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A review of feeding practices and nutritional requirements of postlarval groupers

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ABSTRACT

Groupers (Family: Serranidae) are a very diverse family of predatory fish that are widely distributed throughout the tropical and subtropical seas of the world and notably those of the Indo-Pacific region. Species from this family are probably the most sought-after fish in the live reef fish trade and command high prices. Increased fishery effort has led to a significant decline in the wild catch of groupers and consequently, a heightened need for aquaculture product to supply the market. Improved hatchery technology and a more reliable supply of hatchery-produced fry in the past decade have resulted in a rapid increase in grouper aquaculture production world-wide but especially in the Asia–Pacific region. This expansion has seen an increasing need for more sustainable and environmentally responsible culture practices and especially for the development of manufactured feeds that better meet the nutritional requirements of the fish. This review provides an account of feeding practices used to rear juvenile groupers and advances that have taken place in the development of nutritionally adequate manufactured feeds for post-larval grouper.

Contents

1. Introduction

Groupers are predatory reef fish that are widely distributed throughout the tropical and subtropical seas of the world and notably those of the Indo-Pacific region. They are a very diverse group of fish comprising at least 115 species within 22 genera of the subfamily *Epinephelinae*, one of five subfamilies of Serranidae (Baldwin and Johnson, 1993; Williams et al., 2004a). Biologically, most species are protogynous (change sex from female to male), long-lived and late maturing. Some are small with a maximum size of 250 mm or less such as the plump grouper (*Epinephelus trophies*), but most are large fish with a mature size of 600–1200 mm while the giant of the group, *E. lanceolatus* attains a size of 2.7 m and more than 400 kg (Heemstra and Randall, 1993; FAO Fishbase, 2004). As a group, groupers are probably the most sought-after fish in the live reef fish trade, commanding high prices, especially for species such as humpback grouper (*Cromileptes altivelis*), red grouper (*E. akaara*), giant grouper (*E. lanceolatus*) and the coral trouts (*Plectropomus* spp) (Petersen et al., 2006; Johnston, 2007).

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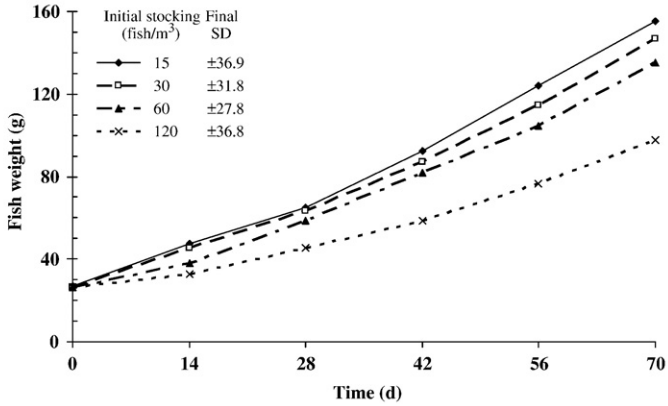

Fig. 1. Effect of stocking density (15, 30, 60 or 120 fish/m^3) on growth of *E. malabaricus* grouper cultured in floating net cages for 70 days (data of Teng and Chua, 1978).

Increased fishery effort, combined with the targeting of spawning aggregations and the use of destructive fishing practices, has led to a significant decline in the wild catch of groupers (Sadovy et al., 2003; Scales et al., 2007) and consequently, a heightened need for aquaculture product to supply the market. Early grouper aquaculture was confined to the on-growing of wild-caught juveniles as hatchery rearing of groupers initially proved difficult (Rimmer, 2000; Rimmer et al., 2004). Consequently, the commonly cultured groupers were the low-value estuarine species *E. coioides* (often incorrectly referred to as *E. tauvina*) and *E. malabaricus* (sometimes referred to as *E. salmoides*) (James et al., 1998; Rimmer, 2000) whose fingerlings could easily be caught using fish traps placed in near-shore nursery grounds. Feeding chopped-up fishery bycatch (trash fish) remains a common practice for on-growing of these fish to the preferred market size of 1–1.2 kg. Improvement in hatchery technology over the past few years has enabled more valuable grouper species to be cultured and has provided a more reliable supply of grouper fry (Liao et al., 2001; Rimmer et al., 2004). Together, these developments have enabled grouper aquaculture production to increase rapidly with FAO data showing total production rising from about 5000 metric tonnes (mt) in 1995 to more than 65,000 mt in 2005 (FAO Fishstat Plus, 2007). Grouper aquaculture is concentrated in Asia with China, Taiwan and Indonesia together providing more than 90% of total global production.

The expansion in grouper aquaculture has seen an increasing need for more sustainable and environmentally responsible culture practices and especially the development of manufactured feeds that better meet the nutritional requirements of the fish. Over the last decade or so, a large body of research has been done in the search for improved culture practices and to define the nutritional requirements for the different species of cultured groupers. In reviewing this research, this paper provides an account of feeding practices used to rear juvenile groupers and the nutritional knowledge that has been gathered to enable the production of better and more economical manufactured feeds for grouper grow-out. Developments that have taken place in hatchery technology and larval rearing of groupers are not addressed but this information can be found in the comprehensive reviews of Liao et al. (2001), Sugama et al. (2003) and Rimmer et al. (2004).

