Review on Nonvenomous Marine Serpentes: Little File *S*ea Snake *Acrochordus granulatus* (Schneider, 1799), with an Observation on Bycatch Composition from India

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Abstract:

The snake family Acrochordidae (non-venomous) includes the single genus, *Acrochordus*. All three *Acrochordus* species are aquatic snakes and confined to tropical oceans inhabiting coastal ecosystems of the Indo-Australian region. The three extant *Acrochordus* species exhibit strikingly different ecology, scalation, internal anatomy, and osteology. They have some of the most functional morphology and physiology for life in the aquatic environment compared to terrestrial and amphibious species viz sea kraits. *Acrochordus granulatus* is the most widely distributed species. There is little information recognized about the factors influencing the spatial and temporal stability of this specie's population. The species is commonly caught as bycatch in India that could lead to significant mortality. However, there is no data on status assessments of these snakes available. Long-term monitoring of populations is essential to evaluate the success of the persistence of marine snakes. This paper aims to compile the existing information on diversity, biology, and ecology of *A. granulatus*. Also, it highlights the threats to the sea snakes in general including the impact of pollution on the coastal and marine environment.

Key words: Coastal ecosystem, Threats, Conservation, Ecology, Human-snake negative interaction

Introduction:

Reptiles play an essential role in ecological processes. However, reptiles' roles in ecosystems, especially those inhabiting coastal areas are undervalued (De Miranda, 2017). Sea snakes are confined to the warm tropical waters of the Indian Ocean and western Pacific Ocean (Stidworthy, 1974). They mostly occupy coral reefs, intertidal areas and muddy beaches (Venkataraman *et al*., 2012). Several adaptations have permitted sea snakes to accommodate to the marine environment (Damotharan *et al*., 2010). The marine adaptations include swimming, respiration, salt excretion, marine fouling and skin shedding (Heatwole, 1999). They also have developed an oar like tail that further enhances their locomotion in water. A posterior sublingual gland under their tongue concentrates and excretes excess salt water from their body (Greene, 1997). Sea snakes shed their skin more often than land snakes, to remove fouling organisms like barnacles (Heatwole, 1999; Cogger, 2000; Karleskint *et al*., 2012). Sea snakes play a crucial trophic role in near-shore marine ecosystems as predators (Venkatraman *et al*., 2012). They are protected in India under the Indian Wildlife Protection Act, 1972 - Schedule IV (Whitaker *et al*., 2004). Though they are ubiquitous, detailed information on these snakes lacks in India.

Family: Acrochordidae:

The family Acrochordidae (file snakes), consists of three extant species distributed over the tropical regions of the eastern Indian Ocean and the western Pacific (Ng, 2011). They are the Arafura file snake (*Acrochordus arafurae*), the Elephant trunk snake (*Acrochordus javanicus*) and the Little file snake (*Acrochordus granulatus*). The Little file snake is the smallest member of family Achrochordidae. All three living species of the Acrochordidae use a combination of aquatic environments ranging from freshwater to seawater and have been living in coastal habitats since 90.7 million years (Vidal *et al*., 2009).

***Acrochordus* species account:**

The three extant *Acrochordus* species displays noticeable difference in ecology, scalation, internal anatomy and osteology (McDowell, 1979). The head is covered with small granular scales; nostrils in annular nasals are rimmed, closely set and no cephalic scutes (Deraniyagala, 1995). The color pattern of the body exhibits alternate rings of dark brown and buff broadest on the side while narrow on the top, which become sub-equal at mid-body (Deraniyagala, 1995). The skull of *Acrochordus* characterized by the absence of a crista circumfenestralis (asynapomorphy) shared by all three species of *Acrochordus* (Rieppel and Zaher, 2001). Eco-toxicological studies revealed heavy metals such as aluminum, cromium, copper, iron, mercury, manganese, lead, strontium, zinc found in nine *A. javanicus* from the Indomalayan and Australian zone (Grillitsch and Schiesari, 2010). *Acrochordus granulatus* occupy a unique phylogenetic position (See Williams *et al*., 2006; Pyron *et al*., 2013; Zheng and Wiens, 2016). *Acrochordus* species diverged in the Miocene epoch i.e., between 16 and 20 million years ago (Sanders *et al*., 2010). *Acrochordus granulatus* (Schneider, 1799) previously classified in a separate monotypic genus (Chersydrus; Sanders *et al*., 2010). Sanders *et al.* (2010) provided the first phylogeny for the three extant species using Bayesian and parsimony analyses of one mitochondrial and two nuclear gene sequences.

