

= Hydrophiinae =

The Hydrophiinae , also known as coral reef snakes or sea snakes , are a subfamily of venomous elapid snakes that inhabit marine environments for most or all of their lives . Most are extensively adapted to a fully aquatic life and are unable to move on land , except for the genus *Laticauda* , which has limited land movement . They are found in warm coastal waters from the Indian Ocean to the Pacific and are closely related to venomous terrestrial snakes in Australia .

All have paddle @-@ like tails and many have laterally compressed bodies that give them an eel @-@ like appearance . Unlike fish , they do not have gills and must surface regularly to breathe . They are among the most completely aquatic of all air @-@ breathing vertebrates . Among this group are species with some of the most potent venoms of all snakes . Some have gentle dispositions and bite only when provoked , but others are much more aggressive . Currently , 17 genera are described as sea snakes , comprising 62 species .

= = Description = =

The majority of adult Hydrophiinae species grow to between 120 and 150 cm (3 @. @ 9 and 4 @. @ 9 ft) in length , with the largest , *Hydrophis spiralis* , reaching a maximum of 3 m (9 @. @ 8 ft) . Their eyes are relatively small with a round pupil and most have nostrils located dorsally . The skulls do not differ significantly from those of terrestrial elapids , although the dentition is relatively primitive with short fangs and (with the exception of *Emydocephalus*) as many as 18 smaller teeth behind them on the maxilla .

Most Hydrophiinae are completely aquatic and have adapted to their environments in many ways , the most characteristic of which is a paddle @-@ like tail that has improved their swimming ability . To a varying degree , the bodies of many species are laterally compressed , especially in the pelagic species . This has often caused the ventral scales to become reduced in size , even difficult to distinguish from the adjoining scales . Their lack of ventral scales means they have become virtually helpless on land , but as they live out their entire lifecycles at sea , they have no need to leave the water .

The only genus that has retained the enlarged ventral scales is the sea kraits , *Laticauda* , with only five species . These snakes are considered to be more primitive , as they still spend much of their time on land , where their ventral scales afford them the necessary grip . *Laticauda* species are also the only sea snakes with internasal scales , i.e. , their nostrils are not located dorsally .

Since it is easier for a snake 's tongue to fulfill its olfactory function under water , its action is short compared to that of terrestrial snake species . Only the forked tips protrude from the mouth through a divided notch in the middle of the rostral scale . The nostrils have valves consisting of a specialized spongy tissue to exclude water , and the windpipe can be drawn up to where the short nasal passage opens into the roof of the mouth . This is an important adaptation for an animal that must surface to breathe , but may have its head partially submerged when doing so . The lung has become very large and extends almost the entire length of the body , although the rear portion is thought to have developed to aid buoyancy rather than to exchange gases . The extended lung possibly also serves to store air for dives .

Most species of the Hydrophiinae are able to respire through the top of their skin . This is unusual for reptiles , because their skin is thick and scaly , but experiments with the black @-@ and @-@ yellow sea snake , *Pelamis platura* (a pelagic species) , have shown this species can satisfy about 25 % of its oxygen requirements in this manner , which allows for prolonged dives .

Like other land animals that have adapted to life in a marine environment , sea snakes ingest considerably more salt than their terrestrial relatives through their diets , and when seawater is inadvertently swallowed . This meant they had to evolve a more effective means of regulating the salt concentration of their blood . In sea snakes , the posterior sublingual glands , located under and around the tongue sheath , evolved to allow them to expel salt with their tongue action .

Scalation among sea snakes is highly variable . As opposed to terrestrial snake species that have imbricate scales to protect against abrasion , the scales of most pelagic sea snakes do not overlap .

Reef @-@ dwelling species , such as *Aipysurus* , do have imbricate scales to protect against the sharp coral . The scales themselves may be smooth , keeled , spiny , or granular , the latter often looking like warts . *Pelamis* has body scales that are " peg @-@ like " , while those on its tail are juxtaposed hexagonal plates .

= = Sensory abilities = =

Vision , chemoreception (tongue @-@ flicking) and hearing are important senses for terrestrial snakes but these stimuli become distorted in water . The poor visibility , chemical dilution and limitation of ground @-@ borne vibrations underwater suggest that sea snakes and sea kraits may have unique sensory abilities to compensate for the relative lack of other sensory cues .

