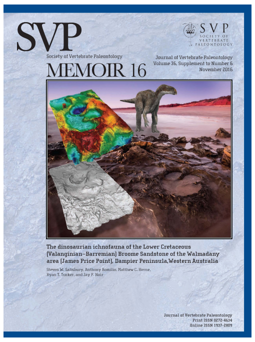

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SHORT COMMUNICATION

FISHING IN THE CENTRAL ATLANTIC, AN EARLIEST CENOMANIAN ICHTHYODECTIFORM FROM DSDP SITE 367, CAPE VERDE BASIN

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Ichthyoliths (fossil fish microremains) from geological core samples are commonly recorded and where present allow dating and contribute to the knowledge of the evolution of fish faunas through time (see, for instance, Sibert et al., 2014; Sibert and Norris, 2015, for the Ocean Drilling Program). However, reports of articulated fish specimens in cores are much rarer due to the limited chance of a core drill returning a small-diameter cylinder of rock encompassing the fossil to the surface.

Examples of articulated fishes described from cores include specimens of Permo-Carboniferous actinopterygians near the city of Zurich, Switzerland (Bürgin, 1990), as well as a new taxon of a Cenomanian ellimmichthyiform from Alberta, Canada (Hay et al., 2007), and two new Eocene cypriniform fishes from Guangdong and Henan, China (Liu, 1957; Zhou, 1990; Chang and Chen, 2008).

In this paper, we report the discovery of an ichthyodectiform fish fossil collected during re-evaluation of a core from DSDP Leg 41 Site 367 at the IODP Bremen Core Repository, Germany (Fig. 1A). The core was recovered from a well drilled in the Cape Verde Basin, ca. 400 km offshore from the West African Atlantic Margin, to test the early basin evolution of the Central Atlantic region (Lancelot et al., 1977). The fossil fish was discovered in core 21 section 6 at 699.9 m measured depth, preserved on the bedding surface of a bituminous marl. Reports from the DSDP expedition had previously recorded fish vertebrae in the same subunit, suggesting abundance and/or high preservation rate of fish remains in Central Atlantic waters during the Albian to Cenomanian period (Lancelot et al., 1977:fig. 6). Associated calcareous nannofossils indicate an earliest Cenomanian age for the cored interval containing this specimen (Fig. 1B).

Institutional Abbreviations—**DSDP**, Deep Sea Drilling Project; **IODP**, International Ocean Drilling Programme; **MHNG**, Natural History Museum of Geneva, Geneva, Switzerland; **NARG**, North Africa Research Group, University of Manchester, Manchester, U.K.

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Lithological Description

Previous descriptions of core 21 (Lancelot et al., 1977) dated the unit as early Turonian to late Aptian/early Albian and placed it in Subunit 4a of their lithostratigraphic classification. The interval is described as black shale facies with a high organic carbon content, and geochemical studies record total organic carbon content ranging from 8% to 28% (Deroo et al., 1978; Brumsack, 1980). Re-examination of core 21 as part of this study allows the facies description to be further subdivided into two interbedded mudstone subfacies (Fig. 1B).

Subfacies A—Light to dark gray, fissile, calcareous mudstone containing an abundant calcareous nannofossil assemblage. The facies is finely laminated, and bedding planes commonly display speckles of white shelly debris (<1 mm in diameter). Core section 21-2 shows a branching form of bioturbation interpreted as *Chondrites*, with a burrow diameter of 0.5 mm, indicating an offshore, fully marine ichnofacies (Gerard and Bromley, 2008). The percentage of subfacies A increases towards the base of core 21 where the ichthyodectiform was discovered.

Subfacies B—A noncalcareous, unlaminated, black, carbonaceous mudstone. The material is extremely fragmented in the core trays and shows a sharp contact with subfacies A. Bands of yellow- to orange-stained mudstone are interpreted as sulfur-rich horizons.

Calcareous Nannofossil Dating

An age no older than latest Albian is confirmed by the high relative abundance (HRA) of the *Broinsonia signata/enormis* group and co-occurrence with *Gartnerago chiastia*, both having first appearance datums (FADs) at the base of the last ammonite zone of the Albian (*A. briacensis* Zone; Gale et al., 1996). A level within the earliest Cenomanian is confirmed by the

