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Isolated vertebrae of teleostean fishes from the Paleogene of Antarctica

ABSTRACT: Basing on isolated vertebrae, fossil fishes of the order Gadiformes have been first discovered in sediments of the La Meseta Formation (upper Eocene — ?lower Oligocene) on Seymour (Marambio) Island, West Antarctica. This is one of the oldest and the only locality with the Gadiformes skeletal remains in the Southern Hemisphere. Other poorly preserved centra have been determined as Teleostei (order *incertae sedis*).

Key words: Antarctica, Seymour (Marambio) Island, Paleogene, teleostean fishes, Gadiformes.

Introduction

Over 40 isolated vertebrae of teleostean fishes have been found in Tertiary strata on Seymour Island, West Antarctica. The material comes from sediment of the upper Eocene — ?lower Oligocene La Meseta Formation (unit III according to Elliot and Trautman 1982). It has been collected by the members of the 9th Polish Antarctic Expedition during the Argentine — Polish Field Party in 1985 (Myrcha and Tatur 1986, 1988). The fish vertebrae come from the lithological sequence described by Gaździcki *et al.* (*in press*) *see*: Fig. 1.

All the fossil remains of the Teleostei known to date from the area of Antarctica come exclusively from the La Meseta Formation on the Seymour Island. The first record (Woodward 1908) of fossil centra of fishes of the family Nototheniidae is doubtful (De Witt, *fide* Andriashev 1986, Grande and Eastman 1986), since the state of their preservation allows only a general statement that they belong to the Teleostei. More numerous isolated remains of these fishes were described by Grande and Eastman (1986). Basing on pectoral fin spine and on a fragment of dentary, they first recorded the presence of a representative of the silurform fishes

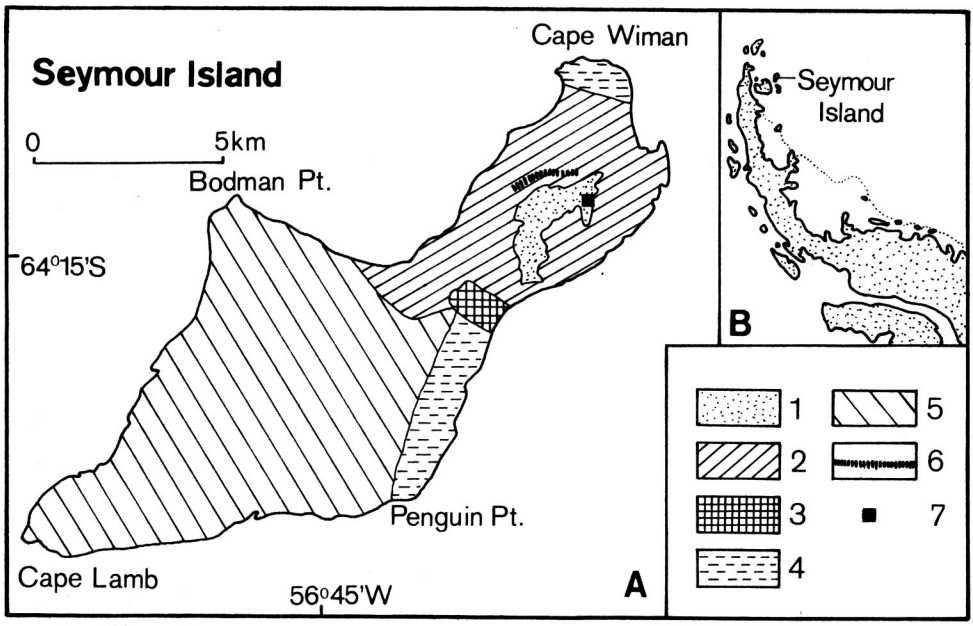

Fig. 1. Location map of Seymour Island (A) in the Antarctic Peninsula sector (B). 1 — Quaternary, 2 — La Meseta Formation, 3 — Cross Valley Formation, 4 — Sobral Formation, 5 — Lopez de Bertodano Formation, 6 — Penguin and fish bone-bearing horizon, 7 — Argentine *Vicecomodoro Marambio* Base.

in Antarctica. The remaining isolated cranial bones and vertebrae were determined only as doubtless Teleostei. According to these authors a part of the vertebrae resemble some extant notothenioid fishes, while two premaxillae were referred to as "... resembling a gadiform type, but specimens are too incomplete to make a positive assignment" (Grande and Eastman 1986, p. 129). Subfossil specimens of fishes of the family Nototheniidae date back at ca. 11 000 years ago. They were found frozen at the surface of a floating ice shelf in the McMurdo Sound, Antarctica (Swithinbank *et al.* 1961).