***Acrochordus granulatus* – Morphology and Distribution:**

Unlike other marine snakes of Hydrophiinae sub-family, *A. granulatus* bear thin and slender tails like terrestrial snakes (See Figure 1b). They usually reach a maximum length of about 90-120 cm (SVL; Rao and Muralidharan, 2017) and show sexual dimorphism; females are larger than males (Wangkulangkul *et al*., 2005). The size at maturation in both sexes is 58 cm (SVL) in Thailand (Wangkulangkul, 2004). Distribution of *A. granulatus* is reported in China, Australia, Indonesia, Bangladesh, India, Malaysia, Myanmar, Philippine Islands, Singapore, Sri Lanka, Thailand, Vietnam and Australia North coast (Voris and Glodek, 1980). Also, this species is distributed in all marine coasts of India from Gujarat to West Bengal, Andaman and Nicobar Islands. The coasts of Gujarat are probably its western most limits (Murthy, 1986; Harikrishnan *et al*., 2010). They typically inhabit streams, lagoons and other areas of permanent fresh water estuaries and occasionally enter the sea (Lilywhite, 1996). Further, it is found to be active in shallow water, no deeper than 20 meters (Wall, 1921). This species can be seen in coastal wetlands and estuaries of Sri Lanka (Deraniyagala, 1995).

Physiology:

Acrochordus granulatus require fresh water and will drink it periodically when living in a range of salinities from seawater to fresh water (Lillywhite, 1996). Further, it has a higher relative blood volume (% body mass) than other snakes, since they have more red blood cells which help to carry more oxygen (Feder, 1980). They have some of the most specialized morphology and physiology for life in saltwater compared to other marine reptiles, including the greatest capacity to store oxygen found in any vertebrate (Heatwole, 1999). This snake is capable of exceptionally prolonged submergence; maximum submergence time averaged 70% longer than in other marine snakes (Feder, 1980). In *A. granulatus* blood parameters such as plasma lipids, plasma cholesterol, plasma proteins and serum calcium greatly increased during the breeding period (*i.e.* during late December to early January); come to basal level and remain normal throughout the nonbreeding period (*i.e.* during late January to early November in India; Phadke and Padgaonkar, 2003). Rise in these blood parameters is due to the secretion of the ovarian estrogen, since only steroids are able to bring about such effect (Phadke and Padgaonkar, 2003). The parathyroid gland of the snake, *A. granulatus*, secretes a parathormone-like factor (Warbhuwan and Padgaonkar, 1996). The expected plasma changes associated with vitellogenesis in the annual ovarian cycle (Phadke and Padgaonkar, 2003).

Acrochordus granulatus are sensitive to low temperatures and rapid thermal changes (Lilywhite, 1996). *A. granulatus* is usually a nocturnal species, during the day it hides inside burrows in mud or among rooted vegetation (Lilywhite, 1996). Additionally, each scale contains a mechanoreceptor that may be used to locate fish in turbid water (Povel and Kooij, 1996). The diving and metabolic physiology of this species is highly specialized and reflects the demands of estuarine environments. A capability for prolonged aerobic diving can be attributed to low rates of oxygen consumption, high capacity for oxygen storage, nearly complete utilization of the oxygen stores, and cutaneous gas exchange (Lilywhite and Tamir, 1994). This species is primarily ammonotelic and requires a source of fresh water for elimination of nitrogenous wastes (Lilywhite, 1996). The requirement for fresh water potentially limits seaward migration due to the dependence of snakes on rivers or coastal rainfall. Adaptations for shallow-water diving conceivably further limits seaward migration, with the result that they have evolved as

Figure 1a, File sea snake *Acrochordus granulatus* caught as bycatch in Amba estuary, Maharashtra, India

Figure 1b, File sea snake *Acrochordus granulaus* caught as bycatch in Amba estuary, Maharashtra, India estuarine specialists that are restricted from deeper waters and the open ocean (Lilywhite and Tamir, 1994).

Trophic Ecology:

Unlike other sea snakes *i.e.* elapids, *A. granulatus* are non-venomous and feed on crustaceans and gobid fish, which are abundant in estuaries (Ng, 2011). In *A. arafurae* females ambush prey in deep water while males actively search for prey in shallow water (Vincent *et al*., 2005). Further, *A. granulatus* show low feeding frequencies and prolonged gestation in adult females (Bergmann, 1958; Gorman *et al*., 1981).

