogenesis, as deciphered from the first appearance of "hot" spermatozoa after 3H-thymidine administration is taken into account. In sharp contrast to 9.68 days in *Colisa fasciata* (Sinha et al., 1979), meiosis and spermiogenesis have a longer total duration of 48 days, the longest among vertebrates explored so far, in man (Heller and Clermont, 1963).

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Observations on *Varanus salvator* feeding on *Oligodon octolineatus*

(with one plate)

The 85-ha coastal wetland reserve at Sungei Buloh Nature Park, on Singapore Island (01° 42'53.5"N; 103° 43'30.8"E) was inaugurated in 1993 as a sanctuary for migratory birds that use the east Asian flyway. This mangrove-dominated wetland supports a population of the water monitor, *Varanus salvator*. In this protected and resource-rich environment, monitors have become abundant and are suspected to have some impact on resident and migrant bird populations through their predation on birds, nestlings and eggs. A study on the population ecology of *V. salvator* was initiated in 1998 to investigate home range use, movement patterns and trophic relationships of water monitors in this wetland reserve.

During fieldwork on 15 February, 1999, at about 1230 h, a *Varanus salvator* (± 1.3 m) was observed by the first author with a snake (± 0.7 m) in its mouth (Fig. 1). The monitor was on the bank of a freshwater pond on the east side of the park's visitor's centre. The snake was identified as a striped kukri snake, *Oligodon octolineatus* (Schneider, 1801) (Family: Colubridae), by its black longitudinal stripes and a prominent red vertebral stripe.

The monitor had been foraging near the banks of the pond which was covered with litter and over run by freshwater macrophytes, including *Ludwigia* sp. and *Ipomoea* sp. The monitor had seized the snake across midbody with its jaws, jerking its head violently sideways apparently to subdue the snake. The snake's body to the right side of the monitor's jaws was coiled around the right forelimb while its head and body on the left moved about in an apparently uncoordinated manner. Bloody bite-marks on the snake's head and neck and its movements suggested that the snake was probably already fatally injured. However, the initial attack and prey capture was not observed.

The monitor released its hold momentarily, but continued to make several more bites down the length of the snake's body. It then began to swallow the snake head first. During the feeding bout, the monitor would raise its head and lurch forward using inertial feeding to swallow an additional length of the snake's body before retracting its head backwards. There were brief

pauses between each swallowing sequence which was sometimes punctuated by lateral jerks of the head, as if to shake down the food. It took 15 minutes for complete ingestion, after which the monitor remained at the site for a while before moving away.

Monitors (except *Varanus olivaceus*) are primarily carnivorous, feeding almost exclusively on invertebrates as well as birds, reptiles (including their eggs), and mammals. Reptilian prey items found in the diet of monitors include lizards (geckos, skinks and monitors), snakes and their eggs, and sea turtles and crocodilian eggs (Pianka, 1986; Bennett, 1998; Losos and Greene, 1988). The importance of snakes in the diet of *V. salvator* is unknown, but in *V. gouldii*, snakes are important dietary items (De Lisle, 1996). In some recent studies, snakes were not recorded as part of the diet of *V. salvator* (Gaulke, 1991; Traeholt, 1994). Apart from two previous reports by Krebs (1991) of predation by *V. dumerilii* on *Elaphe longissima*, and Mattison's (1998) account of feeding of a venomous puff adder, *Bitis arietans*, by *V. albogularis*, there is no other documentation of varanid predation of snakes. Although monitors are active hunters, the predation on *Oligodon octolineatus* by *V. salvator* was probably a chance encounter with the prey, indicating that *V. salvator* can feed high up the food chain.

Field work and manuscript preparation was supported by the Nanyang Technological University research grant RP21/97 to the second author. We thank Van Wallach, and Aaron Bauer for comments on the manuscript.

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A note on the reproductive seasonality of *Varanus panoptes* in the wet-dry tropics of Australia

The wet-dry tropics of Australia are characterised by a marked seasonal change in rainfall and humidity between the wet and dry seasons, with most of the rain falling between November and April (Taylor and Tulloch, 1985). The reproductive seasonalities of several lizard taxa of the region have been examined and most were found to be reproductive during the wet season (James and Shine, 1985). Little is known regarding reproductive seasonalities in most monitor lizards (*Varanus* spp.) of the wet-dry tropics, however.

