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Sea snakes in Australian waters (Serpentes: subfamilies Hydrophiinae and Laticaudinae)—a review with an updated identification key

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Abstract

Sea snakes (Elapidae, subfamilies Hydrophiinae and Laticaudinae) reach high species richness in the South China Sea and in the Australian region; however, most countries in the two regions still lack up-to-date checklists and identification tools for these snakes. We present an updated reviewed checklist and a new complete identification key to sea snakes in Australian waters. The identification key includes 29 species documented and 4 possibly occurring taxa and is based mostly on easy-to-use external characters. We find no evidence for breeding populations of *Laticauda* in Australian waters, but include the genus on the list of possibly occurring taxa.

Key words: biodiversity, Australian sea snake species, identification key

Introduction

Globally there are some 70 species of sea snake (aquatic elapids, in the subfamilies Hydrophiinae and Laticaudinae), found in tropical and subtropical waters of the Indian Ocean and the Pacific Ocean, from the east coast of Africa in the west to the Gulf of Panama in the east (David & Ineich, 1999; Rasmussen, Murphy, Ompi, Gibbons, & Uetz, 2011). Most species occur in the Indo-Malayan Archipelago, the China Sea, Indonesia, and the Australian region (Cogger, 1975; David & Ineich, 1999; Golay *et al.*, 1993; Guinea & Whiting, 2005; Ineich, 2007; Khan, 2004; Kharin, 2005; Kharin & Czeblukov, 2009; Rasmussen, 2000; Rasmussen, Elmberg, Gravlund, & Ineich, 2011; Rasmussen, Murphy, *et al.*, 2011; M. A. Smith, 1926).

The viviparous sea snakes (Hydrophiinae) originated in Australia, having descended from the country's endemic front-fanged terrestrial hydrophiine snakes (Lukoschek & Keogh, 2006; Sanders, Lee, Leys, Foster, & Keogh, 2008). The group has since radiated in shallow water marine habitats throughout the Indo-Pacific, with 62 recognised species in 7 genera (Sanders, Lee, Mumpuni, Bertozzi, & Rasmussen, 2013). However, Australia supports the world's highest recorded diversity and endemism, with more than 35% of the described viviparous sea snake species recorded from its waters and five nationally endemic species: *Aipysurus apraefrontalis*, *A. foliosquama*, *A. fuscus*, *Ephalophis greyae*, and *Hydrophis donaldi* (Cogger, 1975; Elfes *et al.*, 2013; Guinea & Whiting, 2005; Lukoschek, Beger, Ceccarelli, Richards, & Pratchett, 2013; Sanders, Rasmussen, & Guinea, 2014; M. A. Smith, 1926).

Over the last 50 years 8 new species have been described from or adjacent to Australian waters, but large areas still remain much understudied (Cogger, 1975; Cogger & Heatwole, 2006; Heatwole, Busack, & Cogger, 2005; Kharin, 1983, 1984a, 1984b, 1985; Rasmussen & Ineich, 2000; Sanders *et al.*, 2012; L. A. Smith, 1974; Ukuwela, Sanders, & Fry, 2012). The addition of further species must be expected as the geographical ranges of existing

species remain unknown and some of the published studies lack comprehensive review. The taxonomy of the Australian sea snake species has been debated for the last 50 years without consensus being reached (Cogger, 1975; Cogger, Cameron, & Cogger, 1983; David & Ineich, 1999; Heatwole, 1999; Kharin & Czeblukov, 2009; McDowell, 1969, 1972; Rasmussen, 1997; Wells, 2007). However, a recent phylogenetic study using six molecular loci for 39 sea snake species in 15 genera recovered *Hydrophis* as broadly paraphyletic with respect to several other genera (Sanders, Lee, *et al.*, 2013). Instead of erecting multiple new genera, the authors recommended dismantling the mostly monotypic genera *Pelamis*, *Enhydrina*, *Astrotia*, *Thalassophina*, *Acalyptophis*, *Kerilia*, *Lapemis* and *Disteira*, and recognising a single genus, *Hydrophis*, for these taxa (Sanders, Lee, *et al.*, 2013). This classification system avoids confusion and better reflects the history of recent and very rapid diversification of these snakes. This is the taxonomy we follow in the current paper.

An up-to-date species list of Australian sea snakes is thus much needed from a general standpoint of taxonomic hypotheses, but also as a tool for biodiversity research and conservation efforts in this area of high diversity. Alarming declines of sea snake populations have been documented, most severely in the northwest, where two endemic species have been unrecorded on surveys since 2001 and are now listed as Critically Endangered (IUCN Red List; Australia's EPBC Act 1999) (see also Guinea and Whiting 2005 Elfes *et al.* 2013, Lukoschek *et al.* 2013 and Sanders *et al.* In press). Even on the Great Barrier Reef Queensland, Northern Territory and Western Australia, many sea snakes are threatened by coastal and offshore development, fisheries by-catch, and the impact of rising sea temperatures, ocean acidification, sedimentation and changes in rainfall patterns and salinity (e.g. Heatwole, 1999; Milton, 2001). Furthermore, sea snakes are dangerously venomous and pose a significant health risk in many coastal communities: risks are greatest in Southeast Asia but also present in Australia especially to trawler fishers while handling nets and pearl shell divers. Bites can be fatal if untreated, and many survivors suffer life-long disability. Thus, understanding the distribution and taxonomic status of Australian sea snakes is also critically important from a socio-medical standpoint.

The aims of the present paper are to address these deficiencies by publishing an updated checklist based on available preserved specimens and two surveys of Timor Sea reefs conducted in the years 2012 and 2013.

Material and methods

Institutional abbreviations for preserved specimens are as listed at Sabaj Perez, M.H. (editor). 2013. Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 4.0 (28 June 2013). Electronically accessible at <http://www.asih.org/>, American Society of Ichthyologists and Herpetologists, Washington, DC.

Checklist of Australian sea snakes

The following species are broadly accepted as occurring in Australian waters and are represented by multiple preserved voucher specimens in Australian and international museum collections (Cogger, 1975, 2000; Cogger *et al.*, 1983; David & Ineich, 1999; Golay *et al.*, 1993; Greer, 1997; Guinea & Whiting, 2005; Heatwole *et al.*, 2005; Heatwole & Cogger, 1994b; Kharin, 1983, 1984a, 1984b, 1985; Lukoschek & Keogh, 2006; Rasmussen & Ineich, 2010; Sanders, Lee, *et al.*, 2013; Sanders *et al.*, 2012; L. A. Smith, 1974; M. A. Smith, 1926; Ukuwela, Sanders, *et al.*, 2012): *Aipysurus apraefrontalis*, *A. duboisii*, *A. foliosquama*, *A. fuscus*, *A. laevis*, *A. mosaicus*, *A. pooleorum*, *A. tenuis*, *Emydocephalus annulatus*, *Ephalophis greyae*, *Hydrelaps darwiniensis*, *Hydrophis coggeri*, *H. curtus* (formerly in the genus *Lapemis*), *H. czeblukovi*, *H. donaldi*, *H. elegans*, *H. kingii*, *H. macdowellii*, *H. major*, *H. ocellatus* (formerly *H. ornatus ocellatus*, see below), *H. peronii* (formerly in the genus *Acalyptophis*), *H. platurus* (formerly in the genus *Pelamis*), *H. stokesii* (formerly in the genus *Astrotia*) and *Parahydrophis mertoni*.

Over the last 90 years, 16 additional species have been suggested as also occurring in or close to Australian waters: *Hydrophis atriceps*, *H. belcheri*, *H. caeruleus*, *H. cyanocinctus*, *H. inornatus*, *H. laboutei*, *H. melanocephalus*, *H. melanosoma*, *H. obscurus*, *H. ornatus*, *H. pacificus*, *H. schistosus* (formerly in the genus *Enhydrina*), *H. spiralis*, *H. vorisi*, *H. zweifeli* (formerly in the genus *Enhydrina*) and *Microcephalophis gracilis*. We here review the evidence for each of these species occurring in Australian waters, and re-identify records based on uncertain or dubious identifications. We also include a list of sea snake species possibly occurring in Australian

waters. The species on the possible list occur close to the Australian marine boundary and we regard them as likely to be found in Australian waters in future surveys.

