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APPLICATION OF MAHALANOBIS DISTANCE FUNCTION FOR THE MORPHOMETRIC SEPARATION OF SILVERBELLY (*LEIOGNATHUS KLUNZINGERI* STEINDACHNER) STOCKS IN THE GULF OF MERSIN

PRIMJENA MAHALANOBIS-OVE FUNKCIJE DISKRIMINACIJE NA ODREĐIVANJE MORFOMETRIJSKIH RAZLIKA IZMEĐU STOKOVA *LEIOGNATHUS KLUNZINGERI* STEINDACHNER U ZALJEVU MERSIN

Dursun Avsar, Ferit Bingel and Mustafa Ünsal

Institute of Marine Sciences, M. E. T. U., Erdemili Içel, Turkey

Stock differentiation studies of silverbelly from four localities in the northeastern Mediterranean has been carried out morphometrically applying the Generalized Distance of Mahalanobis and shown that silverbellies of Mersin Bay consisted of four different stocks.

INTRODUCTION

L. klunzingeri is one of the most common Indo-Pacific demersal species in the northeastern Mediterranean. The mean catch of this species during the years 1980—1982 period constituted 10.2% in number of the individuals in Goksu, 9.8% in Tirtar, 3.0% in Seyhan and 3.0% in Tuzla (Bingel, 1987). However, because of its small size, (50—70 mm) these fish have to date no commercial importance in Turkey although it might have some economic potential in future (Bingel, 1981).

These fish have ripe gonads during the summer (Ben-Tuvia 1966). The eggs are pelagic and the spawning occurs from the beginning of April until the end of May (Aksiray, 1954). However, from the length frequency curve fitting data given by Bingel (1987), one may conclude that these fish spawn eventually in two main periods; in April-May and August-September.

Silverbelly have come from the Red Sea along the Gulf of Suez to the eastern basin of the Mediterranean in 1898 (Steindachner, 1898). However, their first detection in Iskenderun Bay was made by Erazi (1943). This species has adapted to the new habitats and spreaded considerably. *Leiognathus klunzingeri* in the Mediterranean are distributed in the eastern part, from Port Said to Mersin Bay and Aegean Sea (Ben-Tuvia, 1966). In fact, one specimen was collected from the neighbourhood of Lampedusa, which is near the eastern coast of Tunisia. These adaptations to the new oceanographic environment may cause the changes in their morphometric characters as was also pointed out by K o s s w i g (1974). The aim of this study is to define the stock composition of *Leiognathus klunzingeri* in the northern Cilician Basin (Mersin Bay).

Population dynamics of the local populations of each water product shows great diversity (R i c k e r, 1975). Therefore, the stocks studied, must be differentiated and the unity of the stock or stocks should be stated. In fact, the identification and delimitation of unit stocks are necessary for the assessment of the exploited fish stocks.

MATERIAL AND METHODS

Sample collections were done from the Bay of Mersin, which is located in the northern Mediterranean. Four sampling stations were located along the coast between the Karatas Cape in the east and Goksu River delta in the west (Fig. 1). Seyhan, Tirtar and Goksu stations were directly influenced by the rivers of (Tarsus and Seyban), Lamas and Goksu respectively.

Materials in present study were sampled with two different trawler boats of similar characteristics. Samples were collected by deep trawl net, with a cod-end mesh size of 28 mm streched, towed approximately 1.5 to 4.5 km.

Stations (Fig. 1) were visited for the first time on March 19, 1985 and continued at approximately 9 months until December 20, 1985. Collections were done randomly. The trawled fish were sorted by species, transferred

