

THE STATUS OF THE COBRAS OF THE GENUS *NAJA LAURENTI*, 1768 (REPTILIA: SERPENTES: ELAPIDAE) ON THE ISLAND OF SULAWESI

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Abstract: The affinities of the only specimen of the genus *Naja* reported from the island of Sulawesi (Indonesia) are analyzed by means of multivariate analysis. The specimen is found to belong to the species *Naja sputatrix*, which was hitherto known from the Indonesian islands of Java, Bali, Lombok, Sumbawa, Komodo, Rinca, Flores, Lombok and Alor. The specimen is indistinguishable from Javan specimens of this species, which leads to the suspicion that it may not in fact originate from Sulawesi. The status of the genus *Naja* on Sulawesi therefore remains uncertain.

Key words: *Naja*; snakes; Indonesia; Sulawesi; systematics; biogeography; multivariate analysis.

Introduction

Until recently, the taxonomy of the Asiatic cobras of the genus *Naja* was highly confused. All populations were considered to be part of a single species, *Naja naja*, 10 subspecies being recognized in most recent checklists (e.g., Harding & Welch, 1980; Golay, 1985; Welch, 1988). Recent revisions of the genus (Wüster, 1990, 1992a,b; Wüster and Thorpe, 1987, 1989, 1990, 1991, 1992a,b, 1994; Wüster et al., 1995), employing multivariate analysis of morphological characters and comparative mitochondrial DNA sequencing, have shown that there are in fact ten full species of *Naja* in Asia. Two of these species, *Naja sputatrix* and *Naja sumatrana*, occur in the Indonesian Archipelago. The former occurs on Java, Bali, Lombok, Sumbawa, Komodo, Rinca, Flores, Lombok and Alor, and the latter on Sumatra, Borneo, Bangka, Belitung, Palawan (Philippines) and the Riau Archipelago, as well as in Peninsular

Malaysia and southern Thailand (Wüster and Thorpe, 1987, 1989, 1991).

One problem unresolved until now is that of the occurrence of the genus on the island of Sulawesi. The first claimed record from the island was that of Ahl (1933), who described *Naja celebensis* on the basis of a single specimen taken on the island by a German expedition. The type specimen was later reexamined by Mertens (1961), who found it to be a melanistic specimen of the mangrove tree snake, *Boiga dendrophila*. The only seemingly reliable record of *Naja* from Sulawesi was the report by Kopstein (1936) of a specimen from Makale, which he assigned to *Naja naja sputatrix*. On the basis of this report, *N.n. sputatrix* has been recorded as occurring on Sulawesi by all later faunal lists (in den Bosch, 1985; Golay, 1985; Harding & Welch, 1980; Welch, 1988), but no further specimens have been collected since then. This lack of further material has led to doubts about the occurrence of the genus on the island (Wüster,

1990; Wüster & Thorpe, 1989).

During a recent visit to Indonesia, the author was able to examine the specimen reported by Kopstein (1936), which is now in the Museum Zoologicum Bogoriense in Bogor (no. 394). In this paper, we investigate the affinities of this specimen by means of multivariate analysis of morphological characters.

Materials and Methods

All preserved specimens of *Naja sputatrix* and *N. sumatrana* available from American and European Museums were examined, and a number of characters relating to scalation, colour pattern, dentition, internal anatomy and body proportions were recorded from each specimen, in order to establish a generalized phenotypic profile for each specimen. In order to standardize dorsal scale row counts at various places along the body, the ventral scales were numbered from

the head according to the Dowling (1951) method, and dorsal scale row counts were taken at 20%, 40%, 60%, 80% and 100% of the total ventral scale row count (%VS length). Similarly, the position of scale row reductions along the tail was expressed in relation to the subcaudal scale count as % caudal scale (%CS) position. See Thorpe (1975) for more details on character definition and recording in snakes. A total of 17 scalation and colour pattern characters were used for multivariate analysis (Table 1).

Data analysis

Two multivariate methods were used for the investigation of the affinities of the

Table 1. Characters used for multivariate analysis

1. Number of ventral scales.
2. Number of subcaudal scales.
3. Percentage of subcaudals undivided.
4. Number of cuneates.
5. Number of posterior temporal scales.
6. Number of temporal and nuchal scales in contact with the parietal scales.
7. Number of dorsal scale rows at the level of the 10th ventral scale.
8. Number of dorsal scale rows at 20% VS length.
9. Number of dorsal scale rows at 40% VS length.
10. Number of dorsal scale rows at 60% VS length.
11. Number of dorsal scale rows at 80% VS length.
12. Number of dorsal scale rows at the level of the last ventral scale.
13. Percentage of tail segments with two scale rows.
14. %CS position of the reduction from 6 to 4 scale rows.
15. %CS position of the reduction from 8 to 6 scale rows.
16. %CS position of the reduction from 10 to 8 scale rows.
17. Number of lateral throat spots.

