

Remains of *Saurichthys* (Pisces, Actinopterygii) from the Early Triassic Wordie Creek Formation of East Greenland

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Previously undescribed specimens of *Saurichthys* from the basal part of the Early Triassic Wordie Creek Formation (Griesbachian) of East Greenland demonstrate a remarkably complete squamation especially in the anterior trunk portion. Scales of the mid-lateral row are high and those of the mid-dorsal and mid-ventral rows broad and conspicuous by having a pronounced longitudinal keel on their inner surface; additional dorso-lateral and ventro-lateral scale rows are present. This pattern resembles that of *Saurichthys dayi* from the Early Triassic of Alberta and British Columbia. Differences in fin morphology suggest, however, that the Greenland form is probably not conspecific. A second Early Triassic species of *Saurichthys* occurring in East Greenland probably comes from a higher stratigraphic level (late Griesbachian to early Dienerian) with a different ichthyofaunal composition.

Key words: *Saurichthys*, East Greenland, Wordie Creek Formation, stratigraphy.

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Numerous fossil fishes from the Early Triassic of East Greenland have been collected in the course of several Danish palaeontological expeditions in the 1930s. First remains of *Saurichthys* Agassiz, 1834 were discovered by Eigil Nielsen in 1932 and only briefly mentioned in his subsequent publications (Nielsen 1935, 1936, 1961). The fourteen specimens reported in Nielsen (1961) are stored in The Natural History Museum of Denmark, Copenhagen (Geological Museum – MGUH numbers) and have never been described in detail, except for two skulls (MGUH-VP-992 and -994) that were published by Mutter *et al.* (2008) who referred to them as *Saurichthys* cf. *ornatus*.

Already Nielsen (1936) suggested the possible presence of more than one saurichthyid species in his collection because of differences in size and proportions. A preliminary survey of the material indicates that the occurrence of different morphotypes probably corresponds to two distinct stratigraphic levels. At least the specimens MGUH-VP-988, -997 and -1000 are referable to a single morphotype based on their peculiar squamation. They are described in the following account.

Material and methods

The three specimens described below have been collected by E. Nielsen during the 1930s in the Kap Stosch area at the north coast of Hold with Hope, East Greenland (Fig. 1). Nielsen (1935) distinguished six subsequent vertebrate-bearing levels, i.e. five “fish zones” and one “tetrapod zone”, in his study area. Of the 14 *Saurichthys* specimens enumerated in Nielsen (1961), five were referred to his fish zone 2 and nine to his fish zone 5. According to the labels, specimens MGUH-VP-1000 and -997 were found in 1933 at the so-called Østlokaliteten and Vestlokaliteten, respectively. These localities are mentioned in Nielsen (1935: fig. 19) and belong to his fish zone 2 (Nielsen 1935: 100 ff.). Both localities are situated in the Neviatiakdal area and placed in the former *Otoceras* beds. This level corresponds to the interval from *Hypophiceras martini* to *Metophiceras subdemissum* zone (lowermost upper Griesbachian) in the stratigraphic scheme of Bjerager *et al.* (2006) and occurs near the base of the Wordie Creek Formation only few metres above the presumed Permian-Triassic boundary. No detailed information is given on the specimen MGUH-VP-988.

All specimens are preserved as concretions in laminated mudstones deposited under marine conditions during a period of local sea-level rise (Bjerager *et al.* 2006).

The fossils were studied under a WILD binocular microscope and photographed with a NIKON D 80 digital camera with a 35-70 mm zoom lens. Drawings were made by means of a camera lucida as well as on the basis of photographs. To enhance contrasts, specimen MGUH-VP-988 B was examined and photographed immersed in alcohol.

The use of open nomenclature follows Bengtson (1988).

