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# MERISTIC AND MORPHOMETRIC CHARACTERS OF SMALL SANDEEL, *AMMODYTES TOBIANUS* L. (ACTINOPTERYGII: AMMODYTIDAE), FROM THE GULF OF GDAŃSK, BALTIC SEA

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**Background.** The small sandeel, *Ammodytes tobianus* L., is a fish species of no commercial value, which is probably why its biology and, particularly, taxonomic status has not attracted much interest. However, the ecological importance of this species outweighs its economic value. It has been regarded a "vulnerable" fish species and therefore its taxonomic status urgently needs more detailed studies. The presently reported study was intended to be a contribution to the knowledge on poorly known morphology of this fish, from a single location in the southern Baltic Sea.
**Materials and methods.** The fish (130 specimens, 9.2–16.3 cm TL) were collected in June 1995 from the area between the Puck Bay and open waters of the Gulf of Gdańsk, at the depth of 8 m. Taxonomic analysis involved both meristic and morphometric characters. The lengths were expressed as percentage of the standard length (SL) of the fish while the fish head characters—as percentage of the head length (HL). In addition, the coefficients of correlation and determination ($r$ and $r^2$, respectively) were calculated for the relations between all characters studied and standard length (SL) and for the relations between the characters pertinent to head and the head length (HL) in the sample examined. The fish age was determined from the otoliths.
**Results.** The age of fish examined ranged from 1+ to 4+, and the sandeels aged 2+ were the distinctly dominant age group. The most abundant size group was the 13.0–13.99 cm length class. The coefficients of variation in the meristic characters were relatively low. The vertebral count and the number of plicae were the most stable characters in the sample studied, while the anal- and pectoral fin ray counts proved to be the most variable ones. Meristic characters can be described by the formula: D (47–49) 50–55, P (10) 11–12 (13), A (24, 25) 26–30 (31), sp.br. (21) 22–27 (28), vt. 61–67 (68). The morphometric relations showed a tendency to allometry, only the postdorsal and postorbital distances showed almost the isometric pattern of growth. The head characters expressed as proportion of the head length showed a very low variability. The strongest negative relations, on the course of exponential curve, were recorded in the following characters: (first) depth of head, eye diameters, jaws length, interorbital distance (associated with the head length); (second) predorsal distance (associated with the fin arrangement), minimum and maximum body depths and length of caudal fin (the features associated with the body shape).
**Conclusion.** The mean vertebral count obtained in the present study indicates the sampled sandeel from the Gulf of Gdańsk to belong to the autumn-spawning component of the stock. The sandeel is a species of relatively short lifespan, the age group IV was the oldest one and the least numerous in the sample (3.38% of the all specimens). The head length and pectoral fin rays count may be regarded as the characters differentiating the Baltic and Atlantic populations, however more detailed study from different areas of the Baltic Sea is urgently needed to confirm this assumption.

**Keywords:** *Ammodytes tobianus,* small sandeel, meristics, morphometric characters, Baltic Sea

## INTRODUCTION

Small (or lesser) sandeel, *Ammodytes tobianus* L., is an inshore fish, found associated with sand and fine gravel banks up to, and including, the intertidal zone. It also occurs in estuaries (O'Connel and Fives 1995). The geographical distribution of *A. tobianus* ranges from the Murman Sea to the west coast of Iceland in the north, to the Baltic Sea in the east, and to Spain to the south. In the Mediterranean, it has been recorded from the Balearic Islands (Whitehead et al. 1986). Small sandeel used to be a common fish in the Baltic Sea. In 1998, a Polish fisheries survey, carried out in two naturally varying basins of the southern Baltic Sea (Poland),

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revealed that small sandeel, *A. tobianus*, and great sandeel, *Hyperoplus lanceolatus* (Le Sauvage, 1824), were dominant components of the catches (Trella 1998).

Sandeels either lie buried in the sand or swim in schools in the water column. The fish feeds on zooplankton and some large diatoms (Whitehead et al. 1986) and in winter, they hibernate, buried in sand at depths of 20–50 cm (Hilton-Taylor 2000). Fuiman and Gamble (1988) stated that *A. tobianus* showed also a predation potential, targeting larval Atlantic herring, *Clupea harengus* L. Sand lances—including *A. marinus* Raitt, 1934; *Hyperoplus lanceolatus*; *H. immaculatus* (Corbin, 1950); and *Gymnammodytes semisquamatus* (Jourdain, 1879)—are very important food fish for many fish species, like Atlantic cod, *Gadus morhua* L. or pollock *Pollachius virens* (L.) and are exploited by the reduction fishery. Sandeels are also principal prey of many seabirds and therefore are a very valuable ecological and commercial resource (Nævdal and Thorkildsen 2002).

