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THE COBRAS OF THE GENUS *NAJA* IN INDIA

Wolfgang Wüster

School of Biological Sciences, University of Wales, Bangor, LL57 2UW, Wales, UK
(with one text-figure)

ABSTRACT.- The species of cobra inhabiting India are reviewed. All Asiatic cobras used to be considered part of a single species, *Naja naja*. In fact, four species are found in India alone: *Naja naja* (more or less throughout the country), *Naja kaouthia* (east and north-east), *Naja oxiana* (extreme north-west) and *Naja sagittifera* (the Andaman Islands). The systematics of the four species is reviewed, and all four species are described, and the literature on their natural history and medical importance summarised.

KEY WORDS.- *Naja*, Serpentes, taxonomy, morphology, India.

INTRODUCTION

In the minds of people all over the world, one of the animals that most symbolises India is the cobra, and in particular the image of a cobra rearing out of a basket and "dancing" to the sound of a snake charmer's music. As far as popular awareness is concerned, cobras are by far the best known snakes of India. However, many aspects of their natural history and biology remain poorly known. Even the most basic of all categories of biological knowledge, namely the taxonomy of these animals, has remained largely unstudied until recently.

In this paper, I will summarise recent taxonomic developments concerning the species of *Naja* occurring in India, provide descriptions of the species as currently recognised, and provide guidelines for the identification of cobra specimens from areas where more than one species occurs, a matter which has caused considerable problems in the past. I will also attempt to provide updates on other literature on these animals, especially concerning snakebite and similar topics.

SYSTEMATICS OF THE GENUS

Systematic history.- Few groups of venomous snakes have as confused a taxonomic history as the Asiatic cobras. The extreme variability of these snakes, especially in their colour pattern, has obscured the affinities of many populations for decades. Since the latter part of the 19th century, all Asiatic cobra populations have generally been lumped into one single species, *Naja naja* (referred to as *Naja* (or sometimes *Naia*) *tripudians* in much of the 19th century literature). Over the whole of Asia, 10 subspecies were recognised (e.g., Klemmer, 1963; Leviton, 1968; Harding and Welch, 1980; Golay, 1985; Welch, 1988). Of these, four were listed for India: *Naja naja naja* (spectacled or binocellate cobra), reported to occur throughout India, as well as in Pakistan, Sri Lanka, and Bangladesh; *N. n. kaouthia* (monocellate or monocled cobra), reported from north-eastern India (Gangetic Plain, Orissa, Bengal, Assam) as well as from Bangladesh, and on to Malaysia, southern Vietnam and south-western China); *N. n. oxiana* (Central Asian cobra), reported from Kashmir, and sometimes other parts of north-western India; and *N. n. sagittifera* (Andaman cobra), from the Andaman Islands. This classification has been followed fairly consistently in the literature, even though a number of authors, such as Taylor (1965), Leviton (1968), Saint Girons (1972) and Golay (1985) have remarked on the problems posed by the systematics of this group.

The only major revision of the group this century was carried out by Deraniyagala (1945, 1960, 1961), who split the complex into four species, of which three (*Naja naja*, *N. kaouthia*, and *N. oxiana*) were listed for India, with Indian distributions corresponding to those listed for the subspecies above. Furthermore, Deraniyagala described several subspecies of *N. naja* from India, these being *N. n. indusi* (Punjab and neighbouring areas), *N. n. madrasiensis* (southern India), *N. n. gangetica* (north-eastern India), *N. n.*

bombaya (Maharashtra and neighbouring areas) and *N. n. karachiensis* (southern Pakistan and adjoining parts of India). Deraniyagala considered the nominate form, *N. n. naja*, to be restricted to Sri Lanka. However, the evidence for Deraniyagala's revisions was often rather weak, and his papers have been largely ignored by later workers.

Recent taxonomic developments.- Because of the tremendous variation in colour pattern and other characters displayed by these snakes, any attempt to understand their taxonomy has to be based on the simultaneous analysis of a number of different characters and character systems, and on the use of a large number of specimens. Molecular methods such as comparative mitochondrial DNA sequencing can further resolve problems caused by variation in morphological characters. The taxonomy of the Asiatic cobra complex has now been extensively revised using these methods. The analyses resulted in the splitting of what was considered *Naja naja* into 10 species (Wüster, 1990; 1992a,b; Wüster and Thorpe, 1987; 1989; 1990; 1991; 1992a; 1992b; 1994; Wüster et al., 1995, 1997; reviewed in Wüster, 1996).

Of these 10 species, four are definitely known to occur in India and neighbouring areas: the spectacled cobra (*Naja naja*) is found throughout India, with the exception of Assam and some of the northern mountains; the monocellate cobra (*N. kaouthia*) is found in the Gangetic Plain, Bengal, and north-eastern India; the Central Asian cobra (*N. oxiana*) is found in northern India (Kashmir, Himachal Pradesh); and the Andaman cobra (*N. sagittifera*) is restricted to the Andaman Islands. *Naja naja* and *N. oxiana* occur sympatrically in parts of north-western India and Pakistan, and *N. naja* and *N. kaouthia* do so in parts of north-eastern India (Wüster and Thorpe, 1991; 1992a).

In addition to these four species, Wüster and Thorpe (1992a; 1992b) noted two specimens from Bihar state, northern India, which could not be classified as any of the known species of Asiatic *Naja*. They may represent hybrids, aberrant specimens, a locally differentiated population of *N. naja*, or it is possible that another, as yet undescribed, species is present in north-eastern India. More material will be required to resolve this problem.

Significance of recent taxonomic developments.- The splitting of the formerly single species *Naja naja* has a number of implications for research on other aspects of these animals. For instance, many reports on the natural history of Asiatic cobras cannot be linked to any particular species, which is of some relevance in view of reported differences in such elementary natural history traits as mating season (e.g., Lingenhöle and Trutnau, 1989).

The recent taxonomic discoveries are of particular relevance for research on the venoms of these snakes and the treatment of their bites. The bites of different cobra species have been shown to produce symptoms which differ very considerable, ranging from almost entirely neurotoxic (e.g., *Naja philippinensis* - Watt et al., 1986, 1988, 1989) to principally necrotic in some *N. kaouthia* and/or *N. sumatrana* populations (Reid, 1964), suggesting extensive variation in venom composition.

