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Full Length Research Paper

Evaluation of the morphological difference of wild, farmed and hatchery-released gilthead sea bream

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In May 2001, 60,000 individuals of gilthead sea bream (Sparus aurata) fry, originating from a common bloodstock of the Ionian coastal region, were allocated between Papas lagoon and cages of mariculture enterprises located at Western Greece. During the period of November to December 2001, a sample of 531 gilthead sea bream individuals was collected from the lagoon and the cages. The variations in 24 morphomertic characters and in two indices (condition factor and gonadosomatic index) were examined using multivariate analysis, in order to evaluate the morphological similarity/dissimilarity between hatchery-released (EN), wild (WL) and farmed (RR) individuals. Statistically significant differences were observed among the groups in mean and standard deviation values for most of the morphometric characters, a fact that can be possibly attributed to the life-history of the fish. Principal component analysis along with discriminant analysis identified that the characters of primary importance in distinguishing the three groups were those related to head, fin and lengthwise dimensions. Discriminant analysis also revealed that about 86.1% of the examined specimens could be correctly classified in the three groups. The above findings can be useful for scientific but also for commercial reasons, since the market value of the fish is highly dependant on its origin.

Keywords: *Sparus aurata*, gilthead sea bream, hatchery-release, multivariate analysis, morphometrics, lagoon.

INTRODUCTION

Most of the exploited stocks of aquatic organisms are limited by the supply of juveniles and many also suffer from recruitment overfishing (Munro and Bell, 1997). Enhancement programs have been proposed as a way to increase the biomass of depleted fishery stocks (Blanco et al., 2008; D'Anna et al., 2004; Liao, 1999; Tringali and Bert, 1998).

Recently, the collapse of many of the World's fisheries led to the enhancement of wild fish stocks through the stocking of 59 marine or coastal species in 33 developing countries (Leber et al., 2004). Nonetheless, most of the hatchery-based programs for stock enhancement have failed (Bohnsack, 1996), with the exception of Japanese experiments with red seabream *(Pagrus major)* and flounder *(Paralichthys olivaceus)* (Fushimi, 2001). Most of these releases were made into limited habitats such as coastal lagoons, fjords, and estuaries (McEachron et al., 1995) mainly under the scope of minimizing possible genetic hazards (Vay et al., 2007).

The gilthead sea bream, *(Sparus aurata)*, is a subtropical Sparidae distributed from 62°N - 15°N, 17°W - 43°E. It occurs naturally in the Mediterranean and the Black Sea (rare), and in the Eastern Atlantic, from the British Isles, Strait of Gibraltar to Cape Verde and around the Canary Islands (Froese and Pauly, 2006).

It is a euryaline species inhabiting seagrass beds and sandy bottoms, as well as the surf zone, commonly to depths of about 30 m, but adults may occur at 150 m depth. In early spring it moves towards protected coastal waters in search for abundant food and milder temperatures (trophic migration) (Froese and Pauly, 2006). It is a protandrous hermaphrodite (Zohar et al., 1984) and mainly carnivorous (shellfish, including mussels and oysters), accessorily herbivorous (Froese and Pauly, 2006).

Gilthead sea bream is an autochthonous commercial species of the coastal Greek waters and lagoons which is highly appreciated locally and attains a high market price (Anonymous, 2001). It can be easily reared in hatcheries, and its mariculture has grown rapidly in several Mediterranean countries. The Hellenic mariculture, based on gilthead sea bream and sea bass, covers up half of the Mediterranean mariculture production. During the last 20 years the production of gilthead sea bream has increased greatly from 60 t in 1985 to 48000 t in 2004 (Mariculture Federation of Greece).

Based on the high availability of gilthead sea bream fry by hatcheries, pilot programmes of wild stock enhancement have taken place in coastal waters during the last decade (Sanchez-Lamadrid, 2004; Santos et al., 2006) whereas this practice has been applied in many Greek lagoons from the 1990's onwards (Anonymous, 2001). On the other hand, in coastal waters around the cages a continuous enhancement has been accidentally taking place by a considerable number of escaped cultured specimens (Dimitriou et al., 2007).