Review of species suggested to occur in Australian waters

Hydrophis atriceps Günther, 1864. *Hydrophis fasciatus atriceps* was mentioned by Smith (1926) as occurring in Australian waters based on one specimen from the Australian Museum (AMR6715) and two specimens close to Australian waters (Aru Island and Kaiser Wilhelmsland, New Guinea). Cogger (1975) mentioned the same specimen as Smith, but had doubts about the locality and suggested the specimen was collected in Asian waters. Cogger also mentioned another juvenile specimen collected from Darwin (AMR14022) that he regarded as a *H. fasciatus fasciatus* (Schneider, 1799). We have examined the same specimen and agree with Cogger's (1975) identification using Smith's (1926) characters to separate the two subspecies. The identification and distribution of the two taxa remains based on Smith's monograph from 1926, where he separated them at a subspecies level and mentioned the typical form occurs to west of the Malay Peninsula and the other form is found east of it throughout the Malay Archipelago to Australia. Smith also indicated the dividing line is in the region of Singapore, despite including a specimen from China in the western subspecies and two specimens from India and Rangoon in the eastern form. The specimen from China included by Smith in the western form (*H. f. fasciatus*) is the type of *Hydrophis lindsayi* (Gray, 1831), which antedates the name *H. f. atriceps* by 22 years, indicating that if the taxa are separated into two geographically distinct forms and this specimen was incorrectly assigned by Smith (1926) to *H. f. fasciatus*, the right name for the eastern population would be *H. fasciatus lindsayi* and not *H. fasciatus atriceps*. Later, Cogger *et al.* (1983) raised the two taxa to species level, referring the Australian specimens to *H. atriceps*. Ward (1996) assigned five specimens to *H. atriceps* from the northern Australian continental shelf. All the specimens were collected by prawn trawling ships (Ward, 1996).

It seems likely the characters used by Smith (1926) and all subsequent taxonomists to separate *H. fasciatus* and *H. atriceps* -scale rows around the neck and body together with ventrals -are not useful to assign correctly all specimens to species level in this complex. Whether the name for an Australian population of the *H. fasciatus* complex proves to be *atriceps*, *fasciatus* or *lindsayi*, we regard the species to be in Australian waters based on at least one specimen from the region of Darwin (AMR14022) and the specimens mentioned by Ward (1996). We suggest using the name *H. atriceps* for the Australian population of this species until further taxonomic clarification.

Hydrophis belcheri (Gray, 1849). *Hydrophis belcheri* was described by Gray (1849) who gave the type locality "New Guinea" with no further information. Smith (1926) re-described *H. belcheri* based on 21 specimens mainly from the Philippines, New Guinea and Fiji Islands. Most of Smith's *H. belcheri* specimens have since been re-assigned to the following taxa: *Hydrophis coggeri*, *H. czeblukovi*, *H. pachycercos* and *H. pacificus* (Cogger, 1975; Kharin, 1983, 1984a; Rasmussen, Gravlund, van Nguyen, & Chanhome, 2007; Rasmussen & Smith, 1997). However, *H. belcheri* has been confirmed to occur from the Gulf of Thailand to the South China Sea (McCarthy & Warrell, 1991; Rasmussen, Elmsberg, *et al.*, 2011). There is a single record of *H. belcheri* from Australian waters identified by Kharin and Cheblukov (2007). The specimen is an adult female (# TINRO P 40) from the Arafura Sea, collected by V.P. Cheblukov, March 1970. Cheblukov's specimen is in good accordance with the type of *H. belcheri*, confirming this species' presence in Australian waters (Kharin & Cheblukov, 2007).

Hydrophis caerulescens (Shaw, 1802). We have identified specimens of *H. caerulescens* from the northern part of Australia from the Australian Museum and the Queensland Museum. This species occurs in the Gulf of Carpentaria (Cogger, 1975; Cogger *et al.*, 1983; David & Ineich, 1999; Kharin, 2004a; Redfield, Holmes, & Holmes, 1978). We therefore regard *H. caerulescens* as confirmed from Australian waters.

Hydrophis cyanocinctus Daudin, 1803/*Hydrophis pacificus* Boulenger, 1896.

Boulenger described *Hydrophis pacificus* based on a single specimen from "New Britain" in Papua New Guinea. Wall (1909) later synonymised it with *H. cyanocinctus*. Smith (1926) disagreed with both Boulenger and Wall and synonymised the type specimen of *H. pacificus* with *H. belcheri*. In 1972, McDowell reviewed the *Hydrophis* group and included the *H. pacificus* type in *H. elegans*. Three years later Cogger (1975) resurrected the type of *H.*

pacificus and referred 13 specimens from Northern Australia to this species (ARR examined 6 of the mentioned specimens: AMS 44983, 45092 and AMNH 142394–97). Today, most authorities recognise *H. pacificus* as occurring in the Australian region. However, both external and internal morphological characters (ARR observation) and molecular data show the Australian population of '*H. pacificus*' belongs to the same species as the eastern Asian specimens of *H. cyanocinctus* (Sanders, Rasmussen, *et al.*, 2013). However, as long as the taxonomic status of the Asian specimens of *H. cyanocinctus* remains unclear we suggest following Cogger (1975) and using the name *H. pacificus* until this complex has been investigated more thoroughly.

Hydrophis inornatus (Gray, 1849). *Hydrophis inornatus* was described by Gray (1849) who gave the type locality "Indian Ocean" with no further information. The validity of *Hydrophis inornatus* as a species is doubtful and only the type specimen was recognized by Rasmussen (1989) in this taxon until Kharin and Czeblukov (2005) referred to a specimen collected in Australia (Arafura Sea). However, we have not found any other evidence to support Kharin and Czeblukov's (2005) claim that it occurs in Australia. We find little similarity between Kharin and Czeblukov's *H. inornatus* specimen (TINRO R11) and the type of *H. inornatus* (BMNH 1946.1.1.27). In particular, the maxillary bone shown in figure 2 of Kharin and Czeblukov (2005) is markedly different from that of the type of *H. inornatus* (see also Rasmussen, 1989; M. A. Smith, 1926); further the type does not have any spots on its body, unlike the specimen in Kharin and Czeblukov (2005). The specimen shown in Kharin and Czeblukov (2005) more closely resembles *H. major* in all the morphological characters mentioned, including the number of scale rows around neck and body, ventrals, subcaudals, number of teeth on maxillary bone and body form and colour pattern. Kharin and Czeblukov (2005) also included another specimen from Arafura Sea (NTMR897) mentioned by Cogger (1975) as a possible *H. inornatus*; however, this specimen differs in ventral scale count to *H. inornatus* (Cogger, 1975). We therefore include this species neither in the checklist nor in the list of possible Australian sea snakes. Another recent paper published new records for *H. inornatus* from the Arabian Sea (Kharin & Dotsenko, 2012); however, based on photos included by the authors these specimens bear little resemblance to either the specimen from Australia or the type specimen, and instead clearly resemble *Hydrophis viperinus* (Schmidt, 1852) based on the diagnostic characters for this species (large ventral scales in the anterior part of the body) (Kharin & Dotsenko, 2012 Figures 2 and 3).

Hydrophis laboutei Rasmussen and Ineich 2000. First described from the Chesterfield Reefs New Caledonia based on two specimens deposited at NHMN. We have found another specimen of *H. laboutei* in the collection of the Australian Museum also from Chesterfield Reefs. The type locality is not far from Australian waters so this species is likely to occur on reef complexes within eastern Australian waters (Cogger, 2007) and therefore we include it in the possible list.