However, because of the hitherto incomplete understanding of the systematics of this group, the vast literature on the venoms and bites by these snakes is often taxonomically uninterpretable. The problem extends to some clinical series of bites containing a mixture of victims bitten by different species (e.g., Reid, 1964), and to specimen descriptions so vague that it is impossible to be certain which species were involved. In India, this is particularly the case with cobras lacking a hood mark, which are frequently described as *Naja oxiana* when they are in fact patternless *N. naja*. This leads to difficulty in interpreting some of the literature, to the extent that the vast majority of experimental venoms discussed in the toxinological literature cannot confidently be ascribed to any one single species of Naja (Wüster and McCarthy, 1996).

This confusion in the literature is particularly regrettable because of the potentially devastating effect this can have on the formulation of treatment strategies for human patients bitten by venomous snakes. The venoms of different cobra species can have quite different immunological properties, which can lead to an antivenom against one species being ineffective against the

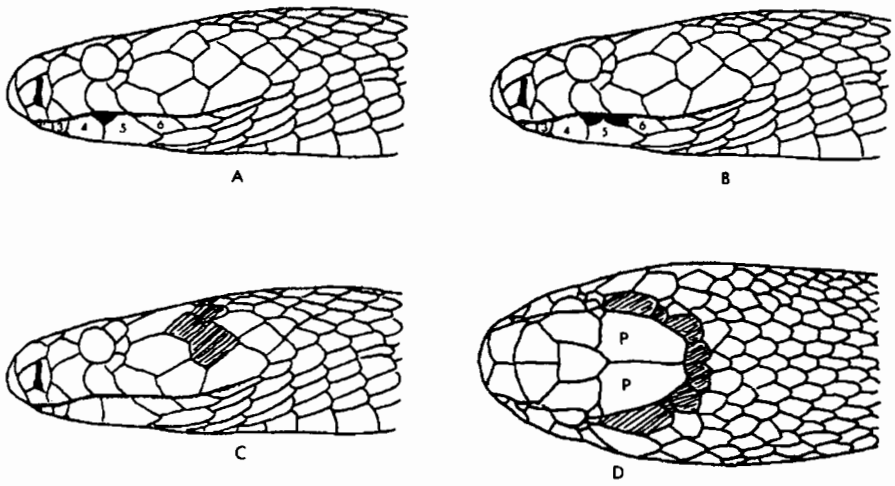

FIGURE 1: Head scalation in Asiatic *Naja*. (Diagrams modified from Bogert, 1943). A. Specimen with one cuneate scale (shaded) between the 4th and 5th infralabials. Typical arrangement in *Naja naja*. B. Specimen with two cuneate scales (shaded), between the 4th and 5th, and the 5th and 6th infralabials. Note that in this arrangement, the 5th infralabial is excluded form the edge of the mouth. Frequent arrangement in *Naja kaouthia*. C. Posterior temporal scales. In this study, posterior temporals (shaded) were defined as all scales other than parietals and supralabials contacting the posterior part of the anterior temporals. D. The nuchals (shaded) are defined in this study as all scales other than postoculars which contact the anterior and lateral edges of the parietal scales.

venom of another (Vogtman, 1950; Warrell, 1986; Viravan et al., 1992). Clearly, a full understanding of the population systematics of these snakes is essential for coherent research into venom effects and antivenom effectiveness, and for the optimization of antivenom efficacy.

THE COBRA SPECIES OF INDIA

Notes on the species descriptions.- Some of the scalation characters used in the descriptions of the various *Naja* species were taken from a previous study of the genus (Wüster, 1990), and are therefore likely to be unfamiliar to many readers:

- The cuneates are small, triangular scales inserted between the 4th and 5th and/or 5th and 6th infralabial scales (Fig. 1A, B). These are diagnostic for the genus, and their number can help distinguish some of the Asiatic *Naja* species, especially *N. kaouthia*.

- Posterior temporals were defined as scales which contact the posterior edge of the anterior temporals (Fig. 1C); other larger shields not in contact with the anterior temporals are excluded. In the scalation tables for each species, the sum for of both sides of the head is given.

- Nuchals are here defined as scales other than the postoculars which contact the lateral and posterior edges of the parietal scales (Fig. 1D)

- Dorsal scale rows are counted in a straight line across the body. In order to determine where dorsal scale rows should be counted, the ventrals were numbered from the head, and counts were taken at specific positions of the total count. For instance, in a specimen with 200 ventral scales, the dorsals at 20% ventral count were recorded at the level of the 40th ventral (20% of the total count), the dorsals at 40% ventral count at the level of the 80th ventral, etc. This is more precise than simple mid-body counts, and since these are the data available from previous studies of the genus, they comprise the most comprehensive database so far of scalation variation in these species.

- Dentition: counts were made by removing gum tissue from each of the jaw bones on one side of each specimen, and counting the number of tooth sockets. It is important to count sockets rather than teeth, because teeth may be missing from some sockets, and this would artificially introduce variance into the sample. The pres-

ence/absence of a solid maxillary tooth is practically impossible to determine without some dissection of gum tissue behind the fang.

NAJA NAJA (LINNAEUS, 1758) -
THE INDIAN SPECTACLED COBRA

Coluber naja Linnaeus, 1758. Type locality: in India orientali, restricted to Sri Lanka by Deraniyagala, 1945).

Naja tripudians Merrem, 1820.

Naia tripudians forma typica Boulenger, 1896.

Naia tripudians var. *caeca* Boulenger, 1896 (part.)

Naja naja Anderson, 1899.

Naja naja naja Stejneger, 1907.

Naia naia col. var. *polyocellata* Deraniyagala, 1939.

Naja naja gangetica Deraniyagala, 1945.

Naja naja madrasiensis Deraniyagala, 1945.

Naja naja indusi Deraniyagala, 1960.

Naja naja bombaya Deraniyagala, 1961.

Naja naja karachiensis Deraniyagala, 1961.

Naja naja polyocellata Mahendra, 1984.