The Baltic Sea is inhabited by two species of the genus *Ammodytes*: *A. tobianus* and *A. marinus*, with the latter is restricted to the western part of the sea. Nævdal and Thorkildsen (2002) regarded those species as difficult to be identified by morphological criteria. When compared to *A. marinus,* the belly scales of *A. tobianus* are *organized* in tight chevrons; scales are present over musculature at the base of the caudal fin, the dorsal fin is a little shorter and the mean vertebrate count is lower. In addition, it has been shown that diagnostic allozyme traits existed for both species (Naevdal and Thorkildsen 2002).

Two distinct, but often sympatric, spawning groups exist in the area of distribution but have not been given subspecies status although spawning groups differ in mean vertebra count (higher in the autumn group than in the spring one), otolith structure, and probably habitats (Whitehead et al. 1986). Also seasonal occurrences of *A. tobianus* observed during ecological studies of the shore of Inishmore (O'Connel et al. 1992) suggested the presence of two spawning components and prompted an in-depth study of the species to elucidate the situation. Kändler (1941) found four *Ammodytes* post-larvae in the southern North Sea and Baltic: the "*lanceolatus*" (presently affiliated to the genus *Hyperoplus*), the "*marinus*", and two forms of the "*tobianus*", a spring brood form and an autumn brood form, each of them differently pigmented.

In Baltic countries, *A. tobianus* has not been considered a commercially valuable fish (sometimes used as a bait), which is probably why particularly its taxonomic status has not attracted wider interest. In 2005, however, the species was included in the list of threatened and declining fish species in the Baltic Sea, classified as VU (vulnerable) (Anonymous 2005). The above-mentioned situation calls for a prompt determination of the taxonomic status of the small sandeel in this area, through a detailed morphologicals study.

The literature on the small sandeel, especially on the small sandeel from the Baltic Sea, is very scarce. Recently, the growth rates of length and weight of the species from the Gulf of Gdańsk have been published by Więcaszek et al. (2007).

The objective of the presently reported study was to fill a gap in the knowledge and to present detailed biomorphometric characteristics, based on a sample from the Gulf of Gdańsk.

