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Government of Greece in Cooperation with
FAO(GFCM) and UNEP
Athens, 14 - 19 March 1978

PRESENT STATE OF KNOWLEDGE
ON CULTIVABLE SPECIES IN THE MEDITERRANEAN

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Preface

The purpose of this document, prepared for the UNEP/FAO(GFCM) Expert Consultation on Aquaculture Development in the Mediterranean (Athens, 13 - 18 March 1978), is to give an outline of the present state of aquaculture in the Mediterranean area with respect to both research and short-, medium- and long-term commercial development prospects. For this reason the following species have been considered: those which are already of wide practical interest and for which research is necessary to solve specific problems of culture techniques (mussels, oysters, eels); those which, although of mainly scientific interest at present, require an investigation of more practical nature in the near future (bass, shrimp, sole); and, finally, some species for which the possibilities of economically feasible culture are a more distant prospect.

Only marine and brackish-water species have been considered and the scientific nomenclature used in Volumes I and II of the "Species Identification Sheets for Fishery Purposes — Mediterranean and Black Sea — Fishing Area 37 — FAO, 1973" has been followed. Bearing in mind the recommendations of the Cooperative Programme of Research on Aquaculture (COPRAQ) of the General Fisheries Council for the Mediterranean (GFCM), this document is primarily intended for those who are new to aquaculture and require advice on what has been done in this field in order to be able to programme their future activities. It will also be useful to those who have been working in this sector for some years, in stimulating ideas and promoting research programmes on a pilot scale.

Emphasis has been laid on the most significant aspects of the methodologies used, pointing out any deficiencies which impede standardization of the techniques on a large scale so that research workers may concentrate on these problems. Although the study is necessarily limited to those species which at present are of greatest interest for aquaculture purposes in the Mediterranean area, this does not exclude the possibility of adding to the list in future other species which are either endemic to the Mediterranean or originate from countries outside this area.

It is hoped that this brief examination of the various Mediterranean species which could be used for aquaculture will be useful in helping aquaculturists to direct their efforts towards achievements of the best possible results, considering the geographical position of their country, the environmental and socio-economic conditions and local contingencies.

Family: MYTILIDAE

Species	Geographical distribution	Size
Mytilus gallo-provincialis (Lamark)	Very common, particularly in the central northern part of the Mediterranean and in the Black Sea. In the Atlantic it is represented by the related species *M. edulis*	Max: 11 cm Common: 7 cm

1. Distinctive characteristics

1.1 Ecology

Lives in shallow water, from high in the intertidal zone to about 10 m below sea level, fixed to hard substrata. This mussel is very resistant to sudden changes in temperature (from a minimum of 0°C, according to many authors, to a maximum of 28°C reported by Renzoni (1963)) and in salinity, and adapts to both euryhaline and hyperhaline environments; however, it prefers low salinity and temperatures. Optimum salinity is between 25 and 35 ppt.

1.2 Natural diet

Feeds on phytoplankton and organic particles suspended in the water which it filters in large amounts. The volume filtered depends on the temperature, so that under optimum conditions the amount of water filtered per hour may equal 50-100 times the volume of the mussel. Mussels feed mainly on peridinia, diatoms, flagellates and planktonic animal organisms, as well as organic particles, preferably smaller than 30 μ.

1.3 Natural reproduction

The sexes are separate, sexual dimorphism being fairly obvious from the colour of the reproductive apparatus. The period of sexual maturity is very long, spawning taking place mainly in autumn, winter and spring (Renzoni, 1974; Hrs-Brenko, 1973). However, the reproductive phase is greatly influenced by external factors, particularly temperature. In the Atlantic there are very distinct rest periods which coincide with the cold months, and spawning commences towards summer (Scalfati, 1970).

1.4 Marketing

Mainly marketed fresh. A very small quantity is canned or deep frozen.

In Italy the retail price of mussels varies from US$ 0.7 to 1.8.

2. Reproduction and rearing

2.1 Induced spawning methods

Induced spawning by means of thermal, mechanical or chemical stimuli is carried out only for experimental purposes (e.g. production of trochophores and veligers as food for fish larvae and crustaceans). Sexually mature animals are normally used; after mechanical stimulation they are transferred to water at a high temperature, where they release the gametes.

MYTIL Mytil 1

1972

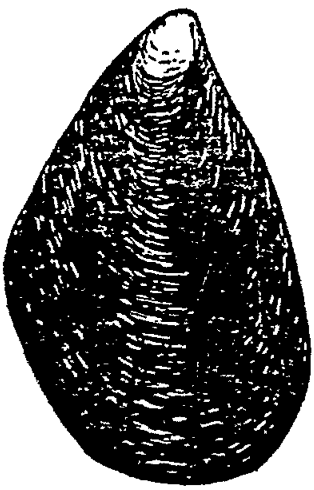
FAO SPECIES IDENTIFICATION SHEETS

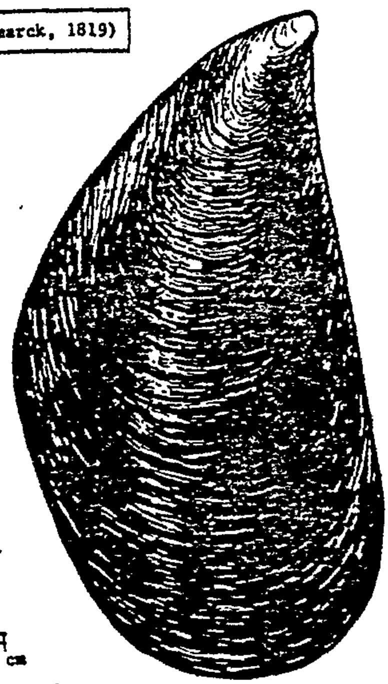
FAMILY: MYTILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mytilus galloprovincialis (Lamarck, 1819)

SYNONYMS STILL IN USE: None





0 2 cm

VERNACULAR NAMES:

FAO - En : Mediterranean mussel
Fr : Moule méditerranéenne
Sp : Mejillón mediterráneo

NATIONAL -

ALBN:		ISRL:	Zidpit galit	ROMN:	Midie
ALGR:	Babbouch	ITAL:	Mitilo	SPAN:	Mejillón
BULG:	Cherna mida	LEBN:		SYRI:	
CYPR:	Mydia	LIBY:		TUNS:	Tamr al bahr
EGYP:		MALT:	Masklu	TURK:	Midye
FRAN:	Moule	MONC:	Mula	USSR:	Midia
GREC:	Mýdi	MORC:	Moule	YUGO:	Dagnja

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

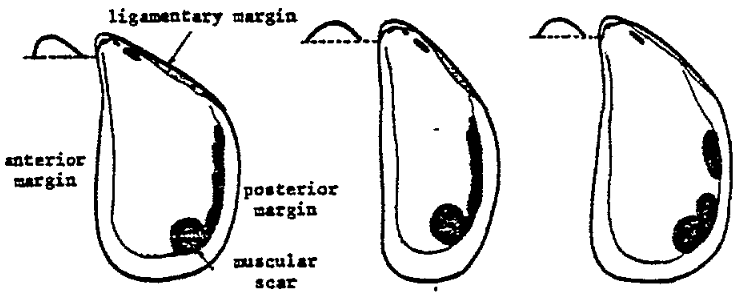
Shell elongate, sub-quadrangular, *equivavle, blackish-violet in colour; umbones (beaks) terminal, pointed* and slightly curved forward; ventral surface of valves flattened behind the beaks; *ventral margin of the shell straight, posterior margin rounded, ligamentary margin forming a distinct angle. Inner side of valves smooth, bearing a large scar which extends dorsally and posteriorly* (consisting of an elongated portion: traces of retractor muscles of foot, medium and posterior retractor muscles of byssus, and a circular posterior portion: trace of posterior adductor muscle). There are also two small anterior muscular scars (traces of the anterior adductor muscle and of the anterior retractor muscle of byssus). Hinge formed by 3 to 4 small teeth.

Other field characters: edge of mantle violet or purplish-violet in colour.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Mytilus edulis has a less prominent ligamentary margin; the ventral surface of the valves is not flattened behind the beak. Its shape is often relatively more elongate.

Perna (Mytilus) perna, which occurs along the coasts of Algeria and northern Tunisia, has a pearly shell; the scar of the retractor muscles of the byssus is distinct from that of the posterior adductor muscle.

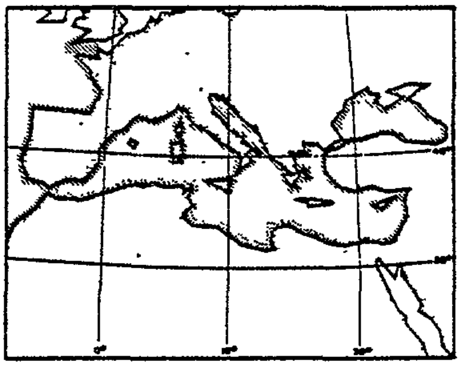


M. galloprovincialis *M. edulis* *P. perna*

SIZE:

Maximum - length: 10-11 cm.
Common - length: 7-8 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:



A very common species with a wide range: western and eastern Mediterranean (though rare along the North African coast), western part of the English Channel and Atlantic coasts of France, Portugal and Spain.

Lives at the upper limit of the infralittoral zone, attached to hard substrates (rocks, poles, boulders, piers, buoys). It is cultivated on a large scale.

Feeds on phytoplankton and suspended organic particles. The sexes are distinct and spawning extends throughout the year.

PRESENT FISHING GROUNDS:

- Mytiliculture is practised in the Mediterranean (Italy, France, Spain, Tunisia, Turkey and Yugoslavia) and in the Atlantic. In the Mediterranean the specimens are attached by their byssus (attachment threads emerging from between the anterior margins of the shell) to strings suspended to frameworks or buoys.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics for this species are collected in Bulgaria, Italy (1971: 18 200 tons), France (1971: 8 900 tons), Spain, Tunisia and Turkey; the production reported in 1971 for the Mediterranean and Black Sea totalling 28 200 tons.

On natural banks it is taken with rakes and dredges, but the main production comes from mytiliculture.

Its commercial value is high, as the flesh is very highly esteemed. It is consumed raw or cooked.

Another method is to break off a chip from the valvular shell at the lever of the visceral ganglion and then transfer the specimens into water at a very high temperature. Finally, a normal thermal stimulus may be sufficient, consisting of transferring the animals from an ambient temperature of 10 - 15°C to 18 - 20°C in an aquarium.

Hrs-Brenko (1973a) used mussels collected in the northern Adriatic where the winter temperature was 0.0 - 1.0°C, and by placing them in a controlled environment at a temperature of 18°C provoked release of the gametes.

In commercial-scale culture the seed is obtained by means of special collectors placed in the sea during favourable periods. These collectors usually consist of grass ropes 3-6 m long placed just below the surface; sometimes the natural seed is collected by tearing it away from the hard substrata (rocks) to which it is fixed.

2.2 Rearing to market size

Mussel culture in the Mediterranean is generally carried out by the suspended method, on vertical esparto grass ropes or in nylon mesh bags.

The larvae attach themselves to the ropes in autumn and the young specimens of about 1 cm, the seed, are collected in March-April. The seed is attached to the inside of new ropes by stretching the strands apart, or is placed directly in long nylon mesh bags; since the bags are very resistant they do not need to be changed 2-3 times during the period of culture (Scalfati, 1970).

The ropes are suspended from frames supported by stakes driven into the bottom of shallow lagoons, or from chains formed of floats securely anchored to the bottom in deep waters (Scalfati, 1970). In the latter case the ropes of mussels are usually placed some metres below the surface, as this type of culture is usually carried out in waters with little protection from storms.

Along the Mediterranean coasts of Spain floating rafts, "bateas", are used, to which the ropes of molluscs are fastened (San Feliu, 1973). This type of culture is being developed on a large scale in the "rias" on the Atlantic coasts of Spain.

Within 12-24 months, according to the zone, mussels reach marketable size (about 6 cm in length).

Mussel farming by the suspended method can yied up to 100 kg/m^2, or 250 tons/ha/year, bearing in mind that only about one-quarter of the total area is used for the floating installations.

3. Prospects for commercial development

The demand for mussels on European markets is greater than the supply, so there is scope for mussel culture expansion (Mason, 1972).

Among marine organisms mussels are one of the most productive sources of noble proteins. As their feed costs nothing production costs are limited to installation (which are reasonably modest), preparation of the seed on ropes, periodic control, cleaning and transport. As compared with other well consolidated aquaculture activities, mussel farming finds a favourable market and suitable environmental conditions in the Mediterranean.

However, certain standards regarding hygiene guarantees (non-polluted growing areas and depuration plants) and proper marketing on foreign markets so that surplus production does not cause dangerous falls in prices, must be respected.

Efforts are being made to encourage the development of mussel farming in Mediterranean countries where there is no tradition of molluscan culture.

This is happening in Greece (Zombolas, 1970) where, although environmental conditions are favourable there is not a receptive market.

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Family: OSTREIDAE

Species	Geographical distribution	Size
Ostrea edulis (Linnaeus)	Common throughout the Mediterranean and in the Atlantic from the northern coasts to Morocco	Max: 12 cm Common: 7 cm
Crassostrea angulata (Lamark)	Common in the Mediterranean and along the Atlantic coasts from the English Channel to the southernmost part of Spain	Max: 20 cm Common: 8 cm
Crassostrea gigas (Thunberg)	Imported from Japan, reared in the Mediterranean and along the eastern and western coasts of the Atlantic	Max: 30 cm Common: 12 cm

1. Distinctive characteristics

1.1 Ecology

The three species of oysters live in shallow water (0.50 – 20 m) on sandy, sandy-mud, detrital and rocky bottoms. While O. edulis prefers typically marine waters (35 ppt salinity) with a wide range of tolerance (24 – 45 ppt), C. gigas and C. angulata adapt well to myxohaline waters, showing distinctive characteristics of estuarine organisms. For this reason, and because of its particular tolerance to sudden changes in temperature, its hardiness, resistance to certain diseases, and rapid growth, C. gigas is particularly suitable for intensive culture in various environments and climates.

1.2 Natural diet

While the larvae feed on small-sized phytoplankton (nanoplankton), the adults feed mainly on diatoms, dinoflagellates, radiolarians, foraminifers, organic waste particles and small zooplankton (larvae of annelids, sponges, molluscs, etc.). Both larvae and adults are selective as regards the size of the food and in some cases as regards the colour as well.

1.3 Natural reproduction

O. edulis is an insufficiently protandrous and larviparous hermaphrodite, i.e. it both fertilizes and incubates the eggs in its pallial cavity and then releases already formed larvae. The larval phase lasts about 10 – 15 days, after which the larva attaches itself to the bottom. Spawning of O. edulis takes place between June and July, although it is not uncommon to find larvae in other periods of the year (Sebastio, 1968). C. gigas also spawns when the temperature of the water begins to rise, i.e. at the beginning of the summer.

C. angulata spawns mainly in July but spawning may continue until October. In the genus Crassostrea the sexes are separate (Quayle, 1969).

1.4 Marketing

Marketed fresh. O. edulis is particularly prized owing to its excellent taste, while oyster growers concentrate more attention on C. gigas because of its hardiness, rapid growth and resistance to certain diseases.

OSTR Ostr 1

1972

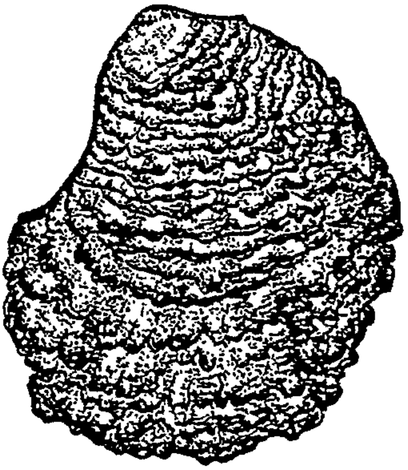
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: OSTREIDAE

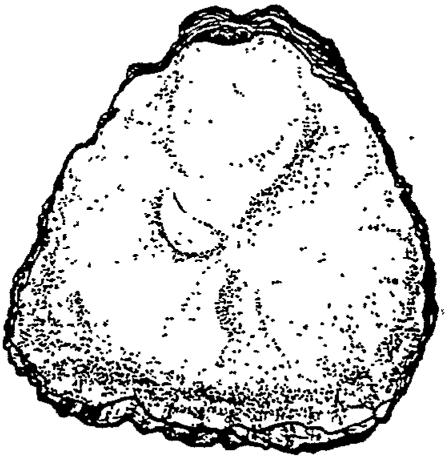
Fishing Area 37
(Medit. and Black Sea)

Ostrea edulis (Linnaeus, 1758)

SYNONYMS STILL IN USE: None



left valve
outer side



left valve
inner side

0 4cm

VERNACULAR NAMES:

FAO - En : European flat oyster
Fr : Huître plate européenne
Sp : Ostra europea

NATIONAL - ALBN:		ISRL:		ROMN:	Stridie
ALGR:		ITAL:	Ostrica	SPAN:	Ostra
BULG:	Strida	LEBN:	Osterit neekhelat	SYRI:	
CYPR:	Stridi	LIBY:		TUNS:	Mahar
EGYP:		MALT:	Koccla	TURK:	Istiride
FRAN:	Huître plate	MONC:	Ostrega	USSR:	Ustritka
GREC:	Stridi	MONC:	Huître plate	YUGO:	Kamenica

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Shell moderately light, irregularly ovate, without a distinct hooked beak; patterned with delicate foliations and yellowish-brown in colour. Outline of both valves identical; *left valve (fixed to the substrate) slightly cupped,* with corrugated borders; right valve flat and marked with inconspicuous radiating folds.

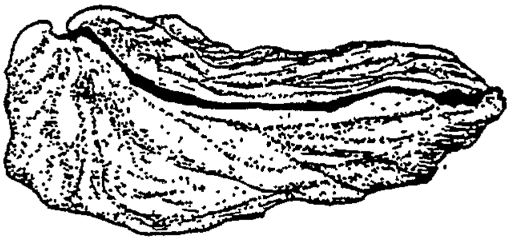
Other field characters: shell consisting of a series of chalky layers which may include laminar, hollow chambers.

O. edulis
lateral view

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Crassostrea angulata is much more elongate; the left (lower) valve is much deeper and has a curved, hooked beak; the right valve is marked with distinct folds.

The species of the genus *Pycnodonta* might also be confused with *O. edulis*, but their shells are more intensely calcified, with vacuolar chalky chambers.



C. angulata
lateral view

SIZE:

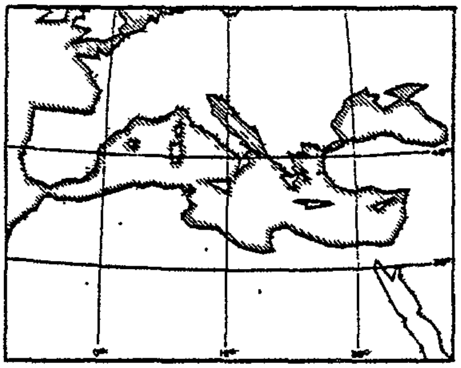
Maximum - length: 12 cm.
Common - length: 6 to 7 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

A very common species of wide range: Mediterranean, Black Sea, North Sea, English Channel and North Atlantic coast down to Morocco.

Inhabits sandy, gravel or rock bottoms of the infralittoral zone, where it may form banks; not found in brackish water areas.

Feeds on plankton and suspended organic particles. The species is larviparous and successively hermaphroditic (alternation of male and female phases); spawning takes place in June/July.



PRESENT FISHING GROUNDS:

The natural banks are over-exploited and have almost completely disappeared, except in the North Sea and the English Channel.

Within the Mediterranean, *O. edulis* is cultivated (ostreiculture) in France, Italy, Spain, Tunisia and Yugoslavia; it is also cultivated along the Atlantic coast of France and in Holland.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics for this species are reported within the area only by France (1971: 200 tons) and Yugoslavia (1971: 100 tons). It is very likely, however, that the actual production by ostreiculture in the Mediterranean is considerably higher.

On natural banks, the flat oyster is taken with dredges or with rakes. In oyster parks (in tidal seas) the species is cultured on the seabottom in perforated plastic containers. In the Mediterranean it is attached to various types of substrate (shells fixed to poles or threaded on nylon strings suspended from frameworks or buoys).

Its commercial value is very high, as the flesh, which is consumed raw, is highly esteemed.