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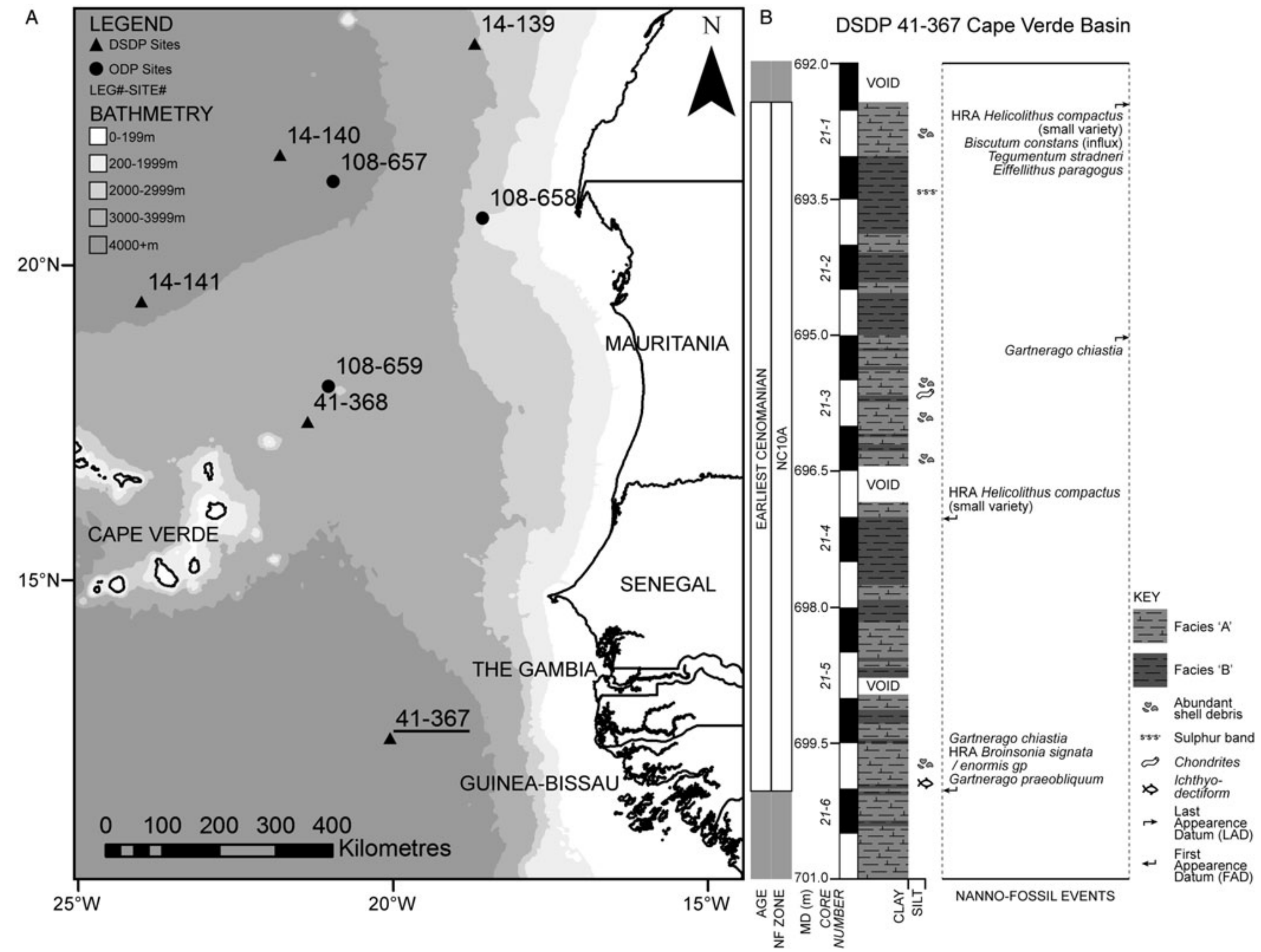

FIGURE 1. Geographical and stratigraphical context for the ichthyodectiform fossil. **A**, map of the West African Atlantic margin with IODP sites; DSDP Leg 41 Site 367 highlighted. **B**, lithology log of core 21 from DSDP Leg 41 Site 367 with calcareous nannofossil events and nannofossil (NF) subzone after Roth (1978) and Roth et al. (1983). Subfacies A and B described in the text. The location of the ichthyodectiform fossil is shown in core 21-6 at 699.9 m measured depth.

sediments lying between the FAD of *Corollithion kennedyi* and last appearance datums (LADs) of *Watznaueria britannica* and *Hayesites albiensis* (Burnett et al., 1998). This age assignment is supported by the presence of *Biscutum constans* (influx), *Eiffellithus paragogus*, *Bukrylithus ambiguus*, and *Tegumentum stradneri*.