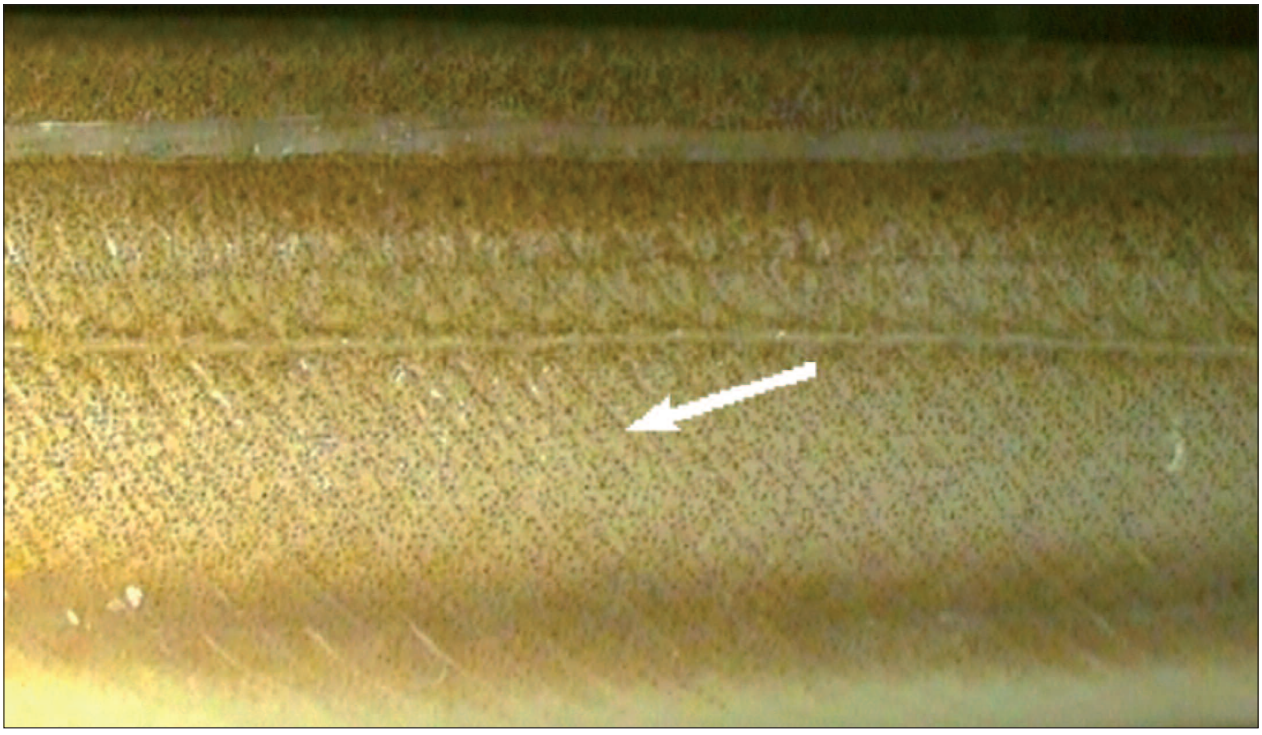

**Fig. 1.** Oblique skin-folds (plicae) bearing the scales, present only in *Ammodytes* species (Photo: A. Antoszek)

## MATERIALS AND METHODS

The material studied for meristic and morphometric study consisted of 130 specimens, measuring from 9.2 to 16.3 cm in total length (TL), the mean length being 12.0 cm. The fish weight was found to range from 2.56 to 10.22 g.

The sample was collected in June 1995 in the area between the Puck Bay and open waters of the Gulf of Gdańsk, at the depth of 8 m (54º36´N, 18º48´20´´E).

Taxonomic analysis involved both meristic and morphometric characters. The fin ray counts (D, A, and P) and gill raker number on the first gill-arch were determined. The pelvic fin (V) is absent or rudimentary. Vertebral counts were determined to find the vertebral count range in the population, and to find out which component of the stock is studied: the spring- or autumn-spawning, as reported from other areas (O'Connel et al. 1992, O'Connel and Fives 1995). The counts were taken from the first vertebra to the hypural (urostyle) bone (inclusive). For the fish with a vertebral count of 65 and higher and the dorsal fin rays equal to 56, the arrangement of belly scales and the presence of scales at the base of the caudal fin were also noted, to distinguish the species from *A. marinus* (cf. Whitehead et al. 1986).

The body of small sandeel is covered by oblique skin-folds (plicae) between the dorsally positioned lateral line canals and the ventrolateral skin-folds (Fig. 1). The count of plicae was recorded, as well.

The following morphometric characters were studied: total, body-, and caudal lengths; length and depth of head; vertical and horizontal eye diameters; interorbital distance, length of upper and lower jaws, predorsal and postdorsal distances, preanal distance, length of caudal peduncle, minimum and maximum body depths, length of caudal and pectoral fins, length of base and height of anal and dorsal fins. Measurements taken to nearest mm, were taken according to Holčík (1989) (markedly modified), and were expressed as percentage of the fish standard length (SL); fish head measurements (to 0.1 mm) were expressed as percentage of the head length (HL). In addition, the pectoral length (lP) was also expressed as percentage of the head length (HL). Symbols of morphometric characters followed those of Holčik (1989) (slightly modified).

The fish were weighed to the nearest 0.01 g.

All the data were statistically processed, involving standard deviation ($s$), standard error of the mean ($s_x$) and coefficient of variation (CV). The most frequent counts (MFC) are reported for meristic characteristics, as well. Additionally, the coefficients of correlation and determination ($r$ and $r^2$, respectively) were calculated for the relationships for all characters studied and standard length (SL), and for the relationships between characters pertinent to the head and the head length (HL) in the sample examined.

Description of relative growth patterns of the all characters was studied as well. Regressions were performed according to the general relative growth formula $y = ax^b$. The exponential equation showed a better fit when analyzed data distribution. The Student's $t$-test was applied to

**Table 1**

Meristic characters of the sample studied ($n$ = 130)

| Character | Range/MFC | Mean | Standard error of the mean | Standard deviation | Coefficient of variation [%] |
|---|---|---|---|---|---|
| Dorsal fin ray count (D) | 47–56/52–54 | 52.52 | 0.16 | 1.84 | 3.5 |
| Anal fin ray count (A) | 24–31/ 27–30 | 27.97 | 0.13 | 1.45 | 5.17 |
| Pectoral fin ray count (P) | 10–13/11–12 | 11.25 | 0.05 | 0.62 | 5.54 |
| Gill raker count | 21–28/23–26 | 24.38 | 0.11 | 1.3 | 5.31 |
| No. of plicae | 126–136/129 | 128.08 | 0.44 | 2.22 | 1.73 |
| Vertebral count | 61–68/62–65 | 63.62 | 0.11 | 1.28 | 2.02 |

MFC = Most frequent count.