OSTR Crass 1
1972

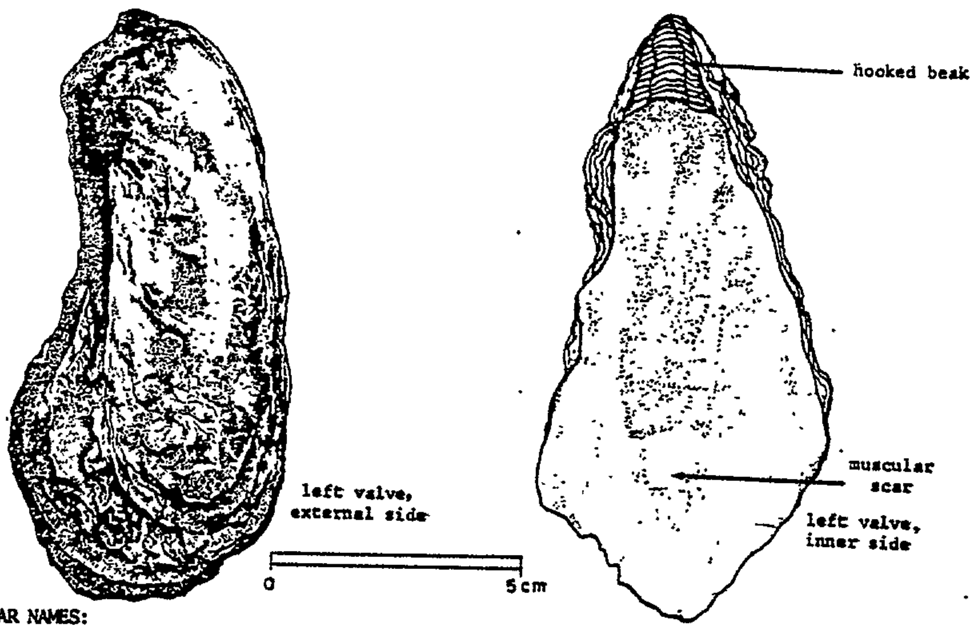
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: OSTREIDAE

Fishing Area 37
(Medit. and Black Sea)

Crassostrea angulata (Lamarck, 1809)

SYNONYMS STILL IN USE: _Cryphaea angulata_ (Lamarck, 1809)



VERNACULAR NAMES:

FAO - En : Portuguese cupped oyster
Fr : Huître portugaise
Sp : Osteón

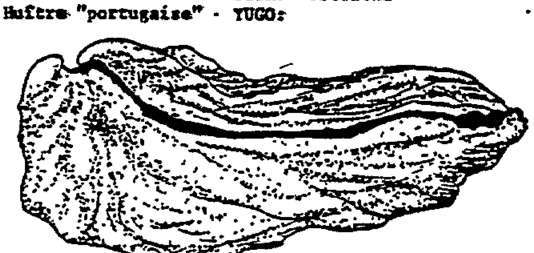
NATIONAL -

ALBN:		ISRL:		ROMN:	
ALGR:		ITAL:	Ostrica porthogese	SPAN:	Ostra portuguesa
BULG:		LEBN:		SYRI:	
CYPR:	Stridi	LIBY:		TUNS:	Mahar
EGYP:		MALT:		TURK:	
FRAN:	Huître portugaise	MONC:		USSR:	Ustritka
GREC:		MORC:	Huître "portugaise"	YUGO:	

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Shell elongate, _thick_, variable in colour; _left or lower valve (fixed to the substrate) deeply cupped and curved, forming a prominent, hooked beak_; right, or upper valve, flattened and bearing thick folds.

Other field characters: shell consisting of a series of chalky layers which may include laminar, hollow chambers.



G. angulata
lateral view

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

The shell of *Ostrea edulis* is thinner, relatively more elongate and irregularly ovate in shape. The left (lower) valve is less concave and has no distinct hooked beak.

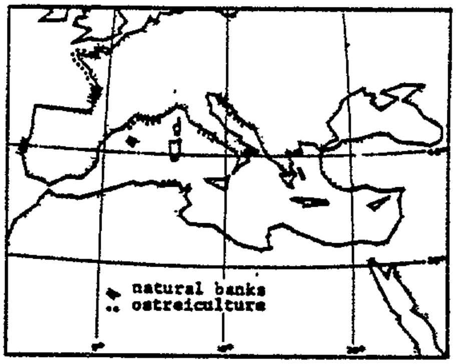
O. edulis
lateral view

SIZE:

Maximum - length: 18 to 20 cm.
Common - length: 7 to 8 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

A common species originally found only at the Tago estuary (Portugal). It has probably evolved from *Crassostrea virginica*, an oyster occurring along the eastern coast of North America. The American species may have been transported on hulls of ships to Portugal, where it became established. During the second half of the 19th century, the implantation of the species on the Atlantic coast of France was successfully attempted. It is now being cultivated (ostreiculture) in the Mediterranean and in the Atlantic.



Inhabits sandy-mud or gravel bottoms in areas subjected to the influence of brackish water.

Feeds on plankton and suspended organic particles. The species is oviparous and requires a brackish water environment to reproduce. Spawning takes place mainly in July, although there is also reduced spawning activity in October. The species is hermaphroditic.

PRESENT FISHING GROUNDS:

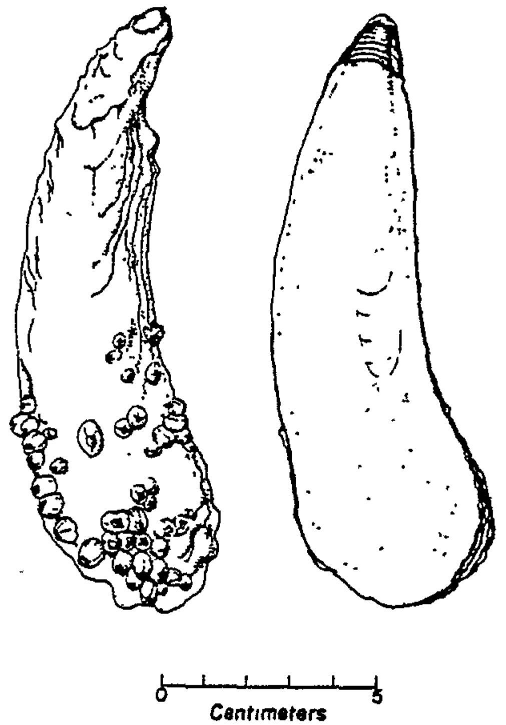
Natural banks are rare (Tago estuary in Portugal, and Gironde, France). The species is cultivated either in parks (English Channel, Atlantic) or attached to suspended strings (Mediterranean).

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

The annual production of this species for the Mediterranean is reported at about 800 tons (1971). It is likely, however, that the actual production is very considerably higher.

Taken mainly with dredges or cultivated.

Its commercial value is very high, although slightly inferior to that of *Ostrea edulis*. Its flesh is highly esteemed and consumed raw.



Crassostrea gigas

Owing to the fluctuating demand in the various Mediterranean countries, the retail of oysters varies between US$ 1.2 and 3.6.

2. Reproduction and rearing

2.1 Induced spawning methods

Interest in the controlled spawning of oysters dates back to the beginning of this century, but a fundamental stage in research was undoubtedly the work carried out by Bruce, Knight and Parke (1940). From that date onwards studies in this field acquired a more precise orientation and led to the definition of a basic methodology which has made it possible, during the last few years, to set up commercial hatcheries for artificial reproduction.

Sexual maturity is usually induced by keeping the oysters in thermostatically controlled conditioning tanks at fairly high temperatures, for a fairly long period, combined with suitable feeding.

Flassch et al. (1974) induced sexual maturity in O. edulis by collecting adults in the wild at a temperature of 8°C and transferring them to tanks in which the temperature is gradually increased in 12 days to 20°C. During this phase in the conditioning tanks a diet of Tetraselmis suecica is given, either continuously at a density of 20 000 cell/ml, or once a day at a density of 600 000 cell/ml.

Artifical heating is also used to obtain O. edulis seed outside the natural spawning period. The method consists of delaying spawning by keeping the genitors in water at 10°C and then inducing ovogenesis at the time desired by raising the temperature to 18°C (O'Sullivan and Wilson, 1976).

Spawning of mature C. gigas is induced by thermal or chemical stimuli. The thermal stimulus consists of subjecting the animal to successive thermal variations, at intervals of 30 minutes, from the ambient temperature to a temperature of 30°C and vice versa. The thermal stimulus is reinforced by a chemical stimulus consisting of introducing sperm into the environment.

The latency period is in direct relation to the stage of the natural gonadal maturity and may last from a few hours to a few months.

Spawning may also be induced by opening the gonads of mature specimens and mixing female and male gametes, but this method does not always give good results.

2.2 Incubation

While there is a phase of incubation, even though short, for Crassostrea eggs, in Ostrea this process takes place directly in the pallial cavity of the genitor, which then expels the larvae already formed.

In the case of C. gigas, the eggs are fertilized within one hour and after a further 30 - 60 minutes they are collected with nets and transferred into sterilized water for a first washing and then into containers for larval rearing.

2.3 Larval rearing

In the case of O. edulis, the larvae are collected with nets of 125 µ mesh immediately after being released and placed in tanks of 125 litres at an average density of 1 000/l (Flassch et al., 1974). The sea water used for rearing the larvae is sterilised with antibiotics (50 mg of streptomycin suphate and 50 000 I.U. of penicillin/l).

In all cases the larvae are fed on Isochrysis galbana, at a density of 50 000/ml, those less than 125 µ are given Monochrysis lutheri, at 50 000/ml, and larger sized larvae T. suecica at 5 000/ml.

Walne (1974) obtained satisfactory results by feeding O. edulis larvae on a mixture of I. galbana, T. suecica and Chaetoceros calcitrans.

Optimum density of the algae varies according to the species used. For Isochrysis it is 58 000 cell/ml, for a smaller species, Micromonas minutus, 132 000 cell/ml, while for the larger Dunaliella tertiolecta the optimum density is 25 000 cell/ml (Walne, 1974). This author has also reared larvae with Cyclotella nana and C. calcitrans with optimum results.

Fixation of the O. edulis larvae takes place after about 20 days of life at a temperature of 23°C and the seed is not transferred into the sea until the second month of rearing.

Helm and Millican (1977) fed C. gigas larvae (120 µ in length) on I. galbana at a density of 50 000 cell/ml and C. calcitrans at 50 000 cell/ml. For larvae larger than 120 µ, the following mixture of algae was given: Isochrysis and Chaetoceros (33 000 cell/ml) and T. suecica (3 300 cell/ml), with aeration of 10 l/h.

With regard to C. gigas, the embryos are placed in bins at a concentration of 100 000/l. After further selection the veligers are collected and placed in special 10-litre recipients containing sterilized water at a temperature of 23 - 24°C. The diet usually consists of C. calcitrans at a density of 150 000 cell/ml (O'Sullivan and Wilson, 1976).

Larval rearing proceeds until the larvae fix themselves to the bottom, on substrata of various kinds consisting of specially prepared PVC sheets or shelves of other material.

2.4 Larval density and survival

Larval density depends on the method of culture and is determined by the size of the organisms. In practice, oyster culture may start with a density of 100 000 veligers/l down to 3 000 veligers/l when the larvae are ready to fix themselves to the substratum, thus obtaining about 50 000 individuals per tray (O'Sullivan and Wilson, 1976).

An optimum density may be considered as 2 000/l for larvae 120 µ in length, or 1 000/l for larger sized larvae.

The survival rate of O. edulis at the time of fixation is 30%, according to Flassch et al. (1974); for C. gigas it is 14.3% and 3.2% when the seed is transferred to the sea (Walne and Helm, 1974). According to O'Sullivan and Wilson (1976), commercial production of C. gigas seed is about 22% and of O. edulis 11%. Optimum growth conditions for C. gigas larvae are a temperature of 28°C and a salinity of 25 ppt (Helm and Millican, 1977). The SATMAR pilot hatchery reports average survival rates of 30% for C. gigas and 80% for O. edulis at the time of fixation (Le Borgne, 1977).

2.5 Rearing to market size

The methods of rearing oyster seed up to market size vary according to regional customs. From the system of culturing O. edulis on lentisk branches or small cement rods threaded on grass ropes, culturists have now passed to different kinds of collectors, such as wooden stakes to which the spat are fixed with quick-drying cement, plastic collectors in the form of a Chinese hat or a tube, shells of dead bivalves threaded onto metal holders to form long chains, baskets and plastic mesh holders, or plastic mesh tubes.

With any type of collector, the criterion followed by all oyster farmers in the Mediterranean area is to keep the oysters always immersed in water, checking periodically for cleanliness and carrying out routine work such as breaking the growing edge in order to make the shell stronger (Marteil, 1974).

O. edulis reaches market size in about 2 years, depending on the characteristics of the rearing zone (temperature, quantity of food, salinity, density of oysters on the collectors, etc.). However, in water of high temperature (thermal effluents), growth may be very rapid and the growing period very reduced ((at 25°C this oyster reaches sexual maturity in about 3 months from larval stage (author's experiment)).

Under natural conditions the growth rate of C. gigas is greatly superior to that of O. edulis and C. angulata. This difference is explained by the greater filtration capacity of C. gigas even when the water temperature becomes very low (3°C) (His, 1972). Under favourable conditions C. gigas may reach marketable size in the short period of about 6 months. In addition, the resistance of this oyster to certain diseases has led various countries to rehabilitate their impoverished natural beds by importing large quantities of seed. This operation has been successful in British Columbia, Canada, in the State of Washington, U.S.A., and, finally, in France. Oyster culture can be carried out successfully in brackish lagoons, in the sea and in earthen ponds.

3. Prospects for commercial development

There are great possibilities for the development of oyster culture in Mediterranean countries, owing to the high demand from northern Europe in particular and the presence of vast areas not yet utilized for this purpose. These possibilities appear particularly favourable for marine areas with lower salinity (33-35 ppt) and a high trophic level.

Industrial pollution presents a serious danger, leading to the destruction of natural and artificial beds of this mollusc. In expanding molluscan culture it will be necessary for countries concerned to introduce legislation limiting the input of particularly toxic contaminants and setting up depuration plants where necessary.

Oyster culture, together with mussel farming, could constitute one of the most important sources of protein in the future, since it is one of the most economical and, from the point of view of energy balance, least costly forms of aquaculture activity.

It should be borne in mind, however, that in some regions of the Mediterranean the collection of oyster spat depends to a large extent on natural banks, which makes the problem of conserving them particularly crucial. There have already been some years when the cost of spat has risen sharply as the result of a poor harvest; hence the desirability of improving hatchery production techniques and setting up demonstration hatcheries.

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Family: PENAEIDAE

Species	Geographical distribution	Size or Weight
Penaeus kerathurus (Forskal)	Common in the Mediterranean, present in the Atlantic from Portugal to Angola	Max: 20 cm Common: 14 - 16 cm
Penaeus japonicus (Bate)	Imported into France from Japan, common in Asiatic waters	Max: 130 g Common: 20 - 25 g
Penaeus semisulcatus (De Haan) Metapenaeus stebbingi (Nobili)	Species originating from the Indo-Pacific Ocean through the Suez Canal, now established along the Mediterranean coasts of Egypt and Israel	Large (normal weight: 20 g) Small

1. Distinctive characteristics

1.1 Ecology

These penaeid shrimps are extremely eurythermic and euryhaline, and are therefore very suitable for pond culture.

They usually live on bottoms of sand, mixed sand and mud or rough detritus, and prefer estuary environments.

As adults they live buried in sand during the day and become active at sunset and night time, when they are usually fished with dragnets or fixed nets.

They prefer deep water (40 - 45 m) during the cold months and shallow water (5 - 15 m) during the warm months when they spawn.

1.2 Natural diet

They feed on small benthic organisms. The diet of P. kerathurus consists, in order of importance, of molluscs (pelecypods, gasteropods, scaphopods and cephalopods), polychaetes, crustaceans and echinoderms (Ben Mustapha, 1967).

1.3 Natural reproduction

P. kerathurus spawns along the northern coasts of Tunisia from May to mid-September, and further south, in the region of Sfax, from April to the end of September (Heldt, 1938).

Along the Spanish coasts spawning takes place from the beginning of April to the beginning of September (San Feliu, 1964), and along the Italian coasts from May to the beginning of September, with peaks in July and August (Lumare, Blundo and Villani, 1971).

P. japonicus spawns in Japan from March to September, with slight variations according to the area and the season (Shigueno, 1975).

PEN Pen 1

1972

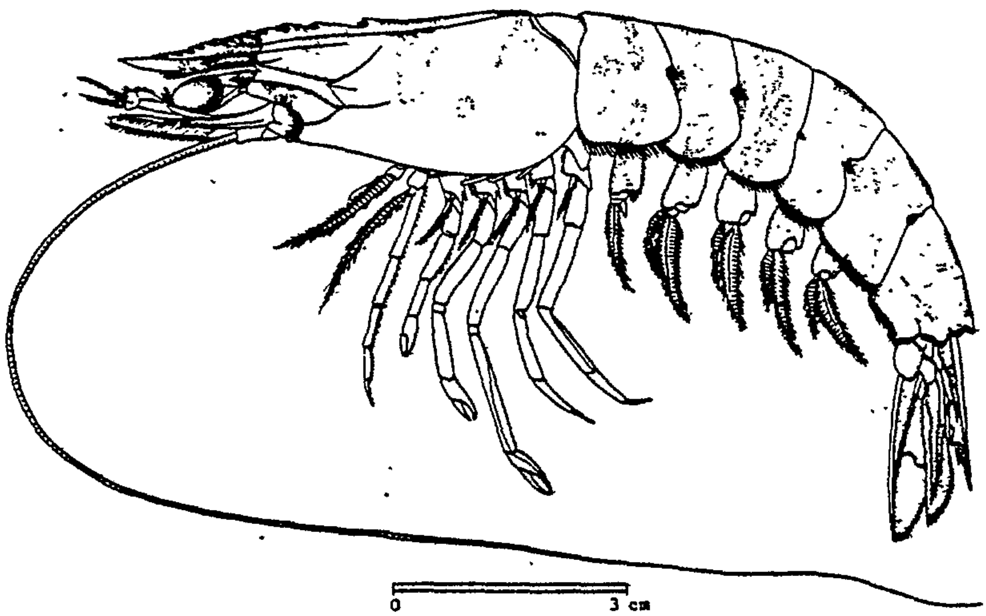
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: PENAEIDAE

Fishing Area 37
(Medit. and Black Sea)

Penaeus kerathurus (Forskål, 1775)

SYNONYMS STILL IN USE: *Penaeus trisulcatus* Leach, 1815



VERNACULAR NAMES:

FAO - En : Triple-grooved shrimp
Fr : Caramote
Sp : Langostino

NATIONAL -

ALBN:		ISRL:	Penon telat-harizi	ROMN:	
ALGR:	Caramote	ITAL:	Mazzancolla	SPAN:	Langostino
BULG:		LEBN:		SYRI:	Kreidès
CYPR:		LIBY:	Gambari,	TUNS:	Gambri kbeir
EGYP:	Gambari azzari	MALT:	Gamblu mperjali	TURK:	Karides
FRAN:	Caramote	MONC:	Gambaru grossu	USSR:	Krevetka
GREC:	Garída	MORC:	Bouquet	YUGO:	

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Carapace strongly calcified, with many grooves on its upper side and on the anterior halves of the sides. *Rostrum strong, extending a little beyond the eyes, armed with one ventral tooth and 10 dorsal teeth which run backward to the middle of the carapace;* behind the last tooth, the median keel divides into 2 branches, leaving a narrow groove between them. *On each side of the midline there is a high and sharp crest which extends to the rostrum;* thus two deep dorsal grooves can be seen running along the carapace throughout its length. A strong hepatic spine is present. The colouration is rather characteristic: there are transverse dark bands or blotches on a lighter background.

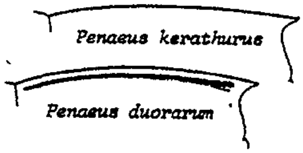
Penaeus kerathurus
dorsal view of
carapace and rostrum

Other field characters: abdominal segments I to III without a keel; each of the segments IV to VI bear a keel which increases in sharpness; that of segment VI ends in a small tooth. Telson with a dorsal groove formed by a pair of longitudinal, sharp keels. Both antennular flagellae are very short.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

The other Mediterranean penaeids can be distinguished from *P. kerathurus* by their different colouration, and by the absence of a tooth on the lower border of the rostrum, of a rostral keel bifid posteriorly and of a pair of secondary keels parallel to the midline.

P. duorarum, a species which is common in the tropical Atlantic off Africa, differs from *P. kerathurus* in the presence of a deep groove on each side of the dorsal keel of the abdominal segment VI.



