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Body abnormalities in relation to size and sex of laboratory reared European sea bass *Dicentrarchus labrax* L.

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*Juvenile sea bass (*Dicentrarchus labrax*) were separated into two groups according to body size. The first group consisted of fish up to a weight of 1.8 g (mean±SD=1.49±0.22 g) and the other from a weight of 3.25 g (4.28±0.96 g). A third or mix group consisted of the samples from the original rearing stock (2.43±0.84 g). After 16 months of rearing, the small fish group showed a higher incidence of mouth and spine deformations than the large one. In both groups fish with deformations had a lower body weight than the normal fish. Deformations of the mouth and spine were not related to sex and were independent from the type of spinal deformation.*

Key words: sea bass, culturing, body deformities

INTRODUCTION

A high occurrence of body deformations in hatchery-produced fish is associated with growth inhibition and increased mortality. Deformations also decreased marketability of the fish (SARÀ *et al.*, 1999). Skeletal deformities in fish are visible by external inspection of the body through dissections, or by radiography. They appear as curvature of the spine or vertebra deformity and can be classified as dorsal-ventral flexures called lordosis or as dorsal flexures called cyphosis, and lateral flexures called scoliosis. Spinal deformities may appear at various stages of development, but the most damaging occur during the embryonic and post-embryonic stages of life (HONDE, 1979). Reports on both vertebra and spine abnormalities in wild fish are very dated and their occurrence in many cases could be linked to water pollution (BENGTSSON, 1979). For example TUDOR and KATAVIĆ (1986), as well as GLAMUZINA *et al.* (1990) noted that exposure of sea bass *Dicentrarchus labrax* and gilthead sea bream *Sparus aurata* eggs to oil dispersants or to the water soluble fraction of oil caused spinal deformities in hatching larvae.

Summarising the results of laboratory research and observations in natural environment, BENGTSSON (1979) reported a list of causative factors of fish abnormalities: hereditary factors, defective embryonic development, unsuitable water temperature, low levels of dissolved oxygen, radiation (x and ultra violet), dietary vitamin deficiencies, parasitic infection, electric currents and trauma. The same author listed several toxic substances, which cause vertebral and spinal deformities. An extremely high incidence of skeletal abnormalities has been recorded in cultured sea bass (BARAHONA-FERNANDES, 1982; JOHNSON and KATAVIĆ, 1984). Spinal deformities are frequently associated with swimbladder malformations, such as unanflated or hyperinflated swimbladder (KATAVIĆ, 1985; DAOULAS *et al.*, 1991).

The present research was performed to obtain more informations on the effect of initial body weight and sex on the incidence of deformations, on the relationship among different kinds of deformities and the effect of body and mouth abnormalities on growth rate.

MATERIAL AND METHODS

Juvenile sea bass were obtained by fertilizing eggs from numerous female with the sperm of few males on January 25, 1995 in the hatchery of the Institute of Oceanography and Fisheries in Split (Croatia). The brood stock was kept in ambient water temperature (11-12 °C) and salinity (37 ppt). The hatched larvae were placed in $2m^3$ cylindrical tanks for rearing. The temperature was gradually increased to 20°C and it remained constant until the 90th day. Fish were fed *Artemia* (nauplii and metanauplii) from 6 to 50 days post hatching. Illumination was regulated to have a 14:10 hours light dark photoperiod. Weaning took place from 45 to 60 days using commercial starter (Brand name "Universal", Italy) and by progressively reducing the amount of *Artemia*. The average survival rate from hatching to 150 days was 10%. No grading or removal of fish with unanflated swimbladders took place during the entire rearing period.

On July 5, fish without visible abnormalities from rearing stock were allocated into three groups. One group consisted of the fish with a body weight less than 1.80 g (S, mean±SD = 1.49±0.22g, n=94) and second group with a body weight bigger than 3.25 g (L, 4.28±0.96g, n=120). A third group was a sample of rearing stock (M, 2.43±0.84g, n=112). Fish were reared under natural photoperiod in rectangular concrete tanks (5x1x1m) receiving a continuous flow of untreated seawater, and were fed twice a day (0800 and 1500) to satiation. After 16 months, in November 1996, fish were sacrificed and stored at -20°C. The total length and weight of the thawed specimens were measured, and inspection for mouth and spine deformities was performed.