Reproduction:

Reportedly, the breeding season of this species in Phang Nga Bay, Thailand begins in July (Padate *et al*., 2009). Their reproduction is seasonal, being ovo-viviparous, directly giving birth up to five young individuals (Voris and Glodek, 1980; Shine and Houston, 1993). They are capable of breeding in freshwater (Waterwatch, 2002).

Threats:

One of the important destructive activities is by-catch of sea snakes during trawl nets, which could lead to significant mortality (Lobo, 2007). Sea snakes captured in a trawl operation are prevented from surfacing to breathe. This is coupled with several other factors such as depth, fishing crafts such as trawl and gill nets in the trawling operation result in their mortality (Lobo, 2006). Some gravid female sea snakes die due to stress of being trapped in fishing nets (Rao and Muralidharan, 2017). The level of mortality of sea snakes within trawls also depends on the depth of the trawl, weight and size of the catch (Milton, *et al*., 2009). Pelagic and coastal marine habitats suffer from intensive and destructive fishing and land-use practices that potentially threaten sea snakes (Heatwole, 1997; Wassenberg, *et al.,* 2001). Sea snakes are susceptible to high mortality from trawling and are at risk of extinction (Milton *et al*., 2009).

Bycatch Records:

Of the 30 sea snakes found along the Indian coast, there are 18 species that are frequently caught as bycatch, *A. granulatus* is one among them (Lobo *et al.,* 2004, 2005; Lobo, 2006; Karthikeyan and Balasubramanian, 2007; Padate *et al*., 2009; Muthukumaran, 2015; Jeyabaskaran, 2015; Venkatraman, *et al*., 2015). The effects of the exploitation or by catch on the sea snakes are almost unknown except limited information is available from the Philippines and Australia (Ward, 2000; Wassenberg *et al*., 2001; Heales *et al*., 2008). Trawling in the Amba estuary is difficult and risky due to uneven sub tidal topography. Experimental trawling was carried out at four stations in Amba estuary (18^{0} 45' N & 73^{0} 10' E) during low and high tides for five consecutive days in pre and post monsoon in 2014 from the mouth of the estuary along the creeks of Amba estuary, India. Bottom trawling was undertaken wherever possible using a high opening bottom net of 20.7 m (636 meshes of 50 mm) length. Trawl net of mesh size 1 – 1.5 inch was used to catch fish.

During experimental trawling *A. granulatus* was caught (Figure. 1a,b) in Amba estuary (18^{0} 45' 16.3" N 72^{0} 59' 11.4" E). The snake was non-offensive and released back to the estuary immediately. The length of the snake was about one meter and the snake was undergoing dysecdysis (See Figure. 1 a, b). Lilywhite, (1996) reported that *A. granulatus* unusual shedding behaviour in captivity by knotting. Earlier bycatch incidence was reported during trawling in Ratnagiri in December 2013 (Swapnil, *pers. comm.*). Recently, Rao and Muralidharan (2017) reported *A. granulatus* bycatch in Malvan during trawling in January 2017. Reportedly the snake was lethargic and fishermen usually handle them routinely, they are typically reluctant to bite when handled, even when injured (Wall, 1921; Ng, 2011; Stuebing *et al.,* 2014).

Bycatch Prevention:

Most of sea snakes caught as by-catch are discarded. To reduce bycatch related mortalities exclusion devices has been used for sea turtle (Werner *et al*., 2017). The same management strategies, such as the use of excluder devices with spatial closure in trawl nets can be designed and implemented to avoid incidental capture of sea snakes in the trawl nets (Udyawer, 2015),

Conservation:

In general, sea snakes are exploited for their meat, skin and internal organs in many parts of the world and are sometimes internationally traded (Heatwole, 1997). However, they are not currently protected under (CITES) Convention on International Trade in Endangered Species of Wild Fauna and Flora (IUCN, 2009). Detailed information on Sea snake's biology and natural history is not available and they are impacted by a number of human activities, including harvesting for food, leather (Heatwole, 1997), incidental mortality in fishing operations (Milton 2009; Courtney *et al*., 2010) and degradation of coastal habitats (Bonnet *et al.,* 2009). Sea snakes are also threatened by the damming of rivers, construction of barrages, fishing pressure, pollution and dredging activity (Naidu *et al*., 2016). Commonly caught by-catch sea snakes exploited for skin and used for the pet trade in western countries, and in Philipines *A. granulatus* is hunted for its skin, where it is used as leather and to make drums (Buddy and Kay, 2006; Smith, 1943). Currently, sea snakes are caught and commercially traded in Gulf of Thailand (Nguyen *et al*., 2014). Although, *A. granulatus* are considered as Least Concerned category in IUCN (2009) red list, this species listed as nationally threatened in Sri Lanka (Kekulandala and Wickramasinghe, 2006; IUCN Sri Lanka, 2000).

