A Century of Confusion: Asiatic Cobras Revisited

by
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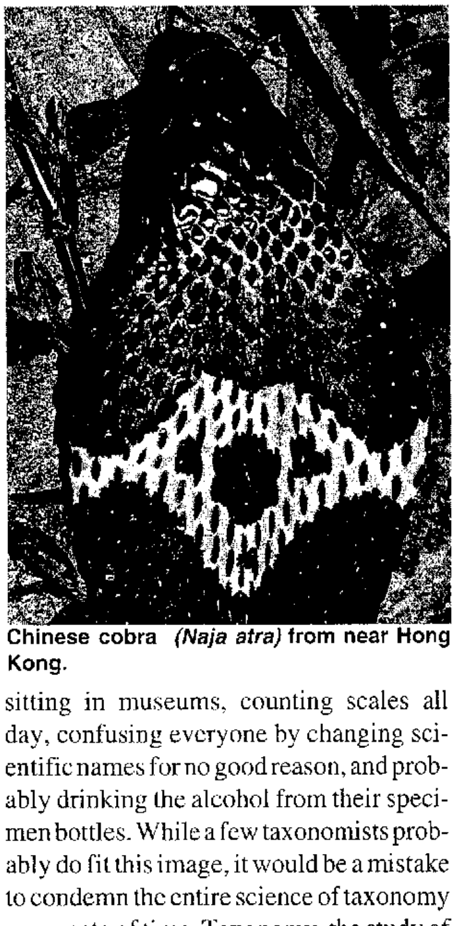
Herpetoculturists often question the value and importance of taxonomic work done by museum herpetologists. In this paper a systematic herpetologist demonstrates how such work may not only enhance captive breeding programs, but also save lives.

The popular image of a cobra rearing out of a wicker basket, hood spread, revealing the spectacle marking on its neck and "dancing" to the music of a turban-wearing Indian snake charmer has made Asiatic cobras the most widely recognized snakes in the world. The fact that cobras are among the most venomous of all snakes, and are responsible for a good proportion of Asia's exceedingly high snakebite mortality, has further contributed to their notoriety.

Considering how well-known these highly impressive animals are, one would expect their basic systematics, meaning the nature and distribution of the species involved, to be thoroughly studied and understood. Until now, nothing could have been further from the truth. Since science first became aware of the diversity of cobra "forms" inhabiting the various parts of Asia, the problems posed by the classification of these snakes have elicited expressions of bewilderment from generations of herpetologists, from Boulenger (1896) to Golay (1985). All populations of Asiatic cobra are traditionally lumped within a single species, *Naja naja,* with ten subspecies recognized by most recent authorities. However, there is no agreement on subspecies definitions, and no one has felt able to produce a key to these subspecies.

Many herpetologists not involved in the study of taxonomy profess disdain for taxonomists and systematists, who are often regarded as rather pompous individuals, sitting in museums, counting scales all day, confusing everyone by changing scientific names for no good reason, and probably drinking the alcohol from their specimen bottles. While a few taxonomists probably do fit this image, it would be a mistake to condemn the entire science of taxonomy as a waste of time. Taxonomy, the study of biological diversity, provides the basis for all other biological research by answering this simple, but fundamental, question: "What's what?" All further research on any aspect of a group of animals, including captive breeding and conservation, depends ultimately on sound taxonomic information being available and applied.



Chinese cobra *(Naja atra)* from near Hong Kong.

Photographs by Wolfgang Wüster.

Because of the snakebite problem, the systematics of dangerously venomous snakes are of applied as well as academic interest. Venom composition may differ between snake species or populations. Consequently, an antivenin against one "form" may not be effective in the treatment of bites by another. Understanding the systematics of venomous snakes therefore becomes a priority when devising treatment strategies for venomous snakebite. A lack of understanding of the systematics of a group of venomous snakes can lead to the inadvertent use of ineffective antivenins. In some cases, such as the carpet vipers (*Echis*), this has led to greatly increased fatality rates.