**Table 2**

Relation between the meristic characters studied and the body length (SL)

| Character | Regression equation | Correlation coefficient $r$ | Determination coefficient $r^2$ |
|---|---|---|---|
| Dorsal fin ray count (D) | $y = 52.23x^{0.004}$ | *0.338 | 0.114 |
| Anal fin ray count (A) | $y = 27.47x^{0.010}$ | *0.295 | 0.087 |
| Pectoral fin ray count (P) | $y = 10.82x^{0.037}$ | *0.460 | 0.212 |
| Gill raker count | $y = 24.36x^{-0.003}$ | 0.089 | 0.008 |
| Vertebral count | $y = 62.97x^{0.008}$ | *0.567 | 0.322 |

*coefficient statistically significant.

evaluate statistically the significance of the correlation coefficient (*r*) (Cobo and Fransozo 1998).

For the purpose of the present work the age of the individuals studied was determined from the otoliths. Whole sagittae with a longer distance from nucleus to the edge of the otolith, placed in ethyl alcohol were examined, over a dark background under the microscope at reflected light over a dark background. Opaque rings were counted on the anti-sulcal otolith surface.

## RESULTS

The sample examined, consisted of 130 specimens, aged from 1+ to 4+. The age was determined from otoliths;

**Table 3**

Morphometric characters of the small sand eel examined, expressed as proportion of body length (SL)

| Character and symbol | Range | Mean | Standard error of the mean | Standard deviation | Coefficient of variation [%] |
|---|---|---|---|---|---|
| Total length (TL) | 108.5–111.8 | 109.9 | 0.14 | 0.71 | 0.65 |
| Caudal length (FL) | 101.1–108.9 | 105.0 | 0.11 | 1.24 | 1.18 |
| Head length (HL) | 17.4–22.0 | 20.2 | 0.28 | 1.39 | 6.89 |
| Preorbital distance (prO) | 6.3–8.2 | 7.3 | 0.09 | 0.46 | 5.95 |
| Horizontal eye diameter (Oh) | 2.6–3.6 | 3.2 | 0.06 | 0.28 | 8.61 |
| Vertical eye diameter (Ov) | 2.4–3.4 | 3.0 | 0.05 | 0.27 | 8.92 |
| Interorbital distance (io) | 2.7–3.6 | 3.4 | 0.46 | 0.23 | 6.80 |
| Postorbital distance (poO) | 8.1–10.1 | 9.1 | 0.12 | 0.60 | 6.41 |
| Head depth (hc) | 6.7–8.7 | 7.9 | 0.10 | 0.48 | 6.04 |
| Length of upper jaw (lmx) | 5.4–7.1 | 6.5 | 0.09 | 0.43 | 6.55 |
| Length of lower jaw (lmd) | 8.5–11.0 | 10.10 | 0.14 | 0.68 | 6.74 |
| Predorsal distance (pD) | 21.3–29.9 | 26.6 | 0.12 | 1.35 | 5.07 |
| Postdorsal distance (poD) | 3.2–7.1 | 4.9 | 0.07 | 0.78 | 15.81 |
| Maximum body length (H) | 6.3–10.3 | 8.4 | 0.07 | 0.82 | 9.77 |
| Minimum body length (h) | 1.7–4.5 | 3.1 | 0.04 | 0.42 | 13.52 |
| Preanal distance (pA) | 58.1–69.3 | 63.7 | 0.14 | 1.59 | 2.49 |
| Length of caudal fin (lC) | 7.4–11.2 | 9.7 | 0.07 | 0.77 | 8.00 |
| Length of pectoral fin (lP) | 7.4–13.5 | 10.6 | 0.08 | 0.91 | 8.66 |
| Length of dorsal fin base (lD bs) | 59.1–70.7 | 67.2 | 0.17 | 1.89 | 2.81 |
| Length of anal fin base (lA bs) | 27.6–37.9 | 31.5 | 0.14 | 1.58 | 5.03 |
| Depth of anal fin (hA) | 3.2–6.8 | 4.8 | 0.06 | 0.68 | 14.10 |
| Depth of dorsal fin (hD) | 3.3–7.4 | 5.1 | 0.06 | 0.72 | 14.24 |
| Length of caudal peduncle (lpc) | 3.0–6.5 | 4.8 | 0.07 | 0.76 | 15.97 |