6th abdominal segment
(lateral view)

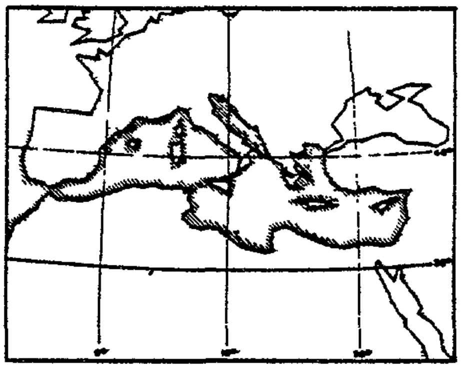
SIZE:

Maximum: about 20 cm; common: 14 to 16 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Present throughout the Mediterranean, but absent from the Black Sea. Also found in the eastern Atlantic from Portugal to Angola.

Inhabits relatively shallow waters, down to about 50 to 70 m, over sandy-mud bottoms.



PRESENT FISHING GROUNDS:

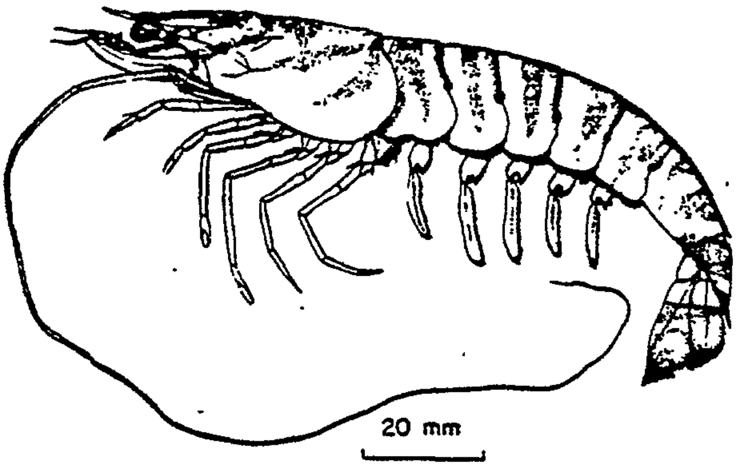
Continental shelf and often in the vicinity of estuaries into which penetrate the juveniles.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

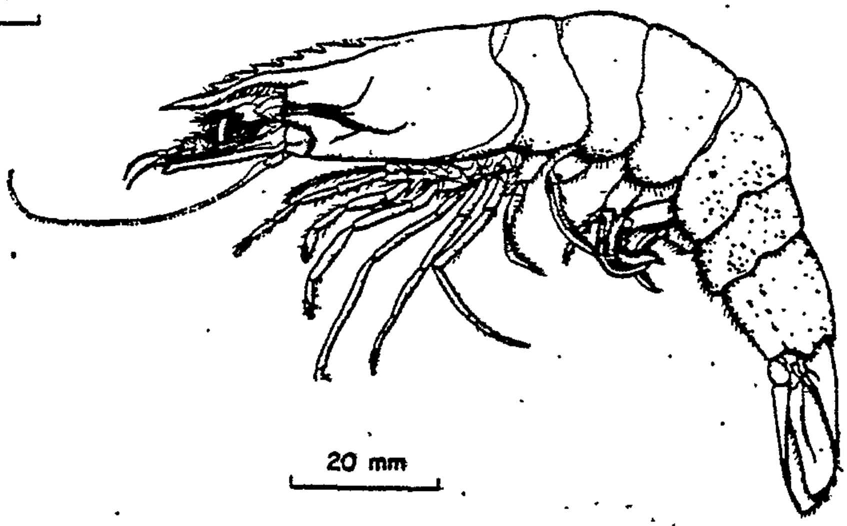
Separate statistics for this species are collected only in Italy (1971: 3 900 tons) and Spain (1971: 100 tons). This species is included in other countries in the statistical category "shrimps", for which the reported catch in 1971 in the Mediterranean and the Black Sea totalled 17 500 tons.

Caught with trawls and occasionally with pots.

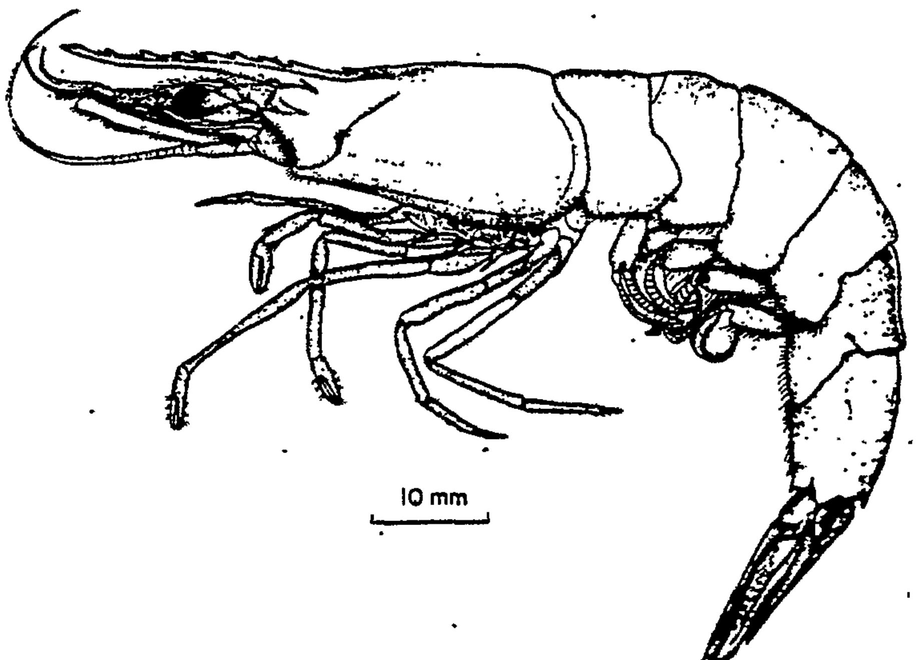
Marketed fresh.



Penaeus japonicus



Penaeus semisulcatus



Metapenaeus stebbingi

For P. semisulcatus and M. stebbingi the spawning period runs from April to October in Mediterranean waters (Samocha and Lewinsohn, 1977).

Full sexual maturity is indicated by the colour of the gonads, which are orange-yellow in P. kerathurus, or also greenish according to Rodriguez (1976). In P. japonicus they appear dark.

The reproductive period of the penaeids is usually very short, being about two years in both P. kerathurus and P. japonicus.

1.4 Marketing

Marketed fresh. The retail price for medium-size penaeids (15 cm) in Mediterranean countries is fairly high, fluctuating between US$ 12 and 35/kg.

2. Reproduction and rearing

2.1 Induced spawning methods

The first organized attempts at inducing spawning in penaeids date back to Hudinaga (1942), who experimented with P. japonicus. Heldt (1938) induced spawning of P. kerathurus in the course of research work on the morphology of the larvae. In Japan the initial studies carried out by Hudinaga led, from 1960 onwards, to commercial-scale reproduction and culture of penaeids. In Europe it was not until after 1960 that studies on the reproduction and rearing of P. kerathurus larvae were resumed thanks to San Feliu (1964, 1969) in Spain, followed by similar experiments in Italy, France and, very recently, Israel. At present research on the reproduction and culture of P. kerathurus is also being conducted in Portugal (De Figueiredo, 1972) and Greece (Anon., 1977).

The release of eggs by P. kerathurus in captivity is usually stimulated by thermal shock, consisting of raising the temperature of the water from ambient to 26 - 29°C, salinity 33 - 38 ppt, using 10 - 20 spawners in aquaria of 2 m^3 (San Feliu et al., 1976); or to 28 ± 1°C, salinity 33 - 37 ppt (Lumare, 1976); Rodrigues (1976) raised the temperature to 29 - 30°C, salinity 31 - 33 ppt and pH 7.6 - 7.8, using 4 - 8 females per aquarium, in absolute darkness.

The number of spawners responding to thermal stimulus varies between 10.5 and 100%. Aquaria of various sizes may be used, with or without double bottoms, either quadrangular or cylindrical, but the shape does not seem to have particular importance.

Lumare (unpublished data) also used eyestalk ablation. In winter the latency period was about two months, in summer about 10 days. This operation resulted in response from a high percentage of females (96%), increased spawnings by individual females (up to 9), and a large number of hatched eggs (67.2%), with the advantage of being able to produce fry in all seasons. Favourable results of this kind have also been obtained by San Feliu (personal communication).

In France P. japonicus is imported from Asia owing to the shortage of natural stocks of penaeids (Caubere et al., 1976). To induce gonadal maturity changes in the environment were effected — temperature, photoperiod, water recycling and renewal — and the genitors were fed on a diet of Carcinus mediterraneus (= C. maenas) and Mytilus galloprovincialis (salinity 30.5 - 36 ppt; temperature 22.5 - 30.2°C; pH 7.5 - 8.5; dissolved O_2 50 - 130% of saturation). Negative thermal shock (temperature 20 - 22°C; salinity 37.2 - 39.2 ppt; pH 7.5 - 8.5) was used to stimulate egg release, with increased pressure (2.5 kg/m^3 for 12 hours). The response obtained from the spawners was 30%, and the rate of live larvae hatched 46%.

There was frequent spontaneous release of eggs in the conditioning tanks as well, with a hatching rate of 99%.

Laubier and Laubier-Bonichon (1977) obtained natural spawning of P. japonicus throughout the year by keeping the animals at 26°C, with 16 hours of light a day in tanks of 8 m^3.

The female P.kerathurus releases an average of 70 000 eggs, although as many as 300 000 are possible (Lumare, Blundo and Villani, 1971).

A female P. japonicus subjected to positive thermal stimulus released eggs twice, 455 000 the first time and 159 000 the second, with a hatching rate of 98%.

2.2 Incubation

The eggs of P. kerathurus and P. japonicus have a diameter of about 290 μ, which increases as the embryo forms. The eggs float when first released and then attach themselves to the bottom owing to the presence of a viscous matrix which envelops them. Incubation usually takes place in the rearing tanks at a temperature of 28 ± 1°C; hatching occurs after 11 – 15 hours; at 20°C, after 33 – 37 hours for P. kerathurus.

2.3 Larval rearing

Penaeid larvae go through three stages of development: nauplial, protozoeal and mysis (total length from 0.30 mm to 4.52 mm), followed by the postlarval stage.

The nauplius develops at the expense of the body's nutritional reserves.

The protozoea is a very active consumer of phytoplankton (optimum density of phytoplankton is from 125 000 to 500 000 cell/ml). The following algae are supplied as feed: Skeletonema costatum, Phaeodactylum tricornutum, Tetraselmis suecica, Thalassiosira decipiens, Chaetoceros sp., Chalmydomonas sp., Nitzschia longissima, Synedra sp., Coscinodiscus sp., Dunaliella sp., with special preference for diatoms.

From the protozoea phase II to the postlarval stage, San Feliu et al. (1976) added zooplankton such as Brachionus plicatilis, Artemia salina nauplii, newly hatched Daphnia, copepods, cirriped larvae, etc. to the diet.

Lumare (1976) prefers to use diatoms for the protozoeal stage; diatoms and A. salina nauplii for the mysis phase; A. salina nauplii only up to the first postlarval phase; A. salina and finely chopped mussel meat for the following 2 – 3 days, and finally mussel meat only.

Rodrigues (1976) obtained the best results by feeding the protozoea and mysis on S. costatum and Thalassiosira sp. (densities of 100 000 – 400 000 cell/ml); from mysis to P_1 on Dunaliella sp. and rotifers, with a salinity of 31 – 35 ppt and a temperature of 21 – 27°C. The highest yields at P_5 averaged 15%.

Samocha and Lewinsohn (1977) fed the protozoea on T. suecica and P. tricornutum, and the mysis on algae, A. salina nauplii (4 – 20 per mysis per day) and Panagrellus nematodes (15 – 80 per mysis a day).

L'Herroux et al. (1977) have developed a technique for producing postlarvae (P_3) without using animal prey.

2.4 Larval density and survival

Larval density is usually kept at 75 to 100/l at the nauplial stage and 35 to 40/l at P_1, with a survival rate of about 77% (San Feliu et al., 1976). From 4 to 20 nauplii/l up to 1.5 – 9 specimens/l at P_9, with yields of between 30 and 88%, according to Lumare

(1976); according to AQUACOP (1977), up to 200 nauplii/l, a survival rate of 60 - 70% at stage P_9, after doubling the density at stage P_2 in order to bring it up to 50 - 60/l.

Rodriguez (1976) maintained a density of 10 to 100 larvae/l, with a survival rate of 14 to 16%, while Samocha and Lewinsohn (1977) used concentrations of 250 - 260 larvae/l.

In the Mediterranean the production of postlarval penaeids hatched in captivity at present amounts to some hundreds of thousands of individuals. However, this numerical limit is imposed, not so much by technological deficiencies in larval rearing, as by the failure to develop growing facilities owing to the low profitability of the undertaking.

2.5 Rearing to market size

Few data are available on P. kerathurus.

Muñoz, San Feliu and Sanz (1974) carried out feeding trials with Trow and Co. and Bioter products, with unsatisfactory results.

Caubere et al. (1976) reared 125 000 P. japonicus postlarvae in ponds of 5 000 m^2 at Maguelone (Herault). After 4½ months the animals, fed on C. mediterraneus in very small fragments and M. galloprovincialis, attained a weight of 13 g, with a total yield of over [illegible] ton.

Samocha and Lewinsohn (1977) reared P. semisulcatus and M. stebbingi in outdoor ponds (1 500 m^2) without feeding and at low stocking density (0.5 - 3 shrimp/m^2). P. semisulcatus increased from 0.01 g to an average of 9.1 g in weight in 100 days; starting with specimens of about 9.6 g, an average weight of 36.7 g was obtained in 164 days. M. stebbingi, which is a very small species, reached an average weight of 2.6 g in 100 days.

3. Prospects for commercial development

The average market size of penaeids ranges from 13 to 22 g. Such sizes can usually be attained in 4 to 10 months. A necessary condition for open-air culture is a high temperature. P. kerathurus grows well at between 25 and 30°C, feeds at temperatures above 15°C, enters a critical phase at 10°C and dies at 6°C.

In small-scale culture fish scraps and other local waste of low economic value (C. mediterraneus, Cerastoderma glaucum (= Cardium lamarkii) and others) can be used as feed.

In order to achieve industrial-scale culture a low-cost artificial feed with minimum food conversion must be developed passing through the pilot-scale phase to eventual polyculture with mugilids.

On the basis of the above considerations, penaeid culture has possibilities of success in the more southern parts of the Mediterranean, where markets are able to accept a product with high production costs (US$ 4 to 6/kg) but on condition that an economical feed is developed.

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1977

Family: PALAEMONIDAE

Species	Geographical distribution	Size
Palaemon serratus (Pennant) = Leander serratus (Pennant)	Common throughout the Mediterranean with the exception of the Black Sea, where it is rare. Present along the Atlantic coasts from Denmark to Mauritania	Max: 11 cm Common: 8 - 9 cm

1. Distinctive characteristics

1.1 Ecology

Eurythermic and euryhaline, this species lives in shallow coastal waters with rocky bottoms covered by algae, also in meadows of *Zostera* sp. and *Posidonia* sp., and on bottoms of mixed sand and mud. It prefers estuaries and brackish lagoons, which it abandons at the first cold weather.

1.2 Natural diet

It is omnivorous, feeding both on algae and on small crustaceans and also on dead fish.

1.3 Natural reproduction

Along the Atlantic coasts spawning starts at the beginning of winter and reaches a peak in March (Reeve, 1969); Forster (1951) reports that the spawning period is from January to June, according to the size of the animals; Zariquiey (1968) has observed ovigerous females in January, March, May, August and December.

San Feliu et al. (1976) obtained ovigerous females from December-January on.

1.4 Marketing

Marketed fresh. In general, this product does not constitute a steady source of income for fishermen, as the supply is conditioned by local and seasonal factors. It is highly appreciated in Spain and France; in Paris and western France the retail price of live *P. serratus* towards the end of 1977 was US$ 16 - 18/kg (specimens weighing 5 - 6 g); the price is less in other Mediterranean regions. In Italy the retail price fluctuates around US$ 2/kg.

2. Reproduction and rearing

2.1 Induced spawning methods

Practical research into the spawning of this decapod is fairly recent, dating back to about 1960, and was started in the United Kingdom (Forster, 1970; Forster and Beard, 1973), followed by France and Spain.

A summary method of inducing spawning in *P. serratus* consists of collecting the ovigerous females and raising the water temperature to 20 - 22°C to accelerate embryonic development. There is a constant relationship between the weight of the females and the fecundity (Reeve, 1969). An individual weighing 2 g can produce 1 400 eggs, one weighing 10 g, 4 500 eggs. Hatching occurs during the night and at this stage it is important to reduce the effects of the marked cannibalism of the females which devour the newly-hatched larvae.

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1972

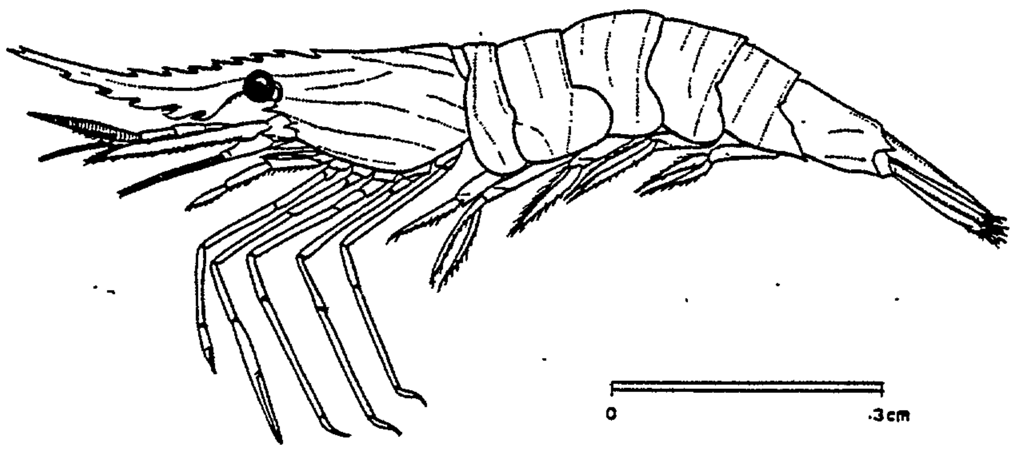
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: PALAEMONIDAE

Fishing Area 37
(Medit. and Black Sea)

Palaemon serratus (Pennant, 1777)

SYNONYMS STILL IN USE: *Leander serratus* (Pennant, 1777)



VERNACULAR NAMES:

FAO - En : Common prawn
Fr : Bouquet
Sp : Camarón común

NATIONAL -

ALBN:		ISRL:	Qapzan	ROMN:	
ALGR:		ITAL:	Gamberello	SPAN:	Quisquilla
BULG:		LEBN:	.	SYRI:	
CYPR:		LIBY:		TUNS:	Gambri sghir
EGYP:		MALT:	Gamblu qsajjar	TURK:	Teke
FRAN:	Bouquet	MONC:	Gambaru russu	USSR:	Krevetka
GREC:	Garidáki	MORC:	Crevette de roche	YUGO:	Kozica obicna

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Carapace smooth, bearing one antennal and one branchiostegal spine. *Rostrum strong, about as long as the rest of the carapace, both of its borders armed with teeth* which are arranged as follows: upper border with 1 small tooth just behind the *rostral tip giving it a bifid appearance*, and, much further back, a series of 6 to 9 more or less regularly spaced teeth of which the last two are post-orbital; lower border with 4 to 6 teeth. First and second pairs of thoracic limbs ending in well-developed pincers. The second pair is clearly stronger than the first. *Background colour transparent greyish-pink with brownish-red longitudinal or oblique lines on the carapace* and with brownish-red dots and transverse lines on the abdomen.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

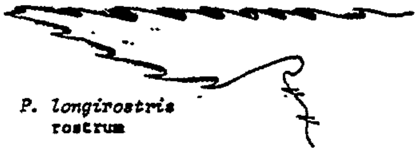
All other species of the genus *Palaemon* known from the Mediterranean do not grow beyond a size of 7 cm (total length) which is smaller than that of *P. serratus*. These species can also be distinguished from *P. serratus* by the following characters:

P. adspersus: rostrum generally with 5 or 6 dorsal teeth (in addition to the subapical tooth) of which only 1 is postorbital; 4 (rarely 3) ventral teeth.

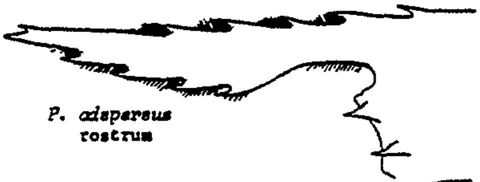
P. longirostris: rostrum with 8 to 10 dorsal teeth, regularly spaced (no larger space behind the subapical tooth); generally 4 ventral teeth.