Hydrophis melanocephalus Gray, 1849. This species is first mentioned by McDowell (1972) and later by Cogger (1975) and Minton (1975), from the Australian region. Kharin (1984a) re-described the Australian specimens referred by McDowell to *H. melanocephalus* and created a new species, *H. coggeri* (Kharin, 1984a). *Hydrophis coggeri* was accepted as a valid species occurring in the Australian and Southeast Asian regions to Fiji (Cogger, 1992; Heatwole & Cogger, 1994a; Ineich, 2007; Sanders, Lee, *et al.*, 2013; Wilson & Swan, 2010). The distribution of *H. melanocephalus* is recorded as the following: Japan, China, Taiwan, Vietnam and Sulawesi (David & Ineich, 1999; Rasmussen, Elmberg, *et al.*, 2011; Sanders, Rasmussen, *et al.*, 2013). We have not found any specimens or other evidence to confirm *H. melanocephalus* in Australian waters. We therefore include this species neither in the checklist nor in the list of possible Australian sea snakes and regard all the Australian specimens referred to *H. melanocephalus* as belonging to the taxon *H. coggeri*.

Hydrophis melanosoma Günther, 1864. Shuntov (1971) suggested that 19% of the trawled specimens from shoal waters of the northwest coast of Australian belong to *Hydrophis melanosoma*. This claim was cited by several subsequent authors (e.g. Cogger, 1975; Cogger *et al.*, 1983; Minton, 1975), although Cogger (1992) considered the presence of *H. melanosoma* in Australian waters as "uncertain". The identifications by Shuntov lacks validation by any specimen of *H. melanosoma* having been collected or reported from this area since. Shuntov's identification, in our opinion, was incorrect. We therefore exclude *H. melanosoma* from the checklist and the list of possible Australian sea snakes.

Hydrophis obscurus Daudin, 1803/*Hydrophis vorisi* Kharin, 1984. McDowell (1972) mentioned *Hydrophis obscurus* for the first time in the Australian region based on a single specimen from the east bank of the Fly River opposite Sturt Island, Papua New Guinea. Cogger (1975), Minton (1975) and Cogger *et al.* (1983) followed McDowell (1972) in recognising *H. obscurus* from Australia. However, Kharin (1984b) later described a new species, *H. vorisi*, based on McDowell's description of the Fly River specimen and referred a second specimen (MCZ 141979) from the same area to this new species. Both specimens of *H. vorisi* are thus recorded from the southern coast of New Guinea (Kharin, 1984b, 2004b) excluding the species from Australian waters. However, we include the species in the possible Australian species list because, given this species' occurrence on the south coast of New Guinea, it may be found in Australian waters in future.

Concerning *H. obscurus*, we have found no evidence or specimens to support its occurring in the Australian region. We therefore regard *H. obscurus* as an Asian endemic known only from the east coast of India, Bangladesh and Myanmar (David & Ineich, 1999; M. A. Smith, 1926).

Hydrophis ornatus (Gray, 1842)/*Hydrophis ocellatus* Gray, 1849. Smith (1926) regarded *H. ocellatus* to be a subspecies of *H. ornatus* and referred Australian specimens previously included in *H. ornatus* to it. Later, *H. o. ocellatus* was raised to species level because of its distinctive DNA, colour pattern and a higher number of midbody scale rows compared with *H. o. ornatus* in Asia (Rasmussen, Murphy, *et al.*, 2011; Sanders, Lee, *et al.*, 2013; L. A. Smith, 1974). However, the name *H. ornatus* is still used by most authors in Australia (Brewer *et al.*, 2006; Cogger, 1975, 2007; Lukoschek & Keogh, 2006; Wells, 2007; Wilson & Swan, 2010). *Hydrophis ocellatus* is a widespread species found in most tropical and subtropical Australian waters (Brewer *et al.*, 2006; Cogger, 1975, 2007; Redfield *et al.*, 1978; L. A. Smith, 1974; Ward, 2000; Wassenberg, Milton, & Burrige, 2001). We have found no specimens or been otherwise able to confirm *H. ornatus* occurs in Australian waters. All the records we have examined of this complex belong to *H. ocellatus*. It is interesting that specimens of *H. ornatus* but not *H. ocellatus* have been collected in New Caledonia waters (Ineich & Rasmussen, 1997), indicating that the two species exclude each other in some regions. There is no evidence that *H. ornatus* does occur in Australian waters. We therefore include *H. ornatus* neither in the checklist nor in the list of possible Australian sea snakes.

Hydrophis schistosus Daudin, 1803/*Hydrophis zweifeli* (Kharin, 1985). McDowell (1972) mentioned a specimen from Sepik River, East Sepik District, New Guinea (AMNH 104340) that was very similar to the 'beaked sea snake', *H. schistosus*, but showed some morphological characters which were not in accordance with *H. schistosus*. Later Kharin (1985) described a new species, *Enhydrina zweifeli*, based on McDowell's (1972) data. The similarity with *H. schistosus* is striking. However, a recently published paper presented molecular evidence showing the two species represent distinct lineages and are not each other's closest relatives, indicating convergent phenotypic evolution probably related to a specialist diet of large, spiny prey (Ukuwela, de Silva, Fry, Lee, & Sanders, 2012). Morphological analysis of 18 specimens from the Asian region and 12 specimens from Australia suggested the specimens in Australian waters all belong to *H. zweifeli* based on scale counts and colour pattern characters, thus excluding *H. schistosus* from Australian waters (Ukuwela, de Silva, *et al.*, 2012). However, more molecular and morphological analyses of additional specimens are needed to determine the precise distributions of the two species (Ukuwela, de Silva, *et al.*, 2012). Based on the above, we exclude *H. schistosus* from the list of sea snakes occurring in Australian waters in favour of *H. zweifeli*.

Hydrophis spiralis (Shaw, 1802). Ineich and Rasmussen (1997) mentioned *H. spiralis* for the first time in New Caledonia, which is surprising, as it has never been collected in Australian waters. The known distributions of *H. spiralis* are the Persian Gulf in the west to Vietnam in the east, Indonesia including Java and Sulawesi in the south (David & Ineich, 1999; Rasmussen, Elmer, *et al.*, 2011). Whether it was a vagrant specimen from Asia or there is a population at New Caledonia is uncertain, but with only one specimen collected from New Caledonia without precise locality (Ineich & Rasmussen, 1997), we do not include it in the possible list until further specimens have confirmed its presence closer to Australian waters.

Microcephalophis gracilis (Shaw, 1802). *M. gracilis* is mentioned by M. A. Smith (1926) as occurring in Australia based on one specimen at the Australian Museum in Sydney (AMR6719). Cogger (1975) regarded this specimen as of doubtful provenance, but mentioned another from the Gulf of Papua (MCR142375), indicating *M. gracilis* does

occur in Australian waters. The specimens mentioned as *M. gracilis* at the Museum Victoria, Melbourne turned out to be *H. elegans* (examined by ARR). Ineich and Rasmussen (1997) could not confirm *M. gracilis* in New Caledonian waters as the specimens identified by Gail and Rageau (1958) turned out to be *H. coggeri*. We have found no evidence to include this species in the checklist, but based on the specimen from Gulf of Papua we include it in the possible list.