Distribution.- Pakistan (except probably most of Baluchistan, parts of the North-West Frontier Province, and desert areas elsewhere - Minton, 1966; Joger, 1984; Khan, 1990), India (throughout, except probably Assam, some areas of Kashmir, high areas above 2,000 m, and extreme deserts), Sri Lanka, southern Nepal and Bangladesh. Mahendra (1984) reports its presence in Bhutan, without further details. The most easterly record appears to be from Tangail District, Bangladesh, and the most westerly record is from Duki, Baluchistan (Wüster and Thorpe, 1992a). As it has been recorded from Drosh, in the Chitral Valley (Wüster and Thorpe, 1992a), it may also occur in the Kabul River Valley in extreme eastern Afghanistan.

DESCRIPTION

Size.- Most adults measure 100-150 cm. Occasional specimens of approximately 210-220 cm have been recorded, especially in Sri Lanka. Hatchlings usually measure 25-30 cm.

Colour pattern.- The Indian spectacled cobra is a very variable snake in terms of colour and pattern. The ground colour can be grey, yellowish, tan, brown, reddish or black. Some specimens have a dorsal colour pattern as well as a hood mark. The most frequently visible pattern feature is a posteriorly convex light band at the level of the 20th to 25th ventral. This often continues across the ventral side, where it forms the light band between the first and second dark bands. Many specimens, especially adults, also exhibit some salt-and-pepper speckling on the dorsal scales. Some specimens, especially those from Sri Lanka, have a series of often ill-defined, ragged bands along the dorsum. Ontogenetic colour change is common in the north-western populations, especially those from southern Pakistan and north-western India. In southern Pakistan, young specimens tend to be grey (after preservation), with or without a hood mark. Adult specimens are normally uniformly black above, although most of the ventral surface, excluding the throat, remains light.

The throat and ventral pattern in this species is also quite variable. In most specimens, there is a light throat area followed by one or several dark bands 4-7 ventral scales wide. In adult specimens, there is often a considerable amount of mottling on the throat and on the venter, so that the pattern is much less clear in this species than in some others, such as *Naja kaouthia*. There is usually one pair of lateral spots on the throat at the junction of the ventral and dorsal scales. Except in specimens from the north-west, these spots extend onto the second dorsal scale row. Their position varies, being more anterior in specimens from the north-west and more posterior in specimens from other areas (anterior edge at level of 7th to 12th ventral). In populations with melanistic adults, e.g., in southern Pakistan, the throat pattern is usually obscured by dark pigment.

Naja naja sometimes lacks a clear border between the light throat area and the darker side of the neck, and there is often no dark line separating the two. The first dark ventral band, which forms the posterior end of the light throat area, is very variable in position: the first ventral involved varies from the 10th to the 21st.

Specimens from Sri Lanka are notable for having a large number of dark bands (sometimes up to 20) across the venter. Specimens from other

areas only have 1-4 dark bands. Specimens from many areas may have a strongly mottled or speckled venter. In adult melanistic specimens from the north-western part of the range, the dark dorsal colour encroaches onto the outer fifth on each side of the ventrals, leaving the middle three-fifths light.

Hood mark.- The best known feature of the colour pattern of the Indian binocellate cobra is the spectacled hood mark. When present, this consists of two light ocelli with dark centres, whose posterior edges are linked by a posteriorly-convex light arc. The dark spot inside the ocelli nearly always has a diameter of at least 2 dorsal scale rows (usually less in other species with a spectacle marking). There is usually a conspicuous black border to the hood mark, which may be interrupted in places. The anterior edge of the hood mark is at the level of the 7th - 12th ventral scale, the posterior edge at the level of the 14th-21st ventral scale. The hood mark of the Indian cobra is never linked to the light colour of the throat. However, it is particularly important to note that the hood mark of *N. naja* is frequently absent, and that the presence or absence of this hood mark is not an adequate character for the distinction of this species from any other cobra species.

Scalation.- The scalation of *Naja naja* is very variable, and shows strong geographic variation. Specimens from the north-west of the range have low dorsal scale row counts, whereas specimens from other areas have the highest dorsal scale row counts of any Asiatic cobra species. More details are given in the paragraphs on geographic variation in this species. Table 1 summarises the variation in selected scalation characters in this species.

Dentition.- The longest fang recorded in this study measured 7.33 mm from the distal end of the basal orifice to the tip, and was measured in a male specimen from Bangladesh measuring 1627 mm in total length. The fangs of this species are the longest in relation to head and body size of any of the Asiatic *Naja*. The fangs of this species are not adapted for spitting. Dentition counts are tabulated in Table 2.

DIAGNOSIS

The Indian spectacled cobra is sympatric with two other cobra species: the Central Asian cobra, *Naja oxiana*, occurs sympatrically in the northern half of Pakistan and probably extreme northern India, and the monocellate cobra, *N. kaouthia*, occurs sympatrically in northern India (from Delhi eastward).

The characters that allow *N. naja* to be distinguished from *N. oxiana* in the zone of sympatry are shown in Table 3, and those used to discriminate between *N. naja* and *N. kaouthia* are listed in Table 4.

The distinction between *Naja naja* and *N. oxiana* has often proved problematic, many authors assigning all specimens without a hood

TABLE 1: Scalation of *Naja naja*. Note that there is considerable geographic variation in many scalation characters, and the whole range is unlikely to be encountered in any particular locality.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Ventrals	171 - 197	187.02 ± 4.61	178 - 196	188.90 ± 3.87
Subcaudals	53 - 67	60.09 ± 3.13	50 - 65	57.96 ± 3.21
Cuneates	0 - 4	2.32 ± 0.85	0 - 4	2.36 ± 1.06
Posterior temporals	6 - 10	7.45 ± 1.00	5 - 9	7.18 ± 0.85
Nuchals	5 - 13	8.09 ± 1.31	5 - 10	7.61 ± 1.11
Dorsal rows at 10th ventral	23 - 37	30.19 ± 3.56	23 - 37	30.00 ± 3.64
Dorsals at 20% ventral count	19 - 25	22.12 ± 1.19	19 - 25	21.97 ± 1.37
Dorsals at 40% ventral count	21 - 25	22.38 ± 1.02	20 - 25	22.28 ± 1.30
Dorsals at 60% ventral count	19 - 23	20.71 ± 1.19	17 - 24	20.46 ± 1.65
Dorsals at 80% ventral count	13 - 18	15.36 ± 0.88	15 - 17	15.51 ± 0.85
Dorsals at vent	15 - 18	16.01 ± 1.00	15 - 18	16.23 ± 0.96

TABLE 2: Dentition of *Naja naja*. Maxillary tooth number is variable, specimens from Pakistan and north-western India usually having 0, specimens from elsewhere 1.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Palatine teeth	6-9	6.98 ± 0.51	6-8	6.90 ± 0.39
Pterygoid teeth	12-21	16.88 ± 1.71	13-20	16.71 ± 1.73
Dentary teeth	13-17	14.08 ± 0.56	12-15	13.90 ± 0.55
Solid maxillary teeth	0-1	0.55 ± 0.49	0-1	0.59 ± 0.49

TABLE 3: Distinguishing characters of *Naja naja* and *N. oxiana* in their zone of sympatry in north-western India and Pakistan. Specimens from other parts of the ranges of the two species are easier to distinguish due to additional scalation differences (lack of a cuneate in northern *N. oxiana* populations; 29 or more scale rows around the hood in southern and eastern *N. naja* populations, versus 23-27 in *N. oxiana*). M = males; F = females.