Very little is known about sea snake vision . A study of retinal photoreceptors of spine @-@ bellied , *Lapemis curtus* , and horned , *Acalyptophis peronii* , sea snakes found three classes of visual pigments all from cone cells . Despite the absence of rod cells in sea snake eyes , Simeos et al. found genes from rod @-@ cells (rh1) were still being expressed suggesting that in sea snakes some cones may be transmuted rods . However , behavioural observations indicate that vision has a limited role for catching prey and mate selection , but sound (i.e. vibration) and chemoreception may be important . One study identified small sensory organs on the head of *Lapemis curtus* similar to the mechanoreceptors in alligators and aquatic snake *Acrochordus* that are used to sense the movement of fish prey . Westhoff et al. recorded auditory brain responses to vibration underwater in *Lapemis curtus* , which are sensitive enough to detect movement in prey but were not as sensitive as fish lateral line systems . Similarly , vision appears to be of limited importance for finding mates . Shine experimented with applying skin secretions (pheromones) to snake @-@ like objects to see if male turtle @-@ headed sea snakes , *Emydocephalus annulatus* , are attracted to female pheromones . Shine found that although vision may be useful over short distances (< 1 m) , pheromones are more important once the male comes in physical contact with an object .

The olive sea snake , *Aipysurus laevis* , has been found to have photoreceptors in the skin of its tail , allowing it to detect light and presumably ensuring it is completely hidden , including its tail , inside coral holes during the day . While other species have not been tested , *Aipysurus laevis* possibly is not unique among sea snakes in this respect .

Other unique senses , such as electro @-@ magnetic reception and pressure detection , have been proposed for sea snakes , but scientific studies have yet to be performed to test these senses .

= = Distribution and habitat = =

The Hydrophiinae are mostly confined to the warm tropical waters of the Indian Ocean and the western Pacific Ocean , with a few species found well out into Oceania . The geographic range of one species , *Pelamis platurus* , is wider than that of any other reptile species , except for a few species of sea turtles . It extends from the east coast of Africa , from Djibouti in the north to Cape Town in the south , across the Indian Ocean , the Pacific , south as far as the northern coast of New Zealand , all the way to the western coast of the Americas , where it occurs from northern Peru in the south (including the Galápagos Islands) to the Gulf of California in the north . Isolated specimens have been found as far north as San Clemente in the United States .

Sea snakes do not occur in the Atlantic Ocean . It is thought that *Pelamis* would be found there were it not for the cold currents off Namibia and western South Africa that keep it from crossing into the eastern South Atlantic , or south of 5 ° latitude along the South American west coast . Sea snakes do not occur in the Red Sea , believed to be due to its increased salinity , so no danger exists of them crossing through the Suez Canal . A lack of salinity is also thought to be the reason why *Pelamis* has not crossed into the Caribbean via the Panama Canal .

Despite their marine adaptations , most sea snakes prefer shallow waters near land , around islands , and especially somewhat sheltered waters , as well as near estuaries . They may swim up rivers and have been reported as far as 160 km (99 mi) from the sea . Others , such as *P. platurus* , are pelagic and are found in drift lines , slicks of floating debris brought together by surface

currents . Some sea snakes inhabit mangrove swamps and similar brackishwater habitats , and two landlocked freshwater forms are found : *Hydrophis semperi* occurs in Lake Taal in the Philippines , and *Laticauda crockeri* in Lake Te Nggano on Rennell Island in the Solomon Islands .

= = Behavior = =

Sea snakes are generally reluctant to bite , and are usually considered to be mild @-@ tempered , although variation is seen among species and individuals . Some species , such as *P. platurus* , which feed by simply gulping down their prey , are more likely to bite when provoked because they seem to use their venom more for defense . Others , such as *Laticauda* , use their venom for prey immobilization ; these snakes are often handled without concern by local fishermen , who unravel and toss them back into the water barehanded when the snakes become entangled in fishing nets . Species reported as much more aggressive include *Aipysurus laevis* , *Astrotia stokesii* , *Enhydrina schistosa* , *Enhydrina zweifeli* , and *Hydrophis ornatus* .

On land , their movements become very erratic . They crawl awkwardly in these situations and can become quite aggressive , striking wildly at anything that moves , although they are unable to coil and strike in the manner of terrestrial snakes .

Sea snakes appear to be active both day and night . In the morning , and sometimes late in the afternoon , they can be seen at the surface basking in the sunlight , and they dive when disturbed . They have been reported swimming at depths over 90 m (300 ft) , and can remain submerged for as long as a few hours , possibly depending on temperature and degree of activity .

Sea snakes have been sighted in huge numbers . For example , in 1932 , a steamer in the Strait of Malacca , off the coast of Malaysia , reported sighting " millions " of *Astrotia stokesii* , a relative of *Pelamis* ; these reportedly formed a line of snakes 3 m (9 @.@ 8 ft) wide and 100 km (62 mi) long . The cause of this phenomenon is unknown , although it likely has to do with reproduction . They can sometimes be seen swimming in schools of several dozen , and many dead specimens have been found on beaches after typhoons .