Among the vertebrae described below, only a part is preserved well enough to allow their determination as belonging to fishes of the order Gadiformes, the remaining can only be referred to as Teleostei. In order to provide more evidence for this conclusion, I have made comparative studies of the structure of vertebral column in extant representatives of the Gadiformes of Antarctica and adjacent areas (*Micromesistius australis* (Norman), *Muraenolepis* sp.), or only of adjacent territories (*Merluccius hubbsi* Marini, *Macruronus magellanicus* Loennberg) and in forms of the Northern Hemisphere (*Gadus morhua* L., *Merluccius merluccius* (L.), *Melanogrammus aeglefinus* (L.), *Merlangius merlangus* (L.), *Enchelyopus* sp.). The possibilities of comparison with fossil Gadiformes are fairly limited, as

descriptions of these fishes have been based on articulated specimens preserved on slabs. Such a state of preservation provides only very few data on the morphology of the centra.

All specimens described here are housed in the Zoological Institute of Wrocław University (abbreviated as UWr).

Systematic paleontology

Division Teleostei
Order Gadiformes
(Figs. 1—12)

Material. — 9 better preserved isolated vertebrae (UWr 1—9) and worse preserved centra (UWr 10—18) from the La Meseta Formation, unit III (upper Eocene — ?lower Oligocene).

Description. — Massive amphicoelous centra with distinct growth rings. Preserved bases of neural arches indicate that they were fused to the centra. Such characters as position and shape of postzygapophyses, lack or presence of parapophyses, sculpture of ventral and lateral surface of the centra, are criteria basing on which the described vertebrae can be assigned

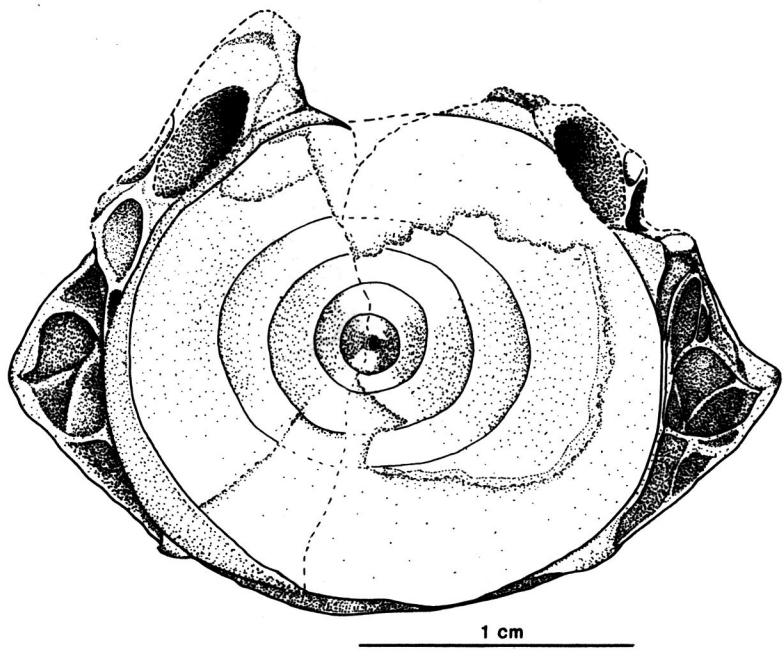

Fig. 2. Gadiformes. Anterior view of the vertebra UWr 1.

to particular sections of the vertebral column. The division of the vertebral column into sections represented by the vertebrae described according to Ford (1937).

The post-cranial section. — Four isolated vertebrae (UWr 1—4) (dimensions in Table 1), with ventral surfaces without large depressions. Specimens UWr 1 and UWr 2 (only left half) show the greatest similarity to the first vertebra of the extant Gadiformes, because of the following characters: a) Deep, narrow canal (Fig. 2) on the right and left side, at the base of the neural arch; the margin of the canal is a trace of the prezygapophysis of the first vertebra, which in extant Gadiformes (Rosen 1985) connects the vertebral column and the cranium. In all the studied extant Gadiformes such a canal was found only in the first prezygapophysis (under the

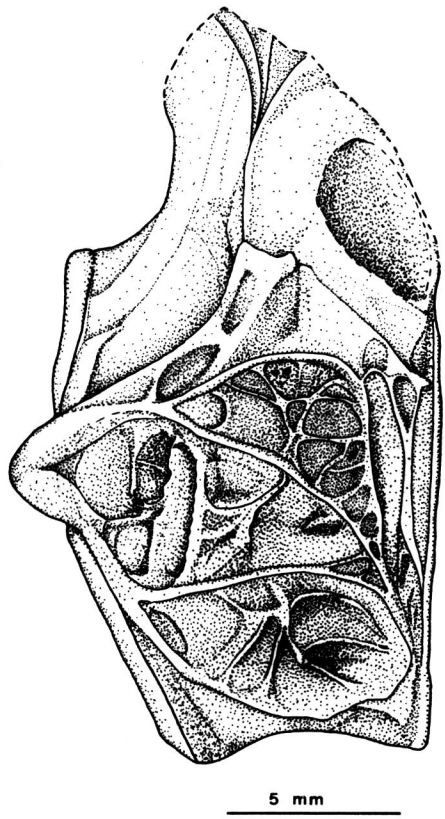

Fig. 3. Gadiformes. Lateral view of the vertebra UWr 1.