It is a fact that the consumers' attitude is directed towards healthy and safe fish consumption (Pieniak et al., 2009), whereas a latent uncertainty exists about the health value of aquaculture products (Kaiser and Steam, 2002). In the Greek market the commercial value of wild gilthead sea bream individuals is about two to three times higher than farmed fish of equal size. This is partially related to consumer-held perceptions, opinions and beliefs about the nutritive and health value of farmed fish also including differences on external morphology, and organoleptic parameters between wild and farmed fish (e.g. lower perivisceral fat and more pleasant taste in wild than higher perivisceral fat and poorer taste of farmed specimens (Grigorakis et al., 2003; Grigorakis, 2007). Therefore, consumers may prefer to consume wild fish, and any differences on external morphology between wild and farmed fish, may be the basis of consumer attitude which in turn, can affect the commercial value of the product.

Differences on morphology have been reported for many species between hatchery-released and wild specimens (Vay et al., 2007), between farmed and/or wild specimens of the commonly reared species in the Mediterranean (gilthead sea bream and sea bass) (Coban et al., 2008; Katselis et al., 2003a; Loy et al., 1999; 2000) as well as between individuals raised in different culture types (Sara et al., 1999). However, comparative studies among wild, farmed and hatchery-released individuals of cultured fish species have not yet been carried out in the Mediterranean.

Findings from previous works indicated that in aquaculture the morphological variability of rearing species is related to their early life stages (Loy et al., 1999, 2000), while in these stages significant higher percentage of skeletic anomalies appeared on hatchery-rearing species than wild ones (Boglione et al., 2001).

The aim of this study is the evaluation of the morphological similarity/dissimilarity of wild, farmed and hatchery-released gilthead sea bream in Western Greece.

MATERIALS AND METHODS

Study area

Papas lagoon (38°11'40"N, 21°23'42"E) is located at the south western part of the Patraikos Gulf, covering a surface of about 3 Km^2. It has a mean depth of 1.2 m and communicates with the adjacent sea by three channels. Water temperature and salinity range throughout the year from 5 to 28°C and from 29 to 43 psu, respectively.

As with the majority of Greek lagoons, Papas lagoon is subject to fish exploitation (Anonymous, 2001; Koutrakis et al., 2007). The fisheries are based on the ontogenetic and seasonal migration of fish in these important nursery and feeding grounds (Katselis et al., 2003b; Koutrakis et al., 2007). This type of exploitation can be considered as a common extensive culture based on the seasonal entrance of young and adult fish in the lagoon mainly during spring, and their reverse offshore migration during autumn and winter. The barrier fish traps as well as nets and long lines consist the most common fishing gears used in the lagoon. Barrier traps (V-shape traps) are passive, fixed gears and are part of the fence installed at the interface between the lagoon and the sea (Katselis et al., 2007). These constructions (fence and barrier traps) control from and toward sea movements of species and have minimized the fish's possibility to escape from the lagoon to the sea.

During the period of 1990 to 2002 the annual landings in the lagoon ranged from 10 to 25 t/km^2 (data derived from fishing co-operative enterprise "LARISSOS") and comprised of the five species of mugilidae (50%), gilthead sea bream (9%), bivalves (9%), eel (7%), sea bass (2%) as well as other species (22%).

Additionally, in the framework of an enhancement project, young gilthead sea bream individuals (mean weight 5 g), provided from a regional hatchery, were released in the lagoon during the spring months (April and May) of the years 2001 and 2002 respectively. In total, 30000 and 33000 individuals were released in years the 2001 and 2002, respectively.

Sampling

In the month of May 2001, a total of 60000 individuals of gilthead sea bream young (mean weight 5 g), originating from a common bloodstock and from a hatchery located at the Ionian coastal region, were evenly distributed among Papas lagoon and the cages of a mariculture enterprise located in western Greece. In the cages, fish were reared according to the typical procedure of mariculture in western Greece. Water temperature during rearing ranged from 14 to 26°C, whereas the final density was approximately 14 kg/m^3. The proximate composition of feed provided was 48% proteins, 21% lipids, 9% ash and 1.5% fibres (Rogdakis et al., 2003).