P. xiphias: rostrum slender, extending well beyond the scaphosclerite; branchiostegal spine located clearly behind the anterior border of the carapace.

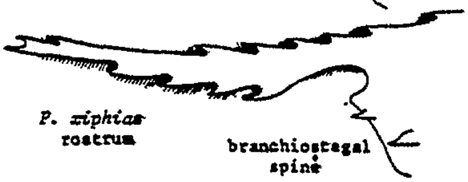
P. elegans: rostrum with 7 to 10 dorsal teeth, of which the last three are postorbitary; 3 or 4 ventral teeth. Fingers of the pincer of the second pair of thoracic limbs equal to one third of the total length of that pincer (in *P. serratus* the fingers represent about two fifths of the length of the palm). Colour close to that of *P. serratus* but the transverse lines on the abdomen are generally not so well marked.



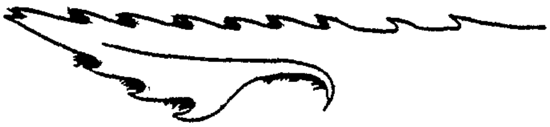
P. longirostris rostrum



P. adspersus rostrum



P. xiphias rostrum



P. elegans rostrum

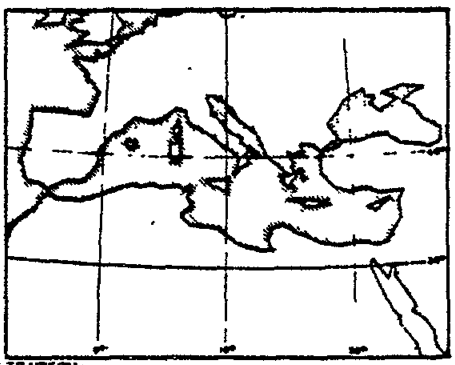
SIZE:

Maximum: 11 cm; common: 8 to 9 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Known throughout the Mediterranean, rare in the Black Sea. Also present in the eastern Atlantic from Denmark to Mauritania.

Inhabits rock bottoms covered with seaweeds, and especially meadows of Zostera and Posidonia (aquatic plants), down to about 10 m depth.



PRESENT FISHING GROUNDS:

Littoral areas and lagoons.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics are not collected for this species within the area. Data for the statistical category "shrimps" are however collected in Algeria, Egypt, France, Greece, Italy (1971: 9 800 tons), Morocco, Spain (1971: 2 200 tons), Tunisia and Turkey. The catch reported by these countries in 1971 for the Mediterranean and the Black Sea totalled 17 500 tons.

Caught with dredges, fyke nets (trabac) and bottom trawls.

Marketed fresh.

San Feliu et al. (1976) usually collected the larvae, which are extremely phototrophic, by means of a light in a corner of the pond and then siphoned them off.

2.2 Incubation

Reeve (1969) reports that incubation lasts 28 days at 20°C, 58 days at 15°C and more than 95 days at 10°C.

According to Phillips (1971), at 12°C 102 days are required for hatching, 55 days at 15°C, 39 days at 18°C, and 21 days at 21°C. The number of larvae hatched is usually lower than the number of eggs carried. According to Reeve (1969), the percentage of loss is greater in young specimens (about 80%) and lower in larger-sized specimens (about 25%).

2.3 Larval rearing

P. serratus goes through one zoeal stage in which the animal feeds on the energy reserves accumulated in the body, four promysis stages in which it is actively zooplanktophagous, three mysis stages in which the contents of the diet do not change but the size of the prey varies, and finally the postlarval stage in which the animal changes from planktonic to benthic and gathers its food from the bottom. While this development requires a fairly long time in nature, at temperatures of a little over 20°C only 15 - 18 days are required.

The larvae are reared in sea water (salinity between 31.5 and 38 ppt). Below 10 ppt total mortality occurs in 12 hours (Reeve, 1969). According to the same author optimum temperature is between 22 and 26°C.

The shape and size of the rearing tank are of secondary importance provided there is good aeration and efficient water circulation.

The diet should preferably consist of animal organisms.

San Feliu et al. (1976) reared P. serratus larvae on the rotifer Brachionus plicatilis, newly-hatched Artemia salina nauplii and a variety of zooplankton from the promysis stage onwards (stages II - III - IV - V); as rearing progressed the rotifers were eliminated and A. salina metanauplii rather than nauplii given; in the mysis stage (phases VI - VII - VIII) the metanauplii were replaced by Artemia adults and gradually by crab eggs and finely chopped mussel meat. At the postlarval stage, mussel and crab meat was mainly given, decreasing the proportion of zooplankton. Skeletonema costatum diatoms were also given throughout the rearing period.

According to the same authors the consumption of A. salina nauplii increases as the larval stage proceeds and the density of the prey increases.

With a density of 1 to 10 A. salina nauplii, the average daily consumption per larva increases from 5.6 to 17.0 in larval stage II, and from 23.0 to 33.8 at stage V.

2.4 Larval density and survival

The information available on this subject is insufficient, since we are still in the experimental stage; larval survival rate varies greatly, as it is directly related to rearing methods and feeding, which have not yet been standardized.

Reeve (1969), using various diets, obtained the best survival rates with A. salina nauplii (43%) and the lowest (5%) with dried Chlorella sp. given in small lumps. According to the same author larval survival is influenced by light, decreasing to 7% in the absence of light and rising to 62% with light. The density of the larvae has a decisive effect on their survival, largely owing to cannibalism.

Reeve (1969) found the mortality rate of isolated larvae was 10%; with a density of 10/1 it was 20%, while a density of 100/1 led to a mortality rate of 35%.

According to Campillo (1975a), the optimum larval density in culture should range from 50 to 100/1. The maximum survival rate obtained by this author was 84.5%.

2.5 Rearing to market size

According to Cole (1958), P. serratus reaches a size of 6.5 - 7 cm in the waters of North Wales in the second season of growth. In order to reach marketable size (10 g) in nature, about 24 months are required, according to Reeve (1969). The same author obtained animals of 5.2 cm in 6.5 months of culture.

In experiments carried out with 800 postlarvae, in a 1 500-1 tank, at a temperature of 20°C, the shrimps barely reached commercial size after 7 months of culture (Campillo, 1975).

L'Herroux (unpublished data) obtained shrimps of 5 g in one year by rearing the larvae at a temperature of 30°C and then transferring them to ponds with temperatures between 12 and 25°C.

3. Prospects for commercial development

On account of the long growing period, the high costs of feeding and the phenomenon of cannibalism, together with the high costs of maintaining and running the plant, industrial production of P. serratus under intensive culture is not economically feasible.

We agree with Campillo (1975), who believes that at the present stage of knowledge culture is possible only if conducted more simply in an extensive form in coastal lagoons during the warmer months.

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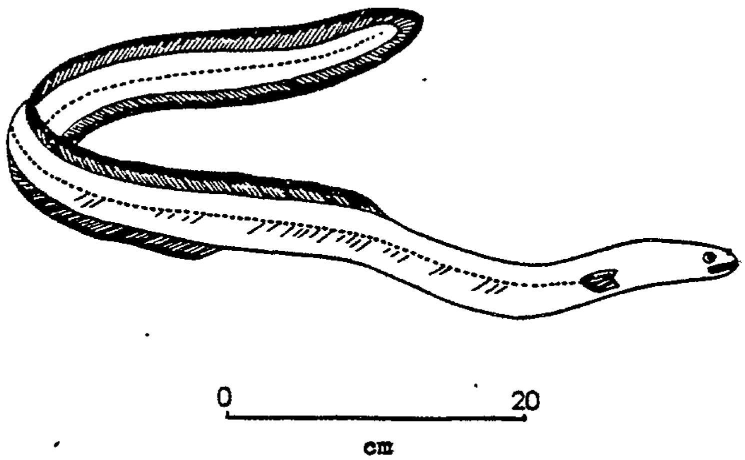
Family: ANGUILLIDAE

Species	Geographical distribution	Size
Anguilla anguilla (Linnaeus)	Common throughout the Mediterranean and in the Atlantic from Iceland to the Equator. Rare in the Black Sea	Max: 100-150 cm Common: 40-55 cm



1. Distinctive characteristics

1.1 Ecology

This is an extremely euryhaline and eurythermic species, and particularly hardy, for which reason it is very suitable for intensive rearing in ponds.

It lives in saline, brackish, fresh, cold and warm waters. It has habits typical of depth-dwelling fish and prefers substrata with mud which it buries into.

1.2 Natural diet

Eels feed on any food of animal origin, but prefer fish, crustaceans, worms and amphibians. The diet varies according to the eel's size. Young eels eat mainly crustaceans, Chironomidae and Odonata (dragonflies) larvae, molluscs and fish; larger ones feed on Chironomidae, Amphipoda, Gasteropoda and Odonata larvae. Eels longer than 55 cm feed exclusively on fish (Ezzat and El-Serafy, 1977).

1.3 Natural reproduction

The reproductive cycle of the eel is not yet well known. Towards the end of autumn, luring heavy storms, the so-called "silver eels" make their way towards the sea. According to the Danish naturalist Schmidt, the European eels migrate to the Atlantic and spawn in the Sargasso Sea at a depth of about 1 000 metres between the end of winter and the middle of summer. The newly-hatched larvae have a foliaceous shape (Leptocephalus) and migrate to the coasts of Europe, which they reach after about two years. Off the coasts they take on the appearance of small transparent ("blind") eels until, at the end of the winter, they reach the entrances to rivers and brackish lakes, when they become coloured and assume the form they retain as adults.

1.4 Marketing

Eels are generally marketed fresh or prepared in various ways (marinated, smoked, etc.). The price varies according to size and season. In Italy the average wholesale price for fresh eel is from US$ 7/kg. In Germany smoked eel is sold wholesale 2.5 to 3 times this price.

2. Reproduction and rearing

2.1 Induced spawning methods

The first attempts to stimulate sexual maturity in eels by using pituitary hormones date back to Boucher, Boucher and Fontaine (1934) and Schreiber (1935, 1935a), which were followed by research work carried out by Bruun, Hemmingsen and Møller-Christensen (1949) and Møller-Christensen, Bruun and Hemmingsen (1958). These experiments were taken up again by Boëtius et al. (1962) and further developed in the following years.

Fontaine et al. (1964) obtained spontaneous release of eggs in European eels (A. anguilla) after injection with carp pituitary extract in doses of 20 mg/kg of body weight.

Boëtius and Boëtius (1967) obtained sexual maturity in male A. anguilla by injecting weekly with 250 I.U. of HCG, keeping the animals in sea water at a temperature of about 14°C. They demonstrated the possibility of obtaining spontaneous emission of sperm by keeping the eels for more than three years at a constant temperature of 14°C.

Lumare and Villani (1973) obtained emission of sperm from A. anguilla males by injecting HCG in doses of 250 I.U. every 16-28 days and keeping the animals in sea water with salinity 3 ppt and temperature 19°C.

Villani and Lumare (1975) obtained mature females which spontaneously released floating eggs following injections with a mixture of HCG, desoxicorticosteronacetate (DOCA) and carp pituitary extract. They also carried out artificial fertilization tests, without success. The use of HCG alone did not give encouraging results.

Ghittino, Glenn and Smith (1975) injected A. rostrata males with HCG in doses of 500 I.U. per fish, obtaining sperm by stripping. They also injected females with HCG, diethylstilbestrol and carp pituitary extract in combined or single doses, obtaining an advanced stage of maturity only in those specimens which had been treated with pituitary extract (the diameter of the immature eggs being 490 to 637 μ); the eels were kept in sea water (salinity 35 ppt and temperature 20-24°C).

Edel (1975) obtained spawning of A. rostrata by weekly injections of 10 mg of carp pituitary body for a maximum period of 1½ months.

Nose (1971) injected A. japonica repeatedly with combined doses of chorionic gonadotropin, diethylstilbestrol, alphatocopherol and trout pituitary extract, obtaining release of floating eggs after about 3 months. Artificial fertilization was not attempted owing to lack of mature males.

Yamamoto, Yamauchi and Morioka (1975) obtained larvae from fertilized eggs released by A. japonica females treated with hormones and kept in sea water at a temperature of 23°C. The larvae survived for about five days.

2.2 Incubation

The A. anguilla eggs obtained by Fontaine et al. (1964) measured between 0.930 and 1.400 mm, those obtained by Villani and Lumare (1975) had, under the best conditions, an average diameter of 1.000 mm and a maximum of 1.066 mm.

The average diameter of the eggs obtained from A. japonica (Nose, 1971) was 1.035 mm, with a maximum of 1.168 mm. Incubation lasted 38-45 hours at a temperature of 23°C in sea water.

2.3 Larval rearing

No data are available on A. anguilla, as no larvae have ever been obtained. The A. japonica larvae measured 2.9 mm on hatching and survived to the 5th day. The largest size attained during that period was 6.2 mm (Yamamoto, Yamauchi and Morioka, 1975).

2.5 Rearing to market size

Two types of rearing can be considered: extensive rearing carried out in fish hatcheries and certain suitably equipped brackish or freshwater ponds, and intensive rearing in ponds made for this purpose.

In the first case "blind" eels 6 cm in length (weight 0.25 g) are caught and put into brackish water at a density of 50/ha; elvers of 15-20 g (about 1 year old) can also be used at a density of 25/ha (Ghittino, 1969). Artificial feeding is not given and market size is reached after 4-7 years.

In intensive rearing very small areas are used in order to allow for close control of the environment. The ponds usually have an area of 2 500 - 10 000 m^2, a depth of 1 - 1.5 m and a stocking density of 2 - 5 kg/m^2; for limited periods and in certain seasons of the year five times this stocking density may be used. In brackish or fresh water ponds the water renewal rate may vary from 50 to 300 l/sec/ha. The optimum temperature ranges from 20 to 22°C. Although eels are very resistant to oxygen shortage, it is a good rule to maintain a fairly high oxygen content. Three mg/l of oxygen is the limit below which the oxygen content should not be allowed to fall. Optimum pH is between 7.5 and 8.5. Intensive rearing is carried out in two main stages: (a) from blind eels (0.25 g) to elvers (15-30 g) and (b) from elvers to market-size animals (150 - 250/800 g).

(a) The first stage is usually carried out in small-sized cement tanks (200 - 1 000 m^2), where strict control is possible. Optimum temperature (20°C) should be maintained, if necessary by means of suitable technical measures, with good water renewal and feeding at the rate of 10% of body weight for artificial feed and 25% if a mixture of artificial and fresh feed is given (Anon., 1974).

(b) The second stage is usually carried out in rectangular ponds of about 2 500 m^2 with a depth of about 1.5 m. These ponds may or may not be supplied with tanks in which the young eels are acclimatized and finally harvested. The eels may reach market size in about one year, fed on normal artificial feed in mash form obtainable on the market and giving a conversion rate between 2 and 2.5.

Studies of the possibility of rearing eels in thermal effluents are being undertaken. Experiments carried out in France (Descamps, Foulquier and Grauby, 1977) have shown the feasibility of this aspect of eel culture. Specimens with initial weight of 30 g reared under such conditions for 18 months weighed 210 g at the end of the period whereas the control group kept in unheated water weighed 90 g.

Attempts are being made to use thermal effluents from the iron and steel industry, through heat exchangers, to rear eels from the blind stage to elvers.

3. Prospects for commercial development

Intensive eel culture is greatly expanding owing to the ever increasing demand for this commodity especially on Northern European markets.

The only limiting factor to a possible excessive development in the future could be a scarcity of elvers, the supply of which is at the present time sufficient for market requirements. It should be remembered that Japan imports *Anguilla* sp. elvers from all over the world in order to maintain a production of over 24 000 tons (Usui, 1974); this activity is still expanding.

However, eel culture is expected to expand in Europe where, among other factors, extensive rearing systems are being converted to intensive rearing.

Therefore it is possible that in the near future the demand for *Anguilla* elvers may exceed supplies. In view of this, although there may be difficulties of a biological and technico-scientific as well as economic nature, research on induced spawning and rearing of *A. anguilla* larvae should be intensified in order to overcome a serious obstacle to the development of eel culture in future years.

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Family: MUGILIDAE

Species	Geographical distribution	Size
Mugil cephalus (Linnaeus)	Found in all oceans and very common in the Mediterranean	Max: 120 cm Common: 40 cm
Mugil capito (Cuvier) - Liza ramada (Risso)	Mediterranean, Black Sea, Atlantic from Morocco to Scandinavia	Max: 60 cm Common: 30 cm
Mugil auratus (Risso) - Liza aurata (Risso)	Mediterranean, Black Sea, Atlantic from Senegal to Scandinavia	Max: 45 cm Common: 25 cm
Mugil saliens (Risso) - Liza saliens (Risso)	Mediterranean, Black Sea, Atlantic from Morocco to Bay of Biscay	Max: 40 cm Common: 20 cm
Mugil chelo (Cuvier) - Crenimugil labrosus (Risso) - Lisa provensalis (Risso)	Mediterranean, Black Sea, Atlantic from Morocco to Iceland	Max: 60 cm Common: 25 cm

1. Distinctive characteristics

1.1 Ecology

Mugilids are distinctly eurythermic and euryhaline and live in coastal waters. They adapt to both extremely saline and brackish waters and also fresh water and frequent even polluted waters such as those around ports. They are therefore particularly suitable for culture in artificial ponds.

1.2 Natural diet

The young fish feed mainly on small invertebrates; the adults are mostly limnivorous (Albertini-Berhaut, 1974).

According to Erman (1959), diatoms and filamentous algae are of great importance in the diet of M. cephalus along the coasts of Turkey. Other, though less important, ingredients are small crustaceans, foraminifera, molluscs and especially organic and inorganic detritus, which is always present in the stomachs in large quantities.

1.3 Natural reproduction

Along the Italian coasts the reproductive period of M. cephalus is from August to October. Along the coasts of Israel spawning occurs from the end of September to November, when the fish is 2 - 3 years old. Along the same coasts M. capito spawns in December and sexual maturity is reached before the fish is even one year old (Abraham, 1963).

MUGIL Mugil 1

1971

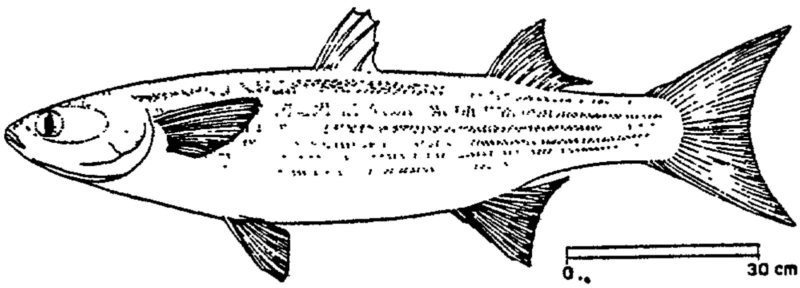
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: MUGILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mugil cephalus Linnaeus, 1758

SYNONYMS STILL IN USE: None



VERNACULAR NAMES:

FAO - En : Flathead grey mullet
Fr : Muge cabot
Sp : Pardete

NATIONAL - ALBN:
ALGR:
BULG: Kefal
CYPR: Kephalos
EGYP: Bouri
FRAN: Muge cabot
GREC: Képhalos
ISRL: Kifon gedol harosh
ITAL: Cefalo
LEBN: Bouri ram
LIBY: Bouri
MALT: Mulett tal-iswed
MONC: Mïsaru
MORC: Bouchakfa
ROMN: Laban
SPAN: Pardete
SYRI:
TUNS: Bouri
TURK: Haskefal
USSR: Loban
YUGO: Cipal batas

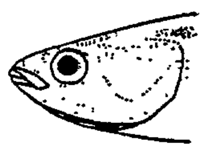
DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Body elongate, slightly compressed from side to side; head short and flattened with a broad terminal mouth; teeth very small, hardly visible; *upper lip thin (its greatest depth less than half the eye diameter) and smooth (without tubercules); a thick adipose lid covers most of the eye; two dorsal fins, the first short, with 4 slender spines; anal fin usually with 8 soft rays;* back bluish-grey; belly silvery, often with grey lengthwise stripes.

Other field characters: scales large and adherent; no external lateral line; a gizzard-like stomach with thick walls.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Other Mediterranean and Black Sea mugilids differ from *M. cephalus* by the absence of a thick adipose lid over part of the eye and by a higher number of anal rays (9 to 11).

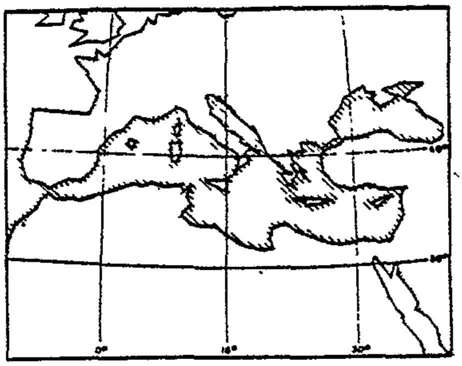


Mugil sp.