Laticauda Laurenti, 1768. The countries around Australia have at least six *Laticauda* species (Cogger & Heatwole, 2006; Heatwole *et al.*, 2005). In the literature two species are reported from Australian waters: *L. colubrina* and *L. laticaudata* (Cogger, 1975; Minton, 1975; M. A. Smith, 1926). At least 3 specimens of *L. colubrina* are deposited in the Australian Museum, Sydney: AMS R20883 from Sydney, R2954 from Wollongong, and R11524 from Victorian N. Hill and one from Museum Victoria, Melbourne: D 4276 from Sydney. Three of the localities are in New South Wales and indicate the specimens are waifs, one is from inland western Victoria (the desert town Northern Hill) indicating a wrong locality. At least three Australian specimens of *L. laticaudata* are deposited in museum collections, one in BMNH:55.10.16.439 from Tasmania, one in ZMUC: 66265 from Sydney and one in Museum Victoria, Melbourne 60287 from Torres Strait also indicating waif specimens. We have found no further specimens reported from Australia indicating that *Laticauda* is not breeding in Australian waters despite there being breeding populations from surrounding countries (Bonnet, Brischoux, Pearson, & Rivalan, 2009; Brischoux & Bonnet, 2009). McCarthy (1986) suggests that competition from the *Aipysurus* species might, at least in part, be responsible for the rarity of *Laticauda* in Australian waters. Greer (1997) suggests that it may be due to the absence of coastal limestone rocks in northern Australia which is the preferred sheltering and egg-laying sites for these species. Further investigation in the northern part of coastal Australia is much needed before we can include *Laticauda* in the checklist; however, we include *Laticauda* sp. in the possible list.

Checklist of Sea Snake Species Known to Occur in Australia

Aipysurus apraefrontalis Smith, 1926
Aipysurus duboisii Bavay, 1869
Aipysurus foliosquama Smith, 1926
Aipysurus fuscus (Tschudi, 1837)
Aipysurus laevis Lacépède, 1804
Aipysurus mosaicus Sanders *et al.* 2012
Aipysurus pooleorum Smith, 1974
Aipysurus tenuis Lønneberg and Anderson, 1913
Emydocephalus annulatus Krefft, 1869
Ephalophis greyae Smith, 1931
Hydrelaps darwiniensis Boulenger, 1896
Hydrophis atriceps Günther, 1864
Hydrophis belcheri (Gray, 1849)
Hydrophis caeruleus (Shaw, 1802)
Hydrophis coggeri (Kharin, 1984a)
Hydrophis curtus (Shaw, 1802)
Hydrophis czeblukovi (Kharin, 1984a)
Hydrophis donaldi Ukuwela, Sanders and Fry 2012
Hydrophis elegans (Gray, 1842)
Hydrophis kingii Boulenger, 1896
Hydrophis macdowellii Kharin, 1983
Hydrophis major (Shaw, 1802)
Hydrophis ocellatus Gray, 1849
Hydrophis pacificus Boulenger, 1896
Hydrophis peronii (Duméril, 1853)
Hydrophis platurus (Linnaeus, 1766)

Hydrophis stokesii (Gray in Stokes, 1846)
Hydrophis zweifeli (Kharin, 1985)
Parahydrophis mertoni (Roux, 1910)

List of Sea Snakes Possibly Occurring in Australia

Hydrophis laboutei Rasmussen and Ineich, 2000
Hydrophis vorisi Kharin, 1984b
Microcephalophis gracilis (Shaw, 1802)
Laticauda sp. Laurenti, 1768

Identification key to Australian sea snakes including 4 possibly

Identifying sea snakes to species level is not an easy task. The genus *Hydrophis* in particular shows great interspecific and intraspecific variation and interspecific convergence making identification problematic when using only external characters. The key is based primarily on counting ventral scales and scale rows around the neck and body, but shape and size of the head and the position of the maxillary bone are other distinguishing characters.

A combination of characters are required to identify a specimen. In using the key it is important that all the identifying characters fit with the specimen at each step in the key. If this is not the case, the alternative “not as above” should be followed. When counting scale rows around the neck and body it is important to note that the count around the neck is a minimum count and the count around the body is a maximum count (as in Smith, 1926). Record the minimum count of three or four scale rows around the neck at one and a half head lengths, two, two and a half, and three head lengths behind the head. The maximum number of body scales occurs just behind midbody, but three to four counts between midbody and vent are required. The most precise scale row count follows a transverse line across the dorsal surface of the body starting from a ventral scale to a ventral scale on the other side of the body (Thomas, 1976). Ventral scales are excluded from the count of scale rows. “Ground colour” refers to the colour between the darker dorsal markings or bands (if present), and is generally the same as the colour on the ventral side. “Bands” here refers to darkish transverse markings anywhere on the body. Drawings are by Mogens Andersen ZMUC. The nomenclature follows Sanders, Lee, *et al.* (2013).

1.
 - A Nasals separated by internasals (fig.1 left) *Laticauda*
 - B Nasals not separated by internasals (fig.1 right) 2.
2.
 - A Three supralabials, the second very elongated (fig.2 left) *Emydocephalus annulatus*
 - B More than four supralabials (fig.2 right) 3.
3.
 - A No preocular scale, the prefrontal borders the eye (fig.3 left) *Hydrelaps darwiniensis*
 - B Preocular scales present (fig.3 right) 4.
4.
 - A Ventrals small, each not more than 2 times as broad as adjacent body scales
 *Hydrophis* and *Microcephalophis* (21 species—key below)
 - B Ventrals large, each at least 3 times as broad as adjacent body scales 5.
5.
 - A At least 28 scale rows around body *Parahydrophis mertoni*
 - B Less than 28 scale rows around body: 6.
6.
 - A Maxillary bone not extending forwards as far as palatine (fig.4 left) *Ephalophis greyae*
 - B Maxillary bone and palatine straight, or maxillary bone reaching beyond palatine (fig.4 right)
 *Aipysurus* (8 species—key below)