In regards to body parts, deformities were divided into two types: mouth deformities (M) and spinal deformities. The most observed mouth deformities were atrophies of upper jaw and deformed lower jaw. The spinal deformities were further classified as anterior flexure (AF) and posterior flexure (PF) or both of them jointly (APF). Anterior flexure was characterised by V-shaped dorsoventral curvature of the body axis. The most prevalent posterior flexure was detected and fusions in the caudal vertebrae with the abnormal rays in the caudal fins (PAVLOV and MOKSNESS, 1997). In contrast to fish with posterior flexure, fish with anterior flexure showed unanflated swimbladders. The three types of deformities can be combined in seven different ways, that is, a deformed fish can have one of the seven possible combinations (M; M,AF; M,PF; M,APF; APF; AF; PF) having from one to a maximum of three abnormalities at the same time.

The sex of each experimental fish was also determined at the end of the experiment. The gonads were removed from the fish with forceps and placed on a glass slide. Oocytes were easily seen in the ovarian tissue, whereas, testicular tissue consisted of cysts of spermatocytes or spermatids by microscope.

A G-test and one way ANOVA were done according to SOKAL and ROHLF (1969). The possible inter-relationship among frequencies of abnormality types was examined using the BRAY-CURTIS similarity coefficient (BRAY and CURTIS, 1957).

RESULTS

Body abnormalities and growth

The frequencies of fish body weight of the three size groups at the beginning and the end of the experiment are shown in Fig. 1. At the beginning of the experiment, distributions of body weight of the small and large fish did not overlap (Fig.1).

After 16 months of rearing, approximately 50% of the specimens from the L group had weights in the same range as fish found in the S group. The number and relative frequencies of deformed fish presenting one or more deformities are reported in Table 1.

In the group of small fish, 13.8% of individuals in total did not have mouth or spinal deformities, while 68.7% of specimens in the group of large fish were normal. The small and mixed fish groups did not differ significantly in the presence of deformities ($P>0.05$). On the contrary, occurrence of deformities between the small and large, as well as between the mixed and large groups were significantly different ($P<0.05$).

Table 1. Relative frequencies (in %) of deformed male and female fish after 16 months of rearing in the groups S (n=72), M (n=63) and L (n=83)

Group	Male	Female	Total
S	55.6	30.6	86.2
M	44.4	30.2	74.6
L	18.1	13.2	31.3

The relative frequencies of the seven possible combinations of deformities are reported in Fig. 2. The most common single deformity was of the mouth (25.9%), followed by anterior flexure (8.9%) and posterior flexure (2.2%). Mouth deformities (M+MAF+MPF+MAPF) represented 68.2% of total deformities. Anterior flexures deformities (AF+MAF+MAPF+APF) were observed in 68.9% of all deformities, while posterior flexures (PF + APF + MAPF + MPF) occurred in 34.8% of deformed fish (Fig. 2). Deformation of the mouth appeared in 57% of sea bass specimen with anterior flexure, in 58.1% of specimens with posterior flexure and in 57% of individuals with both types of flexure.

In Fig. 3. average live weights of normal and deformed fish are reported. Normal fish had the highest mean weight, followed by fish with mouth deformities, and by those having mouth and spine deformities and deformed spines. The highest variation in body weight was found in fish with deformation of the mouth as the only deformity.

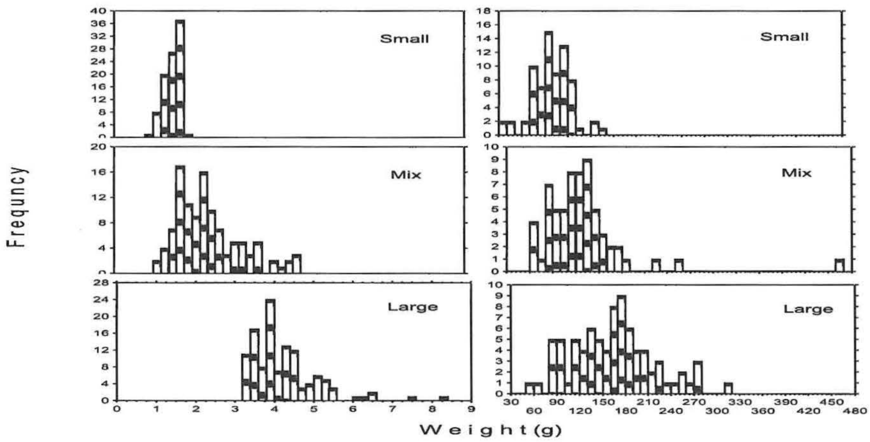

Fig. 1. Frequencies of fish body weight at the beginning and the end (after 16 months of rearing of three fish groups) of an experiment studying the influence of initial fry weight on final weight at 22 months of age in European sea bass

