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Review article

A global review of seahorse aquaculture

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ABSTRACT

Seahorses (*Hippocampus* spp.) are flagship species for many issues in marine conservation including overexploitation, incidental bycatch and habitat loss. Aquaculture has been proposed as one solution to address unsustainable trade for traditional medicine, aquarium fishes and curios. Here we review historical and current information on global seahorse aquaculture including characteristics of aquaculture operations, species in culture, contribution to international trade and technical issues associated with raising seahorses in captivity. We found that prior to the 1990s, seahorse aquaculture was plagued by problems with disease and feeding. In the late 1990s and early 2000s there was considerable expansion in the number and size of aquaculture operations and the number of species in culture. This was reflected in an increasing contribution of captive-bred seahorses to the aquarium trade but not in the larger traditional medicine market. Currently, the majority of seahorse aquaculture involves small-scale operations in developed countries, employing relatively few personnel and selling live animals for the home aquarium market. Although, there are still considerable technical problems with diseases and with breeding and raising some species, others are performing successfully in aquaculture. There are currently at least 13 species in commercial culture or under research for their culture potential. However, economic viability remains a concern to many current aquaculture operations including price competition with wild-caught animals. Large-scale aquaculture to supply the traditional medicine market or as a livelihood venture has not yet been demonstrated to be commercially viable, although it is being actively researched.

Contents

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1. Introduction

World aquaculture (food fish and aquatic plants) has grown significantly during the past half-century. From a production of below 1 million tonnes in the early 1950s, production in 2006 was reported to have risen to 66.7 million tonnes (51.7 million tonnes excluding aquatic plants, with a value of US$85.9 billion (US$78.8 billion excluding aquatic plants) (FAO, 2008). In 2006, countries in the Asia and the Pacific region accounted for 89% of the production quantity and 77% of the value. There are signs that the rate of growth for global aquaculture may have peaked, although high growth rates may continue for some regions and species (FAO, 2008). Aquaculture for the aquarium hobbyist trade, however, is a rapidly growing sector of the industry (Tlusty, 2002) and there is directed effort and increasing pressure within the ornamental trade to develop reliable and sustainable hatchery procedures for the captive breeding of many reef fish species (Moe, 2003; Wabnitz et al., 2003). The value of the world ornamental imports has increased markedly too, from US$50 million to US$250 million over the past two decades (Olivier, 2003).

Over half of all aquaculture production of fish, crustaceans and molluscs is from the freshwater environment, with 34% coming from mariculture and the remainder from brackish systems (FAO, 2008). These figures are even more skewed for ornamental aquaculture, with approximately 90% of freshwater fish cultured (Dawes, 1998), but only 2% of marine ornamentals coming from aquacultured sources (Moe, 2001). Marine ornamentals offer higher value per kg (Hoff, 1996), but their aquaculture is considerably less advanced and sources of commercial quantities of marine species have been slow to develop (Moe, 2001). It has been estimated that 100 of the 800 marine species traded in the pet industry are routinely bred in captivity (Dawes, 1999), with only 21 of these species being commercially feasible (Schiemer, 2001).

Ornamental fish aquaculture has many similarities to food fish aquaculture (Tlusty, 2002). Food production aquaculture is often criticized as having a goal of creating a high-value end product that does not significantly add to overall global food supplies (Naylor et al., 2000). Similarly, the ornamental fish industry produces a luxury item and fish keeping is a hobby that is practiced mainly in industrialized countries (Olivier, 2003). Between 1.5 and 2 million people worldwide are believed to keep marine aquaria (Wabnitz et al., 2003) with the main importing countries being the United States, Japan and Europe (particularly Germany, France and the United Kingdom). However, as opposed to other luxury items but similar to aquaculture production in general, the ornamental fish industry can have, under the proper developmental scenario, a positive impact on the global economy, particularly in less developed areas (Tlusty, 2002). Over 50% of the world's supply of ornamental fish comes from Asia (Olivier, 2003), and 60% of the fish in this industry originate from developing countries (Bartley, 2000).