cartilaginous cap covering it on the cranial side). b) Anterior surface of the centrum much more concave than the posterior one. Such condition was observed in all the studied species of extant Gadiformes. Moreover, on both vertebrae the postzygapophyses are laterally placed and backwardly

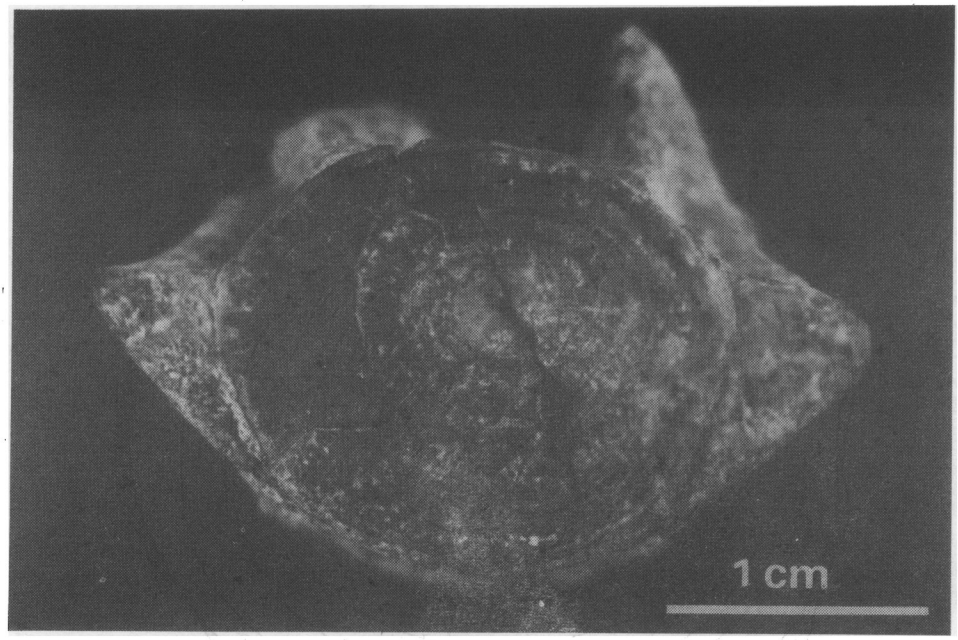

Fig. 4. Gadiformes. Posterior view of the vertebra UWr 1.

directed (Figs 3—4). However, the character is typical for first vertebrae of some Teleostei and for two or three vertebrae in the Gadiformes. The arrangement of depressions in the vicinity of the postzygapophysis on the centra UWr 1 (Fig. 3) and UWr 2 is similar to that in the first vertebra of *Gadus morhua* of similar size. Specimens UWr 3 and UWr 4 (the largest vertebra in the studied material). In both these specimens, despite rather good state of preservation of their lateral surfaces, there is no trace of postzygapophyses. Hence it can be supposed that the vertebrae were a part of the posterior region of the post-cranial section. A comparison with vertebrae of a large individual of *Gadus morhua* indicates the greatest similarity with the fourth vertebra. The similarity concerns both the sculpture of ventral and lateral surfaces, and the position of the deep depression behind the base of the neural arch (Fig. 5). The depression is a place of insertion of rib. The upper margin of the depression (damaged in fossil specimens) forms a small, dorsally placed and backwardly directed postzygapophysis.

The abdominal section. — Three vertebrae (UWr 5—7) of varied size (Table 1), trapezoid in cross-section (Fig. 6), their minimum width at the dorsal and maximum width at the ventral margin. Partly preserved parapophyses grow out of the lower part of the vertebra. Such a position of the parapophyses indicates that the vertebrae were a part of the posterior region of the abdominal section. Width of the parapophyses at their base equal