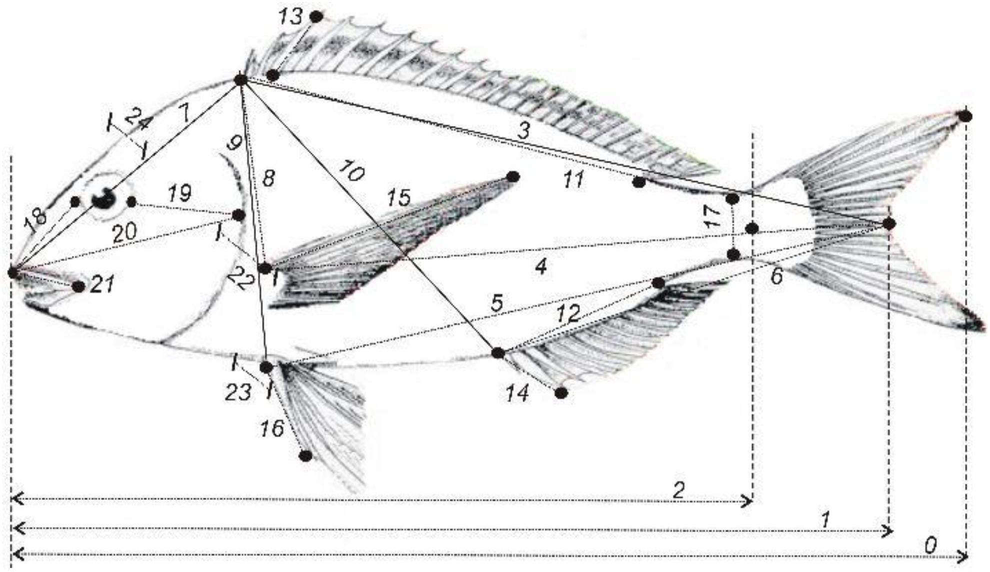

Figure 1. Measurements performed on the body of gilthead sea bream specimens.

During the period from November to December 2001 samples of gilthead sea bream were collected from the cages (hereafter referred as RR specimens) and the lagoon. The samples collected in the lagoon included both wild (WL) and hatchery-released (EN) individuals. Discrimination between WL and EN individuals collected in the lagoon was based on external characteristics as percentage of regenerated scales (Katselis et al., 2003a) and discontinuity of the lateral line (Carrillo et al., 2001). Individuals with obvious skeletal anomalies such as kyphosis, lordosis, opercular and mouth anomalies (Boglione et al., 2001) were excluded from the analysis. The χ^2-test was used to test for differences on the number of excluded specimens among samples.

Individuals of the same class size were selected in order to minimize the effect of allometry associated with the differences on size among the different groups (Katselis et al., 2006; Minos et al., 1995).

Twenty five measurements on each gilthead sea bream individual were performed with an electronic digital calliper to the nearest 0.1 mm (Figure 1). After measuring, the gonads of each individual were removed and observed for sex determination according to gonad colour and form: yellow-orange with ellipsoid form for females and white milky with leaf like form for males. The total body weight (W) and gonad weight (Wg) were measured to the nearest 0.01 g; gonadosomatic Index (GSI = 100*Wg/W) and Fulton Condition factor (Kn = 10^5*W/Standard Length^3) were also measured. The value of each morphometric character was calculated as the ratio of each measurement to the standard length of each individual.

Statistical analysis

Bartlett's test was used to test for differences in the standard deviation of each morphometric character among the groups. One way analysis of variance (ANOVA) was used to test for significant differences on the morphometric characters among the groups. ANOVA is robust to violation of the homogeneity of variances as long as there are no outliers, sample sizes in different groups are large and fairly equal (largest to smallest N is not more than about 4 to 1) and the ratio of largest to smallest sample variance (Fmax) is no more than 10 to 1 (Schinka et al., 2003). Tukey t-test was applied in all cases to check for possible differences between groups (Zar, 1996).