Systematic palaeontology

Subclass: Actinopterygii Cope, 1887
 Order: Saurichthyiformes Aldinger, 1937
 Family: Saurichthyidae Owen, 1860
 [sensu Stensiö 1925]
 Genus: *Saurichthys* Agassiz, 1834
 Type species: *Saurichthys apicalis* Agassiz, 1834

Saurichthys aff. *dayi* (Raymond, 1925)

Referred material: MGUH-VP-1000 (anterior trunk portion and incomplete skull), MGUH-VP-997 (trunk fragment), MGUH-VP-988 A, B (trunk fragment with dorsal and anal fins in part and counterpart); possibly also MGUH-VP-990 (fragmentary skull) and MGUH-VP-996 (caudal peduncle).

Description

Specimen MGUH-VP-1000 (Fig. 2) is an incomplete skull with the anterior body portion preserved in a concretion. Most dermal bones of the skull are weathered away and only the right mandible and the right opercular are preserved in lateral view. The preserved portion of the mandible is 124 mm long and the tip of the snout is missing. Delicate subvertical striae can be recognized on the dentary. Some teeth are preserved on both jaws, the largest of them being ca. 4 mm high by 2.5 mm wide.

The opercular is considerably higher than long (28 mm high, 17 mm long) and ornamented with concentric ridges of ganoin parallel to its margins. The cleithrum has the shape of an inverted 'T' whose anterior and posterior branches are nearly equal in length.

The pectoral fin is fan-shaped and consists of at least 18 unsegmented lepidotrichia.

The postcranial body fragment shows 18 mid-lateral scales. They are very high (ca. 25 mm in height to 5 mm in length along the lateral line) and roughly rectangular in shape, and the lateral line sensory canal divides them into a somewhat smaller upper (dorsal) part and a larger lower (ventral) part. The scales are inclined anteroventrally and ornamented with a combination of ridges and tubercles of ganoin. In the lower parts, subvertical and somewhat sigmoidal ridges predominate and tubercles are restricted to the margins of the scale. The pattern is similar in the upper parts of the anteriormost scales, whereas farther back the ornament is composed of tubercles arranged in subhorizontal rows.

Further scales are present on the body but neither their number nor their exact shape can be determined due to the preservation. It seems, however, that the

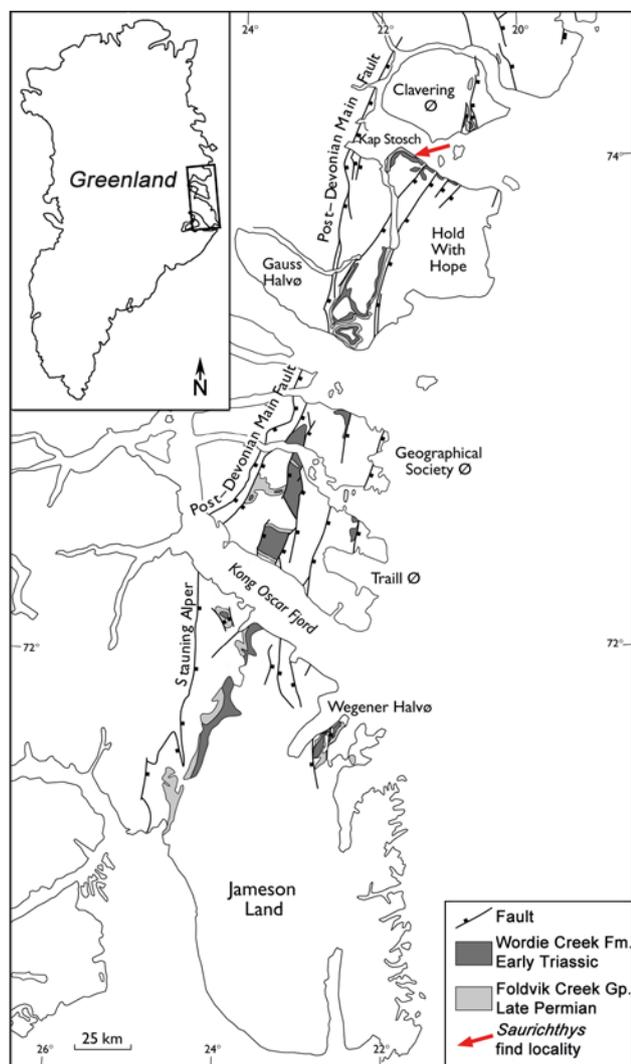


Fig. 1. Map of East Greenland showing the outcrop areas of the Early Triassic Wordie Creek Formation and the assumed find locality of *Saurichthys* aff. *dayi* on the north coast of Hold With Hope. Modified from Bjerager *et al.* (2006).

anterior scales of the mid-dorsal row are oval and very small, increasing in size posteriorly.

