

## Ichthyofauna of the evaporitic Messinian in the Romagna and Marche regions

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KEY WORDS — *Fishes, Palaeoecology, Messinian, Mediterranean basin.*

ABSTRACT — *The ichthyofauna collected in four localities of the Emilia-Romagna and Marche regions (Monte delle Formiche, Borgo Tossignano, Brisighella and Monte Castellaro) are examined. Many specimens of fish have been found in the euxinic shale interstrata in the «Vena del Gesso» sequence (Borgo Tossignano, Brisighella). At Borgo Tossignano the ichthyofauna is characterized by *Aphanius crassicaudus*, a peculiar element of almost all the evaporitic Messinian Mediterranean. At Brisighella, the ichthyofauna is formed by stenohaline marine taxa (*Trachurus*, *Sarda*, etc.), associated with euryhaline taxa (*Gobius*, *Atherina*, *Tilapiinae*, etc.). The presence of *Tilapiinae* gr., in Borgo Tossignano, Brisighella, and Monte Castellaro is very interesting from a biogeographic point of view.*

*The change that occurred in the environment during and before the deposition of the evaporitic sequence can be observed in the localities examined here.*

RIASSUNTO — [Ittiofauna del Messiniano evaporitico in Romagna e nelle Marche] — *Sono esaminate le ittiofaune provenienti da quattro località (Monte delle Formiche, Brisighella, Borgo Tossignano e Monte Castellaro) dell'area romagnolo-marchigiana.*

*Lo studio di queste associazioni permette di delineare variazioni di carattere ambientale avvenute prima e durante la fase evaporitica. Di particolare interesse biogeografico è la presenza a Borgo Tossignano, Brisighella e Monte Castellaro di alcuni ciclidi.*

This paper illustrates the ichthyofauna found in recent years in the sediments of the Gessoso-solfifera Formation of the Emilia Romagna and Marche regions, in particular from Monte delle Formiche, Borgo Tossignano, Brisighella and Monte Castellaro (Text-fig. 1).

The ichthyofauna of the Gessoso-solfifera Formation is well known from the literature and is found in many localities in the Mediterranean area, as is indicated by the map in Text-fig. 2.

In this sort of ichthyofauna specific diversity is always very low, and in many cases there is a tendency towards further structural simplification. Where environmental conditions were extreme, populations monospecific to *Aphanius crassicaudus* were formed.

In these environments, variations in some of the chemico-physical parameters of the water caused on enlargement of the skeletal structure (pachyostosis). This is particularly evident in specimens of *Aphanius crassicaudus*, but is also found in individuals belonging to the genera *Gobius* and *Atherina*.

Tab. 1 gives both a list of taxa identified by us and a list of taxa found so far in the Mediterranean area. Some taxa are new to the Gessoso-solfifera Formation.

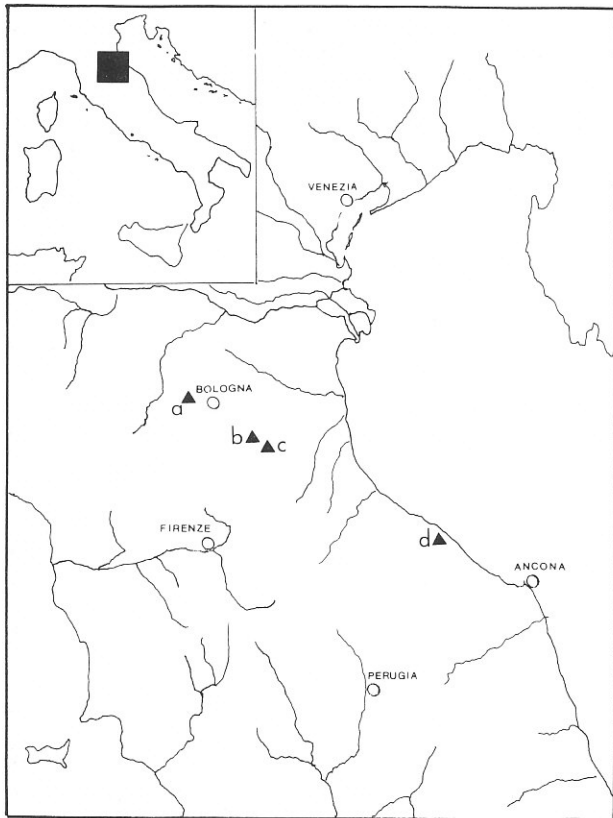
In particular, *Harengula* sp., *Zeus faber*, *Epinephelus* sp., *Lates* sp., *Tilapiinae* gr. were found at Monte Castellaro; *Sarda* gr. sp. and *Tilapiinae* gr. at Brisighel-

