

THE KING COBRA, *OPHIOPHAGUS HANNAH* (CANTOR) IN SINGAPORE (REPTILIA: SQUAMATA: ELAPIDAE)

Kelvin K. P. Lim^{1*}, Tzi Ming Leong¹ and Francis L. K. Lim²

¹Raffles Museum of Biodiversity Research, Department of Biological Sciences
National University of Singapore, S6 Science Drive 2, #03-01
Singapore 117600, Republic of Singapore

²305 Yishun Central, #05-167, Singapore 760305, Republic of Singapore

(*Corresponding author: dbslimkp@nus.edu.sg)

INTRODUCTION

The king cobra or hamadryad, *Ophiophagus hannah* (Cantor), is a distinctive snake. The adult is brown or olive above with scales dark-edged especially on tail and posterior body with traces of whitish crossbars (Tweedie, 1983: 116, 117; Das, 2006: 64). The throat is orange-yellow with irregular blackish markings, and the belly greyish-brown. The young, at least up to about 60 cm TL (total length), is dark-brown or black above with many white or yellow crossbars that are narrow and chevron-shaped with forward-pointing apices. The head is black above with four white cross-bars. The head and body are white below, with the ventrals and subcaudals bordered with black. The dorsal scales are in 15 rows. There are seven upper labial scales, with the third and fourth upper labials in contact with the eye, and the third upper labial touching the posterior nasal. A pair of large and diagnostic occipital shields are found behind the parietals, with the occipital shields in contact with each other at the mid-line. The underside has 215–264 ventral scales, with the anal shield entire. There are 80–125 subcaudal scales, with the anterior subcaudals single and posterior subcaudals paired. In the field, the king cobra is easily confused with the keeled rat snake (*Ptyas carinata*), but its larger head, smaller eyes, its pair of large occipital shields, and, when harassed, its habit of rearing up the anterior one-third of the body with neck flattened dorso-ventrally, are unmistakable.

With a recorded maximum total length of 5.85 m, the king cobra is the world's longest venomous snake. However, most large individuals are between 3–4.5 m long (Tweedie, 1983: 117; Cox et al., 1998: 25). The London Zoo had one in its collection from Negeri Sembilan (Peninsular Malaysia) that grew to 5.71 m TL, when it had to be put down at the outbreak of war in 1939, to avoid it escaping (Carwardine, 2007: 166). Perhaps in relation to its large size, the king cobra is equipped with large venom glands, and a very potent neurotoxin. A bite from this snake may prove fatal within a half-hour, and even elephants have been known to die soon after being bitten by a king cobra. Death results largely from respiratory arrest and cardiac failure (Lim & Lee, 1989: 92; Cox et al., 1998: 25).



Fig. 1. Juvenile king cobra of about 60 cm TL from the Singapore Zoo compound in Jun.1982. (Photograph by: Francis L. K. Lim).

The king cobra is widespread throughout South and Southeast Asia. It is recorded from Pakistan, Bhutan, Nepal, India (including the Andaman Islands), Bangladesh, Myanmar, southern China (including Hong Kong and Hainan), Vietnam, Cambodia, Laos, Thailand, Peninsular Malaysia, Singapore, Borneo (Sarawak, Sabah, Brunei, and Kalimantan), Sumatra (including Simeulue, Nias, Banka, Belitung, and Riau Islands), Java, Bali, Sulawesi, and the Philippines (Dinagat, Luzon, Mindanao, Mindoro, Negros, Jolo, Palawan, and Balabac Islands) (Iskandar & Colijn, 2002: 123).

Records of the king cobra from Pakistan seem doubtful, and the population in the Western Ghats of India appears to be isolated (Vogel, 2006: 49). Although only *Ophiophagus hannah* is presently recognised, there is considerable geographic variation among populations and systematic studies have suggested that a complex of several species is involved (Das, 2006: 64; Vogel, 2006: 8, 50–51).

In this article, we collate records of the king cobra in Singapore known to us, and compare these with what is presently known about this snake in the literature.

PAST AND PRESENT RECORDS

The following list of king cobra records in Singapore is presented in chronological order. The symbol: ● refers to records based on verbal reports and/or literature only. The symbol: ★ refers to records supported by photographs and/or specimens. Specimens preserved and deposited at the Zoological Reference Collection (ZRC), Raffles Museum of Biodiversity Research (RMBR), Department of Biological Sciences, National University of Singapore are indicated by accession numbers with a 'ZRC' prefix.

Ophiophagus hannah has been recorded from Singapore since 1847 (Cantor, 1847: 218 as *Hamadryas ophiophagus* Cantor; de Rooij, 1917: 250 as *Naja bungarus* Schlegel), where it was said to be 'not common' (Sworder, 1923: 72, as *Naja hannah*).

- Sembawang, vicinity of Naval Base: two individuals obtained in 1929. One was 8 ft 6 in (ca. 2.6 m), the other was 10 ft (ca. 3 m). One of them was sent to the zoo at Regents Park in London [London Zoo] (Buddle, 1929: 15–16, as *Naja bungarus*).
- ★ Bras Brasah Road, compound of Malay Volunteer Drill Hall: one adult of about 2.6 m TL collected on 31 Jan.1935 (ZRC 2.3209).
- ★ Sime Road, Sime Road Camp: one female of 8 ft 5 in (ca. 2.5 m) TL collected on 24 Nov.1947 (ZRC 2.3257 — head only).
- ★ Upper Thomson, Island Golf Course: one of 4.77 m TL and weighing 12 kg taken on 10 Jul.1950 (ZRC 2.3210; Tweedie, 1954: 117 as *Naja hannah*; Tweedie, 1983: 118, year cited as 1951).
- ★ Kampung Bahru, Kampung Bahru market: one of 3.64 m TL shot dead on the roof of the market by policeman on 7 Apr.1972, collected by M. Krishna (ZRC 2.3211).

