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REVIEWS

Assessing the state of seahorse research through scientometric analysis: an update

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Abstract Seahorses, widely recognized as a unique genus within aquatic species, are exploited globally across traditional medicine, aquarium, and curio industries. Notwithstanding their popularity, there exists a dearth of current bibliometric investigations capable of discerning key shifts and patterns within seahorse research. In addressing this gap, our study deployed scientometric techniques on the Web of Science database, enabling an encompassing and contemporary bibliometric analysis spanning from 1976 to 2022. Utilizing CiteSpace software, we generated visual data of dual map overlay, citation networks of authors, countries, and documents, and discerned key terms and research clusters prevalent in seahorse-related research. This process yielded 1840 original articles on seahorse research, forming a 13-cluster network, with the three most expansive research clusters being "endangered seahorse", "habitat association", and "male pregnancy". Our investigation highlighted that the terms "gene expression",

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“abdominal”, and “embryonic development” were predominantly employed across seahorse-centric scholarly works. The research ecosystem encompassing seahorses constitutes a diverse array of academic domains, showcasing substantial interdisciplinary linkages among areas such as “Marine and Freshwater Biology”, “Environmental Sciences”, “Biochemistry and Molecular Biology”, “Biodiversity Conservation”, “Ecology”, “Fisheries”, “Zoology”, and “Oceanography”. The implications of our findings not only establish a robust foundation for subsequent research but also illustrate the evolved state and potential impact of seahorse research within the sphere of marine biology.

Keywords Seahorse · Scientometric · Research cluster · CITES · Endangered species · Habitat degradation

Introduction

There are over 300 different species that belong to the family Syngnathidae, which includes seahorses together with pipefishes, and seadragons. In addition to having an enlarged snout, fused jaws, and a bony plate armor covering instead of scales on the body, members of the family Syngnathidae are distinguished by the fact that they are capable of “male pregnancy” (Foster and Vincent 2004; Wang et al. 2019). At present, taxonomically valid species of seahorses total 48, all of which belong to a single genus: *Hippocampus* (Koning and Hoeksema 2021). Seahorses inhabit shallow water seagrass beds, mangroves, and coral reef ecosystems in tropical to temperate coastal waters around the globe (Foster and Vincent 2004; Cohen et al. 2017; Koning and Hoeksema 2021).

Seahorses are exploited for use in traditional remedies, aquariums, and curio trades across the world (Foster and Vincent 2004). Despite the longstanding exploitation of seahorses, there remains a deficit in our comprehension of their ecological significance and population structure (Martin-Smith and Vincent 2005). This knowledge gap, coupled with the widespread destruction of natural seahorse breeding habitats globally, has precipitated a consistent decline in their numbers (Vincent et al. 2011). As a result, all species under the *Hippocampus* genus were incorporated into Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in May 2004. This classification marked them as the first marine fish species to undergo regulation in international trade (Koning and Hoeksema 2021). The Red List from the International Union for Conservation of Nature (IUCN) designates two seahorse species as “Endangered”, twelve as “Vulnerable”, and one as “Near Threatened”. Nonetheless, a significant number of seahorse species are categorized as “Data Deficient”, which underscores the pressing need for additional research on these species (Kleiber et al. 2010; IUCN 2022).

Seahorse research encompasses a wide array of areas including their taxonomy and life history (Lourie et al. 1999, 2016), geographical distribution and ecology (Curtis and Vincent 2005; Lockyear et al. 2006), conservation and management initiatives (Cohen et al. 2017), reproductive strategies (Qin et al. 2017), breeding technologies (Olivotto et al. 2008; Murugan et al. 2009), and the evaluation of secondary metabolites extracted from seahorses (Sanaye et al. 2014). Further areas of focus include feeding regimes and enrichments for captive seahorses (Palma et al. 2011), global seahorse trade (Vincent 1996; Giles et al. 2006), the use of seahorses in traditional medicine (Kumaravel et al. 2012), environmental and habitat challenges (Zhang and Vincent 2019), disease management in captive settings (Balcázar et al. 2009), and explorations into their genetics and molecular biology (Mobley et al. 2011; Je et al.

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2020). The academic literature also boasts a plethora of extensively cited review articles on seahorses (Foster and Vincent 2004; Koldewey and Martin-Smith 2010; Vincent et al. 2011; Foster et al. 2014; Cohen et al. 2017). Pierri et al. (2022) and Cohen et al. (2017) notably employed bibliometric analyses in their respective reviews, with the former focusing on the distribution of *H. guttulatus* and *H. hippocampus* in the Atlantic Ocean, the Mediterranean Sea, and the Black Sea, while the latter presented a trend analysis of seahorse research between 2001 and 2015.

The last few years have seen an escalation in seahorse-related studies, reflected in an increased quantity of publications on the subject. This long history and profusion of seahorse research might make it challenging for researchers and professionals to attain a comprehensive overview of the field (Zhou and Zhao 2015). The recent surge in seahorse investigations enhances the risk of overlooking pivotal research questions and potential areas of improvement (Hosseini et al. 2018). Regular engagement with current literature is crucial for researchers to maintain a deep understanding of their field and identify knowledge gaps requiring further exploration. However, the inherent biases of traditional literature reviews, skewed by easily accessible literature or literature pertinent to the author's objectives, may limit their continued utility in the context of such an expansive research field (Galvagno 2017). To overcome these limitations, scholars have employed bibliometrics. A broad overview of the scientific literature can be gleaned using bibliometric analysis (Donthu et al. 2021). Publication data can be analysed quantitatively to reveal trends in a particular field, as well as its characteristics and development over time (Ellegaard and Wallin 2015; Donthu et al. 2021). Using bibliometric techniques, one can assess the productivity and research patterns of individual authors, journals, countries, and institutions, and identify and quantify patterns of cooperation between these groups (Li and Zhao 2015). Using bibliometrics, one can gain insight into the most recent trends, research directions, and pressing concerns in a given field (Van Nunen et al. 2018). In addition, bibliometrics can be a useful tool for guiding scientific policy. Findings from bibliometric analyses not only inform researchers and policymakers, but also aid in the distribution of funds for scientific investigation (Merigó and Yang 2017).

Despite the existing body of work on seahorses, a holistic bibliometric exploration highlighting the most current evolutions and patterns within this research realm remains uncharted. Consequently, this review is designed to supply a panoramic, bibliometric examination of seahorse research progression. The compiled data offers an expansive perspective on the research strides within this field, thereby equipping scholars and professionals with the capacity to identify the principal influences of particular authors, journals, nations, institutions, citations, and research themes.

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