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## A new species of *Gymnelus* (Perciformes, Zoarcidae) from Greenland, similar to *G. viridis*

N.V. Chernova<sup>1\*</sup> and P.R. Møller<sup>2</sup>

<sup>1</sup> Zoological Institute, Russian Academy of Sciences, Universitetskaya Emb. 1, 199034 Saint Petersburg, Russia; e-mail: chernova@zin.ru

<sup>2</sup> Natural History Museum of Denmark, University of Copenhagen, Universitetsparken 15, 2100 København Ø, Denmark; e-mail: pdrmoller@snm.ku.dk

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### ABSTRACT

Zoarcid fishes of the genus *Gymnelus* Reinhardt inhabit the shelves of the North Pacific Ocean and the Arctic. A new species, *G. pseudosquamatus* sp. nov., is described from trawl samples taken at depths off South-West Greenland. It is most similar to the type species of the genus, Common Fish Doctor *G. viridis*, inhabiting the coastal waters of Greenland. The characters of the latter are specified on materials from the type locality, including the neotype and specimens of J.C.H. Reinhardt. Both species are in the group of *Gymnelus* with an interrupted supratemporal commissura, two supratemporal sensory pores (1+0+1), and a dorsal fin originating above the pectoral fin. The two species differ in a complex of characters, including habitus. In *G. viridis*, the trunk is roundish in cross section, highest above the beginning of the anal fin; the anterior rays of the dorsal fin are shortened, and covered with a thick and somewhat fleshy skin. In *G. pseudosquamatus*, the body is compressed and deeper anteriorly, the dorsal-fin rays are evenly elongated, and the fin membrane is thin. Differences in counts and measurements are statistically significant, including the number of vertebrae and rays in the dorsal, anal and pectoral fins, the number of teeth on the jaws, as well as the length and depth of the head, predorsal length, the length of pectoral fins, eye diameter and length of the gill slit. The color of *G. pseudosquamatus*, with 8–16 wide brown mottled bands, is also unusual, as the skin is dotted with light speckles that create the illusion of tiny scales, which is the reason for the name “*pseudosquamatus*”, the Deceptive Fish Doctor. While *G. viridis* is found inshore in a zone of macroalgae, the new species is found in deeper waters (100–457 m) along the shelf edge of South-West Greenland. The name *Ophidium stigma* Lay et Bennett, 1839 (= *Gymnelus stigma*) should be excluded from the synonymy of *G. viridis*, since the original description mentions the presence of scales on the body, which are absent in *Gymnelus*.

**Key words:** Greenland, *Gymnelus pseudosquamatus*, *Gymnelus viridis*, new species, Zoarcidae

## Новый вид *Gymnelus* (Perciformes, Zoarcidae) из вод Гренландии, сходный с *G. viridis*

Н.В. Чернова<sup>1\*</sup> и П.Р. Мёллер<sup>2</sup>

<sup>1</sup> Зоологический институт Российской академии наук, Университетская наб. 1, 199034 Санкт-Петербург, Россия; e-mail: chernova@zin.ru

<sup>2</sup> Музей естественной истории Дании, Университет г. Копенгаген, Universitetsparken 15, 2100 København Ø, Denmark; e-mail: pdrmoller@snm.ku.dk

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\* Corresponding author / Автор-корреспондент

## РЕЗЮМЕ

Бельдюговые рыбы рода *Gymnelus* Reinhardt населяют шельфы северной части Тихого океана и Арктики. Новый вид гимнелов *G. pseudosquamatus* sp. nov. описан из траловых сборов, выполненных на глубинах у юго-западной Гренландии. Он оказался наиболее сходен с типовым видом рода, обыкновенным гимнелом *G. viridis* из прибрежных вод Гренландии. Признаки последнего уточнены по материалам из типового местонахождения (включая неотип и экземпляры Рейнхардта). Оба вида входят в группу *Gymnelus* с прерванной супратемпоральной комиссурой и числом сенсорных супратемпоральных пор 2 (1+0+1); спинной плавник у обоих начинается над грудным плавником. Два вида различаются комплексом признаков, включая габитус. У *G. viridis* тело спереди вальковатое, округлое в поперечнике, наиболее высокое у начала анального плавника; в передней части спинного плавника лучи укорочены и скрыты в плотной, несколько студенистой коже. Тело *G. pseudosquamatus* сжатое с боков, наиболее высокое спереди; лучи в начале спинного плавника удлинены равномерно, мембрана плавника не утолщена. Статистически значимы различия по числу позвонков, лучей в спинном, анальном и грудном плавниках и числу челюстных зубов, а также по комплексу пластических признаков (длина и высота головы, высота тела, антедорсальное расстояние, длина грудного плавника, диаметр глаза, длина жаберного отверстия). Окраска *G. pseudosquamatus* характерна: на общем фоне из 8–16 широких узорчатых полос кожа испещрена мелкими светлыми пятнышками, создающими иллюзию наличия чешуи (за это вид и получил свое название – «*pseudosquamatus*», обманчивый гимнел). В то время как *G. viridis* населяет зону макроводорослей в прибрежных водах, новый вид встречается на глубинах 100–457 м вдоль кромки шельфа юго-западной Гренландии. Из синонимии вида *G. viridis* следует исключить *Ophidium stigma* Lay et Bennett, 1839 (= *Gymnelus stigma*), поскольку в описании последнего указано наличие чешуи на теле, отсутствующей у всех представителей рода *Gymnelus*.

**Ключевые слова:** Гренландия, *Gymnelus pseudosquamatus*, *Gymnelus viridis*, новый вид, Zoarcidae

## INTRODUCTION

In the large family Zoarcidae the genus *Gymnelus* Reinhardt, 1834 includes up to 15 species, although some are discussed (Chernova 1998, 1999a, 1999b, 2000; Anderson and Fedorov 2004; Mecklenburg and Anderson 2015). These small fishes, which inhabit the shelf areas of the North Pacific Ocean and the circum-continental Arctic, are insufficiently studied. During the last two decades, the investigation of the northern seas has been intensified. A collection of *Gymnelus* specimens from trawl surveys in previously poorly explored waters of Greenland has been deposited in the Natural History Museum of Denmark (ZMUC) and the Center of Natural History, University of Hamburg (ZMH). The identification of these specimens led both authors of this article independently to opinion that a new species exists, which is described below.

Two *Gymnelus* species were previously known from the coastal waters of Greenland and the adjacent Canadian Arctic: *G. viridis* (Fabricius, 1780) and *G. retrodorsalis* Le Danois, 1913 (Møller et al. 2010; Møller 2018). The latter species is well distinguished by the dorsal fin shifted backward, which begins almost above the origin of the anal fin. *Gym-*

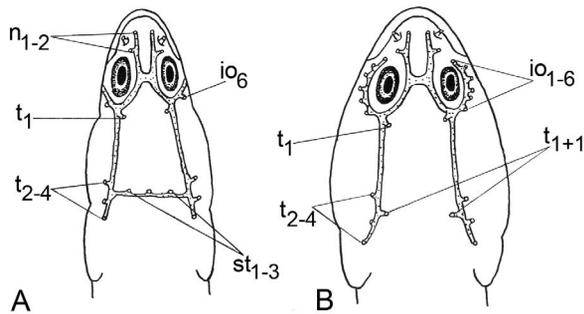
*nelus pseudosquamatus* sp. nov. is similar to the second species, *G. viridis*, in which the dorsal fin begins above the pectoral fin.