In the early 1970's, the king cobra's presence in Singapore was acknowledged by Chuang (1973: 4 as *Naja hannah*) and Sharma (1973: 234 as *Naja hannah*).

- ★ Mandai Lake Road, compound of Singapore Zoo: one juvenile of about 61 cm TL obtained by F. L. K. Lim on 6 Jun.1980 (ZRC 2. 2301; photographs of this individual appear in Lim & Lee [1989: 92] and Lim & Lim [1992: 85]).
- Mandai Lake Road, compound of Singapore Zoo: one juvenile (length not recorded) obtained on 10 Jun.1980.
- Mandai Lake Road, compound of Singapore Zoo: one juvenile of 60 cm TL obtained on 17.Jul 1980.
- ★ Mandai Lake Road, compound of Singapore Zoo: one juvenile of about 60 cm TL obtained in Jun.1982 (Fig. 1).
- Sungei Buloh Wetland Reserve: one of 5 m TL caught at 'Sungei Buloh, off Lim Chu Kang' by Edlyn Choo and Mohamed bin Tang on 22 Jan.1985, and donated to the Singapore Zoo the next day (Anonymous, 1985).
- ★ Pulau Tekong: one juvenile of about 60 cm TL collected by R. C. H. Teo in 1987 (ZRC 2.2509; Teo & Rajathurai, 1997: 385).



Fig. 2. 'Ranger', a male king cobra of 3.6 m TL found on 10 Mar.2000 at the end of Rifle Range Road, was kept on live display at the Singapore Zoo for almost nine years. (Photograph by: Francis L. K. Lim).

- Nee Soon swamp-forest: one of unrecorded length observed between 1987 and 1997 (Teo & Rajathurai, 1997: 377, 385).
- MacRitchie forest, Lornie Track: one of about 4 m TL lying across jogging track on 16 Feb.1992 identified by Roger Sandilands (pers. comm. to Clive Briffett) who nearly stepped on the snake. The snake had a fairly thick body and was a dark green-brown colour. It disappeared into the forest shortly after (Lim & Subharaj, 1992: 8; Teo & Rajathurai, 1997: 377, 385).
- Sime forest, Island Club area, Bukit Kalang Service Road: one juvenile of about 60 cm TL observed by R. Subaraj on 22 Jul.1994 (Subaraj, Lim & Teo, 1995: 3; Teo & Rajathurai, 1997: 377, 385).
- Mandai Lake Road, compound of Singapore Zoo: one of 3 m TL obtained on 14 Jan.1996.
- MacRitchie Reservoir, north-western corner, Golf Link: one example, estimated at 5 m TL sighted by Abdir & Oh (NParks rangers) on 15 Nov.1996 at 2 pm (Teo & Rajathurai, 1997: 377, 385).
- Mandai Lake Road, compound of Singapore Zoo: male of 1.5 m TL found in the act of swallowing a gold-ringed cat-snake, *Boiga dendrophila* on 4 Jul.1998. This individual was taken into captivity where it died on 16 Jun 1999.
- ★ Rifle Range Road, military installation at the end within Central Catchment Nature Reserve: male of 3.6 m TL found on 10 Mar.2000 at 11 am, coiled in a drain behind a building next to dipterocarp forest. Caught by F. L. K. Lim at around 2 pm and then taken to the Singapore Zoo, the snake had offered no resistance during capture, and had remained still and coiled up in the cloth bag. Apart from a number of ticks on the body, the snake was in good health. Weighing in at a hefty 8 kg, the posterior one-third of his body was noticeably distended, and radiographs revealed partially digested remains of a monitor lizard (*Varanus* sp.) in the gut. These remains were defecated on the sixth day after capture. Named 'Ranger' (Fig. 2), this individual was quarantined for one month and then placed on display at the zoo with two other adult king cobras without problems. Ranger lived at the zoo for almost nine years. It died on 18 Feb.2009 measuring 4.13 m TL and weighing 5.2 kg, at an estimated age of 20 years.
- Bukit Panjang, Segar Road (adjacent to Bukit Timah Nature Reserve): a juvenile of about 60 cm TL (Fig. 3) found crossing a grass path on 30 Mar.2000, was caught by workers and donated to the Singapore Zoo, where it subsequently died on 9 May 2000.
- Bukit Panjang, opposite Bukit Panjang Plaza: one of 2 m TL found in a storm water drain in the day on 1 Nov.2000. It was removed and taken to the Singapore Zoo, where it died on 30 Nov 2000.



Fig. 3. Juvenile king cobra of about 60 cm TL from Bukit Panjang in 30 Mar.2000. (Photograph by: Francis L. K. Lim).

- Sungei Buloh Wetland Reserve: one (length not recorded) observed at Tower Hide Loop by S. M. A. Rashid in 2001 (Nick Baker, pers. comm.).
- ★ Upper Thomson, Singapore Island Country Club: one male of 4.42 m TL found beaten to death on 1 Jun.2002, was donated by Alvin Seah to the RMBR (ZRC 2.5442). During the arduous preservation process, both pairs of its hemipenes were completely everted to their full extents by T. M. Leong.
- Kranji, Kranji Nature Trail: one (length not recorded) sighted by workmen in early 2003 reported to Nick Baker (pers. comm.).
- Mandai Lake Road, compound of Singapore Zoo: one female (length not recorded) obtained on 1 Feb.2004.
- Mandai Lake Road, compound of Singapore Zoo: one female (length not recorded) obtained on 12 Feb.2004.
- ★ Adelphi Park, off Upper Thomson Road, Marigold Drive at edge of MacRitchie forest: one juvenile, about 60 cm TL observed along garden fence on 17 Aug.2004 by Ho Hua Chew. A photograph of this individual appears in Baker & Lim (2008: 118).
- Kranji, BBC Far Eastern Relay Station near Kranji Reservoir: one of about 2 m TL observed in Jan.2004 reported by a maintenance worker to Nick Baker (pers. comm.).
- ★ Kranji, National Service Resort & Country Club golf course: one subadult of about 1.5 m TL observed moving across green in the morning of 8 Apr.2005, and killed thereafter, reported with photographic evidence by a Mr. Rodney to Navjot Sodhi (pers. comm.).
- Locality unknown: one wild-caught female (length not recorded) was donated to the Singapore Zoo by the Police on 21 Feb.2006 was fitted with a micro-chip (transponder ID: 00-0665-96CC) and released to the wild on 5 Apr.2006.
- ★ Pulau Tekong, along Tekong Highway, somewhere in the middle section: a juvenile roadkill of about 53 cm TL found on 27 Jun.2006 by Norman Lim & Andrew Tay (ZRC 2.6201).
- ★ Pulau Tekong, along Tekong Highway near oil palm plantation: a juvenile roadkill of about 60 cm TL found dried and stuck to road on 14 Aug.2006 by Norman Lim.
- ★ Sarimbun Reservoir: one example of about 1.8 m TL observed swimming into shore vegetation on 26 Nov.2007. Its tail end was photographed by Norman Lim.
- ★ Sentosa Island: one adult (length not recorded) photographed on the afternoon of 30 May 2007 by Benjamin P. Y. H. Lee. A photograph of this individual appears in Baker & Lim (2008: 118).