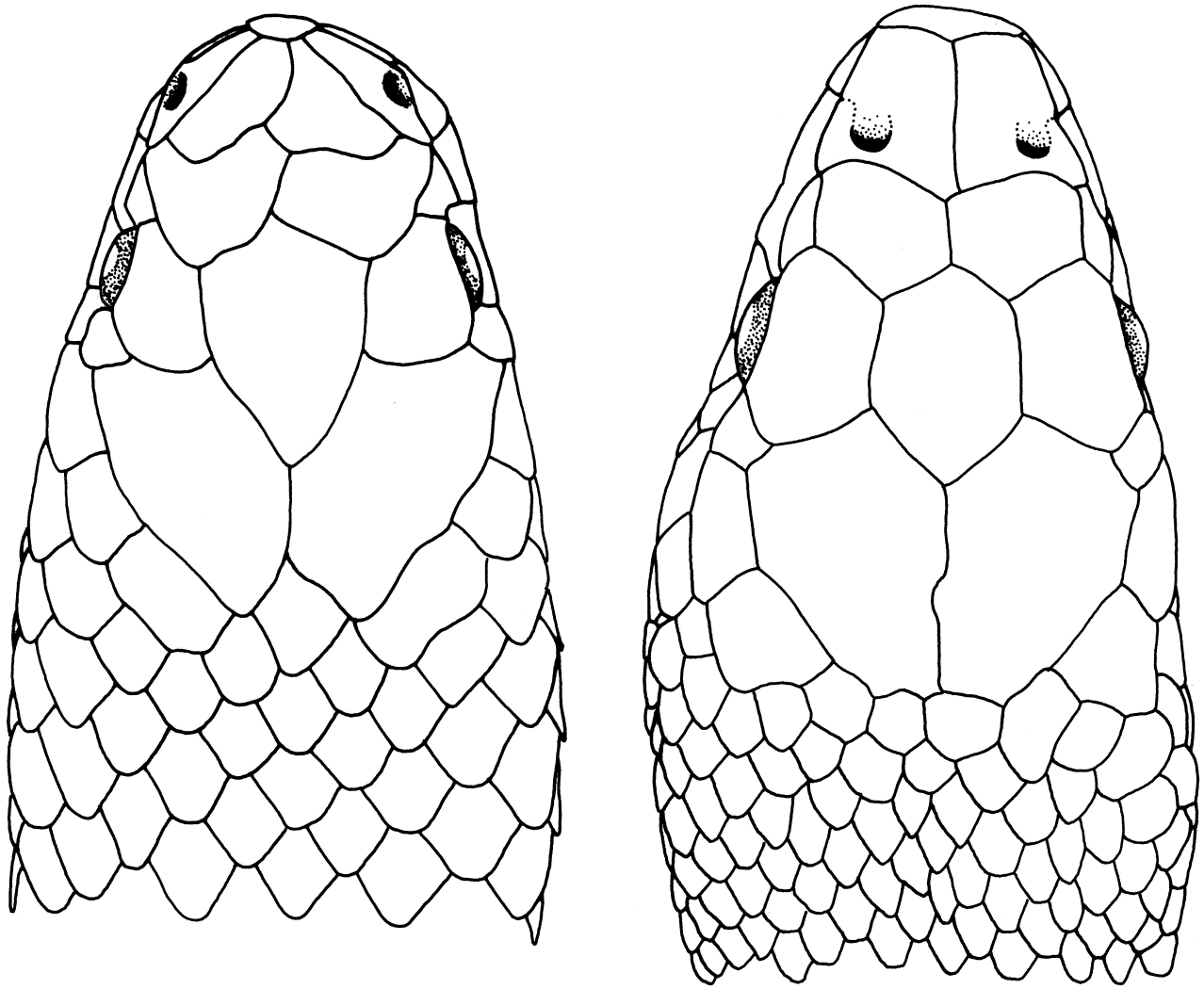
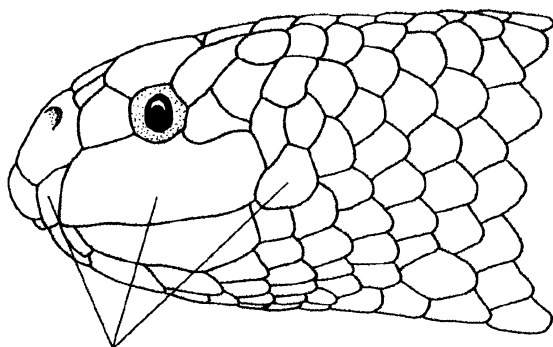
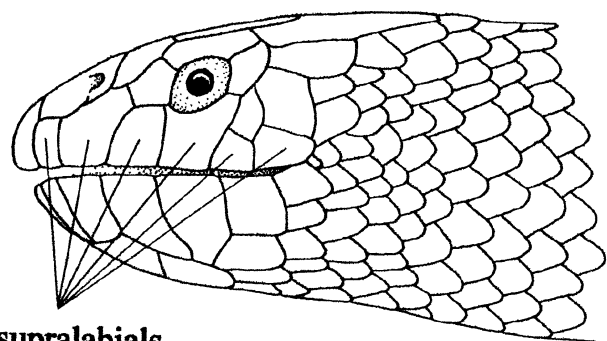


FIGURE 1. Nasals separated by internasals (left): *Laticauda*. Nasals not separated by internasals (right).



supralabials



supralabials

1 cm

FIGURE 2. Three supralabials, the second is very elongated (left): *Emydocephalus annulatus*. More than four supralabials (right).

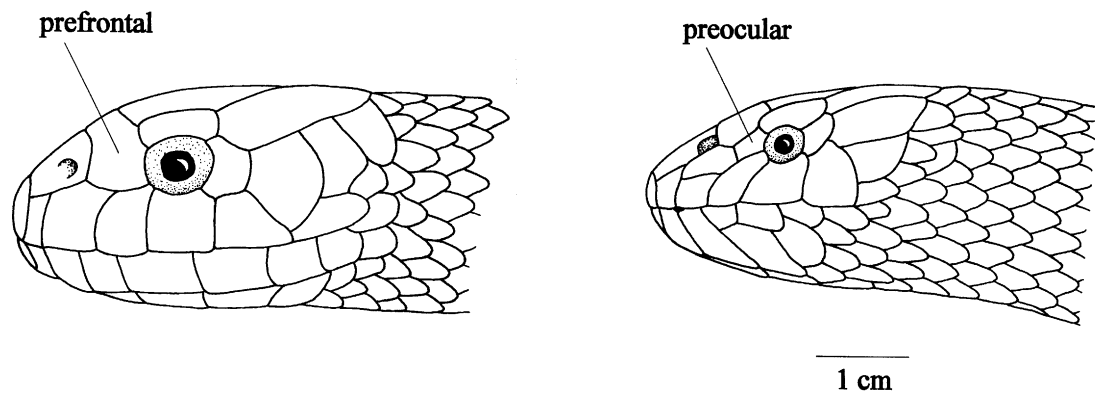


FIGURE 3. No preocular scale, the prefrontal borders the eye (top): *Hydrelaps darwiniensis*. Preocular scales present (bottom).

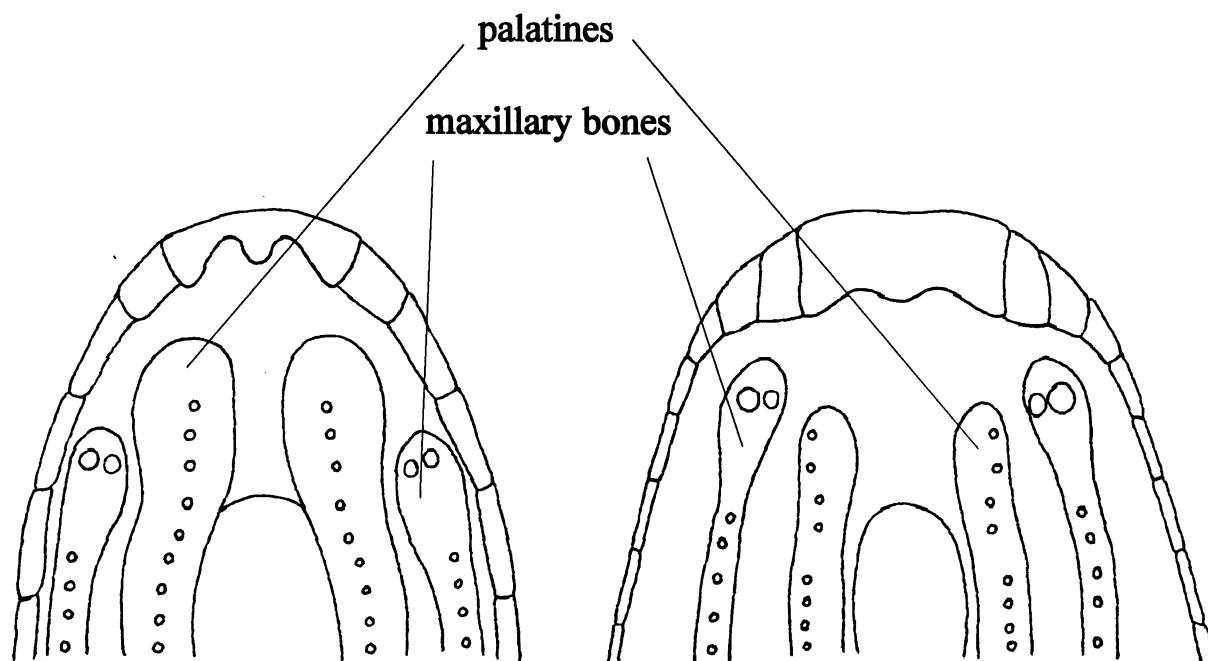


FIGURE 4. The roof of the mouth showing maxillary bone not extending forwards as far as palatine (left): *Ephalophis greyae*. Maxillary bone and palatine straight, or maxillary bone reaching beyond palatine (right): *Aipysurus* (8 species -key below).