Our research team at Aberdeen University launched a research program into venomous snake systematics because of the medical importance of such a study. The Asiatic cobra complex was identified as an ideal trailblazing project, because these snakes are of undoubted medical importance, their taxonomy was widely acknowledged to be unsatisfactory, and they are common enough to be well represented in museum collections. The Asiatic cobras therefore became the pioneer project for our venomous snake research program, which has since expanded to cover many other venomous snake groups.

The approach used modern statistical methods to analyze morphological characters (scalation, color pattern, position of internal organs, body proportions, dentition) recorded from preserved museum specimens. In old-fashioned taxonomic practice, workers would separately analyze each character recorded from their specimens, and problems would occur if different characters told different stories, which is of course very common. In those cases, entirely arbitrary decisions had to be made as to which characters were to be regarded as reliable. Modern, computerized, multivariate statistical analysis can analyze large numbers of characters simultaneously, and reveal the pattern of variation in the overall morphology of the animals. Results obtained by this method are naturally much more reliable than the outdated approach of looking at a few arbitrarily chosen characters.

This strategy also has several advantages over the currently much more fashionable molecular techniques. By making use of the museum specimens collected over the last two centuries, which often have not been looked at by anyone since they were collected, the multivariate approach avoids the need to kill or traumatize large numbers of living specimens for the purposes of obtaining tissue or blood samples. This allows the inclusion of specimens of rare, endangered, or extinct taxa, which would be difficult or impossible to obtain alive for tissue sampling. It is also much cheaper and faster to do than molecular systematics (although in the bizarre world of academic finance, this can in fact be a disadvantage).

In our Asiatic cobra project, this mixed approach was extremely successful, and totally revised our understanding of the population systematics of these snakes. Far from consisting of a single species, the Asiatic cobra complex comprises at least *nine full species* (Wüster and Thorpe, 1989, 1990, 1991, 1992):

Naja naja - Indian spectacled cobra. Distribution: India, Sri Lanka, Pakistan, Nepal, Bangladesh.

"Because of the differences in venom composition, the bites of different Asiatic cobra species result in very different symptoms in humans."

Naja oxiana - Central Asian cobra. Distribution: (Turkmenia, Uzbekistan, Tadzhiki-stan), Iran, Afghanistan, Pakistan, N. India.

Naja kaouthia - Monocled cobra. Distribution: north-eastern India, Bangladesh, Burma, Thailand, Cambodia, Laos, southern Vietnam, northern Malaysia, China (Yunnan), the Andaman Islands, Nepal.

Naja atra - Chinese cobra. Distribution: southern China, northern Vietnam, Laos.

Naja* cf. *atra - Indochinese spitting cobra. Distribution: Thailand, Cambodia, southern and western Laos, southern Vietnam*.

Naja sumatrana - Equatorial spitting cobra. Distribution: extreme southern Thailand, Malaysia, Indonesia (Sumatra, Borneo, Bangka, Belitung and the Riau Islands) and the Philippines (Palawan and Calamianes group).

Naja sputatrix - Southern Indonesian spitting cobra. Distribution: southern Indonesia (Java, Bali, Lombok, Sumbawa, Komodo, Flores, Lomblen, Alor)

Naja philippinensis - Northern Philippine cobra. Distribution: northern Philippines (Luzon, Mindoro, Marinduque, Masbate, possibly also on the Calamianes and/or on Palawan).

Naja samarensis - South-eastern Philippine cobra. Distribution: southern and eastern Philippines (Mindanao, Samar, Leyte, Bohol and Camiguin).

(* Provisionally regarded as conspecific with *N. atra* by Wüster and Thorpe (1991) on the basis of morphological data, but recently revealed major differences in DNA sequence suggest it is a different species. The status of this form is still under study.)

The degree to which the population systematics of this group had until now been misunderstood is little short of stunning. The conventional subspecies of *Naja naja* were largely unrepresentative of these nine species. Some turned out to be insignificant color variations, others consisted of populations of more than one species. For instance, *Naja naja sputatrix* included not only the populations I recognize as *Naja sputatrix*, but also some (but not all!) populations here assigned to *Naja sumatrana*.