Specimen MGUH-VP-997 (Fig. 3) represents a cast of a body fragment presumably between the skull and the pelvic fins. Remnants of 8 mid-lateral scales are visible. They show the same proportions as described for specimen MGUH-VP-1000, but it can be seen that the sigmoidal subvertical ridges that constitute the ornamentation of their lower parts are mainly composed of fused tubercles. The upper parts of the scales are ornamented with distinct tubercles arranged in curved, subhorizontal rows.

Three rows of scales can be distinguished between the mid-lateral and the mid-ventral scale row. The scales correspond to the mid-lateral scales in number. The long axis of all of these ventrolateral scales is anteroventrally directed, opposing the anterodorsal axis of the mid-lateral scales. Scales of the uppermost ventrolateral row are bigger and rectangular in shape (ca. 8 to 4 mm), the remaining scales are 3-5 mm long and oval to triangular. All of them are ornamented with tubercles.

The mid-ventral scales are preserved only as impressions of their outside. They are cordiform to V-shaped, pointing posteriorly, 5 mm wide and 7 mm long. They also roughly correspond in number to the

mid-lateral scales. The ornamentation is composed of tubercles arranged in longitudinal rows.

The portion dorsally to the mid-lateral scales is insufficiently preserved. Several scales of different size are present, which could possibly reflect the pattern in the ventral part.

Specimen MGUH-VP-988 A and B (Fig. 4) represents the region of the dorsal and anal fin in part and counterpart. About 20 mid-lateral scales are preserved anteriorly to the fins; compared to the mid-lateral scales of more anterior body segments, documented by specimens MGUH-VP-1000 and -997 (apparently belonging to individuals of comparable size) they are less high (about 20 mm) and slightly more rhombic than rectangular in outline. Their length, however, is still between 4 and 5 mm, and the ornamentation follows the pattern described above. Comparatively larger areas of the lower part of the scales, near their anterior and ventral margins, are covered with tubercles. The scales of the mid-dorsal and mid-ventral rows are only half as numerous as the mid-lateral ones; further scale rows seem not to be present.

Scales of the mid-ventral and mid-dorsal rows have the same shape in front of the dorsal and anal fins. They are rounded, 10-11 mm broad and 11-12 mm long. On the inside, a prominent longitudinal keel runs



Fig. 2. *Saurichthys* aff. *dayi*, incomplete skull and anterior body portion. Specimen MGUH-VP-1000.

along the midline, passing from one scale to another. The anterior edge of every scale is pointed and fits into a groove on the inside of the preceding one. The surface of the scales presents a V-shaped outline and an ornament of tubercles arranged in longitudinal rows.

The dorsal fin is supported by at least 8 endoskeletal radials divided in elongated proximal axonosts and square-shaped distal baseosts. The fin consists of at least 28 lepidotrichia, the longest of which are segmented no less than 5 times. Basal and fringing fulcra are present on its anterior margin, whose fragmentary preservation precludes from more exact description of these elements. The anal fin is supported by at least 10 endoskeletal radials, and about 40 segmented lepidotrichia can be counted, the posteriormost of which are very thin. Three or four basal fulcra can be recognized in front of it. The anterior margin bears fringing fulcra. Taking into account that in all known saurichthyids the dorsal and anal fins are highly symmetrical, the structures of both might be much more similar than they appear due to the state of preservation.

Four mid-ventral and four mid-dorsal scales are preserved behind the anal and dorsal fin. Their shape is the same as in front of the fins, but both rows are set closer to each other, forming the beginning of the

narrow caudal peduncle. Remnants of smaller scales should belong to the mid-lateral row which would have decreased in height in the caudal part.