A key to the genus *Aipysurus* in Australia

- 1.
 - A At least 180 ventral scales *A. tenuis*
 - B Less than 180 ventral scales 2.
- 2.
 - A Ventrals with a deep notch in the posterior border (Fig.5 top) 3.
 - B Ventrals without or with only a slight median notch on the posterior border (Fig.5 bottom). 4.
- 3.
 - A Less than 19 scale rows around midbody and without prefrontal scales (Fig.6 left) *A. apraefrontalis*
 - B At least 19 scale rows around midbody and with prefrontal scales (Fig.6 right) *A. foliosquama*
- 4.
 - A All head shields symmetrical and no supralabials divided horizontally (Fig.7 left). *A. mosaicus*
 - B Head shields more or less broken up and some of the supralabials divided horizontally (Fig.7 right) 5.
- 5.
 - A All head shields broken up into small irregular scales (fig.8). *A. duboisii*
 - B Only some of the head shields broken up, especially parietals. 6.

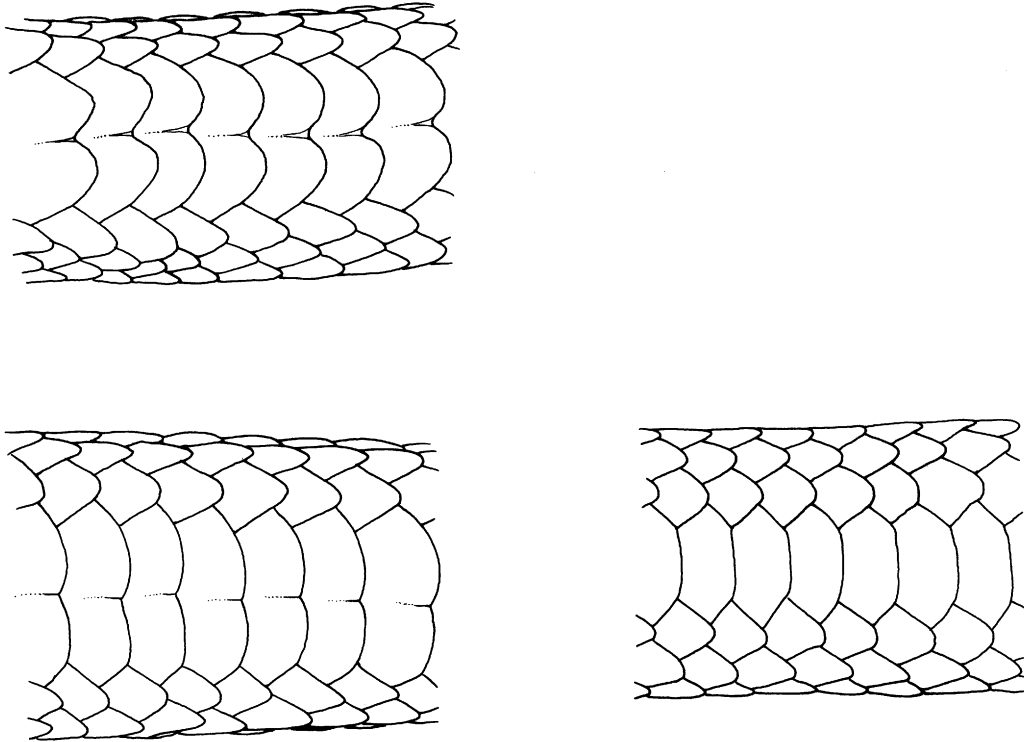


FIGURE 5. Ventrals with a deep notch in the posterior border (top): *Aipysurus apraefrontalis* and *A. foliosquama*. Ventrals without or with only a slight median notch on the posterior border (bottom).

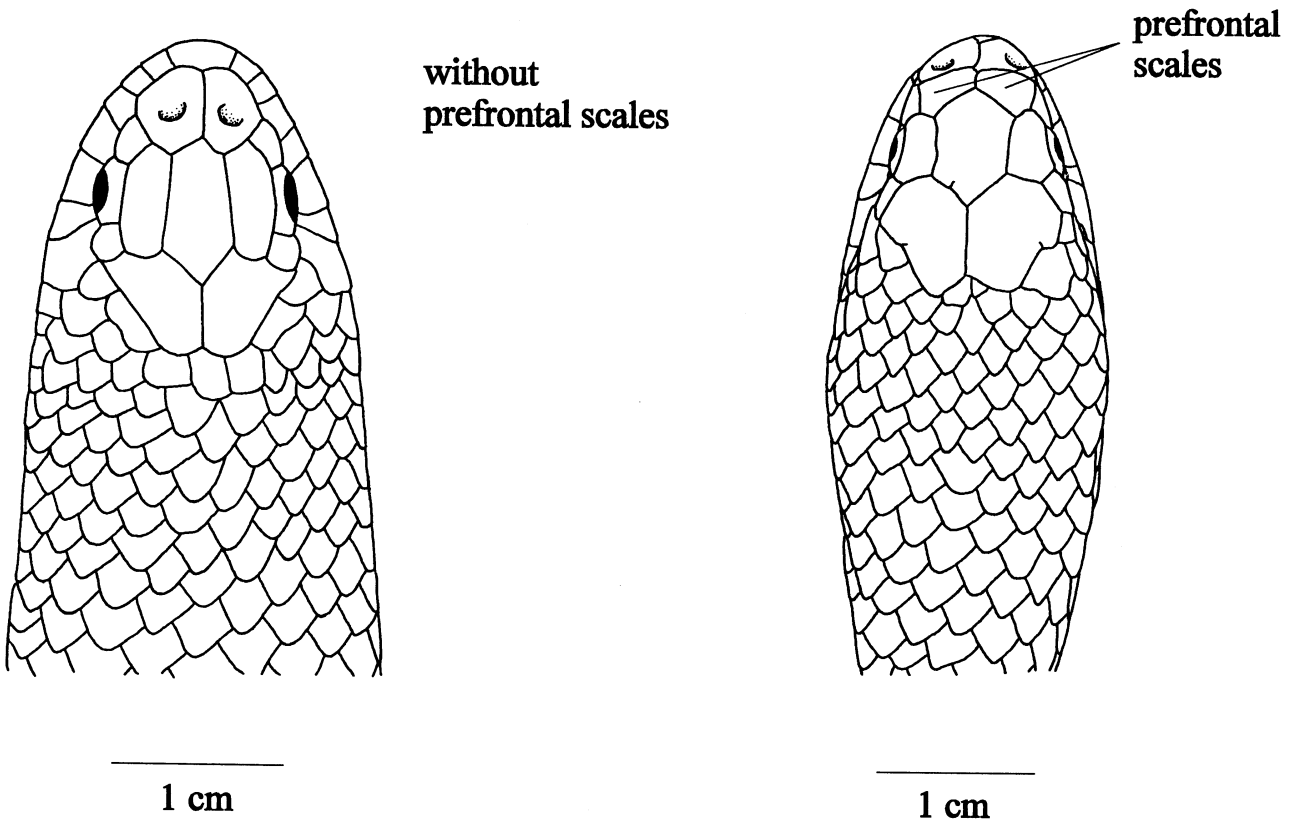


FIGURE 6. Without prefrontal scales (left): *A. apraefrontalis*. With prefrontal scales (right).

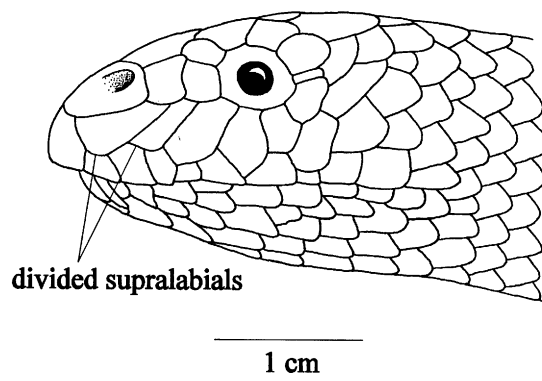
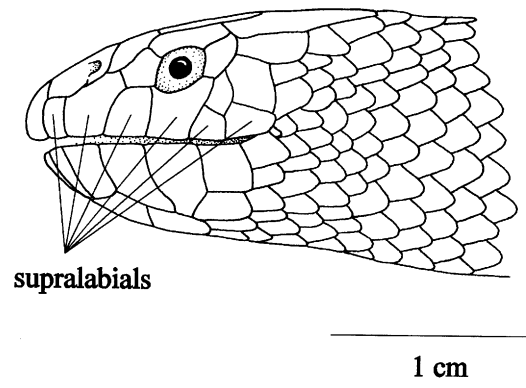


FIGURE 7. No horizontal dividing of supralabials (top): *A. mosaicus*. Some of the supralabials divided horizontally (bottom).