In many parts of southeastern Asia, where only a single subspecies of *Naja naja* had been recognized, there are in fact two sympatric cobra species. In some cases, such sympatric species are strikingly different at first sight. Figure 1 and 2 shows specimens of the monocellate cobra (*N. kaouthia*) and the Indochinese spitting cobra (*N. cf. atra*) from western central Thailand. The differences in color pattern could not be more obvious, and they are matched by differences in scalation. Differences in behavior and ecology are just as striking: the monocellate cobra is a large (often 150 cm or more), generally very placid snake, which never, or only very exceptionally, spits, and occurs mainly in very wet, low-lying, irrigated rice fields; on the other hand, the Indochinese spitting cobra is a smaller (90-120 cm), highly-strung cobra, which will rarely miss an opportunity to cover an adversary with venom, and occurs primarily in slightly higher, drier areas. Thai farmers and snake catchers are of course well aware of the differences between these species. Indochinese spitting cobras are handled with some caution, while monocled cobras are often handled like pet corn snakes. The occasional irritable specimen only seems to add to the fun. My use of a grabstick to manipulate these snakes was generally regarded as rather unsporting by the Thais. In comparison, Thai snake catchers manipulating Russell's vipers in my presence usually asked to borrow my grabstick. Despite these very obvious differences, the presence of two different cobra species in much of Thailand had been missed by a number of eminent herpetologists working in Thailand, including Malcolm Smith (1943) and Edward H. Taylor (1965).

However, any reader contemplating free-handling a *Naja kaouthia* should remember that risk assessment includes (1) the probability of things going wrong, and (2) the price one has to pay for getting it wrong. While the probability of getting bitten while free-handling an adult monocellate cobra is quite low, the price could be an unpleasant death, or the loss of an appendage.

Although the two species in western central Thailand are easily distinguishable, superficial resemblance alone tends to be a very poor guide to relationships of Asiatic cobras. Figure 3 shows some of the color pattern variation found in the three cobra species from Thailand and Malaysia, and demonstrates the extent to which specimens of different species can look much more alike than specimens of the same species.

Before this study, venom researchers had already noticed marked differences between the venoms of different Asiatic cobra "forms". However, no sound systematic framework existed to make sense of the venom results. In fact, the research into snakebite symptoms and venom composition was hampered by the lack of an understanding of the systematics of these snakes.

Because of the differences in venom composition, the bites of different Asiatic cobra species result in very different symptoms in humans. There is a widespread belief among herpetologists that all cobras cause primarily neurotoxic bites, with symptoms such as drooping eyelids, speech difficulties, and respiratory paralysis. However, for some Asiatic cobra species neurotoxic symptoms are very rare, whereas severe tissue damage, usually thought to be characteristic of viper bites, is a common problem.

In a mixed series of *N. kaouthia* and *N. sumatrana* bites reported from northwestern Malaysia (Reid, 1964 - unfortunately, it is not possible, from the information

