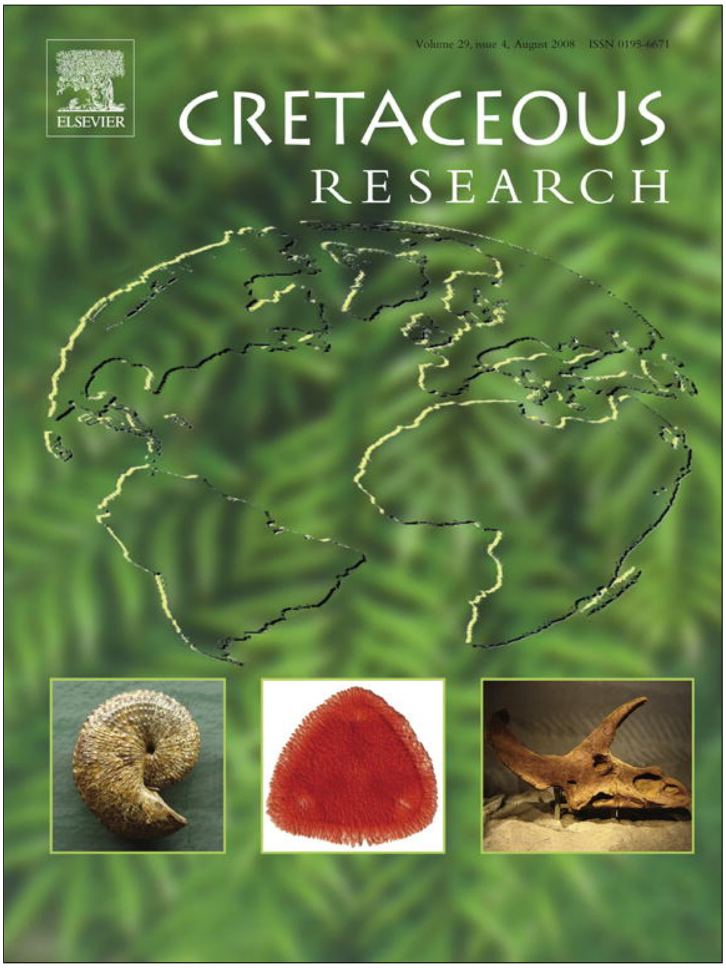
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New records of teleosts from the Late Turonian (Late Cretaceous) of the Bohemian Cretaceous Basin (Czech Republic)

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Abstract

New discoveries of articulated partial skeletons of teleosts from Upper Turonian strata in the Bohemian Cretaceous Basin (BCB) are described. The infrequent occurrence of articulated skeletons is discussed and compared with comparable taxa from the same time-equivalent successions in southern England. The similarity suggests links between both regions during the Late Turonian. Some palaeoecological interpretations of the fishes are provided.

Keywords: Late Cretaceous; Turonian; Teleosts; Marine palaeoecology; Czech Republic

1. Introduction

Specimens of bony fishes (Osteichthyes) occur only infrequently in Upper Turonian strata of the Bohenian Cretaceous Basin (BCB), and early records (Fritsch, 1878; Frič, 1889) document only isolated teeth of Pycnodontiformes and isolated scales and bones of teleosts.

The early discoveries were derived mainly from the Upper Turonian Jizera and Teplice formations. The following species of pycnodonts have been recorded by Reuss (1844, 1845–1846) and Fritsch (1878): '*Sphaerodus mammillaris* Agassiz, 1839' (*Gyrodus? cretaceus* Agassiz – Woodward, 1909, p. 167); '*Sphaerodus tenuis* Reuss, 1845'; '*Gyrodus angustus* Agassiz, 1839' (genus *Anomoedus* – Woodward, 1893, pp. 4, 5); '*Gyrodus mammillaris* Agassiz, 1839' (*Gyrodus? cretaceus* Agassiz – Woodward, 1909, p. 167); '*Pycnodus complanatus* Agassiz, 1839'; '*Pycnodus scrobiculatus* Reuss, 1845' (? genus *Coelodus* – Schultz and Paunović, 1997); '*Pycnodus semilunaris* Reuss, 1845' (? genus *Coelodus* – Schultz and Paunović, 1997); '*Pycnodus rhomboidalis* Reuss, 1845' (syn. *Anomoedus angustus* Agassiz – Woodward, 1895); '*Pycnodus subdeltoideus* Reuss, 1845' and '*Pycnodus subclavatus* Agassiz, 1839' (genus *Anomoedus* – Woodward, 1893, pp. 4, 5). However, due to the fact that these taxa are represented only by isolated teeth, the revised names are still taxonomically uncertain and are therefore marked by quotes. Ancient records of the Upper Turonian consists of scales and isolated bones of teleosts. Fritsch (1878) and Frič (1889) mention the following species: '*Beryx ornatus*' synonym of *Hoplopteryx lewesiensis* Mantell, 1822; '*Cladocyclus strehlensis* Geinitz, 1868' (nomen nudum, Ichthyodectiformes indet.) and '*Lepidenteron longissimum* Fritsch, 1878'. The last mentioned species must be assigned to the trace fossil *Terebellum*, characterized by an open burrow with a lining of teleost scales and bones. Stratigraphically uncertain but possibly Upper Turonian in age are (according Frič, 1889): *Osmeroides lewesiensis* Agassiz, 1822; '*Osmeroides divaricatus* Geinitz, 1868'; 'Aulolepis reussi' (synonym of '*Cyclolepis agassizi* Geinitz, 1868'); *Enchodus* '*halocyon*' (synonym of *E. lewesiensis* Mantell, 1822); and '*Saurocephalus marginatus* Reuss, 1845' (synonym of *Cimolichthys*).

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During the past several years, in context with renewed collecting and research on Turonian macrofauna from the Bohemian Cretaceous Basin (Čech et al., 1996; Ekrt et al., 2001; Větvička, 2003; Wiese et al., 2004; Košťák et al., 2004), a considerable number of disarticulated bonyfish elements (bones, scales, teeth) were collected. They belong to the genera *Osmeroides*, '*Cladocyclus*' (Ichthyodectiformes indet.), *Cimolichthys*, *Dercetis*, *Enchodus* and *Hoplopteryx*. One specimen of *Dercetis* sp. (PV-00028 – col. FSCU; Ekrt, 2000), interpreted as Upper Turonian in age is, judging from the matrix and locality, presumably somewhat older (Cenomanian to Lower Turonian). In this paper, we present new data from the BCB and consider it in the light of European Turonian fish faunas and their palaeobiogeography.

2. Geological setting and short stratigraphic comment

According to recent studies (Wiese et al., 2004; Košťák et al., 2004), the BCB represents a distinctive palaeobiogeographic area located between the northern temperate areas and the Tethys. As a gateway to the Tethys, the Turonian rocks were deposited in a narrow seaway linking the Boreal Realm and the northern Tethys. Gradual lateral change from a siliciclastic-dominated nearshore succession towards basinal marls, marly limestones and marl/limestone alternations of distal basin areas are typical (Wiese et al., 2004). The Upper Turonian strata belong to the Jizera Formation and lower part of the Teplice Formation (Čech et al., 1996; Ekrt et al., 2001; Wiese et al., 2004; Košťák et al., 2004).

3. Locality details

The material for this study derived from several localities within the BCB, the geologic context of which considered below. For locations see Fig. 1.

3.1. Hudcov, Řetenice, Lahošť

Hudcov (Hundorf in old German papers) is located between Teplice and Bílina, approximately 90 km NNW of Prague (Fig. 1). A number of small quarries, operating during the late 19th and early 20th century, exposed Upper Turonian to lowermost Coniacian successions. Presently, only one working quarry exposes Upper Turonian strata. Lithostratigraphically and biostratigraphically, the marl/limestone alternations of the lower part of the succession belong to the lower parts of the Teplice Formation, a lithostratigraphic and time-equivalent of the 'Strehlener Schichten' of Saxony (Germany) (Geinitz, 1875; Petrascheck, 1903; Schlüter, 1876; Tröger, 1969; Voigt and Tröger, 1996; Wanderer, 1909). The ammonite assemblage (*Lewesiceras mantelli*, *Scaphites geinitzii*, *Eubostrychoceras saxonicum*, *Hyphantoceras reussianum*) is typical of the so-called '*reussianum* Fauna', known to occur from England to Kazakhstan (e.g. Wright, 1979; Kaplan, 1986; Metzdorf, 1992; Marcinowski et al., 1996; Wiese et al., 2004), and is of middle Late Turonian age (upper *Subprionocyclus neptuni* Zone). The uppermost parts of the Hudcov quarry consist of lighter marls with cremnoceramid inoceramids of an Early Coniacian age (S. Čech, pers. comm.), an age additionally supported by the occurrence of *Neocrioceras paderbornense* and *Scalarites turoniense* (Kaplan and Kennedy, 1996; Wiese, 2000): both taxa were confirmed in the uppermost strata exposed in Lahošť' (pers. obs.).