The latter species had been described by Otto Fabricius, a Danish missionary, naturalist and explorer of Greenland, in his “Fauna Groenlandica” (1780) under the name *Ophidium viride*. No specimen has been preserved. Later J.C.H. Reinhardt (1834) who studied Greenland fishes established the new genus *Gymnelus* for the species of O. Fabricius. Reinhardt donated some of his specimens to the Museum of the Imperial Academy of Sciences in St. Petersburg; five of them exist now (ZIN 1945) and are included in our study. Other specimens of *G. viridis* used for comparison also originated from the type locality, coastal waters of southern Greenland.

## MATERIALS AND METHODS

We used the same methods of measurements and counts as in previous studies of *Gymnelus* and *Lycodes* (Chernova 2000; Møller 2001). Museum specimens, stored in alcohol were examined.

Previously, radiography was not available to researchers and the numbers of dorsal (*D*) and anal



**Fig. 1.** Sensory pores of *Gymnelus*: A – “three-pore type”: *commissura supratemporalis* connects temporal canals, supratemporal pores 3 (*G. bilabrus*); B – “two-pore type”: *commissura supratemporalis* is interrupted, supratemporal pores 1+0+1 (*G. viridis*, *G. pseudosquamatus*): io1-6 – infraorbital, n1-2 – nasal, st – supratemporal and t1-4 – temporal pores.

(A) fin rays were counted together with half of the rays of the caudal (C) fin:  $D + 1/2 C$  and  $A + 1/2 C$ . To be precise, the dividing point for counting was the gap between the ends of two hypuralia and the bases of central C-fin rays (A.P. Andriashev, personal communication, 1990s). This is practical during field research, as the gap is clearly visible on fresh fish. To make the data comparable, we give the mentioned counts in addition to the usual numbers  $D$  and  $A$ . Vertebral counts include the ural center.

The teeth in paired bones were counted from one side of the head. The teeth formula includes their numbers in outer, intermediate (if present) and inner rows (for example 13/8/3).

The cephalic sensory pores formula includes the number of pores: nasal, infraorbital (=suborbital of Anderson 1982), preoperculo-mandibular, temporal in the *canalis temporalis* (postorbital pore + 3 other), and supratemporal (=occipital) in the *commissura supratemporalis* (=occipital canal) (Fig. 1).

Respiratory membranes (oral valve) are the skin folds inside the mouth on the upper and lower jaws behind the tooth plates that are involved in the acts of breathing.

Ocelli (or “stigma”) are black eye-like spots, often with white edges, that may be present on the dorsal fin of *Gymnelus* (*Gymnelopsis* and *Krusensterniella* as well), usually in males.

**Abbreviations:**  $TL$  – total length,  $HL$  – head length from tip of snout to end of opercular lobe,  $SL$  – standard length;  $D$ ,  $A$ ,  $P$ ,  $C$  – dorsal, anal, pectoral and caudal fins; st – station. Most previous descriptions of *Gymnelus* species used proportions in percent  $TL$ ,

so measurements below are as percentages of  $TL$  (but not  $SL$ ). To make the data comparable to the publications that use  $SL$  percentage, formulas were provided for  $SL / TL$  conversion. Data from literature were not used, if we considered it based on samples mixed with other species.

**Fish collections:** ISH, Institute für Seefischerei, Zoologisches Institut und Zoologisches Museum (have been handed over to ZMH); ZIN (ЗИН), Zoological Institute of Russian Academy of Sciences (St. Petersburg, Russia); ZMH, Center of Natural History (CeNak), University of Hamburg (Germany); ZMUC, Natural History Museum of Denmark, University of Copenhagen (Denmark).

**Comparative materials** examined (see also: Chernova 1998, 1999a,b, 2000).

*Gymnelus bilabrus* Andriashev, 1937: ZMUC P765150 (from ZIN) (1), female 156 mm  $TL$ , Bering Sea, Bay of Anadyr, 63°49'N, 173°58'W, “Shursha”, trawl 1–2, autumn 1996, 50–51 m depth, coll. V.N. Tuponogov.

*Gymnelus knipowitschi* Chernova, 1999: ZIN 14143 (holotype), male 142 mm  $TL$ , Novaya Zemlya, Kostin Shar Strait, Kazarinova Bay, 18 August 1901, st 593, 9–17.5 m depth; ENPIM Expedition. – ZMUC P766948, female 107 mm  $TL$ , Kara Sea, 1 June 1885, 46 Fv [= 86.6 m], coll. A. Gamel.

*Gymnelus esipovi* Chernova, 1999: ZIN 30558 (holotype), male 107.5 mm  $TL$ , northern part of Kara Sea, 78°53'N, 80°34'E, Icebreaker “Georgy Sedov” st 20, 7 August 1934, 40 m depth; coll. V. Vagin. – ZMUC P766949, female 95 mm  $TL$ , juv 76 mm  $TL$ , northern Barents Sea, 81°29'N, 32°44'E, RV “Nerey”, 10 September 2001, 430 m depth, PINRO, from A.V. Dolgov.

*Gymnelus taeniatus* Chernova, 1999: ZIN 51567 (holotype), immature female, 91.5 mm  $TL$ , Franz-Josef Land, Kuhn Island, RV “Pomor”, 29 August 1992, 25–40 m depth, coll. V.G. Averintsev.

## RESULTS

In comparison with the closely related zoarcid genus *Lycodes* Reinhardt, 1831, *Gymnelus* possesses less distinguishing features, as these fish are scaleless, and all have a lateral line of the mediolateral type consisting of superficial neuromasts. The cephalic sensory system is of two main types. One group of *Gymnelus* species has a *commissura supratemporalis*, which connects the supratemporal canals of the right

**Table 1.** Measurements of *G. viridis* and *G. pseudosquamatus* sp. nov.

Characters	<i>G. viridis</i> <sup>1</sup>			<i>G. pseudosquamatus</i> <sup>2</sup>			Stat
	Neotype	Min–max	Mean±m	Holotype	Min–max	Mean±m	
<i>TL</i> , mm	150	90–213	157.3	142	108–152.5	120.7	
<i>SL</i> , mm	146	88–208	151	138	100–147.5	116.6	
Measurements as % <i>TL</i> :							
Head length ( <i>HL</i> )	13.7	13.4–17.6	14.5±0.3	16.9	14.9–16.9	16.0±0.1	+
Head depth	6.3	4.1–7.9	6.9±0.2	8.5	6.8–9.2	7.9±0.1	+
Body depth over <i>P</i> -fin	6.8	6.8–8.8	7.5±0.2	9.5	6.7–9.5	8.0±0.1	+
Body depth over <i>A</i> -fin origin	6.7	6.7–9.2	7.8±0.2	9.5	6.9–9.5	8.0±0.1	
Predorsal length	18.8	16.5–21.7	19.1±0.4	19.0	18.8–23.6	20.8±0.3	+
Preanal length	32.7	31.1–35.4	33.0±0.4	34.2	31.7–36.0	33.6±0.2	
Pectoral-fin length	6.3	6.0–7.4	6.6±0.1	8.0	7.2–9.1	8.3±0.1	+
Measurements as % <i>HL</i> :							
Head depth	46.3	46.3–58.5	50.6±1.1	50.0	44.1–55.6	49.3±0.8	
Body depth over <i>P</i> -fin	49.8	47.4–56.7	51.8±1.4	56.3	40.0–58.3	50.2±1.0	
Body depth over <i>A</i> -fin origin	48.8	48.8–67.9	55.2±1.5	56.3	30.4–56.3	49.3±1.2	+
Head width	45.9	42.4–55.6	47.6±1.1	50.0	42.1–58.1	49.9±1.1	
Predorsal length	137.6	123.5–155.9	134.2±3.0	112.5	112.5–147.2	130.5±1.9	
Eye diameter	16.6	16.6–24.7	21.3±1.1	22.9	20.0–29.1	24.6±0.5	+
Snout length	22.0	18.2–27.8	22.4±0.8	22.9	21.0–27.8	23.8±0.4	
Gill slit length	24.4	23.5–30.9	26.2±0.9	22.9	21.0–27.8	24.0±0.4	+
Upper jaw length	46.3	27.2–55.6	43.6±2.4	53.3	41.7–53.3	46.3±0.6	
Pectoral fin length	46.3	41.3–52.9	47.1±0.9	47.1	45.6–57.1	51.3±0.7	+
As % of <i>P</i> -fin length:							
Pectoral-fin base	42.1	32.0–56.7	43.3±1.6	44.2	31.6–44.2	36.6±0.6	+