Part of the vertebral column is exposed in specimen MGUH-VP-988 B (Fig. 4B, C, 5). Ossified dorsal and ventral elements (pairs of neural and haemal arches, respectively) are placed dorsolaterally and ventrally to the notochord, which has partly been calcified. The neural arches consist of an enlarged, rounded basal part narrowing dorsally, and short anterodorsal articulation processes (praezygapophyses). Conspicuous posterodorsally ascending neural spines emerge from the neural arches anterior to the dorsal fin. They are cylindrical proximally but become slightly flattened distally. It is not clear if separate postzygapophyses were also developed to articulate with the praezygapophyses of the following neural arch. The haemal arches are of roughly rectangular shape and are separated from each other by round foramina. They seem to correspond to the neural arches in number. Presence of haemal spines is indicated by a couple of elongated elements apparently associated with the haemal arches (Fig. 4C). The vertebrae are more numerous than the mid-lateral scales in the corresponding body portion.

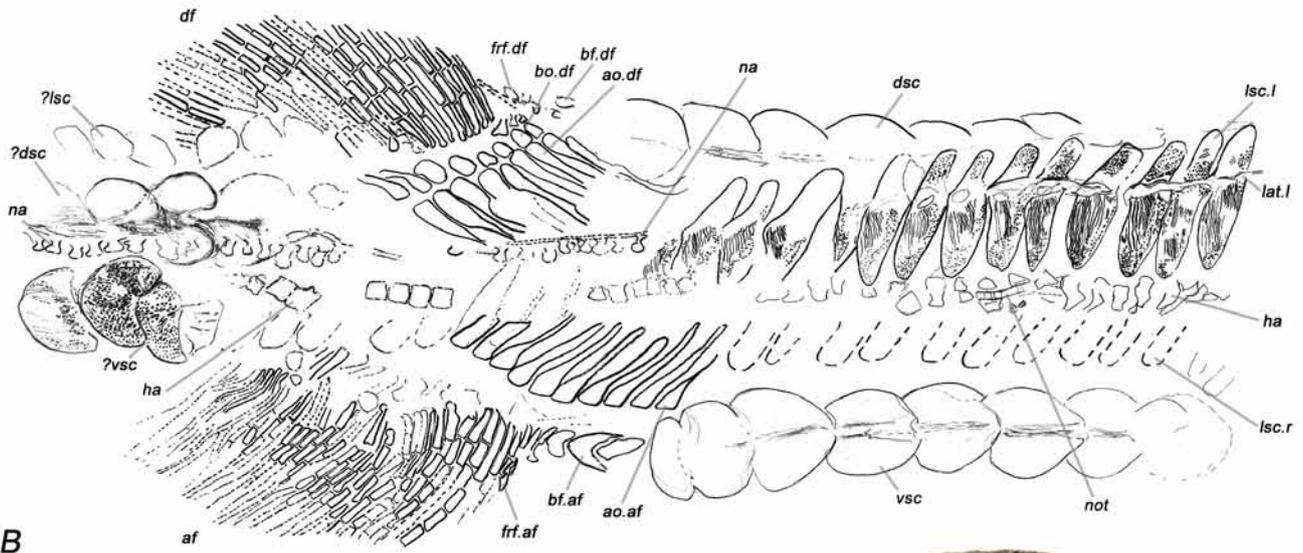
Specimens MGUH-VP-990 and -996 are attributed to the same species only tentatively. MGUH-VP-996



Fig. 3. *Saurichthys* aff. *dayi*, fragment probably from the abdominal region as preserved in specimen MGUH-VP-997. Anterior to the left.



A



B



C

Fig. 4. *Saurichthys* aff. *dayi*, posterior body portion with the opposed dorsal and anal fins. **A**, specimen MGUH-VP-988 A (anterior to the right); **C**, its counterpart MGUH-VP-988 B (anterior to the left); **B**, sketch compiled after both parts (anterior to the right). Abbreviations: *af* anal fin, *df* dorsal fin, *ao* axonosts, *bo* baseosts, *bf* basal fulcra, *frf* fringing fulcra, *dsc* mid-dorsal scale row, *vsc* mid-ventral scale row, *lsc* mid-lateral scales, *lsc.l* left mid-lateral scale row, *lsc.r* right mid-lateral scale row, *lat.l* lateral line, *na* neural arches, *ha* haemal arches, *not* notochord. The box in **C** indicates the frame of Fig. 5.