Fig. 4. Adult king cobra roadkill (TL: ca. 2.7 m) found along Upper Thomson Road just before junction of Tagore Drive on 29 Nov.2008. (Photographed on-site by: Vilma D’Rozario).



Fig. 5. Head of king cobra roadkill of about 2.7 m TL found along Upper Thomson Road just before junction of Tagore Drive on 29 Nov 2008. (Photographed on-site by: Vilma D’Rozario).

- ★ Vicinity of MacRitchie Reservoir, most likely Thomson Road area: one large adult of around 7–9 ft (ca. 2.1-2.7 m) TL killed in compound of a house on 16 Apr.2008, reported with photographic evidence by Chee Wei-Lin.
- ★ Upper Thomson, Venus Drive just after left turn to Singapore Island Country Club: a juvenile roadkill of 69 cm TL found by Tzi Ming Leong on 22 May 2008 (ZRC 2.6701).
- Upper Thomson, Venus Drive: one of between 9 and 12 ft (ca. 2.7 and 3.6 m) TL with head raised about 3 ft off the ground and with sides of neck stretched out, observed by Siva Venthan at 1515 hours on 25 Oct.2008. Record unconfirmed due to lack of photographic evidence.
- ★ Upper Thomson Road just before junction of Tagore Drive towards Yio Chu Kang Road junction: one individual of about 2.7 m TL seen writhing on road by Andrew Tay and Vilma D’Rozario at around 1200 hours on 29 Nov.2008 (Figs. 4 and 5). Andrew and Vilma parked their vehicle nearby and pulled the snake to the side of the road along a patch of wooded area and covered it with leaves intending to retrieve it later. The snake had most likely been run over by vehicles moments earlier, and parts of its skin were split. Although there was movement in the tail and mouth, it had seemed unlikely to recover. When Andrew and Vilma returned at 1730 hours to collect the carcass, it was no longer there. It appeared that someone had removed it.



Fig. 6. T. M. Leong posing with an adult female king cobra (ZRC 2.6837, TL: 3.66 m) roadkill, found along Island Club Road on the morning of 7 Aug.2009. (Photograph by: H. Y. Kim).

- ★ Upper Thomson, Island Club Road, in roadside drain just before guardhouse at fork of road: one female of 3.66 m TL found freshly dead on the morning of 7 Aug.2009, collected by Tzi Ming Leong, Hong Yi Kim & David Groenewoud (ZRC 2.6837, Figs. 6–10). No apparent external injury, but may have succumbed to internal injuries (e.g., cardiac, spinal) upon being run over by vehicles. The snake was heavily infested with ticks that probably belong to the genus *Amblyomma*.
- ★ Upper Thomson, Island Club Road: one male of 4.13 m TL and weighing 10 kg was caught by staff of NParks and Singapore Zoo from within a drain on the morning of 27 Mar.2010 (Fig. 11). The specimen had a bloated belly and radiographs revealed that a large snake had been consumed. From the relatively large size of its vertebrae, the prey was probably a reticulated python (*Broghammerus reticulatus*). This king cobra is presently alive and on display at the Singapore Zoo.

DISCUSSION

From the 39 records available to us, the king cobra has been recorded from Singapore in the following localities: Central Catchment Nature Reserve, particularly around Upper Thomson Road (9 records), Sime Road-MacRitchie area (4 records), and the compound of the Singapore Zoo at the end of Mandai Lake Road (7 records); Kranji, including the Sungei Buloh Wetland Reserve (5 records) (Anonymous, 2003: 92); the Western Catchment Area (1 record); Sentosa (1 record), and Pulau Tekong (3 records). This suggests that the king cobra is not particularly rare in Singapore. It shows that this species occurs not only in forested areas, but also adjacent to human habitation (see Sharma, 1973: 234-235 as *Naja hannah*). Reports that the king cobra prefers undisturbed forests (e.g., Cox et al., 1998: 25) may not apply to the population in Singapore, for it has even been obtained from built-up areas, such as Bras Basah, and Kampong Bahru.