<sup>1</sup> Neotype ZMUC P761096; ZMUC P2397033, ZMUC P766955, ZMUC P2397029, ZMUC P2397030, ZMUC P766952, P2397032, P766953, P766954, ZIN 1945 (1–5) ZMUC 761130, ZMUC P766950 (number of specimens 16).

<sup>2</sup> Holotype ZMUC 764452 and paratypes ZMUC 2396102–110, 2396113–122, 2396125–129 (number of specimens 26).

Max – maximal, Mean – average and Min – minimal values; m – standard error of the mean; Stat – statistical significance of differences: the difference between the means is statistically significant (+) by Student's *t*-criterion (probability value *P* 0.05).

and left sides (the number of supratemporal pores is 1+1+1) (Fig. 1A). Another group of species has separated supratemporal canals, since the *commissura supratemporalis* is interrupted in the middle (the number of supratemporal pores is 1+0+1) (Fig. 1B). In both *G. viridis* and the new species, the number of supratemporal pores is 1+0+1. Within each of the two groups, species differ in the number of vertebrae and fin rays, the degree of reduction of the dorsal fin, the number of teeth, the shape of the trunk in cross section (the ratio of depth-to-width of the body), the shape of the pectoral fin, the maximal species size, and the general type of coloration.

The new species differs from *G. viridis* in a complex of characters. Adults of *G. viridis* and *G. pseudosquamatus*, proportionally reduced to the same length, differ in general habitus. In the first, the head is flat, the trunk is rounded, and the body is slightly higher towards the anal-fin origin (Table 1). In the second, the head and trunk are compressed laterally and the body depth declines posteriorly. In *G. viridis*, the anterior portion of the dorsal fin is covered with thick, rather fleshy skin, and the anterior 4–6 rays are shorter than the posterior elongated rays (Fig. 2A, C); in *G. pseudosquamatus* the dorsal-fin membrane is thin anteriorly, as in other species, and

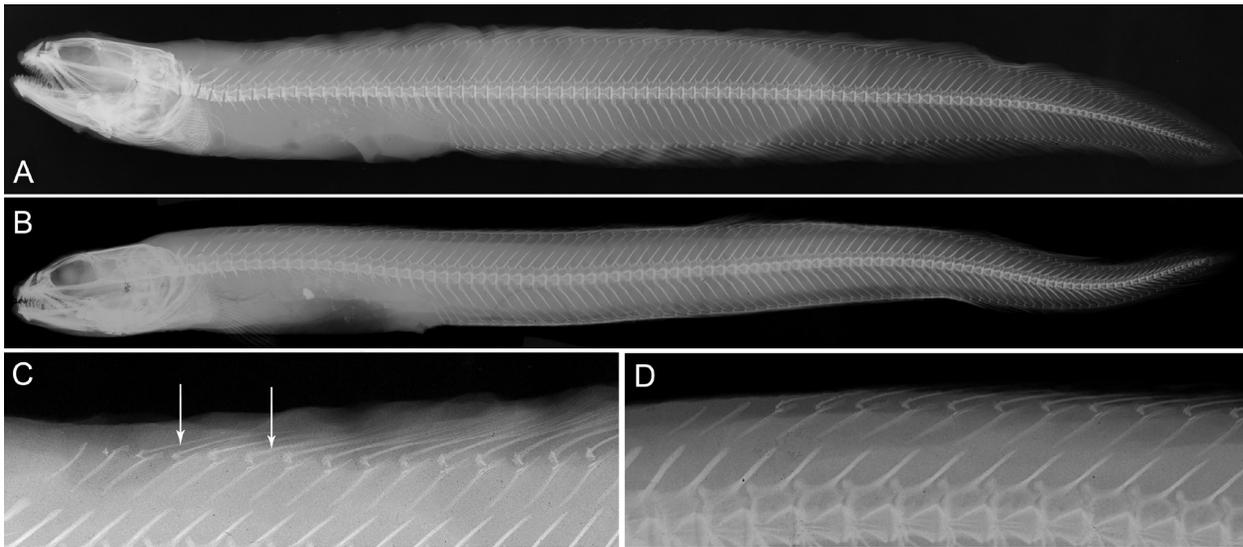


Fig. 2. Radiographs of *Gymnelus*: A, C – *G. viridis*, male 196 mm TL (ZIN 1945, one of the Reinhardt's specimens); B, D – *G. pseudosquamatus*, male 108 mm TL (ZMUC P2396127, paratype). Arrows indicate four anterior shortened rays of the dorsal fin.

the rays are evenly increased in length (no group of short rays anteriorly) (Fig. 2B, D). Mean values of a few counts and measurements differ statistically: the number of vertebrae and rays *D*, *A* and *P*, teeth number, head length and depth, predorsal distance, body depth, pectoral fin length, eye diameter and length of the gill slit (Tables 1, 2).

A peculiar distinguishing character of *G. pseudosquamatus* is its unusual coloration, as the skin is dotted with small light speckles that create the illusion of tiny scales. In addition, *G. pseudosquamatus* occurs offshore and in much deeper horizons (mostly 100–457 m), whereas *G. viridis* was found in coastal waters. The complex of all these differences does not allow us to consider these two fish as identical. We regard *G. pseudosquamatus* as a separate species.

#### Family Zoarcidae Swainson, 1839

#### Genus *Gymnelus* Reinhardt, 1834

*Gymnelus* Reinhardt 1834: XXI; 1837a: XXI (reprint).

***Gymnelus viridis* (Fabricius, 1780)** – Common Fish doctor

(Figs 1B, 2A, C, 3A–D)

*Ophidium viride* Fabricius 1780: 141–142 (South-West Greenland, no exact location). [Correct spelling for genus of type species is *Ophidion*].

*Ophidium viride*: Reinhardt 1830: LIV–LV (branchial rays 6, *P* 11, *D* 97).

*Gymnelus viridis*: Reinhardt 1834: XXI; 1837a: XXI (reprint).