Principal component analysis (PCA) was used to examine the contribution of each of the 24 morphometric characters, GSI and Kn in the configuration of fish shape variance (Hair et al. 1998). A forward stepwise discriminant analysis (DA) on the characters, based on the generalized Mahalanobis distance, was used in order to determine the dissimilarity between the groups as well as the ability of morphometric variables to identify the specimens correctly (Hair et al., 1998).

The percentage of discrimination per pair of groups (PDPG) was estimated as the proportion of correctly classified individuals of two groups on the total classified individuals in two groups. In other words, the PDPG represented the probability of the correctly identified individuals of two particular groups. All statistical analyses were performed using SPSS PC ver. 10.

RESULTS

A total of 531 gilthead sea bream individuals were collected. Among these, 210 were identified as wild-caught (WL), 149 as farmed (RR) and the other 172 as hatchery-released (EN). Standard length ranged from 141 to 253 mm. Individuals with obvious skeletal malformations were not recorded in the WL group, whereas in the RR group a significant higher percentage of malformed individuals was recorded in comparison to the EN group (8.2 and 1.7% respectively) (X^2 = 7.1; df = 1; P < 0.05). As a total, 109 WL, 111 RR and 119 EN individuals, belonging at 160-210 mm standard length class size, were included in the analysis. The majority of individuals (<89%) were males whereas no female individuals were found in the sample.

The within-groups variation was less evident as indicated by the relative low *CV* values (*CV* < 10%) of each character while the morphometric characters of WL measurement 9), body width (Figure 1: measurement 22) and anal base (Figure 1: measurement 12) for CaV2. individuals presented lower CV values than in EN and RR groups (Table 1).

The standard deviation of fourteen characters (Table 1) differed significantly between the three groups (Bartlett' test; $P < 0.05$) whereas the standard deviation in the WL group was found significantly lower (apart of standard deviation of measurements 4, 15 and 19) of that in EN and RR groups (Tukey-type test; $P < 0.05$). In all cases, the variance ratio (Fmax) among the largest to smallest ranged from 1.28 to 6.61 (Table 1) whereas the n-ratio among the largest to smallest n was 1.09. No outlying values were observed. These values allowed the application of ANOVA despite the violation of homogeneity of variance (Schinka et al., 2003).

Significant differences among the groups were also observed for the majority of morphometric characters (ANOVA; $P < 0.05$) with the exception of the characters one and five (Figure 1) as well as the GSI (Table 1). Tukey t-test on the average values of the characters, showed that the RR group differed significantly from the WL and EN groups ($P < 0.05$) in 17 characters as well as in the Kn, whereas no significant differences were observed between the WL and EN groups on these characters ($P > 0.05$). Specimens belonging to the WL group, differed significantly from the other two in only one character (Figure 1, measurement 7), whereas differences between all groups were observed for four characters (Figure 1, measurements 8, 9, 11 and 12) (Table 1).

The PCA analysis extracted seven factors with eigenvalues higher than one, explaining 70.1% of the variance (Table 2). Using a cut-off value of 0.55 for the factor loadings, factor 1 expressed characters associated with the body heights and head measurements (Figure 1: measurements 7 to 10 and 18 to 21, 23), factor 2 expressed variables associated with body width and fish condition factor (Figure 1: measurements 22, 24 and Kn), factor 3 expressed variables associated with the fin height (Figure 1: measurements 13 to 16), factor 4 expressed variables associated with the lengthwise body length (Figure 1: measurements 0, 1, 4 and 5) and finally, factor 5 expressed variables associated with the dorsal and anal fin bases and lengthwise distance between dorsal and caudal fin (Figure 1: measurements 3, 11 and 12).