2. Culture and feeding practices

Being euryhaline and thermally-tolerant, groupers are amenable to pond or net cage culture in waters of 11 to 41‰ salinity (Leung, 1976; Yashiro et al., 1999), 22 to 31 °C (Leung, 1976; Anon, 2000), and 4.9 to 9.3 ppm dissolved oxygen (Anon, 2000). While polyculture of groupers with tilapia or siganids in saline ponds is advocated in the Philippines, groupers are more typically reared as a monoculture (Anon, 2000, 2001). In many Asian countries, on-growing of groupers comprises a 2–3 month nursery phase where fry of 50–60 mm (3–4 g) are reared to juveniles of 140–150 mm (50–60 g) followed by a grow-out phase until fish reach a preferred market size of 600–1200 g (Anon, 2001).

There have been few controlled studies reporting the effect of stocking density on grouper grow-out. Teng and Chua (1978) examined four stocking densities (15, 30, 60 and 120 pieces/m^3) with estuary grouper *E. malabaricus* (reported as *E. salmoides*) of 15 or 26 g initial weight that were held in floating net cages of 1.5 × 1.5 × 1.65 m. Following a 10-week grow-out period, average weight of the fish declined slightly as stocking density increased from 15 to 60 fish/m^3 (from 113 to 102 g for the smaller group of fish and 155 to 135 g for the larger group of fish, respectively) but markedly thereafter to 72 g and 98 g respectively for the 120 fish/m^3 stocking density (Fig. 1). Survival rate did not differ significantly for fish stocked at densities between 15 and 60 fish/m^3 (from 93 to 96%, irrespective of the starting size) but was lower for fish at the higher stocking rate (83% for the small fish and 89% for the large fish). Although net biomass yield of fish for both starting sizes increased with increasing stocking density, the adverse effects on final weight and fish survival of stocking at 120 fish/m^3 suggested that the optimal stocking density was around 60 fish/m^3. Abdullah et al. (1987) reported nursery and grow-out stocking density experiments with *E. coioides* (reported as *E. tauvina*) cultured in raceways of 7 × 1.5 m. For the 52-day nursery study with fry of 17 g, stocking at either 200 or 400 fish/m^3 in the raceway (depth of 0.25 m; 2.2 m^3 total volume) resulted in similar end weights (62–64 g) and excellent survival of 98%. For the 31-week grow-out study, fish of 150–170 g initial size were stocked at densities of 5, 20 or 60 fish/m^3 in the raceway (depth of 0.6 m; 6.0 m^3 total volume). Final average size of the fish declined with increasing density (770, 560 and 450 g, respectively; Fig. 2) but final biomass increased (3.9, 7.7 and 14.7 kg/m^3, respectively); survival decreased from 100% for the two lower densities to 87% for the highest density. Worthy of note was the large within-treatment size variation of the fish in the grow-out study where coefficients of variation increased from 30 to 34 and 44% as stocking density increased from 5 to 20 and 60 fish/m^3, respectively. In a 12-month grow-out study with *E. polyphekadion* of 56 to 59 g start weight held in round tanks of 3.0 m dia. and 10 m^3 effective volume, final average fish weight declined non-significantly from 545 to 540 and 513 g as stocking density increased from 5 to 15 and 45 fish/m^3, respectively (James et al., 1998). Survival declined significantly with increasing stocking density (from 98 to 90 and 85%, respectively) and size variability was again observed with coefficients of variation ranging from 26 to 31%.

From the above grouper studies, it is clear that increasing stocking density adversely affects growth and survival rates of the fish while biomass yield is increased over the examined range of densities. Moreover, increasing stocking density results in a greater variability in fish size, which under commercial conditions would require regular

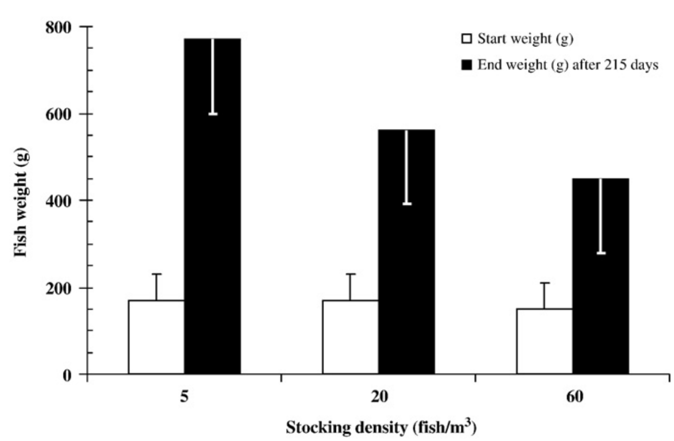

Fig. 2. Effect of stocking density (5, 20 or 60 fish/m^3) on growth of *E. coioides* grouper cultured in PVC-lined raceways for 215 days (data of Abdullah et al., 1987). Error bars are + or − 1 SD.