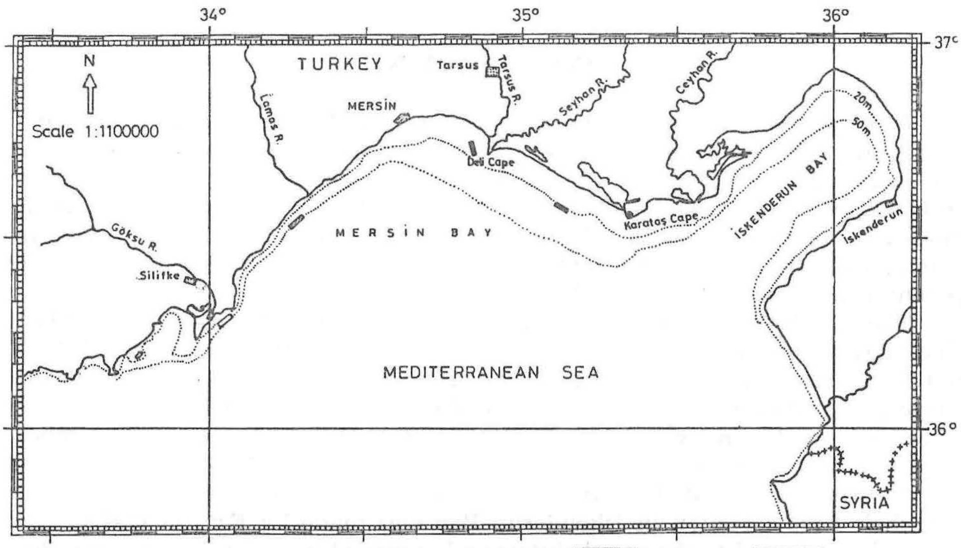

Fig. 1. Sampling locations in the Mersin Bay ▓ : TUZLA, |——| : SEYHAN, ▨ : TIRTAR, |___| : GOKSU)

into the plastic containers of 5 litres and preserved in 10% formalin solution (Healey, 1978; Hesthagen, 1977; Mais, 1972) immediately after separation of the catch.

The definition of 11 morphometric measurements of individual fish were shown in Fig. 2. Morphometrics and sex of a total of 1772 fish were determined and 1542 specimens were used for the discrimination. For the elimination of the differences in percentage ratios of males and females on the results of Discriminant Analyses, at different stations, the percentage of males and females was equalized.

Leiognathus klunzingeri reaches the sexual maturity at rather small size (50 mm), since its maximum length is 120 mm (Bingel, 1987). It is difficult to discriminate this species on their sex due to its small size. Hence the incorrect determination of sex of *L. klunzingeri* would possibly influence the results. Because of higher probability of wrong sex discrimination of smaller individuals, it was decided to analyse larger individuals.

In order to select perfectly matured individuals, time series of the length frequency distribution given in Bingel (1987) was examined. Individuals between 50 and 60 mm in length were considered as the first sexually mature group using Petersen Method, Holden & Raitt (1974). To avoid further errors, Discriminant Analyses were made for 60 mm and longer individuals. Total length ranges of the samples and number of sampled individuals collected from four locations are given in Table 1.

Table 1. Minimum, maximum total length ranges and number of specimens at four sampling stations

Whole data	TUZLA min	TUZLA max	SEYHAN min	SEYHAN max	TIRTAR min	TIRTAR max	GOKSU min	GOKSU max
			ROW DATA					
Total length (mm)	28	96	26	115	41	86	32	98
* of specimens	498		498		278		498	
			EQUALIZED DATA					
Total length (mm)	60	96	60	91	60	86	60	94
* of specimens	219		194		131		227	

During washing of each fish in the laboratory, under cold running top water, the body of each specimen was turned in a tail-to-head direction and the washing operation was done with weakly flowing water. Sub-sampling was performed using the method described by Holden & Raitt (1974). During the length measurement, each individual was laid on its right side, the jaws being closed and the length was measured by means of a clipper as a straight line. The distance between the tips of the clipper was read off in millimetric scale. The weighing was done on an electronic balance (accuracy 0.01 gr).

According to Blackith and Reyment (1971), the weight unit can be used for the standardization of the row data. It is well known that the weight is a power of the length (Ricker, 1975). Based on this idea, the weight unit was used in present study, for the standardization of the row data. In order to prevent any bias in total weight measurements due to food factor and different maturation stage, the weight after cleaning was used for standardization. The fish was laid straight on a millimetric paper. Much care was paid to fit the axis, which passes through maxillary symphasis (U) to the membraneous edge of caudal fin at fork (F) to the straight line drawn in a horizontal plane on the millimetric paper (Fig. 2). For dissection through gill-cover notch at an angle of 90° between the above described axis and the gill-cover notch was arranged and dissection was made by one stroke.