SIZE:

Maximum: 120 cm; common: 30 to 50 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:



Cosmopolitan species inhabiting the warm belt of the Atlantic, Indian and Pacific Oceans and adjacent seas; very common in coastal waters of the Mediterranean and the Black Sea, including the Azov Sea; in the eastern Atlantic it occurs as far north as the Bay of Biscay.

Schools of *M. cephalus* occur mostly in shallow waters especially in coastal lagoons of varying salinity; a fast swimmer, leaping out of the water when disturbed; enters estuaries and rivers for feeding but spawning takes place in the sea only; juveniles often concentrate near the outflow of freshwater streams. In some countries fry of *M. cephalus* is brought into fresh- or brackish-water ponds and reservoirs for culture purposes, generally together with other fish. Promising results were recently obtained with induced spawning in confinement.

Feeds on minute bottom-living organisms or on algae floating near the surface; also on organic matter contained in mud and sand.

PRESENT FISHING GROUNDS:

Shallow coastal waters including hypersaline lagoons, lower arms of rivers and brackish water lakes and reservoirs.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

All mugilid species are included in a single statistical category. Countries reporting on this category are: Algeria, Egypt, France, Greece, Israel, Italy (1970: 6 900 tons), Libya (1969: 2 500 tons), Malta, Romania, Spain, Turkey (1969: 3 700 tons), USSR and Yugoslavia, the catches in the area reported for 1970 totalling 17 000 tons.

Caught with gill nets, trammel nets, beach seines, cast nets, handlines and occasionally with purse seines.

Marketed fresh, frozen or salted; the roe is often marketed as a salted caviar-like product.

MUGIL Mugil 3
1971

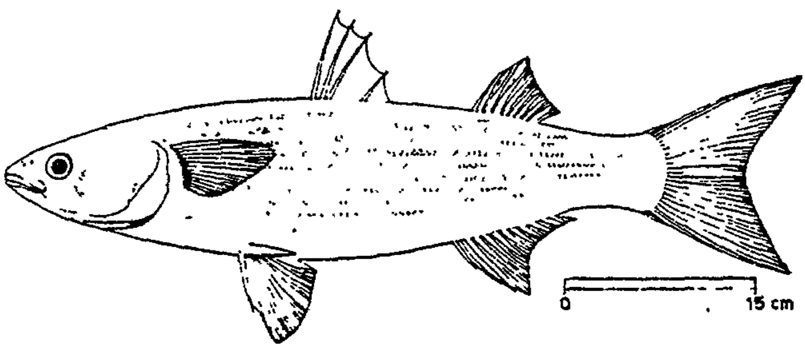
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: MUGILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mugil capito Cuvier, 1829

SYNONYMS STILL IN USE: *Liza ramada* (Risso, 1826)

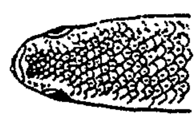


VERNACULAR NAMES:

FAO - En : Thinlip grey mullet
Fr : Muge porc
Sp : Morragute

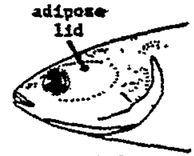
NATIONAL - ALBN:		ISRL:	Kifon matzui	ROMN:	
ALGR:		ITAL:	Cefalo calamita	SPAN:	Morragute
BULG:		LEBN:	Bouri dahban	SYRI:	
CYPR:	Kephalos	LIBY:		TUNS:	Bitoum
EGYP:	Tobar	MALT:	Mulett tal-incarrat	TURK:	Pulatarina
FRAN:	Mulet porc	MONC:	Misaru	USSR:	
GREC:	Mavraki	MORC:	Mulet	YUGO:	Cipal balavac

DISTINCTIVE CHARACTERS AND DIAGNOSIS:



Body elongate, slightly compressed from side to side; head short and flattened with a broad terminal mouth; teeth very small, hardly visible; *upper lip thin (its greatest depth less than half the eye diameter) and smooth (without tubercles);* anal fin usually with 9 soft rays; *scales on the top of the head extending forward to the anterior nostrils, (almost to the upper lip); eye is not covered by a thick adipose lid;* colour of the back bluish-grey, belly silvery, often with grey lengthwise stripes.

Other field characters: two dorsal fins, the first short with 4 slender spines; scales large and adherent; no external lateral line; pectoral fin short; when folded forward its extreme tip at most reaches the rear edge of the orbit; a gizzard-like stomach with thick walls.



M. cephalus

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

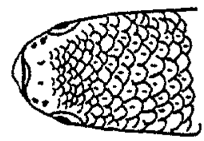
Mugil cephalus differs from *M. capito* by the presence of a distinct adipose lid around the eye, and of usually 8 rays in the anal fin.

M. saliens: differs from *M. capito* by its more slender body, by having 2 to 3 grooves (instead of 1) on the scales of the top of the head and the back (in small fish this is visible only under a magnifying glass); also by a comparatively long pectoral fin (when folded forward its extreme tip reaches well past the rear edge of the orbit).

scales (schematic)

M. saliens.

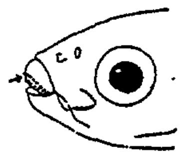
M. auratus differs from *M. capito* by the scales on the top of the head not extending forward beyond the level of the posterior nostrils; also by a comparatively long pectoral fin; (when folded forward, its extreme tip reaches well beyond the rear edge of the orbit).



M. auratus

M. chelo: differs from *M. capito* by the presence of small tubercules on the upper lip.

M. labeo: differs from *M. capito* by its thick upper lip (its depth greater than half of the eye diameter) and by the high number of rays (11) in the anal fin.



M. chelo

SIZE:

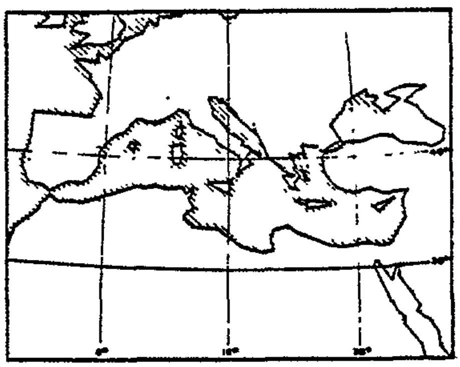
Maximum: 60 cm; common: 20 to 40 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Common throughout the Mediterranean and along the northwestern coast of the Black Sea; also occurs in the eastern Atlantic, from southern Norway to Natal (South Africa).

Schools of *M. capito* occur mostly in shallow water, especially in brackish and coastal lagoons of varying salinity; a fast swimmer, leaping out of the water when disturbed; enters estuaries and rivers for feeding but spawns in the sea; juveniles often concentrate in the vicinity of freshwater outflows.

Feeds on minute bottom-living or planktonic organisms; also on suspended organic matter.



PRESENT FISHING GROUNDS:

Shallow coastal waters, including lagoons, lower arms of rivers, brackish water lakes and reservoirs.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

All mugilid species are included in a single statistical category. Countries reporting on this category are: Algeria, Egypt, France, Greece, Israel, Italy (1970: 6 900 tons), Libya (1969: 2 500 tons), Malta, Romania, Spain, Turkey (1969: 3 700 tons), USSR and Yugoslavia, the catches in the area reported for 1970 totalling 17 000 tons.

Caught mainly with gill nets, trammel nets, beach seines, cast nets and occasionally with purse seines.

Marketed fresh, frozen and salted.

MUGIL Mugil 5
1971

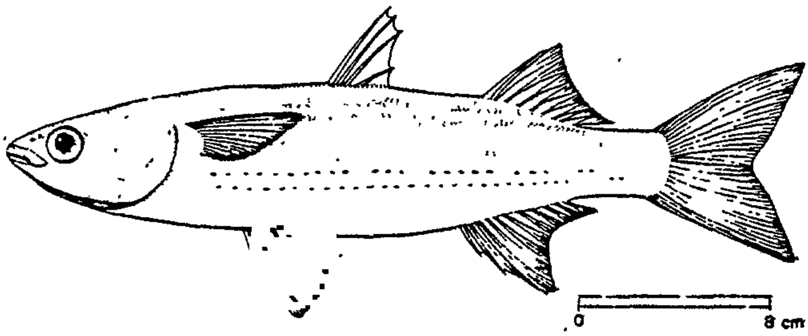
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: MUGILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mugil auratus Risso, 1810

SYNONYMS STILL IN USE: *Lisa aurata* (Risso, 1810)



VERNACULAR NAMES:

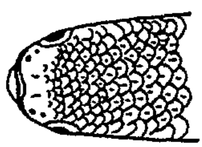
FAO - En : Golden grey mullet
Fr : Muge doré
Sp : Galupe

NATIONAL -

ALBN:		ISRL:	Kifon happaz	ROMN:	Singhil
ALGR:		ITAL:	Cefalo dorato	SPAN:	Galupe
BULG:	Platerina	LEBN:	Bouri chilau	SYRI:	
CYPR:	Kephalos	LIBY:	Mulett tal-misluta	TUNS:	Saffraya
EGYP:	Halili	MALT:		TURK:	Altinbas kefal
FRAN:	Mulet doré	MONC:		USSR:	Singil
GREC:	Mixinári	MORC:	Mulet	YUGO:	Cipal zlatac

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

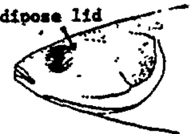
Body slender and elongate, slightly compressed from side to side; head short and flattened with a broad, terminal mouth; *teeth small but clearly visible ; upper lip thin, (its greatest depth less than half the eye diameter) and smooth (without tubercles); anal fins usually with 9 soft rays; scales on the top of the head not extending beyond the level of the posterior nostrils; each scale is provided with one groove; eye not covered by a thick adipose lid;* colour of the back bluish grey, belly silvery, often with grey lengthwise stripes; *a golden blotch on the gill cover.*



Other field characters: two dorsal fins, the first short with 4 slender spines; scales large and adherent; no external lateral line; pectoral fin comparatively long (when folded forward its extreme tip reaches well beyond the rear edge of the orbit); a gizzard-like stomach with thick walls.

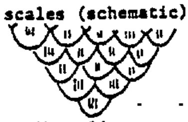
DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Mugil cephalus differs from *M. auratus* by the presence of a distinct adipose lid around the eye and usually 8 rays in the anal fin.

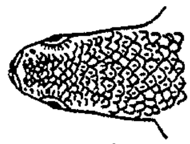


M. cephalus

scales (schematic)



M. saliens



M. capito

M. chelo

M. labeo

M. saliens differs from *M. auratus* by having 2 to 3 grooves (instead of 1) on the scales of the top of the head and the back (in small fishes this is visible only under a magnifying glass).

M. capito differs from *M. auratus* by the scales on the top of the head extending to the level of the anterior nostrils (almost to the upper lip), by the comparatively short pectoral fin (when folded forward, its extreme tip at most reaches the rear edge of the orbit) and by the absence of a golden blotch on the gill cover.

M. chelo differs from *M. auratus* by the presence of small tubercles on the upper lip.

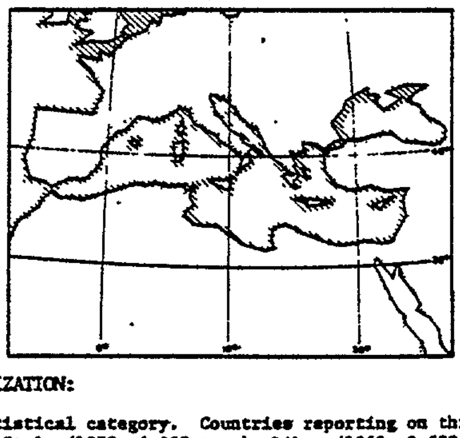
M. labeo differs from *M. auratus* by having a thick upper lip (its depth greater than half the eye diameter) and by the high number of rays (11) in the anal fin.

SIZE:

Maximum: 50 cm; common: 15 to 40 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Common throughout the Mediterranean and the Black Sea; introduced also into the Caspian Sea; in the eastern Atlantic it occurs from Scotland and southern Norway to Natal (South Africa).



Schools of *M. auratus* occur mostly in shallow water, especially in coastal lagoons of varying salinity; a fast swimmer, leaping out of the water when disturbed; enters rivers and estuaries for feeding, but spawns in the sea; juveniles often concentrate in the vicinity of freshwater outflows.

Feeds on minute bottom-living and planktonic organisms.

PRESENT FISHING GROUNDS:

Shallow coastal waters, including lagoons, lower arms of rivers and brackish water lakes and reservoirs.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

All mugilid species are included in a single statistical category. Countries reporting on this category are: Algeria, Egypt, France, Greece, Israel, Italy (1970: 6 900 tons), Libya (1969: 2 500 tons), Malta, Romania, Spain, Turkey (1969: 3 700 tons), USSR and Yugoslavia, the catches in the area reported for 1970 totalling 17 000 tons. It is estimated that *M. auratus* makes up about 80 per cent of the mugilid catches in the Black and Azov Seas.

Caught with gill nets, trammel nets, beach seines, cast nets and occasionally with purse seines and handlines.

Marketed fresh, frozen and salted.

MUGIL Mugil 4

1971

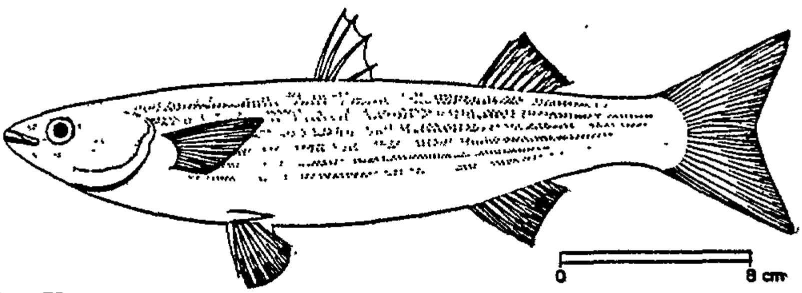
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: MUGILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mugil saliens Risso, 1810

SYNONYMS STILL IN USE: *Liza saliens* (Risso, 1810)



VERNACULAR NAMES:

FAO – En : Leaping grey mullet
Fr : Muge sauteur
Sp : Galúa

NATIONAL –

ALBN:		ISRL:	Kifon harur	ROMN:	Ostreinos
ALGR:		ITAL:	Cefalo verzelata	SPAN:	Galúa
BULG:	Ilarija	LEBN:	Bouri toubaraii	SYRI:	
CYPR:	Kephalos	LIBY:		TUNS:	Karshou
EGYP:	Garan	MALT:	Mulett buri	TURK:	Kefal
FRAN:	Mulet sauteur	MONC:	Müsaru	USSR:	Ostronos
GREC:	Gástros	MORC:	Mulet	YUGO:	Cipal skocac

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

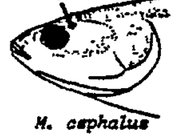
Body slender and elongate, slightly compressed from side to side; head short and flattened, with a broad terminal mouth; *eye not covered by an adipose lid;* teeth very small, hardly visible; *scales on the top of head and back with 2 or 3 grooves* (in small fish these are visible only under a magnifying glass); *upper lip thin* (its greatest depth less than half the eye diameter) *and smooth* (without tubercles); anal fin usually with 9 soft rays; colour of the back bluish-grey, belly silvery, often with grey lengthwise stripes.

scales
(schematic)

Other field characters: 2 dorsal fins, the first short, with 4 slender spines; scales large and adherent; no external lateral line; pectoral fin comparatively long (when folded forward, its extreme tip reaches well beyond the rear edge of the orbit); a gizzard-like stomach with thick walls.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Mugil cephalus differs from *M. saliens* by the presence of a distinct adipose lid around the eye and of usually 8 rays in the anal fin.



M. cephalus

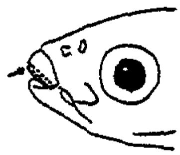
M. capito and *M. auratus* differ from *M. saliens* by having 1 groove only (instead of 2 to 3) on the scales of the top of the head and the back (in small fishes this is visible only under a magnifying glass); *M. capito* also differs by a shorter pectoral fin (when folded forward, its extreme tip does not reach the rear edge of the orbit).

scales (schematic)

M. capito
M. auratus

M. chelo differs from *M. saliens* by the presence of small tubercles on the upper lip.

M. labeo differs from *M. saliens* by a thick upper lip (its depth greater than half the eye diameter) and by the high number (11) of rays in the anal fin.



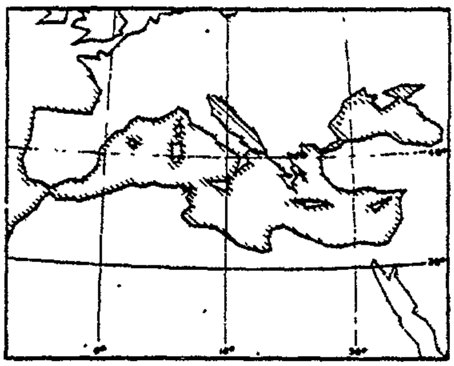
M. chelo

SIZE:

Maximum: 40 cm; common: 15 to 30 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Common throughout the Mediterranean and the Black and Azov Seas; also occurs in the eastern Atlantic from the Bay of Biscay to South Africa.



Schools of *M. saliens* occur mostly in shallow waters, often in brackish and coastal lagoons of varying salinity; a fast swimmer, leaping out of the water when disturbed; enters rivers and estuaries for feeding but spawning takes place in the sea.

Feeds on minute bottom-living and plankton organisms and suspended organic matter.

PRESENT FISHING GROUNDS:

Shallow coastal waters including lagoons, lower arms of rivers, brackish water lakes and reservoirs.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

All mugilid species are included in a single statistical category. Countries reporting on this category are: Algeria, Egypt, France, Greece, Israel, Italy (1970: 6 900 tons), Libya (1969: 2 500 tons), Malta, Romania, Spain, Turkey (1969: 3 700 tons), USSR and Yugoslavia, the catches in the area reported for 1970 totalling 17 000 tons.

Caught with gill nets, trammel nets, beach seines, cast nets and hand lines; occasionally also with purse seines.

Marketed fresh, frozen and salted.

MUGIL Mugil 2
1971

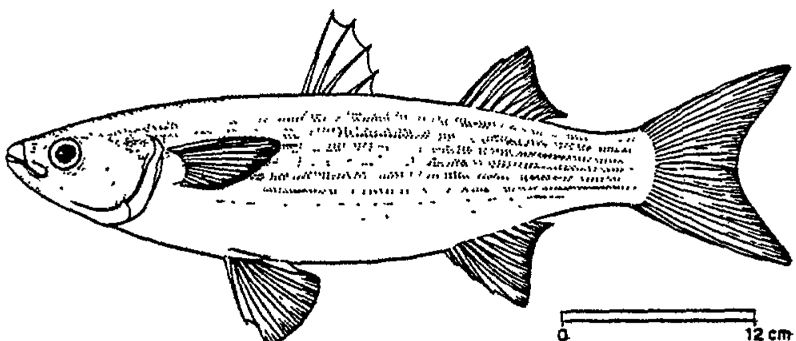
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: MUGILIDAE

Fishing Area 37
(Medit. and Black Sea)

Mugil chelo Cuvier, 1829

SYNONYMS STILL IN USE: *Crenimugil labrosus* (Risso, 1826)
Liza provensalis (Risso, 1826)



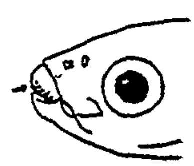
VERNACULAR NAMES:

FAO - En : Thicklip grey mullet
Fr : Muge à grosses lèvres
Sp : Lisa

NATIONAL - ALBN:		ISRL:	Kifon belut hassafa	ROMN:	
ALGR:		ITAL:	Cefalo bosega	SPAN:	Lisa
BULG:		LEBN:	Bouri sailoun	SYRI:	
CYPR:	Kephalos	LIBY:	Bouri	TUNS:	Kahlayoun
EGYP:	Gabayesh	MALT:	Kaplat	TURK:	Kefal
FRAN:	Mulet à grosses lèvres	MONC:	Müsaru	USSR:	
GREC:	Velanitsa	MORC:	Mulet	YUGO:	Cipal putnik

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Body elongate, slightly compressed from side to side, head short and flattened with a broad terminal mouth; teeth very small, hardly visible; *upper lip thick* (its greatest depth more than half the eye diameter); *on the lower edge of the lip, a series (2 to 5 rows) of small tubercules;* anal fin usually with 9 soft rays; *the eye is not covered by an adipose lid;* colour of the back bluish-grey; belly silvery, often with grey lengthwise stripes.