The incidental, unintentional take of non-commercial and non-target species in fishing gear has been an ever-increasing threat to the marine life and considered one of the major threats to marine biodiversity. Incidental capture and consequential removal of predators such as sea snakes by commercial fishing operations could have negative impacts on the functioning of marine ecosystems (Lobo, 2006). This leads to commonly encountered by-catch in fishing operations (Lobo *et al*., 2004).

Heavy metals such as Mercury, are being circulated in a marine food chain due to various natural and anthropogenic activities. Further, requisite action is needed in order to control the anthropogenic activities that are responsible for Polycyclic Aromatic Hydrocarbons and metal contamination in the coastal environment. Reptiles living in polluted habitats also accumulate trace elements, which are expelled when the skin is sloughed (Loumbourdis, 1997; Campbell and Campbell, 2001; Hopkins *et al*., 2001; Jones and Holladay, 2006**)**, concentrations of trace elements were higher in snakes from urban-industrial areas and higher in darker than paler skin (Goiran *et al.,* 2017). The effect of pollution and survival rate after getting entangled in fishing on the distribution and abundance of *A. granulatus* is unknown and thus merit for further evaluation.

Conclusion:

Information on the movement, dispersal and ecological association with other organisms of *A. granulatus* is lacking. Less information is available about the physiological tolerance in marine environment. Understanding major distribution and essential microhabitats of these species can help to minimize the encounter of the bycatch problem**.** Gathering information on breeding cycles, bycatch mortality, growth rates, population density and sexual maturity would help in formulating management plans. We aim to develop awareness programs for better understanding of cumulative impacts affecting on sea snakes in inshore habitat. In addition, an education campaign should be designed to educate fishermen on the general biology, potential dangers and species identification of sea snakes in general, that would help to reduce the negative interaction of sea snake in its distribution area and the setting up of proper treatment facilities in the event of casualties could help to save human lives.

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References:

Bergman, R.A.M. (1958) The anatomy of the Acrochordinae, *Proceedings of Akad Wetensch series C*, **61**,145-184.

Bonnet, X., Brischoux, F., Pearson, D. and Rivalan. P. (2009) Beach rock as a keystone habitat for amphibious sea snakes, *Environmental Conservation*, **36**, 62–70.

Buddy, D. and Kay, D. (2006) *Marvels of creation Sensational Sea Creatures*, China, pp. 55.

Campbell, K.R. and Campbell, T.S. (2001) The accumulation and effects of environmental contaminants on snakes: a review*, Environmental Monitoring Assessment*, **70,** 253–301.

Cogger, H.G. (2000) *Reptiles and Amphibians of Australia*. 6th edition. Sydney. Reed Books Australia, Melbourne.

Courtney, A.J., Schemel, B.L., Wallace, R., Campbell, M.J., Mayer, D.G. and Young, B. (2010) *Reducing the impact of Queensland's trawl fisheries on protected sea snakes.* Fisheries Research and Development Corporation (FRDC) Project #2005/053, Final Report.

Damotharan, P., Arumugam, M., Vijayalakshmi, S. and Balasubramanian, T. (2010) Diversity, biology and ecology of sea snakes (Hydrophiidae) distributed along the Parangipettai coast, Southeast coast of India, *International journal of current research,* **4**,62-69.

De Miranda, E.B.P. (2017) The Plight of Reptiles as Ecological Actors in the Tropics, *Frontiers in Ecology and Evolution*, **5**, 159.

Deraniyagala, P.E.P. (1995) A coloured Atlas of some vertebrates from Ceylon, 3, *Serpentoid Reptilia,*pp.121.

Feder, M. E. (1980) Blood Oxygen Stores in the File Snake, *Acrochordus granulatus* and in Other Marine Snakes, *Physiological Zoology*, **53**(4), 401.