	Naja naja	*Naja oxiana*
Ventral scales	M 184 - 193; F 182 - 196	M 199 - 207; F 191 - 210
Subcaudal scales	M 58 - 67; F 53 - 63	M 66 - 71; F 62 - 70
Solid maxillary teeth	0 (very rarely 1)	1
Juvenile pattern	Speckled or uniform, one or two ventral bands, often hood mark and lateral throat spots	Conspicuously banded, both ventrally and dorsally, along most of body length, no hood mark or lateral throat spots

TABLE 4: Distinguishing characters of *Naja naja* and *N. kaouthia* in northern and north-eastern India. Specimens from other parts of the ranges of the two species may differ with respect to the characters listed.

	Naja naja	*Naja kaouthia*
Hood mark	Spectacle-shaped or absent	Monocellate or mask-shaped, never totally absent
Scale rows at level of 10th ventral	Usually > 29	Usually 29 or fewer
Scale rows at 40% of the ventral scale count	Usually 23	Usually 21
Throat pattern	Often indistinct, lateral spots usually encroach on second dorsal scale row	Usually distinct, lateral spots usually encroach on lowest dorsal scale row only

mark to *N. oxiana*. In particular, it should be noted that the black cobras found in parts of north-western India, Pakistan, south-western Nepal and some other areas are not *N. oxiana*, which is normally some shade of brown, but, to my knowledge, never black.

Distinguishing *Naja kaouthia* and *N. sagittifera* from *N. naja* is usually straightforward due to the difference in hood mark shape and throat pattern, and, in the case of the latter, geographic distribution.

GEOGRAPHIC VARIATION

As mentioned in the description, *Naja naja* exhibits extensive geographic variation in colour pattern and scalation. This pattern variation has led to considerable confusion regarding the affinities of some populations. Specimens without hood marks have been routinely assigned to *N. oxiana* or equivalent taxa by some workers, and other workers have encountered difficulties in interpreting pattern variation in some regions, such as Pakistan (Minton, 1966; Joger, 1984).

The great geographic variation displayed by this species has led to a number of subspecies being described, principally by Deraniyagala (1945; 1960; 1961). These subspecies were all synonymised with *Naja naja* by Wüster and Thorpe (1992a). The reasons for this are summarised in the following paragraphs. For more details and a multivariate analysis of geographic

variation in *N. naja*, see Wüster and Thorpe (1992a).

Deraniyagala (1945) restricted the type locality of *Naja naja* to Sri Lanka, calling the populations of that island *N. n. naja*. He had previously (Deraniyagala, 1939) referred to some Sri Lankan specimens, with further hood markings other than the spectacle, as *Naia naia* col. var. *polyocellata*, but considered this a colour variety rather than a subspecies. However, the name *polyocellata* has subsequently been used as a subspecific name for *N. naja* specimens from Sri Lanka (e.g., Mahendra, 1984). Since Sri Lanka has also been selected as the restricted type locality of *N. naja*, and there has been no suggestion that "*Naja naja polyocellata*" represents a geographically separated population found on the same island, this is clearly self-contradicting.

Deraniyagala (1945) regarded the populations from southern India as different because they have a lower number of dark ventral bands (1-3) than the Sri Lankan specimens (up to 15 or more). He also stated, citing Bogert (1943), that Sri Lankan cobras have fangs adapted for spitting, whereas those from southern India lack this adaptation. On this basis, the southern Indian populations were described as a new subspecies, *Naja n. madrasiensis*. In fact, the Sri Lankan cobras, like all *N. naja* populations, have non-spitting fangs (Wüster and Thorpe, 1992b). Sri Lankan specimens do tend to have a higher number of dark ventral bands than Indian specimens, but there is in fact no major differentiation in the overall phenotype which might warrant the recognition of these forms as taxonomically distinct.

The cobras of north-western India and Pakistan, which Deraniyagala (1960) described as *Naja n. indusi*, were considered distinct from the southern and eastern populations primarily on the basis of the absence of a solid maxillary tooth, as noted by Bogert (1943). Unfortunately, Bogert examined only relatively small samples from northern India and Pakistan. In fact, the number of solid maxillary teeth is variable even within populations of *N. naja*; there are occasional specimens from Pakistan with solid maxillary teeth, and in other parts of India, occasional specimens lack solid maxillary teeth. There is no other indication of phenotypic differentiation between specimens with and without solid maxillary teeth, so that this character cannot be regarded as being of taxonomic importance. The main differences between north-western populations of this species and those from the remainder of the range concern the scalation: the north-western populations have fewer dorsal scale rows around the hood (25-29) and at mid-body (19-21) than those from other regions (29-37 and 23-25, respectively). The pattern of differentiation in the scalation between the north-western and the other populations appears to be clinal rather than categorical, as populations from Maharashtra and Madhya Pradesh are intermediate between the north-western populations and the others. Consequently, the north-western populations should not be recognized as a separate subspecies.

Deraniyagala (1945) also recognized the populations from the Gangetic Plain as a separate subspecies, *Naja n. gangetica*. In his original description, this subspecies was never properly diagnosed from other Indian populations. The populations from the Gangetic Plain are not in any way strongly differentiated from other populations of this species.

Naja naja karachiensis Deraniyagala, 1961 was described on the basis of most adult specimens being black dorsally, without any sign of a hood mark. The young specimens that we have examined often had a spectacled hood mark. The black colour of the adult specimens is an ontogenetic change, superimposed upon the basic colour pattern. Otherwise, these populations are not consistently distinct from other Pakistani/northwest Indian spectacled populations, and therefore do not warrant subspecific recognition.