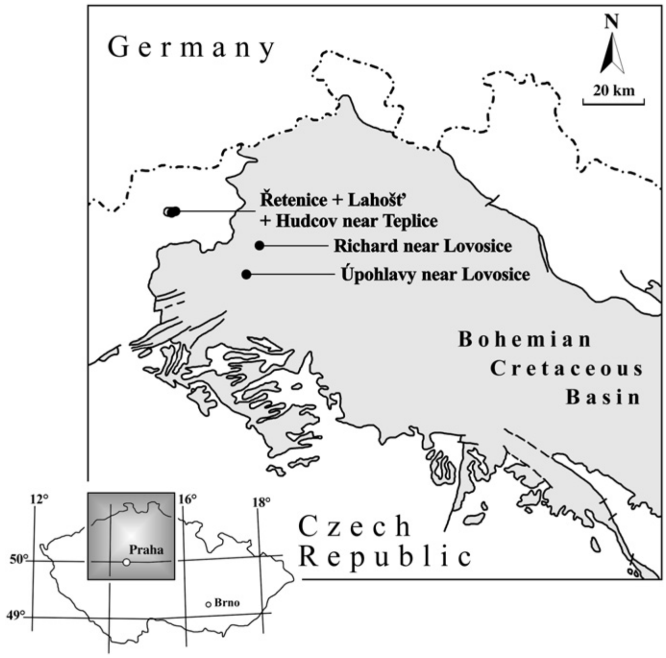

Fig. 1. Schematic position of localities in BCB.

3.2. Úpohlavy working quarry

The Úpohlavy working quarry is located ca. 70 km NW of Prague (Fig. 1) and exposes the lower Teplice Formation of Late Turonian age (Ekrt et al., 2001; Čech et al., 1996; Wiese et al., 2004). The lowermost part is characterized by dark marls, whereas the upper part is composed of marl/limestone alternations. The facies shift from the dark marls to the marl/limestone alternations is foreshadowed by a conspicious horizon, the so-called 'Lower Coprolite Bed', a calcareous intercalation in the dark marls. Only some distance (ca. 1.5 m) above, a second coprolite horizon, the 'Upper Coprolite Bed' is present; this also represents an abundance of vertebrate and invertebrates fauna (shark teeth, fish bones, gastropods, bivalves, ammonites; see Wiese et al., 2004 for details). This bed marks an abrupt turnover towards autochthonous marl/limestone alternations and is recognizable over the entire BCB (Wiese et al., 2004).

From the interval between the Upper Coprolite Bed and ca. 5 m above, ten ammonite species were recorded by Wiese et al. (2004) (*Allocrioceras* sp.,?*Jimboiceras* sp., *Eubostrychoceras saxonicum*, *Hyphantoceras reussianum*, *Lewesiceras mantelli*, *Sciponoceras bohemicum*, *Subprionocyclus neptuni*, *Subprionocyclus branneri*, *Scaphites geinitzii*, *Yezoites bladenensis*) permiting precise dating as Late Turonian (*reussianum*

Fauna of the upper *Subprionocyclus neptuni* ammonite Zone; see above).

Of interest is the associated, rich shark assemblage from the Upper Coprolite Bed (*Notidanus simplex*, *Acrodus affinis*, *Squalicorax appendiculatus*, *S. heterodon*, *S. kaupi*, *Scapanorhynchus raphiodon*, *Cretolamna subulata*, *C. acuminata*, *Cretodus semiplicatus*, *C. acuminatus*, *Squatina lobata*, *Hybodus cristatus*, *Ptychodus latissimus*, *P. mammilaris*, *Ptychodus* sp., *Paranomotodon angustidens* and *Cretoxyrhina mantelli*). Marine reptile remains (probably plesiosaurs) were described by Ekrt et al. (2001).

3.3. Locality 'Richard'

This locality is an abandoned mine situated at the flank of the Radobýl hill (Tertiary basalt dyke) near Litoměřice, ca. 80 km N of Prague (Fig. 1). Formerly, it mined light-grey to yellowish limestones of the Teplice Formation. The limestones are highly fossiliferous, and contain marcasite nodules (Raffelt, 1883, pp. 131, 132). According to Hibsch and Seemann (1913, pp. 21–22), two ammonites were collected: *Scaphites geinitzi* and *Hamites* sp. This presumably dates the succession to at least late Middle Turonian to Upper Turonian, but a more precise date is not possible. The shark assemblage is represented by typical Upper Turonian taxa such as *Paranomotodon angustidens*, *Squalicorax appendiculatus*, *S. heterodon*, *Cretoxyrhina mantelli*, *Ptychodus latissimus*, *P. mammilaris* and *Cretolamna subulata*.

4. Systematic palaeontology

Anatominal abbreviations. Art, articulare; cl, cleithrum; cor, coracoid; d.ptt, dorsal limb of the posttemporale; dpal, dermopalatin; dt, dentale; ecpt, ectopterygoid; enpt, entopterygoid; epo, epioticum; eth, ethmoid; fr, frontale; hmd, hyomandibulare; hmd.h, head of the hyomandibulare; chy, ceratohyale; chy.d, distal ceratohyale; chy.p, proximal ceratohyale; iop, interoperculare; l.e, lateral ethmoid; meth, mesethmoid; mpt, metapterygoid; mx, maxillare; op, operculare; pa, parietale; pin. pect, pectoral fin; pmx, premaxillare; pop, praeoperculare; pto, pteroticum; ptt, posttemporale; q, quadratum; r.br, branchiostegal rays; s, scale; sc, dermal scute; scl, supracleithrum; scler, sclerotic capsule; so, supraorbitale; sop, suboperculare; spo, sphenoticum; vtb, vertebra.

Institutional abbreviations. BCB, Bohemian Cretaceous Basin; NHM, Natural History Museum, London; CGS, Czech Geological Survey; FSCU, Charles University in Prague, Faculty of Sciences; GIAS CR, Geophysical Institute of the Academy of Sciences of the Czech Republic; NMP, National Museum, Prague; RMT, Regional Museum in Teplice.

Order: Aulopiformes
Family: Halecidae
Genus *Halec* Agassiz, 1834

Type species. *Halec sternbergi* Agassiz, 1844, vol. 5, pt. 2, p. 123, pl. 63

Halec sternbergi Agassiz, 1844
Fig. 2A–G

Type. *Halec sternbergi* Agassiz, 1844, col. NMP, no. Oc 259.

1844 *Halec sternbergii* Agassiz: Agassiz, vol. 5, pt. 2, p. 123, pl. 63.
1845 *Halec sternbergii* Agassiz: Reuss, A. E., 1. abt., p. 13, pl. 22, 23.
1878 *Halec sternbergii* Agassiz: Fritsch, A., 1878, pp. 37, 38, pl. 9.

Material
No. Xb-769, col. CGS; locality: Hudcov near Teplice.

Description

The specimen exhibits a complete, about 140 mm long, three-dimensionally preserved cranium with parts of pectoral fin preserved (Fig. 2A–C). The following description refers to the facies interna.

The cranium is significantly shorter than twice the maximum height; the skull roof is generally flattened, but highly rugose (Fig. 2C). The frontale occupies the major part of the skull roof, which is widest at the level of the growth centre, and is posteriorly and anteriorly tapered. The bone surface is extensively folded forming a pattern of ridges and grooves projecting radially from the growth centre. The parietals are small and approximately triangular. Some parts of the neurocranium (such as the lateral ethmoid, mesethmoid, epioticum, pteroticum, internally deflected sphenoticum and supraoccipitale) are observable, but provide no information about its general construction. The orbit is comparatively large, and the sclerotical capsule is ossified. The hyomandibula has a wing-like, radially folded dorsal part and a ventral stick-like part connecting to the caudal margin of the radially ornamented metapterygoid. The quadratum is approximately triangular, with a distinct extremity projecting anterodorsally which is inserted between the metapterygoid and the ectopterygoid. The entopterygoid bears very small teeth (Fig. 2D) on its medial surface and, as on the dermopalatin, the ventral margin bears longer conical teeth (minimum length 2 mm), which are curved posteriorly (Fig. 2D). The ventral edge of the premaxilla is densely covered with fine conical teeth and the maxilla bears larger conical teeth (Fig. 2D). The mandible is low and relatively long and the articulare reaches to half of its length. The dentale is equipped with conical, posteriorly curved teeth (Fig. 2E) that are slightly larger that those on maxilla, but smaller than those on the ectopterygoid and maxilla. The mandibula, together with the upper jaw, reaches beyond the level of the orbita. The operculum is large and higher than wide, with its posterodorsal margin rounded and its posteroventral and anterior edges straight. There are stout horizontal ribs and many radial grooves on its internal surface.

