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Pharyngeal Teeth, Lateral Ethmoids, and Jaw Teeth of Fishes and Additional Fossils From the Late Miocene (Late Khersonian / Early Maeotian) of Eastern Paratethys (Yalova, Near İstanbul, Turkey)

NERİMAN RÜCKERT-ÜLKÜMEN[1] & ERDİNÇ YİĞİTBAŞ[2]

[1] Bayerische Staatssammlung für Paläontologie und Historische Geologie, Richard-Wagner-Straße 10, D–80333 München, Germany

[2] Çanakkale Onsekiz Mart Üniversitesi, Jeoloji Mühendisliği Bölümü, Terzioğlu Kampüsü, TR–17020 Çanakkale, Turkey (E-Mail: eyigitbas@comu.edu.tr)

Abstract: A late Khersonian to early Maeotian fossil assemblage from the Upper Miocene to Lower Pliocene Yalakdere Formation near Yalova city (northwestern Anatolia, Turkey) is documented. The following fish taxa, represented by pharyngeal teeth, lateral ethmoids and jaw teeth are described: Cyprinidae with *Carassius* sp., *Tinca* sp., *Scardinius* sp., *Leuciscus* sp., *Barbus* sp., Cobitidae with *Cobitis* sp., Siluridae with *Silurus* sp., and Esocidae with *Esox* sp.. Further described vertebrates are reptiles (*Trionyx* sp.) and small mammals (cf. *Eliomys intermedius* FRIANT). Additional invertebrate fauna and flora, comprising diverse gastropods, ostracods, charophytes, pollen and limnic green algae, are listed. The fossil assemblage from the Yalakdere Formation indicates fresh to slightly brackish water environments.

Key Words: pisces, systematics, biostratigraphy, Neogene, Turkey

Doğu Paratetis'te Geç Miyosen (Geç Khersoniyen / Erken Maeotiyen) Yaşlı Balıklara ve Diğer Bazı Fosillere Ait Yutak, Yan Kalburumsu ve Çene Dişi Kalıntıları (Yalova, Türkiye)

Özet: Yalova (Kuzeybatı Anadolu, Türkiye) dolaylarında yaygın mostra veren Erken Miyosen–Erken Pliyosen yaşlı Yalakdere Formasyonu içerisinde bir geç Khersoniyen–erken Maeotiyen fosil topluluğu tespit edilerek tanıtılmaktadır. Birim içerisinde yutak dişleri (pharyngeal teeth), yan kalburumsu (lateral etmoid) ve çene dişleri (jaw teeth) ile temsil edilen şu balık kalıntıları tanımlanmıştır: Cyprinidae'den *Carasius* sp., *Tinca* sp., *Scardinius* sp., *Leuciscus* sp., *Barbus* sp., Cobitidae'den *Cobitis* sp., Siluridae'den *Silurus* sp., Esocidae'den *Esox* sp.. Bunların yanısıra omurgalı ve sürüngenler (*Trionyx* sp.) ile küçük memeliler (cf. *Eliomys intermedius* FRIANT) de tespit edilmiştir. Birim içinde bulunan gastropod, ostracod, charophytes, polen ve tatlısu yeşil alg flora toplulukları da ayrıca listelenmiştir. Yalakdere Formasyonu içerisinden derlenen bu fosil topluluğu geç Khersoniyen–erken Maeotiyen döneminde bir tatlısu-acısu ortamını işaret etmektedir.

Anahtar Sözcükler: balık, sistematik, biyostratigrafi, Neojen, Türkiye

Introduction

The investigated material was collected from the Safran coal section near Yalova city, 40 km SE of İstanbul in northwestern Turkey (Figure 1). Biostratigraphic age of the section is assigned to late Khersonian / early Maeotian (Rückert-Ülkümen *et al.* 2006).

The sediments of the Safran coal section are assigned to the Yalakdere Formation (Figure 2). They consist, from bottom to top, of: 100 cm coal, 40 cm white clay, 52 cm coal, 10 cm light clay, 150 cm coal (intensely folded and broken), 48 cm white sandy clay (laminated and fossiliferous), 64 cm coal, 170 cm light beige clay, 10 cm clay with chalk, 90 cm light beige clayey marl, 200 cm alternations of coaly and thin clayey beds, 200–250 cm coal, 40–120 cm beige clay, 150–180 cm alternations of coaly, peaty and clayey beds, 35 cm fossiliferous sand with overlying laminated clay, 300–350 cm fossiliferous clay and coal, 300 cm beige clay, 500 cm light brown clay.

The 40 cm white clay bed contains a rich fauna of pharyngeal teeth, jaw teeth, otoliths and lateral ethmoids of fishes, reptile bone fragments, a small mammal tooth,

