European seabass (*Dicentrarchus labrax*) – Current status of selective breeding in Europe

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Summary

This report describes the status of selective breeding of European seabass (*Dicentrarchus labrax*) in European aquaculture. Surveys were conducted among the five existing breeding companies to gain insight into the main characteristics of breeding companies and their juvenile production. The market share of breeding companies was estimated from the total juvenile production by breeding companies relative to the total European juvenile production. Three breeding companies performed mass selection and two performed family selection. Commonly selected traits were growth performance, morphology, processing yield and disease resistance. The number of selected generations ranged from two to eight. Strains of breeding companies that have performed over four generations of selection may, based on estimates of genetic parameters, be twice as heavy after an equal growing period compared to wild strains. The market share of breeding companies in total juvenile production was 38-51% in 2012.

1. Introduction

European aquaculture production of seabass is about 70 thousand tonnes (table 1). This production is achieved from over 300 million 2-10g juveniles, which are grown to a harvest weight of 400g in 18 months (FAO, 2014a). More than 50% of the European production of fish and juveniles takes place in Greece. France exports the majority of its juvenile production. The survival from egg to juvenile is highly variable among different hatcheries, but also among different batches within the same hatchery. The industry average survival from egg to juvenile ready for sales or stocking is 30-35% (Anonymous, 2015).

Table 1. European seabass production volume and value in Europe in 2012

Country	Production volume [a] (tonnes)	Production volume [b] (tonnes)	Production value [b] (1000 €)	Juvenile production [a] (million)
Croatia	2 375	2 453	12 865	8
Cyprus	1 096	1 100	7 264	5
France	2 300	2 300	15 189	46
Greece	41 500	42 500	217 558	184
Italy	7 200	6 700	55 450	40
Malta		126	831	
Portugal	500	531	3 408	
Slovenia		52	312	
Spain	14 270	14 455	92 752	36
United Kingdom		800	8 884	
Total	69 241	71 017	414 513	319

[a] (FEAP, 2014)

[b] (FAO, 2014b)

Aquaculture of European seabass (*Dicentrarchus labrax*) started in the 1970's and was based on the collection of wild juveniles. The development of reproductive technologies was crucial to the development of the industry (Coves et al., 1991 ; Divanach & Kentouri, 2000). Global seabass production increased rapidly from four thousand tonnes in 1990 to 153 thousand tonnes in 2012 (FAO, 2014b). Thereby seabass has also become one of the main aquaculture finfish species in Europe. Until the 1990's, production relied entirely on wild broodstock. Since then the first selective breeding programs were being developed in several countries, but even in 2006 less than 20% of production was realised from broodstock which has been selected on for two or more generations

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(Chatain & Chavanne, 2009). It is unclear to what extent advances in selective breeding have been adopted by the sector and what part of the current production originates from breeding companies. Therefore this report aims to:

1. Describe the main characteristics of breeding companies.
2. Estimate the market share of breeding companies in Europe.

2. Materials and Methods

2.1. Characteristics of breeding companies

In a first survey conducted in collaboration with AQUATRACE[1], questionnaires were distributed among the five breeding companies in Europe. This extensive questionnaire included questions related to the type of selection, the number of selected generations, selected traits, the application of genetic markers and genomic selection, the monitoring of inbreeding, protection strategies and the quantity of juveniles produced.

As not all companies completed the extensive questionnaire, a second survey was carried out involving a limited number of questions. The aim of this second survey was to identify whether a breeding company employed mass or family selection and how many juveniles it produced in 2012.

2.2. Market share of breeding companies

The market share is defined as a firm's sales relative to the total sales of all firms in the same industry (Ghosh, 2004). Here it is used as the total juvenile production of breeding companies relative to the national and relative to the total European juvenile production (table 1). Both surveys provided information on the quantity of eggs and juveniles produced per breeding company. The juvenile production data were compared to national and European statistics in order to estimate market shares. On a national level the market share of breeding companies was determined by comparing the pooled juvenile production of breeding companies per country to the national juvenile production. On a European level the market share of breeding companies was determined by comparing the pooled juvenile production of breeding companies to the total European juvenile production.