**Table 4**

Morphometric characters of the small sandeel head, expressed as proportion of head length (HL)

| Character | Range | Mean | Standard error of the mean | Standard deviation | Coefficient of variation [%] |
|---|---|---|---|---|---|
| Preorbital distance (prO) | 33.50–38.61 | 36.38 | 0.240 | 1.20 | 3.30 |
| Horizontal eye diameter (Oh) | 14.43–16.67 | 15.97 | 0.112 | 0.56 | 3.49 |
| Vertical eye diameter (Ov) | 13.33–15.69 | 15.01 | 0.129 | 0.65 | 4.31 |
| Interorbital distance (io) | 14.93–17.82 | 16.66 | 0.161 | 0.80 | 4.83 |
| Postorbital distance (poO) | 41.33–47.20 | 45.37 | 0.310 | 1.55 | 3.41 |
| Head depth (hc) | 33.82–43.07 | 39.10 | 0.452 | 2.26 | 5.78 |
| Length of upper jaw (lmx) | 30.22–34.16 | 32.56 | 0.169 | 0.85 | 2.60 |
| Length of lower jaw (lmd) | 46.22–50.99 | 50.10 | 0.185 | 0.93 | 1.85 |
| Length of pectoral fin (lP) | 52.06–62.18 | 57.35 | 0.500 | 2.50 | 4.35 |

the otolith radius length ranged from 0.70 to 1.40 mm. The sample was markedly dominated by the sandeels aged 2+ (62.84% of all the specimens); the fish aged 3+ contributed 29.73% to the sample, while individuals aged 1+ and 4+ were scarce (4.05 and 3.38% of the sample, respectively). The total length of the sandeel studied ranged from 9.2 to 16.4 cm, with the average of 12.0 cm. Eight 1.0-cm-wide length classes were established; the most abundant class was 13.0–13.99 cm, with 31.7% of the fish examined. Another abundance peak was found in the 10.0–10.99 cm class, with 19.2% of the sample.

**Meristic characters** of the small sandeel examined are summarised in Table 1. Values of coefficient of variation were relatively low, indicating low meristic variability features. The vertebral count was the most stable character in the sample studied, while the ray counts in the anal and pectoral fins were the most variable meristics.

All the fins of the small sandeel were supported by soft, unbranched rays only. In the dorsal fin, the most frequent ray counts were 52–54, with a slight domination of 52–53, recorded altogether in 48% of all the individuals. The most frequent ray count (30.5%) in the anal fin was 28, 11 being the most frequent (61%) count in the pectoral fin. The most frequent gill raker counts on the first gill arch were 23–25, with the domination of 23–24 (in 58% of the individuals studied). The most frequent plicae count was 129, observed in 56% of the sandeel. Over 90% of all the fishes showed the number of skin folds to range within 126–129. The dominant vertebral counts were: 63 and 64, recorded in 29% and 30% of the sample examined, respectively.

The relationships studied, for the meristic characters and body length (SL), showed a positive relationship, however rather low, in all features except for the gill rakers count (Table 2). The highest relationship was noted between the pectoral fin rays count and the body length and between the vertebral count and the body length.

**Morphometric characters** of the small sand eel examined, expressed as percentage of standard length (SL) are presented in Tables 3 and 4, respectively, while relationships between all morphometric characters studied and standard length (SL) and the relationships between characters pertinent to the head and the head length (HL), as well as mean values of morphometric characters of the

**Table 5**

Relationships between all morphometric characters studied and body length (SL) and the relationships between characters pertinent to the head and the head length (HL)

| Symbol of character | SL-related | | | HL-related | | |
|---|---|---|---|---|---|---|
| | Regression equation | Correlation coefficient $r$ | Determination coefficient $r^2$ | Regression equation | Correlation coefficient $r$ | Determination coefficient $r^2$ |
| Total length (TL) | $y = 110.1x^{-0.003}$ | *0.869 | 0.756 | | | |
| Caudal length (FL) | $y = 105.0x^{-0.002}$ | *0.440 | 0.194 | | | |
| Head length (HL) | $y = 21.59x^{-0.04}$ | *0.610 | 0.372 | | | |
| Preorbital distance (prO) | $y = 7.174x^{-0.08}$ | *0.637 | 0.406 | $y = 33.26x^{-0.03}$ | *0.261 | 0.068 |
| Horizontal eye diameter (Oh) | $y = 3.600x^{-0.09}$ | *0.771 | 0.595 | $y = 16.67x^{-0.04}$ | *0.794 | 0.630 |
| Vertical eye diameter (Ov) | $y = 3.249x^{-0.15}$ | *0.793 | 0.629 | $y = 15.08x^{-0.11}$ | *0.669 | 0.448 |
| Interorbital distance (io) | $y = 3.533x^{-0.15}$ | *0.637 | 0.406 | $y = 16.38x^{-0.11}$ | *0.490 | 0.240 |
| Postorbital distance (poO) | $y = 10.11x^{0.000}$ | 0.007 | 0.000 | $y = 46.84x^{0.047}$ | *0.470 | 0.221 |
| Head depth (hc) | $y = 8.697x^{-0.11}$ | *0.983 | 0.967 | $y = 40.34x^{-0.07}$ | *0.773 | 0.597 |
| Length of upper jaw (lmx) | $y = 6.884x^{-0.16}$ | *0.694 | 0.482 | $y = 31.93x^{-0.11}$ | *0.555 | 0.308 |
| Length of lower jaw (lmd) | $y = 9.918x^{-0.08}$ | *0.617 | 0.381 | $y = 45.97x^{-0.03}$ | *0.276 | 0.076 |
| Length of pectoral fin (lP) | $y = 11.09x^{-0.03}$ | *0.702 | 0.493 | $y = 51.48x^{0.008}$ | 0.100 | 0.010 |
| Predorsal distance (pD) | $y = 27.76x^{-0.037}$ | *0.743 | 0.552 | | | |
| Postdorsal distance (poD) | $y = 5.047x^{-0.003}$ | 0.032 | 0.001 | | | |
| Maximum body length (H) | $y = 9.292x^{-0.09}$ | *0.946 | 0.895 | | | |
| Minimum body length (h) | $y = 3.415x^{-0.09}$ | *0.874 | 0.764 | | | |
| Preanal distance (pA) | $y = 63.43x^{0.004}$ | *0.356 | 0.127 | | | |
| Length of caudal fin (lC) | $y = 10.19x^{-0.04}$ | *0.861 | 0.742 | | | |
| Length of dorsal fin base (lD bs) | $y = 65.80x^{0.018}$ | *0.733 | 0.537 | | | |
| Length of anal fin base (lA bs) | $y = 31.52x^{-0.00}$ | 0.138 | 0.019 | | | |
| Depth of anal fin (hA) | $y = 5.047x^{-0.05}$ | *0.401 | 0.161 | | | |
| Depth of dorsal fin (hD) | $y = 5.685x^{-0.10}$ | *0.918 | 0.843 | | | |
| Length of caudal peduncle (lpc) | $y = 5.284x^{-0.09}$ | *0.688 | 0.473 | | | |