According to Cox et al. (1998: 25), David & Vogel (1996: 149) and Lim & Lee (1989: 92), the king cobra is usually considered a diurnal snake, but it is also known to be active at night. It inhabits tropical and subtropical wet forests from the lowlands up to 2,135 m, swamps and marshes, open scrubland, plantations, cultivated areas, rice paddies and often

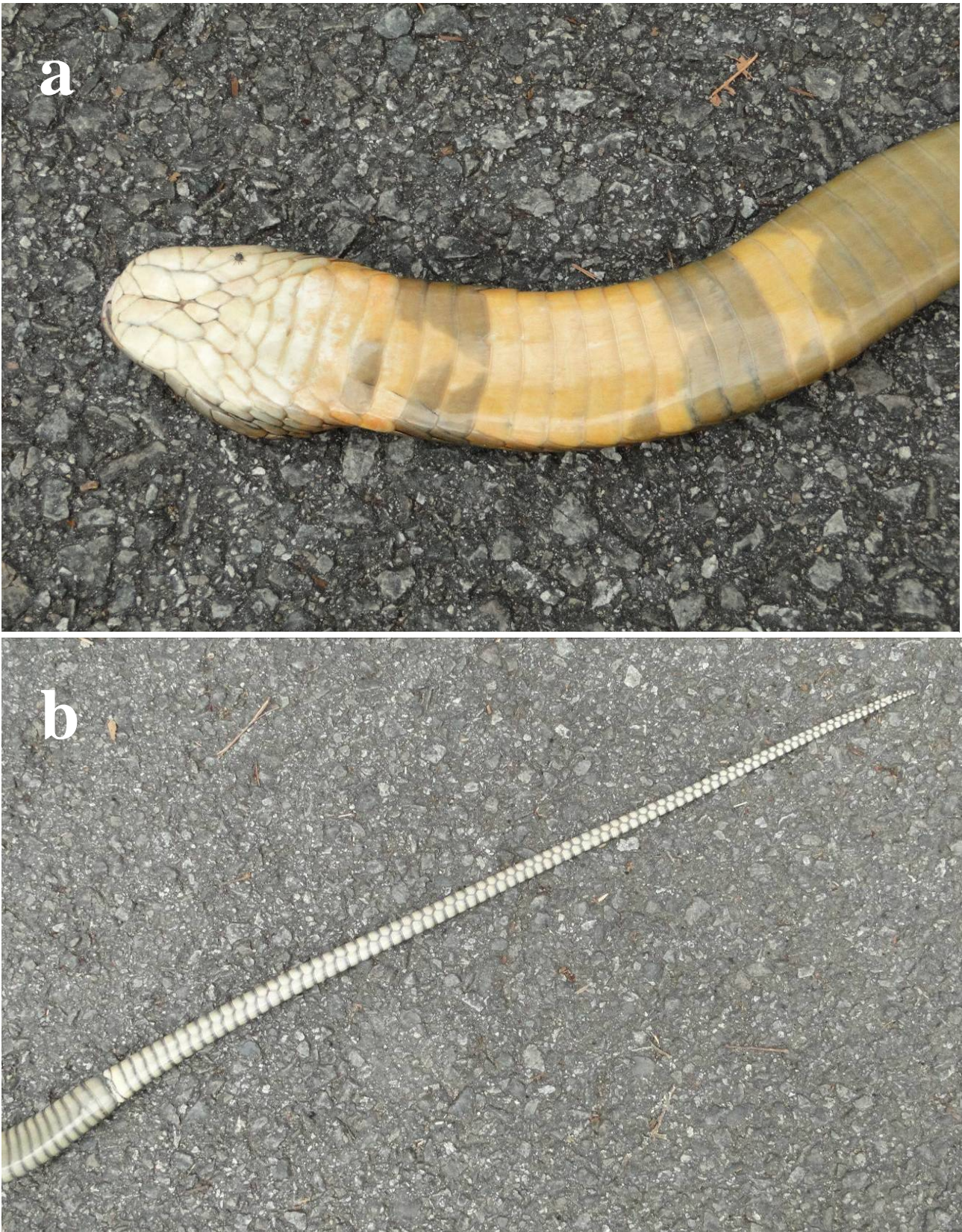


Fig. 7. Ventral views of head and neck region (a) and tail (b) of king cobra (ZRC 2.6837), to appreciate sculation patterns. For the tail region, note that the anterior subcaudals are undivided, while the others are divided. (Photograph by: H. Y. Kim).

in the vicinity of human habitation. Nevertheless, it requires dense vegetation in which to retreat and hide. Although mainly terrestrial, this agile and fast-moving snake can climb well, and in captivity, is often observed resting on branches and logs above the ground. The young is also said to be semi-arboreal. The king cobra is also found frequently near streams and enters water readily. Buddle (1929: 16) mentioned that the species seemed 'to have a liking for road-drains and culverts'. Four of the records featured here are of king cobras taken in drains.



Fig. 8. Dorsal view of head and neck region of king cobra (ZRC 2.6837), with skin laterally stretched to expose the broad black and narrow yellow bands otherwise concealed between the scales. (Photograph by: H. Y. Kim).

Except for one instance, all records of the king cobra in Singapore have been terrestrial in nature. The exception is the snake from Kampong Bahru in 1972. It was shot dead by a policeman on the roof of the market. The king cobra's affinity for water is shown by the sighting of one at the Sarimbun Reservoir in November 2007. The snake had voluntarily entered the water and swam across the reservoir at its own leisure and in no hurry (Norman Lim, pers. comm.). This implies that the king cobra would have no difficulties entering and leaving Singapore via the narrow Johor Straits, bounded by Peninsular Malaysia along its northern shore.

The appropriately assigned generic name, *Ophiophagus* literally means 'snake eating'. The king cobra feeds chiefly on snakes, particularly pythons and large rat snakes of the genus *Ptyas*, as well as large monitor lizards such as *Varanus* (David & Vogel, 1996: 149; Tweedie, 1983: 117). Buddle (1929: 16) had introduced a local king cobra to a 6 ft cobra (apparently *Naja sumatrana*). The larger snake struck the cobra which died 'within a few seconds and was then slowly swallowed'. Buddle also reported that a king cobra had been seen to eat another conspecific slightly over half its size. However, prey has been known to strike back. Lim & Lee (1989: 92) mentioned a report of an adult king cobra having been constricted to death by a reticulated python (*Broghammerus reticulatus*).