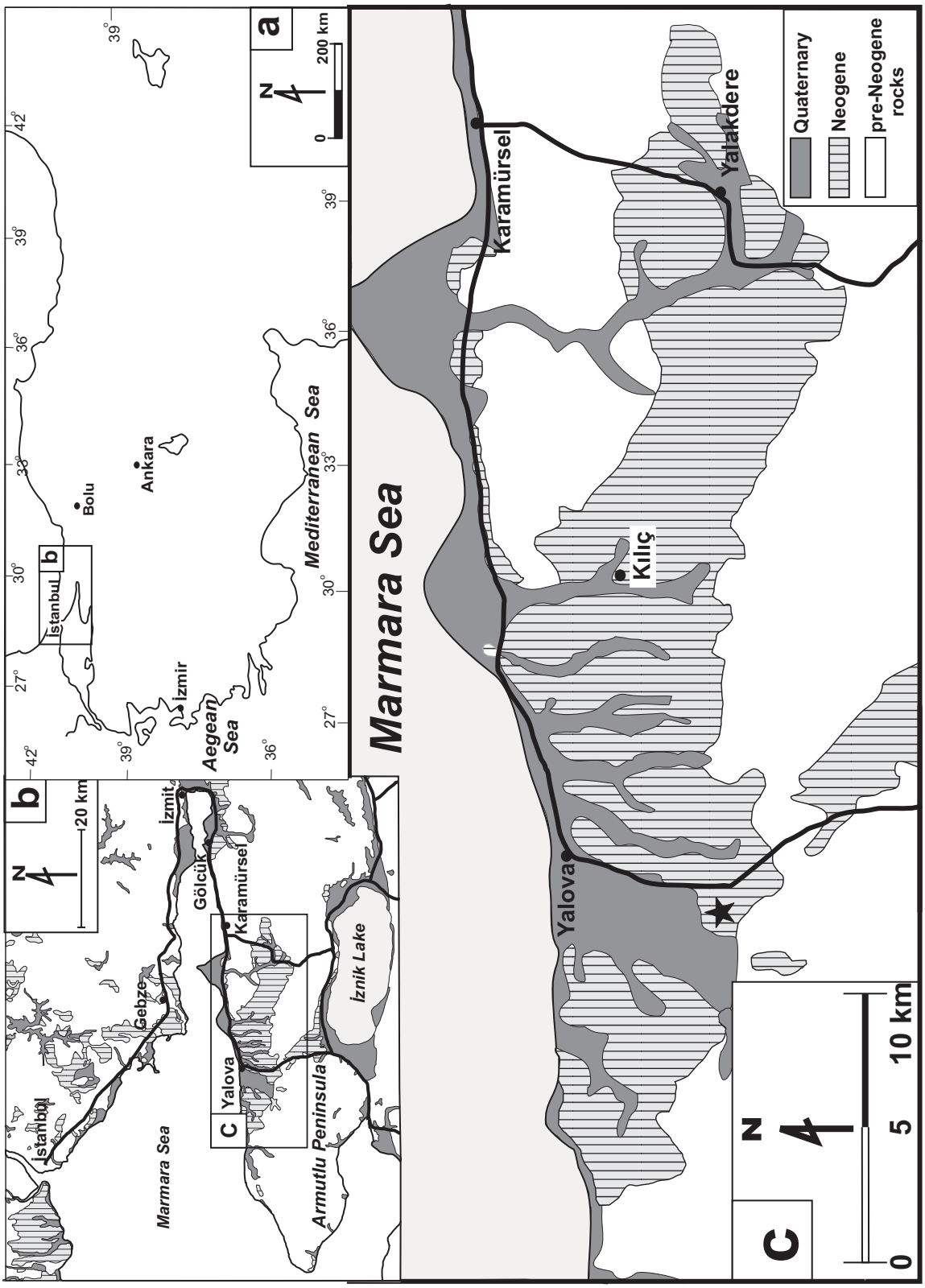

Figure 1. Location maps showing the investigated areas: (a) Location of investigated area in the frame of Anatolia, Turkey; (b) Location of investigated area and distribution of Neogene–Quaternary formations around Yalova and İstanbul; (c) Location of Safran coal section (indicated by solid star) and distribution of Neogene and Quaternary formations around investigated area.

ostracods and gastropods. Charophytes are also present in the 40 cm white clay bed. Pollen and spores came from the 64 cm coal bed and the succeeding 170 cm light beige clay bed. A special publication on otoliths has just appeared (Rückert-Ülkümen 2006). The present paper focuses on pharyngeal teeth, lateral ethmoids and jaw teeth of fishes. Additional described vertebrates include reptiles (*Trionyx* sp.) and small mammals (cf. *Eliomys intermedius* FRIANT); gastropods, ostracods, charophytes, pollen and limnic green algae are listed.

Material and Methods

The investigated material was collected by the authors in 2002–2005. N. Rückert-Ülkümen mixed 107 kg of sediment samples with 3/20 hydrogen peroxide, sieved it in fractions of 0.5–0.25 mm, selected fossil remains from the residue and gave all except those of fishes and reptiles to specialists. Further investigation of biota has been made by the following researchers from Münich: N. Rückert-Ülkümen (pharyngeal teeth, lateral ethmoids and jaw teeth of fishes, reptiles), R. Matzke-Karasz and W. Witt (ostracods), Th. Kowalke (gastropods), B. Bassler (charophytes), K. Heißig (mammals). M. Hottenrott from Wiesbaden listed pollen and spores. The material is deposited in the Bavarian State Collection, BSP 1980 X and the Zoological State Collection ZSM 3105, Münich.

Stratigraphy and Geology

Neogene and younger sedimentary rocks, which contain the Safran coal section, rest unconformably on pre-Neogene basement around Yalova city (Figure 1). These sedimentary rocks can be divided into two parts: the Kılıç and Yalakdere formations (Figure 2). Upper Pleistocene marine terrace deposits crop out between Yalova and Karamürsel.

The Kılıç Formation consists of conglomerate, sandstone, mudstone and claystone alternations, 400 m thick and rests on the pre-Neogene basement with angular unconformity. The formation shows lateral and vertical transition to the Yalakdere Formation, which consists of limestone and marl alternations. The Kılıç Formation consists of reddish brown conglomerate and sandstone alternation in the lower part of the section. The clasts of these sedimentary rocks were derived from underlying schists, marbles, limestones and volcanic rocks. The clastic rocks are medium- to thick-bedded, poorly sorted and composed of sub-rounded to sub-angular grains. Sandstones are represented by beige, yellowish and pink lithic greywacke and lithic arenite. This section contains mudstone-siltstone and carbonaceous sandstone-marl levels with coal beds and the formation is interpreted as being deposited within fluviatile and/or fan delta environments (Emre *et al.* 1998).

The clastic rocks of the Kılıç Formation grade laterally and vertically into white marl and limestone successions, known as the Yalakdere Formation. In some places the Yalakdere Formation rests directly on the pre-Neogene basement rocks with angular unconformity. The succession contains sandstone, siltstone, claystone, and sandy-clayey limestone with local coal beds; total thickness is about 150 m in the surroundings of Yalova.