The DA extracted two canonical variables (CaV) that contributed to the overall variance. The first canonical variable contributed 97.6%, whereas the second one contributed the rest 2.4% of the total variance (Table 3). Height of fins (Figure 1: measurements 13 to 15) and head length (Figure 1: measurement 20) were the characters primarily responsible in distinguishing groups for CaV1 whereas maximum body height (Figure 1:

The unstandardized coefficients of the eight variables for the morphometric characters of each discriminant function (canonical variable) are presented in Table 3. These discriminant functions identified the membership (classification) of individual fish in the data set to one of the three groups with a success rate of 86.1% (Table 4). All RR individuals were identified correctly, whereas the percentage of correctly identified WL and EN individuals was 91.8 and 62.9% respectively. The incorrectly identified WL and EN individuals were all classified as EN and WL, respectively (Table 4). The graphical presentation of the first and second canonical variables is presented in Figure 2. The highest values of PDPG were found between RR and WL as well as between RR and EN (100%), whereas the smallest between EN and WL (76%) (Table 4).

DISCUSSION

In the present study, the analysis of morphological variability indicated significant differences on external shape among wild, farmed and hatchery -released gilthead sea bream individuals. The differences were mainly detected on the head, trunk and caudal regions as well as on fin dimensions.

The morphometric characters (phenetic characters) derived from the composite effect of genotype and environmental factors and are under the influence of natural selection (Dobzansky, 1970). In the present study due to the use of progeny from common bloodstock for farmed (RR) and released (EN) specimens, the genotypic effect on their morphology is expected to be minimized.

The allometric growth of fishes (ontogenetic stages) as well as the season of sampling, which is related to the feeding activity and maturation, could impose some major limitations for the study of morphological relationships in the species.

In this case, the selection of individuals belonging to the same size class overcomes the possible problems in allometry attributable on the various ontogenetic stages of the species (Katselis et al., 2006; Minos et al., 1995). On the other hand, the common sampling period for the three groups attempted to minimize the effect of feeding activity and maturity stages on the group's morphology. Indeed, GSI indicated that the part of specimens in the present study were mature males (Zohar et al., 1984: GSI > 0.4%) while their low contribution on the species morphometric variation (Table 2) indicated the small effect of maturity stage on morphology variation in the three different groups. However, due to the lower water temperature of the lagoon than the sea during the sampling period (data not shown here), it is expected that the lagoon groups would present the lowest feeding activity (Petridis and Rogdakis, 1996). Therefore, part of differences on the morphological traits, such as the trunk region, is expected (Park et al., 2007) among the lagoon (WL and EN) and farmed (RR) individuals.

Table 1. Results of descriptive statistics (ANOVA, Bartlett's test, Tukey t-test) on the measured morphometric characters (as % ratio respect to SL) in g CV%: coefficient of variation; Fmax: higher to smaller variance ratio; For Tukey t-test results: statistically significant values are separated by paren mean value; *Xm*: mean value; *SD*: standard deviation; NS: no significant differences at P=0.05; **: significant differences at P=0.05; *Character*: a characteristics; WL: wild, RR: farmed: EN: hacthery-released). Explanation of morphometric characters are given in Figure 1.