*Gymnelis viridis*: Reinhardt 1837b: 37, 49 (unjustified change in spelling of generic name); Reinhardt 1838: 116, 131 (reprint).

*Gymnelus viridis*: Anderson 1982: 29 (part). – Chernova 1998: 169 (part: ZIN 1945, ZMUC P76169, P761131–32).

#### Material examined

*Neotype* ZMUC P761096, ♂ 150 mm TL, 146 mm SL; South-West Greenland; coll. M.H. Vahl, registered 24 October 1829 [one of Reinhardt's specimens].

*Other material*: 20 specimens 90–213 mm TL, from 9 localities in Greenland. ZIN 1945 (5), 2 ♀♀ 196 and 206 mm, 2 ♂♂ 192 and 201 mm and juv. 90 mm, South-West Greenland; coll. J.C.H. Reinhardt. – ZMUC P766950 (1), ♂ 213 mm, Greenland, 11 April 1844 – 22 May 1845. – ZMUC P766951–P766954 (1, 1, 1, 1), ♀♀ 103–166 mm, Greenland; no other data. – ZMUC P766955, P2397029–P2397030 (1, 1, 1), ♀♀ 143 and 132 mm, ♂ 168 mm; Greenland, no other data; registered 6 October 1851. – ZMUC P2397032 (1), ♀, – TL, 115 mm SL, South-West Greenland, Egedesminde [now Aasiaat], from Atlantic cod stomach, about 68°43'N, 52°54'W; coll. C.S.M. Olrik; registered 1 July 1861. – ZMUC P2397033 (1), ♀ 116 mm, Davis Strait, 65°34'N, 54°31'W, R/V “Ingolf”, st 29, 5–18 July 1895, 124 m

**Table 2.** Counts of *Gymnelus viridis* and *G. pseudosquamatus* sp. nov.

Counts	<i>G. viridis</i> <sup>1</sup>			<i>G. pseudosquamatus</i> <sup>2</sup>			Stat
	Neotype	Min–max	Mean±m	Holotype	Min–max	Mean±m	
Vertebrae, total	102	97–103	99.6±0.4	96	94–101	97.6±0.33	+
precaudal	20	19–21	19.9±0.2	18	17–20	19.0±0.14	
caudal	82	77–83	79.7±0.4	78	75–82	78.4±0.30	
Fin rays:							
dorsal	98	92–99	95.4±0.6	93	90–98	92.9±0.39	+
anal	82	77–84	80.5±0.6	79	76–82	78.8±0.27	+
total caudal	11	9–11	10.2±0.2	10	9–13	10.7±0.22	
pectoral	10	10–11	10.4±0.2	12	10–12	11.3±0.26	+
Teeth, total:							
upper jaw	27	17–29	20±1.4	27	19–31	24.6±1.4	+
lower jaw	27	11–27	16.9±1.6	19	18–31	23.4±2.2	+

<sup>1</sup> Neotype ZMUC P761096 and additional material ZMUC 761130–761132, P766950–P766955, P2397029–P2397030, P2397032–P2397033; ZIN 1945 (1–5) (number of counts 19).

<sup>2</sup> Holotype ZMUC 764452 and paratypes ZMUC P764452–P764453, P765160, P7651778–P7651780, P7651784–P7651785; ZMH Nos 8436 (2), 8437 (4), 8484 (5), 8432 (6), 25459 (4) (number of counts 29).

See Table 1 for designations.

depth. – ZMUC P2397034 and P2396751 (1, 1), juv 114 mm, ♀ 165 mm, South Greenland, Julianehaab [now Qaqortoq], Kakarsuak sound, 1 October 1932; coll. R. Bogvad. – ZMUC P761130 (1), ♂ 205 mm, Julianehaab, ca. 60°45'N, 46°00'W. – ZMUC P761131–P761132 (1, 1), 124 and 128 mm, Julianehaab, May 1902; coll. Mr. Mildorf.

**Etymology.** The species name “*viridis*” means “green” in Latin, and was given by O. Fabricius due to colour of fishes, which live in a zone of macroalgae.

**Diagnosis.** *Gymnelus* with supratemporal pores 2 (1+0+1). Dorsal fin begins above posterior third of pectoral fin, predorsal length 16.5–21.7% (on average 19.1%) *TL*. Trunk distinctly roundish in cross section. Anterior 4–6 dorsal rays shortened and covered by thick skin. Eye usually less than snout length; gill slit slightly longer than eye diameter. Head short, on average 14.5% *TL*. Pectoral fin on average less than one-half of head length (47%); base of pectoral fin averaging 43% of fin length. Vertebrae 97–103 (on average 99.6); *D* 92–99 (95.4), *A* 77–84 (80.5). Skin without tiny light spots that give illusion of false scales. Length up to 256 mm *TL*; mature at length of more than 180 mm.

## Description

The *neotype* is a subadult male 150 mm *TL* (Fig. 3A). Counts and measurements are given in Tables 1 and 2. The maximum body depth is 14.7 times in *TL* and equal to one-half of the head (49.8% *HL*). The trunk is roundish; at the pectoral-fin base, the depth-to-width ratio is 1.3, and is the same at the beginning of the anal-fin. The dorsal fin begins above the posterior third of the pectoral fin; the predorsal length is 1.4 times the head length. The anterior 4–6 *D*-rays are equally shorter than the following ones, and inserted into a thick, rather fleshy fin membrane. The depth of the dorsal and anal fins is less than 1/4 of the body depth. The pectoral fin is rounded, with the base being 42% of the fin length; it inserts close behind the vertical of the opercular-lobe edge.

The head is 7.3 times in *TL*, its width is slightly less than the head depth. The eye is 6 times in *HL*; its diameter is less than the snout length. The nostrils are approximately equal to the pupil diameter. The mouth is terminal. The teeth are strong, forming 3 rows in front of each premaxilla; there are 27 teeth

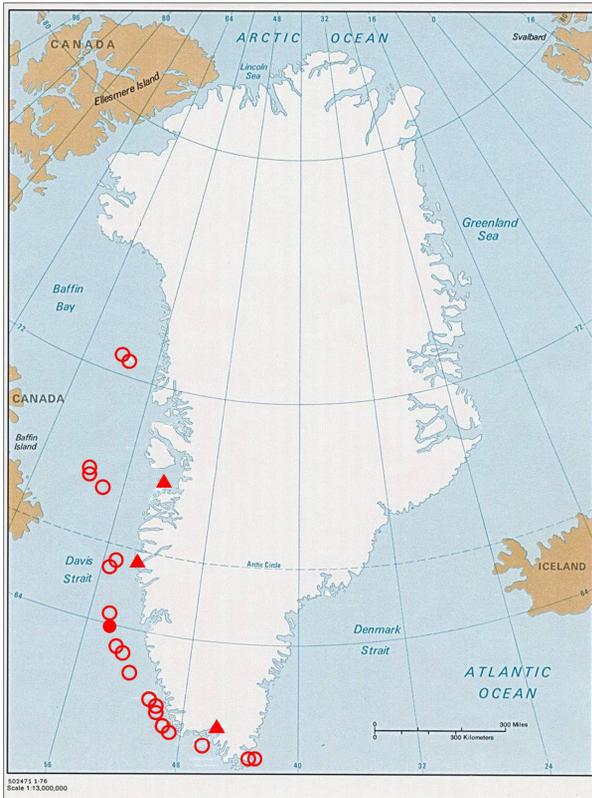


**Fig. 3.** *Gymnelus viridis*: A – neotype, subadult male 150 mm TL (ZMUC P 761096); B – adult male 213 mm TL (ZMUC P766950); C – adult, head side view; D – adult, head dorsal view.