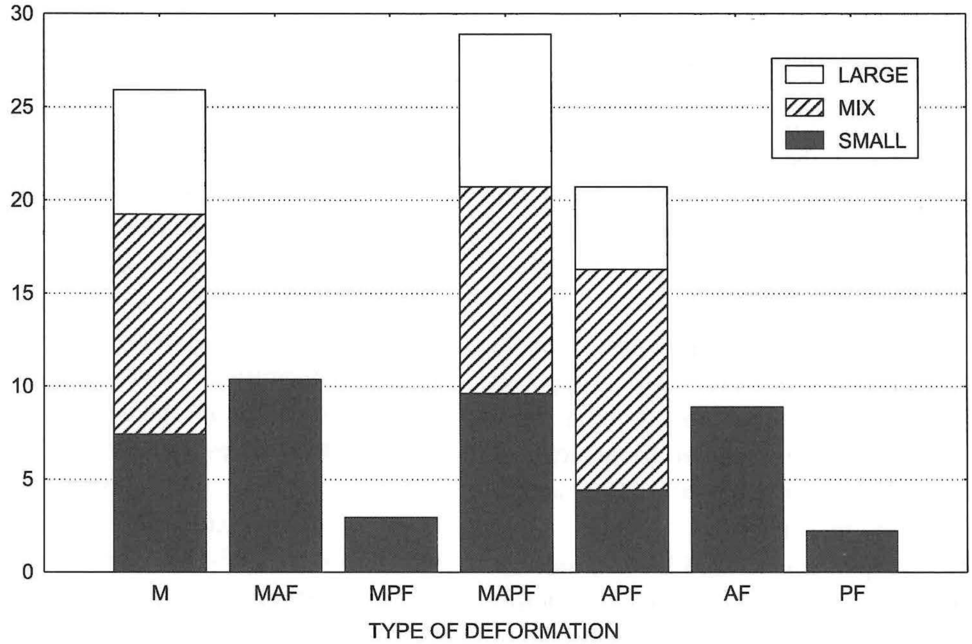

Fig. 2. The relative frequencies of the seven possible combinations of three types of deformities (M-mouth, MAF-mouth and anterior flexure of the body, MPF-mouth and posterior flexure of the body, MAPF-mouth, anterior and posterior flexure, APF-anterior and posterior flexure, AF-anterior flexure, PF-posterior flexure) in the three size groups