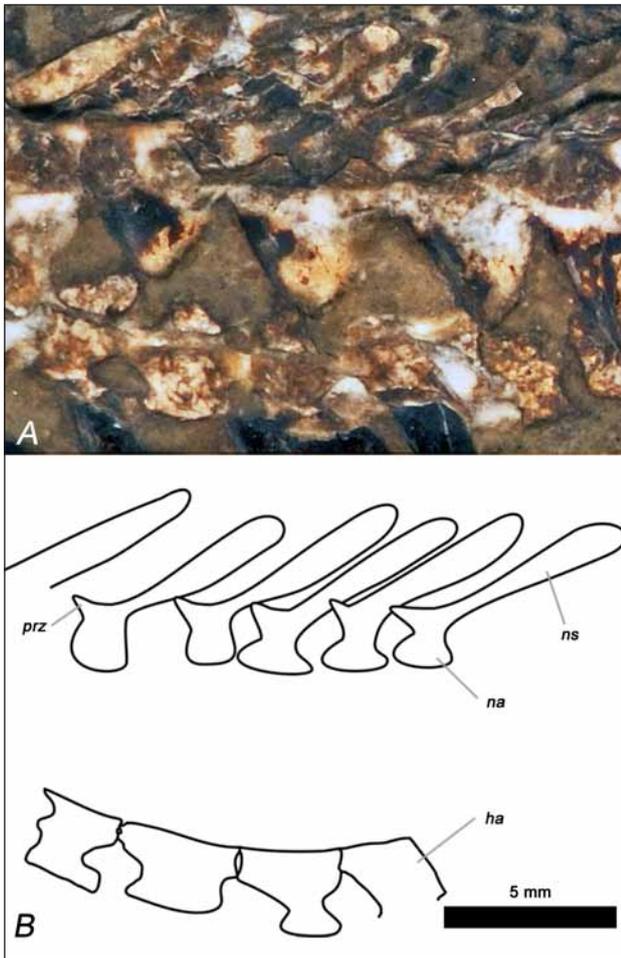


Fig. 5. **A**, *Saurichthys aff. dayi*, detail of the vertebral column as preserved in specimen MGUH-VP-988 B; **B**, interpretative sketch of A. Abbreviations: *na* neural arch, *ha* haemal arch, *prz* praezygapophysis, *ns* neural spine. Anterior to the left. Position of picture is shown in Fig. 4C.

is the fragment of a caudal peduncle, showing a part of a dorsal or anal fin and several V-shaped scales ornamented with tubercles. MGUH-VP-990 is a fragmentary skull with rather short, rounded opercular, resembling that of MGUH-VP-1000. Both specimens probably also come from Nielsen's (1935) fish zone 2, as suggested by their finding localities: MGUH-VP-996 was collected at Østlokaliteten, and MGUH-VP-990 at River 13 which is also located in the Nevatiakdal area.

Remarks

If the assumption of their provenience is correct, the specimens here referred to *Saurichthys aff. dayi* are the five *Saurichthys* specimens listed by Nielsen (1961) for fish zone 2. Accordingly, the remaining nine specimens must be those collected from fish zone 5; indeed, this is in agreement with their find-

ing localities that, as far as indicated on the labels, correspond to outcrops of fish zone 5 mentioned in Nielsen (1935). This is also the case for MGUH-VP-992 and -994 described by Mutter *et al.* (2008) as *Saurichthys cf. ornatus*. The opercular bone as preserved in specimens MGUH-VP-991 and -992 is posterodorsally expanded, resembling the opercular of *Saurichthys ornatus*, and the skull fragment MGUH-VP-999 closely resembles MGUH-VP-994 in general shape. Therefore, the specimens MGUH-VP-991, -992, -994 and -999 can preliminarily be referred to *Saurichthys cf. ornatus*; remaining fossils lack diagnostic features. In summary, the distribution of distinguishable specimens suggests that *Saurichthys aff. dayi* most probably comes from fish zone 2, whereas *Saurichthys cf. ornatus* occurs in fish zone 5.