In Singapore and adjacent areas, the reproductive habits and behaviour of the king cobra have not been studied. We presume that it should be similar to that of its Indian conspecific, in which the female constructs a nest by gathering a large mound of dead vegetation and soil with her body and tail. In it, she lays a clutch of eggs, between 20–43, and then coils herself within the nest above or near the eggs throughout the period of incubation. It is not clear if she does this for thermoregulation or to protect her brood, or both. The male may also be in attendance. Egg incubation lasts 63 days, and hatchlings measure between 28.8–42.2 cm. Indian king cobras have a distinct breeding season, usually in Apr., and snakes exhibit seasonal monogamy (Tweedie, 1983: 118-119; Lim & Lee, 1989: 92; Greene, 1997: 219; Das, 2006: 64). However, it is not known if this breeding season also applies to the population in Southeast Asia. Although we have no records of nesting king cobras in Singapore, juveniles account for 11 out of 34 snakes recorded since 1980, and is evidence that the species breeds locally.



Fig. 9. The adult king cobra (ZRC 2.6837) was heavily infested with ectoparasitic ticks, with large specimens attached behind its head (a) and along its mid-section (b). When subsequently processed at the laboratory, numerous other ticks of smaller sizes (earlier instars) were retrieved from underneath the snake's scales. The ticks were preserved in 75% ethanol. (Photograph by: H. Y. Kim).



Fig. 10. A brief examination of the pair of front fangs of the 3.66 m TL king cobra (ZRC 2.6837) revealed that both were in good condition. (Photograph by: H. Y. Kim).

The king cobra has a fearsome reputation: it is said to ‘wantonly attack’ and ‘even pursue man’ (Buddle, 1929: 3, 16). When annoyed, it spreads a narrow hood and growls loudly, but its legendary aggressiveness seems exaggerated (Greene, 1997: 219). Tweedie (1983: 117) felt that ‘this notion is based on the general tendency to dramatise all attributes of snakes with little regard for the truth about them. A moment’s reflection shows that this must be so, for the species is not uncommon, even in populated areas, and consciously or unconsciously, people must encounter king cobras quite frequently. If the snake were really habitually aggressive records of its bite would be frequent; as it is they are extremely rare.’

In Singapore, encounters with live king cobras have been far from exciting. Tweedie (1954: 117; 1983: 118) illustrated this with the capture of the 4.77 m TL specimen at the Island Golf Course in 1950. The large size of the snake led to its being mistaken for a python, and the three greensmen who caught it had first seized it by the tail; to which the king cobra offered no effective resistance. Tweedie believed that the snake’s sluggishness at that time may have been because it was digesting a heavy meal. However, he added that it had probably spent a long time in the vicinity before it was noticed, and attributed this to the species’ unaggressive and reclusive character. A similar account was given by Batchelor (1958: 111) in Melaka, Malaysia. He had dragged a king cobra by its tail out of some thick vegetation, having initially mistaken it for a rat snake.

In most of the local encounters with live, wild king cobras, the snakes appear to be of rather placid disposition, and they usually end up being killed or subdued with hardly any hysterics. These support the view that wild king cobras generally have a mild temperament, and despite their frequent occurrence in disturbed and built-up areas, are adept at avoiding humans. Nevertheless, it must always be remembered that this species is highly venomous and powerful, and should never be taken for granted. Cornered individuals, especially those in captivity without avenue for retreat can be especially dangerous. They will not hesitate to defend themselves by rearing up and striking, and it is not inconceivable that they would be capable of pursuing their tormentors under desperate situations.

Bites from the king cobra are not unknown, and accidents can occur if a snake finds its way into houses and is unknowingly disturbed. Such a tragic incident occurred in October 2004, at Pekan, Pahang, Malaysia. A 23-year old

Table 1. A selection of studies on the discovery, characterisation and/or effects of the multiple constituents in king cobra venom presented in chronological order.

No.	Constituent/s	Citation
1.	Two long-chain neurotoxins (Toxins a & b)	Joubert, 1973
2.	Species-specific differences in hemorrhagic effects of hemorrhagin	Weissenberg et al., 1987
3.	A protease with substrate specificity on oxidized insulin B-chain	Yamakawa & Omori-Satoh, 1988
4.	Two major phospholipase A ₂ enzymes (OHPLA-DE1 and OHPLA-DE2)	Tan & Saifuddin, 1990
5.	A postsynaptic neurotoxin (α -neurotoxin: Oh-4)	Chang et al., 1993
6.	L-amino acid oxidase (induction of human platelet aggregation)	Li et al., 1994
7.	An arginine/lysine amidase (OhS1)	Zhang et al., 1994
8.	A phospholipase A ₂ (Oh-DE-2)	Chiou et al., 1995
9.	A specific blood coagulation factor X activator	Lee et al., 1995
10.	An analgesic neurotoxin (hannalgesin)	Pu et al., 1995
11.	Pathological effects of an acidic phospholipase A ₂ (OHV A-PLA ₂)	Huang & Gopalakrishnakone, 1996
12.	L-amino acid oxidase (cytotoxicity to tumor cells)	Ahn et al., 1997
13.	An acidic phospholipase A ₂ (OHV A-PLA ₂) – platelet aggregation inhibitor	Huang et al., 1997
14.	The solution structure of a long neurotoxin (Toxin b)	Peng et al., 1997
15.	A fibrinolytic peptide (Hannahpep)	Gomes & De, 1999
16.	Two α -neurotoxins (Oh-6A and Oh-6b)	Lin et al., 1999
17.	A chymotrypsin inhibitor	Chang et al., 2001
18.	A lethal cardiotoxic, hemorrhagic protein toxin (Toxin CM55)	Gomes et al., 2001
19.	A neurotoxin (Oh9-1), structurally distinct from α -neurotoxins	Chang et al., 2002
20.	A multiheterodimeric, convulxin-like C-type lectin (ophioluxin)	Du et al., 2002
21.	A cardiotoxic phospholipase A ₂ which contains a “pancreatic loop”	Zhang et al., 2002
22.	Cloning of cDNA sequences from king cobra venom gland cDNA library	He et al., 2004
23.	Three cytotoxin-like proteins (Oh11-2, Oh11-3, Oh11-4)	Chang et al., 2006
24.	The complete cDNA and genomic organization of ohanin	Pung et al., 2006
25.	A non-protein toxin (KC-MMTx) with anticonvulsant potential	Saha et al., 2006
26.	A fibrinogenolytic, P-III class metalloproteinase (ohagin)	Guo et al., 2007
27.	A three-finger toxin (β -cardiotoxin) – a natural exogenous beta-blocker	Rajagopalan et al., 2007
28.	A dual serine protease inhibitor (OH-TCI) – against trypsin, chymotrypsin	He et al., 2008
29.	A homodimeric three-finger neurotoxin (haditoxin)	Roy et al., 2010
30.	A heat-stable form of L-amino acid oxidase (LAAO, EC 1.4.3.2)	Lee et al., 2011