la; *Tilapiinae* gr. at Borgo Tossignano, and *Sardina pilchardus* at Monte delle Formiche. These taxa have great palaeogeographic and palaeoecological significance.

### PALAEOECOLOGICAL CONSIDERATIONS

We will now present the ichthyofaunistic associations from these localities, beginning with those with the least specific variability. Sporadic samples show that the ichthyofauna of Monte delle Formiche consists exclusively of *Sardina pilchardus*, with numerous large-sized specimens, chaotically distributed and strongly concentrated on bedding surfaces (Pl. 1, Text-fig. 1). This gregarious fish is of particular interest, in that it lives exclusively in marine environments with normal salinity, and often near the coast, where it groups in very large shoals. Because of lack of systematic sampling, no other observations can be made at present.

In recent years, numerous ichthyolites have been found in the Vena del Gesso sequence, within the euxinic shale interstrata that correspond to evaporitic cycles. In particular, the most important palaeoichthyological sites are: Spes quarry at Borgo Tossignano and the Monticino quarry at Brisighella.



Text-fig. 1 - Map of fish bed localities: a) Monte delle Formiche; b) Borgo Tossignano; c) Brisighella; d) Monte Castellaro.

At Borgo Tossignano, about a hundred fish were found in the euxinic shale interstrata of the 13th and 14th cycles (Text-fig. 3). The association is characterized by low specific diversity, and consist of *Aphanius crassicaudus*, which makes up about 80% of the ichthyofauna *Atherina boyeri*, *Gobius ignotus* (Pl. 1, fig. 7), and two specimens belonging to the Tilapiinae group (Pl. 1, fig. 6). The specimens attributed to *A. crassicaudus* and *G. ignotus* have clearly undergone pachyostosis.

The particular composition of the association, completely consisting of euryhaline elements, coupled with the presence of pachyostosis in some specimens,

indicates a hypersaline aquatic environment. According to Por's (1980) hypersaline water classification, this is an  $\alpha$ -metahaline type association, which indicates salinity values between 40‰ and 70‰. Moreover, the  $\alpha$ -metahaline type is divided into waters of continental (limnogenic) origin and waters of marine (thalassogenic) origin on the basis of its faunal content. The latter is characterized by the absence of Cyprinodontic fish *Aphanius* and of migratory estuarine fish (Atherinidae, Gobidae, Mugilidae).

The faunistic elements collected from Borgo Tossignano (Spes quarry) therefore indicate an environment consisting of hypersaline thalassogenic waters; moreover, the presence of pachyostosis in some specimens suggests that salinity values were highly variable.

The lack in the deposit of other taxa characteristic of hypersaline thalassogenic waters, such as molluscs (Cardiidae, Potamiidae, etc.), can be linked to the particular anoxic conditions of the bottom. In fact, the generally good fossilisation of fish and phillites in this deposit and the absence of a benthonic fauna indicate anaerobic conditions near the bottom.

In the Monticino quarry at Brisighella, about a hundred specimens were found in the euxinic shale interstrata from the basal evaporitic cycles. This association also consists of few taxa (low specific diversity), though its composition differs substantially from that of Borgo Tossignano.