Finally, Deraniyagala (1961) described the Maharashtra populations as *Naja n. bombaya*, primarily on the basis of the combination of a lack of solid maxillary teeth and cuneate scales. Only a single specimen was examined by that author. Deraniyagala's reasons for conferring subspecific status on these populations are misleading: all the specimens from Maharashtra that I have examined have at least one cuneate on each side, and 6 out of 10 had a solid maxillary tooth. Cuneate scales can occasionally be absent in any of the Asiatic *Naja* species, so that their

absence in one specimen cannot be used to infer a separate taxonomic status. In any case, the description of a new subspecies on the basis of a single specimen is ill-considered, as it ignores the extent of variation within the proposed subspecies.

In conclusion, the subspecies of *Naja naja* erected by Deraniyagala are all invalid, either because the character differences used to define them are insignificant when related to the pattern of variation in the overall phenotype, or because the data on which the description was based were insufficient, or simply wrong. There is no disputing that *N. naja* exhibits considerable geographic variation in many character systems, and that this deserves in-depth study once sufficient material is available. However, the pattern is clearly a complex one, and the description of subspecies on the basis of a few arbitrarily selected characters will do nothing to enhance our understanding of this problem.

NATURAL HISTORY

Much of the published information on the natural history of Asiatic cobras is difficult to interpret due to the past confusion regarding the systematics of these animals. Many authors dealing with the natural history of Asiatic cobras simply referred to them as *Naja naja*, and, in many cases, it is impossible to determine which of the 10 species of the genus now recognised was being referred to. Other authors lumped their experiences of different species into one set of observations on "*Naja naja*", and again, it is often impossible to determine which piece of information refers to which species. For instance, in the case of information provided by Smith (1943) and Wall (1913a, 1921), it is probable that at least some of the information is based on *N. kaouthia*, but it is unfortunately not possible to determine the effect of this.

Habitat.- The spectacled cobra is highly adaptable, and can be found in a variety of habitats, including agricultural areas (particularly rice-growing areas) and even in and around villages and cities. Holes in the dams of rice fields and termite mounds are favourite haunts. It is reported to be more common in open areas than in jungles. In Pakistan, it has been reported to favour damp grasslands (Minton, 1966).

Reproduction.- Twelve to 30 eggs are laid between April and July, probably depending on location (Wall, 1913a; Whitaker, 1978). The female is reported to stay with her eggs until they hatch after about 2 months. Communal nesting is known to occur. In captive hybrids of *Naja naja* and *N. kaouthia*, apparent cooperation in brood care between male and female has been observed (Campbell and Quinn, 1975).

Food.- Adults are reported to eat mostly rats, as well as amphibians and other vertebrates, such as lizards (even monitors have been reported as prey - Wall, 1913a) and snakes, including venomous species such as *Echis carinatus* (Minton, 1966). Eggs are also taken, and cobras will raid chicken coops and eat both eggs and chicks. Juveniles feed mostly on amphibians, as well as other snakes (Whitaker, 1978) and lizards in drier areas.

Behaviour.- Diurnal and crepuscular, but has also been observed active at night. This species is shy, and always attempts to escape if it feels threatened. If cornered, it spreads a hood, raises up to the first third of its total length, and may face the adversary, producing a loud, hollow-sounding, explosive hiss. It generally bites only as a last resort, and many specimens just strike with their mouths closed, "headbutting" their opponent. Many bites result only in minimal symptoms, presumably because little or no venom is injected. Young specimens are reported to be more emphatic in their self-defence than adults. The fangs of this species are not adapted for spitting. Reports of spitting are probably due to confusion with other species.

MEDICAL IMPORTANCE

Naja naja is the most widespread cobra in India and neighbouring countries, and is thought to be an important cause of snakebite in much of its range. Statistics from India are lacking, although it is usually thought to be the most important venomous snake there (e.g., Swaroop and Grab, 1954; Murthy, 1990). In Sri Lanka, it is one of the three species causing the highest snakebite mortality (Sawai et al., 1984; de Silva, 1976,

1981; de Silva and Ranasinghe, 1983). Bites by Sri Lankan specimens have been reported to cause both neurotoxicity and necrosis (Theakston et al., 1989; de Silva, 1990a,b; Warrell, 1995). Detailed studies appear to be lacking from India, but Wall (1913a,b, 1921) also reported a combination of neurotoxicity and local symptoms. In view of the vast geographic range of *N. naja*, a study of venom variation in this species would be of great importance.

Neostigmine and other acetylcholinesterase drugs have been shown to reverse respiratory paralysis caused by the venom of this and other cobra species (Banerjee et al., 1972; Pandey et al., 1979; Sharan, 1982; Watt et al., 1986, 1989), and should be tried on cobra bite victims with neurotoxic symptoms (Warrell, 1990, 1995).

NAJA OXIANA (EICHWALD 1831) - THE CENTRAL ASIAN COBRA

Tomyris oxiana Eichwald, 1831.
Naja tripudians var. *caeca* Boulenger, 1896.
Naja naja oxiana Stejneger, 1907.
Naja oxiana Bogert, 1943.

DISTRIBUTION

Well known from Turkmenia, Uzbekistan, Tadzhikistan, north-eastern Iran, south-eastern and northern Afghanistan, and northern Pakistan (North-West Frontier Province and northern Baluchistan). There are more recent records from several parts of the Pakistani Punjab (Khan, 1977, 1983, 1984, 1986, 1990). In India, Murthy and Sharma (1976) and Murthy, Sharma and Sharma (1979) reported specimens from the Punch Valley, north-west of Jammu, and Mahajan and Agrawal (1976) described a specimen from the Simla Hills, in Himachal Pradesh. Reports from Rajahstan and Gujarat (e.g., Biswas and Sanyal, 1977; Murthy, 1990; Sundersingh, 1960) and other parts of north-western India are probably based on specimens of *Naja naja* which lacked a hood mark. The range of *N. oxiana* is split into two parts by the Hindukush mountains and the deserts of southern Afghanistan, south-eastern Iran and south-western Pakistan (Joger, 1984).