Along its stratigraphic contact with the Kılıç Formation, the Yalakdere Formation begins with reddish mudstone or sandy limestone-marl succession on the yellowish conglomerate-sandstone of the Kılıç Formation. The mudstone is about 10 m thick and shows gradual transition into a white coloured marl and clayey limestone. South of Safran village, the formation is represented mainly by white, thin- to medium-bedded algal limestone (lacustrine?), and also thin-bedded limestone-marl alternation with graded-, and thick-bedded sandstone intercalations. The Yalakdere Formation may be interpreted as deposited within a low energy lacustrine-swamp environment (Emre *et al.* 1998).

Taxonomy

Fish Remains

Pharyngeal Teeth

Cyprinidae BONAPARTE 1837

Carassius JAROCKI 1822

(Crucian Carp)

Carassius sp.

Figures 3.1–3 & 4

Material. 18 pharyngeal teeth. Figured specimens: Figures 3.2–3 (fossil specimens), BSP 1980 X 1109-91. Figure 3.1 (modern specimen), ZSM 3105.

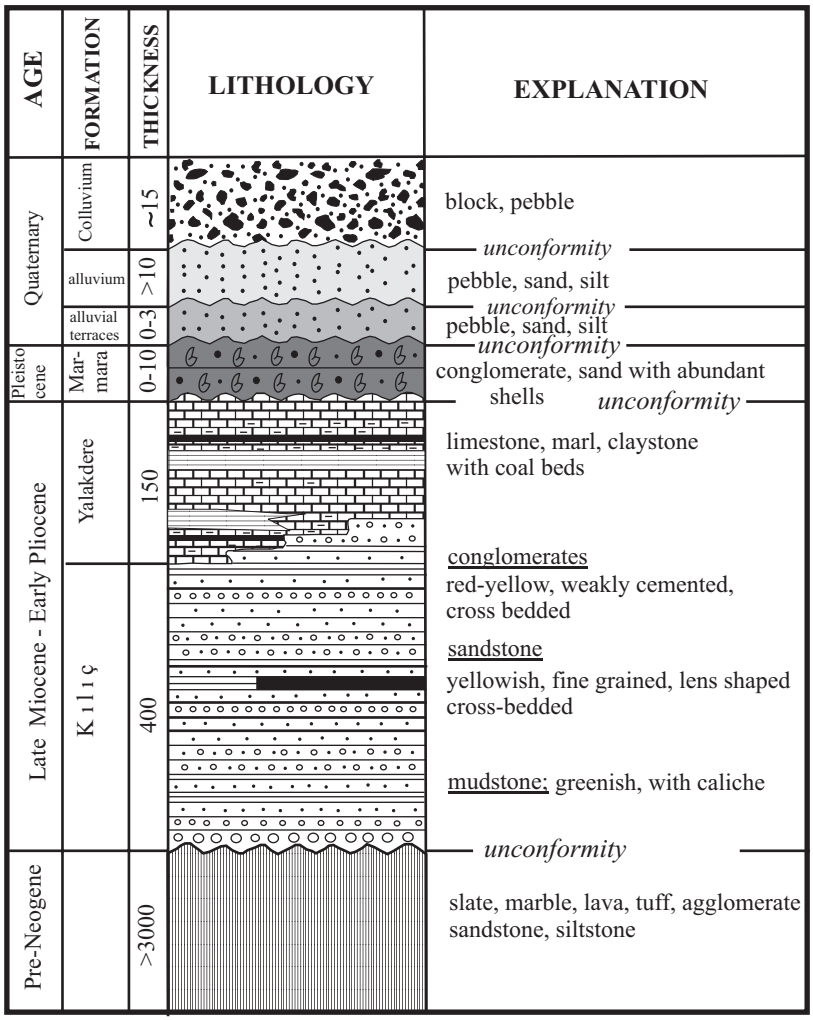

Figure 2. Generalized stratigraphic section for Neogene–Quaternary formations around Yalova.

Locality: Safran coal section.

Measurements of Figured Teeth (in mm): Carassius sp.: width= 4.5, height= 1.5; width= 2.5, height= 1.5; *C. carassius*: width= 4.5, height= 2.5.

Description. The 18 fossil pharyngeal teeth of *Carassius* sp. represent tooth positions 2–4 (see Figure 4). The teeth are submolar and compressed with a broad grinding surface, drawn to width.

The grinding surface of the position 4 teeth is oblique with a distinct sharp frontal edge (see modern specimen on Figure 3.1). The grinding surface of the position 2 and 3 teeth is smooth (see fossil specimen on Figure 3.2–3). Sometimes there is a very small marginal tip on the grinding surface, at the base of the teeth is always broken. The material contains both smaller and larger teeth.

Remarks. The pharyngeal jaw of the modern *Carassius carassius* (LINNAEUS, 1858), shown for comparison (Figure 4), was collected from a pool at the Botanical Garden in Munich (Zoological State Collection ZSM 3105, Munich). There is one row of four pharyngeal teeth on each side of the pharyngeal jaw. The pharyngeal teeth of the modern *Carassius carassius* do not differ from those of the investigated fossil *Carassius* sp. from Safran and