The monitor lizard *Varanus panoptes* [nomenclature as in Cogger (1992: 370)] is a

pauses between each swallowing sequence which was sometimes punctuated by lateral jerks of the head, as if to shake down the food. It took 15 minutes for complete ingestion, after which the monitor remained at the site for a while before moving away.

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The monitor lizard *Varanus panoptes* [nomenclature as in Cogger (1992: 370)] is a

ground-dwelling, often riparian monitor lizard of the wet-dry tropics (Shine, 1986, Cogger, 1992). The only previous accounts of reproduction of this species were by Shine (1986), who observed courtship behaviour in July and found females of reproductive condition among specimens collected in February. R. Pengilley (pers. comm.) observed mating *V. panoptes* in Darwin in May. Some further observations of reproduction in this monitor, made at Fog Bay (12°43'S; 130°20'E) ~ 150 km south west of Darwin, and around Darwin (12° 25' S; 131°50' E), Northern Territory, Australia, are described herein.

Three adult specimens, one male and two females, were found dead at Fog Bay and taken to the laboratory at the Northern Territory University and dissected and their gonads were examined for signs of reproductive condition. The two females appeared to have been hit by vehicles but the cause of death of the male was unknown. Another female specimen, found at Ludmilla Creek, Darwin Harbour, by M. Nobbs, was also dissected in the laboratory and its gonads were examined for signs of reproductive condition. This specimen appeared to have died from attack by another animal. The male specimen from Fog Bay was discarded as it was beginning to decompose. One female specimen from Fog Bay was frozen and kept by the Museum and Art Galleries of the Northern Territory (unregistered), the second female specimen from Fog Bay and the Ludmilla Creek specimen are held at the Northern Territory University. The stomach contents of the specimens were also examined. SVL = snout-vent length; TL = total length.

The male specimen from Fog Bay (SVL = 43.1 cm, TL = 111.9 cm) was found in July, its testes appeared enlarged, however volume was not determined so it was inconclusive whether this specimen was reproductive. This specimen's stomach was full with eggs of the flatback sea turtle (*Natator depressus*). One female from Fog Bay (SVL = 42.5 cm, TL = 104.3 cm) was found in May, it clearly had regressed ovaries. The major food retrieved from its stomach was insects, mostly grasshoppers and cockroaches. The other female from Fog Bay (SVL = 40.3 cm, TL = 98.8 cm) was found in October, this specimen had five developed but unshelled eggs within its ovaries. The stomach contents of this specimen were largely indistinguishable, containing mostly dirt and some insects (cockroaches and crickets). The female specimen collected from Ludmilla Creek (SVL = 44.0, TL = 109.0 cm) was found in April and had seven shelled eggs within its ovaries. This specimen had two cockroaches in its stomach.

Four small *Varanus panoptes* were captured by hand at Fog Bay and were measured. Their total lengths were 24 cm, 27 cm, 28 cm and 30 cm. These were about the regular size of *V. panoptes* at birth (Bennett, 1998: 178, as *V. gouldii*). Two were seen in October and one was seen in both January and February. A further capture of a hatchling (TL = 30.5 cm) was made in Darwin in February. I have never witnessed mating or egg oviposition by this species.

The above evidence suggests mating by *Varanus panoptes* in May and, based on Shine's (1986) observations, possibly in July. Shine (1986) found enlarged ovarian follicles in a female specimen in February, this does not necessarily mean it was mating at this time, but is indicative of reproductive condition. I found gravid female specimens in April and in October, and thus breeding must occur at these times. It appears that gravid females eat relatively little, probably to conserve energy spent on foraging.

King and Green (1993: 34) estimated incubation periods for monitor lizard eggs based on adult body length, and since the specimens examined were between 98 and 112 cm body length, an incubation period of around 140 days may be assumed. Hatchlings were observed in October-February, therefore oviposition might begin around May/June and continue until around September/October. This would agree with Shine (1986), who suspected dry season ovipositing in this species.

These observations suggest that *V. panoptes* breeds during the dry season, beginning between February and April and continuing until around October. Eggs are probably laid between April and November and hatchlings probably emerge between September and March. Some lizards in the wet-dry tropics however have year round

breeding seasons (James and Shine, 1985), and this should not be ruled out for *V. panoptes* under favourable conditions. The observations herein were made only at Fog Bay and Darwin and those of Shine (1986) were made only in the Jabiru area. By examination of more specimens and making further field observations, over wider geographic areas, more may be learned regarding the breeding season in this monitor lizard of the wet-dry tropics.