DESCRIPTION

Size.- Most adults measure between 110 and 140 cm in overall length. Specimens longer than 150 cm are rare.

Colour pattern.- The Central Asian cobra exhibits considerable ontogenetic variation in its pattern. Young specimens are strongly banded, both dorsally and ventrally. Anteriorly, the dark and light bands are approximately 3-5 ventrals wide, of equal width, and completely encircle the body. Going back along the body, the bands become narrower, and less clear on the ventral side. The ventral banding disappears altogether in the posterior third of the body. Going back, the dorsal light bands split into double bands, which then split into quadruple bands, and so on. The total number of light bands is approximately 45. Despite the presence of very obvious bands, the general appearance of the young specimens is very faded. The banding fades slowly with increasing size, but is still faintly visible, at least in the anterior part of the body, in young adults (up to 90-100 cm SVL).

The dorsum of large adult specimens is more or less uniform, and of various shades of brown, but not normally black. The scales often have lighter edges than centres. The ventral surface is much lighter (cream-coloured after preservation), with some mottling. The first 2-6 dark ventral bands present in young specimens persist. The first two are generally distinct, the more posterior ones less so. The first of these bands occupies a more anterior position (first ventral involved: 4-10) than in other Asiatic cobras. There are no lateral blotches on the throat. The pattern of *Naja oxiana* is not very variable.

Hood mark.- *Naja oxiana* has no distinct hood mark. The banding seen on the dorsum continues onto the neck.

Scalation.- *Naja oxiana* differs from all other Asiatic cobras by its very high ventral and subcaudal scale counts. Only *N. naja*, and, very occasionally, the monocellate cobra, *N. kaouthia*, may overlap in both ventral and subcaudal scale counts. Specimens from the former Soviet Central Asia and Iran do not generally have any cuneate scales, whereas specimens from east of the Hindukush Mountains generally have one on each side. The total variation in the

TABLE 5: Scalation of *Naja oxiana* from throughout the species' range. Cuneates are generally present in specimens form India, Pakistan and eastern Afghanistan, but absent in specimens from Turkmenia, Uzbekistan, Tadzhikistan, Iran and northern Afghanistan.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Ventrals	193 - 207	198.11 ± 3.36	191 - 210	201.16 ± 4.88
Subcaudals	63 - 71	68.00 ± 1.95	57 - 70	63.25 ± 2.70
Cuneates	0 - 2	0.5 ± 0.86	0 - 4	0.95 ± 1.39
Posterior temporals	6 - 9	7.81 ± 0.85	6 - 10	7.68 ± 1.06
Nuchals	8 - 12	9.57 ± 1.21	7 - 12	9.89 ± 1.15
Dorsals at 10th ventral	23 - 27	24.88 ± 0.86	23 - 26	24.63 ± 0.76
Dorsals at 20% ventral count	19 - 23	21.00 ± 0.89	19 - 21	20.73 ± 0.65
Dorsals at 40% ventral count	21 - 25	21.46 ± 1.03	21 - 23	21.31 ± 0.67
Dorsals at 60% ventral count	19 - 23	20.69 ± 1.01	19 - 22	20.63 ± 0.83
Dorsals at 80% ventral count	15 - 17	15.54 ± 0.86	15 - 17	16.53 0.70
Dorsals at vent	15-18	16.77 ± 0.82	16-17	16.95 ± 0.23

scale counts of this species is summarised in Table 5.

Dentition.- This species has two peculiarities as far as its dentition is concerned: firstly, there is a tendency in many specimens to have two teeth ankylosed to the same socket, giving the appearance of having two rows of teeth on the palatine, pterygoid and dentary bones; secondly, the venom discharge orifice of the fangs is in a much more lateral position than in other Asiatic cobras, where it tends to face directly forward.

The fangs of this species are not adapted for spitting. The longest fang recorded in this study measured 5.62 mm, and originated from a specimen from the Dushanbe area, Tadzhikistan, which measured 1448 mm in total length. The fangs of this species are relatively shorter than those of *Naja naja* and *N. kaouthia*. Dentition counts are given in Table 6.

DIAGNOSIS

The only cobra species which occurs sympatrically with *Naja oxiana* is the Indian spectacled cobra, *N. naja*. The differences between the two taxa are shown in Table 2. *Naja oxiana* can be distinguished from all other Asiatic cobras on the basis of its high ventral and/or subcaudal scale counts. Specimens of the monocellate cobra (*N. kaouthia*) with exceptionally high ventral and subcaudal scale counts may be distinguished from *N. oxiana* by the possession of a hood mark, a distinct throat pattern with lateral spots, and a higher number of dorsal scale rows at the level of the 10th ventral.

NATURAL HISTORY

Habitat.- This species favours drier areas than the other Indian cobra species, being found mainly in arid or semi-arid areas, and in dry mountain situations, up to about 2000 m in Baluchistan. In Pakistan, it is reported to occur in drier areas than

TABLE 6: Dentition of *Naja oxiana*. Note that contrary to some literature statements, exactly one maxillary tooth is present on each side.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Palatine teeth	7 - 10	8.09 ± 0.80	6 - 8	7.29 ± 0.56
Pterygoid teeth	14 - 20	7.52 ± 1.5	15 - 21	17.09 ± 1.55
Dentary teeth	13 - 14	13.69 ± 0.42	12 - 14	13.56 ± 0.55
Maxillary teeth	1	1 ± 0	1	1 ± 0

the sympatric *Naja naja* (Khan, 1977).

Food.- Juveniles eat amphibians and lizards, adults also feed on small mammals.

Behaviour.- Like other cobras, this species is shy and will avoid confrontation if possible. When alarmed or cornered, spreads hood and hisses loudly. *Naja oxiana* does not spit venom.

MEDICAL IMPORTANCE

In India and neighbouring areas, *Naja oxiana* occupies mostly relatively thinly populated regions, and it does not appear to be a very common snake, at least compared to the two other species in other parts of India. No detailed accounts of bites by this species in India or Pakistan have been published to my knowledge.

NAJA KAOUTHIA LESSON 1831 - THE MONOCELLATE COBRA

Naja kaouthia - Lesson in: Ferussac, 1831.

Naja tripudians var. *fasciata* - Boulenger, 1896.

Naja naja naja - Stejneger, 1907.

Naja naja atra - Stejneger, 1907.