Goiran C., Bustamante, P. and Shine, R. (2017) Industrial Melanism in the Seasnake *Emydocephalus annulatus*, *Current Biology***,** **27**, 1–4.

Gorman, G.C., Licht, P. and Collum, Mc. (1981) Annual reproductive patterns in three species of marine snakes from the Central Phillipens, *Journal of Herpetolgy*, **15**, 335-354.

Greene, H.W. (1997) *Snakes: The Evolution of Mystery in Nature*, University of California Press, pp. 236.

Grillitsch, B. and Schiesari, L. (2010) The Ecotoxicology of Metals in Reptiles, *Ecotoxicology of Amphibians and Reptiles*, 337-446.

Harikrishnan, S., Vasudevan, K. and Choudhury, B.C. (2010) A review of herpetofaunal descriptions and studies from Andaman and Nicobar Islands, with an updated checklist. *Recent Trends in Biodiversity of Andaman and Nicobar Islands*, Zoological Survey of India, Kolkata, pp.387-398.

Heales, D.S., Gregor, R., Wakeford, J., Wang, Y.G, Yarrow, J. and Milton, D.A. (2008) Tropical prawn trawl *bycatch of fish and sea snakes reduced by Yarrow Fisheye Bycatch Reduction Device, Fisheries Research*, **89**, 76-83.

Heatwole, H. (1997) Marine Snakes: Are They a Sustainable Resource? *Wildlife Society Bulletin,* **25**, 766-772.

Heatwole, H. (1999) Sea Snakes. *Australian Natural History Series*. University of New South Wales Press, Sydney.

Hopkins, W.A., Roe, J.H., Snodgrass, J.W., Jackson, B.P., Kling, D.E., Rowe, C.L. and Congdon, J.D. (2001) Nondestructive indices of trace element exposure in squamate reptiles, *Environmental Pollution*, **115,** 1–7.

IUCN. (2009) *Status of the World's Sea Snakes IUCN Red List Assessment*, 11-14 February 2009, Workshop at Brisbane, Australia, Final Report, pp.18.

IUCN Sri Lanka. (2000) 1999 List of threatened Flora and fauna of Sri Lanka, Colombo: IUCN Sri Lanka viii+, pp.114.

Jeyabaskaran, R., Abhilash, K.S., Gishnu M., Vishnu, P.G., Abbas, M., Aswathy K.S, Khambedkar, L.R., Prema D. and Kripa, V. (2015) Some observations on the beaked sea snake *Enhydrina schistosa* (Daudin, 1803) in the mud bank area, off Alapuzha, Kerala, southwest coast of India, *Journal Marine Biological Association India*, **57** (2), 109-112.

Jones, D.E. and Holladay, S.D. (2006) Excretion of three heavy metals in the shed skin of exposed corn snakes (*Elaphe guttata*). *Ecotoxicology and Environmental Safety*, **64,** 221– 225.

Karleskint, G., Turner, R. and James, S. (2012) Introduction to Marine Biology, pp.298.
Karthikeyan, R. and Balasubramanian, T. (2007) Species diversity of sea snake (Hydrophiidae) distributed in the Coromandel Coast (East Coast of India), *International journal of zoological research,* **3**(3), 107-131.

Kekulandala, C.B. and Wickramasinghe, M. (2006) Distribution and conservation of File snake *Acrochordus granulatus* Schneider, 1799, Reptila: Acrochordidae from Sri Lanka, *Tiger Paper*, **33**(2), 31-32.

Lillywhite, H.B. (1996) Husbandry of the Little File Snake, *Acrochordus granulatus, Zoo Biology,* **15**,315-327.

Lilywhite, H. B. and Tamir, M.E. (1994) Ecophysiological Aspects of the Coastal-Estuarine Distribution of Acrochordid Snakes, *Estuaries,* **17**(1A), 53-61.

Lobo, A., Pandav, B. and Vasudevan, K. (2004) Weight-length relationships in two species of marine snakes along the coast of Goa, Western India, *Hamadryad*,**29**, 89-93.

Lobo, A.S., Vasudevan, K. and Pandav, B. (2005) Trophic ecology of *Lapemis curtus* (Hydrophiinae) along the western coast of India, *Copeia*, **3,** 637-641.

Lobo, A.S. (2006) *Sea snakes of the Gulf of Mannar Marine National Park: The species and their conservation,* Technical report submitted to the Rufford Foundation.