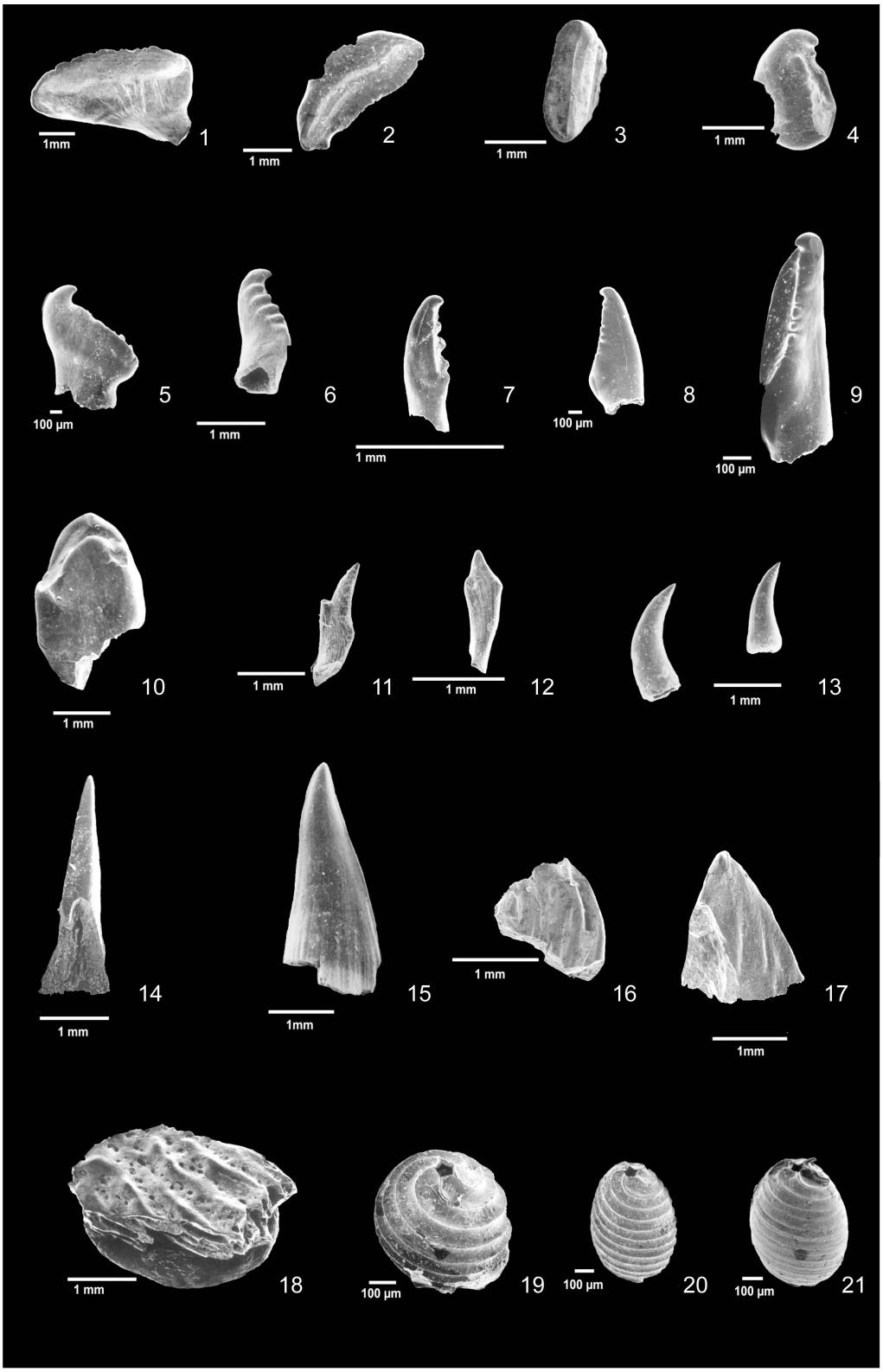
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Figure 3.

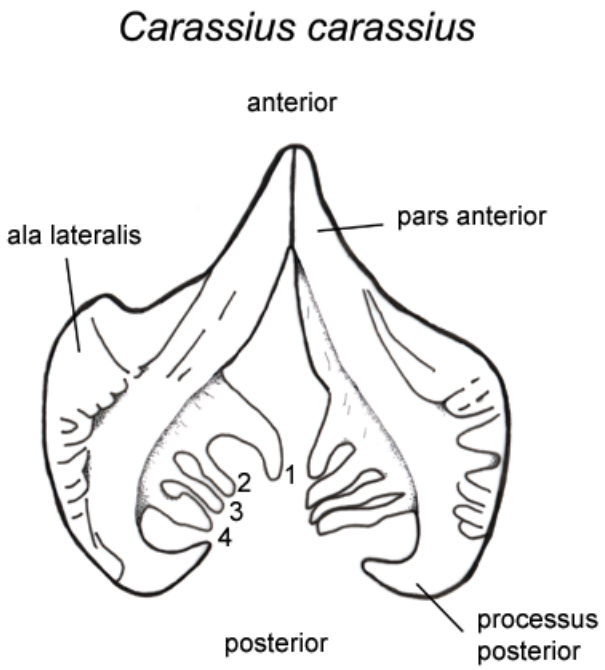

Figure 4. Pharyngeal jaw with teeth (*C. carassius*).

we prefer to use the same genus for our material. We also record *Carassius* from the coal-bearing strata of the Safran coal section (Western Turkey), of late Khersonian / early Maeotian age.

Fossil Distribution. Carassius is known from younger Tertiary/Neogene strata at Sandelzhausen (Middle Miocene) (Böhme 1999, 2002) and Willershausen (Ruscinian) (Hierholzer 1998).

Ecology and Modern Distribution. Carassius lives in fresh water to brackish water, at the bottom of water bodies, and feeding on plants and small animals. When living conditions deteriorate, *Carassius* does not reach maximum size, but individuals are adaptable to varying oxygen ratios. The genus is known from lakes and rivers in Europe, northern Asia and China (Sterba 1990).

Tinca CUVIER 1816

(Tench)

Tinca sp.

Figures 3.4–5

Material. Eight pharyngeal teeth. Figured specimens: BSP 1980 X 1192, 1297.

Locality. Safran coal section.

Measurements of Figured Teeth (in mm): width= 2, height= 1.5; width= 1.5, height= 1.

Description. The teeth of *Tinca* sp. are subconical and compressed, drawn to width. The crown is bluntly rounded at the broad grinding surface is oval. All teeth have a distinct, blunt and hooked tips (Figures 3.4–5).

Fossil Distribution. Tinca is described from the Middle Miocene of Hambach 6C (Hierholzer & Mörs 2003) and Öhningen and the Upper Miocene of Höwenegg (Germany) (Rutte 1962; p. 196–198). It occurs also in Lower Pliocene to Upper Pleistocene strata from Denizli (western Turkey) (Rutte & Becker-Platen 1980; p. 210, plate 3, figure 22). *Tinca* cf. *furcata* AGASSIZ is described in Lower to Middle Miocene strata from Alpagut-Dodurga (Çorum, central Anatolia) (Rückert-Ülkümen 1998; p. 174–175, plate 4, figures 1, 6). *Tinca sayanica* SYTCHEVSKAYA, 1989 is found in Middle/Upper Miocene to Lower Pliocene strata of Mongolia (Sytchevskaya 1989; p. 64–66).