The suboperculare is markedly smaller and its ventral border is rounded. The interoperculare is small, with a rounded ventral edge and fine radial grooves on its internal surface. The praeoperculare is narrow and its dorsal branch is directed vertically. Incomplete hyoid arch exhibits only dorsal and ventral hypohyale and large posterior branchiostegal ray.

The pectoral girdle is fragmentary, the dorsal part of posttemporale is very long (ca. 30 mm), flat, and joins immediately to the posterior end of the neurocranium. The remains of supracleithrum and scapula are poorly preserved. A rather large pectoral fin, consisting of about 13 rays, lies together with a long rounded caudal process of the coracoid (Fig. 2F). Small tubercles are present on the anterior half of medial surface of the fin rays (Fig. 2G).

Discussion

Except for the number of branchiostegal rays, which is unknown, the specimen shows all the diagnostic features (cf. Goody, 1969, pp. 126, 127) of the cranium of *Halec*, and is comparable to the holotype of *Halec sternbergi* (Oc 259, col. NMP). The only minor difference is that the cranium is slightly narrower than in the holotype. This can, however, best be explained by greater compaction of the marls (material of Xb-769) compared to the silty marl in which the holotype is preserved. Compared to the holotype of *H. eupterygius* (Dixon, 1850), in which the cranial length is twice as long, or greater, than the maximum height (Goody, 1969, p. 127), the cranium of the specimen Xb-769 is shorter. The flat and non-ornamented anteromedial part of the frontale is narrow in Xb-769, in contrast to the condition in *H. eupterygius* (Goody, 1969, fig. 56). The parietale is broadly trapeziform in *H. eupterygius* (Goody, 1969, fig. 56) but trianguloid in Xb-769. Compared to the cranium size of *H. haueri* (Bassani, 1879) (cf. Goody, 1969, fig. 63), the cranium of specimen Xb-769 is markedly larger (about 2.5 times larger). While size is not a good character, the diagnosis of *H. haueri* specified that the standard length does not exceed 220 mm (Goody, 1969, p. 137). The estimated standard length of the whole body of the examined specimen is estimated at 550 mm. The size of the cranium of Xb-769 is equal to the holotype of *H. sternbergi*. Furthermore, *H. haueri* is characterized by 11–12 pectoral fin rays (Goody, 1969, p. 139), while specimen Xb-769 bears at least 13 pectoral fin rays.

Family: Dercetidae
Genus *Dercetis* Agassiz, 1834
Type species. *Dercetis scutatus* Agassiz, 1844, vol. 2, p. 259.

Dercetis cf. *elongatus* Agassiz, 1844
Fig. 3A–G

Type. *Dercetis elongatus* Agassiz, 1844, vol. 2, pt. 2, pp. 258, 259, pl. 66a, figs 1, 2, 5–8. Syntype

1844 *Dercetis elongatus*: Agassiz, L., vol. ii, pt. ii, p. 258, pl. lxvi a, fig. 1, 2, 5–8 (non figs 3, 4).
1903 *Leptotrachelus elongatus*: Woodward, A. S., pp. 68–74, pl. 16.
1940 *Benthesikyme elongatus*: White and Moy-Thomas, pp. 98–103.
1966 *Dercetis elongatus*: Siegfried, P., pp. 206, 207.
1969 *Dercetis elongatus*: Goody, P. C., pp. 51, 52.
1987 *Benthesikyme elongatus*: Taverne, L., p. 105.
2000 *Benthesikyme (Dercetis) elongatus*: Ekrt, B., p. 130.

Material

Oc 452, Oc 453 (counterpart), col. NMP from the Úpohlavy working quarry.

Description

The specimen, part and counterpart, exhibits an incomplete cranium 45 mm in length, a part of the vertebral column and dermal scutes (Fig. 3A–G).

The endocranium is broken and individual bones are barely distinguishable from each other. The skull roof has an extended caudal part the major portion of which probably comprises the frontals; the precise position of parietals is unclear. Between the anterior end of the frontals, two ethmoidals are inserted, which are long, narrow and anteriorly tapered. Bones of the hyo-opercular apparatus are markedly small (Fig. 3A). The hyomandibulare is long and triangular. The quadratum is triangular with a small joint, and the metapterygoid is triangular (Fig. 3A). Morphology of the other pterygoidal bones and palatinum are unclear. All jaws are narrow and considerably elongated. The paired premaxilles (Fig. 3A–B) have a rather extended terminal part. The mandibles are 11 time longer than high (the length corresponding to the length of the maxilla–premaxilla complex) and are decorated by longitudinal striae; both are markedly tapered at the symphysis. The dentale (Fig. 3B) bears the remains of long needle-like teeth.

Several fragments of pectoral girdle are preserved (Fig. 3E). The largest element could be a supracleithrum or the incomplete dorsal part of the posttemporale, which is oval and has a shallow furrow on the surface. A stick-like bone that is located adjacent to the bone may be a ventral limb of posttemporale. Only a few fin rays are preserved here. The precaudal vertebrae (Fig. 3C–D) are preserved in lateral and dorsoventral aspect. Their centra are elongate, medially constricted with two pairs of transverse processes. The anterior pair is 2–2.5 times longer than the posterior pair.

Two types of dermal scutes occur (Fig. 3E–G). Scutes of the first type are elongated, asymmetrically forked and without sculpture, while those of the second type are shortened, broad, symmetrical, roughly triangular, and shallowly undulating. Compared to the scutes of *Dercetis* (Goody, 1969, fig. 82a), it is clear that scutes of the first type come either from the dorsal or ventral series, while those of the second type come from the lateral series. Among the disarticulated elements are preserved very fine cycloid scales, previously unreported for this genus. Presumably the scale is allochthonous or represents undigested remains from the alimentary tract of the fish.

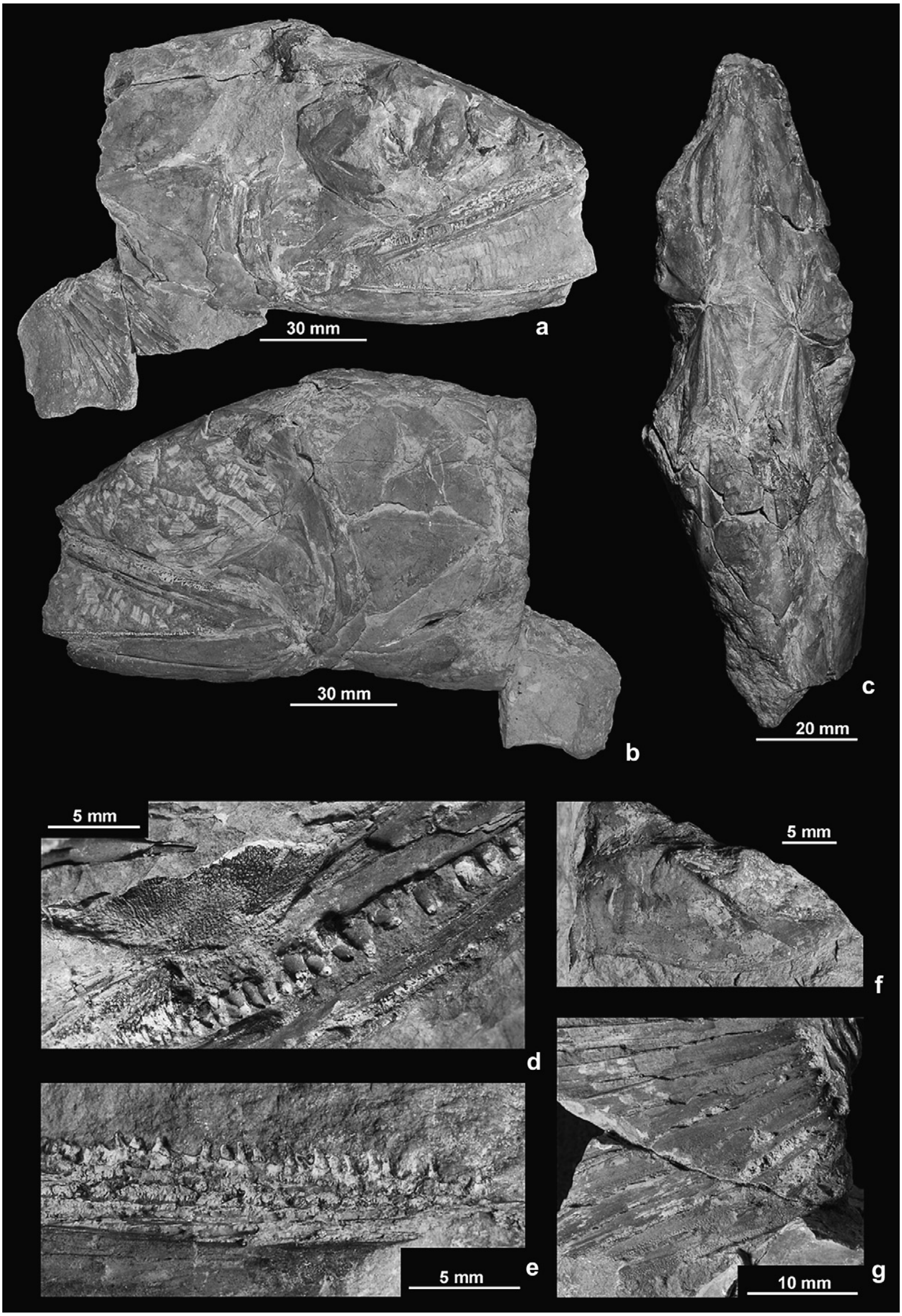

Fig. 2. *Halec sternbergi* Agassiz, 1844. Loc. Hudcov by Teplice. Col. CGS (No. Xb-769). A, right side of cranium. B, left side of cranium. C, skull roof. D, pterygoido-palatinal region. E, anterior part of dentale. F, posterior processus of coracoid. G, pectoral fin rays. H, line drawing of figures 2A–C (for abbreviations see text).