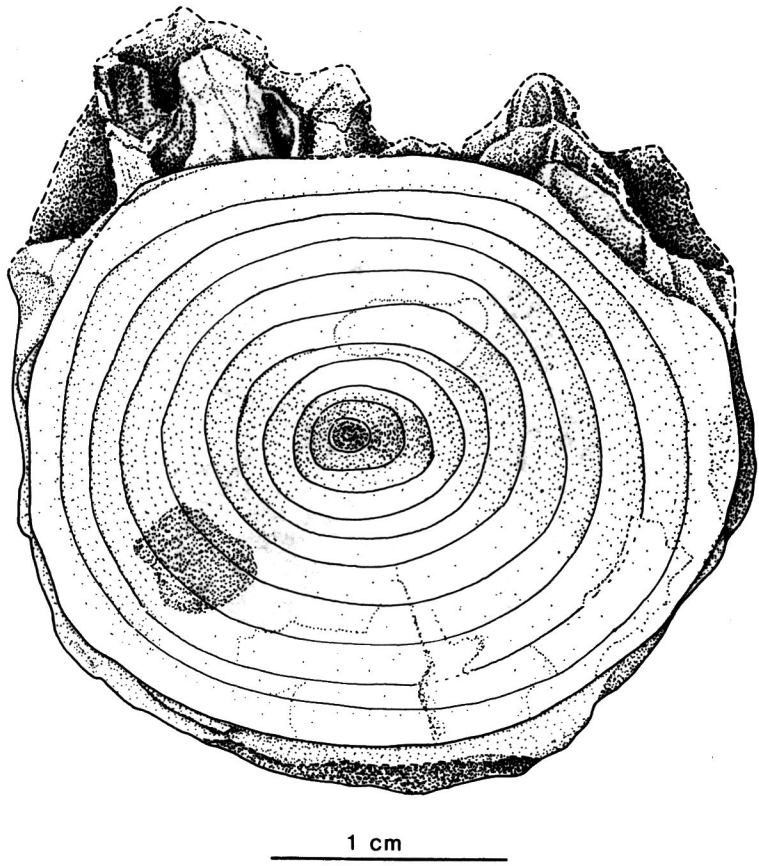

Fig. 5. Gadiformes. Posterior view of the vertebra UWr 4.

to the length of the centrum (UWr 5), slightly smaller (UWr 6) or equal to 2/3 centrum length (UWr 7). Length of the best preserved (through incomplete) parapophyses (UWr 5) is 15 and 7 mm for the left and the right respectively. On the ventral surface of each of the three abdominal vertebrae there is a single narrow groove along the middle line, and one broad and deep depression at the base of the right and the left parapophysis (Fig. 7). On the dorsal side of the vertebra UWr 5 a well preserved base of neural arch with a small neural prezygapophysis visible on the left side of the arch (Fig. 8). Along middle line of the dorsal surface there are two narrow, deep grooves separated by a thin bone lamella. On the posterior margin of the dorsal surface only small traces of post-zygapophyses visible. Lateral surface, best preserved on the left side of the specimen UWr 5, has four depressions. Two middle depressions are narrow and shallow, the remaining two are deep. One of the latter is situated in the immediate vicinity of the parapophysis, the other one near the base of the neural arch (Fig. 8).

The anterior caudal section. — Two vertebrae UWr 8—9, of which UWr 8 is better preserved, of trapezoid cross-section (Fig. 9), minimum width at the dorsal and maximum width at the ventral margin (Table 1), with visible bases of the neural and the haemal arch (Fig. 10). The middle of the dorsal surface occupied by a very deep broad depression of oval outline. On the sides of the vertebra three depressions on each side, along the whole length of the centrum, and one shorter depression behind the base of the haemal arch (Fig. 10). The middle of the ventral surface occupied by a narrow, oval depression (Fig. 11).

The remaining material comprises worse preserved isolated centra (UWr 10—18), which, because of their similarity to those described above, can be also determind as belonging to the Gadiformes.

Remarks. — The dimensions of the vertebrae of the post-cranial section (UWr 1, 3—4, Table 1) indicate that the vertebrae belonged to at least two individuals of different size. The comparison with vertebrae of an extant *Gadus morhua*, of body length without caudal fin equal to 80 cm, allows an estimate of the length of the fossil specimens for ca. 90 cm (UWr 1, UWr 3) or much exceeding 100 cm (UWr 4). Besides, it can be stated that the Gadiformes from the Seymour Island had their parapophyses and bases of neural arches more ossified.

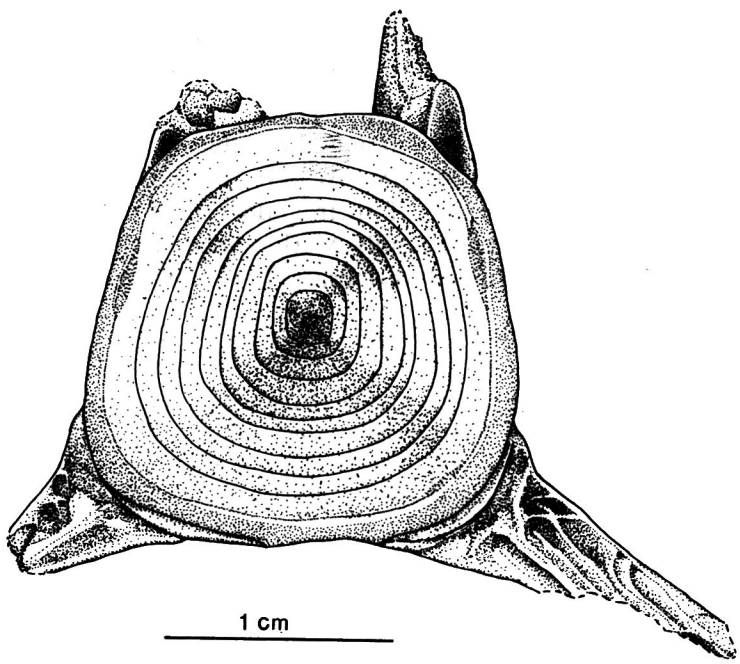

Fig. 6. Gadiformes. Anterior view of the vertebra UWr 5.