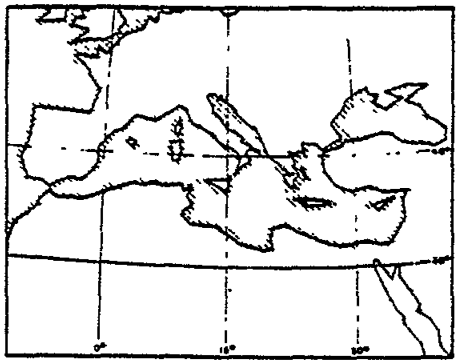
Other field characters: two dorsal fins, the first short with 4 slender spines; scales large and adherent; no external lateral line; a gizzard-like stomach with thick walls.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Other Mediterranean mugilids differ from *M. chelo* by the absence of tubercules on the upper lip.

SIZE:

Maximum: 60 cm; common: 20 to 40 cm.



GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Common throughout the Mediterranean and the Black Sea; also occurs in the eastern Atlantic from Scotland and Norway to Morocco.

Schools of *M. chelo* occur mostly in shallow waters, often in brackish and coastal lagoons of varying salinity; a fast swimmer, leaping out of the water when disturbed; enters rivers and estuaries for feeding but spawning takes place in the sea.

Feeds on minute bottom-living and planktonic organisms.

PRESENT FISHING GROUNDS:

Shallow coastal waters, brackish lagoons and reservoirs.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

All mugilid species are included in a single statistical category. Countries reporting on this category are: Algeria, Egypt, France, Greece, Israel, Italy (1970: 6 900 tons), Libya (1969: 2 500 tons), Malta, Romania, Spain, Turkey (1969: 3 700 tons), USSR and Yugoslavia, the catches in the area reported for 1970 totalling 17 000 tons.

Caught with gill nets, trammel nets, beach seines, cast nets and occasionally with purse seines and handlines.

Marketed fresh, frozen or salted.

According to Erman (1959), M. cephalus spawns along the Turkish coasts from May to October and reaches sexual maturity in its fifth summer.

According to Slastenenko (quoted by Erman, 1959), sexual maturity is reached in the Black Sea between the 6th and 7th year for males and between the 7th and 8th year for females.

The spawning season for M. saliens in the Venetian lagoon is from the end of May to August, with maximum intensity in July (Gandolfi and Orsini, 1970). The same is true for the Dalmatian coast, Tunisian waters, (Heldt, 1948) and the eastern Mediterranean (Abraham, Blanc and Yashouv, 1966).

Following is a summary of the spawning seasons of the various mugilid species:

(a)	Italian coasts:	M. capito	spawns during the winter months, up to January;
		M. auratus	is already mature at one year and spawns from the end of September to the beginning of November
		M. saliens	spawns in May and the migration of the fry into brackish lagoons and pools lasts from June to October
		M. chelo	spawns from January to April
(b)	Israeli coasts:	M. saliens	spawns during the first summer months
		M. auratus and M. capito	spawns from the same period until the end of November
		M. chelo	spawns last during the winter months
		M. cephalus	spawns from mid summer to the end of November

1.4 Marketing

Marketed fresh. Mullets are particularly appreciated in southern Mediterranean countries, less in the northern ones. The roe are also marketed, after being coated with wax and dried on grids. In Turkey this product costs US$ 20/kg.

In Italy the retail price of large-sized mullets fluctuates from US$ 2 to 4/kg, while medium and small-sized specimens cost less than half.

2. Reproduction and rearing

2.1 Induced spawning methods

The first successes in induced spawning date back to the experiments carried out by Tang (1964) on M. cephalus, followed by those of Abraham, Yashouv and Blanc (1967) on M. capito, and those of Yashouv (1969) and Liao (1969) with M. cephalus.

Yashouv (1969) used genitors obtained from freshwater ponds which were transferred to tanks (1.65 x 1.25 m) supplied with running sea water and fresh water. The salinity was increased gradually and in 12 to 24 hours it was raised to 100% sea water. The first injection of carp pituitary extract (5.5 mg/kg of body weight) was given while the fish were being acclimatized to sea water, the second followed 7 hours later and the third 14 hours later. In some cases the pituitary extract was combined with another hormone such as luteinic hormone (LH). In general the females were given three injections at fixed intervals; for the males a single injection of about 1.5 mg of hormone/kg of body weight was sufficient.

Yashouv et al. (1969), using the same methodology, also obtained hybrid larvae from an M. cephalus female and an M. capito male. Shehadeh and Ellis (1972) and Shehadeh and Kuo (1972) experimented with M. cephalus administering intraperitoneal injections of mullet and salmon pituitary extract combined with ACTH (adrenocorticotrophic hormone). The genitors were kept in aquaria of about 225 litres' capacity with running water, salinity 32 ppt, temperature 26°C and pH 7.60. Injections were given three times a week on alternate days. The total dosage varied between 11 900 and 20 900 mg/kg of body weight. The latency period varied between 10 and 15 hours. Fecundity was estimated at about 648 ± 62 eggs/g of body weight.

Lumare and Villani (1972) used carp pituitary extract and HCG, in combination or alone, on animals acclimatized to sea water (salinity 35 ppt) at a temperature of 23°C, administering three, and occasionally four, injections. Dry fertilization was usually carried out about 40 hours after the first injection.

Liao (1975) induced ovulation by injecting mixtures of hypophyseal extract and synahorin (2 - 3 glands and 20 - 30 rat-units) obtaining results 30 - 60 hours after the injection.

Alessio, Gandolfi and Schreiber (1976) acclimatized the genitors in aquaria of various sizes (200 to 8 000 litres) with salinity ranging from 30 to 38 ppt and running water renewed at a rate of 4 to 30 l/m. The temperature was about the same as in the open air (15 - 18°C). They used carp pituitary extract in doses of 10 to 30 mg and 500 to 5 000 I.U. of HCG/kg of body weight; three consecutive injections were generally given at the base of the first dorsal fin. The males were usually not injected as they were already fully mature, but if they were not, small doses of hormones were administered (from 5 to 10 mg of pituitary extract and 500 I.U. of HCG).

Artificial spawning was effected using the dry method and stripping 2 to 3 females. The same treatment was then given to the males and the sperm and the eggs gently mixed. After being washed the floating eggs were transferred into incubators.

Kuo and Nash (1975) induced sexual maturity in M. cephalus outside the natural cycle, obtaining the best results with photoperiods (6 hours of light and 18 of darkness) at a constant temperature of around 21°C. They used salmon gonadotropin (SG-G100), considered to be the most effective hormone, in varying doses depending on the stage of gonadal maturity.

Kuo, Shehadeh and Nash (1973) induced maturity in M. cephalus by injecting HCG in doses ranging from 20 000 I.U./kg to about 40 000 I.U./kg of body weight.

2.2 Incubation

The average size of the eggs is 910 μ, varying between 880 and 980 μ. They are planktonic and have a single oil globule of about 330 μ.

Incubation is carried out in tanks using nets and other devices to prevent the eggs being carried away by the flow of water.

Yashouv (1969) obtained prelarvae after 40-44 hours of incubation at 22 - 23°C. Alessio, Gandolfi and Schreiber (1976) obtained prelarvae 36 hours after fertilization at a temperature ranging from 22 to 27°C.

Liao (1975) obtained hatching 59 - 65 hours after fertilization at a temperature ranging from 21 to 24°C and salinity from 32.4 to 32.9 ppt.

Kuo and Shehadeh (1972) incubated eggs in stagnant or circulating sea water of 32 ppt salinity in tanks of 140 to 3 000 litres at temperatures varying from 22 to 24°C.

Optimum conditions for the incubation of M. cephalus eggs are obtained with salinity ranging from 30 to 32 ppt and temperature from 19.5 to 20.5°C. In addition, the oxygen content should be more than 5.0 ppm (Sylvester, Nash and Emberson, 1975).

2.3 Larval rearing

Existing methods used in rearing mullet larvae are substantially the same, the main difference being in the type of feeding and holding tanks. These aspects have been analysed by Nash and Kuo (1975).

Kuo and Shehadeh (1972) carried out various feeding tests with *M. cephalus* larvae giving them, over a period of 15 days, zooplankton collected in the sea, *Artemia* nauplii and *Gymnodinium*. The zooplankton were accepted from the 5th to the 15th day and *Artemia* nauplii from the 9th day onwards; the *Gymnodinium* were not accepted at any time during the experiment.

Kuo, Shehadeh and Milisen (1973) used oyster and sea-urchin veligers, followed by *Artemia* nauplii and metanauplii, as live feed for *M. cephalus* larvae.

Nash, Kuo and McConnel (1974) fed *M. cephalus* larvae on phytoplankton such as *Gymnodinium*, *Chlorella*, *Dunaliella* and *Isochrysis*. However, best results were obtained by feeding larvae on rotifers (*Brachionus* spp.) and *Isochrysis* during the first growing stages, and on *Artemia* nauplii from the seventh day onward.

Sylvester, Nash and Emberson (1975) obtained maximum larval survival with a salinity of between 26 and 28 ppt and an oxygen content above 5.4 ppm.

2.4 Larval density and survival

Not many data are available on larval rearing density. Nash, Kuo and McConnel (1974) used a density of eggs and larvae of about 250/l, while Liao *et al.* (1972) used less than 50/l.

The best survival rate has been obtained with a density of 12 larvae/l, a salinity of 32 ppt, 24-hour illumination and static water conditions (Kuo and Tanaka, 1973).

Mass production of mugilid postlarvae has not yet been achieved. Kuo and Shehadeh (1972) obtained survival rates of between 0.2 and 5%. Liao (1975) obtained 22 000 juveniles in 1972-73, with survival rates of up to 19%. Higher rates of up to 25% have been achieved in tests with small numbers kept under strict control.

Owing to the high mortality rate, it is not possible to obtain a sufficient number of 42-day-old larvae for industrial-scale production of mullet juveniles to be undertaken.

2.5 Rearing to market size

There is considerable interest in mullet culture, especially in the southern Mediterranean countries.

In Israel, in particular, mugilids are reared in freshwater ponds, both in polyculture (density 5 000 /ha with *M. cephalus*, *M. capito*, *Tilapia aurea*, *Cyprinus carpio*) and in monoculture. The ponds (0.10 ha) are fertilized twice a week with ammonium sulphate (60 kg/ha) and once a week with chicken manure (150 kg per pond). *M. cephalus* fingerlings weighing 20 g attain 760 g in 215 - 225 days; fingerlings of 30 g attain 810 g after 197 days of rearing (Yashouv, 1972).

Pruginin, Shilo and Mires (1975) report that *M. cephalus* grows in ponds better than *M. capito*; the former attains a weight of more than 500 g in 10 months, and the latter 100 - 150 g in the same time. The density of fingerlings in rearing ponds is about 30 000/ha, often with a small number of carps; in growing ponds it varies between 700 and 1 200/ha. A loss of 20% is considered normal.

In polyculture mugilids are associated with carps (800 - 3 000 carps/ha), with Tilapia (1 000 - 4 000/ha) and recently also with silver carp (Hypophthalmichthys molitrix 500 - 1 000/ha). Ponds used for polyculture of M. cephalus, M. capito, Tilapia and carp, at stocking rates from 18 000 to 26 500/ha and fed with artificial feed, yield an average of 3 500 - 9 000 kg/ha.

There is also a trend towards a two-year rearing period in which the mullets reach a weight of 1 kg or more.

Attempts are also being made in Israel to adapt to fresh water both M. auratus (Chervinski, 1975), and M. chelo and M. saliens (Chervinski, 1977).

Rearing trials conducted in sea water with M. auratus gave poor results (Chervinski, 1976).

Acclimatization of M. saliens has been successfully carried out in Lake Quarun (Egypt) (salinity 19.0 - 29.4 ppt) where this mugilid spawns spontaneously (El-Zarka, 1963).

Tests have also been conducted on the possibility of culturing M. cephalus in thermal effluents. During two years of tests the survival rate varied from 50 to 85% and the yield from 293 to 804 kg/ha, with a food conversion rate of 2.2 to 3.3 with artificial feed (Linder, Strawn and Luebke, 1975).

In Italy the culture of grey mullet is widely practised in "valliculture" and emphasis is being placed on intensive rearing of fry in tanks for an initial period of one to two years and then extensive culture (Ravagnan, 1977).

Research on the spawning of M. capito has also been started in Tunisia, where an attempt has been made to adapt mugilids to progressively lower levels of salinity, down to fresh water. Experimental research has made it possible to produce 1 012 kg/ha of mullet in monoculture in little more than 15 months. In polyculture with carp the yield has been estimated at around 2 000 kg/ha/year (Anon., 1975). In Cyprus research work has been undertaken on mullet culture (M. cephalus, M. capito, M. auratus, M. chelo and M. saliens) on a semi-intensive scale in fertilized ponds where salinity varies from 25 to 60 ppt and temperature from 11 to 32°C (Anon., 1976).

3. Prospects for commercial development

Due to the unsatisfactory results obtained from induced spawning, the intensive culture of mugilids through control of their life cycle is not anticipated in the immediate future.

The Mediterranean basin still constitutes a satisfactory reserve for the supply of fry, but with all the disadvantages of uncertainty.

On the basis of these data, future prospects are for the development of semi-intensive culture (modern valliculture) or even polyculture (particularly in fresh water). There are also interesting possibilities for a culture method consisting of an initial intensive phase to rear the young mugilids up to the first year and a second semi-intensive or extensive phase for larger-size animals.

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Family: SERRANIDAE

Species	Geographical distribution	Size
Dicentrachus labrax (Linnaeus)	Common throughout the Mediterranean and in the eastern Atlantic from England to Senegal	Max: more than 100 cm Common: about 45 cm

1. Distinctive characteristics

1.1 Ecology

The sea bass is eurythermic and very euryhaline and can therefore adapt to fresh water. However, it prefers estuarine and brackish waters to which it penetrates in spring. During the spawning period it returns to the sea. It always frequents coastal waters, venturing into extremely shallow waters even as adult.

1.2 Natural diet

This species is extremely voracious. It feeds on small fish, crustaceans and cephalopods. In brackish water it may show a marked preference for the common shrimp, Crangon crangon, and amphipods of the genus Gammarus sp. Among the pelagic fish it feeds on Sardina pilchardus and Sprattus sprattus (Barnabé, 1976).

1.3 Natural reproduction

In D. labrax the sexes are separate. In the Mediterranean spawning usually takes place from the end of October to the beginning of March, with maximum sexual activity about January. Females cannot reach full sexual maturity unless salinity exceeds 10 ppt (Colombo, Colombo Belvedere and Arcarese, in press).

1.4 Marketing

Marketed fresh. It is one of the most esteemed species on the market, for which reason it is much in demand and fetches very high prices. (In Italy, from US$ 7 to 14/kg, retail price). The gradual decrease in number of fingerlings along the coasts and the reduced penetration of the fry into brackish pools on the one hand, and the need to increase the supply of this species through extensive and intensive culture on the other, have led to many studies on controlled spawning and larval rearing.

2. Reproduction and rearing

2.1 Induced spawning methods

The first reproduction trial with D. labrax is undoubtedly that of Dr. Bini who, on the Lake of Orbetello, Italy, in 1965, obtained fertile eggs and some thousands of larvae by hand stripping and artificial fertilization; the larvae lived only a few days (personal communication). Programmed research started in 1972 in France (Barnabé and Tournamille, 1972) and Italy (Arcarese, Ravagnan and Ghittino, 1972), followed by a number of other experiments in these two countries.

Spawning can be induced by hormone injections or obtained in animals which have matured naturally.

SERRAN Dicen 1

1971

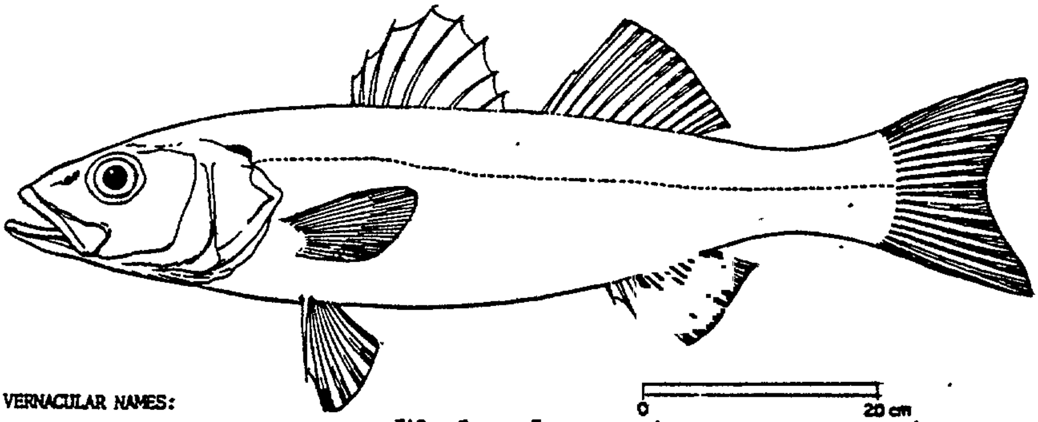
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: SERRANIDAE

Fishing Area 37
(Medit. and Black Sea)

Dicentrarchus labrax (Linnaeus, 1758)

SYNONYMS STILL IN USE: *Morone labrax* (Linnaeus, 1758)
Labrax lupus (Lacépède, 1802)



VERNACULAR NAMES:

FAO - En : European seabass
Fr : Bar européen
Sp : Lubina

NATIONAL -					
ALBN:	Lavraku	ISRL:	Lavraq	ROMN:	Lavrac
ALGR:	Spina	ITAL:	Spigola	SPAN:	Lubina
BULG:	Lavrak	LEBN:	Ghanbar	SYRI:	Ghanbar
CYPR:	Lavraki	LIBY:	Garus	TUNS:	Qatous
EGYP:	Karous	MALT:	Spnotta	TURK:	Levrek
FRAN:	Bar, loup	MONC:	Luvassu	USSR:	Lavraki
GREC:	Lavraki	MORC:	Daru	YUGO:	Lubin

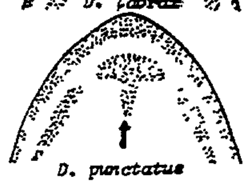
DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Elongate body and *two well separated dorsal fins, the first spiny and the second with one spine and soft rays; back of grey or greenish-black colour, sides silvery, belly white;* a small dark patch on the upper edge of the gill cover; young fish up to 10 cm in length are often spotted with black.

Other field characters: wide mouth with very small pointed teeth on jaws, palate and tongue; the teeth on the centre of the palate (vomerine teeth) form a patch of semilunar shape; gill cover provided with 1 or 2 strong spines.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

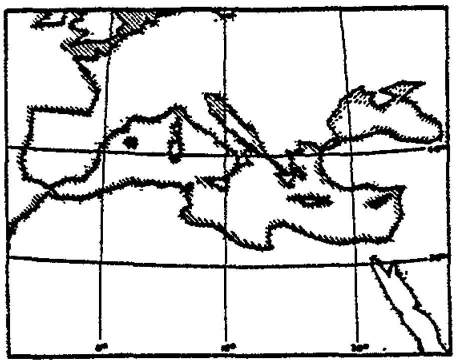
Dicentrarchus punctatus: differs from *D. labrax* by having always (also in adult specimens) the back and sides heavily spotted with black, by a large black patch on the edge of the gill cover and by the different disposition of the teeth on the centre of the palate (vomerine teeth) which form a T-shaped patch.



SIZE:

Maximum: 100 cm; common: about 50 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:



Common in the Mediterranean, rare in the Black Sea; also occurring in the eastern Atlantic, the North Sea and the Baltic Sea.

Inhabits shallow waters over a wide variety of grounds; particularly common in inshore waters (mouths of rivers, brackish lagoons, creeks) and sometimes even well up-river. Often used in pond culture.

Feeds mainly on small shoaling fish and a wide range of invertebrates including shrimps, prawns, crabs, squids and other cephalopods.

PRESENT FISHING GROUNDS:

Shallow coastal waters.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics are not reported for this species. The catch of serranid species in the area reported for 1970 totalled 3 500 tons.

Caught mainly with beach seines; with lines and spears in brackish waters.

Marketed fresh or frozen; its flesh is highly esteemed.

Alessio, Gandolfi and Schreiber (1976) administered to females doses of between 500 and 5 000 I.U. of human chorionic gonadotropin (HCG) or from 10 to 50 mg of pituitary extract per kg of body weight given in 1 to 3 injections. For the males it was sufficient, together with transfer to sea water, to inject 500 to 1 000 I.U. of HCG in order to increase sperm emission.

Arcarese, Ravagnan and Ghittino (1972) used 0.5 carp pituitary/kg of body weight, sometimes in succession up to a total of 3 to 4 pituitaries/kg. They also used HCG in doses of 2 000 I.U./kg of body weight. Before treatment the animals had been acclimatized to marine conditions (salinity 36 ppt, temperature 15°C).