	WL			RR			EN					
	N=109;Males 89%			N=111;Males 92%			N=119;Males 95%					
character	***Xm***	**SD**	**CV%**	***Xm***	**SD**	**CV%**	***Xm***	**SD**	**CV%**	**ANOVA**	**Bartlett's test**	**Fm**
2 (SL;mm)	185.31	6.97	3.8	182.65	13.31	7.3	189.03	8.82	4.7	**	**	3.
Kn	1.73	0.115	6.6	2.12	0.181	8.5	1.77	0.154	8.7	**	NS	2.
GSI	0.34	0.05	14.7	0.35	0.03	10.0	0.29	0.09	31.0	NS	NS	6.
0	124.6	2.4	1.9	121.8	2.3	1.9	124.2	2.9	2.4	**	NS	1.
1	114.1	1.1	1.0	114.2	1.8	1.6	114.4	1.4	1.2	NS	NS	2.
3	86.7	1.3	1.5	85.2	2.2	2.5	87.0	1.9	2.1	**	**	2.
4	85.7	1.1	1.3	84.6	1.8	2.1	85.5	1.1	1.3	**	**	2.
5	83.7	1.3	1.5	83.4	1.7	2.1	83.5	1.5	1.8	NS	NS	1.
6	52.6	1.3	2.5	50.2	1.4	2.7	52.5	1.5	2.8	**	NS	1.
7	38.6	0.8	2.0	39.5	1.2	3.0	39.2	1.0	2.6	**	NS	2.
8	25.5	0.6	2.4	26.5	1.0	3.8	25.9	0.9	3.4	**	**	2.
9	37.8	1.0	2.7	40.0	1.5	3.8	38.7	1.5	3.9	**	NS	2.
10	50.3	1.0	2.0	52.0	1.4	2.6	50.7	1.6	3.2	**	**	2.
11	54.8	0.9	1.6	53.5	1.5	2.8	54.3	1.0	1.9	**	**	2.
12	20.5	0.8	3.9	19.3	1.4	7.1	20.0	0.9	4.5	**	**	2.
13	11.0	0.7	5.9	7.9	0.9	11.6	11.1	0.9	8.1	**	NS	1.
14	7.8	0.5	6.4	6.5	0.6	9.2	8.0	0.7	8.9	**	**	2.
15	33.0	1.1	3.2	29.7	2.0	6.7	33.1	1.1	3.3	**	**	3.
16	12.4	0.7	5.4	11.7	0.8	6.8	12.6	1.2	9.2	**	NS	3.
17	8.4	0.3	3.9	8.8	0.5	5.1	8.5	0.4	4.3	**	NS	1.
18	11.2	0.3	2.9	11.8	0.6	4.9	11.4	0.4	3.7	**	**	3.
19	12.4	0.5	3.7	13.0	0.6	4.7	12.4	0.5	4.2	**	**	1.
20	27.6	0.5	1.9	29.9	0.9	3.0	27.9	0.7	2.4	**	**	2.
21	11.7	0.3	2.4	12.2	0.5	4.0	11.7	0.4	3.7	**	**	3.
22	14.8	0.8	5.2	16.2	1.1	6.6	14.6	0.9	6.1	**	NS	1.
23	8.0	0.3	3.9	8.5	0.4	4.4	8.1	0.4	4.9	**	NS	1.
24	14.2	0.5	3.5	15.0	0.9	5.9	14.3	0.5	3.6	**	**	3.

Thus, the observed differences in the condition factor (Kn) among the lagoon (1.73 and 1.77 for WL and EN respectively) and sea-cultured (2.12) individuals as well as the positive relationships of Kn with body he attributed to.

Table 2. Results of Principal Components Analysis (PCA) and factor loadings for each morphometric character on the five extracted PCA factors after varimax normalized rotation (for explanation of character abbreviations see Figure 1).

	Factors				
	F1	**F2**	**F3**	**F4**	**F5**
Percentage of variance (PV)	24.83	13.06	12.25	10.81	9.19
Cummulative PV	24.83	37.89	50.14	60.95	70.14
			Factor loadings		
character	**F1**	**F2**	**F3**	**F4**	**F5**
Kn	0.39	0.65	-0.46	-0.28	-0.12
GSI	0.11	0.21	-0.12	-0.11	-0.20
0	0.08	-0.34	0.50	0.57	0.08
1	0.40	-0.14	0.03	0.72	0.25
3	0.06	-0.02	0.23	0.33	0.69
4	-0.04	0.02	0.21	0.75	0.35
5	-0.06	0.23	0.04	0.86	0.00
6	-0.26	-0.47	0.29	0.39	0.33
7	0.89	-0.09	0.06	0.00	0.03
8	0.77	0.38	0.07	0.10	0.05
9	0.75	0.38	-0.04	0.20	-0.07
10	0.58	0.53	-0.07	0.20	-0.03
11	-0.10	0.10	0.22	0.12	0.85
12	-0.09	-0.39	0.07	0.10	0.57
13	-0.35	-0.34	0.69	0.02	0.34
14	-0.17	-0.40	0.60	0.07	0.34
15	-0.18	-0.21	0.72	0.19	0.18
16	0.12	0.22	0.79	0.11	0.06
17	0.50	0.46	0.05	0.08	-0.20
18	0.80	0.00	-0.26	-0.11	-0.09
19	0.68	0.23	-0.05	0.08	-0.25
20	0.76	0.24	-0.42	-0.02	-0.22
21	0.74	0.25	-0.17	-0.07	0.14
22	0.45	0.62	-0.27	0.13	0.04
23	0.66	0.40	-0.02	-0.05	-0.08
24	0.48	0.62	-0.06	0.03	0.00