* coefficient statistically significant.

**Table 6**

Mean values of morphometric characters of the small sandeel examined, expressed as proportion of body length (SL) in the length classes

| Character | Length class [cm] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 9.00–9.99 ($n$ = 11) | 10.00–10.99 ($n$ = 38) | 11.00–11.99 ($n$ = 13) | 12.00–12.99 ($n$ = 14) | 13.00–13.99 ($n$ = 40) | 14.00–14.99 ($n$ = 8) | 15.00–15.99 ($n$ = 5) | 16.00–16.99 ($n$ = 1) |
| Total length (TL) | 110.10 | 109.80 | 110.01 | 109.70 | 109.25 | 109.33 | 109.23 | 109.4 |
| Caudal length (FL) | 104.81 | 104.99 | 105.19 | 105.14 | 104.94 | 104.48 | 104.46 | 104.7 |
| Head length (HL) | 21.76 | 21.40 | 20.00 | 18.78 | 20.50 | 20.55 | 20.75 | 18.79 |
| Preorbital distance (prO) | 6.49 | 7.42 | 7.23 | 6.61 | 5.98 | 5.8 | 5.91 | 6.04 |
| Horizontal eye diameter (Oh) | 3.58 | 3.42 | 3.21 | 2.98 | 3.20 | 3.23 | 3.17 | 2.68 |
| Vertical eye diameter (Ov) | 2.92 | 3.12 | 3.00 | 2.67 | 2.53 | 2.57 | 2.45 | 2.01 |
| Interorbital distance (io) | 3.06 | 3.35 | 3.42 | 3.12 | 2.90 | 2.47 | 2.88 | 2.01 |
| Postorbital distance (poO) | 11.07 | 9.97 | 8.92 | 8.78 | 10.68 | 10.84 | 10.95 | 10.07 |
| Head depth (hc) | 8.59 | 8.13 | 7.78 | 7.34 | 7.08 | 7.05 | 7.06 | 6.71 |
| Length of upper jaw (lmx) | 5.90 | 6.78 | 6.52 | 5.83 | 5.50 | 5.42 | 5.05 | 4.03 |
| Length of lower jaw (lmd) | 8.95 | 10.29 | 10.02 | 9.00 | 8.30 | 7.8 | 8.64 | 8.05 |
| Length of pectoral fin (lP) | 11.04 | 10.96 | 10.91 | 10.33 | 10.19 | 9.99 | 10.23 | 10.74 |
| Predorsal distance (pD) | 27.89 | 26.51 | 26.18 | 27.39 | 26.41 | 26.45 | 25.93 | 24.83 |
| Postdorsal distance (poD) | 5.30 | 5.08 | 4.97 | 4.44 | 4.76 | 5.04 | 5.33 | 5.37 |
| Maximum body length (H) | 9.17 | 8.74 | 8.43 | 8.26 | 7.98 | 8.19 | 7.64 | 7.38 |
| Minimum body length (h) | 3.43 | 3.20 | 3.08 | 2.82 | 3.00 | 3.05 | 2.88 | 2.68 |
| Preanal distance (pA) | 63.90 | 63.37 | 62.83 | 63.98 | 64.14 | 64.04 | 63.54 | 64.43 |
| Length of caudal fin (lC) | 10.10 | 9.80 | 10.01 | 9.82 | 9.35 | 9.33 | 9.23 | 9.40 |
| Length of dorsal fin base (lD bs) | 65.65 | 67.09 | 67.44 | 67.17 | 67.77 | 66.72 | 67.59 | 69.80 |
| Length of anal fin base (lA bs) | 31.21 | 31.63 | 31.77 | 31.71 | 31.26 | 31.11 | 31.86 | 30.87 |
| Depth of anal fin (hA) | 4.69 | 5.04 | 5.50 | 4.44 | 4.55 | 4.67 | 4.9 | 4.03 |
| Depth of dorsal fin (hD) | 5.63 | 5.40 | 5.19 | 4.63 | 4.88 | 4.75 | 4.47 | 4.70 |
| Length of caudal peduncle (lpc) | 5.31 | 5.01 | 4.51 | 4.82 | 4.60 | 4.18 | 5.05 | 4.03 |