Naja tripudians var. *sagittifera* - Wall, 1913a.

Naja tripudians var. *viridis* - Wall, 1913a.

Naja naja sputatrix - Bourret, 1936.

Naja naja kaouthia - Smith, 1943.

Naja kaouthia kaouthia - Deraniyagala, 1960.

Naja naja leucodira (non-Boulenger 1896) - Reid, 1964.

DISTRIBUTION

Northern and eastern India (Gangetic Plain, Bengal, Orissa, Sikkim, Assam; most westerly record is Sonipat, Haryana - Wüster and Thorpe, 1992a; most southerly record is from Orissa - Murthy and Acharjyo, 1987), Bangladesh, Burma, southern China (Sichuan, Guanxi, Yunnan - Zhao, 1990; Zhao and Adler, 1993), Thailand (absent or rare in north and north-east, common elsewhere), northern Malaysia, Cambodia and Vietnam, north to at least Hue; recent records from northern Vietnam (Szyndlar and Nguyen Van Sang, 1996) require confirmation, as confusion with the superficially similar *Naja atra* is possible. *N. kaouthia* is also likely to occur in southern Laos, Bhutan and southern Nepal. A previous report of "*Naja naja kaouthia*" from Nepal (Kramer, 1977) was in fact based on misidentified specimens of *N. naja* (Wüster and Thorpe, 1992a).

DESCRIPTION

Size.- Most adults measure 110-150 cm. Record size is approximately 230 cm.

Colour pattern.- The colour pattern of the monocellate cobra is fairly variable. The ground colour is generally some shade of medium to dark brown or grey-brown, or blackish. Many specimens are uniform, others show some banding. The type of pattern varies geographically. In Bengal and the Gangetic Plain, many specimens are conspicuously banded. The light bands are wide in the anterior part of the body, and become narrower as one goes back along the body, dividing into double, then quadruple bands in the process. In the posterior third to two-thirds of the body, they often become difficult to identify as individual bands, and form a strongly contrasting reticulate pattern instead. The pattern tends to be most strongly contrasting in the posterior portion of the animal, and is illustrated in Whitaker (1978). Specimens from other areas tend to have a less strongly patterned body, and may be uniform except for the hood mark, which is almost always present in this species, although it may be faint.

Hood mark.- The hood mark of this species usually consists of light circle with a dark centre, but may sometimes be mask-shaped, with further dark spots in the light fields of the circle. In some specimens, the hood mark is connected to the light throat area. Occasionally, the hood mark may be "scrambled", making it impossible to assign it to one of the "standard" hood mark shapes, but this is rare in India. See Cox (1991) for photographs of hood mark variation in this species in Thailand.

Most specimens of the monocellate cobra have a very distinct throat pattern. The light throat colour generally extends less far backwards than in sympatric Indian spectacled cobras (*Naja naja*), although there is overlap. There is one pair of small lateral throat spots, which are restricted to the outer edge of the ventrals and the lowest row of dorsal scales. Occasional specimens have more than one pair, some have none.

TABLE 7: Scalation of *Naja kaouthia*. Specimens from the Gangetic Plain tend to have dorsal scale row counts near the lower end of the range indicated here.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Ventrals	170 - 192	180.43 ± 4.67	178 - 197	186.51 ± 4.13
Subcaudals	48 - 61	54.66 ± 2.52	46 - 59	52.20 ± 2.62
Cuneates	1 - 6	3.32 ± 1.12	1 - 6	3.63 ± 1.26
Posterior temporals	4 - 9	6.46 ± 0.97	4 - 9	6.37 ± 1.00
Nuchals	5 - 10	6.70 ± 1.01	5 - 9	7.41 ± 0.91
Dorsals at 10th ventral	26 - 34	29.26 ± 1.62	24 - 33	29.08 ± 1.82
Dorsals at 20% ventral count	19 - 23	21.09 ± 0.72	19 - 23	21.01 ± 0.66
Dorsals at 40% ventral count	19 - 23	21.20 ± 0.79	19 - 23	21.05 ± 0.71
Dorsals at 60% ventral count	17 - 21	19.80 ± 1.03	17 - 21	19.61 ± 1.11
Dorsals at 80% ventral count	14 - 17	15.16 ± 0.57	15 - 17	15.25 ± 0.60
Dorsals at vent	14 - 19	15.85 ± 1.04	15 - 18	15.86 ± 0.97

The ventral coloration is variable in this species. Most specimens have a clearly defined dark band behind the light throat, followed by a light band, followed by another dark band, followed by a mottled light area, which becomes darker posteriorly until the entire ventral surface is dark. The underside of the tail is usually light, but often suffused with dark pigment. The subcaudals often have conspicuous dark edges.

In Thailand, uniformly yellowish or cream-coloured specimens are found in parts of the central plain. These are sometimes referred to as "Suphan cobras" (Cox, 1991), but are variants of no taxonomic significance (Wüster et al., 1995).

Scalation.- The most notable features of the scalation of this species are a tendency to have more than one cuneate scale on each side, unlike the other Asiatic cobra species, and the shape of the frontal scale: in *Naja kaouthia*, this is conspicuously short and square, being almost as broad as, or broader than, long, and much shorter than its distance from the rostral scale. Table 7 summarises the variation found in selected scalation characters in this species.

Dentition.- The largest fang recorded in this study measured 6.78 mm, and was measured in a male specimen from Bengal measuring 1555 mm in total length. The fangs of this species are moderately adapted for spitting in that the venom discharge orifice is shorter than in the non-spitting *Naja naja* and *N. oxiana*, and terminates further from the tip of the fang than in those species (Wüster and Thorpe, 1992b). Variation in tooth counts is summarised in Table 8.

DIAGNOSIS

In India, *Naja kaouthia* occurs sympatrically with *N. naja* in much of northern and north-eastern India. Characters that can distinguish between these two forms are given in Table 4. The shape of the hood mark alone is usually sufficient to distinguish these two forms. *N. kaouthia* is not known to be sympatric with *N. oxiana*, but the higher ventral and subcaudal scale counts of the latter, coupled with the absence of a hood mark

TABLE 8: Dentition of *Naja kaouthia*.