Table 2. Operational Taxonomic Units of *Naja sumatrana* and *Naja sputatrix*, with their sample sizes (*n*). Male specimens only were used, since the Sulawesi specimen was male.

OTU number	Locality	<i>n</i>
<i>Naja sumatrana</i>		
33.	Peininsular Malaysia and southern Thailand	26
34.	Medan area, northern Sumatra	15
35.	Padang, western Sumatra	6
36.	Kuching area, Sarawak, Borneo	2
37.	Sabah State, Borneo	7
38.	South-eastern Borneo	5
39.	Pulau Bulan, Riau Islands	1
40.	Pulau Penuba, Lingga Islands	1
41.	Pulau Karimon, Riau Islands	1
42.	Bangka Island	1
43.	Belitung Island	1
44.	Lebongtandai, Bengkulu, Sumatra	2
45.	Palembang, Sumatra	1
<i>Naja sputatrix</i>		
46.	West Java	21
47.	Central Java	4
48.	East Java	5
49.	Komodo Island	4
50.	Flores Island	3
51.	Sumbawa Island	2
52.	Makale, Sulawesi	1

Sulawesi specimen. Only male specimens were used, as the Sulawesi specimen is male (contrary to Kopstein, 1936). The first was a canonical variate analysis (CVA) of all male Indonesian specimens of *Naja sputatrix* and *Naja sumatrana*, run using the BMDP 7M program (Dixon, 1985). For this, the specimens were grouped into operational taxonomic units (OTUs) according to geographic origin, and these OTUs were tested for heterogeneity by means of principal components analysis (PCA). The OTUs used in this study, and their sample sizes, are listed in Table 2. In addition, a further PCA (Program by R. G. Davies, with modifications by R. S. Thorpe) was run on all male specimens of *Naja sputatrix* in order to elucidate the relationship of the Sulawesi specimen with the other populations of the species.

Results

The first two canonical variates of the CVA (Fig. 12) show very clearly the separation between *Naja sputatrix* and

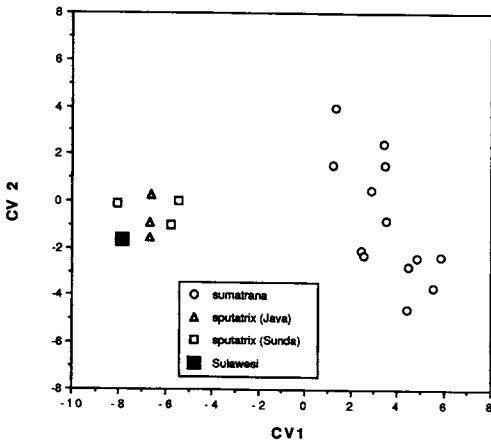


Fig. 1. Ordination of the means of the OTUs of *Naja sputatrix* and *Naja sumatrana* along the first two canonical variates of CVA 1. The axes are graded in units of within-group standard deviation.

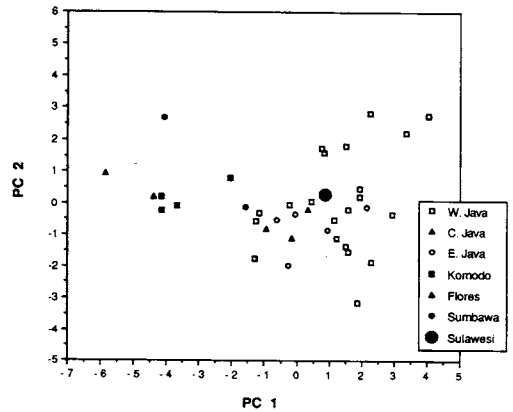


Fig. 2. Origination of the specimens of *Naja sputatrix* along the first principal components of PCA 1. Symbols indicate individual specimens.

Naja sumatrana. Equally clearly, the Sulawesi specimen groups with the *Naja sputatrix* OTUs rather than with the *Naja sumatrana* OTUs. The Mahalanobis D^2 distance matrix shows the Sulawesi specimen to be phenetically especially close to the Javan OTUs (not the populations from the Lesser Sunda Islands). This is confirmed by the PCA (Fig. 2), which shows clearcut geographic variation between the Javan and Lesser Sunda populations, the Sulawesi specimen grouping with the Javan specimens. The Sulawesi specimen is thus morphologically very similar to the Javan specimens.

Discussion

Our analyses have shown that the cobra specimen reported by Kopstein (1936) to originate from Makale, Sulawesi, is clearly referable to the southern Indonesian spitting cobra, *Naja sputatrix*, and is not in any way distinct from Javan specimens. On the other hand, we have found that the specimen is distinct from specimens from Sumbawa, Komodo and Flores. The individual character states for the Sulawesi speci-

mens are within the range of variation of the Javan populations for all characters, but outside the range of variation of the Lesser Sunda Islands specimens.

