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Zaragoza : CIHEAM

Cahiers Options Méditerranéennes; n. 47

2000

pages 359-363

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=600638>

To cite this article / Pour citer cet article

Skaramuca S., Kozul V., Glavic N., Tutman P., Glamuzina B., Katavic I., Grubisic L. **Recent advances on the diversification of marine finfish species in Croatia.** *Recent advances in Mediterranean aquaculture finfish species diversification.* Zaragoza : CIHEAM, 2000. p. 359-363 (Cahiers Options Méditerranéennes; n. 47)



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Recent advances on the diversification of marine finfish species in Croatia

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SUMMARY – Research on the introduction of new finfish species to mariculture followed commercial development during the eighties in Croatia. Although a few species were under investigation, such as the common dentex, *Dentex dentex*, two-banded sea bream, *Diplodus vulgaris*, and sea bream, *Diplodus puntazzo*, the technology was not developed to a commercial level. In the meantime, following the recent interest for mariculture development in Croatia, more research was undertaken to diversify production and to add new species with a higher market value. There are about ten species in all of Croatia which are the subjects of mariculture research. In our laboratory, we chose the following species: groupers of the genus *Epinephelus*, amberjack, *Seriola dumerili*, pink dentex, *Dentex gibossus*, stone fish, *Scorpaena scrofa*, and some other species of lower commercial interest, but important for the repopulation of destroyed ecosystems, such as the brown wrasse, *Labrus merula*.

Key words: Diversification, amberjack, pink dentex, brown wrasse, salema, scorpionfish.

RESUME – "Progrès récents en diversification des espèces de poissons marins en Croatie". Les recherches sur l'introduction des espèces nouvelles de poissons en mariculture suivaient l'exploitation commerciale pendant les années 1980 en Croatie. Quoique quelques espèces étaient recherchées, denté commun, *Dentex dentex*, sar à tête noir, *Diplodus vulgaris*, sar à museau pointu, *Diplodus puntazzo*, la technologie n'était pas développée au niveau commercial. Cependant, comme conséquence de l'intérêt récent pour le développement de la mariculture en Croatie, il y a eu plus de recherches entreprises pour la diversification de la production et pour l'augmentation des espèces nouvelles avec une haute valeur de marché. En Croatie, il y a environ dix espèces qui sont le sujet de recherches en mariculture. Dans notre laboratoire, nous avons choisi les espèces suivantes : les mérours du genre *Epinephelus*, sériole couronnée, *Seriola dumerili*, denté bossu, *Dentex gibossus*, rascasse rouge, *Scorpaena scrofa*, et autres espèces de peu d'intérêt commercial, mais importantes pour le repeuplement d'écosystèmes détruits, telles que le merle, *Labrus merula*.

Mots-clés : Diversification, sériole couronnée, denté bossu, merle, saupe, rascasse rouge.

Introduction

The present mariculture industry in the Mediterranean is mainly based on the intensive production of two finfish species: sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*). Their life cycles are well known and their production potential is much exploited. The hatchery-produced juveniles are easily meeting the requirements of existing production that is approaching 80,000 tons/year (Harache and Paquotte, 1998). The majority of this production comes from floating cages, whose technology is very well developed and constantly progressing.

One of the consequences of such success has been a drop in market prices, and problems in maintaining the sustainability and profitability of the whole mariculture sector (Stephanis and Divanach, 1993). To overcome the existing difficulties in the mariculture sector, diversification of cultured fish species seems to be a good strategy for the future of the mariculture industry in the Mediterranean. In this respect, several sea bream species have been reported as highly suitable for mariculture (Abellán and García-Alcázar, 1995; Barbato and Corbari, 1995). However, commercial production for most of them is still at an experimental or pre-industrial level. Kentouri *et al.* (1995) proved an important lack of basic knowledge and stressed the need for further research if these fish species are to be fully integrated into the mariculture industry.

Diversification of Croatian mariculture was initiated in the mid-eighties in the commercial and

scientific institutions. Research focused on the introduction of a few species from the *Sparidae* family. At the time, the targeted species were the common dentex, *Dentex dentex*, two breams, *Diplodus vulgaris* and *Diplodus puntazzo*, and salema, *Sarpa salpa*.

At the beginning of the nineties, new species were selected for research. They were: the greater amberjack, *Seriola dumerili*, dusky grouper, *Epinephelus marginatus*, scorpionfish, *Scorpaena scrofa* and pink dentex, *Dentex gibbosus*. Research on the salema was continued since the species has been recognized as a low-cost production fish, as it fed very efficiently on low food level.

After reports on the decline of some stocks of fish species in the Adriatic and Mediterranean, we also decided to diversify our investigations to endangered species. So, we started with the brown wrasse, *Labrus merula*.