woman was bitten on her toe by a 3 m-long king cobra that was found on a bed in a house. Soon after, the offending snake was shot dead. Although she was immediately taken to hospital, the woman, who became unconscious after being bitten, died after she was admitted (Anonymous, 2004: A8). We are not aware of any record of a king cobra biting a person in Singapore.

The king cobra's potent venom has earned a reputation for itself within scientific and medical circles, with multiple research laboratories around the region (including Singapore) having devoted their resources to elucidate the concoction of toxic chemical components for the past few decades. Novel enzymes are continually being isolated, identified, and even cloned, with some of these products demonstrating diverse biomedical applications. A representation of these research efforts are summarised in Table 1. Apart from king cobra venom, investigations into its blood serum have also revealed that they possess antihemorrhagic activity against the conspecific hemorrhagin (Chanhome et al., 2003). This may imply that king cobras are armed with a certain degree of immunity against potential attempts of cannibalism.

Teo & Rajathurai (1997: 420) and Lim et al. (2008: 167) classified the king cobra as locally endangered in Singapore, citing habitat degradation, and persecution and hunting by humans as threats to the species. While we have not heard of



Fig. 11. Captive male king cobra of 4.13 m TL, captured from Island Club Road on 27 Mar.2010. (Photograph courtesy of: the Singapore Zoo).

cobras being hunted, the enormous specimen from the Island Golf Course reported by Tweedie (1954: 117) was apparently ‘... on its way to market to be sold as python meat’ (Lim, 1958: 118). There were a number of cases where the snakes were destroyed out of fear. King cobras do have a fearsome reputation, and provoked individuals are unmistakable as a formidable and highly venomous species.

Vehicular traffic may be regarded as another type of threat to the king cobra. At least four of the records consist of snakes having been run over by vehicles on the road. The haunts of king cobras are by no means restricted to forest habitats, and the snakes do live in exposed environments, frequently in close proximity to people. Despite their large sizes, they seem adept at avoiding human detection, and thus, are probably not as rare as presumed.

CONCLUSIONS

In Singapore, the king cobra inhabits forest and scrubland habitats. It sometimes wanders into gardens and golf courses, and is perhaps not as rare as presumed. It is certainly breeding in Singapore, but no nest has ever been recorded thus far. Despite its large size and extremely potent venom, this snake seems to be generally non-aggressive, and there is no record of bites in Singapore. Regardless, it is persecuted for the potential danger it poses to humans. The species also falls victim to vehicles while crossing roads between green spaces.

ACKNOWLEDGEMENTS

We extend our appreciation to the Singapore Zoo, the National Parks Board and the Nature Society (Singapore) for contributions of various records. We thank Nick Baker, and Navjot Sodhi for records from the Kranji area, Andrew Tay, and Vilma D’Rozario for the record from Upper Thomson, Norman Lim for the record from the Western Catchment Area, and Alvin Seah for presenting the specimen from Island Country Club in 2002 to the Raffles Museum of Biodiversity Research. We are grateful to Kim Hong Yi, and David Groenewoud for their enthusiastic field and museum assistance, as well as detailed photographic documentation (ZRC 2.6837).