SYSTEMATIC PALAEONTOLOGY

TELEOSTEI Müller, 1846
ICHTHYODECTIFORMES Bardack and Sprinkle, 1969
gen. and sp. indet.

Description

The specimen is housed at the Natural History Museum of Geneva, Switzerland (catalog number MHNG GEPI V5709). It has been prepared with a thin needle under a binocular microscope. It consists of a small skull, about 20 mm estimated length, with the anterior-most ethmoid region and anterior part of the mandible absent (Fig. 2). The anterior part of the trunk, with about 10 vertebral centra and their corresponding ribs, and the proximal part of the pectoral fin, are preserved.

The ethmoid region, which is highly derived in ichthyodectiforms (Patterson and Rosen, 1977), is poorly preserved. However, a part of the lateral ethmoid with a posteroventrally directed blunt spine is identified. Anterior to the lateral ethmoid, an anteroventrally oriented ossification is interpreted as the ethmopalatine, which is an autapomorphic ossification of the ichthyodectiforms (Patterson and Rosen, 1977). A large and elongated extrascapular is present above the posterior part of the skull roof. Its presence, as well as the visible departure of a medial dorsal extension, indicates that a large supraoccipital crest is likely present underneath the extrascapular. The limits between the bones of the skull roof cannot be recognized, but the massive otic and occipital parts of the braincase are typical features of ichthyodectiforms. The base of a parietal-epioccipital ridge is present, but the original extent of the crest is unknown. The posttemporal fossa is visible. A posterior extension at the level of the base of the posttemporal fossa is made by the intercalar, but the precise contour of this