Figure 3. Specimens from the Safran coal Section, Yalakdere Formation (SEM micrographs). (1) *Carassius carassius* (LINNAEUS 1858), Pharyngeal tooth, pond of the Botanical Garden in Munich, Recent, lateral, ZSM 3105. (2) *Carassius* sp., Pharyngeal tooth, occlusal, BSP 1980 X 1190. (3) *Carassius* sp., Pharyngeal tooth, occlusal, BSP 1980 X 1191. (4) *Tinca* sp., pharyngeal tooth, lateral, BSP 1980 X 1192. (5) *Tinca* sp., pharyngeal tooth, lateral, Recent, BSP 1980 X 1297. (6–7) *Scardinius* sp., Pharyngeal teeth. (6) lateral, BSP 1980 X 1193. (7) lateral, BSP 1980 X 1294. (8–9) *Leuciscus* sp., pharyngeal teeth. (8) lateral, BSP 1980 X 1194. (9) lateral, BSP 1980 X 1299. (10) *Barbus* sp., pharyngeal tooth, lateral, BSP 1980 X 1195. s 11–12: *Cobitis* sp., ethmoids. (11) BSP 1980 X 1196. (12) BSP 1980 X 1293. (13) *Silurus* sp., teeth, lateral, BSP 1980 X 1197, 1980 X 1298. (14–15) *Esox* sp., teeth. (14) lateral, BSP 1980 X 1199. (15) lateral, BSP 1980 X 1257. (16–18) *Trionyx* sp. (16) plastron fragment, BSP 1980 X 1229. (17) nuchal fragment, BSP 1980 X 1230. (18) carapace fragment, BSP 1980 X 1231. (19) *Lychnothamnus* sp. 1, BSP 1980 X 1205. (20) *Chara globularis* THUILLER 1799, BSP 1980 X1204. (21) *Chara aspera* DETH. EX WILLDENOW 1809, BSP 1980 X 1203.

Ecology and Modern Distribution. Tinca lives in standing to slowly flowing fresh to brackish waters and feeds on plants and small animals. The genus is found in Europe, Asia and Asia Minor (Sterba 1990).

Scardinius BONAPARTE 1837

(Rudd)

Scardinius sp.

Figures 3.6–7

Material. Nine pharyngeal teeth. Figured specimens: BSP 1980 X 1193, 1294.

Locality. Safran coal section.

Measurements of Figured Teeth (in mm): width= 1, height= 3; width= 1, height= 3.

Description. The conical pharyngeal teeth are hooked at the tips. Grinding surface is very narrow with a higher edge that has 5 to 7 robust pointed jags and a lower edge without jags (Figures 3.6–7). Hook is robust and angle of grinding surface is 20 degrees. Position 2 to 4 pharyngeal teeth of *Scardinius* of the main row differ distinctly from those of *Leuciscus* in having a narrower grinding surface, no oblique lamellas and more robust jags on the higher edge (see Rückert-Ülkümen 1997, p. 711, figure 4a; Rutte 1962, p. 181, figures 4A, B). The pharyngeal teeth of *Scardinius prolixus* SYTCHEVSKAYA (1989; p. 39, plate VII, figures 1–8) from Lower/Middle Pliocene strata of the Chirgis Nur Lake, Mongolia differ from those of Safran in having a longer grinding surface. *Scardinius* sp. from Hambach (Hierholzer & Mörs 2003, p. 23–27, figures 9, 10, plate 3, figures 7–15) is similar but has a higher serrated edge and only 2 to 5 jags.

Fossil Distribution. Scardinius is known from the Molasse of Southern Germany and from Upper Miocene strata of Höwenegg (Germany) (Rutte 1962). Further occurrences are in the Lower Pliocene of Willershausen (Ruscinian), the Upper Pliocene of Hambach 11 (MN 16), Hajnácka (MN 16) and the uppermost Pliocene of Tegelen (MN 17) (Hierholzer & Mörs 2003).

Ecology and Modern Distribution. Scardinius lives in ponds, lakes and rivers where they prefer muddy bottom, overgrown water bodies and feed on plants and small animals (Sterba 1990).

Leuciscus CUVIER 1817

(Dace)

Leuciscus sp.

Figures 3.8–9

Material. Eleven pharyngeal teeth. Figured specimens: BSP 1980 X 1194, 1299.

Locality. Safran coal section.

Measurements of Figured Tooth (in mm): width= 0.5, height= 1.5.

Description. The pharyngeal teeth are hooked and slender; angle of the grinding surface estimated as 35 degrees. There is a higher edge with weak serrations and a lower edge without serrations lying parallel to the longitudinal axis of the tooth. Length of the grinding surface is about half that of the tooth (Figures 3.8–9).

Remarks. The pharyngeal teeth of *Leuciscus* sp. from Safran are very similar to those of *Leuciscus etilius* RÜCKERT-ÜLKÜMEN (1997, p. 712, figure 4a) in which the pharyngeal teeth are found in-situ (Rückert-Ülkümen 1997, p. 712, figure 4a). The following characteristics of *Leuciscus* (sensu Woodward 1901) are recognized in *L. etilius*: the pelvic fin is opposite the dorsal fin; dorsal and anal fins are short. *Leuciscus* differs from *Barbus* in having no pseudobranchiae and no dorsal spine. The anal fin is just behind the dorsal fin and the caudal fin is forked. There is no difference between fossil to modern *Leuciscus*. The pharyngeal teeth of modern *Leuciscus* are hooked, with the high edge weakly serrated and the angle of the grinding surface between 30 and 35 degrees (sensu Rutte 1962, p. 187; Rutte & Becker-Platen 1980, p. 197). The typical characteristics of modern *Leuciscus* are also present in fossil *Leuciscus* sp.. *Palaeoleuciscus*

(OBRHELOVÁ) GAUDANT 1993 is accepted as a subgenus, but not as a genus (see Rückert-Ülkümen & Matzke-Karasz 2000). There is no evidence to raise subgenus *Palaeoleuciscus* OBRHELOVÁ (Obrhelová 1969, 1971), to generic rank. *Leuciscus (Palaeoleuciscus) socoloviensis* OBRHELOVÁ is accepted as type species for the subgenus *Palaeoleuciscus*. Genus *Palaeoleuciscus* sensu Gaudant (in Sach *et al.* 2003, p. 11) is not accepted here.