LITERATURE CITED

- Ahn, M. Y., B. M. Lee & Y. S. Kim, 1997. Characterization and cytotoxicity of L-amino acid oxidase from the venom of king cobra (*Ophiophagus hannah*). *International Journal of Biochemistry and Cell Biology*, **29**(6): 911–919.
- Anonymous, 1985. Zoo gets 'rare' catch. *The Straits Times*. Friday, 25 January 1985.
- Anonymous, 2003. *Sungei Buloh Wetland Reserve — A Decade of Wetland Conservation*. National Parks Board, Singapore. 98 pp.
- Anonymous, 2004. King cobra bite kills bride-to-be. *The Straits Times*. Monday, 4 October 2004. P. A8.
- Baker, N. & K. K. P. Lim, 2008. *Wild Animals of Singapore. A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Draco Publishing and Distribution Pte. Ltd. and Nature Society (Singapore). 180 pp.
- Batchelor, D. M., 1958. Some notes on the snakes of Asahan, Malacca. *The Malayan Nature Journal*, **12**(3): 103–111.
- Buddle, R., 1929. *Snakes of Singapore Island*. Kelly & Walsh, Ltd., Shanghai. 48 pp.
- Cantor, T., 1847. Catalogue of reptiles inhabiting the Malayan Peninsula and islands. *Journal of the Asiatic Society of Bengal*, **16**: 112–257.
- Carwardine, M., 2007. *Animal Records: Amazing Feats and Fascinating Facts*. Allen & Unwin, Australia. 256 pp.
- Chang, C-C., T-Y. Huang, K-W. Kuo, S-W. Chen, K-F. Huang & S-H. Chiou, 1993. Sequence characterization of a novel α -neurotoxin from the king cobra (*Ophiophagus hannah*) venom. *Biochemical and Biophysical Research Communications*, **191**(1): 214–223.
- Chang, L-S., C. Chung, H-B. Huang & S-R. Lin, 2001. Purification and characterization of a chymotrypsin inhibitor from the venom of *Ophiophagus hannah* (king cobra). *Biochemical and Biophysical Research Communications*, **283**(4): 862–867.
- Chang, L-S., J-C. Liou, S-R. Lin & H-B. Huang, 2002. Purification and characterization of a neurotoxin from the venom of *Ophiophagus hannah* (king cobra). *Biochemical and Biophysical Research Communications*, **294**(3): 574–578.
- Chanhome, L., O. Khaw, T. Omori-Satoh & V. Sitprija, 2003. Antihemorrhagin in the blood serum of king cobra (*Ophiophagus hannah*): purification and characterization. *Toxicon*, **41**(8): 1013–1019.
- Chang, L-S., K-C. Chen, S-R. Lin & H-B. Huang, 2006. Purification and characterization of *Ophiophagus hannah* cytotoxin-like proteins. *Toxicon*, **48**(4): 429–436.
- Chiou, J-Y., L-S. Chang, L-N. Chen & C-C. Chang, 1995. Purification and characterization of a novel phospholipase A₂ from king cobra (*Ophiophagus hannah*) venom. *Journal of Protein Chemistry*, **14**(6): 451–456.
- Chuang, S. H., 1973. Introduction. In: Chuang, S. H. (Ed.), *Animal Life and Nature in Singapore*. Singapore University Press, Singapore. Pp. 1–6.
- Cox, M. J., van Dijk, P. P., Nadhitabhata, J. & K. Thirakhupt, 1998. *A Photographic Guide to Snakes and Other Reptiles of Peninsular Malaysia, Singapore and Thailand*. New Holland Publishers (UK) Ltd., London. 144 pp.
- Das, I., 2006. *A Photographic Guide to Snakes and Other Reptiles of Borneo*. New Holland Publishers (UK) Ltd., London. 144 pp.
- David, P. & G. Vogel, 1996. *The Snakes of Sumatra*. Edition Chimaira, Frankfurt, Germany. 260 pp.
- de Rooij, N., 1917. *The Reptiles of the Indo-Australian Archipelago. II. Ophidia*. E. J. Brill Ltd., Leiden. xiv + 331 pp.
- Du, X-Y., J. M. Clemetson, A. Navdaev, E. M. Magnenat, T. N. C. Wells & K. J. Clemetson, 2002. Ophioluxin, a convulxin-like C-type lectin from *Ophiophagus hannah* (king cobra) is a powerful platelet activator via glycoprotein VI. *Journal of Biological Chemistry*, **277**(38): 35,124–35,132.
- Gomes, A. & P. De, 1999. Hannahpep: a novel fibrinolytic peptide from the Indian King Cobra (*Ophiophagus hannah*) venom. *Biochemical and Biophysical Research Communications*, **266**(2): 488–491.
- Gomes, A., P. De & S. C. Dasgupta, 2001. Occurrence of a unique protein toxin from the Indian King Cobra (*Ophiophagus hannah*) venom. *Toxicon*, **39**(2–3): 363–370.
- Greene, H. W., 1997. *Snakes: The Evolution of Mystery in Nature*. University of California Press, Berkeley, California. xiii + 351 pp.
- Guo, X-X., L. Zeng, W-H. Lee, Y. Zhang & Y. Jin, 2007. Isolation and cloning of a metalloproteinase from king cobra snake venom. *Toxicon*, **49**(7): 954–965.
- He, Y-Y., W-H. Lee & Y. Zhang, 2004. Cloning and purification of α -neurotoxins from king cobra (*Ophiophagus hannah*). *Toxicon*, **44**(3): 295–303.
- He, Y-Y., S-B. Liu, W-H. Lee, J-Q. Qian & Y. Zhang, 2008. Isolation, expression and characterization of a novel dual serine protease inhibitor, OH-TCI, from king cobra venom. *Peptides*, **29**(10): 1692–1699.
- Huang, M. Z. & P. Gopalakrishnakone, 1996. Pathological changes induced by an acidic phospholipase A₂ from *Ophiophagus hannah* venom on heart and skeletal muscle of mice after systemic injection. *Toxicon*, **34**(2): 201–211.
- Huang, M. Z., P. Gopalakrishnakone & R. M. Kini, 1997. Inhibition of human platelet aggregation by a phospholipase A₂ platelet inhibitor from *Ophiophagus hannah* (king cobra) venom. *Toxicon*, **35**(4): 492.
- Iskandar, D. T. & E. Colijn, 2002. *A Checklist of Southeast Asian and New Guinean Reptiles. Part 1: Serpentes*. Biodiversity Conservation Project (Indonesian Institute of Sciences — Japan International Cooperation Agency — The Ministry of Forestry), The Gibbon Foundation and Institute of Technology, Bandung. 195 pp.
- Joubert, F. J., 1973. Snake venom toxins: the amino acid sequences of two toxins from *Ophiophagus hannah* (King Cobra) venom. *Biochimica et Biophysica Acta (BBA) — Protein Structure*, **317**(1): 85–98.

