



SYMPOSIUM

Introduction to the Symposium “New Frontiers from Marine Snakes to Marine Ecosystems”

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Synopsis Interest in sea snakes and mythological “sea serpents” dates to ancient times and is represented in the writings of Aristotle, early voyagers, and explorers, and references in the Bible. Since then, awareness of the myriad species of snakes inhabiting the oceans has grown at a gradual pace. Scientific investigations into the biology of marine snakes—especially those in behavior, physiology, and other disciplines requiring living animals or tissues—have been comparatively challenging owing to difficulties in acquiring, transporting, handling, and husbanding these secondarily marine vertebrates. A broadening perspective with increasing interest in these animals peaked during the 1960s and 1970s, and literature from this period contributed to a growing knowledge that marine snakes comprise a very diverse fauna and are a significant part of marine ecosystems. Two persons figured prominently as influential drivers of research on sea snakes during this period, namely William Dunson and Harold Heatwole, and this symposium recognizes the contributions of these two individuals. Following a decline in scientific publications on sea snakes during the 1980s and 1990s, there has been a renaissance of scientific interest in recent years, and a wealth of new research findings has improved the understanding of phylogeny and diversity of marine snakes while simultaneously recognizing threats to marine ecosystems arising from climate change and other anthropogenic causes. The purposes of the symposium are to (1) illustrate the importance and relevance of sea snakes as contributors to better understanding a range of issues in marine biology, (2) establish and promote the use of marine systems as models for investigating conceptual issues related to environment, changing climate, and persistence of biological communities, with focus on marine snakes as novel or useful examples, (3) promote interest in sea snakes as useful organisms for study by scientists in a range of disciplines who might presently work with other organisms or systems, and (4) identify leading-edge topics for which studies of marine snakes might contribute uniquely to the advancement of research.

Interest in sea snakes and mythological “sea serpents” dates to ancient times and is represented in the writings of Aristotle, early voyagers and explorers (Culotta and Pickwell 1993), and references in the Bible (Amos 9, 3). Since then, awareness of the myriad species of snakes inhabiting the oceans has grown at a gradual pace. Scientific investigations into the biology of marine snakes—especially those dealing with behavior, physiology, and other disciplines requiring living animals or tissues—have been comparatively challenging owing to difficulties in acquiring, transporting, handling, and husbanding these secondarily marine vertebrates. Some species are very sensitive to handling, and many persons have been unsuccessful at keeping sea

snakes in captivity for more than very short periods (e.g., Chinnadurai et al. 2008). Increasingly robust scientific investigations became more feasible, however, following improvements in accessing sea snakes using research-dedicated vessels, and with the development of coastal laboratories and facilities in tropical locations. Knowledge of the physiological requirements of sea snakes also helped to facilitate the use of these animals in research (e.g., Graham 1974; Seymour 1974; Seymour and Webster 1975; Graham et al. 1987; Lillywhite et al. 2008a).

Many of the earlier studies on sea snakes are related to the systematics, distribution, and descriptive accounts of species that were collected in various tropical

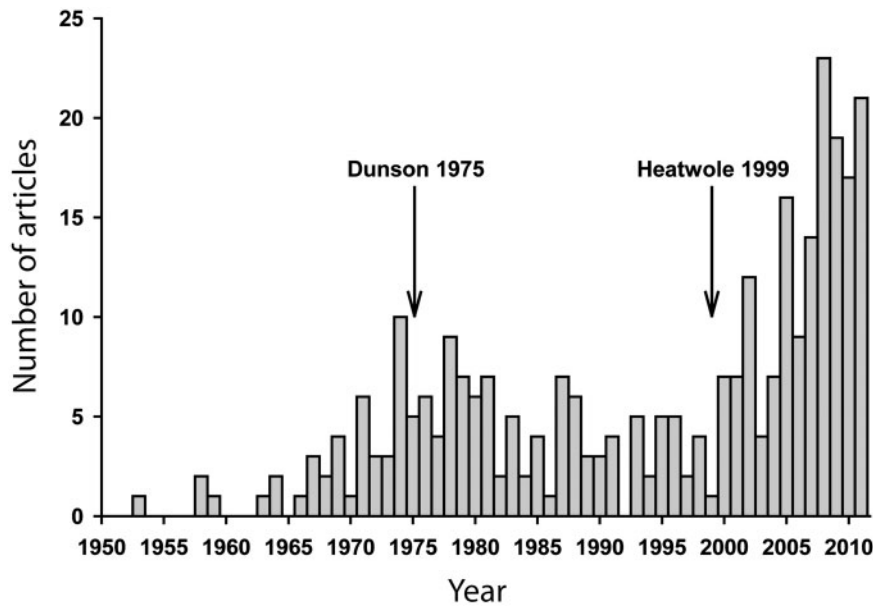


Fig. 1 Number of scientific articles with foci on marine snakes (Acrochordidae, Homalopsidae, Laticaudinae, and Hydrophiini) published each year between 1950 and 2011. The two arrows indicate the publication dates of the most influential books published on marine snakes (Dunson 1975; Heatwole 1999). These books were not included in the article count. Note that we tried to be as comprehensive as possible, but we nonetheless acknowledge that we might have missed a few of the papers published within these 61 years.