Barnabé (1976; 1976a) administered HCG in doses of 800 I.U./kg of body weight during sexual maturity and considers that this product is much more effective and constant in its characteristics than lyophilized carp pituitary extract.

Girin (1976a) did not use hormones but made use of the gametogenesis natural in captivity, keeping the sea bass in sea water on an open circuit (salinity 35 ppt), with total renewal every 10 hours and a load not greater than 2 kg of fish/m^3.

Lumare and Villani (1973) administered doses increasing from 1.5 to 10 mg of carp pituitary extract per fish, as well as HCG in doses of 1 000 to 2 000 I.U./kg of body weight, keeping the animals in sea water (salinity 36 - 37 ppt and temperature 15 to 19°C). The males were not treated, having reached sexual maturity naturally.

The hormones are usually administered in 1 to 2 injections at an interval of 1 to 2 days and the eggs are usually released 3 days after treatment.

The maximum quantity of eggs released per kg of body weight is about 200 000.

2.2 Incubation

The eggs of D. labrax are usually buoyant owing to 2 -3 lipidic globules which enable them to float. They are transparent, with a diameter of 1.10 - 1.20 mm. Incubation is effected in containers of various shapes and dimensions, and under conditions as similar as possible to natural marine conditions; with a salinity of less than 34.5 ppt and a temperature of 13°C the eggs become demersal.

The hatching time varies according to the temperature. With a temperature of 11 to 19°C incubation requires from 166 to 47 hours, respectively, but an optimum temperature would seem to be around 13°C. The percentage of eggs hatched depends on many factors and in particular the physiological state of the genitors. The highest hatching rate obtained, reported by Barnabé (1976), is 96%.

2.3 Larval rearing

The newly-hatched larvae measure about 3.5 mm and usually start to eat on the 4th or 5th day, depending on the ambient temperature.

Larvae are reared in the same containers in which the eggs are incubated, or in containers with a larger volume in which there may or may not be artificial lighting, and in which the environmental conditions are as similar as possible to the natural ones (temperature: 14 - 20°C; salinity: 34 - 37 ppt; pH: 7.9 - 8.2; O_2: 6 - 9 ml/l, water renewal: 50 - 100%; direct or indirect aeration). Usually the only difference made is in the temperature, which is raised a few degrees higher than ambient.

Either natural or artificial feed may be used; in the latter case the survival rate is very low. The food most often supplied consists of: Brachionus from the 6th to the 16th day, Artemia salina and copepods from the 12th to the 35th day, artificial feed and pieces of fish meat from the 30th day on (Barnabé, 1976).

Girin (1976a) obtained the best results with the following diet: Brachionus from the 4th to the 14th day; Artemia nauplii from the 11th to the 50th day; Artemia of 1 mm from the 25th to 50th day; Artemia of 2 mm from the 40th to the 50th day; frozen Artemia from the 50th to the 60th day, and thereafter mixed food containing lyophilized Artemia from the 50th to the 76th day.

In feeding the larvae with live prey both Brachionus sp. and Artemia nauplii are essential ingredients.

Artificial feeds are being increasingly used for D. labrax larvae. Barnabé (1976) used compound feeds, lyophilized mussels, lyophilised Artemia and dried Ulva lactuca with the addition of vitamins, food colouring, etc. The mixture was then prepared and given in the form of pellets.

The work carried out by Barahona-Fernandes and Girin (1976) and Gatesoup et al. (1977) show that it may soon be feasible, although difficult, to pass directly from rotifer to dry pellets.

2.4 Larval density and survival

The larval density varies from more than 150 to 1/1, according to the method of culture. a guide, the best level would seem to be 10 larvae/1, which can be reduced as culture proceeds.

The survival rate is also variable, but during recent years it has become increasingly stabilized at fairly high levels.

Barnabé (1976a) obtained a survival rate of 60-day-old fingerlings of 10.5%. With live food the young fish attained a survival rate of 25%; with mixed dry food the rate dropped to 4%.

Girin et al. (1976) obtained a survival rate of 38% after 3 months.

Ravagnan (1977) reports some data on the production of D. labrax fingerlings during the 1974-75 season, referring to operations on an industrial scale, with survival rates of about 30%.

2.5 Rearing to market size

In the wild D. labrax attains market size (about 220 g) in the 2nd year, exceeds 500 g in the third year and attains 1 kg in the fourth year (Barnabé, 1973).

Chervinski (1975), in rearing trials with D. labrax and D. punctatus in polyculture with lapia aurea in fresh water, found that Dicentrarchus specimens of 230 - 300 g attained a weight of 650 - 780 g in about seven months.

Barnabé (1976) obtained fish with an average weight of 110 g held in tanks for about 22 months.

In culture using selected feed and with the possibility of keeping the fingerlings in water at a higher temperature than in nature, the above results should be improved on. The scanty data available on culture in ponds seem to indicate that market size can be attained in about 20 months.

D. labrax also seems suitable for culture in floating cages, with results similar to those obtained from culture in tanks.

Artificial production of D. labrax fry in 1976-77 amounted to about 500 000 in France (Anon., 1977) and 1 000 000 in Italy (personal communication).

3. Prospects for commercial development

The results obtained to date in producing fry under controlled conditions are extremely positive and indicate that it may be possible to resolve the various aspects of the problem. However, the very high costs due largely to the use of live food make it impossible to use this method on an industrial scale. This problem could be solved when a satisfactory dry feed giving a consistently high survival rate is devised.

Present results, if further improved, would make it possible to meet the demand from small intensive and extensive culture installations, even though only in part, as well as from traditional valliculture and pond culture.

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Family: SPARIDAE

Species	Geographical distribution	Size
Sparus aurata (Linnaeus)	Common in the Mediterranean; present in the Black Sea and in the Atlantic from the British Isles to Senegal	Max: 70 cm Common: 25 cm

1. Distinctive characteristics

1.1 Ecology

The gilthead bream is eurythermic and euryhaline, frequenting coastal areas. It prefers brackish coastal pools to which it penetrates in spring, remaining all summer and leaving well into autumn.

1.2 Natural diet

It is a carnivorous fish and usually feeds on molluscs and crustaceans.

1.3 Natural reproduction

Along the Italian coasts S. aurata spawns between October and December when the water temperature falls from 17° to 13°C. In this period there is group migration from brackish waters to the sea (Lumare and Villani, 1973). In the more southern part of the Mediterranean, too, the spawning period is the same.

This fish is characterized by protandric hermaphroditism, which occurs from the second to the fourth year.

1.4 Marketing

Marketed fresh. Although its commercial value is very high, fishing of this species is tending to decrease in many parts of the Mediterranean. These factors together have aroused great interest in controlled reproduction and larval rearing. The present retail price in Italy ranges from about US$ 9 to 15/kg.

2. Reproduction and rearing

2.1 Induced spawning methods

The first research on induced spawning and larval rearing was initiated simultaneously in France and Italy in 1969-1970, followed by Israel and, more recently, Spain.

Sexual maturity is induced by injections of human chorionic gonadotropin (HCG) in doses ranging from 500 to 2 000 I.U./kg of body weight up to a total of 800 to 20 000 I.U. given either in a single injection or, more frequently, in a series of injections (from 2 to 9), according to the stage of natural gonadal maturity. During the period of treatment the animals are kept in conditions as similar as possible to a marine environment (salinity 35 - 37 ppt, temperature 17 - 21°C). The interval between injections may vary from seven hours to 5 days; the animals are most frequently injected at intervals of 2 - 3 days. The eggs are usually released 4 - 5 days after the first treatment, either spontaneously or by stripping. The maximum number of eggs released per kg of body weight is approximately 60 000.

SPARID Spar 1

1971

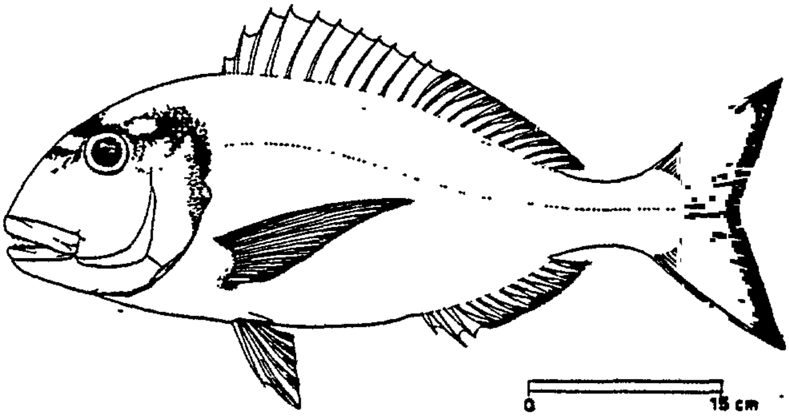
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: SPARIDAE

Fishing Area 37
(Medit. and Black Sea)

Sparus aurata Linnaeus, 1758

SYNONYMS STILL IN USE: *Chrysophrys aurata* Cuvier, 1829



VERNACULAR NAMES:

FAO - En : Gilthead seabream
Fr : Daurade
Sp : Dorada

NATIONAL -

ALBN:	Koce	ISRL:	Sparus	ROMN:	Dorada
ALGR:	Dorad	ITAL:	Orata	SPAN:	Dorada
BULG:	Chipura	LEBN:	'iggag	SYRI:	Jarbiden
CYPR:	Tsipoura	LIBY:	Orata	TUNS:	Jerraf
EGYP:	Denis	MALT:	Awrata	TURK:	Cipura
FRAN:	Daurade	MONC:	Aurada	USSR:	
GREC:	Tsipoura	MORC:	Zrika	YUGO:	Komarca

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Body oval-shaped, laterally compressed, *deep in front; head strong, snout blunt*, lips thick; *eyes moderately developed*, their diameter twice, sometimes a little more, in the preorbital length; *jaws bearing in front 6 strong canines (long, curved and conical teeth) and laterally, 4 to 5 rows of molars (rounded teeth) in the upper jaw, and 3 to 4 rows in the lower;* no cardiform teeth; *back grey and dark blue*, sides silvery-yellow with golden reflections in fresh specimens; *a V-shaped golden band between the eyes;* a black spot at the beginning of the lateral line, a rust-coloured spot on the hind edge of the gill cover and a reddish spot at the axil of the pectoral fin; all these spots are sometimes rather diffuse.

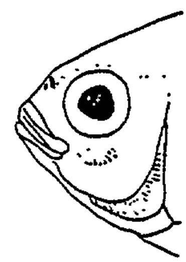
Other field characters: scales large, pectoral fins long, extending beyond the level of the vent.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Pagellus bogaraveo differs from *S. aurata* by its very large eyes, whose diameter is longer than the preorbital length.

Diplodus sargus differs from *S. aurata* by the presence of a black spot on the caudal peduncle, of dark vertical bands on the sides and of incisors (flattened and cutting teeth) in the jaws.

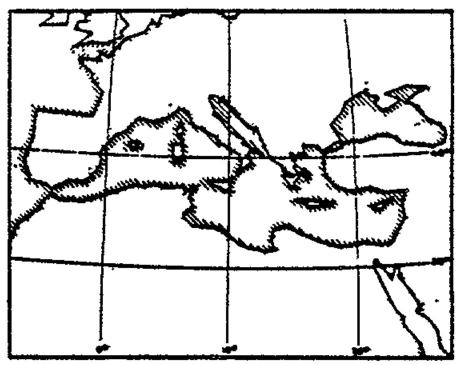
Pagrus pagrus differs from *S. aurata* by its pink colouration and the absence of a golden V-shaped band between the eyes, and of the characteristic spots on the gill cover and at the beginning of the lateral line.



P. bogaraveo

SIZE:

Maximum: 70 cm; common: about 20 to 40 cm.



GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Very common throughout the Mediterranean; also present in the Black Sea and on the eastern Atlantic coasts from the British Isles to Senegal.

Lives in coastal waters down to about 60 m depth and in saline littoral lagoons.

Feeds on molluscs, crustaceans and worms.

PRESENT FISHING GROUNDS:

Saline coastal lagoons and coastal waters of the continental shelf.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics for this species are collected in Egypt, Greece, Italy, Spain and Turkey; the catch reported in 1970 by these countries for the Mediterranean and the Black Sea totalled 1 800 tons. In other countries the species is apparently included in larger statistical categories.

Caught with trammel nets, longlines, pots, fixed nets and fish weirs. Fishing is particularly intensive in autumn, when the fish leaves the littoral lagoons for the sea.

Marketed mostly fresh, sometimes frozen; its flesh is highly esteemed.

According to Girin (personal communication) in 1977 natural spawning in captivity was obtained without hormone injections at Eilat (Israel) and Brest (France) (see Devauchelle and Girin, in press).

2.2 Incubation

The diameter of the eggs is about 950 μ and they are buoyant owing to an oil globule of 230 μ. Incubation can take place in containers of different sizes and material, usually at temperatures of between 15 and 20°C, with closed or even open water circuits, with slight aeration.

Arias (1976) used water filtered with a Millipore 0.8-μ filter and sterilized by ultraviolet rays, with salinity about 36 ppt, temperature 18°C, moderate aeration, and periodic water renewal.

Barnabé (1976) used 700-l cylindrical tanks in which cylindrical incubators of about 32 l, the bottoms covered by plankton net of 500 μ mesh, were placed. Each incubator was supplied with running water which kept the water circulating throughout the tanks. The complex was fitted with aeration.

Villani (1976) used rectangular and circular incubators supplied with running water at temperatures ranging from about 16 to 19°C and salinity of about 36 ppt.

Alessio, Gandolfi and Schreiber (1976) incubated eggs in open-circuit hemispheric tanks of 200 to 600 l, supplied with sea water at a rate of 3 - 4 $l/min/m^3$ of pond and very limited aeration. The water was treated with ozone and filtered through a cartridge with porosity of 0.2 μ; antibacterial products were also used. The incubation period is approximately 5 hours at temperatures varying from 15 to 20°C.

The maximum hatching rate may be as high as 96% (Barnabé and René, 1973).

2.3 Larval rearing

Newly hatched larvae of wild genitors measure about 2 mm, and the larvae of spawners in captivity about 2.5 mm. They start to feed on the 3rd - 4th day, depending on the ambient temperature.

Larval rearing may be carried out in various types of containers using various methods.

San Feliu et al. (1976) used cylindrical tanks of 600 l, with an open circuit (120 l/hour), at a temperature of 18°C. The best results were obtained, according to Barnabé (1976), with tanks 3 m in diameter and 1 m deep (capacity 7 m^3), from which the water was drained through an opening covered by plankton net with a 500 μ mesh.

Villani (1976) used rectangular and circular containers (between 98- and 141-l capacity), with indirect oxygenation and open circuit.

Alessio, Gandolfi and Schreiber (1976) used the same hemispherical tanks (200 - 600 l) for larval rearing as for incubation. Light indirect aeration was maintained and the water renewal rate increased after the first few days to 8 - 10 $l/min/m^3$. The salinity, initially 37 ppt, was progressively reduced to 26 - 30 ppt. The partly artificial lighting lasted from 12 to 16 hours a day, with intensity ranging from 600 to 3 500 lux. The oxygen content varied from 8.5 to 9.8 mg/l, pH from 7.8 to 8.3.

In conclusion, the shape of the tank does not seem to have much importance, but particular attention should be given to its size and to the type and intensity of aeration, which should be indirect.

A number of products, particularly natural ones, are used as larval feed.

The sequence can be summarized as follows: Brachionus plicatilis, 20 - 25/ml (from the 4th day); Artemia salina nauplii, 8 - 10/ml (from the 16th to the 40th day); A. salina metanauplii and juveniles, 5 - 8/ml (from the 40th day to fry stage) (San Feliu et al., 1976).

Barnabé (1976) adopted the following larval rearing regime: B. plicatilis and Pedalia phenica rotifers, 5 - 10/ml (from the 4th to the 15th day); A. salina nauplii and copepods (particularly Eurytemora velox), 1 organism/ml (from the 12th to the 30th day); A. salina, copepods and fish waste (crabs and chopped fish) from the 30th to the 35th day; fish waste alone from the 35th day onwards.

Villani (1976a) used B. plicatilis, copepods (Euterpina sp., Tisbe sp.) and ciliates (Stylonychia sp.) at a density of 2 - 4 organisms/l, as well as A. salina nauplii from the 27th day on.

Alessio, Gandolfi and Schreiber (1976) fed the larvae on ciliates, copepods (Euterpina acutifrons and Tisbe furcata), B. plicatilis and A. salina nauplii from the 4th day. After the 55th day a diet of A. salina adults, chopped mussels and tiny pieces of fish meat was given.

2.4 Larval density and survival

Larval density varies from 3 to 50/l according to the method of culture; however, the best density is considered to be 10 larvae/l. The best survival rate of juveniles recorded is 16% (Alessio, 1975) at the 90th day of life. Normally survival at the juvenile stage ranges from 0.1% to 10%.

2.5 Rearing to market size

A number of experiments have been conducted on the culture of fingerlings both in the laboratory and in outdoor tanks, but information on the subject is fairly scanty.

In the wild S. aurata grows very rapidly, particularly from the 1st year on. From the first to the second year, the increase in weight is about three times that of the initial increase (Suau and Lopez, 1976).

Under laboratory conditions, with suitable diet and high winter temperatures, a size of more than 250 g can be attained in the second year.

At present research is being conducted on the culture of gilthead bream in ponds, tanks and floating cages, to which they seem to adapt very well. Girin (personal communication) reports having seen at Eilat (Israel) batches of bream with an average weight of 350 g at the end of the second year, and fish in cages weighing 80 kg/m^3.

3. Prospects for commercial development

Intensive culture of S. aurata on a commercial scale depends on the supply of fry, which have now become scarce in many coastal areas of the Mediterranean; and collection is restricted by legislation in a number of countries. However, small quantities are caught for extensive culture in lagoons and in "valli". In some countries, however, for example Turkey, juveniles are available in appreciable quantities. Although experimental studies have resolved the problem of induced spawning, much research is still required for successful larval rearing, the yield from which remains very low and production costs high.

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Family: SOLEIDAE

Species	Geographical distribution	Size
Solea vulgaris (Quensel) = Solea solea (Linnaeus)	Common in the Mediterranean and along the eastern coasts of the Atlantic from Norway to Cape Verde	Max: 40 cm Common: 25 cm
Pegusa impar (Bini) = Solea impar (Benn)	Common in the Adriatic and Tyrrhenian Seas	Max: 25 cm Common: 20 cm

1. Distinctive characteristics

1.1 Ecology

Both species are benthic and live on muddy and sandy bottoms at depths of down to 80 m; during the spawning period they come in close to the coast. They can penetrate into brackish waters provided salinity is fairly high. They are moderately eurythermic and euryhaline.

1.2 Natural diet

They feed on small animal organisms. *S. vulgaris* prefers polychaetes, followed by ophiuroids, small holothurians, molluscs and crustaceans (decapods and amphipods).

1.3 Natural reproduction

For both species the spawning period is usually very protracted, lasting from the end of winter throughout the spring. According to San Feliu *et al.* (1976), *S. vulgaris* spawns from May to September. In the North Sea *S. vulgaris* spawns from April to July. During the spawning period both species come close to the coast in very shallow water.

1.4 Marketing

Usually marketed fresh, very occasionally deep-frozen. The market value is usually very high, especially for *S. vulgaris*, which in Italy may fetch a retail price of more than [illegible] 12/kg.

2. Reproduction and rearing

2.1 Induced spawning methods

One of the first attempts at artificial propagation of *S. vulgaris* dates back to Cunningham (1890), who dissected male gonads to fertilize the eggs. A complete report on the development of eggs and larvae was given by Fabre-Domergue and Bietrix (1905), who attempted to rear the fry; similar attempts were also made by Dannevig (1948).

Programmed experiments in this field, however, were only undertaken after 1960, mainly in the United Kingdom and Germany.

Brasola (1974) administered a single injection of 250 I.U. of HCG to *S. vulgaris* males and females in an advanced stage of maturation. During the period of treatment the animals were kept in running sea water (salinity 37 ppt and temperature 16-18°C). Ovulation and fertilization took place spontaneously a few days after the injection.