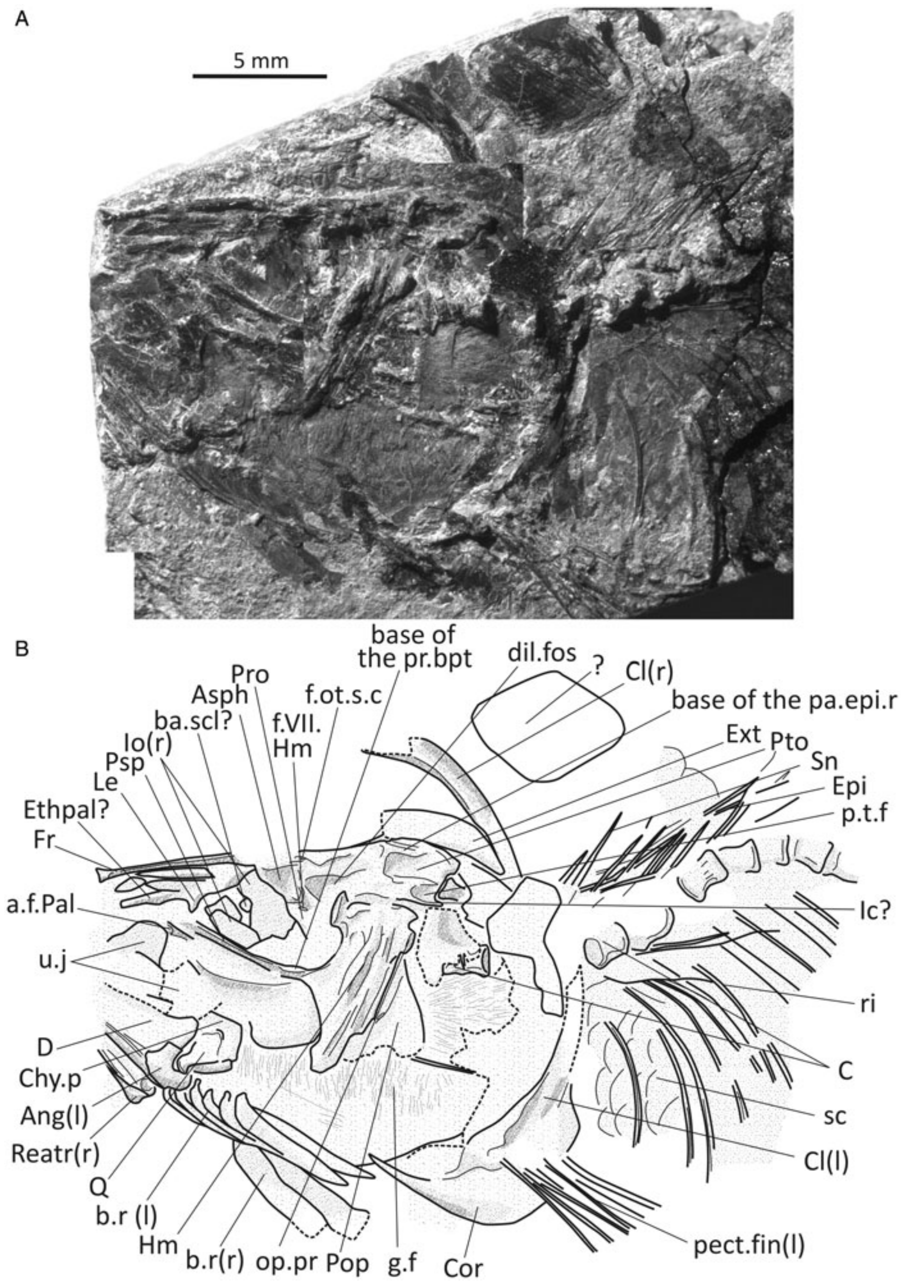

FIGURE 2. MHNG GEPI V5709, ichthyodectiform indet. **A**, photograph and **B**, line drawing. **Abbreviations**: **a.f.Pal**, articular facet for the autopalatine; **Ang**, angular; **Asph**, autosphenotic; **ba.scl**, basal sclerotic bone; **b.r**, branchiostegal ray; **C**, centrum; **Chy.p**, ceratohayl posterior; **Cl**, cleithrum; **Co**, Coracoid; **D**, dentary; **dil.fos**, dilatator fossa; **Epi**, epineural; **Ethpal**, ethmopalatine; **Ext**, extrascapular; **f.ot.s.c**, foramen for the otic sensory canal; **f.VII.Hm**, foramen for the hyomandibular branch of the facial nerve; **Fr**, frontal; **g.f**, gill filament; **Hm**, hyomandibula; **Io**, infraorbital; **Le**, lateral ethmoid; **Pop**, preopercle; **op.pr**, opercular process; **pa.epi.r**, parietal-epioccipital ridge; **pect.f**, pectoral fin; **pr.bpt**, basipterygoid process; **Pro**, prootic; **Psp**, parasphenoid; **p.t.f**, posttemporal fossa; **Pto**, pterotic; **Q**, quadrate; **Rart**, retroarticular; **ri**, rib; **sc**, scales; **Sn**, supraneural; **u.j**, upper jaw.

ossification cannot be recognized. A deep dilatator fossa is present more anteriorly. A pore for the otic sensory canal opens above the autosphenotic and seems to extend anteriorly by a groove. The exact shape of the autosphenotic cannot be reconstructed, but a moderately developed lateral spine is present.

Visible ventral to the autosphenotic is the prootic, which is pierced by a large pore for the hyomandibular branch of the facial nerve. The parasphenoid is preserved as an elongated edentulous bar in the orbital region. The basipterygoid process was originally present but was broken during preparation. Initial observation, as well as the orientation of the broken surface, indicates that the process was prominent and angled upward. Fragments of thin ossifications are present in the orbital space; they probably correspond to pieces of the right infraorbitals. A small fragment, which appears to be thicker, is regarded as a fragment of a basal sclerotic, but this identification is very tentative. Except for a few fragments, nothing from the upper jaw and from its potential dentition can be recognized. The hyomandibula is relatively well preserved, although crushed. The opercular process is well defined, but the articular head is difficult to follow. An articular surface is anteriorly located, in an almost vertical plane. This is an unusual condition possibly caused by deformation. There is a well-developed lateral crest and apparently a fossa located anterior to the crest, but only a faint fossa is observable posterior to it. Anteriorly, the hyomandibula forms a thin, blade-like extension. The quadrate is a stout ossification, with a reduced posterior process. Underneath the quadrate is visible a fragment of the posterior ceratohyal. The upper part of the vertical limb of the preopercle with the sensory canal running along its anterior margin is preserved and indicates that this part of the bone was broad. The other bones of the opercular series are not preserved, but numerous long and closely spaced gill filaments are visible in this area. Part of the left lower jaw is visible in lateral view, and the posteroventral corner of the right mandible is visible in internal view. The latter shows a retroarticular bone, extending slightly anteriorly under the angular. It is unclear if this bone has a tiny or no contribution to the articular facet. The angular appears to be small in lateral view, and it clearly contributes to the articular facet. The shape of the articular in internal view cannot be determined. The dentary is deep, but its dorsal margin cannot be identified. No teeth are visible. A deep groove running along the ventral margin marks the path of the mandibular sensory canal.

The cleithrum has a regularly curved anterior margin, not marking a right angle. The coracoid is well developed ventrally and probably meets its counterpart. About eight rays are present in the pectoral fin. There is no enlarged anterior ray, but it is likely than the anterior-most rays are missing.