3. Results

3.1. Characteristics of breeding companies

In 2012 four companies were active in selective breeding of seabass. Three out of four breeding companies completed the questionnaire of the first survey. Of these three companies two performed mass selection and one performed family selection. The different companies reported to have performed selection for three, four and eight generations. Most breeding companies performed selection on growth performance and morphology (table 2). The rate of inbreeding was monitored by all three companies. One of the breeding companies that performed family selection applied artificial fertilization to create families and the other applied mass spawning and reconstructed pedigrees

[1] AQUATRACE - https://aquatrace.eu/ - 7th Framework Programme for research (FP7)

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with the use of genetic fingerprints. All three companies indicated to apply marker assisted selection and one applied genomic selection.

Table 2. Traits in selection of gilthead seabream breeding companies in Europe

Selected traits	Mass selection [a]	Family selection [a]
Growth performance	1	2
Processing yield	1	1
Product quality	0	1
Disease resistance	0	2
Reproduction (maturity, fecundity)	0	0
Morphology	1	2
Feed efficiency	0	1

[a] *Number of respondents that performed selection on a trait. Three companies completed the questionnaire, of which one applied mass selection and two applied family selection.*

3.2. Market share of breeding companies

The juvenile production data of all four breeding companies were collected (figure 1). One breeding company did have a breeding program, but did not produce any juveniles from it in 2012. The combined juvenile production by breeding companies was 82-102 million, corresponding to 26-32% of the total European production. Three breeding companies were located in Greece and one in France (figure 2).

Most breeding companies did not sell egg to other parties, but one company indicated to have sold 200 million eggs. Assuming an average egg to juvenile survival of 30-35% (Anonymous, 2015), these eggs have potentially resulted in the production of an additional 60-70 million juveniles. However, as part of the eggs was sold outside Europe, it was estimated that these eggs have resulted in the production of an additional 40-60 million juveniles in Europe. Therefore, the market share of breeding companies in the total European production of juveniles was estimated at 38-51%. The egg sales were ignored in the national market shares as presented in figure 2, since it was unclear in which countries these egg have resulted in the production of juveniles.

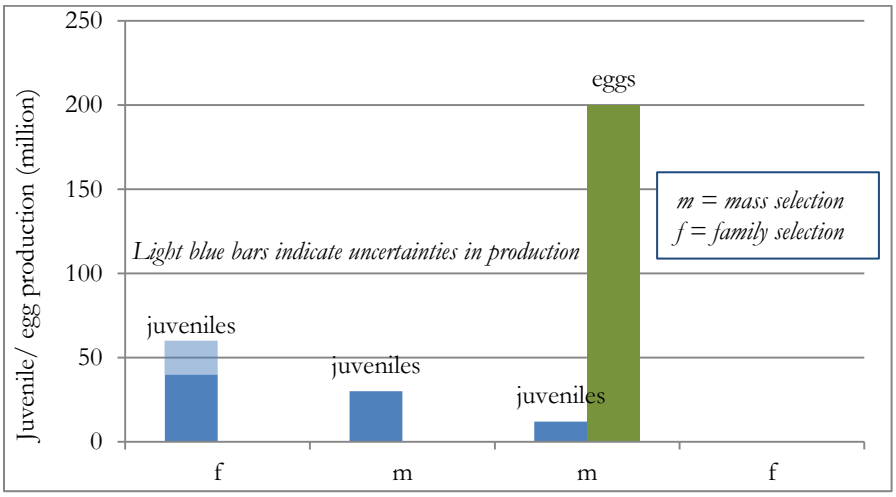

Figure 1. The egg and juvenile production of four European seabass breeding companies in Europe in 2012.