Fossil Distribution. Various *Leuciscus* remains are found in Upper Miocene strata from Turkey: Etili-Çan (east of the Dardanelles; Rückert-Ülkümen 1960, 1963), Uşak-Muratdağı (northeast of İzmir; Rückert-Ülkümen 1978), Beşkonak Köyü-Kızılcahamam (near Ankara; Rückert-Ülkümen 1980), Alpagut-Dodurga (central Anatolia; Rückert-Ülkümen 1998). *Leuciscus* is described from Oligocene to upper Middle Pliocene strata in Turkey from Konya and the Ereğli Basin (Rutte & Becker-Platen 1980), and from Upper Pliocene (MN 16) strata of Germany from Hambach 11 (Hierholzer & Mörs 2003).

Ecology and Modern Distribution. Leuciscus prefers flowing fresh-water but also occurs in standing freshwater to brackish water environments. It lives in North America, Europe, Eastern Asia and Asia Minor (Sterba 1990).

Barbus CUVIER 1817

(Barbel)

Barbus sp.

Figure 3.10

Material. 33 pharyngeal teeth. Figured specimen BSP 1980 X 1195.

Locality. Safran coal section.

Measurements of Figured Tooth (in mm). width= 1.5, height= 2.5.

Description. In the investigated material, there are two characteristic types of pharyngeal teeth of *Barbus*; both types come from the main row. Very large, big pillar-like teeth with a rounded crown and more or less developed tip represent the first type; spatulate teeth (Figure 3.10) represent the second type. The pharyngeal teeth of *Barbus* sp. from Develiköy near Manisa, Western Turkey (Upper Miocene to Lower Pliocene) (Rückert-Ülkümen *et al.* 2002, p. 57–58, plate 2, figures 5–9) are of similar but more elevated shape. The investigated teeth from the Safran coal section are of various sizes with height from 0.5 to 4 mm and width from 1.25 to 1.5 mm (Figure 3.10).

Remarks. Modern Barbus have pharyngeal teeth in three rows, 5+3+2 teeth each side. The teeth in the main row are the larger; those in the second and third rows are smaller, pointed and conical.

Fossil Distribution. Barbus bispinosus is described from Upper Miocene strata of Etili-Çan (east of the Dardanelles, Turkey; Rückert-Ülkümen 1963, p. 98–99, plate 25, figures 1–2), *Barbus guendogani* from Upper Miocene strata at Alpagut-Dodurga (central Anatolia; Rückert-Ülkümen 1998), *Barbus schizakanthus* from Upper Miocene strata at Kızılcahamam (near Ankara, Turkey; Rückert-Ülkümen 1980), *Barbus* sp. from Upper Miocene to Lower Pliocene strata from Develiköy near Manisa (western Turkey; Rückert-Ülkümen *et al.* 2002) and Barbus sp. from Upper Pliocene strata at Hambach (MN 16a; Hierholzer & Mörs 2003).

Ecology and Modern Distribution. Barbus lives in flowing fresh-water environments with gravelly to sandy beds and when conditions turn to brackish, *Barbus* does not reach its maximum size. It is often found together with *Leuciscus*. The temperature of the *Barbus barbus* zone is 12–18 °C. *Barbus* occurs in western, central and southern Europe, Asia Minor, Syria, Iran, Turkmenistan and Africa in tropical to temperate water bodies (Sterba 1990).

Lateral Ethmoids

Cobitidae SWAINSON 1838

Cobitis LINNAEUS 1758

(Loach)

Cobitis sp.

Figures 3.11–12

Material. Three lateral ethmoids. Figured specimens: BSP 1980 X 1196, 1293.

Locality. Safran coal section.

Measurements of Figured Lateral Ethmoids (in mm). length= 2, width= 0.75; length= 1.5, width= 0.5.

Description. There are two different types of lateral ethmoids in the sample. The posteromedial spine of the first type is long, slender and slightly curved, the posterolateral spine is short and stump-shaped, the medial projection is not prominent, the lateral projection is not preserved (Figure 3.11). The base of the lateral ethmoid is worn. The second type of lateral ethmoids has a broad triangular tip with a short posteromedial spine, a nearly absent posterolateral spine level with the medial projection, and a slender stalk (Figure 3.12). Both types of lateral ethmoids may belong to different species or to various degrees of maturity within the same species. The first type of investigated lateral ethmoids is similar to those of modern *Cobitis aurata* (FILIPI) 1865 (ZSM 19387-93) but has no lateral projection. Both types of lateral ethmoids (Figures 3.11–12) fit well with those of *Cobitis* sp. from Develiköy, near Manisa described by Rückert-Ülkümen *et al.* (2002, p. 58, plate 2, figures 10–12). The specimens from both localities resemble those of *C. ichberchae* SYTCHEVSKAYA (1989) from Schargain-Gobi in having a rudimentary posterolateral spine, but differ in having no lateral projection.

Remarks. In modern *Cobitis*, erectile lateral ethmoids (spines) occur below the orbita, one each side, and are linked to the praeorbitale (Sterba 1990; 316 f.).

Fossil Distribution. *Cobitis angustus*, *C. centrochir* AGASSIZ and *C. cephalotes* AGASSIZ are known from Middle Miocene strata at Öhningen (Agassiz 1833–43). *Cobitis* sp. is described from Upper Miocene to Lower Pliocene strata at Develiköy near Manisa (Turkey; Rückert-Ülkümen *et al*. 2002) and from Neogene strata in Mongolia (Sytchevskaya 1989). *Cobitis taenia* is found in the Pliocene of France (Gaudant 1976).