The vertebral centra are poorly preserved. They are hourglass-shaped, and a longitudinal lateral ridge separating two deep elongated pits is visible on some centra. Fragments of supraneurals, whose shape cannot be reconstructed, as well as long epineurals, are present. The ribs are stout, elongated, and grooved. Cycloid scales deeper than long are present.

AFFINITIES

The probable presence of an ethmopalatine, an edentulous parasphenoid, a contribution of the angular to the articular facet for the quadrate, the presence of very elongated epineurals, the probable presence of a well-developed supraoccipital crest, the large coracoid, and the shape of the scales are evidence for referring this specimen to the ichthyodectiforms (Patterson and Rosen, 1977). The specimen, however, is too poorly preserved to be easily identified at the generic and specific levels, or to be included in a phylogenetic analysis. Below, we discuss its characters within the phylogenetic framework of Cavin et al. (2013) in order to search for characteristics shared with ichthyodectiform clades.

Vertebral centra with a longitudinal lateral ridge separating two deep elongated pits are characters present in most taxa of the clade including *Heckelichthys* and more derived taxa. The occurrence of a prominent, angled-upward basipterygoid process is a character shared by *Gillicus* and the cladocyclids. The mandible marked by a groove associated with the openings of the mandibular sensory canal is a homoplastic feature present in *Gillicus*, the cladocyclids, the ichthyodectids, and some basal ichthyodectiforms, but not in saurodontids more derived than *Gillicus* (but this character is not known in all saurodontid genera). The fossa located anteriorly to the lateral crest of the hyomandibula was also observed in *Gillicus arcuatus* (Cope, 1875) and *Prosaurodon pygmaeus* (Stewart, 1999). The angled shape of the parasphenoid of our specimen allows us to exclude it from the ichthyodectids. Consequently, the specimen shares most of its characters with *Gillicus* and the cladocyclids. Unfortunately, both characters distinguishing these clades are uncertain in our specimen (i.e. retroarticular contribution to the articular facet with the quadrate and shape of the opercular process on the hyomandibula). The opening of the otic sensory canal seems to extend anteriorly in a groove in our specimen, which is a character found in *Cladocyclus* and *Chiromystus* among the cladocyclids, and in *Gillicus*. We can exclude the genus *Cladocyclus*, which shows a right-angled cleithrum, in contrast to the fish studied here (Berrell et al., 2014). Both species of *Gillicus* and *Chiromystus mawsoni* have a broad dorsal extremity of the preopercle such as the one encountered here. Another character shared by the new specimen and *Chiromystus*, not used in the phylogenetic analysis of Cavin et al. (2013), is the presence of a deep dilatator fossa. Body size is not a reliable specific character for fish, but it should be mentioned that the specimen described here is very small compared with most Cretaceous ichthyodectiforms. *Chiromystus mawsoni* (Cope, 1885) is one of the smaller known ichthyodectiforms.

Currently, three species of *Chiromystus* are recognized. The type species, *Chiromystus mawsoni*, is a poorly known species ranging from the late Hauterivian to the early Albian of the Recôncavo and Sergipe basins in Brazil (Silva Santos, 1949). The Recôncavo Basin has also yielded *?Chiromystus woodwardi*, but the systematic status of that taxon is still uncertain (Silva Santos, 1949, Cavin et al., 2013). *Chiromystus guinensis* has been recorded from the Aptian of Punta Yeke and Bolondo, Equatorial Guinea, and Cocobeach, Gabon (Weiler, 1922), and was redescribed by Taverne (2010). *Chiromystus* thus constitutes a potential close relative of our new specimen, although it occurred in older and freshwater or brackish deposits. *Gillicus arcuatus* is reported from marine deposits at several localities from the late Albian to the Campanian of North America, and *G. serridens* (Woodward, 1901) is described from a single specimen from the Albian of Folkestone, Kent, England, in marine deposits as well.

SUMMARY

The discovery of the ichthyodectiform specimen in a borehole sample collected ca. 400 km offshore the West African Atlantic Margin at 699.9 m measured depth is an exceptional event that deserves to be recorded. Although its systematic assignment is too uncertain to draw precise palaeobiogeographical implications, the fish bears a strong similarity to *Chiromystus*, which would indicate a late marine connection of this genus (or a related representative of this lineage), which has been described on both sides of the opening South Atlantic in the Early Cretaceous. If the fish is related to *Gillicus*, with which it also shares characteristics, it extends southward the known geographical distribution of that genus, currently known from the North Atlantic only.

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