small sand eel examined, expressed as percentage of standard length (SL) in the length classes are shown in Tables 5 and 6, respectively.

The most stable morphometric characters (Table 3) were the dorsal fin base and the preanal distance, whereas the most variable characters were those related to body shape: the maximum and minimum body depths, the head depth, and the depths of the dorsal and anal fins as well as the eye diameters. The head characters expressed as proportion of the head length (Table 4) showed a low variability. The most stable characters were the lengths of both jaws, preorbital and postorbital distances and horizontal eye diameter.

The morphometric relations showed a tendency to allometry (Table 5). Only the postdorsal and postorbital distances showed almost the isometric pattern of growth. The preanal distance and length of the dorsal fin base increased along with the body length. The mean value of pA in the 9.00–9.99 cm length class was 63.90, while in 16.00–16.99 cm class it reached 64.43% of SL. The mean of length of the dorsal fin base lDbs was 65.65 and 69.80%, respectively (Table 6). All the remaining characters decreased with the increasing body length. The strongest negative relations, on the course of exponential curve, were recorded in the following characters: (first) depth of head, eye diameters, jaws length, interorbital distance (associated with the head length); (second) predorsal distance (associated with the fin arrangement), minimum and maximum body depths and length of caudal fin (the features associated with the body shape). The mean values of the characters in the length classes are presented in Table 6.

**Table 7**

Comparison of the mean values of the meristic characters of the small sandeel from different areas

| Location | Dorsal fin ray count (D) | Anal fin ray count (A) | Pectoral fin ray count (P) | Vertebral count |
|---|---|---|---|---|
| Iceland (Andriâšev 1954) | 52.9 | 27.1 | 12.2 | 62.6 |
| Faroe Islands (Andriâšev 1954) | 54.7 | 28.4 | 12.2 | 64.5 |
| Denmark (Andriâšev 1954) | 53.4 | 28.2 | 12.2 | 63.4 |
| Shetland Islands (Andriâšev 1954) | 53.4 | 28.0 | 12.1 | 63.62 |
| Present study, Gulf of Gdańsk | 53.2 | 27.97 | 11.25 | 63.62 |
| North Sea (Kändler 1941) | | Spring-spawning population | | 63.09 |
| | | Autumn-spawning population | | 64.08 |
| Baltic Sea (Kändler 1941) | | Spring-spawning population | | 63.17 |
| | | Autumn-spawning population | | 63.49 |
| Galway Bay, Ireland | | Spring-spawning population | | 63.24 |
| (O'Connel and Fives 1995) | | Autumn-spawning population | | 63.62 |
| Langstone Harbour, Hampshire | | Spring-spawning population | | 63.21 |
| (Reay 1973) | | Autumn-spawning population | | 63.94 |
| Celtic Sea (Corbin and Vati 1949) | | Undetermined | | 64.15 |

**Table 8**

Comparison of the relative values of some morphometric characters of the small sandeel from different areas

| Character | Locality | |
|---|---|---|
| | Sctland (UK), Diabaig, Torridon (Froese and Pauly 2007) (number of individuals and range of TL undetermined) | This study (Gulf of Gdańsk), Baltic Sea ($n$ = 130, 9.3–16.4 cm of TL) Range of character |
| Body length SL | 91.9% TL | 90.85%–91.57% TL |
| Caudal length FL | 96.3% TL | 94.56%–95.71% TL |
| Pre-anal distance pA | 68.0% TL | 56.52%–58.90% TL |
| Pre-dorsal distance pD | 19.6% TL | 21.74%–23.31% TL |
| Pre-pectoral distance pP | 16.3% TL | — |
| Body depth (H) | 10.5% TL | 6.52%–9.82% TL |
| Head length (HL) | 14.8% TL | 16.61%–19.86% TL |
| Eye diameter (Oh) | 17.5% HL | 14.43%–16.67% HL |
| Pre-orbital distance prO | 32.5% HL | 33.50%–38.61% HL |

Among the characters related to head length, only the postorbital distance increased along with the head length. All the remaining characters decreased with the increase of head length. The head length–pectoral fin length relation was not statistically significant.