Two possible conclusions can be reached on the basis of this specimen. The first is that *Naja sputatrix* is indeed found on the island of Sulawesi, and that the local population, at least in the Makale area, is morphologically very similar to the Javan populations. This assumes primarily that the locality record for the specimen is correct, which cannot be taken for granted in any collection.

The second possibility is that the specimen in the Bogor museum is not actually from Sulawesi, but from Java, and received its present label through some error. The fact that this specimen is indistinguishable from the Javan specimens suggests that it may indeed be from Java. While there is no absolute expectation that specimens from different islands must differ in their phenotypic profile, experience with other Asiatic snake species, including the above analysis of the *Naja sputatrix* populations from Java and the Lesser Sunda Islands, indicates that some differentiation can be expected, especially when the animals come from islands which were not linked by landbridges during Pleistocene cold phases. Sulawesi is separated from the Sunda Shelf by water over 200 m deep, indicating that it was not connected to the Asian mainland or Java at any stage during the Pleistocene. Consequently, a *Naja* population on Sulawesi would have had to colonise the island by overwater dispersal. A likely consequence of this would be some differentiation of the island population due to the founder effect. The complete absence of differences between MZB 394 and Javan *Naja sputatrix* does leave the suspicion that the

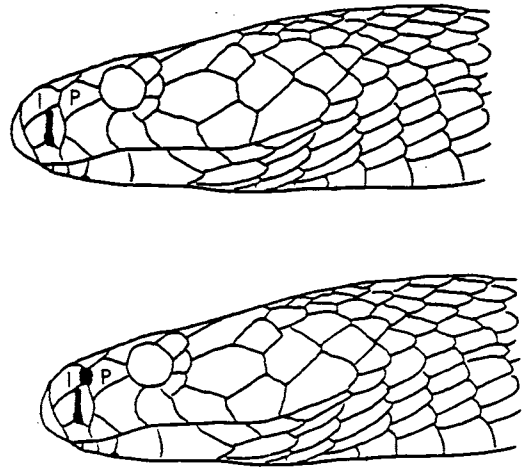


Fig. 3. Head scalation of Asiatic cobras. (Top) Scalation in most Asiatic cobras, showing contact between the preocular and the internasal (Bottom) Situation often found in Javan *Naja sputatrix*: the preocular and the internasal are separated by a small accessory scale (in black). In other specimens, especially on the Lesser Sunda Islands, the prefrontal and the nasal enter into contact, thus separating the preocular from the internasal. Abbreviations: I=Internasal, P=Preocular. Modified from Bogert (1943)

specimen in fact originates from Java.

Kopstein (1936) cited as a difference between MZB 394 and Javan *Naja sputatrix* the fact that in the Sulawesi specimen, the internasal is separated from the preocular by a small accessory scale, whereas in Javan specimens, the two scales are in contact. In fact, this lack of contact, either due to the presence of a small accessory scale, or a prefrontal-nasal contact, is common in *Naja sputatrix*, both from Java and the Lesser Sunda Islands, whereas this condition is exceptional in all other Asiatic *Naja* species (Fig. 3). Of 76 specimens of *Naja sputatrix* examined, 20 (26.3%) had the internasal separated from the prefrontal on at least one side. Interestingly, the nature of the separation shows geophaphic variation:

in most Javan specimens, the separation is due to a small accessory scale as described by Kopstein, whereas in the specimens from the Lesser Sunda Islands, the separation is more commonly due to a contact between the prefrontal and the nasal.

We conclude that the status of the genus *Naja* on Sulawesi remains unresolved. The specimen of *Naja sputatrix* reported to originate from that island by Kopstein (1936) is indistinguishable from Javan specimens, and, while this does not preclude its originating from Sulawesi, it does leave the possibility of a mistake wide open. The occurrence of *Naja sputatrix* on Sulawesi is thus possible, but unproven. Rumours about the existence of cobras on Sulawesi persist (D. Knowles, pers. comm.), but until more specimens with unquestionable locality data are collected, the problem remains unsolved.

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Rijksmuseum van Natuurlijke Historie (Leiden), University of Florida (Gainesville), University Zoological Museum (Copenhagen), Zoologisches Forschungsinstitut und Museum A. Koenig (Bonn), and Zoologisches Museum Hamburg.

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要 約

スラウェシ島のコブラの位置づけ

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スラウェシ島産として知られるコブラ属 (*Naja*) 唯一の標本と、他の地域の標本との近縁性を多変量解析で分析した。この標本自体は、インドネシアのジャワ、バリ、ロンボク、スンバワ、コモド、リンカ、フロレス、ロンブレン、アロールに分布する、ジャワドクフキコブラ (*Naja sputatrix*) であり、特にジャワ産の標本とは区別できない。したがって、スラウェシの標本が本当にスラウェシでとれたものかどうかにも疑問が残り、スラウェシのコブラの位置づけは、まだはっきりしない。

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