Lobo, A.S. (2007) The Bycatch Problem Effects of Commercial Fisheries on Non-Target Species in India, *Resonance*, 60-70

Loumbourdis, N.S. (1997) Heavy metal contamination in a lizard, Agama stellio stellio, compared in urban, high altitude and agricultural, low altitude areas of north Greece, *Bulletin of Environmental Contamination, Toxicology* ,**58**, 945–952.

McDowell, S.B. (1979) A catalogue of the snakes of New Guinea and the Solomons, with special reference to those in the Bernice P. Bishop Museum: Part III, Boinae and Acrochordoidae (Reptilia, Serpentes), *Journal Herpetology*,**13**, 1–92.

Milton, D.A., Fry, G.C. and Quinton, D. (2009) Reducing impacts of trawling on protected sea snakes: By-catch reduction devices improve escapement and survival, *Marine and Freshwater Research*, **60**, 824-832.

Murthy, T.S.N. (1986) The snake book of India. International Book Distributors, pp. 49.Muthukumaran, M., Rao, A.V.B. and Alexandar, R. (2015) Threats of passive fishing activities on sea snake *Enhydrina schistosa* (Daudin 1803) of Puducherry coast, India, *International Journal of Pure and Applied Zoology,* **3**(1) 53-58.

Naidu, V. Simhadri, Thomas, J., Bari S. and Kachave, S. (2016) The impact of dredging on residence time in the Amba estuary, west coast of India, *Environmental Earth Sciences*, **75**(2), 1-14.

Ng, T.H. (2011) A record of the banded file snake, *Acrochordus granulatus* (reptilia: squamata: Acrochordidae) in a freshwater habitat in Singapore, *Nature in Singapore***, 4** , 91-93.

Nguyen, V.C., Nguyen T.T., Montoya, A.M.A., Redsted A.R., Broad, K., Voris, H.K and Zoltan, T. (2014) Sea Snake Harvest in the Gulf of Thailand. *Conservation Biology,* **28**(6), 1677-1687.

Padate, V.P, Baragi, L.V. and Rivonker, C.U. (2009) Biological aspects of sea snakes caught incidentally by commercial trawlers off Goa, west coast of India, *Journal of threatened taxa*, **1**(12), 609-616.

Padgaonkar, A.S. and Das, N.P. (2000) Seasonal variations in the blood biochemistry of the estuarine snake, *Acrochordus granulatus* (Schneider), *Journal of Advanced Zoology* **21**(1), 54-60.

Phadke, S.A. and Padgaonkar, A.S. (2003) Changes in the plasma during the annual ovarian cycle of the snake *Acrochordus granulatus* (Schneider). *Journal of Advanced Zoology,* **24**(1), 41-45.

Povel, D. and Kooij, J.V.D. (1996) Scale Sensillae of the File Snake (Serpentes: Acrochordidae) and Some Other Aquatic and Burrowing Snakes, *Netherlands Journal of Zoology*, **47**, 443–456.

Pyron, R., Frank, A., Burbrink, T. and Wiens, J.J. (2013) A phylogeny and revised classification of Squamata, including 4161 species of lizards and snakes. *BMC Evolutionary Biology*, **13**, 1-53.

Rao, C. and Muralidharan, M. (2017) A quick guide to sea snakes of Sindhudurg, Dakshin Foundation, Bangalore, pp. 20.

Rieppel, O. and Hussam, Z. (2001) The development of the skull in *Acrochordus granulatus* (Schneider) (Reptilia: Serpentes), with special consideration of the Otico-Occipital Complex, *Journal Of Morphology*, **249**, 252–266.

Sanders, K.L., Hamidy, A.M., Head, J.J. and Gower, D.J. (2010) Phylogeny and divergence times of filesnakes (Acrochordus): Inferences from morphology, fossils and three molecular loci, *Molecular Phylogenetics and Evolution,* **56**, 857–867.

Shine, R. and Houston, D. (1993) Family Acrochordidae. *In*: Walton D, editor. *Fauna and Flora of Australia, Volume 2.* Canberra: Australian Government Publishing Service, pp. 322–324.

Smith, M. A. (1943) The fauna of British India, Ceylonh and Burma, including the whole of the Indo-Chinese sub-region, Reptilia and Amphibia, (Serpentes),Taylor and Francis, London, pp. 583.

Stidworthy, J. (1974) *Snakes of the World*. Grosset & Dunlap Inc..published by Bantam, ISBN 0-448-11856-4.pp.160.