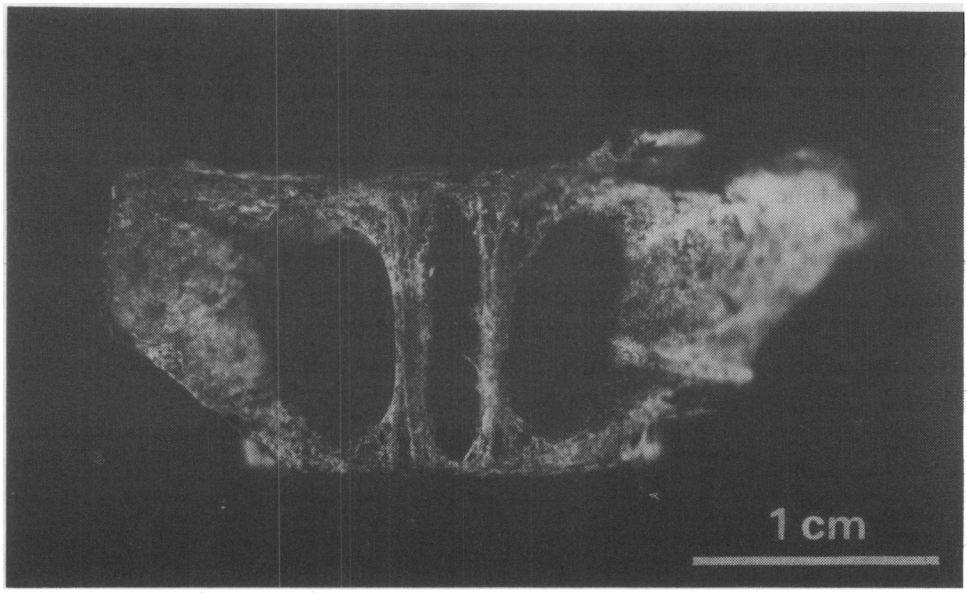

Fig. 7. Gadiformes. Ventral view of the vertebra UWr 5.

It appears rather likely that all the specimens described belong to one kind of short centra with strongly ossified bases of neural arches, wide parapophyses and three depressiones of characteristic shape on the ventral surface (at least at a certain part of the abdominal region). In the literature there are no data on the variability of the latter character in either extant or fossil Gadiformes. Short vertebrae with wide parapophyses are known in fossil and extant species of the genus *Merluccius* (Jerzmańska 1968, Fedotov 1976, Inada 1981). Among the latter the studied specimens of *Merluccius hubbsi* and *M. merluccius* have only two rather shallow depressions on the ventral surface of their abdominal vertebrae. However, in *Macruronus magellanicus* of the family Merlucciidae (Cohen 1984) I found a certain similarity to the studied vertebrae. The similarity concerns ante-

Table 1

Dimensions (in mm) of vertebrae of the Gadiformes from the La Meseta Formation of the Seymour Island

Specimen	Height	Width	Length
UWr 1	17	max. 20	8
UWr 3	18	max. 22	11
UWr 4	25	max. 30	17
UWr 5	19	min. 15 max. 19	13
UWr 8	16	min. 12 max. 16	12

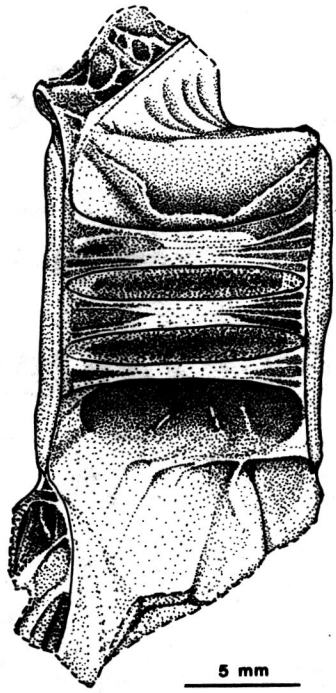

Fig. 8. Gadiformes. Lateral view of the vertebra UWr 5.