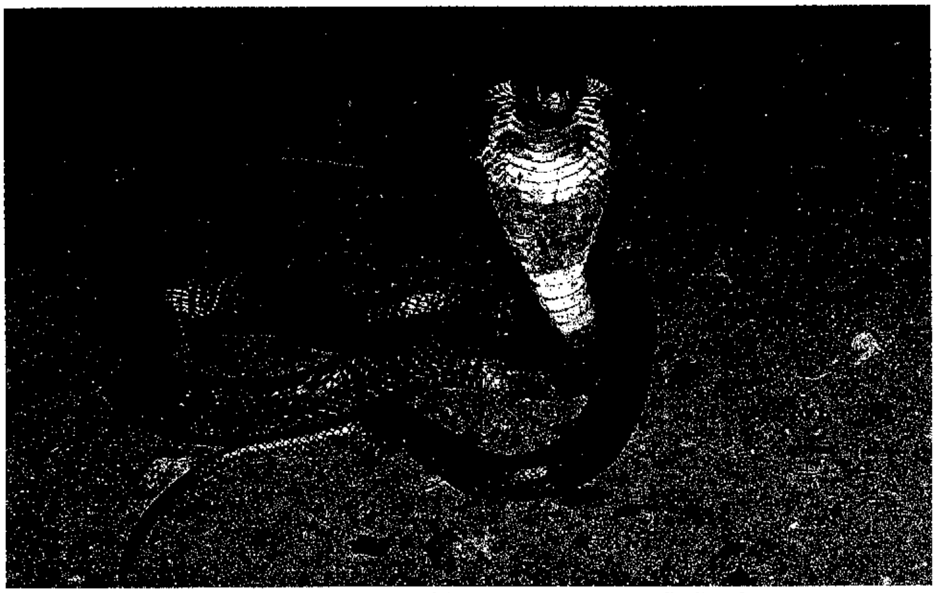


Fig 1. An Monocellate cobra (*Naja kaouthia*) from western central Thailand.

given in that paper, to separate the bites by species), only 12% of the victims developed neurotoxic symptoms; on the other hand, 44% of the victims developed local tissue destruction (necrosis), generally believed to be characteristic of viper bites; many patients did not develop any significant symptoms. In complete contrast, in a recent series of *N. philippinensis* bites in the Philippines (Watt et al., 1988), no fewer than 97% of patients developed neurotoxic symptoms, often with frightening rapidity, whereas necrosis was exceptional, occurring in only 7% of patients. Clearly, this variation in bite symptoms between the various species is of great importance for the treatment of human cobra bite victims.

These enormous differences in venom composition affect the usefulness of the antivenins produced to treat cobra bites in humans. Antivenins are produced by injecting snake venom into horses, which react by producing antibodies that give them immunity against the venom. The antibodies are then extracted from blood samples taken from the horse, purified, bottled, and used as antivenin. The problem is that if the venom of the snake that bit a human patient is very different from the venom used for antivenin production, then the antivenin will not neutralize the venom of the offending snake, and the treatment will be useless. It is therefore essential to know how the venoms of the various cobra species differ.

There are two possible ways of circumventing problems caused by sympatric species with different venoms. One is the production of a polyvalent antivenin, which is effective against all local species. The other is the use of ELISA test kits, which can detect and identify the offending snake from venom traces at the bite site or in the patient's urine, allowing the correct monovalent antivenin to be used. These test kits are necessary for the identification of the offending species, because snakebite patients and the medial practitioners dealing with them are usually unable to correctly identify the various venomous snakes occurring in their area. However, these test kits are only as good as the manufacturer's knowledge of the systematics of the snakes involved: the production of test kits which can distinguish the venoms of two closely related species requires that the manufacturer is aware of the existence of the two species. Here again, understanding the systematics of the snakes involved is essential for further progress.

Understanding the systematics of dangerously venomous snakes is an absolute prerequisite for the effective treatment of their bites. Polyvalent antivenins need to be produced and distributed so as to cover all the cobra species occurring in the relevant area.

One point to bear in mind is that cobras are by no means the only venomous snakes with a confused taxonomy, and a complex pattern of variation in venom composition. Many venomous snake groups have never been comprehensively reviewed. Other genera of venomous snakes are known to pose serious problems with regard to antivenin compatibility (e.g., the carpet vipers, *Echis* spp.), and furthermore, significant venom variation can occur even within some species, such as Russell's viper (Warrell, 1989; Wüster et al., 1992a,b) or the Neotropical rattlesnake (*Crotalus durissus*).

This has serious consequences for the herpetoculturist. Anyone planning to keep or breed dangerously venomous snakes should investigate the literature on the systematics and venoms of their animals. They need to be sure which species they are actually about to acquire, and they need to make sure that they are buying the correct antivenin. For instance, buying Iranian antivenin for a Nigerian *Echis*, or Thai *N. kaouthia* antivenin for *N. sumatrana*, could quite literally be a fatal mistake. In the case of widespread species, such as Russell's viper, it is always preferable to buy an antivenin produced as near to the snake's origin as possible. If you are about to acquire Thai Russell's vipers, you should