= = Feeding = =

They feed on small fish and occasionally young octopodes .

= = Reproduction = =

Except for a single genus , all *Hydrophiinae* species are ovoviviparous ; the young are born alive in the water where they live their entire lives . In some species , the young are quite large : up to half as long as the mother . The one exception is the genus *Laticauda* , which is oviparous ; its five species all lay their eggs on land .

= = Venom = =

Like their relatives in the *Elapidae* family , the majority of the *Hydrophiinae* species are highly venomous ; however , when bites occur , venom injection is rare , so envenomation symptoms usually seem nonexistent or trivial . For example , *P. platurus* has a venom more potent than any terrestrial snake species in Costa Rica based on LD50 , but despite its abundance in the waters off its western coast , few human fatalities have been reported . Nevertheless , all sea snakes should be handled with great caution .

Bites in which envenomation does occur are usually painless and may not even be noticed when contact is made . Teeth may remain in the wound . Usually , little or no swelling occurs , and rarely are any nearby lymph nodes affected . The most important symptoms are rhabdomyolysis (rapid breakdown of skeletal muscle tissue) and paralysis . Early symptoms include headache , a thick @-@ feeling tongue , thirst , sweating , and vomiting . Symptoms that can occur 30 minutes to several hours after the bite include generalized aching , stiffness , and tenderness of muscles all

over the body . Passive stretching of the muscles is also painful , and trismus , which is similar to tetanus , is common . This is followed later on by symptoms typical of other elapid envenomations : a progressive flaccid paralysis , starting with ptosis and paralysis of voluntary muscles . Paralysis of muscles involved in swallowing and respiration can be fatal .

= = Taxonomy = =

Sea snakes were at first regarded as a unified and separate family , the Hydrophiidae , that later came to comprise two subfamilies : the Hydrophiinae , or true / aquatic sea snakes (now 16 genera with 57 species) , and the more primitive Laticaudinae , or sea kraits (one genus , Laticauda , with five species) . Eventually , as it became clear just how closely related the sea snakes are to the elapids , the taxonomic situation became less well @-@ defined . Some taxonomists responded by moving the sea snakes to the Elapidae , thereby creating the subfamilies Elapinae , Hydrophiinae , and Laticaudinae , although the latter may be omitted if Laticauda is included in the Hydrophiinae . No one has yet been able to convincingly work out the phylogenetic relationships between the various elapid subgroups , and the situation is still unclear . Therefore , others opted to either continue to work with the older traditional arrangements , if only for practical reasons , or to lump all of the genera together in the Elapidae , with no taxonomic subdivisions , to reflect the work that remains to be done .

*) Not including the nominate subspecies

= = Molecular studies = =

Molecular data studies suggest all three monotypic semiaquatic genera (Ephalophis , Parahydrophis and Hydrelaps) are early diverging lineages . The Aipysurus group is monophyletic : the egg @-@ eating specialists form separate , early @-@ diverging lineages . The Hydrophiini last shared a common ancestor about 6 million years ago with the majority of extant lineages diversified over the last 3 @.@ 5 million years ago . The Hydrophis group shared a last common ancestor about 1 @.@ 5 @-@ 3 million years ago .

= = Captivity = =

At best , Hydrophiinae make difficult captives . Ditmars (1933) described them as nervous and delicate captives that usually refuse to eat , preferring only to hide in the darkest corner of the tank . Over 50 years later , Mehrtens (1987) wrote , although they were rarely displayed in Western zoological parks , some species were regularly on display in Japanese aquariums . Available food supply limits the number of species that can be kept in captivity , since some have diets that are too specialized . Also , some species appear intolerant of handling , or even being removed from the water . Regarding their requirements in captivity , the Laticauda species need to be able to exit the water somewhere at about 29 ° C , along with a submerged shelter . Species that have done relatively well in captivity include the ringed sea snake , Hydrophis cyanocinctus , which feeds on fish and eels in particular . Pelamis platurus has done especially well in captivity , accepting small fish , including goldfish . However , care has to be taken to house them in round or oval tanks , or in rectangular tanks with corners that are well @-@ rounded , to prevent the snakes from damaging their snouts by swimming into the sides .

= = Conservation status = =

Most sea snakes are not on the CITES protection lists , however , one species , Laticauda crockeri , is classified as vulnerable , another , Aipysurus fuscus , classified as endangered , and two , Aipysurus foliosquama and Aipysurus apraefrontalis , are classified as critically endangered according to the IUCN Red List of Threatened Species .