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HERPETOLOGICAL BIBLIOGRAPHY OF INDONESIA by Indraneil Das. 1998. Krieger Publishing Company, Malabar, Florida. 96 pp. ISBN 1-57524-026-2. Available from: Krieger Publishing, P. O. Box 9542, Melbourne, Florida 32902, USA. Fax: + 407 951 3671; Email: info@krieger-pub.com. Price US$22.50.

My first reaction on paging through this slim volume was "where's the map?" We all enjoy pouring over a good map, and here's a case when it would have been constantly referred to as you read through the titles. Aside from that, the typos (that never reveal themselves till the book is published) and the fairly hefty price, this is an extremely handy compilation of references from papers, books, chapters, theses and reports. Das has examined the literature in a number of languages, and the researcher's only frustration may be the difficulty in obtaining many of these references. The "Indonesian region" is truly a vast and fantastic tropical archipelago.

With close to 15,000 islands to choose from and over 600 herps dwelling therein, here several lifetimes of herp research await the field biologist. My own delve into this wonderland began about 25 years ago when I first started visiting the Andaman and Nicobar Islands. A world of saltwater crocodiles and king cobras, plus day geckos and amphibious sea snakes opened up, and I was instantly hooked. Actually, you get hooked long before you get there. Just reading the scant herp notes and instantly memorizing the shape, name and place of each island, have you deeply in the hilly rainforests before you even have your steamer ticket. Later, my good fortune took me to Java, the Moluccas, Borneo and the Philippines in search of strange crocodiles like the long-snouted *Tomistoma*, and magnificent snakes like the reticulated python. Things are changing fast though, and forests are disappearing so quickly that large wild creatures like tiger, rhino and elephant, just cannot compete with the human onslaught. Herps suffer too, and a number of species with very specific habitat needs (fossorial forest snakes, mangrove monitors and rainforest dwelling king cobras, to name some) are losing ground. Indonesia has arguably the world's largest trade in live and dead herps for the pet trade, food and skins. Some of this could be sustainable it seems, but most is unstudied, rarely monitored, and out of control. When you look at trade figures (500,000 water monitor hides and reticulated pythons on the market each and every year) and see the huge warehouses full of reptile skins, you really wonder how long populations can hold out. As the author Das states, there is scant literature on reptile husbandry for the region. This reflects the virtual dependence on wild stocks of reptiles for the skin trade and the lack of effort to keep the trade sustainable.

It is hoped that the *Herpetological Bibliography of Indonesia* will help provide an impetus for much needed research. We still have a lot to learn about the reptiles and amphibians of this vast network of islands. Success of any conservation and education efforts depend on our level of knowledge of the species and habitats concerned.

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CONTRIBUTIONS TO THE HERPETOLOGY OF SOUTH ASIA (NEPAL, INDIA) edited by H. Hermann Schleich & Werner Kästle. 1998. Veroffentlichungen Fuhlrott-Museum, Band 4. 322 pp. ISBN 3-87429-404-8. Available from: Fuhlrott-Museum, Auer Schulstr. 20, D-42103, Wuppertal, Germany. Email: fuhlrott-museum@t-online.de. Price: DM 68, plus DM 12 for shipping worldwide.

Contributions to the Herpetology of South Asia (Nepal, India) is Volume 4 of a series of publications by the Fuhlrott-Museum in Wuppertal, Germany. One of the Editors of the work (Schleich) is Director of the Museum.

The book contains 18 scientific contributions, followed by an advertisement of a newly-founded society at the Fuhlrott-Museum: ARCO- Nepal, Amphibian and Reptile Conservation Organisation- Nepal. Major sections of the book include.- 1. studies on *Tylototriton verrucosus*; 2. Miscellanea Batrachologica, which contains two contributions, one on a new species of *Tomopterna*, the other on a new record of *Polypedates taeniatus* from Nepal; 3. sections on systematics and biology of the genera *Sitana* and *Japalura*; 4. Miscellanea Herpetologica, comprising description of a new species of *Gonydactylus* from western Nepal; aspects of turtle conservation in Nepal; intestinal infections in captive-bred gharial (*Gavialis gangeticus*) hatchlings; and 5. a section on fossil reptiles with contributions on microreptiles from the Shiwaliks of India; egg shells from the Intertrappeans of Kachchh (India), and reptiles from the Intertrappean Beds of Bombay (now Mumbai).