in total (16/5/6). The dentary teeth are arranged in two rows of 27 (21/6). The number of teeth is 6 on the vomer and 10 and 12 on palates (each in two rows, 9/1 and 9/3). The end of the upper jaw extends slightly behind the posterior edge of the eye. The palatine respiratory membrane is wide, extending to the teeth of the vomer. The width of the upper lip is  $2/3$  of the eye diameter; the lower lip is interrupted (attached) anteriorly. The gill slit is slightly longer than the eye diameter and reaches down the level of the upper third of the pectoral-fin base. The opercular flap is rounded; on the body beneath it there is a thin and shallow skin fold that closes tightly the gill opening. The sensory system has an interrupted supratemporal commissura; there are 2 supratemporal pores (1+0+1). Other pores: there are 2 nasal, 7 infraorbital (8 on the right side of the head as one pore with a double opening), 8 preoperculo-mandibular, and 4 temporal (1+3) pores. The lateral line consists of superficial neuromasts on the anterior part of the body.

**Variability.** In adult specimens (192–213 mm TL), specific characters are more pronounced (Fig. 3B). The trunk is distinctly roundish in cross-section; the depth-to-width ratio above the pectoral-fin base is 1.2 on average. The depth of the body increases posteriorly; on average, it is 50.6% HL at the occiput, 51.8% above the pectoral fin and 55.2% above the anal-fin origin. The depth of the unpaired fins is less than  $1/3$  of the body depth. The anterior portion of the dorsal fin is lower than the rest of the fin, with a rather thick fin membrane, almost not emarginated at ray tips.  $SL = 0.975 TL$ .

The head is small, on average 14.5% TL, its width is less than the head depth. The eye diameter is shorter than the snout (Fig. 3C); the gill slit is slightly longer than the eye. The gill slit reaches the level of the upper third of the pectoral-fin base. The upper jaw teeth are in 3 rows, 14–19 in total number (11–17/3–7/2–8); the teeth of the outer row are large and even. The lower jaw teeth form two rows, 11–27 (9–17 / 2–6). The teeth number on the vomer



**Fig. 4.** Distribution of *Gymnelus viridis* (triangular marks) and *G. pseudosquamatus*, holotype (solid circle) and other materials (empty circles).

is 4–7, on the palate 5–10. The pseudobranchia consists of 7 filaments, sitting in one row; the number of gill rakers on the 1st arch (outer and inner sides) is 6 and 9 (counted in one specimen). The sensory system has an interrupted supratemporal commissura; there are 2 supratemporal (1+0+1), 2 nasal, 4 temporal (1+3), 6–8 infraorbital, and 7–8 preoperculo-mandibular pores (there may be double openings of some pores).

**Radiographs.** D92–99, A77–84. D+1/2 C98–105, A+1/2 C81–93. Vertebrae 97–103: abdominal 19–21 and caudal 77–83. Vertebrae without ribs 2–3. Dorsal rays in precaudal part 15–19. First dorsal-fin ray inserted between processes of vertebrae 2–5; rayless pterygiophores in front 0–3. Anal-fin rays before first haemal spine 2–3. Caudal fin consists of 9–11 rays, including 7–9 (3–4 / 3–5) primary rays (usually 4/4), 1–2 upper secondary and 0–2 lower ones.

**Allometry.** The eye decreases with the body size, accounting for 23.3–24.7% *HL* in specimens 90–143 mm *TL* and 17.9–19.6% in specimens

192–206 mm *TL*. The upper jaw usually does not extend to the vertical of the posterior edge of the eye in individuals *TL* < 150 mm (both sexes), and reaching further in larger fish. In juveniles of 55–98 mm, the gill slit is longer than in adults, reaching to the mid-level of the pectoral-fin base (rarely to the 6–9th *P*-fin ray, counting from above).

**Sexual dimorphism.** Like other *Gymnelus*, males have a longer upper jaw than females, extending beyond the eye. The cheek muscles are somewhat swollen; the dorsal muscles behind the occiput are better developed, enlarged (Fig. 3B, C). The anal-fin membrane in females is always pale, and in males it is blackish along the edge (even if they are immature).

**The color** of live fishes was greenish, which is reflected in the Latin name. Skin of the museum specimens is uniform without fine speckles (both sexes). The peritoneum and orobranchial cavity are pale. Ocelli may be present on the dorsal fin, usually 1 or 2, and are more common in males. The smallest specimens (females 98 and 116 mm *TL*) have signs of juvenile color with 10 to 17 vertical uniform dark stripes on the body and tail.

**Size.** In our series, the length of males reaches 213 mm and that of females 206 mm *TL*. The maximum recorded size is 256 mm *TL* (Anderson 1982).

**Distribution.** The specimens were collected from the coastal waters of Greenland, in the south (Qaqortoq, approximately 60°45'N, 46°00'W) and in the southwest: in the Davis Strait near the shore (65°17'N, 54°17'W) and in Aasiaat (approximately 68°43'N, 52°54'W) (Fig. 4). The maximum depth of collection is 101 m.

The wide distribution of “*G. viridis*”, shown by E. Anderson (1982), is based on a mixture of species, including those from the Pacific Ocean with three supratemporal pores of the sensory system.

**Biology.** This fish lives close to shore in a zone of macroalgae. The body shape with strong neck muscles, low at the occiput and increasing in height posteriorly, as well as the presence of thick skin covering the front of the dorsal fin, suggest that it may live among and under stones.

Spawning may occur in the fall, as a mature female 165 mm *TL*, caught in early October in Julianehaab (Kakarsuak sund) (ZMUC P2396751), has 78 eggs in the ovaries with a diameter of 4–5 mm.

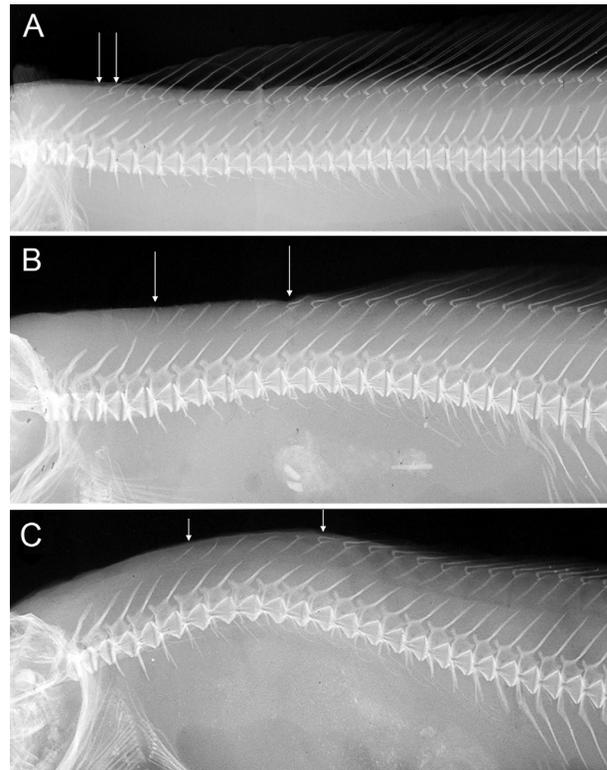
One of our specimens was found in the stomach of an Atlantic cod, but *G. viridis* is unlikely to be abundant enough to be an important food for it.