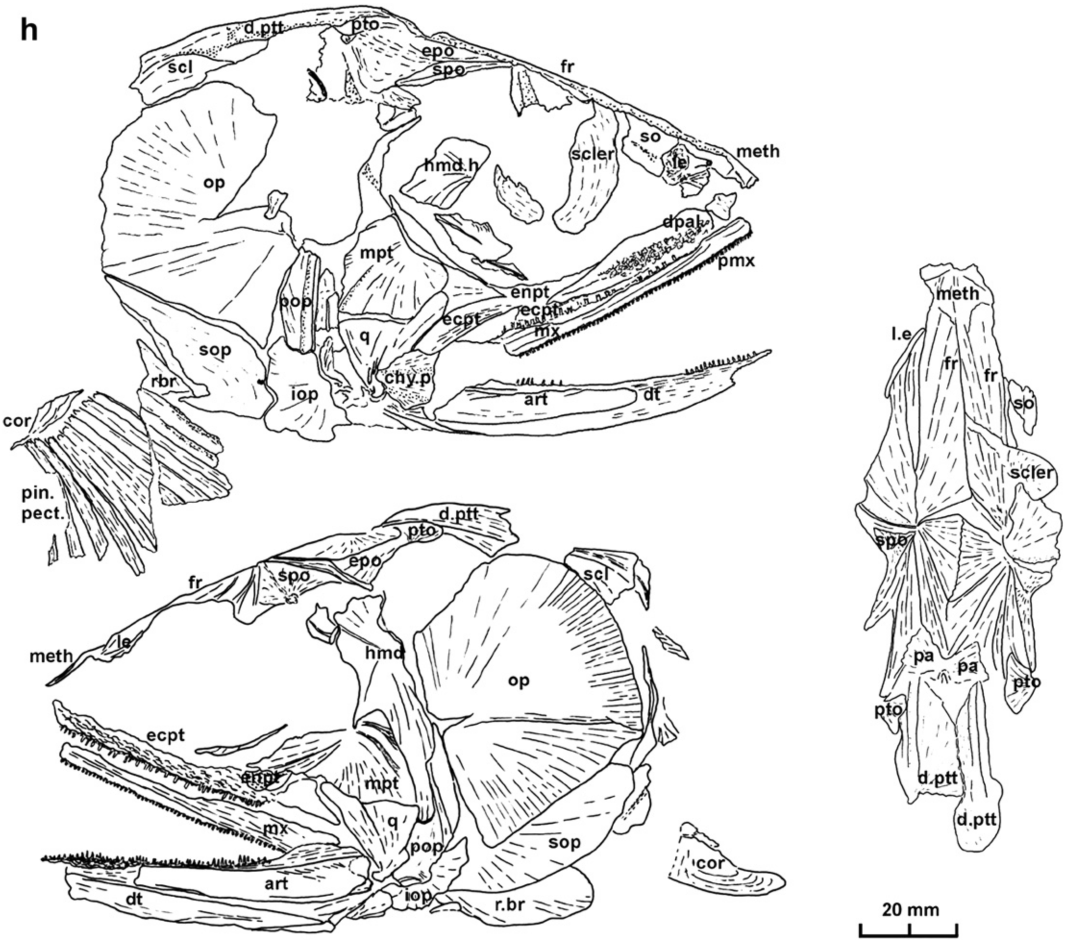

Fig. 2 (*continued*).

Discussion

The specimen described here corresponds to the diagnosis of the genus *Dercetis* (Goody, 1969, p. 51) and is very similar to the holotype of *Dercetis elongatus* from the Upper Cretaceous of England (P 4132, P 4133, col. NHM). This species is regarded by Taverne (1987, p. 94) as a distinct genus: *Benthesikyme*. Unfortunately, one important taxonomic feature of *Benthesikyme* – the position and size of the parietale – is not visible in Oc 452 and Oc 453. *Benthesikyme* is regarded by Siegfried (1966, pp. 206–207) and Goody (1969, p. 51) as synonymous with *Dercetis*: a taxonomic interpretation that is accepted here. The poor preservation of the specimen does not preserve enough diagnostic features for *D. elongatus*, though it is strikingly similar to this species. The absence of point sculptures on the visceral bones and dermal scutes eliminates the species *D. latiscutatus* and *D. maximus*.

Order: Beryciformes
Family: Trachichthyidae
Genus *Hoplopteryx* Agassiz, 1838
Type species. *Hoplopteryx antiquus* Agassiz 1838, vol. 4, pp. 4, 131, pl. 17, figs. 6–8.

Hoplopteryx lewesiensis (Mantell, 1822)
Figs. 4A–B; 5A–B; 6A–B; 7A–B; 8; 9A–D

Type. *Zeus lewesiensis* Mantell, 1822, p. 234, pls 35, 36. Holotype by monotypy.

1822 *Zeus lewesiensis* Mantell, G. A., p. 234, pls 35, 36.
1834 *Beryx zippei* Agassiz, L., p. 68.
1834 *Beryx zippei* Agassiz, L., 1834, t. 4, pp. 120, 121, pl. 15, fig. 2.
1835–1839 *Beryx ornatus* Agassiz, L., pp. 55, 115, pls 14a, 14b, figs. 1, 2, pl. 14c, figs. 1, 3–6, pl. 14d.
1845 *Beryx zippei* Agassiz, L.: Reuss, H. B., pp. 11, 12, pl. 1, pl. 2, fig. 1.
1845 *Beryx ornatus* Agassiz, L.: Reuss, H. B., p. 12, pl. 2, fig. 2.
1878 *Beryx zippei* Agassiz, L.: Fritsch, A., pp. 41–43, text-fig. 62, pl. 5, fig. 1
1878 *Beryx ornatus* Agassiz, L.: Fritsch, A., pp. 43, 44, text-figs. 63–65, pl. 5, figs. 2, 3.
1897 *Beryx zippei* Agassiz: Leonhard, R., p. 68, text-fig. 12.
1905 *Hoplopteryx brevis* Fritsch, A. and Bayer, F., p. 8, pl. 3, fig. 3.