Ecology and Modern Distribution. *Cobitis* lives in standing to flowing freshwater or brackish water bodies. It favours fine, sandy or muddy bottoms with aquatic vegetation and feeds on small animals. *Cobitis* is found in Europe, Asia and northwestern Africa (Maroc) (Sterba 1990, p. 323), and four modern species occur in the Black Sea region (Slastenenko 1939, p. 239).

Jaw Teeth

Siluridae CUVIER 1817

Silurus LINNAEUS 1758

(Catfish)

Silurus sp.

Figure 3.13a, b

Material. 44 teeth. Figured specimens: BSP 1980 X 1197, 1298.

Locality. Safran coal section.

Measurements of Figured Teeth (in mm): length= 2, width= 0.7; length= 1.5, width= 0.5.

Description. Cross-sections of the small, pointed, more or less curved teeth are nearly circular, decreasing regularly in diameter towards the tip. The morphology of the teeth corresponds to those of modern *Silurus glanis* LINNAEUS, 1758 and fossil *Silurus* sp. from Upper Miocene strata at Develiköy near Manisa, western Turkey (Rückert-Ülkümen *et al*. 2002, plate 2, figure 13).

Remarks. Modern *Silurus* has a more or less depressed head with a large mouth bearing small pointed teeth on the vomer. The vomerine teeth are curved to the interior.

Fossil Distribution. *Silurus* is documented in Lower Pliocene strata from Willershausen (Ruscinium), and Hambach (MN 16) (Hierholzer 1998, p. 26–27, Hierholzer & Mörs 2003), and Hajnácka (Slowaky; Hierholzer & Mörs 2003). Further occurrences are reported in Upper Miocene to Lower Pliocene strata from Develiköy near Manisa (Turkey; Rückert-Ülkümen *et al*. 2002).

Ecology and Modern Distribution. Silurus lives at the bottom of standing and flowing water bodies and can tolerate brackish water. It is active at night, feeding on fish, birds, mice, amphibians and molluscs. *Silurus* is found in Europe, Near East and India. Only one modern speciesis found in the Black Sea Region (Slastenenko 1939, p. 239).

Esocidae CUVIER 1817

Esox LINNAEUS 1758

(Pike)

Esox sp.

Figures 3.14–15

Material. 11 tips of teeth. Figured specimens: BSP 1980 X 1199, 1257.

Locality. Safran coal section.

Measurements of Figured Teeth (in mm). length= 4, width= 1.5; length= 4.5, width= 1.5.

Description. The long, slender, pointed teeth have two sharp edges (Figures 3.14–15). Cross-sections of the teeth are interiorly smooth and exteriorly convex. A modern *Esox lucius* LINNAEUS, 1758 found in a pond near Erling-Machtlfing, Bavaria (BSP 1980 X 1189) was taken for comparison. *Esox sibiricus* SYTCHEVSKAYA (Sytchevskaya 1989, p. 22–23, plate I, figure 10) from Siberia is similar in its long pointed teeth with broad base. The teeth from Safran are longer than those of *Esox sibiricus*.

Remarks. Modern *Esox* are predators with a flattened, duck-billed snout. Pointed teeth are found only in the lower jaw, and the upper jaw has no teeth. The frontal fangs are the smaller, those behind have longer tips and more robust roots.

Fossil Distribution. Esox papyraceus is reported from Upper Oligocene strata at Rott, near Bonn, *E. lepidotus* is known from Middle Miocene strata at Öhningen; *E. waltschanus* from Lower Miocene strata near Waltsch, and *E. otto* from Pleistocene strata oat Breslau (Woodward 1901, p. 288). *Esox lucius* is documented from the Lower Pliocene at Willershausen (Ruscinium), Upper Pliocene of Hambach 11 (MN 16), the uppermost Pliocene of Tegelen (MN 17), and *Esox* sp. from the Upper Pliocene of Hajnácka (MN 16) (Hierholzer & Mörs 2003).

Ecology and Modern Distribution. Esox lives in standing and slowly flowing waters and can tolerate brackish water. Five species are distributed across northern Eurasia and North America. In the Black Sea region, only *Esox lucius* is found (Slastenenko 1939, p. 119–121).

Reptiles

Family Trionychidae BELL 1828

Genus *Trionyx* GEOFFROY 1809

Trionyx sp.

Figures 3.16–18

Material. Numerous carapace, plastron and nuchal fragments. Figured specimens: BSP 1980 X 1229, 1230, 1231.

Locality. Safran coal section.

Description. The surface of the dorsal carapace fragment (Figure 3.18) has short, wavy, comb-like elevations separating grooves with small perforations that extend in rows parallel to the elevations. The perforations reach the lower layer of the carapace, and the bottom side of the carapace is smooth. Specimens from Safran have been compared to better preserved material from Küçükçekmece (BSP 1980 X 230). Transversal thin sections of the carapace fragments from Safran (BSP 1980 X 1300, 1301) show a thick spongy mass of bone with perforations between the upper and lower layers. A thin section of carapace from Küçükçekmece (BSP 1980 X 230) shows identical microstructures. Figure 3.16 shows a plastron fragment and Figure 3.17 nuchal fragment.

Remarks. The oldest known fragments of fossil *Trionyx* carapaces have been found in Maden, the hill Karamurat

Tepe near İstanbul (fragment height= 45 mm, length= 30 mm) (Rückert-Ülkümen 1960). Carapace fragments of *Trionyx* sp. from Safran coal section compare well with fragments from Küçükçekmece (BSP collection Rückert-Ülkümen, BSP 1980 X 230; height= 24 mm, width= 16 mm) and with *Trionyx rostratus* ARTHABER (sensu Müller 1985, p. 106, figure 119); all three show the same structures. Carapace fragments from Küçükçekmece belong possibly to *Trionyx rostratus* ARTHABER (sensu Müller 1985, p. 106, figure 119).