Although the book is impressive by physical standards and both editors have clearly invested an enormous amount of effort in producing the work, one feels that the book could have been improved through more careful editing. For instance, the headings under contents are not dealt with in a consistent manner as regards the fonts used; the text for tables are at the bottom of the tables (not, as is the usual practise, on top); throughout the text, the authors use "spec." rather than "sp." for abbreviating "species". The format for individual papers too is rather heterogenous. Some contain a list of contents, which I consider unnecessary. On page 122, this list is even included in the text of the paper. In another paper (p. 281), contents are provided under the title of the paper. Contrary to common usage, key words are placed above the abstracts.

Readers not familiar with the series from Fuhlrott-Museum would have certainly expected to read an introduction to volume 4 and possibly also wish to be informed about the volumes published earlier. I would have liked to have read about the background for compilation of the papers presented in the book. Probably most, if not all, of the work presented were carried out under the auspices of the project "Natural History of the Amphibians and Reptiles from Nepal", sponsored by Volkswagen Foundation.

Despite all these shortcomings, the publication of Schleich and Kästle provides a wealth of information for readers interested in herpetology in general, or in south Asian amphibians and reptiles in particular. For instance, the papers by Anders et al. on the biology of *Tylototriton verrucosus* not only contain new information on this poorly known species, but provides a good overview of its biology. In addition, the book describes several new taxa belonging to the genera *Tomopterna, Gonydactylus* and *Sitana*. Some of the studies presented, such as the behavioural work by Kästle, shows how important information on a species can be obtained by having a close look at very specific compotents of their overall behavioural repertoire. For many of the topics covered in the work, instructive flow diagrams are provided, and line drawings and particularly colour photographs nicely supplement the information provided in the text. In sum, I strongly recommend reading of *Contributions to the Herpetology of South Asia* by Schleich and Kästle to all working on the highly diverse and fascinating herpetofauna of the region.

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A KANSAS SNAKE COMMUNITY: COMPOSITION AND CHANGES OVER 50 YEARS by Henry S. Fitch. 1999. Krieger Publishing, Malabar, Florida. xi + 165 pp. ISBN 0-89464-996-5. Available from: Krieger Publishing, P. O. Box 9542, Melbourne, Florida 32902, USA. Fax: + 407 951 3671; Email: info@krieger-pub.com. Price: US$ 42.50.

Fitch's latest is surely Krieger's finest in herpetology- a magnificent volume, well printed with all those little bits of data that were not in the technical papers Fitch published during his over half of century of research on the snakes of the American State of Kansas.

What follows the Acknowledgments are an Introduction, that includes the taxa covered in the study; a description of the study site and methods and materials, followed by accounts of individual taxon. In all, 18 species are covered, and topics covered under each include: traits of the species, behaviour, spatial relationships, prey, reproduction, growth, numbers and geographic distribution. Following the species descriptions is the chapter Discussion and Conclusions, that provides overall summaries of diversity of diet and demography, size relationships, temporal changes, snake occurrence, sex ratios and maturity, geographic differentiation and mortality factors. A short section on literature cited and an index wraps up this work. Tucked away in the text are many useful nuggets of information, such as the activity pattern of *Crotalus horridus*, the so-called timber rattler, which tends to be nocturnal in hot weather, but diurnal when daytime temperatures are near their preferendum (p. 41), or that over half (sample size being 1,285!) the captured *Agkistrodon contortrix*, alias copperhead, had only one fang on each side (p. 10).

What is different between this study and virtually any study done on snakes in general or, for that matter, anything living, is the enormous temporal scale involved. Scale is of tremendous significance in ecology, and generalisations true at one scale may not be true at another scale. Fitch's data (based on 31,000 capture records over 50 consecutive years of study) show significant fluctuations in many population parameters making one realise that generalisations made from short-termecological observations may be open to question.

The only nit I will complain about are the colour plates printed between pages 85-100 (the photos used on the dust jacket have printed exceptionally well). Each plate carries 2-3 colour photos of snakes, nearly all of which suffer from problems of exposure, focussing and/or framing and composition. The fact that most are on artificial surfaces detracts, and subsequent editions can perhaps fix the problem through the judicious selection of photographs.

In conclusion, I think the highly readable text of *A Kansas Snake Community* would make young readers seek out Henry S. Fitch's other ecological works (published in scholarly journals and out of reach of many of those outside of universities and museums), and perhaps draw even more young naturalists to the science of herpetology.

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