In this paper, we will present research on the diversification of marine finfish species in our Institute, including both sparids and non sparid fish species.

Species of interest

The following list of species has been defined as candidate species, although some of them have been commercially produced elsewhere. This classification is based on the main information available through literature examination and our personal experiences aiming to reconsider their aquaculture potential and to explore them in a better way.

(i) For commercial rearing:

- Greater amberjack, *Seriola dumerili*.
- Dusky grouper, *Epinephelus marginatus*.
- Pink dentex, *Dentex gibbosus*.
- Scorpionfish, *Scorpaena scrofa*.

(ii) For stock enhancement:

- Dusky grouper, *Epinephelus marginatus*.

(iii) Repopulation of endangered species:

- Brown wrasse, *Labrus merula*.

(iv) Genetic studies and hybridization:

- White grouper, *Epinephelus aeneus* and dogteeth grouper *Epinephelus caninus*.
- Annular bream, *Diplodus annularis*, *Pagellus bogaraveo*.

Mediterranean amberjack *Seriola dumerili* (Risso, 1810)

The Mediterranean amberjack *Seriola dumerili* (Risso, 1810) is a pelagic migratory fish of warmer seas. Due to its fast growth rate, good acclimation in captivity and high commercial value (between 5 and 18 USD/kg), there is growing interest for this species in mariculture.

The average size ranges from 30 to 50 cm. The maximum size reported is 180 cm in total length and 80.6 kg in body weight (Fisher, 1973).

In the south-eastern Adriatic, the Mediterranean amberjack appears near the coast at the beginning of the spawning season, when the sea temperature exceeds 18°C. This is the time for the intensive fishing of amberjack. Adult fish of 101.4-134.8 cm in total length and 10.5-25.5 kg in weight were caught. Scale reading analysis showed that the fish caught aged from one to ten year (Kožul *et al.*, in press).

In the first and second year of the capture, there were no differences in the gonad development of males or females from either wild and cultured amberjack. In the third year, captured females showed advanced oocyte development at the prespawning size. Three year old wild males showed a completely developed testis as opposed to that of cage reared males, which released a small amount of sperm. Four year old caged females had mature gonads with 400-600 μm oocyte diameter during the spawning season and males released a higher amount of sperm (Kožul *et al.*, 1998).

During our observations on juvenile amberjack growth in tanks and cages, we found a fast growth rate and very good acclimation to tanks and cage rearing. The final average weight after one year of cage rearing was 1239 g and the average length was 47.8 cm (Skaramuca *et al.*, 1998). After two years of cage rearing, the average weight was 1960 g, while after three years it was 5100 g. The average length was 52.1 cm after two years and 77 cm after three years in cages (Kožul *et al.*, 1998).

These research results have shown that the Mediterranean amberjack could become a potential species for mariculture in the Adriatic Sea, and in future observations special attention has to be given to reproduction studies. This will enable the faster introduction of this species to commercial aquaculture.

Pink dentex, *Dentex gibbosus* (Rafinesque, 1810)

The pink dentex [*Dentex gibbosus*, (Rafinesque, 1810)] is one of the potentially interesting fish species to be fully included in future mass rearing programs. Highly appreciated by consumers, the pink dentex enjoys high market prices. This is a carnivorous species whose natural diet is composed mainly of crustaceans, fish and cephalopods. Given its fecundity rate and easy egg and larval development, this fish also has a good potential for reproduction in captivity (Fernández-Palacios *et al.*, 1994). The maximum size reported for this species is 100 cm, with an average of 60 cm (Bauchot and Hureau, 1981). Its area of distribution is the Mediterranean and the east Atlantic coast, from Portugal to Angola. Juveniles and subadults live closer to the shore, often inhabiting sandy bottoms, and as such are very common in estuaries, while adult individuals are found in deeper waters, with preferences for rocky habitats up to the limits of the continental shelf.

The first efforts in the culture of the pink dentex in Croatia started at Institute of Oceanography and Fisheries in 1997, when subadults (1 and 2 year olds) were caught from the wild and successfully acclimated to both land and floating cage installations.

Preliminary comparative studies have shown that this species displays high survival and excellent growth potential; the growth rate was much better than in any other sparid species tested (Katavić *et al.*, unpublished). However, it is very probable that fresh food (trash fish and squids) will be needed to simulate natural food, as the survival and growth of fish fed dry pellets have been quite disappointing (Grubišić *et al.*, unpublished). We also found that 3-year old fish reared in cages released sperm from August to October. Further studies are needed to confirm the biological response of the pink dentex to a variety of both natural and artificially made complete diets.