Stuebing, R. B., Inger, R. F. and Lardner, B. (2014) *A Field Guide to the Snakes of Borneo*. Second edition. Natural History Publications (Borneo), Kota Kinabalu, Malaysia. viii + pp. 310.

Thomson, D. A., Lloyd, F., Kerstitch, T. and Alex, N. (2000) Reef Fishes of the Sea of Cortez: *The Rocky-Shore Fishes of the Gulf of California*. University of Texas Press, pp. 407.

Udyawer, V. (2015) *Spatial ecology of true sea snakes (Hydrophiinae) in coastal waters of North Queensland.* PhD thesis, James Cook University.

Venkataraman, K., Raghunathan, C., Sreeraj, C.R. and Raghuraman, R. (2012) *Guide to the Dangerous and Venomous Marine Animals of India*, 1-98.

Venkatraman, C., Padmanaban P. and Sivaperuman C. (2015) Seasonal Abundance of Sea Snakes on the Chennai Coast, Southern India in *Marine Faunal Diversity in India : Taxonomy, Ecology and Conservation,* edited by Krishnamoorthy Venkataraman and Chandrakasan Sivaperuman, (Elsevier ,United States of America) **49**, pp.259.

Vidal, N.R.J., Couloux A. and Hedges S. B. (2009) Snakes (Serpentes). In: Hedges, S.B. and Kumar, S. (Eds.), The Timetree of life. Oxford University Press, pp. 390-397.

Vincent, S.E., Shine R. and Brown, G.P. (2005) Does foraging mode influence sensory modalities for prey detection in male and female filesnakes, *Acrochordus arafurae*. *Animal Behaviour*, **70**, 715-721.

Voris, H. K. and Glodek, G.S. (1980) Habitat, Diet and Reproduction of the File Snake, *Acrochordus granulatus,* in the Straits of Malacca, *Journal of Herpetology*, **14**, 105-108.

Wall, F. (1921) Ophidia Taprobanica or the Snakes of Ceylon. Colombo Museum, Colombo. xxiv +, pp. 581.

Wangkulangkul, S. (2004) Morphology, reproductive biology and ecology of the little file snake, *Acrochordus granulatus* at Phangnga Bay, Thailand, PhD Thesis.

Wangkulangkul S., Thirakhupta, K. and Harold, K.V. (2005) Sexual size dimorphism and reproductive cycle of the Little File Snake *Acrochordus granulatus* in Phangnga Bay, Thailand, *Science Asia,* **31**, 257-263.

Warbhuwan, A.P. and Padgaonkar, A.S. (1996) Effects of partial and total parathyroidectomy on serum calcium and inorganic phosphorus levels in the snake, *Acrochordus granulatus* (Schneider), *Zoological studies*, **35**(4), 286-291.

Ward, T.M. (2000) Factors affecting the catch rates and relative abundance of sea snakes in the by-catch of trawlers targeting tiger and endeavour prawns on the northern Australian continental shelf, *Marine and Freshwater Research,* **51,**155-164.

Wassenberg, T.J., Milton, D.A. and Burridge, C.Y. (2001) Survival rates of sea snakes caught by demersal trawlers in northern and eastern

Australia, *Biological Conservation,* **100**, 271-280.

Waterwatch. (2002) *Waterwatch Australia National Technical Manual Module 4 Physical and Chemical Parameters*. Water Watch Australia Steering Committee Environment, Australia. http://www.waterwatch.org.au.

Werner, T., Scott, K., Andrew, R. and Erika, Z. (2017) Fishing Techniques to Reduce the Bycatch of Threatened Marine Animals, *Marine Technology Society Journal*, 50-68.

Whitaker, R., Captain, A. and Ahmed, F. (2004) *Snakes of India.* Draco Books, pp. 390-391.

Williams, D., Wüster, W. and Fry, B.G. (2006) The Good, the Bad and the Ugly: Australian Snake Taxonomists and a History of the Taxonomy of Australia's Venomous Snakes, *Toxicon,* **48** (7), 919–930.

Zheng, Y. and Wiens. J.J. (2016) Combining Phylogenomic and Supermatrix Approaches, and a Time-Calibrated Phylogeny for Squamate Reptiles (Lizards and Snakes) Based on 52 Genes and 4162 Species. *Molecular Phylogenetics and Evolution,* **94**. *Elsevier Inc*., 537–547.