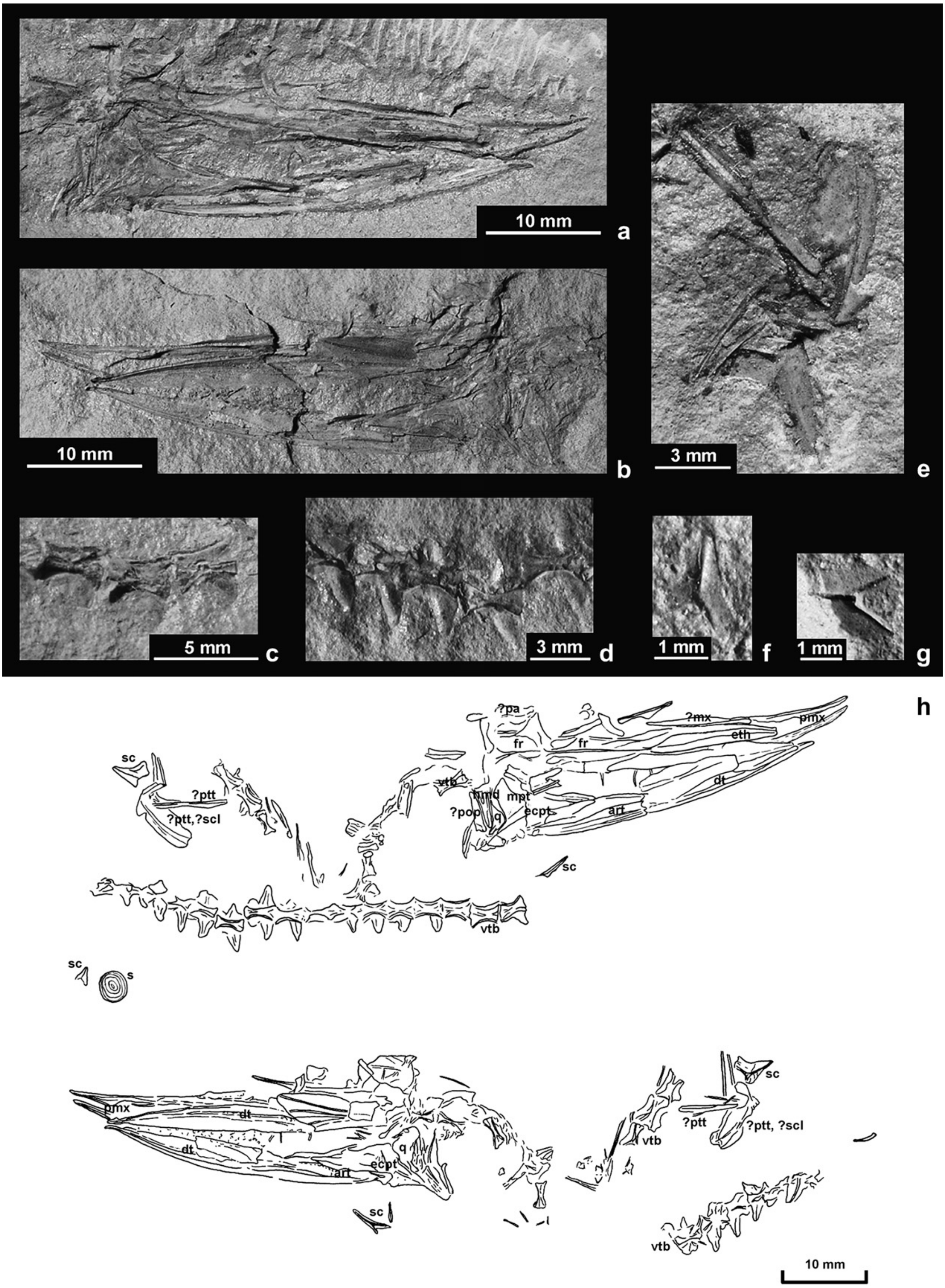

Fig. 3. *Dercetis* cf. *elongatus* Agassiz, 1844. Loc. Úpohlavy near Lovosice. Col. NMP (No. Oc 452, Oc 453). A, cranium, counterpart of Fig. 3B. B, cranium, counterpart of Fig. 3A. C, vertebral column from lateral view. D, vertebral column from dorsal view. E, pectoral girdle. F, dermal scute. G, dermal scute. H, line drawing of Fig. 3A–B (for abbreviations see text).

1902 *Hoplopteryx superbus* (Dixon): (errore), Woodward, A. S., pl. 6.
1912 *Hoplopteryx zippei* Agassiz: Peetz, H., p. 95, pl. 1.

Material

Oc 501 – head and anterior part of trunk; Oc 502 – head only. Both col. NMP, quarry near Řetenice (Fig. 4A); PV-00026, col. FSCU, Richard Mine (Radobýl hill near Litoměřice) – posterior part of the cranium and the anterior half of the postcranial, ca. 80 mm in length (Fig. 5A); PA 1273, col. RMT, Lahošt' by Teplice – disarticulated cranium and anteroventral part of the body (Fig. 6A); PA 1272, col. RMT, Hudcov-Lahošt' near Teplice – postcranial part of the body, about 140 mm in length (Fig. 7A); PA 1271, col. RMT, Lahošt' by Teplice – the hyomandibulare and the pectoral girdle (Fig. 8); PV-00003, col. FSCU, precise locality unknown, the specimen was found in 1879 and the attached light-grey marl typically represents Upper Turonian sediments found in the BCB – the postcranial part, ca. 150 mm in length (Fig. 9A).

Description

Specimens of the moderately deep-body fish attained a standard length of ca. 200 mm. The neurocranium is poorly preserved, and the external surfaces of the bones of the skull are smooth. Any other details are obscured and therefore only the viscerocranium is described. The hyomandibulare (Figs. 4A, 8) is positioned almost vertically, its dorsal part is rather extended and roughly rectangular. A small foramen for the hyomandibular trunk of the facial nerve is located in the centre of the dorsal part. The two hyomandibular projections unite with the metapterygoid to form a large oval fenestra (Fig. 4A). The quadratum (Fig. 4A) is triangular with a large condyle. The premaxilla (Fig. 4A) has toothed alveolar process and on its dorsal surface is a triangular post-maxillary process. The shallow maxilla (Fig. 4A–B) is only slightly deeper posteriorly and lacks sculpture. Two ornamented supramaxillae are present (Fig. 4A–B). The anterior supramaxilla is small, while the posterior is large. The mandibulare (Fig. 4A–B) is deep and massive. It exhibits a particularly large groove for the mandibular sensory canal on the ventro-lateral face of the articulare. The operculare is triangular (Fig. 6A). The lower third of the praeoperculare (Figs. 4A–B, 5A) is sharply curved anteroventrally. The interoperculare (Figs. 4A–B, 7A) is comparatively large, oval, and with a round posterior margin and radial ridges on the external surface. The posterior half of a bow-like proximal ceratohyale is preserved, with four curved branchiostegal rays attached (Fig. 6B).

A posttemporale is present within the pectoral girdle (Fig. 5A–B). It has an extended dorsal edge with a finely serrated and sinuous margin. The cleithrum (Figs. 5A–B, 8) is sickle-shaped and has a narrow and curved ventral part and an extended postero-dorsal part (cleithral plate). Its outer surface is well ornamented with ridges and grooves that are arranged in a chevron-like pattern. The dorsal postcleithrum is oval with a thickened anterior border, and the ventral postcleithrum is long, narrow and is directed posteroventrally (Fig. 7A).

At least 19–20 vertebrae of the vertebral column are preserved (Figs. 7A, 9A) but it is clear that the column is incomplete and the original vertebral count must have been higher. The pre-caudal vertebrae are 4–5 mm long and 3–5 mm high, their middle parts are rather constricted, and two deep cavities are developed on each side. Large prezygapophyses are present on the anterodorsal part of the centra (Fig. 9B): these articulate with the posterodorsal part of the previous centrum.

The anal fin (Figs. 6A, 9A) consists of three stout, gradually increasing spines and about eight soft rays. The pelvic fin is situated close to the cleithrum and consists of seven rays which are attached to the comparatively large and folded basal element (Fig. 6A).

The endoskeleton of the caudal fin (Fig. 9C) consists of large triangular hypurals 1 and 4, with the small hypurals 2 and 3 between. Hypurale 5 and 6 and the epurale are narrow strips. The dorsal and ventral marginal rays (Fig. 9C) are 1.5 times longer than the hypurals. Distal dermal fin elements are very short and obliterated.

The scales (Figs. 7B, 9D) are large and ctenoid, the foremost are circular (10 mm in diameter) and the others are elliptical with an average length of 5 mm and a depth of 9 mm. The anterior edges are sinusoidal and the posterior margins are serrated.

Discussion

Based on body proportions, the shape and sculpture of the bones of the head- and pectoral girdle, the shape of the vertebrae and scales, and the structure of the fins, the specimens can be referred to *Hoplopteryx*. The number and length of anal fin rays, shape of the maxilla, and spiny sculptures on the superficial bones are diagnostic of *H. lewesiensis* (Mantell, 1822) (cf. Woodward, 1902, pp. 15–20, pl. 3, fig. 1, pl. 4, f. 1; Patterson, 1964, pp. 313–321, figs 50, 53; Patterson, 1970, fig. 16) and we therefore refer the specimens to this species. The number of specimens in England and especially in Bohemia do not permit any body size analyses; however, the size of the Upper Turonian specimens from BCB are generally smaller than those from the English Chalk.

Teleostei indet.

Material

PA 1268, PA 1269 (counterpart), col. RMT; Hudcov near Teplice.

Description

PA 1268 (PA 1269) preserves the visceral part of the cranium and the anterior part of the trunk (Fig. 9A–C). Combined, they measure ca. 80 mm in length.

The antorbitale is relatively large and oval in outline and the margin is not serrated. Remains of the sensoric line occur on the surface of the bone (Fig. 9B). The hyomandibulare has a rather large dorsal part: two narrow branches project ventrally from this, connecting the element with the metapterygoid.