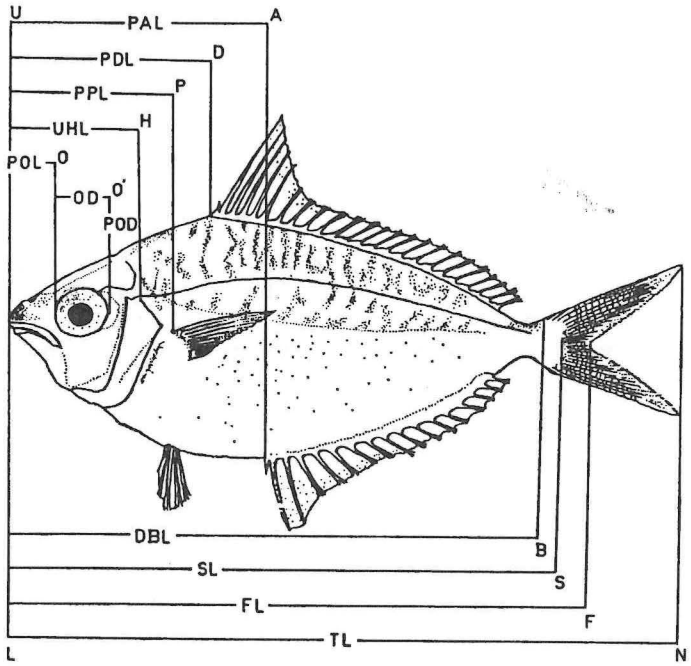

Fig. 2. Measured morphometric characteristics of *L. klunzingeri*
TL = Total length, SL = Standard length, DBL = Dorsal body length, UHL = Upper head length, PPL = Pre-Pectoral length, POL = Pre--Orbital length, OD = Orbital diameter, POD = Post-Orbital distance, FL = Fork length, PDL = Pre-Anterior dorsal length, PAL = Pre-Anal length
[Figure is redrawn from (Tortonese 1975)]

The Generalized Distance of Mahalanobis (Mahalanobis et al., (1949) cited in Weber, 1972) was used in the present study for the numerical discrimination of the stocks of silverbelly:

$$D^2 = (b_1 d_1 + b_2 d_2 + b_3 d_3 + \dots\dots\dots + b_m d_m)/m$$

Where:
D^2: Generalized Mahalanobis Distance

b_i : discriminant functions of the (i)'th measurement
d_i : mean difference of the (i)'th measurement
m : number of measured characters

Clustering technique of Davis (1973) was combined with Generalized Distance of Mahalanobis to obtain qualitative relationship between stocks. Significant testing of Sneath & Sokal (1973) was used to observe the presence or absence of significancy between the groups for the calculated D^2 values.

RESULTS AND DISCUSSION

Mahalanobis Distance values and calculated significant testing results are shown in four different local areas in Table 2.

Table 2. Generalized Mahalanobis Distances (D^2) of *L. klunzingeri* longer than 60 mm, above the diagonal. Results of the significant testing were shown below the diagonal; (*) significant

STATION	TUZLA D^2	SEYHAN D^2	TIRTAR D^2	GOKSU D^2
TUZLA		0.473	0.475	0.608
SEYHAN	*		0.757	0.857
TIRTAR	*	*		0.429
GOKSU	*	*	*	

As can be seen from the Table 2 the two least Generalized Distances were found for Tirtar-Goksu (0.429) and for Tuzla-Seyhan (0.473). The mean of the combinations, formed by the members of this pair of groups, is 1.5 times (0.674) larger than any of two groups. Maximum Generalized Distance value was found to be 0.857 for Seyhan-Goksu. The F values calculated for Silverbellies larger than 60 mm using the methods described by Davis (1973), Overall & Klett (1972) and Sneath & Sokal (1973) at 5% error possibility were 3.22, 2.15, 3.28, 3.66, 7.08, 2.12 for Tuzla-Seyhan, Tuzla-Tirtar, Tuzla-Goksu, Seyhan-Tirtar, Seyhan-Goksu, and Tirtar-Goksu respectively. These calculated F values were much higher than the F values read from the table of 1.83, 1.83, 1.82, 1.83, 1.82 and 1.82 respectively. Therefore the hypothesis, that »there is no difference between the groups« was rejected and concluded that four different stocks of silverbellies (Tuzla, Seyhan, Tirtar and Goksu) inhabit the Bay of Mersin.