Already Nielsen (1935) observed differences in the fossil assemblages of fish zones 2 and 5. For instance, *Bobasatrania* that by far dominates the assemblage of fish zone 2 is nearly absent in zone 5, which in contrast is dominated by *Pteronisculus* and parasemionotids (rare in zone 2) and coelacanths (Nielsen, 1961). According to the stratigraphic scheme of Bjerager *et al.* (2006), zone 5 can be placed in the late Griesbachian to possibly early Dienerian, whereas zone 2 is clearly Griesbachian. Whatever the reasons for a faunal change, it is not surprising to find different species of *Saurichthys* in short stratigraphic succession, as was demonstrated e.g. by Rieppel (1992) for the Monte San Giorgio area.

Discussion and conclusions

The new Greenland saurichthyid most closely resembles *Saurichthys dayi* (Raymond, 1925) from the Early Triassic (Griesbachian–Smithian or Spathian) of Alberta and British Columbia, as described and depicted by Mutter *et al.* (2008). Characteristics of this species are very high, somewhat rhomboidal mid-lateral scales and V-shaped to oval, broad mid-dorsal and mid-ventral scales; these are ornamented with longitudinal rows of tubercles and have a conspicuous longitudinal keel on their inside which takes part in the scale-to-scale articulation within each row (Mutter *et al.* 2008: fig. 11). This pattern is best seen in the specimen MGUH-VP-988. The mid-lateral scales also strongly resemble those depicted by Mutter *et al.* (2008).

High mid-lateral scales have also been reported by Stensiö (1925) for *Saurichthys wimani* (Woodward, 1912) and *Saurichthys elongatus* Stensiö, 1925 from the Smithian of Spitzbergen, and by Lehman (1952) for the Dienerian *Saurichthys madagascariensis* Piveteau, 1944-45. However, the two aforementioned forms differ from

the Greenland material in having small mid-dorsal and mid-ventral scales (Stensiö 1925). *Saurichthys madagascariensis*, in turn, has mid-dorsal and mid-ventral scales of comparable shape (but ornamented with striae rather than with tubercles), but Rieppel (1980) judged the high scales to be the ventro-lateral ones, suggesting that the lateral line is supported by a series of smaller, square-shaped to rounded scales. According to Rieppel's (1980) description, there are no smaller scales between the high lateral scales and the mid-ventral scale row, in contrast to what is seen in the Greenland material.

The existence of additional ventrolateral and/or dorsolateral scale rows in *Saurichthys dayi* could not be ruled out by Raymond (1925), neither by Schaeffer & Mangus (1976) who even questioned the validity of the species, nor by Mutter *et al.* (2008) who described additional material. However, Mutter *et al.* (2008) reported on anterior flanks entirely covered by scales. In the Greenland form, ventrolateral and dorsolateral scales seem to be absent in the region behind the pelvic fins, as indicated by the specimen MGUH-VP-988.

Nevertheless, belonging of the present material to *Saurichthys dayi* seems improbable because this latter species has all fin rays unsegmented (Schaeffer & Mangus 1976; Mutter *et al.* 2008). The strong segmentation of dorsal and anal fin in MGUH-VP-988 represents, for the moment, the only diagnostic feature distinguishing the new form from *Saurichthys dayi*.

It is therefore probable that the material described constitutes a new species of *Saurichthys*. The incompleteness of the specimens and the fact that material of *Saurichthys dayi* could not be examined, however, prevents from establishing a new taxon. According to Mutter *et al.* (2008), further saurichthyid fossils from Greenland should exist in collections. If so, they have to be incorporated into a more detailed study, which should also include the re-investigation of the forms from North America and Spitzbergen.

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