Fossil Distribution. Fossil *Trionyx* is documented from four sites in Thracian, Turkey: *Trionyx* sp. in Sarmatian strata at Silivri-Maden (Rückert-Ülkümen 1960, p. 74, plate 31, figures 1a, b; Rückert-Ülkümen 1963, p. 103, plate 31, figures 1a, b); *Trionyx* sp. in Oligocene strata from Tekirdağ-Malkara-Yörük, Suvatderesi near İbribey (Lebküchner 1974, p. 13, plate 23, figure 7); *Trionyx* sp. in Sarmatian to Pannonian strata from Küçükçekmece (not published, BSP 1980 X 230); *Trionyx rostratus* ARTHABER in Upper Miocene strata at Küçükçekmece (Rückert-Ülkümen *et al.* 1993, p. 63). In Germany, *Trionyx* sp. is documented from Middle Miocene strata at Viehhausen and Hambach (Klein & Mörs 2003) and Sandelzhausen (MN 5) (Schleich 1981). In Austria, *Trionyx rostratus* is known from Upper Miocene strata in the Vienna Basin (Au, Leitha Gebirge) (Müller 1985, p.106, figure 119); *Trionyx* sp. from Upper Miocene strata at Brunn-Vösendorf near Vienna (Thenius 1952).

Ecology and Modern Distribution. Trionyx lives in temperate climates in flowing or standing water bodies in North America, Africa, Asia and Minor Asia (Müller 1985, p. 107).

Mammals

Order Rodentia BOWDICH 1821

Family Gliridae THOMAS 1897

cf. *Eliomys intermedius* FRIANT 1953

Material. One molar: Left M3 without roots, BSP 1980 X 1198.

Locality. Safran coal section.

Stratigraphic Range. Pliocene–Pleistocene.

Ostracods

A complete documentation of the ostracod fauna from various sites of Safran and Yalova is given by Matzke-Karasz & Witt (2005). Here we briefly list the taxa from the Safran coal section: *Darwinula stevensoni*, *Vestalenula cylindrica*, *Candona decimai*, *C. compressaeformis*, *C. burdurensis*, *Pseudocandona* cf. *compressa*, *Cyclocypris nitida*, *Heterocypris salina*, *Cyprideis torosa*, *Cyclocypris* cf. *laevis*.

Gastropods

A short documentation of the gastropod fauna from various sites of Safran and Yalova is given by Rückert-Ülkümen *et al.* (2006). Here we list taxa from the Safran coal section: *Melanopsis narzolina*, *M. stricturata*, *M. pterochilia*, *Viviparus sandleri*, *Bithynia* sp., *Valvata neglecta, V. simplex*, *Gyraulus inornatus*, *Stagnicola* sp., *Galba* cf. *halavatsi*.

Plants

Seeds

Taxa from the Safran coal section include: *Linum usitatissium* LINNAEUS 1758, *Cladium oligorasculare* MAI 1978, *Cladiocarya* sp., *Potamogeton* sp..

Pollen and Spores

The following taxa have been recorded from the Safran coal section: Polypodiaceae, *Pinus*, *Abies*, ?Picea, Taxodiaceae, Gramineae, Cyperaceae, Ericaceae, Compositae (Asteraceae) Chenopodiaceae, *Polygonum persicaraia*, *Ephedra*, *Ulmus, Quercus*, *Pterocarya*, *Acer*, *Liquidambar*, *Carya*, *Betula*, *Alnus*, *Fagus*, *Carpinus*, *Tricolporopollenites wackersdorfensis* (? Verbenaceae) and colonies of limnic green algae *Pediastrum* and *Botryococcus*.

Charophytes

Figures 3.19–21

The following charophyte taxa are recognized: *Chara aspera* DETH. Ex WILLDENOW, 1809, BSP 1980 X 1203; Figure 3.21.

Fossil Distribution. Develikköy (Turkey) – Upper Miocene (Rückert-Ülkümen *et al*. 2002), Fass (Senegal) – Pleistocene (Soulié-Märsche 1991).

Stratigraphic Range. Late Miocene–Recent.

Chara globularis THUILLIER, 1799,
BSP 1980 X 1204; Figure 3.20.

Fossil Distribution. Develikköy (Turkey), Upper Miocene/Lower Pliocene (Rückert-Ülkümen *et al*. 2002), Soknang Section (Kashmir, India; Bhatia *et al*. 1998), Megara Isthmus (Greece) – Pliocene (Soulié-Märsche 1979), Velona Basin (Siena, Italy) – Upper Miocene (MN13) (Ghetti *et al*. 2002).

Stratigraphic Range. Late Miocene–Recent.

Nitellopsis megarensis SOULIÉ-MÄRSCHE, 1979,
BSP 1980 X 1256.

Fossil Distribution. Megara Isthmus (Greece) – Pliocene (Soulié-Marsche 1979), Develikköy (Turkey) – Upper Miocene/Lower Pliocene (Rückert-Ülkümen *et al*. 2002), Karewa Group (Kashmir, India) – Pliocene (Bhatia *et al*. 1998), Louga (Senegal) – Pleistocene (Soulié-Märsche 1991).

Stratigraphic Range. Late Miocene–Pleistocene.

Lychnothamnus sp. 1: BSP 1980 X 1205;
Figure 3.19.

Fossil Distribution. Europe and Australasia (Casanova *et al*. 2003).

Stratigraphic Range. Eocene–Recent.

Palaeoecology

The fish assemblage indicates freshwater to slightly brackish water environments. Diversity of the fish fauna indicates various habitats. *Barbus* and *Leuciscus* prefer flowing waters with sandy to gravelly bottom. *Scardinius* prefers muddy bottom. *Carassius, Tinca, Cobitis* and *Silurus* prefer standing to slowly flowing waters; *Carassius* and *Tinca* are typical indicators of reduced oxygen content. *Silurus* is an impressive predator which feeds on small animals, waterfowl, and even small mammals. Most of the investigated teeth and reptile bone fragments are assumed to come from the intestine of *Silurus*. Some yellowish coprolites assigned to *Silurus* from the Safran coal section contain various fragments of fishes and other vertebrates. According to the fish fauna, three freshwater to slightly brackish-water habitats can be assumed: a high-energy habitat with flowing water and accordingly a coarse-grained bottom, a habitat with slowly flowing to standing water and a probably muddy bottom and a mainly standing-water habitat with seasonally stagnant conditions.

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