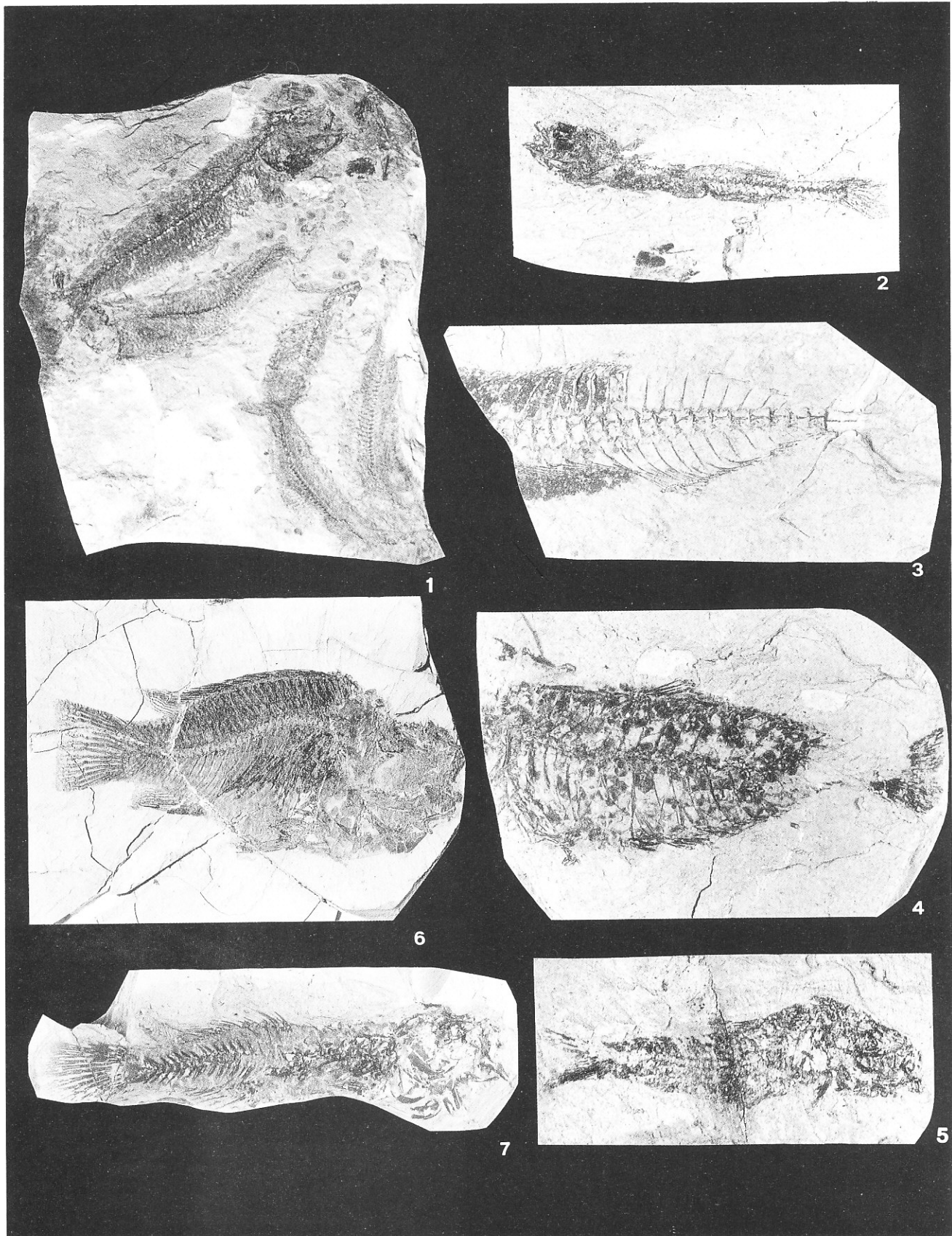
Stenohaline marine taxa are present (*Trachurus* gr. sp., *Sarda* gr. sp.), accompanied by euryhaline taxa (Clupeidae, *Gobius* sp., Tilapiinae gr.) (Pl. 1, figs. 2-5). The absence of *A. crassicaudus*, characteristic element of almost all associations of the evaporitic Mediterranean Messinian, and the lack of pachyostosis in all the specimens found, are to be noted.