Brown wrasse, *Labrus merula* (Linnaeus, 1758)

The brown wrasse, *Labrus merula* (Linnaeus, 1758), is the subject of intensive commercial and sport fisheries along the eastern Adriatic coast and has consequently become rare (Jardas, 1996). It is distributed throughout the Mediterranean, and is absent from the Black Sea and in the eastern Atlantic from Portugal to Morocco, including the Azores (Quignard and Pras, 1986). The species is a protogynous hermaphrodite. This is shown by the fact that 50% of the population are males that have changed sex, and the other 50% of the population consists of younger females.

The embryonic and larval development under aquaria conditions was described (Dulčić *et al.*, 1999).

Parental stock (three males and five females) were kept under natural conditions. Fish spawned spontaneously in March. The eggs (0.92 ± 0.005 mm) are demersal and it is difficult to identify the morphological characteristics by which brown wrasse eggs differ from those of other labrid species. Only two labrid species *Ctenolabrus rupestris* and *Coris julis* spawn pelagic eggs (Russell, 1976) in the Mediterranean. The length of newly hatched larvae of brown wrasse was significantly greater than

those of the other labrid species, but it is similar to that of *Labrus bergylta*. The pigmentation of brown wrasse larvae is similar to that of *Labrus bergylta*. The spawning period and geographical distribution could be of help in determining the early life history stages of labrids.

Due to its behaviour, this species is an easy catch for sport fishermen. The biological and ecological investigations of brown wrasse in our laboratory can help in the protection of this species, which has become very rare along our coast over the past decade. The production of juveniles for the restocking projects of this endangered species is important for the survival of brown wrasse.

Salema, *Sarpa salpa* (Linnaeus, 1758)

The salema, *Sarpa salpa* (Linnaeus, 1758), is a fish found along rocky coasts covered with algae. It belongs to the family *Sparidae*. It is mostly found in the Mediterranean, but it can also be found along the eastern Atlantic coastline, up to the Bay of Biscay and the shores of South Africa and is rarely found in the Black Sea. It reaches lengths of c. 51 cm and weights of up to 3 kg (Bini, 1968; Fisher, 1973; Tortonese, 1975; Smith, 1977). In the Adriatic Sea, it is distributed all along the entire coastal belt up to 20 m depths (Grubišić, 1982). It is a protogynous hermaphrodite which sexually mature at approximately 20 cm lengths, and spawns at the beginning of fall and in winter (Jardas, 1996; van der Walt and Mann, 1998). Under natural living conditions, it is mostly a herbivore, changing its food habit by the age and flesh chemistry at the same time (Joubert and Hanekom, 1980; Pelivan, 1981; Gerking, 1984; Antolić *et al.*, 1994; Tomec *et al.*, 1998).

Our preliminary research has shown that the salema could be a potentially interesting species for aquaculture, in polyculture with other carnivorous fish. It adapts quickly to food of various origin, from herbal (i.e. garden lettuce), frozen sardines to pellet food, and in production could prove to be a very cheap fish (Skaramuca and Sanko-Njire, 1988). It supports and acclimates well to various salinities. In our experiment, the transfer of fish from ambient seawater (38‰) to water at 16‰ showed a mortality of less than 5% (Lucu *et al.*, 1989).

Even though a significant number of juvenile could be caught for stocking purposes all along the eastern shores of the South Adriatic, a future task will be to research the spawning possibilities and survival of early developmental stages in captivity.

Scorpionfish, *Scorpaena scrofa* (Linnaeus, 1758)

The scorpionfish lives on harsh rocky and grassy bottoms up to 400 m depths. It is distributed along the eastern Atlantic from the Bay of Biscay to Senegal. In the Mediterranean, it can be found everywhere, except in the Black Sea. In the Adriatic, it is a frequent species, especially along the shores of outer islands and reefs (Jardas, 1996). Spawning occurs at the end of spring and at the beginning of summer. The roe is found in a slimy mass and is pelagic. It feeds upon crustaceans, fish and cephalopods. It reaches lengths of up to 66 cm and weights of about 5 kg. Along the eastern Adriatic coast of Croatia, an average of approximately 150 tons is caught annually. It is highly prized fish, reaches a high market value.

The scorpionfish has the potential of becoming an interesting fish for aquaculture. Over the last three years, we have been intensely gathering a broodstock. Fifty fish of from 0.1 to 1 kg weight were acclimated in our laboratory tanks. It adapts easily to captivity conditions. The fish are fed with frozen small blue trash fish.

Our next task will be to investigate the time of sexual maturity, the possibility of spawning under laboratory conditions, artificial spawning, survival and feeding of early developmental stages.

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