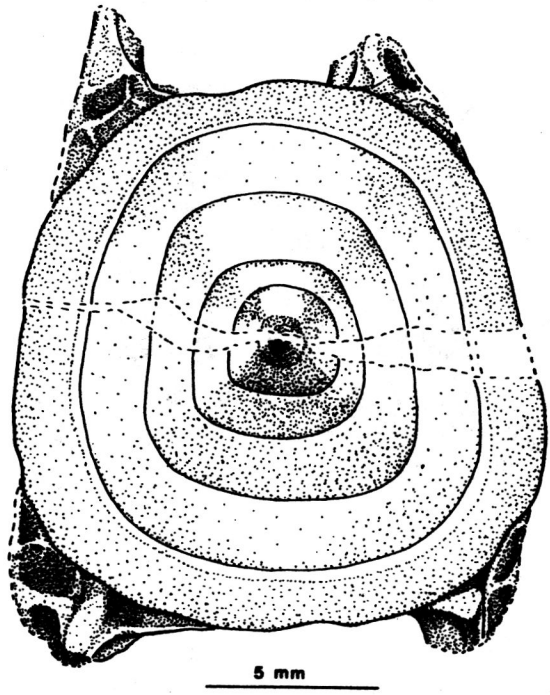

Fig. 9. Gadiformes. Anterior view of the vertebra UWr 8.

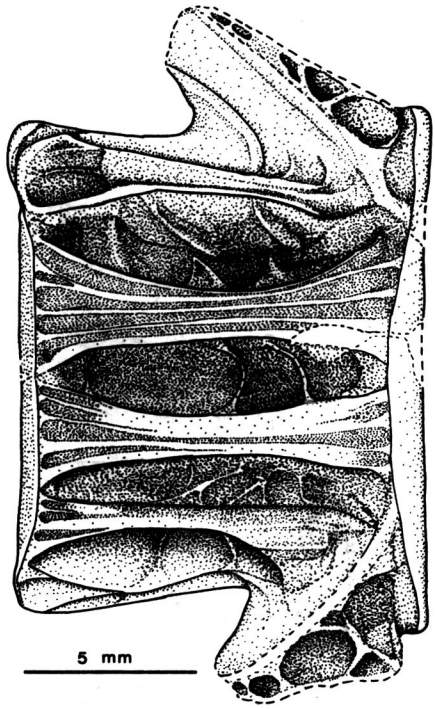

Fig. 10. Gadiformes. Lateral view of the vertebra UWr 8.

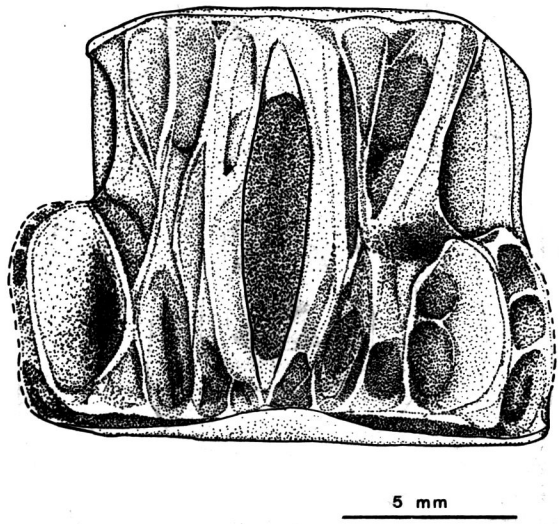

Fig. 11. Gadiformes. Ventral view of the vertebra UWr 8.

rior abdominal vertebrae with wide parapophyses but only with two deep depressions on the ventral side. On posterior abdominal vertebrae of *M. magellanicus* the parapophyses are narrow but the middle depression

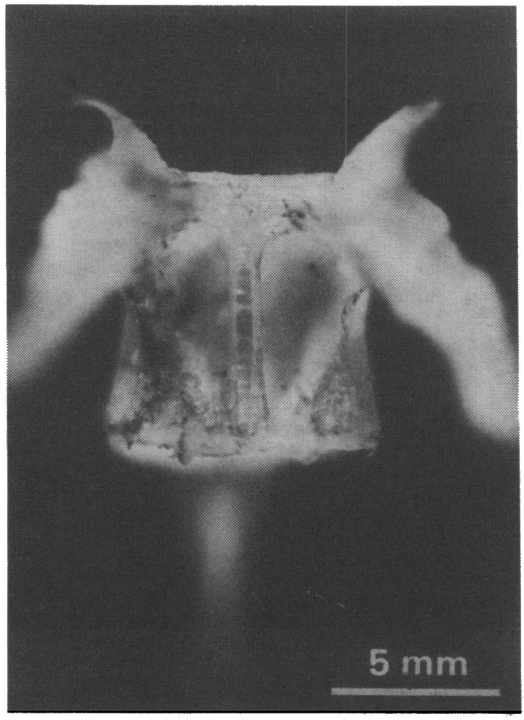

Fig. 12. *Macruronus magellanicus*. Ventral view of the posterior abdominal vertebra.