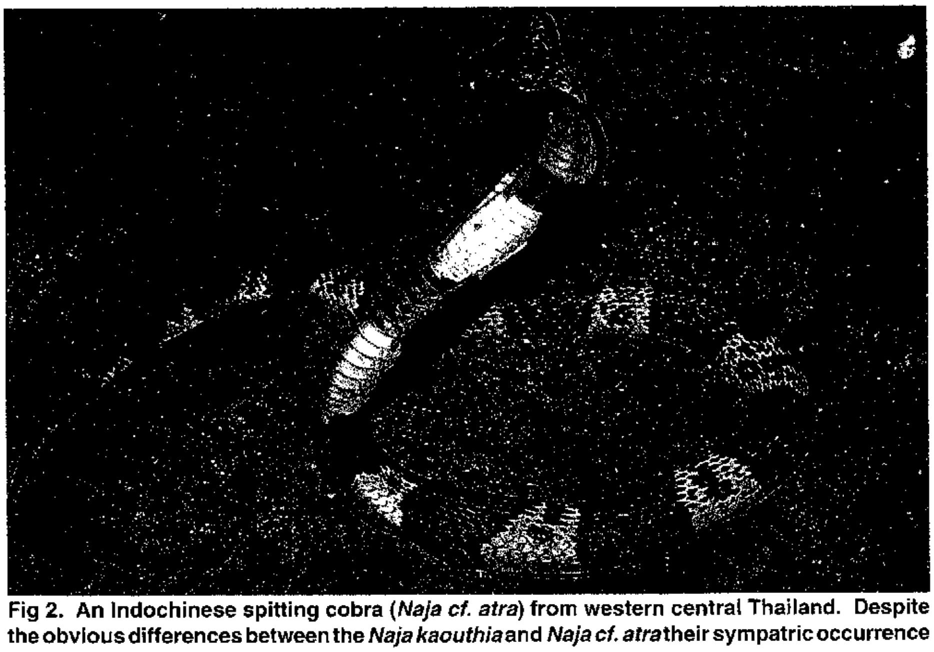
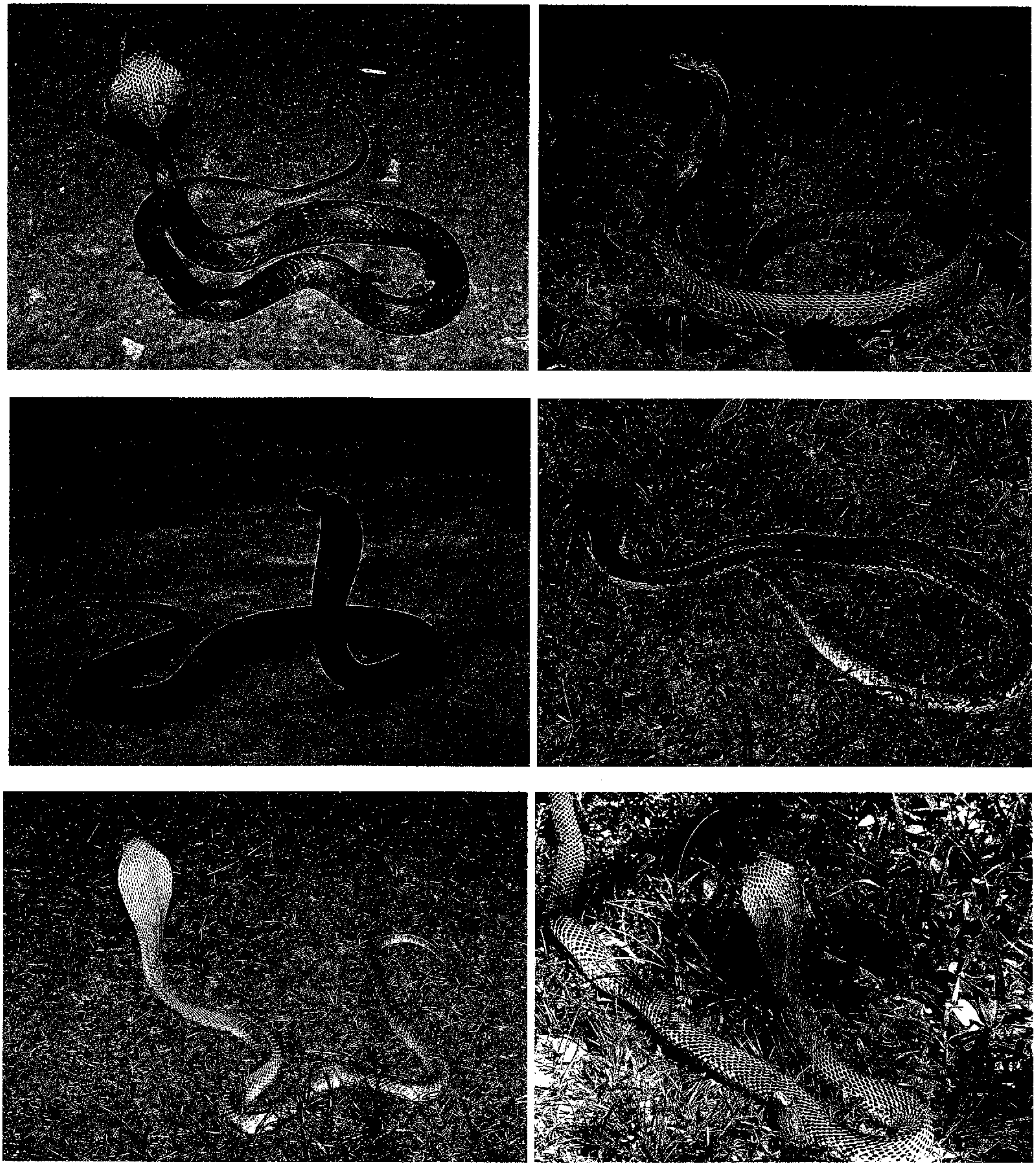