**Comparisons.** In the Eastern North Atlantic and adjacent Arctic, there are other *Gymnelus*, which belong to the “two-pore” group. *Gymnelus knipowitschi* differs from *G. viridis* in fewer vertebrae (88–94 versus 97–103), in the anterior position of the beginning of the *D*-fin (above the first third as compared to the last third of the *P*-fin), the absence of shortened rays on the first part of the *D*-fin (Fig. 5A) (present in *G. viridis*) and other characters (Chernova 1999a).

The second species, *G. esipovi*, differs from *G. viridis* by a more posterior location of the dorsal fin origin (Fig. 5B), the first ray inserted between 5/6 to 8/9 vertebrae vs. 2/3 to 5/6 vertebrae in *G. viridis*, longer predorsal length (21.2–25.1% vs. 16.5–21.7% *SL*), and larger eye (22–26% *HL* vs. 16.6–24.7%). In addition, *G. esipovi* is a small-sized species: the maximum length of mature adults does not exceed 132 mm (females of *G. viridis* are immature at this length, reaching a twice-longer size – 256 mm).

Our understanding of *G. viridis* is narrower than that of E. Anderson (1982), since he did not use the type of supratemporal commissure as a diagnostic character. In our opinion, his “*G. viridis*” is based on a mixture of species, including those from the Pacific Ocean with three supratemporal pores.

**Taxonomic notes.** The name *Ophidium stigma* Lay et Bennett, 1839 (= *Gymnelus stigma*) usually is included in synonymy of *G. viridis*. The species had been described from Kotzebue Sound (Alaska, Chukchi Sea). The type was not preserved. The characters in the description are scarce (Lay and Bennett 1839: 67, tab. 20, fig. 1). However, it can be concluded that the fish may belong to the subfamily Gymnelinae Gill, 1863, because the pelvic fins are absent and *D* and *A* overlay the caudal fin. The questionable detail is the presence of scales (“scales were very small”), while the skin of all *Gymnelus* is naked. This character was ignored when the species was included in the synonymy of *G. viridis*. It is more likely that *O. stigma* may belong to the related genus *Gymnelopsis* (subfamily Gymnelinae), which includes six scaly species: *G. brashnikovi* Soldatov, 1922, *G. brevifenestrata* Anderson, 1982, *G. ocellata* Soldatov, 1922, *G. humilis* Nazarkin and Chernova, 2003, *G. japonica* (Katayama, 1943) and *G. ochotensis* (Popov, 1931) (Fricke et al. 2020). The conclusion is that *Ophidium stigma* (*Gymnelus stigma*) should be excluded from the synonymy of *G. viridis*.



**Fig. 5.** Radiographs of *Gymnelus*: A – *G. knipowitschi*, holotype; B – *G. esipovi*, holotype, C – *G. taeniatus*, holotype. Arrows indicate the first free pterygiophore and the first ray of the dorsal fin.

***Gymnelus pseudosquamatus* sp. nov.** – Deceptive Fish Doctor

(Figs 2B, D, 4, 6–8)

*Gymnelus viridis* (non Fabricius, 1780): Anderson 1982: 29 (part, fig. 16). – Chernova 1998: 163 (part: ZMUC P761126).

**Holotype.** ZMUC P764452, male 142 mm *TL*, 138 mm *SL*, South-West Greenland, 64°38'N, 55°06'W, R/V “Paamiut”, st 14, 23 July 1998, 326 m depth; coll. P.R. Møller.

**Paratypes**, 57 specimens 54–172 mm *TL* from 12 stations. ZMUC P764453 (1), ♂ 137 mm, caught with holotype. – ZMUC P765160 (1), ♂ 120 mm, 72°05'N, 57°34'W, R/V “Paamiut”, st 3, 17 August 1997, 267 m depth; coll. P.R. Møller. – ZMUC P765177–P765185 (9), 121–156 mm, 66°01'N, 56°11'W, R/V “Paamiut”, st 22, 25 July 1998, 245 m depth; coll. P.R. Møller. – ZMUC P766368 (1), ♂ 160 mm, Davis Strait, 68°22'N, 58°19'W, R/V “Paamiut”, 06 August 2003, 429–457 m depth; coll. P.R. Møller. – ZMUC P766369 (1), ♂ 114 mm, 67°26'N, 56°14'W,

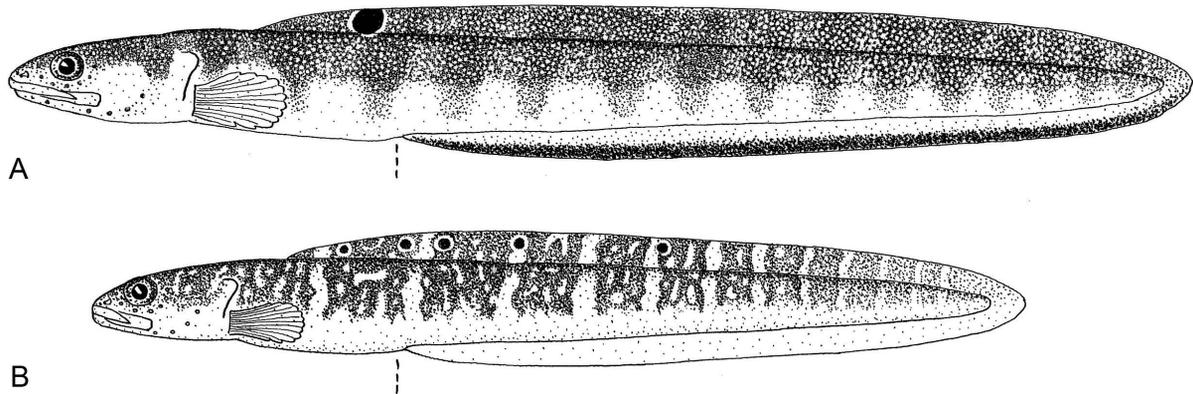


Fig. 6. *Gymnelus pseudosquamatus*: A – male 155 mm TL and B – female 122 mm TL (paratypes ZMH 8438).