This association indicates the presence of an aquatic environment with salinity close to that of seawater. Furthermore, the presence of a representative of the Ciclidae indicates open coastal lagoonal conditions, similar to those found today in some Egyptian Mediterranean coastal lagoons, where these taxa coexist.

A comparison between the associations of Borgo Tossignano and Brisighella shows that they have nothing in common, except the specimens belonging to the Tilapiinae group. In particular, although the Borgo

#### EXPLANATION OF PLATE 1

- Fig. 1 - *Sardina pilchardus* (Walbaum, 1792), Monte delle Formiche. L. approx. 12 cm.  
 Fig. 2 - *Gobius* sp., Brisighella. L. approx. 3,5 cm.  
 Fig. 3 - *Sarda* sp., Brisighella. L. approx. 4,5 cm.  
 Fig. 4 - *Trachurus* sp., Brisighella. L. approx. 5 cm.  
 Fig. 5 - Clupeidae, Brisighella. L. approx. 3,5 cm.  
 Fig. 6 - Tilapiinae gr., Borgo Tossignano. L. approx. 8,7 cm.  
 Fig. 7 - *Gobius ignotus* Gaudant, 1978, Borgo Tossignano. L. approx. 11,5 cm.





Text-fig. 2 - Distribution of fish bed localities in the Mediterranean basin.

1) S. Vittoria d'Alba; 2) Monticello d'Alba; 3) Scaparoni; 4) Piobesi; 5) Guarene; 6) Castagnito; 7) Costigliola; 8) Cherasco; 9) San Lazzaro; 10) Monte delle Formiche; 11) Borgo Tossignano; 12) Brisighella; 13) Monte Castellaro; 14) Senigallia; 15) Racalmuto; 16) Creta; 17) Poggio della Maestà; 18) Cava del Malandrone; 19) Podere Pane e Vino.

Tossignano association consists of typical elements of the *Aphanius* association of the evaporitic Messinian, the composition of the Brisighella association is rather particular, being formed of either estuarine or marine euohaline species.

Although the Borgo Tossignano association fits perfectly into the general context of Messinian evaporitic ichthyofauna, the Brisighella fauna, found in the euxinic shale interstrata of the basal evaporitic cycles, has palaeoecological and palaeogeographical significance similar to that of the ichthyofauna from the «calcare di base» of the Messinian series of Monte Castellaro.