In general, the benefits of aquaculture are considered to be increased global production of food, lessened impacts on wild stocks, more efficient production, and economic support of smaller coastal communities, and the production of both juvenile and market-size fish of a wide variety of species year round (Landau, 1992; New, 1996; Olsen, 1996; Pillay, 1996; Wabnitz et al., 2003). However, there are also numerous well-documented detrimental effects on the environment over the past few decades (e.g. Eng et al., 1989; Páez-Osuna, 2001; Grosholz, 2002; Gyllenhammar, and Hakanson, 2005; Utter and Epifanio, 2002; Primavera, 2005; Pullin and Sumaila, 2005; Weir and Grant, 2005). The risks from food fish aquaculture include nutrification of water bodies, addition of antibiotics and other chemicals to the ecosystem, introduction of non-native species, user conflicts, impacts on wild fish stocks through sourcing of broodstock or harvesting for fish meal production and consequent effects on wild predators (Raa and Liltved, 1991; Goldburg and Trippet, 1997; Kautsky et al., 1997; Naylor et al., 2000). Although generally unstudied, most of these benefits and risks apply to the aquaculture of ornamental species.

To achieve sustainable aquaculture, environmental impacts on water quality and use, land use, biological pollution, feeds, diseases and treatments and escapes need to be recognized and minimized (Boyd et al., 2005). Sustainability can only be attained when environmental conditions are appropriate and maintained, and this includes ecological, socio-anthropological and economic aspects of the environment (Frankic and Hershner, 2003; Dempster et al., 2006; Pomeroy et al., 2006). Aquaculturists, especially those working at the production level, often have little knowledge about the environmental and social issues related to aquaculture (Boyd et al., 2005). However, there are a comprehensive set of policies and associated regulatory frameworks that are emerging that support sustainable aquaculture (Frankic and Hershner, 2003). In addition, there is a move to develop codes of practice (Boyd, 2003), international principles (FAO et al., 2006) and certification and ecolabelling schemes (Boyd et al., 2005; Yamamoto, 2007) for aquaculture production facilities, in response to the concerns about negative environmental and social impacts, as well as food safety. Such certification schemes require development through the involvement of stakeholders and verification by independent certification companies. The Marine Aquarium Council (www.aquariumcouncil.org) has now developed such standards for marine ornamental aquaculture: The Mariculture and Aquaculture Management (MAM) International Standard addresses the propagation, collection, and culturing of marine aquarium organisms, and specifies requirements from broodstock/post-larvae receipt through to grow-out for market; packaging and transport of cultured marine ornamentals. Such certification schemes will help ornamental aquaculture companies to meet internationally defined and recognized standards and promote sustainable practices.

Aquaculture involves a huge diversity of production systems which range from intensive systems where all food is provided, to extensive aquaculture where predators and competitors are controlled. In each case, the benefits and risks need to be understood, but criticism has particularly focussed on intensive systems in coastal areas e.g. shrimp and salmon farming (Naylor et al., 2000; Naylor and Burke, 2005; Primavera, 2006). Ornamental aquaculture tends to be conducted in closed tank systems or ponds, often in developed areas where there is sufficient capital investment for infrastructure development and close to an airport for easy transportation (Tlusty, 2002). Elucidating the position of ornamental fish production in the overall aquaculture scheme will assist in determining where further development would be most beneficial, and where it should be developed cautiously.

2. Seahorses — a case study

Seahorses, *Hippocampus* spp., are highly unusual marine fishes that have provided a focus for global conservation efforts. Their unique body morphology, with horse shaped head, large eyes, curvaceous trunk and prehensile tail, has made them charismatic icons for issues such as overfishing, bycatch or habitat destruction (Lourie et al., 1999). Many of their specialized life history traits including male pregnancy, lengthy parental care, small brood sizes, strict monogamy in most species, low mobility, small home ranges and sparse distribution may make seahorse populations particularly susceptible to anthropogenic disturbance (e.g. Foster and Vincent, 2004; Martin-Smith & Vincent, 2005; Vincent et al., 2005; Curtis and Vincent, 2006; Freret-Meurer and Andreata, 2008).

At least 46 species of seahorses are currently known, found worldwide in tropical and temperate shallow coastal habitats including seagrass beds, coral reefs, mangroves and estuaries (Kuiter, 2001, 2003, 2009; Lourie and Randall, 2003; Lourie et al., 2004; Piacentino and Luzzatto, 2004; Lourie and Kuiter 2008; Gomon and Kuiter, 2009; Randall and Lourie, 2009). Although our understanding of seahorse biology has improved greatly since the early 1990s, there are still large gaps in our knowledge for many species (see review by Foster and Vincent, 2004). Similarly, species identification remains challenging, with some of the taxonomy unresolved (Lourie et al.,