SOL Sol 1

1971

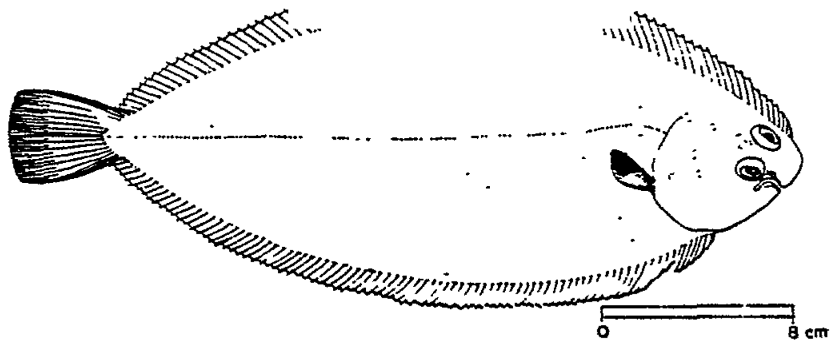
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: SOLEIDAE

Fishing Area 37
(Medit. and Black Sea)

Solea vulgaris Quensel, 1806

SYNONYMS STILL IN USE: *Solea solea* (Linnaeus, 1758)



VERNACULAR NAMES:

FAO - En : Common sole
Fr : Sole commune
Sp : Lenguado común

NATIONAL -

ALBN:		ISRL:	Sulit mezuia	ROMN:	Limba
ALGR:	Melkha	ITAL:	Sogliola	SPAN:	Lenguado
BULG:	Morski ezik	LEBN:	Moussa	SYRI:	Moussa
CYPR:	Glossa	LIBY:		TUNS:	Mdass
EGYP:	Samak moussa	MALT:	Ingwata tar-rig	TURK:	Dil
FRAN:	Sole	MONC:	Sola	USSR:	
GREC:	Glossa	MORC:	Hout-moussa	YUGO:	List

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Body oval and elongate; eyes placed on the right side of the body; snout rounded; both pectoral fins well developed; *nostril of the blind side small and tubular; ground colour brown,* with darker marblings and small spots; *pectoral fin of the upper side marked with a black blotch on its upper edge, running to the fin margin.*

Other field characters: mouth strongly arched; dorsal and anal fins joined to the caudal fin by a membrane; dorsal fin originating in front of the eyes; blind side of head bearing cutaneous fringes; teeth villiform; scales small.

DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

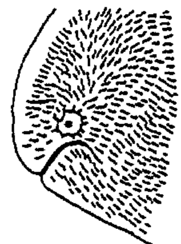
Pegusa lascaris, P. impar and *P. nasuta* differ from *S. vulgaris* by the very wide, rosette-shaped nostril of the left (blind) side of the head.

Pegusa sp.
blind side of head

Monochirus hispidus, *Solea variegata* and *S. lutea* differ from *S. vulgaris* by the absence (in *Monochirus* only) of a pectoral fin on the blind side or by its strong reduction (much smaller than that of the eyed side).

Solea ocellata differs from *S. vulgaris* by the presence, on the upper side, of large brown spots.

Pegusa kleini differs from *S. vulgaris* by the presence of a black band along the dorsal and anal fin margins and of a black spot at the base of the right pectoral fin; also by the following features of the blind side of the head: anterior nostril in the shape of a fringed rosette, and presence of very long sensorial fringes.



P. kleini
blind side of head

SIZE:

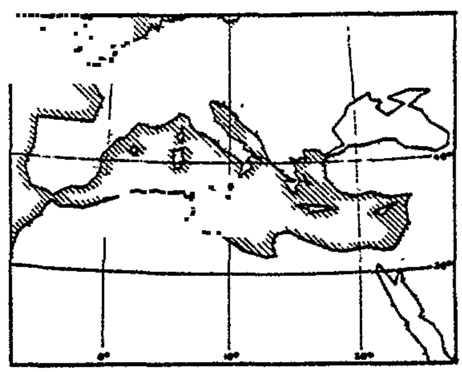
Maximum: 40 cm; common: about 25 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Common throughout the Mediterranean, but absent from the Black Sea; also found along the eastern Atlantic coasts from Norway to Cape Verde.

Lives on mobile muddy and sandy-mud bottoms, from the edge of the continental shelf to more than 180 m depth; common in estuaries and littoral pools.

Feeds on small molluscs, worms and small crustaceans.



PRESENT FISHING GROUNDS:

Continental shelf.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics for this species are collected in Algeria (1970: 100 tons), Egypt (1970: 300 tons), France (1970: 400 tons), Italy (1970: 2 700 tons) and Spain (1970: 400 tons). It is likely that in other countries this species is included in larger statistical categories.

Caught with bottom trawls and trammel nets.

Marketed fresh in the Mediterranean; its commercial value is very high, as the flesh is very much esteemed.

Flüchter (1972) obtained eggs from animals which released spontaneously; he also used sole pituitary extract, without success.

San Feliu et al. (1976) administered HCG in doses increasing from 500 to 1 000 and 1 500 I.U./kg of body weight at intervals of 3 days. The trials carried out in 1975 did not give positive results. The following year results were very positive (personal communication).

Shelbourne (1975) obtained eggs spontaneously, using specimens kept in non-filtered water at a temperature of 12°C.

Villani (1977) worked with *P. impar*, injecting 500 I.U. of HCG per fish. Ovulation took place about one day after treatment. The number of eggs obtained was about 65 000 /kg of body weight.

2.2 Incubation

The eggs are buoyant and have a diameter of 1.10 to 1.20 mm if obtained from Mediterranean specimens, larger (1.10 - 1.50 mm) if from Atlantic genitors.

Brasola (1974) incubated eggs in stagnant sea water at a temperature of about 17°C. After about 50 hours 90% of the eggs hatched.

Flüchter (1972) used open-circuit aquaria provided with internal filtering systems.

Villani (1977) obtained hatching of *P. impar* eggs after 48 - 50 hours at a temperature of 15-18°C.

2.3 Larval rearing

The larvae of Mediterranean *S. vulgaris* measure about 2 mm, those from Atlantic spawners 3 to 4.5 mm. They start to feed towards the 4th - 5th day and are reared initially in containers of various types and sizes under conditions similar to the natural environment (salinity 36-37 ppt, pH 7.9 - 8.2, direct and indirect oxygenation, open circuit).

Brasola (1974) fed the larvae on the following diet: dinoflagellates *Gymnodinium* sp., *Prorocentrum micans* (for 4 - 5 days); copepod eggs and nauplii (*Tigriopus* sp. and *Calanus* sp.) from the 5th to the 8th - 10th day; *A. salina* nauplii and metanauplii up to the 40th day. From this time on artificial feed in the form of moist mash was given and willingly accepted.

Flüchter (1972) adopted the following feeding regime: protozoa in the first days; *Artemia* nauplii from the 4th - 6th day. He also used the copepod *Tisbe helgolandica*.

Girin (1974) obtained the best results with a temperature of 18°C and a diet of *Brachionus* sp. and *Tisbe* sp., live *Artemia* nauplii and subsequently frozen *Artemia* nauplii.

Shelbourne (1975) fed the larvae only on *A. salina* nauplii up to metamorphosis stage.

Villani (1977) fed *P. impar* larvae on the following diet: *Brachionus plicatilis* and *Fabrea salina* (from the 4th to the 16th day), and then on *A. salina* nauplii and metanauplii.

2.4 Larval density and survival

Optimum density is considered to be 10 larvae/l.

Girin (1974) obtained fry at a density of 3 000/m^2 with a survival rate of 80% after one month of culture.

Brasola (1974) obtained survival rates of 75% after 40 days.

Shelbourne (1975) obtained survival rates of metamorphosed animals of approximately 43%, at a density of about 5 000/m².

In 1976 Ramos achieved a survival rate of 80% in metamorphosed animals at a density of 6 000 to 10 000/m² (personal communication).

Villani (1977) succeeded in rearing *P. impar* fingerlings with a survival rate of 28%.

2.5 Rearing to market size

The minimum market size is about 150 g, which should be attained in the second year of culture. However, there is not enough data on the subject to draw more precise indications.

Scattered experiments do indicate the suitability of *S. vulgaris* in particular for culture in tanks, ponds and floating cages. Some culture trials in 10-m³ tanks have yielded specimens with an average weight of 100 g after 19 months of rearing at a density of not more than 1.5 kg/m², at ambient temperature (from 4 to 26°C) and with a diet of dry pellets.

Trials carried out in the United Kingdom have yielded specimens with an average weight of 250 g after 18 months of culture, at temperatures above 14°C and on a wet diet.

Finally, trials in which fingerlings of average weight 75 mg were released in a lagoon have yielded specimens with an average weight of 51 g at 9 months, with natural feeding at ambient temperature (from 9 to 25°C).

3. Prospects for commercial development

The high survival rate of fingerlings and the very short larval cycle (15 days according to Brasola, 1974), which make it possible to limit the use of live prey as food, indicate that *S. vulgaris* is extremely suitable for intensive aquaculture, but a still more interesting aspect could be the production of fry for marine restocking. However, more intensive research is required on inducing sexual maturity in this species, on larval feeding and, finally, feeding with artificial food from fry stage up to market size.

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Family: SCOPHTHALMIDAE

Species	Geographical distribution	Size
Scophthalmus rhombus (Linnaeus)	Frequent in the western sector of the Mediterranean, less common in the eastern part. Very common along the Atlantic coasts, from Scandinavia to Morocco	Max: 100 cm Common: 50 cm

1. Distinctive characteristics

1.1 Ecology

A coastal species which lives on sandy, muddy (except in the Atlantic) and detrital bottoms at depths of between 20 and 80 m. Grows well in sea water of low salinity.

1.2 Natural diet

According to Deniel (1973), young brill feed mainly on crustaceans and polychaetes, the adults on fish.

1.3 Natural reproduction

Spawns in the Mediterranean from the end of winter to spring. In the Atlantic spawning occurs from the end of spring to summer, and especially June-July in the Brittany-Scotland zone.

1.4 Marketing

Usually eaten fresh and sold whole or in fillets. Sometimes marketed deep-frozen. In the Mediterranean, however, there is not a large market for this fish; it finds a more receptive market in northern European countries owing to the large-scale fishing carried out in German-Dutch waters, which accounts for more than 70% of the total world catch of this species (Anon., 1973). The retail price in Italy is about US$ 7/kg.

2. Reproduction and rearing

2.1 Induced spawning methods

The first attempts at induced spawning of S. rhombus date back to Dannevig (1895), who obtained a great number of larvae from artificially fertilized eggs but did not carry out any rearing experiments. Anthony (1910) induced spontaneous release of eggs, which were then fertilized, keeping the genitors caught at sea in 300-m^3 tanks. This author kept the larvae alive for a short period by feeding them on plankton collected in the sea. Methodical studies on the artificial reproduction and larval rearing of this species have only recently been undertaken.

Flüchter (1972) injected brill with two carp pituitaries/kg of body weight without success. He then successfully used Gadus callarias pituitary extract in doses of one unit/kg and subsequently also ½ unit/kg of body weight. The females responded to treatment after 16-20 hours, at a temperature of 12°C, releasing 700 to 300 000 eggs which did not become fertilized after an attempt at fertilization by the dry method. The females can, however, SCOPH Scoph 1

1971

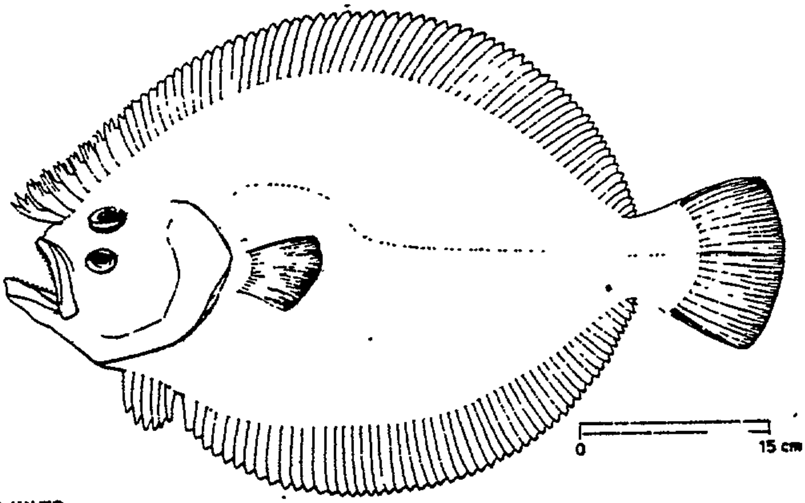
FAO SPECIES IDENTIFICATION SHEETS

FAMILY: SCOPHTHALMIDAE

Fishing Area 37
(Medit. and Black Sea)

Scophthalmus rhombus (Linnaeus, 1758)

SYNONYMS STILL IN USE: *Rhombus laevis* (Turton, 1802)



VERNACULAR NAMES:

FAO - En : Brill
Fr : Barbu
Sp : Rémol

NATIONAL - ALBN:		ISRL:		ROMN:	Calcan mic
ALGR:	Rum	ITAL:	Rombo liscio	SPAN:	Rémol
BULG:	Kalkan	LEBN:		SYRI:	
CYPR:		LIBY:		TUNS:	Sidi moussa
EGYP:	Samak moussa	MALT:	Partun	TURK:	Civisiz kalkan
FRAN:	Barbu	MONC:	Rumliu lisciu	USSR:	Kalkan
GREC:	Rõmbos-pissi	MORC:	Lkarâ	YUGO:	Platak

DISTINCTIVE CHARACTERS AND DIAGNOSIS:

Body oval, very broad, covered with rather small, adherent scales, but not with bony tubercles; snout short; *eyes placed on the left side of the body, widely separated from one another;* dorsal fin originating in front of the eyes; *upper side yellowish-brown* with dark spots of unequal size; underside whitish.

Other field characters: lateral line present on both sides, describing a curve above the pectoral fin; mouth wide, extending beyond the anterior eye margin.

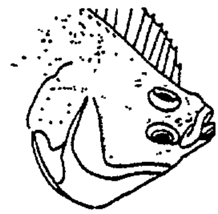
DISTINCTION FROM MOST SIMILAR SPECIES OCCURRING IN THE AREA:

Psetta maxima and *P. maeotica* differ from *S. rhombus* by the presence of bony tubercles and the absence of scales on the body.

Platichthys flesus differs from *S. rhombus* in having the eyes placed on the right side and in that the dorsal fin originates above the eyes.

Citharus linguatula differs from *S. rhombus* by its small and closely set eyes and by its much larger scales.

Arnoglossus laterna differs from *S. rhombus* by the absence of a lateral line on the blind side.



P. flesus

C. linguatula

SIZE:

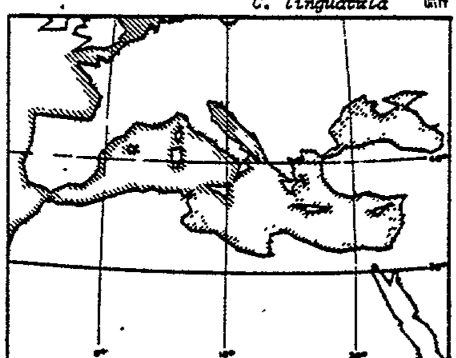
Maximum: 75 cm; common: about 40 to 50 cm.

GEOGRAPHICAL DISTRIBUTION AND BEHAVIOUR:

Present throughout the Mediterranean, although rare in the eastern basin; also rare in the Black Sea; on the Atlantic coasts it is found from Norway to Morocco.

Inhabits sandy and muddy-sand bottoms down to depths of 80 m, although it may sometimes occur at greater depths; frequently found in the vicinity of river estuaries.

Feeds on fishes, molluscs and crustaceans.



PRESENT FISHING GROUNDS:

Continental shelf.

CATCHES, MAIN FISHING GEAR AND PRINCIPAL FORMS OF UTILIZATION:

Separate statistics for this species are reported only by Spain (negligible quantities).

Caught with bottom trawls and trammel nets.

In the Mediterranean it is marketed fresh, and its flesh is highly esteemed.

also release eggs naturally in sufficiently large ponds of from 25 m^3 (Jones, 1972) to 300 m^3 (Anthony, 1910). In ponds of 20 m^3 the females spawn, but the eggs are not fertilized (Girin and Devauchelle, in press). There is usually no fertilization in 25-m^3 ponds (Jones, 1972). Fertilization usually occurs in ponds of 40 m^3 (Girin and Devauchelle, in press) or more (Anthony, 1910).

2.2 Incubation

S. rhombus eggs have a single oil globule, are buoyant and measure between 0.90 and 1.20 mm. The hatching time is in strict relation to the temperature, since 9 days are necessary at 5°C and 4 days at 15°C (Jones, 1972). Jones (1973) incubated eggs in the laboratory in sea water at 12°C. The maximum hatching rate reported in the literature is about 90%.

2.3 Larval rearing

Newly-hatched larvae measure about 3 mm. They start to feed about 3 days after hatching at a temperature of 17.5°C.

Jones (1972) used the following feeds for rearing larvae: copepod nauplii (particularly Acartia and Temora sp.), the rotifer Brachionus plicatilis and Mytilus edulis veligers. In other cases he used rotifers almost exclusively as the first food, then Artemia nauplii and later Artemia of more than 0.2 mm. The metamorphosed fish were fed on chopped polychaetes (Nereis diversicolor), and then on a diet based on fish meat (Jones, 1973).

Girin (1974) used, at a temperature of 20°C, B. plicatilis alone or mixed with the copepod Tisbe furcata from the 2nd to the 12th day, A. salina of 1.1 mm from the 29th day and Artemia of 5 mm from the 40th day, as well as artificial feed containing Artemia from the 43rd to the 75th day. In larval rearing experiments he also used tanks of 60 to 500 l with photoperiods of 24 hours after the 10th day.

Howell (1974) fed the larvae on a mixture of algae (Dunaliella tertiolecta, Chlamydomonas coccoides, Phaeodactylum tricornutum) and rotifers, and from the 16th day also on Artemia nauplii. He noted that the growth of the larvae was in proportion to the number of eggs carried by the rotifers and also that the increase in size was greater than when rotifers were given without the algae.

Macé (personal communication) and Person-Le Ruyet (personal communication) have shown that it is possible to accustom the larvae to eat dry pellets from the age of 1 month at 18-20°C, that is, two weeks before the end of metamorphosis.

2.4 Larval density and survival

Girin (1974) used a density of 40 larvae/l, reduced to less than 10/l on the 15th day. According to this author the best survival rate obtained after about 16 days of rearing was 33%, and 6% after 90 days. The average survival rates for these periods, however, were 6.7% and 0.1% respectively.

Jones (1973) obtained a survival rate of 1% at metamorphosis which took place about 60 days after hatching.

2.5 Rearing to market size

The optimum growing temperature is between 18 and 22°C.

S. rhombus fingerlings of 3 g may attain a weight of 400 g in the first year of culture and more than 1 000 g in the following 6 months (Purdom, Jones and Lincoln, 1972). Stocking density may vary between 5.7 kg/m^3 and 2.6 kg/m^3. At a temperature of 18°C the water can be renewed at a rate of 13.6 l/day per kg of fish stocked (Purdom, Jones and Lincoln, 1972). However, the maximum stocking densities tried with success are 22 kg/m^3 in tanks (Smith, 1976) and 41 kg/m^3 in floating cages (Hull and Edwards, 1976).

According to Deniel (1976), in culture using artificial feed, it is possible to obtain animals of similar size to those of the same age caught in the wild. He found that specimens of 23.8 g grew to 120 g in 4½ months.

Adron et al. (1976) experimented with various artificial diets containing high percentages of cod meat, obtaining animals with an average weight of 41.5 g, after 4½ months of culture, from specimens of initial weight 10.5 g.

S. rhombus is a voracious predator and after metamorphosis easily accepts artificial feed. In their experiments various authors have tried different kinds of experimental feeds, some based on fish meal (more than 50%), some on fish meat suitably prepared and given in the form of long cylinders. These trials showed that S. rhombus easily accepts such food, with interesting conversion factors.

Smith (1976) carried out rearing experiments with both wild and cultured fry, feeding them initially on a diet of mysids, then on fish meat, and later on moist pellets made of fish meal, fish processing waste, soya by-products and vitamins. He noted that the best growth was achieved at a temperature of 18°C, while at 6 - 10°C it was negligible.

Hull and Edwards (1976) obtained a conversion rate of 2:1 using artificial feed. A similar rate was obtained, at a lower cost, using Sprattus sprattus meat.

S. rhombus is very suitable for culture both in tanks and floating cages.

The total production of fry of this species rose in 1977 to about 45 000, of approximately 1 g in weight, of which 40 000 were produced in the United Kingdom.

3. Prospects for commercial development

Experiments conducted in the culture of S. rhombus have shown that it is profitable and also that this species attains market size in a relatively short time. In addition, the species seems to accept very economical food. It may therefore be considered as particularly suitable for intensive culture, thanks also to its hardiness, which makes it possible to handle the fish with ease, and its capacity for adapting to high densities with low rates of water renewal.

Despite these advantageous aspects, commercial culture is not being undertaken owing to the difficulty of obtaining fry through controlled reproduction and larval rearing (Kingwell et al., 1977).

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