L. klunzingeri move towards the estuaries even into the mouth of rivers to lay their eggs (Aksiray, 1954). Possible niches for the newly hatched larvae can be either the shallow estuaries or the mouth of rivers. Tarsus and Seyhan rivers flow into the northeastern part of the Mersin Bay, whereas Lamas and Goksu rivers to southwestern parts (Fig. 1). The mouths of Seyhan and Tarsus rivers may be the habitats for Tuzla and Seyhan stocks and the mouths of Lamas and Goksu rivers for the Tirtar and Goksu stocks, respectively.

Results of the cluster analysis (Fig. 3) support also the existence of four different stocks mentioned above. However, the dissimilarity (D^2 value) between the samples of Seyhan and Tuzla was higher (0.47) than the samples of Tirtar and Goksu (0.43). As can be seen from the Fig. 3, Tuzla-Seyhan stocks and Tirtar-Goksu stocks differ from each other with a Generalized Distance value of 0.7.

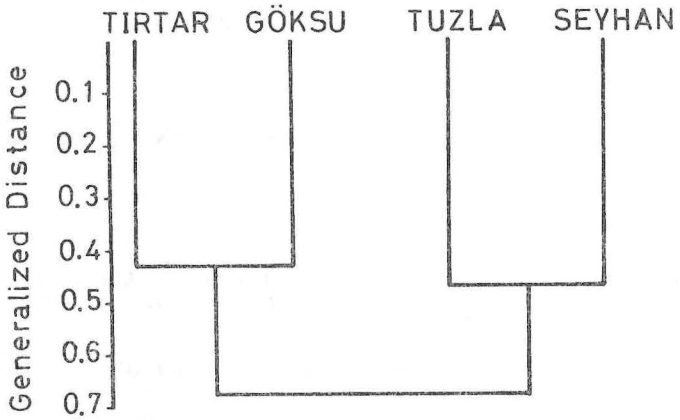

Fig. 3. Dendogram of Generalized Distance matrix of *L. klunzingeri*

Individuals of Tirtar and Goksu stocks show much more similarity among themselves than Tuzla and Seyhan stock do. Here, Deli Cape seems to be a barrier in the genetic exchange between the individuals of Tuzla and Seyhan stocks. This situation would result in less similarity between the individuals of Tuzla and Seyhan stocks than Tirtar and Goksu stocks.

CONCLUSION

The stock composition of the *Leiognathus klunzingeri*, collected from the northeastern Mediterranean (Mersin Bay) was studied statistically employing the Generalized Distance of Mahalonobis.

Four different stocks of the *L. klunzingeri* were distinguished, i. e., Tuzla, Seyhan, Tirtar and Goksu stocks. This characteristic has been explained by utilizing the numerical compositions of the generalized distances (Table 2) for related stations.

Results of the Cluster analysis also supported the existence of four different stocks. The individuals of Tirtar and Goksu stocks show more similarity than individuals of Tuzla and Seyhan stocks (Fig. 3).

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Dursun Avsar, Ferit Bingel i Mustafa Ünsal

Institut za istraživanje mora, M. E. T. U., Erdemly, Icel, Turska

KRATKI SADRŽAJ

Diferencijacija stocka *Leiognathus klunzingeri* sa četiri lokaliteta sjeveroistočnog Mediterana izučavana je na osnovu morfometrije. Primijenjena je Mahalanobis-ova funkcija diskriminacije i ustanovljeno da postoje četiri različita stoka *Leiognathus klunzingeri* Steindachner u zaljevu Mersin.