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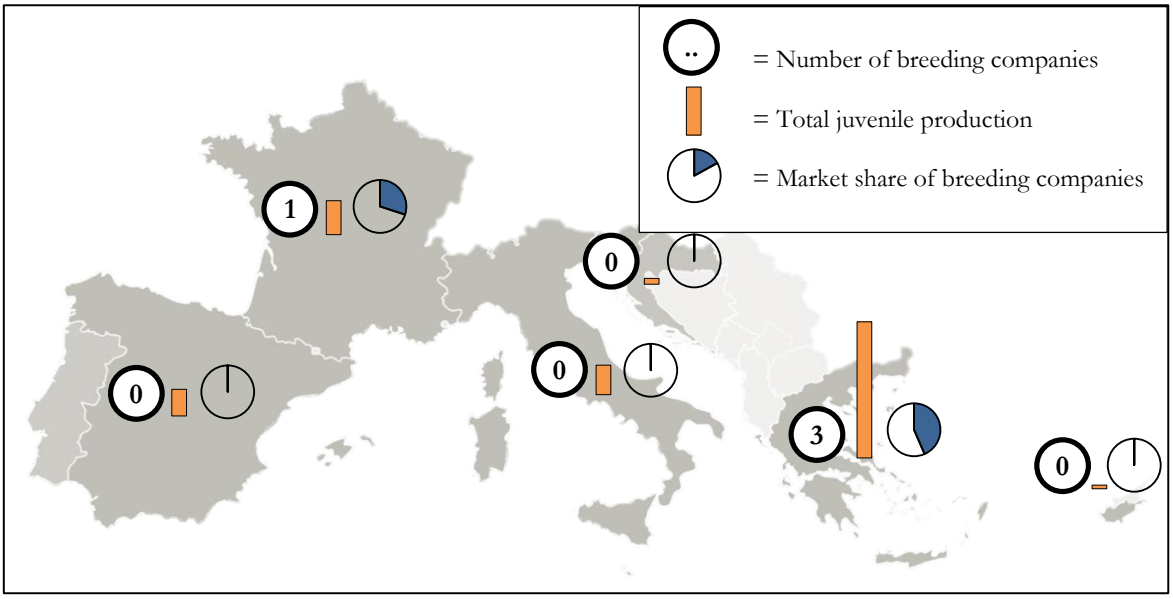

Figure 2. The distribution of European seabass breeding companies across Europe, the juvenile production per country and the national market share of breeding companies in 2012.

4. Discussion

A generation interval of two years can be obtained in controlled rearing conditions, but in practice it is longer and ranges between four and six years (Haffray et al., 2006). The highest reported number of selected generations was eight, indicating that the oldest breeding program started in the mid 1980's.

Only one breeding company operates a breeding program as its core activity. Most of the breeding programs are part of large integrated companies which control the entire process from reproduction to harvest. Deliveries of eggs and juveniles by these integrated companies to other parties are generally limited, which is different from the specialized breeding company. Compared to 2006 when less than 20% of production was realised from broodstock which has been selected on for two or more generations (Chatain & Chavanne, 2009), the market share of breeding companies has substantially increased. This increase should be attributed to an increase in scale of breeding companies.

The impact of selective breeding on seabass production depends on the market share of breeding companies as well as the genetic gain that has been achieved. Studies comparing the performance of strains that have been selected for multiple generations to the performance of wild strains are lacking. Vandeputte et al. (2009) compared the growth performance of offspring from wild seabass, to the offspring of selected sires and wild dams. They found a 12% higher bodyweight at harvest in the offspring of the selected sires compared to the offspring of unselected parents after equal growing periods and they predicted a selection response of 23% on weight at harvest when selecting on both males and females. Similar selection responses were achieved by Le Boucher et al. (2013) in the first generation of selection and slightly higher responses of 25-30% were predicted by Chatain and Chavanne (2009). However it is unlikely that such a high selection response has been achieved across multiple generations, as the response to selection decreases a bit after the first generation (Bulmer, 1971). Nevertheless it seems feasible that strains of breeding companies that have

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performed over four generations of selection are twice as heavy as wild strains after equal growing periods. In practice this is likely to have resulted in a combination of a reduced growing period and an increase in harvest weight.

5. Conclusion

1. In 2012 four companies were active in selective breeding of seabass.
2. Both mass and family selection are performed, with commonly selected traits being growth performance, morphology, processing yield and disease resistance.
3. The number of selected generations ranged from three to eight.
4. The market share of breeding companies in the total European juvenile production was 38-51% in 2012.
5. Strains of breeding companies that have performed over four generations of selection may, based on estimates of genetic parameters, be twice as heavy after an equal growing period compared to wild strains.

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