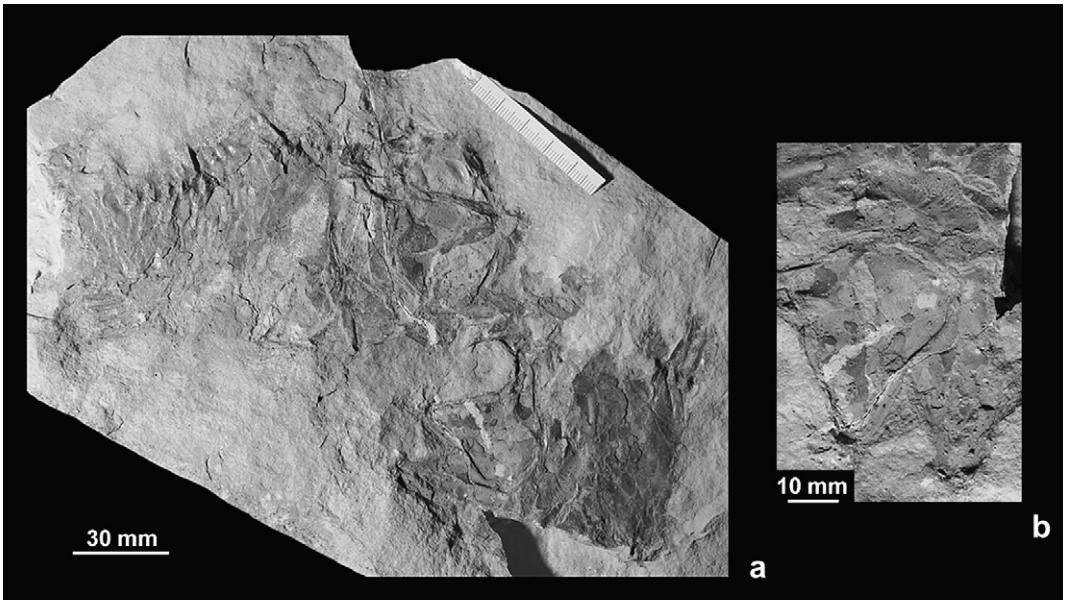

Fig. 4. *Hoplopteryx lewesiensis* (Mantell, 1822). Loc. Řetenice. Col. NMP (No. Oc 501; Oc 502). A, almost complete body and isolated head of other specimen. B, detail of jaws and pterygoids (rotated counterclockwise).

The pterygoids are fragmentary, and there are no dents on their medial surfaces. The quadratum is triangular (Fig. 9B), higher than wide, and with its internal surface ornamented by striae that originate from the articular joint. The mandibular (Fig. 9B) is about 2.5 times longer than its maximum height. The articulare (in medial view) reaches almost half the length of the complete mandible and the articular joint is short. The operculare (Fig. 9C) is tall, with its dorsal part rounded and the ventral part pointed. A few short and fine grooves occur on the external surface close to the opercular articulation. The exposed part of the suboperculum is rounded, the praeoperculum is only fragmentarily preserved. The ceratohyale distale (Fig. 9B) is pentagonal and the posterior part is larger than the anterior. The external surfaces are decorated by radial grooves that project anteriorly and posteriorly from the bone centre. The ceratohyale proximale is triangular. Several branchiostegal rays extend from the subjacent part of the ceratohyale.

The pectoral girdle is curved anteroventrally and anterodorsally; the cleithrum is not distinctively extended. The vertebral centra are poorly preserved, the basal parts of the neural arches are rather dilated and, between the neural spines, long axonosts are interposed, of which ca. 11 are preserved. The proximal half of the axonosts are finely extended. Four or five stout spines of the dorsal fin are visible (Fig. 9B). The scales are thin, moderately large, exhibit concentric growth zones, and

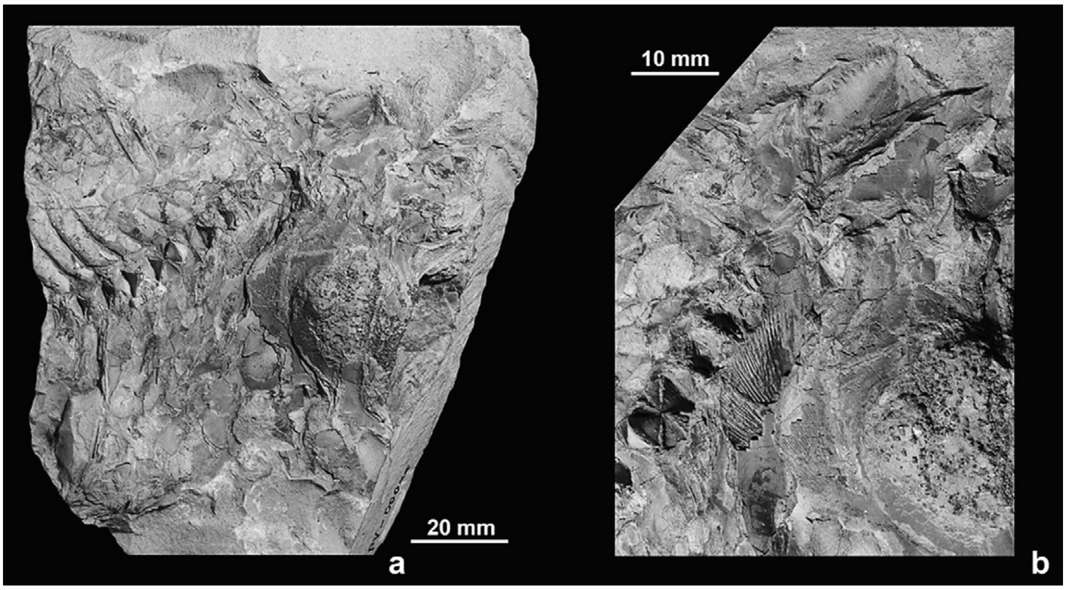

Fig. 5. *Hoplopteryx lewesiensis* (Mantell, 1822). Loc. mine Richard near Litoměřice. Col. FSCU (No. PV-00026). A, anterior part of body. B, detail of operculare and cleithral plates.

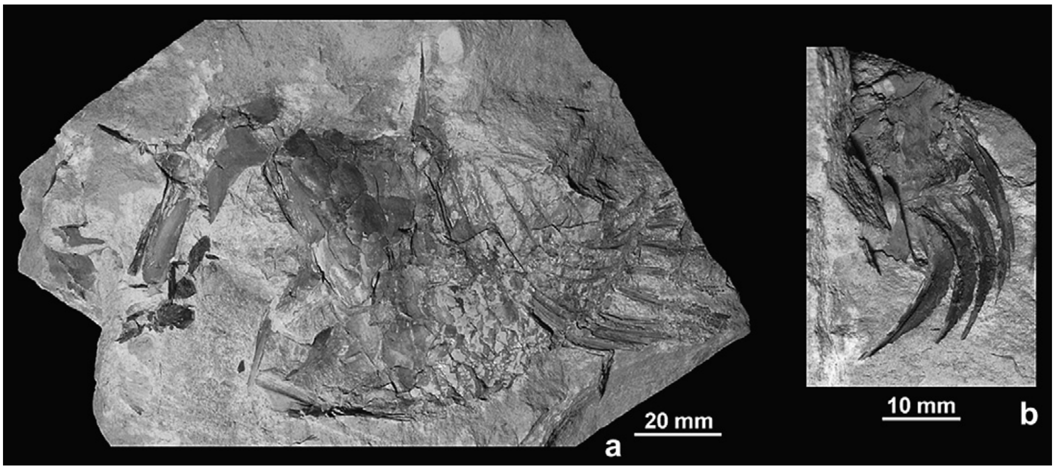

Fig. 6. *Hoplopteryx lewesiensis* (Mantell, 1822). Loc. Lahošt' by Teplice. Col. RMT (No. PA 1273). A, anteroventral part of body. B, ceratohyals and branchiostegal rays (rotated counterclockwise).

have rounded posterior margins and sinusoidal (longbow-like) anterior margins.

Discussion

The specimen does not show similarities to any taxa previously described from the BCB. Some characters (shape of operculum lacking marked sculptures on its outer surface; large antorbitale; proportions of the mandible; tall quadratum; similar shape of proximal and distal ceratohyales; cleithrum not expanded caudally; stout rays of dorsal fin increase gradually) resemble *Berycopsis elegans* Dixon, 1850 from the English Chalk (Woodward, 1902, pp. 7–10, pl. 1, f. 1; Patterson, 1964, pp. 271–275, fig. 23, 28–30). However, other significant features of *B. elegans* (dorsal fin shifted more caudally, antorbitale tall and circular, hyomandibulare narrower and not divided into two branches, the length of articulare visible from medial aspect which attains more than half of the mandible length - compared with Patterson, 1964, pp. 271–273, f. 23, 28, 29) cannot be recognized in PA 1268 (PA 1269). Due to these differences, we hesitate to refer the described specimen to *Berycopsis elegans*, and although the gross morphology is indicative of *Berycopsis*, we prefer to place PA 1268 (PA 1269) in open nomenclature until more material permits a diagnosis.