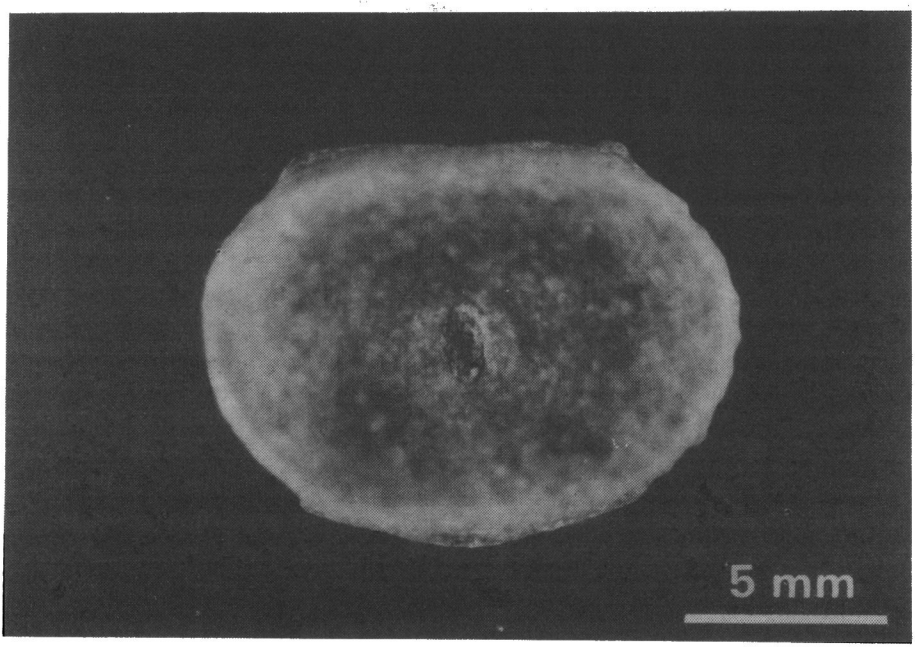

Fig. 13. Teleostei (order *incertae sedis*). Form A. The articular surface of the vertebra UWr 19.

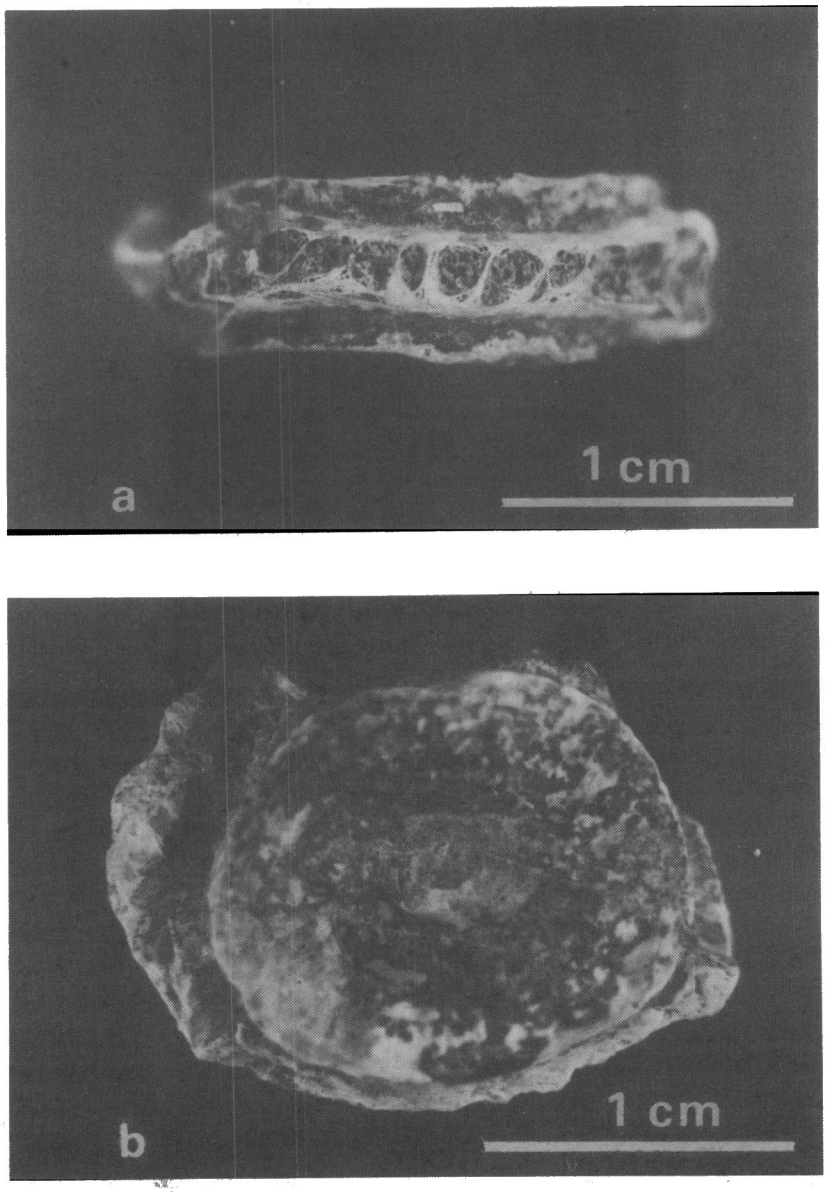

Fig. 14. Teleostei (order *incertae sedis*), Form B. Ventral (a) and posterior (b) views of the vertebra UWr 20.