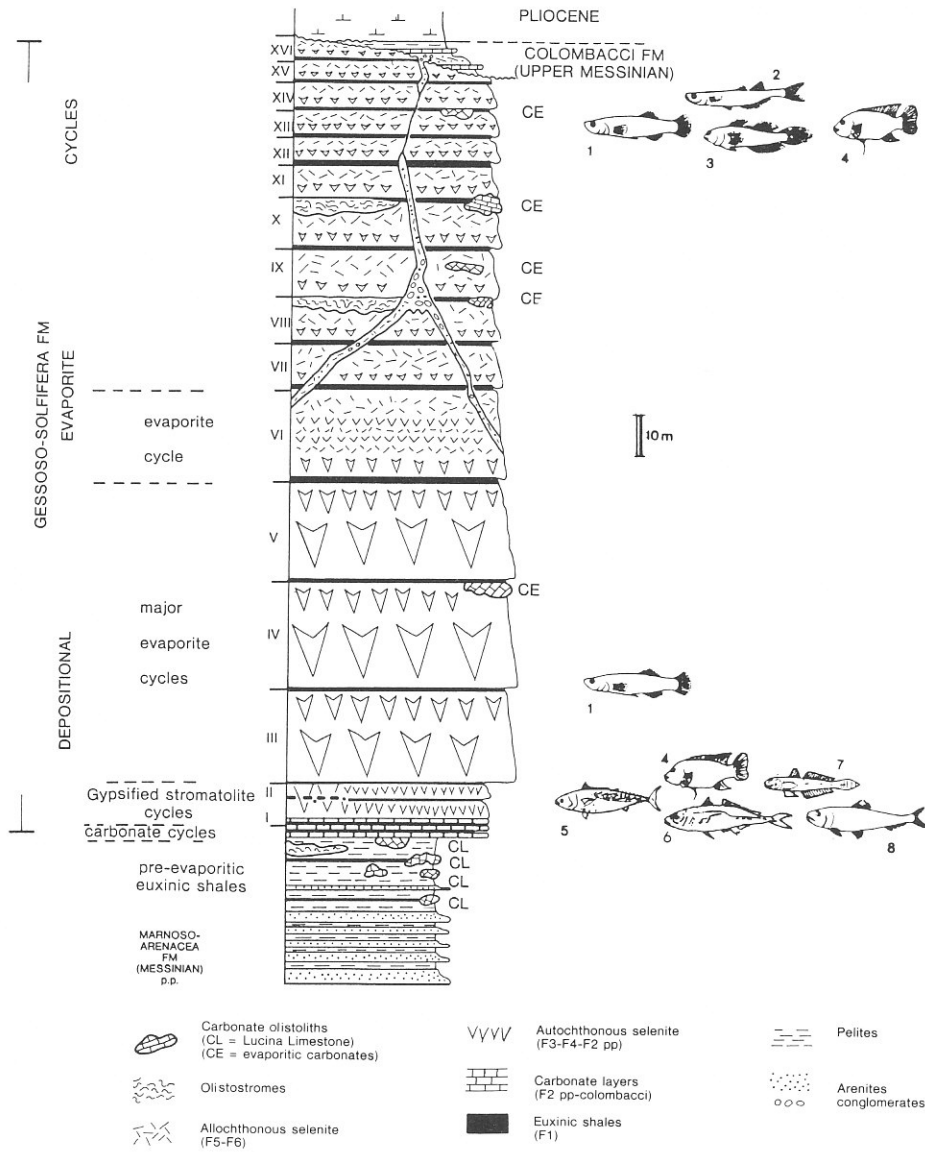
In addition the Brisighella ichthyofauna, is structurally simpler than those found in the «Tripoli», which crop out in the same geographical area. It is represented only by migratory, nearshore marine and/or estuarine fish; the mesopelagic component characteristic of the Mondaino (Bedini *et al.*, 1986), and Senigallia (D'Erasmo, 1929), associations is completely absent.

In the sequence of Monte Castellaro recently illustrated by Sorbini (1987), we can observe the alternation of the varying environmental conditions previous-

ly described in the Romagna deposits. This deposit, is particularly interesting because of both good exposition of the Messinian series and the intense collecting of recent years.

The marine stenohaline component is well represented by taxa not found in other deposits of the Gessoso-solfifera Formation of the Mediterranean, such as *Zeus faber*, *Epinephelus* sp., *Harengula* sp., Furthermore, euohaline elements, such as *Lates* sp., *Atherina boyeri* and *Gobius* sp., are present. It is necessary however to emphasize that the *Aphanius crassicaudus* association is the most characteristic association found in the Gessoso-solfifera Formation at Monte Castellaro.

Therefore a complex palaeoenvironmental reconstruction emerges in which marine, coastal lagoon, and hypersaline environments alternated. The latter environmental situation was the most frequent, as is indicated by numerous individuals displaying pachyostosis, and by the repeated *Aphanius* associations in the stratigraphic succession, which in some levels become monospecific, indicating the presence of  $\beta$ -hypersaline waters (Por, 1980) characterized by salinity values between 70‰ and 140‰.



Text-fig. 3 - Schematic lithostratigraphic column of the Messinian units in the Vena del Gesso basin (Marabini & Vai, 1985). The position of the most important fossil fishes in the euxinic shale interstrata are indicated.  
 1) *Aphanius crassicaudus*; 2) *Atherina boyeri*; 3) *Gobius ignotus*; 4) Tilapiinae gr.; 5) *Sarda* sp.; 6) *Trachurus* sp.; 7) *Gobius* sp.; 8) Clupeidae.

PALAEOGEOGRAPHIC CONSIDERATIONS

What emerges from both the literature and the study of these sediments is that during the deposition of the Gessoso-solfifera Formation in eastern part of the Mediterranean basin there was a succession of aquatic environments of a varying ecological importance. This is shown by the associations with stenohaline marine fish, euryhaline fish, and fish from hypersaline lagoons. All these associations are however characterized by a low specific diversity, and in conditions of great environmental stress take on a monospecific character.