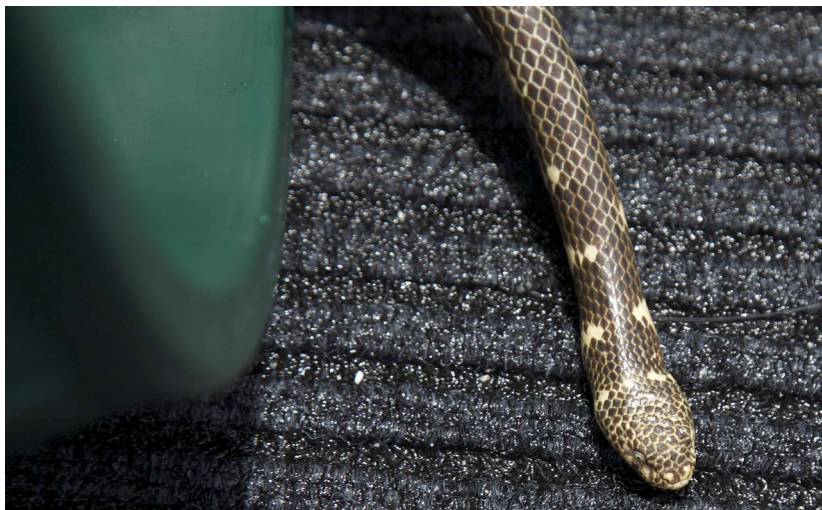


FIGURE 8. All head shields broken up into small irregular scales: *A. duboisii*.

6.
 A At least 155 ventrals and less than 21 scale rows around midbody *A. fuscus*
 B Less than 155 ventrals and at least 21 scale rows around midbody *A. laevis/pooleorum*

A key to the genus *Hydrophis* and *Microcephalophis gracilis*

1.
 A Elongated mental shield several times longer than broad (Fig.9 left) *H. zweifeli*
 B Mental shield not much longer than broad (Fig.9 right) 2.
 2.
 A Ventrals (except on the throat) divided into pairs of overlapping scales (Fig.10 top) *H. stokesii*
 B Ventrals in the posterior part of body divided into pairs of not overlapping scales (Fig.10 bottom) .. *Microcephalophis gracilis*
 C Not as above 3.
 3.
 A Blunt spines on rear edge of some of the head shields (Fig.11) *H. peronii*
 B Not as above 4.
 4.
 A Head elongated with snout bill-like and flattened, very wide gape (Fig.12), the normal colour pattern is yellow on ventral side and black on dorsal side *H. platurus*
 B Not as above 5.
 5.
 A Ventrals very small and difficult to distinguish, scales in the lowermost scale rows on flanks enlarged compared to dorsal scales (Fig.13) *H. curtus*
 B Not as above 6.
 6.
 A Less than 275 ventrals and less than 30 scale rows around neck 7.
 B Not as above 8.
 7.
 A Between bands and on the sides two or three series of spots or dark-edged markings, head very small and body compressed posteriorly (Fig. 14). *H. macdowellii*
 B Not as above 8.
 8.
 A Less than 25 scale rows around neck and more than 70 dark cross bands on body and tail. *H. vorisi*
 B Not as above 9.
 9.
 A Less than 275 ventrals and less than 44 scale rows around body 10.
 B Not as above 11.
 10.
 A Less than 38 bands on body and small dark spots on the sides. *H. major*
 B Not as above 11.
 11.
 A Less than 37 scale rows around body, less than 320 ventrals and more than 45 bands on body and tail 12.
 B Not as above 13.
 12.
 A Between 57 and 69 bands on body and tail. *H. belcheri*
 B Between 46 and 56 bands on body and tail. *H. donaldi*
 13.
 A More than 345 ventrals and spots on the flanks and between bands (Fig. 15) *H. elegans*
 B Not as above 14.
 14.
 A Less than 285 ventrals. 15.
 B Not as above 16.
 15.
 A Less than 30 scale rows around neck and more than 41 scale rows around body. *H. laboutei*
 B Not as above 16.
 16.
 A More than 50 scale rows around body and one or two rows of regular black pentagonal markings on the side, primary colour dark brown to black (Fig. 16) *H. czeblukovi*
 B Not as above 17.
 17.
 A More than 30 scale rows around neck and body with ocelli on the sides, ground colour white (Fig.17). *H. ocellatus*
 B Not as above 18.

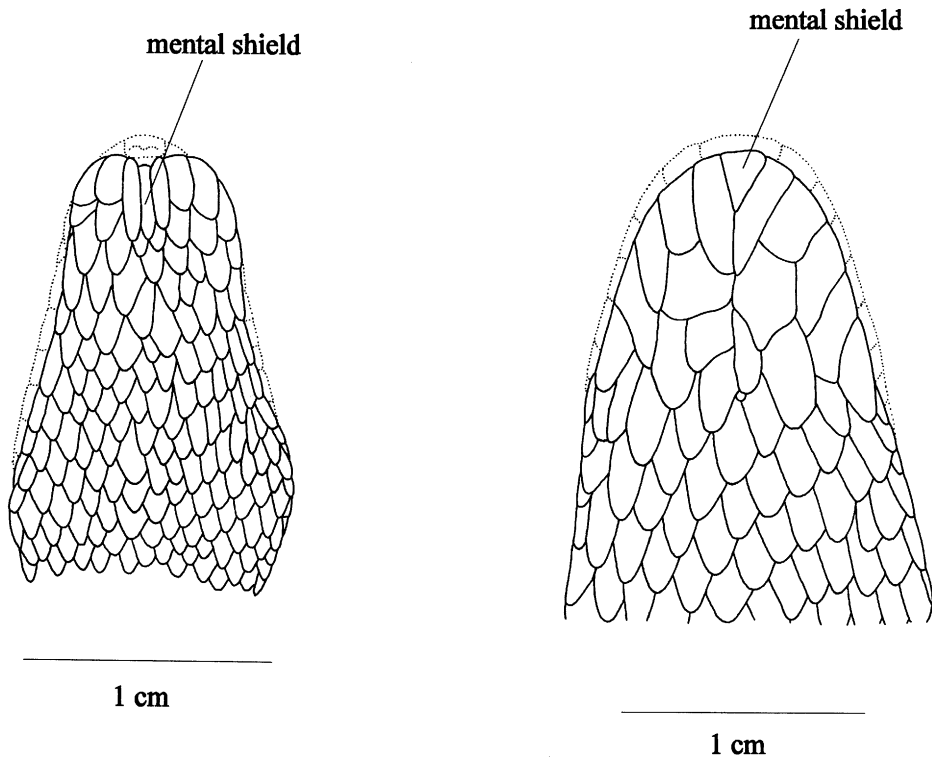


FIGURE 9. Elongated mental shield several times longer than broad (left): *H. zweifeli*. Mental shield not much longer than broad (right).