	Males		Females	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Palatine teeth	6 - 9	6.98 ± 0.51	5 - 8	6.86 ± 0.60
Pterygoid teeth	10 - 17	13.01 ± 1.47	10 - 17	13.30 ± 1.49
Dentary teeth	13 - 17	14.00 ± 0.66	13 - 15	13.84 ± 0.45
Solid maxillary teeth	1 - 2	1.04 ± 0.20	0 - 1	0.97 ± 0.18

and lateral throat spots make differentiating between these two species simple.

NATURAL HISTORY

Habitat.- In areas where *Naja kaouthia* occurs sympatrically with other *Naja* species, it generally tends to occupy low-lying, wetter areas than those occupied by other species. This has been observed in the zone of sympatry between *N. kaouthia* and *N. naja* in northern India (Sights, 1949). This species adapts well to human presence, unless persecuted excessively. It is common in rice-growing areas, where it lives in rodent burrows in the dykes between the fields; in some such areas, it has become almost semi-aquatic. Various plantations are another favourite haunt.

Reproduction.- Egg-laying, like all cobras. Egg-laying takes place in January-March (Whitaker, 1978). The female generally stays with the eggs. Some collaboration between male and female in guarding eggs has been reported in *Naja naja* x *N. kaouthia* hybrids (Campbell and Quinn, 1975).

Food.- Juveniles take mostly amphibians, adults also eat small mammals. Snakes and fish are also eaten occasionally.

Behaviour.- Most active at dusk and in the evening, but may also be encountered at other times. Generally rather quieter and less excitable than other cobras, but shows considerable individual variation. Like all cobras, will flee if encountered, and only faces an adversary if cornered. The fangs of this species are somewhat adapted for spitting venom, but spitting is apparently very rare in this species. However, instances of spitting in cobras were recorded by Goring Jones (1900 - Mandalay, Burma), Shaw and Shebbeare (1930 - north-eastern India and Sikkim) and Dickinson (1945 - Sundarbans and Assam). The specimens were not adequately described, but the common cobra species of these areas is *N. kaouthia*. Spitting of some form was also attributed to cobras identifiable as *N. kaouthia* by Duckett (1964), from Malaysia.

MEDICAL IMPORTANCE

Naja kaouthia is an important cause of snakebite mortality and morbidity in much of its range (Reid, 1964; Looareesuwan et al., 1988; Viravan et al., 1986, 1992). Its importance in India relative to that of the spectacled cobra (*N. naja*) is unknown, but Acharji and Mukherjee (1966) considered it a pest in parts of Bengal, and blamed it for many fatal bites. Outside India, bites by this species have been the subject of two in-depth studies by Reid (1964) and Viravan et al. (1986). Symptoms included both neurotoxic effects and necrosis, which was extensive in some cases. Bites by this species in India have not been studied in any detail. Geographic variation in venom composition is possible. A series of bites from northern Malaysia (Reid, 1964) suggested a substantially higher incidence of necrosis and a lower incidence of neurotoxic symptoms than a later study in Thailand (Viravan, 1986); however, the study of Reid (1964) is difficult to evaluate, as some of the snakes involved were *N. sumatrana*.

NAJA SAGITTIFERA WALL, 1913A - ANDAMAN COBRA

Naia tripudians var. *sagittifera* Wall, 1913a.

Naja kaouthia sagittifera - Deraniyagala, 1961.

Naja naja sagittifera - Klemmer, 1963.

Naja naja kaouthia - Whitaker, 1978.

Naja kaouthia - Wüster and Thorpe, 1991.

DISTRIBUTION

Restricted to the Andaman Islands. Recorded with certainty only from South Andaman, but is also likely to occur on North and Middle Andaman, and possibly on other islands in the group.

DESCRIPTION

Size.- Adult size is unknown, as the only few specimens available in scientific collections are juveniles, the longest measuring 635 mm in total length.

Pattern.- The dorsal ground colour of the known juvenile specimens is dark, whereas the ventral side is light. On each side, light lines rising up from the ventral side form a series of irregular, triangular or shark-fin-like outlines on the sides of the animal. The pattern has been described as a series of white A-shaped marks

TABLE 9: Scalation of *Naja sagittifera*.

	Males		Females
	Range	Mean ± S.D.	(one specimen only)
Ventrals	175 - 176	175.40 ± 0.55	183
Subcaudals	60 - 64	62.40 ± 1.82	61
Cuneates	2 - 4	2.80 ± 1.10	2
Posterior temporals	5 - 6	5.20 ± 0.45	4
Nuchals	6 - 7	6.80 ± 0.45	8
Dorsals at 10th ventral	27 - 29	27.60 ± 0.89	27
Dorsals at 20% ventral count	21 - 23	22.00 ± 1.00	21
Dorsals at 40% ventral count	21 - 23	22.60 ± 0.89	21
Dorsals at 60% ventral count	21	21	21
Dorsals at 80% ventral count	15 - 17	16.40 ± 0.89	16
Dorsals at vent	15 - 17	15.40 ± 0.55	15

when seen from the side. The apices of triangles from opposite sides of the body often meet in the middle of the back of the animal; when seen from above, this gives the impression of a series of forward-pointing chevron marks. This pattern may fade in adult specimens.

The known juvenile specimens have a light throat area which extends back to the 10th-13th ventral scale, and one dark spot on each side of the light throat area at the junction between the ventral scales and the lower part of the first dorsal scale row.

The ventral surface behind the first throat band may be uniformly light, or there may be up to 13 dark bands, each a few ventral scales wide, across the ventral surface. Some darker mottling may also be present.

Hood mark.- The hood mark shape of this specimen is based on the monocellate pattern: it consists of a light circle with a dark center, and usually with one or several smaller black mark in the light field of the white ocellus.

TABLE 10: Dentition of *Naja sagittifera*. Both sexes were combined due to the small number of specimens available.

Palatine teeth	6 - 8
Pterygoid teeth	12 - 14
Dentary teeth	13 - 15
Solid maxillary teeth	1

Scalation and dentition.- The variation in scalation and dentition in the few specimens of this species known is summarised in Tables 9 and 10.

NATURAL HISTORY

Largely unknown. Appears to be a rare species. The intestine of one specimen, a juvenile with a total length of 468 mm, contained insects, suggesting that it had probably eaten and mostly digested an anuran.

MEDICAL IMPORTANCE

There are no published reports of envenomations by this species in the Andaman Islands. Nothing is known of its venom.

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