is present (Fig. 12). I did not find a similar combination of characters in any of the remaining extant species examined. Short vertebrae are observed also in *Gadus morhua*, *Melanogrammus aeglefinus*, *Merlangius merlangus* and *Enchelyopus* sp., but in these species the parapophyses and depressions on the ventral side are developed in a completely different manner. In *Muraenolepis* sp. and *Micromesistius australis* long vertebrae and the structure of the parapophyses do not resemble those of the studied specimens.

The oldest and not studied in detail up to date representative of the Gadiformes is known from the Paleocene of West Greenland (Rosen and Patterson 1969, Cohen 1984). A few skeletons have been described from the Lower Eocene of England (Casier 1966) and Denmark (Bonde 1966), and the Middle Eocene of Syria (Signeux 1959). The fossil Gadiformes reached their more intense development in the Oligocene (Fedotov 1976), and their numerous skeletal remains are known mostly from the Carpathians and the Caucasus (Jerzmańska 1968). Outside the Northern Hemisphere, the known Tertiary Gadiformes are represented only by their otoliths from Australia and New Zealand (Schwarzhans 1985). Therefore the late Eocene — ?early Oligocene skeletal remains of the Gadiformes found for the first time on Seymour Island (Antarctica) come from one of the oldest and at the same time the only locality in the Southern Hemisphere.

Division Teleostei
Order *incertae sedis*
(Figs. 13—14)

The material comprises 23 isolated centra (UWr 19—41) from the La Meseta Formation, unit III (upper Eocene — ?lower Oligocene) belonging probably to three or four groups of the Teleostei. Two of them, described below as a form A and form B are represented by single centra. The remaining specimens, being poorly preserved (UWr 21—41) can be used only when new material accumulates.

Form A

Material. — One isolated centrum (UWr 19) from the La Meseta Formation, unit III.

Description. — Centrum amphicoelous (Fig. 13), in cross-section oval. Height 10 mm, width 13,5 mm, length 7 mm. In the central part on each of the articular surfaces a deep funnel-like depression, probably with a small opening for the notochord on its bottom. Considering the absence of preserved arches, the horizontal surface with a trace of depression in its central part is determined as dorsal, the slightly convex opposite side — as ventral.

Form B

Material. — A single isolated centrum (UWr 20) from the La Meseta Formation, unit III.

Description. — On a greater part of the poorly amphicoelous centrum a protruding, characteristically ornamented bone ridge (Fig. 14a). On the lower surface of the centrum it is wider (3 mm), on the sides — narrow and more protruding (Fig. 14b). The upper part of the centrum border partly damaged. Length of the centrum 6,5 mm. The remaining dimensions (without the bone ridge) are: height 13 mm, width 16 mm.

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Streszczenie

Izolowane kręgi ryb kościstych (Teleostei), znalezione na Wyspie Seymour podczas IX Polskiej Wyprawy Antarktycznej PAN, pochodzą z osadów późnego eocenu lub wczesnego oligocenu formacji La Meseta (fig. 1). Duże kręgi (tab. 1) należą do osobników o różnej długości ciała. Na podstawie najlepiej zachowanych kręgów i porównawczych materiałów współczesnych ryb dorszokształtnych stwierdzono, że badane okazy kopalne pochodzą z przedniej (fig. 2—5), środkowej (fig. 6—8) i ogonowej (fig. 9—11) okolicy kręgosłupa. Wydaje się, że wszystkie te kręgi reprezentują jeden rodzaj ryb dorszokształtnych o pewnym stopniu podobieństwa do kręgów współczesnego przedstawiciela z gatunku *Macruronus magellanicus* Loennberg (fig. 12). Na półkuli południowej znane są jedynie otolity ryb dorszokształtych z trzeciorzędu Australii i Nowej Zelandii. Stwierdzone po raz pierwszy w obszarze Antarktyki szczątki szkieletów ryb dorszokształtnych pochodzą z jednego z najstarszych i jedynego na półkuli południowej stanowiska. Wśród pozostałych izolowanych trzonów oznaczonych jako Teleostei (rząd *incertae sedis*) dwa najlepiej zachowane określono jedynie jako formę A (fig. 13) i formę B (fig. 14).