5. Discussion and conclusions

In the BCB, the taxa described here were previously known exclusively from the Lower and Middle Turonian. The new records extend their stratigraphic ranges into the Upper Turonian. The genus *Halec* is represented by *H. 'laubei'* Fritsch (Lower Turonian) and *H. sternbergi* (Lower and Middle Turonian: the specimen described here extends the occurrence to the Upper Turonian). The specimen of *Dercetis* described here is a small form, but representatives of the genus can vary considerably in size in the Lower-Middle Turonian of the BCB. Larger sized (twice the size) taxa include *D. reussi* Fritsch from the Lower Turonian and '*Schizospondylus dubius* Bayer' (congeneric with *Dercetis* sp.: see Ekrt, 2000) from the Middle Turonian (Fritsch and Bayer, 1905, p. 5, fig. 4–7, pl. 1, fig. 6). The only Upper Turonian representatives of *Hoplopteryx* (*H. lewesiensis*) are morphologically identical to those

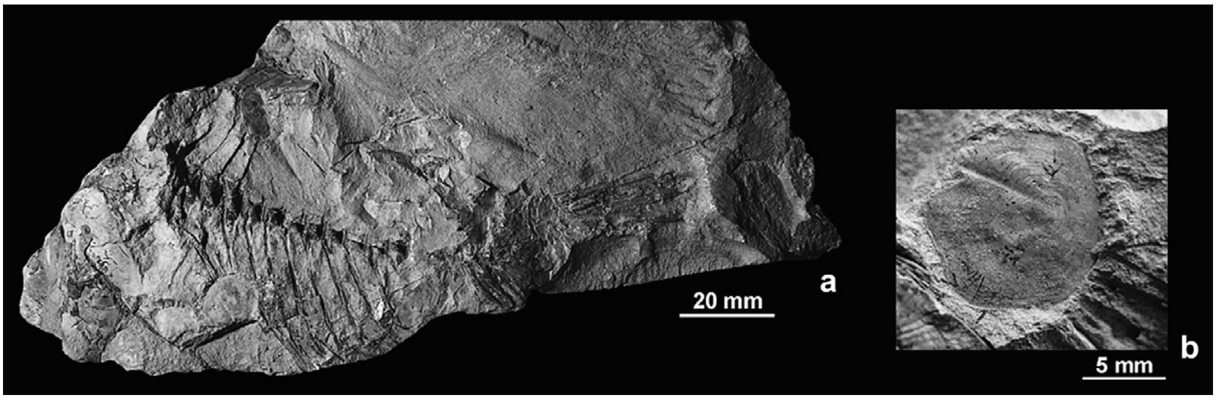

Fig. 7. *Hoplopteryx* sp. Loc. Hudcov-Lahošt' by Teplice. Col. RMT (No. PA 1272). A, postcranial part of body. B, isolated scale.

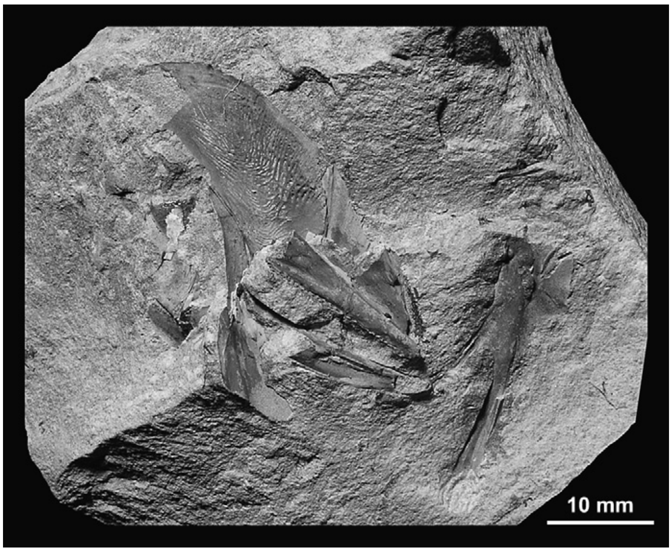

Fig. 8. *Hoplopteryx lewesiensis* Loc. Lahošt' by Teplice. Col. RMT (No. PA 1271). Hyomandibulare and remains of pectoral girdle.

from the Lower to Middle Turonian; however, they tend to be larger and compare well with those described from southern England.

Palaeobiogeographically, the Turonian fish fauna from Bohemia is a typical Boreal assemblage and the overall similarity between the Bohemian and English fish faunas indicates faunal communication between the two areas. Based on Turonian palaeogeography (Ziegler, 1988), both areas were part of the same large European shelf sea. *Hoplopteryx lewesiensis* is known from Cenomanian-Lower Senonian successions of the English Chalk (Patterson, 1964, p. 321). It is likewise recorded from the Turonian of Rouen and Fontvanne in France (Patterson, 1964, p. 321), the Upper Cretaceous of Korotoyak Voronezh in Ukraine (Peetz, 1912, pp. 1–8, pl. 5), the Turonian of Opole in Upper Silesia, Poland (Leonhard, 1897, p. 68) and from the Lower Campanian of Texas (Stewart, 1996, p. 391). Isolated remains from the Turonian of Saxony (Geinitz, 1875, pp. 220–222, pl. 43, figs 29–31, pl. 44, figs 8–13; Geinitz, 1868, pp. 45, 46, pl. 3, figs 1, 2), from the Upper Cretaceous of the Moscow area (Russian Federation) (see

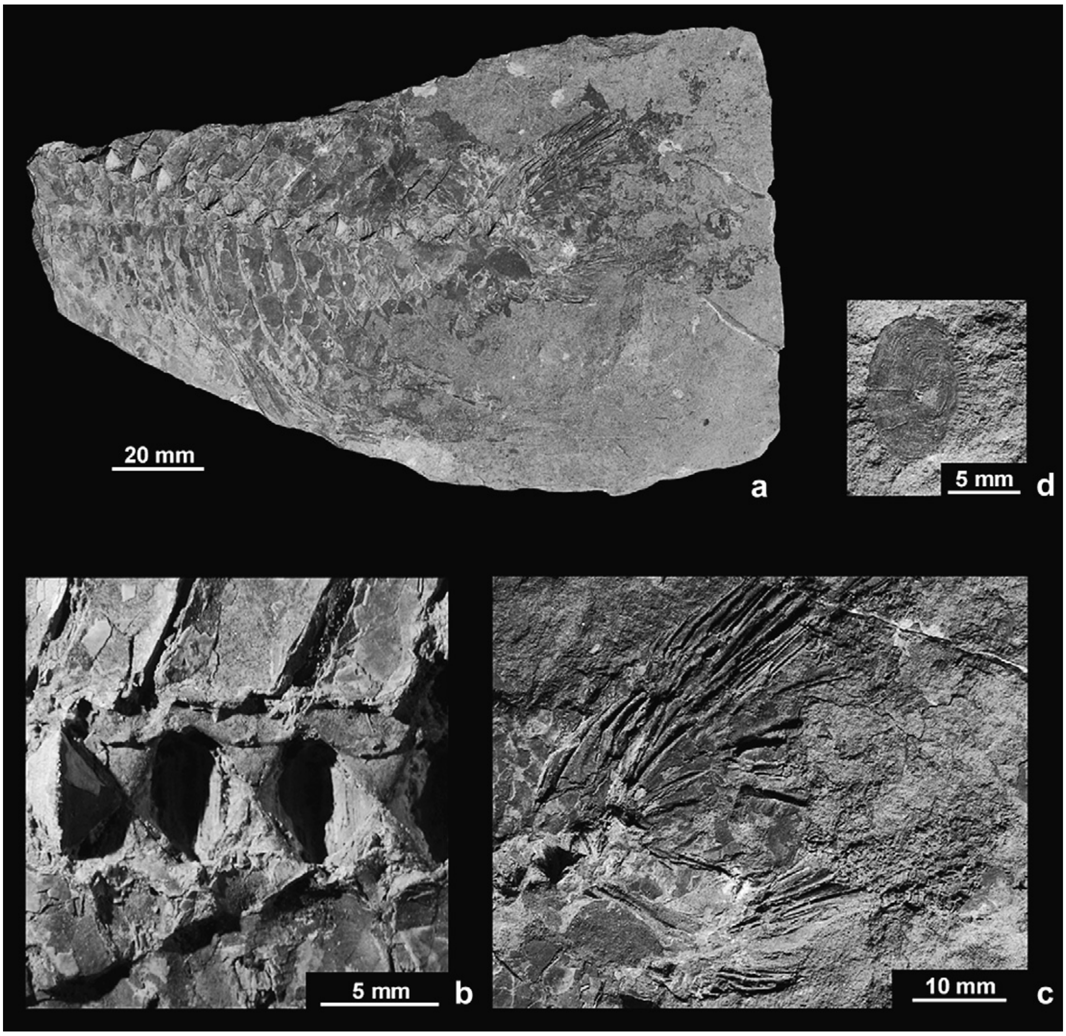

Fig. 9. *Hoplopteryx* sp. Loc. unknown (BCB). Col. FSCU (No. PV-00003). A, postcranial part of body. B, detail of vertebral column. C, endoskeleton of caudal fin. D, isolated scale.