- Lee, M. L., N. H. Tan, S. Y. Fung & S. D. Sekaran, 2011. Antibacterial action of a heat-stable form of L-amino acid oxidase isolated from king cobra (*Ophiophagus hannah*) venom. *Comparative Biochemistry and Physiology, Part C*, **153**(2): 237–242.
- Lee, W-H., Y. Zhang, W-Y. Wang, Y-L. Xiong & R. Gao, 1995. Isolation and properties of a blood coagulation factor X activator from the venom of king cobra (*Ophiophagus hannah*). *Toxicon*, **33**(10): 1263–1276.
- Li, Z-Y., T-F. Yu & E. C-Y. Lian, 1994. Purification and characterization of L-amino acid oxidase from king cobra (*Ophiophagus hannah*) venom and its effects on human platelet aggregation. *Toxicon*, **32**(11): 1349–1358.
- Lim B. L., 1958. Colour patterns of some Malayan snakes. *The Malayan Nature Journal*, **12**(3): 116–118.
- Lim, F. L. K. & M. T.-M. Lee, 1989. *Fascinating Snakes of Southeast Asia — An Introduction*. Tropical Press Sdn. Bhd., Kuala Lumpur. xvii + 124 pp.
- Lim, K. K. P. & F. L. K. Lim, 1992. *A Guide to the Amphibians & Reptiles of Singapore*. Singapore Science Centre, Singapore. 160 pp.
- Lim, K. K. P. & R. Subaraj, 1992. Current records: reptiles & amphibians. *The Pangolin*, **5**: 5–11.
- Lim, K. K. P., N. Baker, R. Teo & T. M. Leong, 2008. Reptiles. In: Davison, G. W. H., Ng, P. K. L. & H. C. Ho (Eds.). *The Singapore Red Data Book. Threatened Plants & Animals of Singapore. 2nd Edition*. The Nature Society (Singapore). pp. 160–176.
- Lin, S-R., L-S. Chang & C-C. Chang, 1999. Disulfide isomers of α -neurotoxins from king cobra (*Ophiophagus hannah*) venom. *Biochemical and Biophysical Research Communications*, **254**(1): 104–108.
- Peng, S-S., T. Krishnaswamy, S. Kumar, G. Jayaraman, C-C. Chang & C. Yu, 1997. Solution structure of Toxin b, a long neurotoxin from the venom of the king cobra (*Ophiophagus hannah*). *Journal of Biological Chemistry*, **272**(12): 7817–7823.
- Pu, X. C., P. T. H. Wong & P. Gopalakrishnakone, 1995. A novel analgesic toxin (hannalgesin) from the venom of king cobra (*Ophiophagus hannah*). *Toxicon*, **33**(11): 1425–1431.
- Pung, Y. F., S. V. Kumar, N. Rajagopalan, B. G. Fry, P. P. Kumar & R. M. Kini, 2006. Ohanin, a novel protein from king cobra venom: its cDNA and genomic organization. *Gene*, **371**(2): 246–256.
- Rajagopalan, N., Y. F. Pung, Y. Z. Zhu, P.T. H. Wong, P. P. Kumar & R. M. Kini, 2007. β -Cardiotoxin: a new three-finger toxin from *Ophiophagus hannah* (king cobra) venom with beta-blocker activity. *FASEB (Federation of the American Societies of Experimental Biology) Journal*, **21**(13): 3685–3695.
- Roy, A., X-D. Zhou, M. Z. Chong, D. D'hoedt, C. S. Foo, N. Rajagopalan, S. Nirthanan, D. Bertrand, J. Sivaraman & R. M. Kini, 2010. Structural and functional characterization of a novel homodimeric three-finger neurotoxin from the venom of *Ophiophagus hannah* (King Cobra). *Journal of Biological Chemistry*, **285**(11): 8302–8315.
- Saha, A., A. Gomes, A. K. Chakravarty, A. K. Biswas, B. Giri, S. C. Dasgupta & A. Gomes, 2006. CNS and anticonvulsant activity of a non-protein toxin (KC-MMTx) isolated from King Cobra (*Ophiophagus hannah*) venom. *Toxicon*, **47**(3): 296–303.
- Sharma, R. E., 1973. Noxious and toxic animals. In: Chuang, S. H. (Ed.), *Animal Life and Nature in Singapore*. Singapore University Press, Singapore. Pp. 229–250.
- Subaraj, R., Lim, K. & R. Teo, 1995. Late records (1993–1994). *The Pangolin*. The Nature Society (Singapore). **8**: 1–9.
- Sworder, G. H., 1923. A list of the snakes of Singapore Island. *The Singapore Naturalist*, **2**: 55–73.
- Tan, N.-H. & M. N. Saifuddin, 1990. Purification and characterization of two acidic phospholipase A₂ enzymes from king cobra (*Ophiophagus hannah*) snake venom. *International Journal of Biochemistry*, **22**(5): 481–487.
- Teo, R. C. H. & S. Rajathurai, 1997. Mammals, reptiles and amphibians in the nature reserves of Singapore — Diversity, abundance and distribution. *The Gardens' Bulletin, Singapore*, **49**(2): 353–425.
- Tweedie, M. W. F., 1954. Notes on Malayan reptiles, no. 3. *Bulletin of the Raffles Museum*, **25**: 107–117.
- Tweedie, M. W. F., 1983. *The Snakes of Malaya. 3rd Edition*. Singapore National Printers (Pte) Ltd., Singapore. 167 pp.
- Vogel, G., 2006. *Terralog Vol. 14: Venomous Snakes of Asia*. Edition Chimaira/Aqualog Verlag, Frankfurt, Germany. 148 pp.
- Weissenberg, S., M. Ovadia & E. Kochva, 1987. Species specific sensitivity towards the hemorrhagin of *Ophiophagus hannah* (Elapidae). *Toxicon*, **25**(5): 475–481.
- Yamakawa, Y. & T. Omori-Satoh, 2003. A protease in the venom of king cobra (*Ophiophagus hannah*): purification, characterization and substrate specificity on oxidized insulin B-chain. *Toxicon*, **26**(12): 1145–1155.
- Zhang, H-L., S-J. Xu, Q-Y. Wang, S-Y. Song, Y-Y. Shu & Z-J. Lin, 2002. Structure of a cardiotoxic phospholipase A₂ from *Ophiophagus hannah* with the “pancreatic loop”. *Journal of Structural Biology*, **138**(3): 207–215.
- Zhang, Y., W-H. Lee, Y-L. Xiong, W-Y. Wang & S-W. Zu, 1994. Characterization of OhS1, an arginine/lysine amidase from the venom of king cobra (*Ophiophagus hannah*). *Toxicon*, **32**(5): 615–623.