R/V “Paamiut”, st 34, 12 July 2003, 221 m depth; coll. P.R. Møller. – ZMUC P2396102–P2396110 (9), 2396113–122 (10), 2396124–129 (6), 108–153 mm, “Grønlands Fiskeriundersøgelser”, PA 0200 37. – ZMH 8432 (6), ♂♂ (5) 114.5–146 mm and ♀ 114 mm, 60°14.10'N, 47°39.20'W, R/V “Walter Herwig”, st 698/94, 25 October 1994, 240–242 m depth; coll. M. Stehmann. – ZMH 8436 (2), ♀♀ 109 and 116 mm, 61°00.20'N, 49°29.80'W, R/V “Walter Herwig”, st 709/94, 27 October 1994, 142 m depth; coll. M. Stehmann. – ZMH 8437 (4), ♂♂ (2) 120 and 134 mm, ♀♀ (2) 111 and 113 mm, 61°21.80'N, 50°05.50'W, R/V “Walter Herwig”, st 711/94, 27 October 1994, 127–151 m depth; coll. M. Stehmann. – ZMH 8438 (15), ♂♂ (6) 106–146 mm, ♀♀ (5) 97–120 mm and 4 juv 70–99 mm, 61°36.70'N, 50°17.10'W, R/V “Walter Herwig”, st 714/94, 28 October 1994, 130–142 m; coll. M. Stehmann. – ZMH 8484 (5), ♂ 145 mm and ♀♀ (4) 105–145 mm, 66°39.80'N, 54°57.40'W, R/V “Walter Herwig”, st 777/1994, 8 November 1994, 89–90 m depth, coll. M. Stehmann. – ZMH 25459 (4), ♂♂ (2) 172 and 164 mm, 2 juv 105 and 86 mm, 59°51.9'N, 43°10.5'W, R/V “Walter Herwig”, st 832/1993, 3 October 1993, 165–168 m depth; coll. M. Stehmann. – ZIN 56451 (3), ♂♂ 102–132 mm, 61°02'N, 49°29'W, R/V “Walter Herwig III”, st 1062, 03 November 2001, 118–152 m depth; coll. N.V. Chernova. – ZIN 56452 (1), ♂ 98 mm, 63°01.39'N, 52°13.93'W, R/V “Walter Herwig III”, cruise 233, st 1091, 06 November 2001, 239–253 m depth; coll. N.V. Chernova. – ZIN 56504 (4, from ZMH 8438): ♂ 159 mm, ♀ 126 mm, 2 juv 54 and 85 mm, 61°36.70'N, 50°17.10'W, R/V “Walter

Herwig”, st 714/1994, 28.10.1994, 130–142 m depth; coll. M. Stehmann.

*Additional materials*: 9 specimens from 6 stations, 94–164 mm TL. ZMUC P765172 (1), ♀ 158 mm, 66°31'N, 54°40'W, R/V “Paamiut”, st 4, 21 August 1998, 167 m depth; coll. P.R. Møller. – ZMUC P764454 (1), 108 mm, Baffin Bay, 72°03'N, 57°55'W, R/V “Paamiut”, st 36, 23 August 1998, 231 m depth; coll. P.R. Møller. – ZMUC P765156–P765158 (1, 1, 1), ♂♂ 124–164 mm, 60°56'N, 48°52'W, R/V “Paamiut”, st 27, 12 September 1998, 221 m depth; coll. P.R. Møller. – ZMUC P765159 (1), ♂ 111 mm, 64°23'N, 54°20'W, R/V “Paamiut”, st 12, 23 July 1998, 218 m depth; coll. P.R. Møller. – ZMUC P766753–P766754 (2), ♂♂ 94 and 96 mm, 61°34'N, 50°13'W, R/V “Paamiut”, st 30, 27 July 2009, 171 m depth; coll. P.R. Møller. – ZMUC P2396752 (1), ♂ 111 mm, 70.88°N, 44[54].26°W [=70°52'48"N, 54°15'36"W], “Kap Farvel”, Sigsby trawl, 29 September 1985, 95–180 m depth, Project 06419, AG 90034. – ZIN 56453 (1), ♀ 99 mm, 62°41.15'N, 51°40.05'W, R/V “Walter Herwig III”, cruise 233, st 1086, 06 November 2001, 227–239 m depth; coll. N.V. Chernova.

**Etymology.** The species name “*pseudosquamatus*” (Latin squāmātus = scaly) is given due to the presence of small light specks in the color, which can easily be mistaken for scales.

**Diagnosis.** Species of *Gymnelus* with supratemporal pores 2 (1+0+1). Dorsal fin begins above middle of pectoral fin; predorsal length 18.8–23.6 (on average 20.8)% TL. Trunk compressed in cross section. Dorsal-fin rays evenly lengthened (no group of short



**Fig. 7.** *Gymnelus pseudosquamatus*: A, D and E – male 142 mm *TL* (holotype ZMUC P 764452); C, F and G – female 126 mm *TL* (paratype ZMUC 765177); B – tiny pale speckles on the skin, giving the illusion of scales (paratype ZMH 25459, 164 mm *TL*).

rays in front); fin membrane thin anteriorly. Eye not less than snout length; gill slit does not exceed eye diameter. Head on average 16.0% *TL*. Pectoral fin slightly longer than half of head length (on average 51.3% *HL*); pectoral fin base averages 36.6% of fin length. Vertebrae 94–101 (on average 97.6), *D* 90–98 (92.9), *A* 76–82 (78.8). Color with 8–16 wide dark-brown mottled bands; skin with small light speckles

giving illusion of false tiny scales (Fig. 7B). Length up to 172 mm *TL*.

#### Description

*The holotype* is an adult male 142 mm *TL* (Fig. 7A, D, E). The maximum body depth is 10.5 times in *TL* and exceeds one-half of the head (56% *HL*). The trunk is compressed; at the base of the pectoral-fin,

the depth-to-width ratio is 1.4 and 1.6 at the origin of the anal fin. The dorsal fin begins above the middle of the pectoral fin; predorsal length is 1.3 times of the head length. The anterior *D*-fin rays gradually and evenly lengthen and are covered with a thin fin membrane (rays are visible through it). The height of the *D* and *A* fins is less than 1/3 of the body depth. The pectoral fin has a narrow base (equal to 37% of the fin length), located obliquely under the opercular lobe.

The head is 5.9 times in *TL*, its width is equal to the head depth (both 50.0% *HL*). The eye is 4.3 in *HL* and is not less than the snout length. The nostrils are shorter than the pupil diameter. The mouth is terminal. The teeth are large and stout, of uneven size; they form 2–3 rows at the jaw symphysis, but are uniserial behind. There are 27 (17/4/6) teeth on the upper jaw, 19 (16/3) on the lower jaw, 7 on the vomer and 7 on the palatines. Respiratory membranes on the upper and lower jaws are wide; the one on the upper jaw almost reaches the teeth on the vomer. The gill slit is as long as the eye diameter and reaches down to the level of one-half of the *P*-fin base. The opercular flap is rounded; on the body under it there is a thin skin fold, closing tightly the gill opening. The sensory system has an interrupted supratemporal commissure; there are 2 supratemporal pores (1+0+1). Other pores: there are 2 nasal, 6 infraorbital, 8 preoperculo-mandibular, and 4 temporal (1+3) pores. The lateral line is mid-lateral and is indistinct at the posterior half of the tail. There is a row of rear neuromasts under the base of the anterior part of the dorsal fin.

*Color* in alcohol includes 12 broad dark-brown patterned bands separated by lighter intervals. The skin is mottled with tiny light specks, creating the illusion of small scales. This character is unique among all *Gymnelus* species. The belly, the underside of the head, and the pectoral fins are pale. The mouth and peritoneum are not pigmented. The anal fin is blackish as in the males of other *Gymnelus* species.

*Variability*. Paratypes are similar to the holotype in basic characters and measurements, including proportions (Tables 1, 2). Body depth is uniform along the entire length (on average, 49% *HL* at the occiput, 50% above the *P*-fin and 49% above the *A*-fin beginning). The trunk is compressed; the depth-to-width ratio is 1.3 above the *P*-fin base and 1.6 above the *A*-fin origin. The dorsal fin begins above the middle of the pectoral fin; anterior rays lengthen gradually; the fin membrane is transparent, emarginating at the tips of the rays. *SL* = 0.965 *TL*.