parts of the world. This literature contributed to a growing knowledge that marine snakes comprise a very diverse fauna and are a significant part of marine ecosystems. A broadening perspective with increasing interest in these animals peaked during the 1960s and 1970s (Fig. 1). Two persons figured prominently as influential drivers of research on sea snakes during this period, namely William Dunson and Harold Heatwole. Each had a productive academic career, and together produced more than 100 publications on sea snakes. Bill Dunson and his students stimulated interest in marine and estuarine reptiles, osmoregulation, and the evolutionary transition from land to sea. Hal Heatwole and his numerous students stimulated interest in a variety of topics focused primarily on the ecology and physiology of these animals. These advancements also were paralleled by continuing research on the taxonomy and systematics of sea snakes. Much of the growth of information during this period was summarized in the publication of Bill Dunson's *The Biology of Sea Snakes* in 1975. Scientific interest then tended to wane for some years, but has been followed by a renaissance of research on sea snakes in recent years (Fig. 1). Hal Heatwole published another book on *Sea Snakes* in 1999, and various other books have appeared with varying foci on marine snakes (e.g., Collard 1993; Culotta and Pickwell 1993; Ineich and

Laboute 2002; Ineich 2004; Murphy 2007). This symposium pays tribute to both Dunson and Heatwole in recognition of their collective influence.

Relatively recent as well as current research on marine snakes includes works by a French group in New Caledonia; biologists in Australia; Taiwanese and Japanese workers; and several American scientists working in various parts of Asia, Australia, and Central America. Recent investigations include multidisciplinary topics related to genetics, geography, systematics, physiology, behavior, morphology, ecology, and evolution published in a wide range of prominent journals. Given recent advances in understanding the phylogeny and diversity of marine snakes while simultaneously recognizing threats to marine ecosystems arising from climatic change and other anthropogenic causes, a symposium with a focus on marine snakes is both timely and significant. The purposes of the present symposium are to (1) illustrate the importance and relevance of sea snakes as contributors to better understanding a range of issues in marine biology, (2) establish and promote the use of marine systems as models for investigating conceptual issues related to environment, changing climate, and persistence of biological communities, with focus on marine snakes as novel or useful examples, (3) promote interest in sea

snakes as useful organisms for study by scientists in a range of disciplines who might presently work with other organisms or systems, and (4) identify leading-edge topics for which studies of marine snakes might contribute uniquely to the advancement of research. Examples are: (1) understanding overall patterns of biodiversity in the Indo-Pacific, (2) applying how molecular studies can advance understanding of evolutionary processes including diverse and prolific radiations, and (3) better understanding the importance of bioindicators related to the health and conservation of coral reef ecosystems.

This symposium focuses on sea snakes, but we also include work on other taxa of marine snakes. Marine snakes face various environmental challenges that are different from those of other vertebrates, and they are of special interest with respect to evolutionary transitions between habitats (Lillywhite et al. 2008b, 2009; Karns et al. 2010). The systematics of these taxa is becoming better known (Lukoschek et al. 2008; Sanders et al. 2008, 2010), and novel aspects of functional biology are becoming evident. As example, recent work has shown that several representative species of sea snakes, in addition to other marine taxa, require fresh drinking water in spite of the fact these species possess salt glands (Bonnet and Brischoux 2008; Lillywhite et al. 2008a). This information is contrary to prior textbook dogma and has important implications for geographic distribution, conservation, and interpretations of recent extinctions. Sea snakes have been proposed as important indicators of the health of coral reefs (Ineich et al. 2007; Brischoux et al. 2009), and they are potential harbingers of climatic change (Lillywhite et al. 2008a; Lillywhite and Tu 2011; Brischoux et al. 2012). There is new evidence of declines in sea snake populations as well as a growing interest in their importance and conservation (Lukoschek et al. 2007; Anonymous 2012). Owing to their many challenging and unique attributes, sea snakes are attracting wide and intense interest on the part of scientists and the lay public.

We express our deepest regret for the sudden passing of Daryl Karns, who had earlier agreed to participate in this symposium. We acknowledge his many contributions to understanding the biology of marine snakes, and we hope that science will continue to move forward owing to the dedication and zeal of young investigators who conceivably might take his place.

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