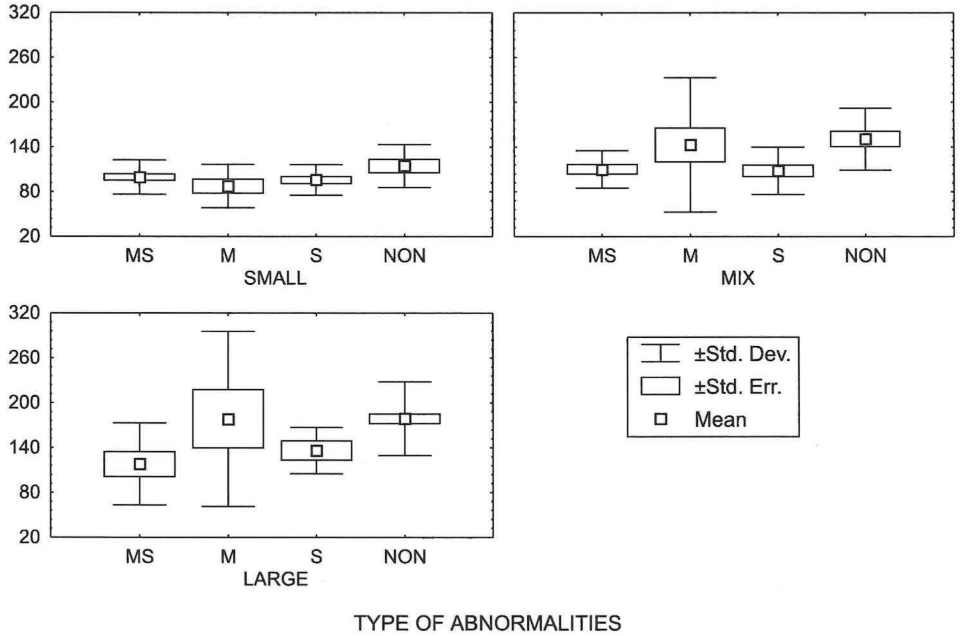

Fig. 3. Mean weights for three groups of fish (small, mix, and large) without body and mouth deformities (NON), with mouth deformities (M), mouth plus spine (MS=MPF+MAF+MAPF), and spinal deformities alone (S=AF+PF+APF)

Table 2. Relative frequencies (in %) of deformities of cultured European se bass of 22 months of age in relation to sex (M-mouth, MAF-mouth and anterior flexure of the body, MPF-mouth and posterior flexure of the body, MAPF-mouth, anterior and posterior flexure, APF-anterior and posterior flexure, AF-anterior flexure, PF-posterior flexure, NON-normal fish)

Sex	Type of deformation							
	NON	M	MAF	MPF	MAPF	APF	AF	PF
Female	40.9	15.9	3.4	1.2	19.3	13.6	5.7	0
Male	36.2	16.1	8.5	2.3	16.9	12.3	5.4	2.3

Body abnormalities and sex

In all groups of fish, there were 88 female and 130 male specimens in total (male/female = 1.48). Of that, 52 females and 83 males had some body abnormalities (male/female = 1.59). There was no correlation between sex and the appearance of deformities ($P>0.05$). Also, on the basis of the frequencies of the various types of spinal deformities it was established that they are independent from sex (Table 2).

Inter-relations between types of deformities

The strongest correlation between the frequencies of deformities was observed between mouth deformities and combinations in which all three types of observed deformations are found (Fig. 4). The frequencies of these two deformation groups are linked at a lower level of similarity with the combination of anterior and posterior flexures. The anterior flexure alone or in combination with a deformed mouth has a high similarity frequency, which is separate from previously described types of deformities. The separated group of deformities on a lower level of similarity is comprised of the posterior flexure separately and in combination with mouth deformities.

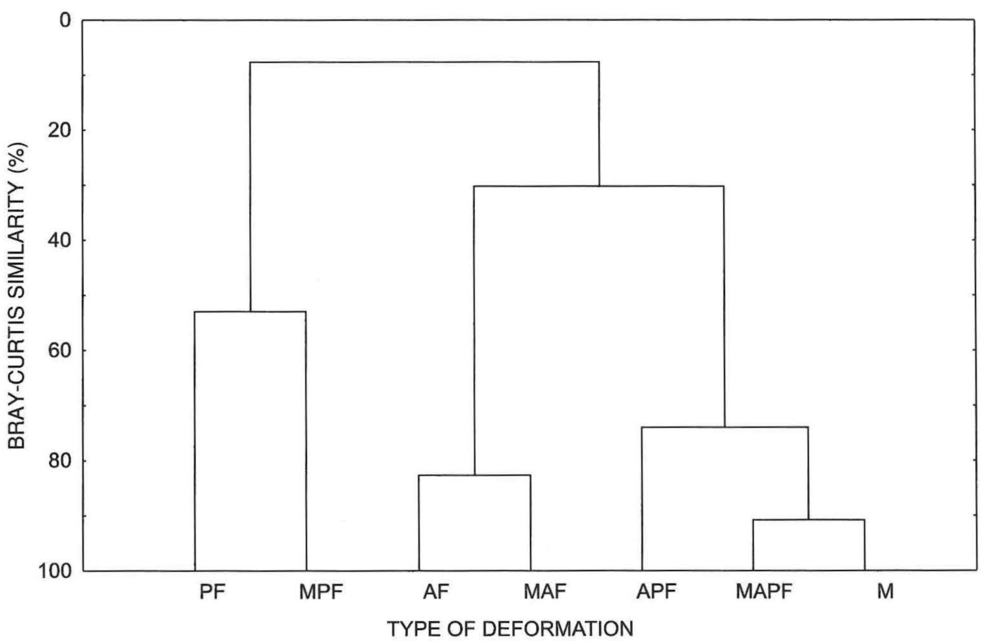

Fig. 4. Similarity indices between deformation types (see Fig. 2. for definition of signs)