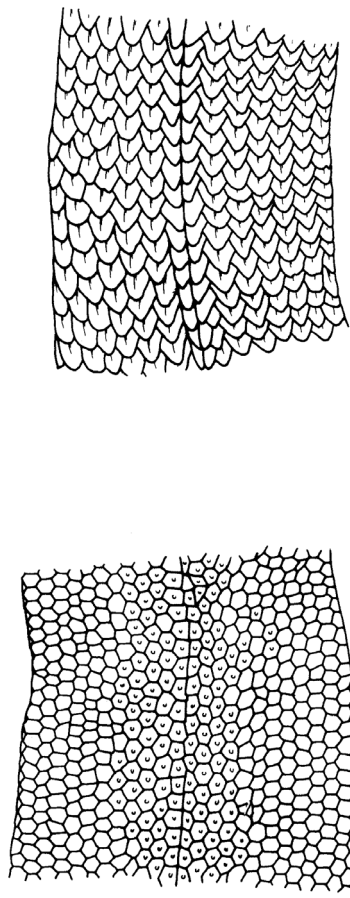


FIGURE 10. Ventrals (except on the throat) divided into pairs of overlapping scales (top): *H. stokesii*. Ventrals on the posterior part of the body divided into pairs of not overlapping scales (bottom): *Microcephalophis gracilis*.

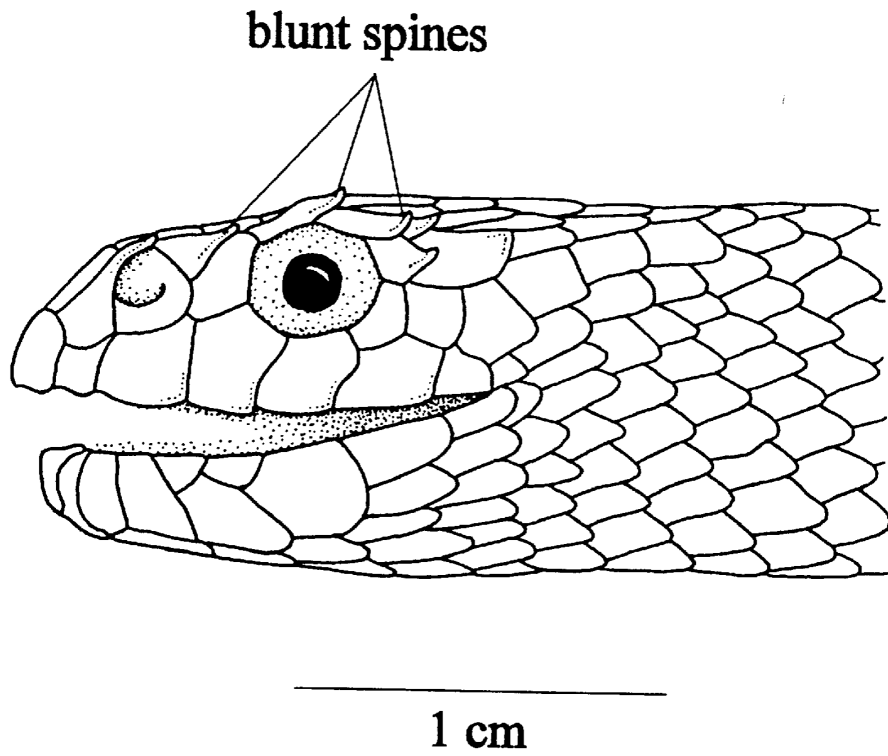


FIGURE 11. Blunt spines on rear edge of some of the head shields: *H. peronii*.

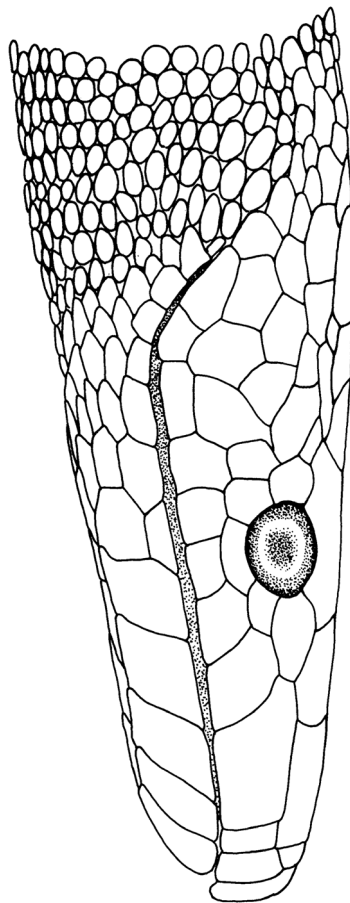


FIGURE 12. Head elongated with snout bill-like and flattened, very wide gape: *H. platurus*.

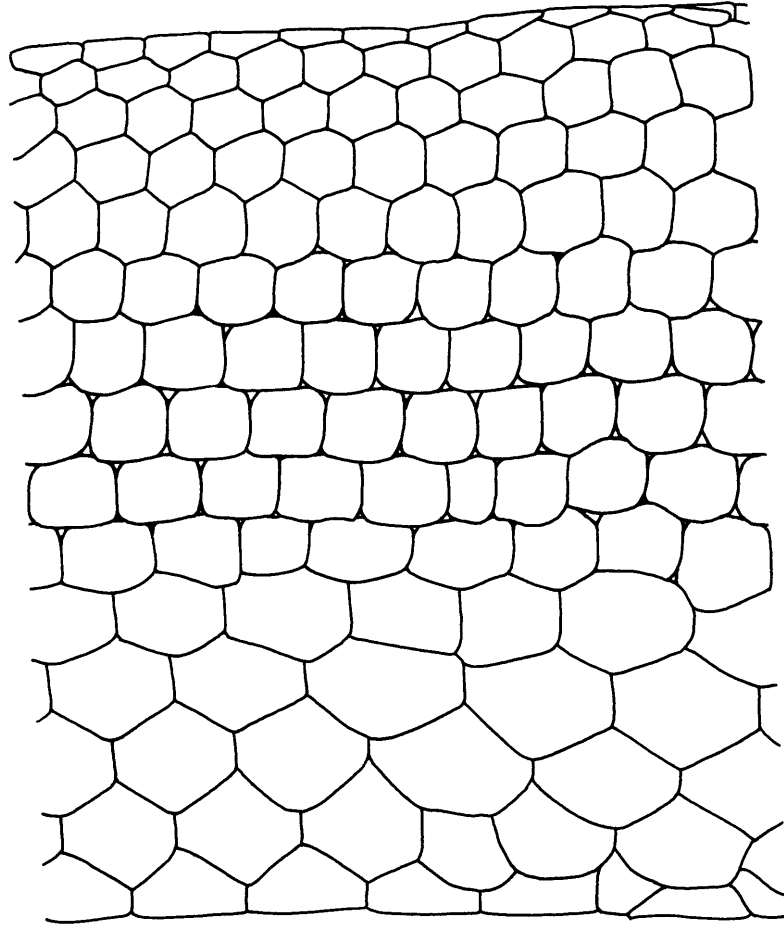


FIGURE 13. Scales in the lowermost scale rows on flanks enlarged compared to dorsal scales: *H. curtus*.



FIGURE 14. Two or three series of spots or dark-edged markings between dark bands, head very small and body compressed posteriorly: *H. macdowellii* (juvenile pictured).



FIGURE 15. Spots on the flanks and between the bands: *H. elegans*.



FIGURE 16. One or two rows of regular black pentagonal markings on the side, primary colour dark brown or black: *H. czeblukovi*.



FIGURE 17. Body with ocelli on the sides, ground colour white: *H. ocellatus*.

- 18.
 - A More than 30 scale rows around neck, ground colour not yellow and more than 12 maxillary teeth behind fang *H. caeruleus*
 - B Not as above 19.
- 19.
 - A Head small and neck elongated and body more than 3 times as broad as head 20.
 - B Not as above 22.
- 20.
 - A A white ring around the eye and less than 5 maxillary teeth behind fang *H. kingii*
 - B Not as above 21.
- 21.
 - A Less than 38 scale rows around neck *H. coggeri*
 - B More than 38 scale rows around neck *H. atriceps*
- 22.
 - A More than 40 bands on body and tail *H. pacificus*
 - B Less than 40 bands on body and tail *H. coggeri*

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