the lagoon and the sea.

In all cases, the characters of primary importance in distinguishing between the three groups as revealed by PCA and DA, were those related to head, fin and lengthwise dimensions. The RR specimens were characterised by a more blocky-belly body with shorter fins and longer head in comparison to WL and EN specimens. The blocky-belly body has also been observed in many farmed species (*Scophthalmus maximus*: Ellis et al. 1997; *S. aurata*: Loy et al. 1999; *Diplodus puntazzo*: Sara et al. 1999; *D. labrax*: Loy et al. 2000; *Perca fluviatilis*: Mairesse et al., 2005). On the contrary, wild individuals are characterised by a more elongated body shape when compared to farm ones (Mairesse et al., 2005).

These differences can be attributed to various factors related to the rearing conditions such as stock density, aggressivity, stress, accumulation of perivisceral fat, hepatic hyperplasia and the type and quality of food (Favaloro et al., 2002; Favaloro and Mazzola, 2003; Sara et al., 1999), as well as modified swimming performance (Basaran et al., 2007) and fish mobility (Hanson et al., 2007).

Contrary to this, there is evidence of morphological similarity between farmed and wild gilthead sea bream individuals (Coban et al., 2008). However, these results should be considered cautiously due to the small number of examined specimens belonging to different ontogenetic stages which lead to increased variance, able to mask any statistical differences among the different groups (Zar, 1996).

The significantly higher variance in the morphometric

Table 3. Results of Discriminant Analysis (DA); unstandardized coefficients (UCF) of each morphometric character on the two canonical variables (*CV_i*) (for explanation of character abbreviations see Fig.1).

% of variance	***CV_1***	***CV_2***
	97.60	**2.40**
character	**UCF**	
8	3.00	-62.36
12	11.91	56.05
13	67.35	-1.84
14	65.71	-61.39
15	38.74	8.33
20	-90.61	-3.37
23	-24.86	73.63
Constant	1.86	4.86

Table 4. Results of discriminant analysis classification showing the percentage of specimens classified in each group as well as the percentage of distinguishing per pair of groups (PDPG) based on the results of discriminant analysis classification (WL: wild-caught, RR: farmed, EN: hacthery-based release group).

	Predicted Group			**Total number of specimens**
Real group	**WL**	**RR**	**EN**	
WL	91.8	0.0	8.2	109
RR	0.0	100.0	0.0	111
EN	37.1	0.0	62.9	119

Total number of specimens correctly classified: 86.1%

Percentage of distinguishing per pair of groups (PDPG)