DISCUSSION

The causes of skeletal anomalies in cultured sea bass are still unclear. Some authors link these deformities to pathological changes in the swimbladder (PAPERNA, 1978; KITAJAMA *et al.*, 1981). DAOULAS *et al.* (1991) found that in laboratory reared sea bass fingerlings, spinal column anomalies were frequent and these were often associated with swimbladder malfunction. One of the causative factors in the formation of skeletal deformities during rearing of fish in tanks may be water current (BACKIEL *et al.*, 1984). Mouth deformities were found in 68% of deformed sea bass in the present study. DAOULAS *et al.* (1991) found a notable frequency of deformities of the upper jaw in sea bass fingerlings, while an abnormal lower jaw was less common. LAGARDERE *et al.* (1993) found more frequent jaw deformities in common sole (*Solea solea*) larvae reared in laboratory. The frequency of mouth deformities can be linked with the rearing density of larvae, while the temperature was only a secondary factor because the anomalies were also present at lower temperatures (LAGARDERE *et al.*, 1993). Temperature induced abnormalities in the caudal skeleton were described in plaice, *Pleuronectes platessa* (MOLANDER and MOLANDER-SWEDMARK, 1957). In wolffish, *Anarhichas lupus* (PAVLOV and MOKSNESS, 1997) also found skeletal deformations in the caudal part of fish being not only by extremely high but also by extremely low temperature. When no food restrictions exist, deformities of the spinal column and mouth do not prevent a sea bass to live through the second year of life. Under similar rearing conditions, ŠARUŠIĆ (1990) obtained the same results. Deformed sea bass specimens had a significantly lower body weight than normal fish. Early selection of fish according to weight, showed that the group of larger fish would also include animals whose skeletal anomalies would become visible later on. Other authors noted a delayed growth of fish with skeletal deformities as PAPERNA (1978) in a gilthead sea bream *Sparus aurata*. When comparing wild gilthead sea bream with fish reared in extensive, semi-intensive and intensive conditions, FRANCESCON *et al.* (1988) found 19-48% of deformed individuals in the cultured population, compared to only 1% in the wild fish.

In the present study all fish were fed to satiation, so that the effect of nutritional competition of normal and deformed fish was reduced to the lowest possible. For this reason, a slower growth of deformed fish cannot be accounted by to the nutritional domination of normal and bigger fish only. A slower growth of deformed fish with anterior flexure, could be because the fish most likely cannot accept a larger amount of food in their stomach, because it is pressed towards the ventral part of the body. Also, fish with vertebral deformities exhaust more energy for movement than normal fish.

According to present study, it can be concluded that the susceptibility of sea bass to mouth deformities is the same, regardless of the type of spinal deformation. It is still debatable whether anterior and posterior flexures are linked, more specifically if one anomaly precedes the other. Therefore, it is questionable, whether fish with posterior flexure later develop anterior flexure as well or vice versa, or these two types of vertebral deformities appear simultaneously.

No correlation was found between the sex of the sea bass and deformation of the spine or mouth.

CONCLUSIONS

Deformations of the mouth and spine were not related to sex, actually, the occurrence of deformations is equal in the male and female samples of sea bass.

Anterior and posterior flexures are not related to the deformation of mouth. Body deformities are slowing down the growth of juvenile sea bass.

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Tjelesne abnormalnosti u odnosu na veličinu i spol laboratorijski uzgojenog lubina *Dicentrarchus labrax* L.

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SAŽETAK

Uzorci mlađi lubina *Dicentrarchus labrax* iz uzgojenog jata su odvojeni u dvije skupine prema veličini. Prva se skupina sastojala od ribe težine od 1.8 g (aritmetička sredina ± standardna devijacija = 1.49±0.22 g), a druga od težine od 3.25 g (4.28±0.96 g). Treća ili miješana se skupina sastojala od primjeraka iz izvornog uzgojenog jata (2.43±0.84 g). Nakon 16 mjeseci uzgajanja, skupina malih riba je ukazala na veću pojavu u nepravilnostima usta i kralježnice od skupine većih riba. U obje je skupine riba s nepravilnostima imala manju tjelesnu težinu od normalne ribe. Nepravilnosti usta i kralježnice se nisu odnosili na spol. Nepravilnosti usta u lubina su bile neovisne o tipu deformacije kralježnice.