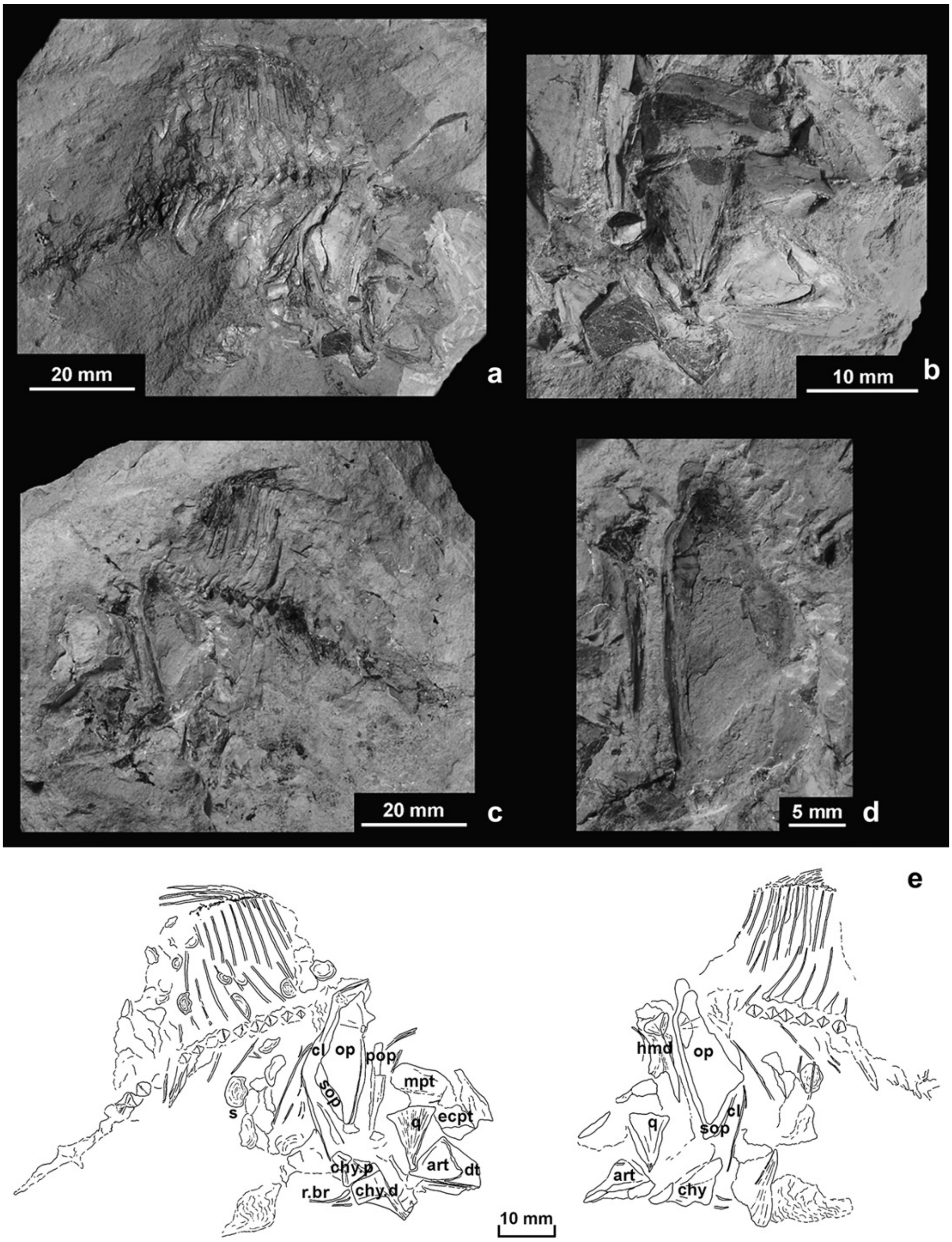

Fig. 10. Teleostei indet. Loc. Hudcov by Teplice. Col. RMT (No. PA 1268, PA 1269). A, anterior part of body, counterpart of Fig. 10C. B, detail of cranium. C, anterior part of body, counterpart of Fig. 10A. D, detail of operculare. E, line drawing of Fig. 10A–C (for abbreviations see text).

Auerbach, 1865), and from the Lower Senonian of Cracow (Poland; see Książkiewicz, 1927, pp. 983, 1002, pl. 1) also show close affinities to this species and may be synonymous with it. *Dercetis elongatus* is only known from the Turonian to Campanian of southern England (Taverne, 1987, p. 105). A possible representative of the species, however, may be the vertebral column described from the Turonian of Saxony (Geinitz, 1875, pl. 43, fig. 32). *Halec sternbergi* is known only from the BCB, but the *H. eupterygius* from the Turonian and Senonian of southern England is quite similar and they seem to be closely allied. Whether or not they are synonymous can only be decided with more and better preserved material.

Some ecological observations on the genera and species discussed here can be based on morphological comparisons and recent analogies. On the basis of body shape and osteology, *Halec* was presumably a fast swimming predator, ca. 1 m long. Direct evidence for predation on other fish is provided by one specimen from the Lower Turonian of the BCB, which is preserved with the skeleton of small fish in the alimentary canal. *Halec* was adapted to a pelagic life style.

The Dercetidae were probably small predators, as suggested by fish remains preserved in the alimentary canal of a specimen from the English Chalk (Woodward, 1903, p. 69, fig. 16). As the smallest specimens reached only ca. 300 mm, it is likely that they preyed only on small (juvenile) fishes, possibly even on invertebrates. Based on its morphological similarity to some recent bathypelagic fishes, some authors have suggested a bathypelagic mode of life for the Dercetidae (Siegfried, 1954, pp. 28–30), with episodic excursions to the littoral zone (Taverne, 1987, p. 106). Albers and Weiler (1964, p. 26) described remains of small Dercetidae from the Lower Campanian of Aachen (Germany). This locality is characterized by a facies interpreted as representing a circumlittoral environment (Albers and Weiler, 1964, pp. 28–31), and so they suggested that juveniles may have lived in littoral settings and that adults migrated to bathypelagic settings. No bathypelagic setting ever occurred in the BCB and water depth, even in distal settings with the most pelagic influence (e.g. Úpohlavy area; see Wiese et al., 2004), hardly exceeded 100 m. However, adult Dercetidae occur frequently in the Turonian of the BCB.

Hoplopteryx, ca. 250 mm long when adult, is inferred to have been a good swimmer with excellent maneuverability; morphologically it was well adapted to littoral environments. Scales – most probably from *Hoplopteryx* – were also found in Aachen (see above). Similar scales come from 'Lower Senonian' locality near Cracow in Poland and are interpreted as pelagic (Książkiewicz, 1927, pp. 982–984, 1002). The fishes were probably active hunters of small invertebrates and their predatory activity might have occurred at twilight and daybreak.

In the Upper Turonian of the BCB, numerous localities yielded disarticulated but identifiable fish remains that complete our impression of the palaeoecology. Pycnodontiforms are represented by isolated button-like teeth that reflect their durophaguous diet. Especially common are scales of *Osmeroides*, a fish which reached 500 mm in total length. *Osmeroides* probably trawled for small invertebrates and was well adapted for the pelagic environment. Rather sparse are jaws, teeth and opercular bones of *Enchodus*, a small predator (hunting small fishes) estimated to reach 200 mm in length, but the discovery of some very large teeth (Wiese et al., 2004), indicates the presence of some specimens that must have been considerably larger. They are regarded as predators of open pelagic settings (Kriwet and Gloy, 1995, p. 335) but, according to Goody (1976, pp. 108, 109), the forms could be fossilised under a variety of conditions: shallow water near the coastline to deep water. Some rare, isolated barbed teeth document the occurrence of *Cimolichthys*. In body size, the representatives of the genus were comparable to *Enchodus*. Similarly, they are interpreted as predators of the open sea (Goody, 1970, p. 17), but specimens from Aachen (see above) suggest that they also inhabited circumlittoral environments (Albers and Weiler, 1964, p. 31). Scales of fishes classified as indet. Ichthyodectiformes are frequently found and represent large fishes (reaching ca. 1 m). These were fast steady swimmers of pelagic waters.

The specimens described here represent almost all of the articulated fish remains from the Upper Turonian of BCB. The rather low number is out of accord with large number of well preserved invertebrate fossils and numerous disarticulated fish bones and scales in these Upper Turonian fossil sites. The fossilization conditions are suitable for excellent preservation of scales and bones but, except for a few specimens recorded here, are always disarticulated. Most of the fish bodies were surely desintegrated by predators, scavengers and microbial decompositors.

The ecological structure of the described Upper Turonian ichthyofauna, combined with the ecological role played by sharks and reptiles (Ekrt et al., 2001; Wiese et al., 2004), reveals a large number of predators of different sizes combined with a shortage of vertebrates feeding on invertebrates and plankton.

This example from the BCB represents one of many similar ichthyofaunas from the other Turonian areas of the boreal region. The existence of these boreal ichthyofaunas was related to the extension of pelagic seas caused by the eustatic maximum of the Upper Turonian.

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