The eye is about equal to the snout or slightly larger. The gill slit is not longer than the eye, reaching usually to the level of the upper third of the *P*-fin base. The cheek muscles in mature males are better developed than in females (Figs 7E and G), but insignificantly compared to other *Gymnelus*. The supratemporal commissura is interrupted ( $n=25$ ), there are always 2 supratemporal pores (1+0+1); others pores: there are 2 nasal, 6 infraorbital (7 in one specimen), 4 temporal (1+3), and 8 preoperculo-mandibular pores.

*Radiographs*. *D* 90–98, *A* 76–82. *D*+1/2 *C* 95–101, *A*+1/2 *C* 81–87. Vertebrae 94–101: abdominal 17–20 and caudal 75–82. Vertebrae without ribs 2–3. Dorsal rays in precaudal part 15–17. First *D*-fin ray inserted between processes of 4/5 to 6/7 vertebrae; rayless pterygiophores in front 1 to 3 (rarely absent). Anterior dorsal-fin rays increase uniformly in length (Fig. 2B, D). Anal-fin rays before first haemal spine 2–4 (usually 3). Caudal fin with 9–13 rays, including 7–9 (usually 8) primary rays on hypurals, 1–2 upper and 1–2 lower secondary rays.

The specimen collected at the maximum depth of 429–457 m (male 160 mm *TL*, ZMUC P766368) does not differ from fishes caught in shallower waters (100–300 m) in main characters and proportions. The difference is in the main color, which is almost completely gray, including the head underside, lips and belly; but the upper part of the body is densely speckled with fine pale spots (false scales).

*Allometry*. In young individuals, the eyes are larger than in the adults and are usually bulging and protruding laterally. Compared to mature individuals, the upper jaw of young males (< 137 mm *TL*) is shorter and does not extend behind the eye. The gill slit reaches the middle of the *P*-fin base (to the 5–6th rays).

*Sexual dimorphism*. Like other *Gymnelus*, males have slightly larger and broader head than females (Fig. 7E, G), with a longer upper jaw. In adult males the cheek muscles are enlarged (Fig. 7D, F). Like in other *Gymnelus*, the anal fin in females is pale and in males is blackish along the edge (even if they are immature). The ocelli on the dorsal fin (Fig. 7B) are more common in males.

*Color*. The number of dark brown stripes varies from 8 to 16, they become indistinct towards the end of the tail, especially in larger individuals. Scale-like speckles are always present on the nape, the upper side of the body and the dorsal fin. In males,

the bands are rather uniform, in some specimens indistinct. In females (92–111 mm *TL* and more), the bands are usually bright and contrasting, chocolate brown with mesh spots; leopard patterns are present in some individuals. In larger females (158 mm *TL*) the banding is less distinct, the upper side of the head and body becomes more uniformly brown, but the nape and back are also dotted with small specks. The underside of the head and lips are pale. The ocelli (one to six, sometimes touching each other) may be present on the dorsal fin, usually in front, rarely in the middle, or even behind. The peritoneum, mouth and gill cavities are pale. The smallest fishes have a juvenile coloration consisting of 18 narrow vertical stripes on the body (Fig. 8).

**Size.** Among congeners, *G. pseudosquamatus* is a medium-sized species. Males reach a total length of 172 mm, females 158 mm.

**Distribution.** The specimens have been caught at the outer shelf of the South-West Greenland (Fig. 4). The southernmost record is at Kap Farvel (59°46'N, 43°55'W); the most northern and western are in the Baffin Bay (at 72°05'N, 57°34'W and 68°22'N, 58°19'W). The species occurs at a depth of 85 to 457 m; 76% of recordings were made below 100 m.

**Biology.** Females with a length of 125 mm *TL*, caught in August (ZMUC P765171) and in November (ZMH 8438), have maturing eggs in the ovaries with a diameter of about 4 and 3 mm. Spawning probably occurs in autumn, as the female 144 mm *TL* caught in November (ZMH 8438), had an egg size of 5 mm. It is obvious that it takes more than a year for an egg to develop.

**Comparisons.** Differences between the new species and *G. viridis* are shown above. *Gymnelus pseudosquamatus* differs from the second Greenland species, *G. retrodorsalis*, in the more anterior position of the dorsal fin (starting above the pectoral fin vs. almost above the beginning of the anal fin).

In the Eastern North Atlantic and adjacent Arctic, there are three other *Gymnelus*, which belong to the “two-pore” group: *G. esipovi*, *G. knipowitschi* and *G. taeniatus*. The new species differs from *G. knipowitschi* and *G. taeniatus* in the number of vertebrae (94–101 vs. 86–94), rays of the dorsal fin (90–98 vs. 86–92), in the position of the first dorsal-fin ray (Fig. 5A, C) and other characters (Chernova 1999a). *Gymnelus pseudosquamatus* differs from *G. esipovi* in the lesser reduction of the anterior dorsal fin elements (the number of free dorsal-fin pterygiophores



Fig. 8. *Gymnelus pseudosquamatus*, banded color of juveniles, 105 and 86 mm *TL* (ZMH 25459).

is 0–3 vs. 3–5 (Fig. 5B); the first dorsal-fin ray is inserted between the vertebrae from  $\frac{3}{4}$  to  $\frac{6}{7}$  vs.  $\frac{5}{6}$  –  $\frac{8}{9}$ ; the predorsal length is 18.8–23.6% *TL* vs. 24.8–30.8%); also in color, maximum size (*G. esipovi* does not exceed 132 mm *TL*) and other characters (Chernova 1999b).

## CONCLUSION

*Gymnelus* are small-sized non-migratory bottom dwellers with a low number of eggs and the lack of a pelagic stage. These characters are not conducive for the widespread dispersal of species. The presence of sexual dimorphism in all known species may indicate that behavioral mechanisms play an important role in the selective choice of a partner during the breeding season, which contributes to reproductive isolation. The clutches of *Gymnelus* eggs are unknown *in vivo*, which means that the parents may hide them. The enlarged muscles of the cheeks of adult males in all *Gymnelus* species suggest that they can make burrows by eroding the ground by blowing water out of their mouths. A case when pairs of *Gymnelus* were sharing common burrows was reported (Emery 1972; Anderson 1982). The possibility and ability to dig holes are known among the zoarcids. For *Melanostigma atlanticum* Koefoed, 1952 from the Laurentian Through (estuary of St. Lawrence), it is shown that it spawns in burrows and burrowing in the sediment may be a necessary phase of the reproductive cycle (Silverberg et al. 1987). All these factors increase evolutionary trends for local speciation of *Gymnelus* in distant areas of a huge Arctic region and in adjacent waters. By these reasons, existence of 16 species (including the new one) in this genus, is not a surprise. Similarly, the diversity of the closely related *Lycodes* in the Arctic is not less than 20 species, and much more representatives are known in the boreal Pacific Ocean (Møller 2018; Fricke et al. 2020).

Although both species, *G. viridis* and *G. pseudosquamatus*, occur in Greenland waters, they are bathymetrically separated and inhabit different biotopes; one lives in the coastal zone of macroalgae and the other at a depth below the photic zone. The distribution also suggests that their habitats are associated with two different water masses. The coastal areas of southern Greenland are impacted by the cold East Greenland Irminger current, while the deeper shelf is affected by a warmer branch of the North Atlantic current (Fontela et al. 2016).

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