The structural simplification of these associations contrasts sharply with the underlying marine ichthyofauna of the Messinian Tripoli, which show both a

quantitative and qualitative abundance in all the deposits of the Mediterranean basin.

In the localities under study (Monte Castellaro, Borgo Tossignano and Brisighella) Cyclids, at present widespread principally in the freshwaters of India, Africa and South America, are the most characteristic biogeographic element. Fossil Cyclids are found in Africa, in South America and the Caribbean, and Jordan.

We feel that the presence of Cyclids in Central Italy during this brief time interval is linked to a North African or Eastern Near Orient centre of dispersion that became active during the course of the evaporitic event.

Nothing definite can be said about the environmental conditions under which this radiation occurred. According to the literature (Briggs, 1987) these fish,

	S. Vittoria d'Alba	Monticello d'Alba	Scaparoni	Piobesi	Gaurene	Castagnito	Costigliola	Cherasco	San Lazzaro	Monte delle formiche*	Borgo Tossignano*	Brisighella*	Monte Castellaro*	Senigallia	Racalmuto	Creta	Poggio della maestà	Cava del malandrone	Podere Pane e Vino
<i>Alosa crassa</i>														+		+			
<i>Aphanius crassicaudus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Arnoglossus</i> cf. <i>abropteryx</i>			+			+													
<i>Atherina boyeri</i>			+			+					+		+						
<i>Atherina cavalloi</i>								+											
Fam. Clupeidae												+							
<i>Clupeonella maccagnoi</i>								+											
Fam. Cobitidae													+						
<i>Epinephelus</i> sp.													+						
<i>Gobius ignotus</i>								+			+		+						+
<i>Gobius meneghini</i>			+											+					
<i>Harengula</i> sp.													+						
<i>Lates</i> sp.													+						
<i>Lepidopus albyi</i>			+																
<i>Lepidopus</i> sp.						+													
<i>Leuciscus</i> cf. <i>oeningensis</i>								+											
<i>Microbirus</i> sp.													+						
<i>Mugil?</i>								+											
<i>Muraena?</i>		+																	
Fam. Ophichthidae														+					
<i>Palaeoatherina etrusca</i>																			+
<i>Salvelinus oliveroi</i>								+											
<i>Sarda</i> sp.												+							
<i>Sardina pilchardus</i>										+									
<i>Scorpaena</i> cf. <i>minima</i>			+																
<i>Scorpaena</i> sp.													+						
<i>Spratelloides gracilis</i>													+						
<i>Spratelloides lemoinei</i>		+	+		+														
<i>Tavania sturani</i>		+																	
Fam. Tetraodontidae											+								
Tilapiinae gr.											+	+	+						
<i>Trachurus</i> sp.												+							
<i>Zeus faber</i>													+						

Tab. 1 - Systematic list of the fish bed localities in the Gessoso-solfifera Formation mentioned in this paper.

\* Fish bed localities examined in this paper.

though typical of fresh water, can sometimes cross wide stretches of salt water, and are also able to live in hypersaline lagoon environments.

The other taxa examined here are not so biogeographically important. Among these *Epinephelus* sp. and *Lates* sp. can be considered relicts of Tethys.

#### PALAEOCLIMATIC INDICATIONS

From a palaeoclimatic point of view, the presence of *Lates*, *Harengula*, *Spratelloides* and of the Cyclids is

important and these taxa are all from tropical or subtropical environments. The rest of the associations consist of taxa that at present also live in temperate seas.

#### ACKNOWLEDGEMENTS

Many thanks are due to T. Benericetti, M. Diversi and P. Viaggi for the invaluable and patient excavations they have carried out over the years at the Brisighella and Borgo Tossignano sites. Their work is responsible for the samples examined in this paper. We also give our thanks to Dr. G.P. Costa of the Museo Civico di Scienze Naturali di Faenza for his help and the loan of materials.

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(manuscript received May 21, 1988  
accepted September 30, 1988)

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