Fig 2. An Indochinese spitting cobra (*Naja cf. atra*) from western central Thailand. Despite the obvious differences between the *Naja kaouthia* and *Naja cf. atra* their sympatric occurrence in central Thailand had so far been overlooked.

Which is which? Your life may depend on it.

Fig 3. These six photographs show two color morphs of each of the three cobra species occurring in Thailand (*Naja kaouthia, Naja sumatrana* and *Naj atra*). This shows how superficial resemblance can be a very poor guide to taxonomic affinities. Can you guess which is which? Answers below.



Solution. Top left: Monocellate cobra *(Naja kaouthia)* normal color morph. Top right: Indochinese spitting cobra *(Naja* cf. *atra)* brown color morph. Cen left: Equatorial spitting cobra *(Naja sumatrana)* black color morph (Photo courtesy Francis Lim). Center right: Indochinese spitting cobra, black-and-wh color morph. Bottom left: Monocellate cobra, cream-colored morph. Bottom right: Equatorial spitting cobra, golden morph.)

also buy Thai Russell's viper antivenin, and not Indian or Taiwanese antivenin.

Of course, the relevance of taxonomic studies such as this is not restricted to snakebite and venom research. Correct taxonomic information is essential for all fields of biological research, pure or applied. It is required by herpetoculturists who wish to develop breeding programs to raise genetically pure wild-type populations, rather than artificial, biologically and scientifically worthless hybrids, albinos or other designer forms.

Most of all, sound systematic information is needed for the conservation of what is left of the Earth's biodiversity, the main aim of current conservation strategy. The relevance of taxonomic research can be summed up by stating that if we are to make coherent efforts to preserve the diversity of animal and plant life, we need to be aware of it in the first place. The case of the Asiatic cobras illustrates one potential disastrous consequence of insufficient systematic understanding: until now, all these cobras were thought to belong to one single species, so that if these animals were under severe threat of extinction in one part of their range, this would not necessarily ring many alarm bells, since there are plenty of cobras left in other areas. However, if there are nine different species, some with very restricted ranges, relatively localized threats could wipe out endemic species for good. In a hypothetical scenario, if cobras throughout the Philippines were to be exploited to the edge of extinction, we now know that we would lose two endemic species, *N. samarensis* and *N. philippinensis*, and we could therefore make the appropriate efforts to prevent their extinction. *Wolfgang Wüster, Ph.D., Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, Scotland, U.K.*

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