## DISCUSSION

The total length of the small sandeel comprised in the sample studied ranged within 9.2–16.3 cm, the 13.0–13.99 cm length class being the dominant. According to Żmudziński (1990) and Andriâšev (1954), the maximum length of the species under study does not exceed 20 cm. Reay (1973) recorded the overall length range as 4.5–18.7 cm, whereas O'Connel and Fives (1995) working in the Galway Bay area (Irish coast)—found 3.4–19.3 cm (spring-spawning group) and 4.4–20.2 cm (autumn spawning group); they, however, reported data on the fork length (FL).

No literature data could be found on the meristics of the *A. tobianus* from the Baltic Sea except for the vertebral count (Table 7). The comparison of the ray counts of the dorsal- (D), anal- (A), and pectoral- (P) fins and vertebral count of the small sandeel off the Icelandic, Shetland Islands, Danish, and Faroe Islands coasts (Andriâšev 1954) revealed the lowest means to be typical off Iceland, the highest being recorded off the Faroes. The mean P ray counts are very similar in all the area listed, except for the Gulf of Gdańsk, where the count is distinctly lower. On the other hand the mean A ray counts were similar, too, in all the areas, with the exception of the sandeel sample off the Icelandic, with a markedly lower count. When compared the mean value of the D rays it was seen that distinctly lowest one was noted in the Icelandic coast area.

In all those locations, where the spring- and autumn-spawning components of the stock are distinguished, the mean vertebral counts were lower in the spring-spawning groups. In the samples collected from the Galway Bay (O'Connel and Fives 1995) and Langstone Harbour (Reay 1973) differences in the average counts were not great, but statistically significant (Table 7). A comparison of the mean vertebral count between the data in the present study and those reported by Corbin and Vati (1949) for the Baltic Sea indicates the Gulf of Gdańsk sandeel sample to belong to the autumn-spawning component of the stock.

A comparison of the mean number of plicae between those estimated in the present paper (128.2) and those reported from the Finnish coast (Goltberg 1910), the former is seen to be markedly lower than the latter (135). The plicae count range (126–136) is in agreement with that reported by Whitehead et al. (1986) (120–138).

When the mean values of particular meristic characters of the sandeel from different areas are analysed (Table 7), there is no clear evidence for a latitudinal, longitudinal, or salinity clines in the rays or vertebral counts. The most clearly evident difference (although not statistically confirmed) between the Baltic and Atlantic small sandeel is the pectoral rays count, lower by one ray in the sample from the Gulf of Gdańsk.

No morphometric data of *A. tobianus* from the Baltic Sea are available in the literature, except for the pectoral fin length expressed as a proportion of the head length. Goltberg (1910) reported, the value for *A. tobianus* to be 46% and higher, whereas it was below 46% in the great sandeel, *Hyperoplus lanceolatus*, which was confirmed by the presently reported data (range: 52.06%–62.18%, average: 57.35%) (Table 4).

The genus *Ammodytes* is characterized by the longer lower jaw when compared to the length of pectoral fin, while in the *Hyperoplus* the relation is converse (Gąsowska 1962). This character differentiated (among other) two genera in the Ammodytidae, was in agreement with the results obtained in the present study, too. The mean value of the lower jaw length was 0.90 cm, whereas the mean of the pectoral fin length amounted to 1.20 cm (50.10% and 57.35%, respectively, when related to HL) (Table 4).

A comparison of the relative values of morphometric characters between those estimated in the present paper and those reported off the Scottish coast (Froese and Pauly 2007), demonstrated in Table 8, showed the differences in the preanal- and predorsal distances, as well as in the body depth and the head proportions. In the sample from the Baltic Sea the sandeel have markedly shorter pA distance and longer pD distance. The body of the Baltic fish was evidently slender, however with the longer head and with the relatively smaller eyes when compared to the fish from the Scottish waters. Whitehead et al. (1986) noted the bigger head length (HL) in Baltic herring, *Clupea harengus membras*, as the significant diagnostic character, differentiated the subspecies among the Atlantic herring, *C. harengus* L., species.

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