	Group	
Group	**WL**	**RR**
RR	100	0
EN	76.7	100

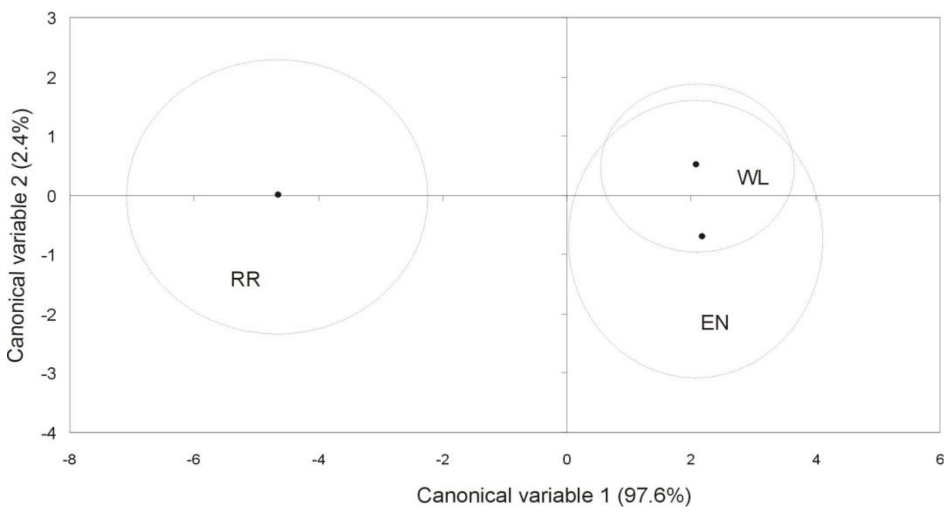

Figure 2. Discriminant analysis (DA) plot based on the measured morphometric characters of gilthead sea bream. WL: Wild, RR: Farmed and EN: Hatchery-released gilthead sea bream. Ellipses include 95% of the specimens.

characters that was observed in the hatchery-based and reared specimens than in wild ones could be attributed to the life history of the specimens since the determination of shape features in adult fish occur during the larval and postlarval stages (Loy et al., 1999; 2000). The morphological features of reared gilthead sea bream larvae and postlarvae present significantly higher variation than wild ones (Sfakianakis et al., 2005). It has also been shown that gilthead sea bream larvae and post larvae reared in hatcheries present high frequency (47 to 100% according to hatchery enterprise) of at least one serious anomaly such as kyphosis, lordosis, vertebrae fusion or deformation and splanchnocranium deformities, whereas in wild-caught individuals this frequency was only 4.7% (Boglione et al., 2001).

The considerable smaller frequency of individuals with obvious skeletal malformations observed in EN than RR group can be possibly explained by a selective survival mechanism of some functional pattern in the wild habitat (Swain et al., 2005). On the other hand, the high variance observed in the morphometric characters of EN group might be a result of the existence of non-lethal malformations as has been also proposed by Verhaegen et al. (2007). This fact is also supported by the rather high (56.4%) survival of EN individuals in the Papas lagoon (Rogdakis et al., 2003).

The above findings support that the morphological variability of hatchery-realised gilthead is a result of both their morphological variability at early life stages and the habitat conditions in the later stages of development.

According to DA classification, 86.1% of the specimens examined in this study could be classified correctly into three groups and for the RR group the classification accuracy reached 100%. However, the probability of incorrect classification of individuals belonging in the WL or EN group was considerable (0.24), with possible effects on the price of the fish in the market. This limitation could be overtaken by using other identification criteria such as the number of regenerated scales which is higher in the RR and EN groups than in the wild specimens (Katselis et al., 2003a), an easily recognizable characteristic as the regenerated scales lead to a dull fish coloration.

In conclusion, the results of this study revealed that released gilthead sea bream after a 6 to 7 month period in a wild habitat configured a wild-like shape, but the differences on mean values and variances of some morphological characters supported that it comprised a separate morphological group. Although this study revealed that the morphology of released specimens showed a wild-like shape, it's obvious that this is a process which requires time until the configuration of a clear morphological difference a procedure which is possibly, also dependant on the ontogenetic stage of release. On this idea, the findings of the present study could have a limited application on specimens that have escaped from cages due to continuous escapes at various ontogenetic stages. In environments such as lagoons where fish production is almost totally controlled, the easy recognition of released specimens is very useful for both scientific and commercial reasons. However, more investigations should be carried out to find out any possible differences on the proximate body composition and sensory characteristics, such as taste, aroma etc., among the wild and released gilthead sea bream individuals.

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