

The myxosporean parasitofauna of the Atlantic horse mackerel, *Trachurus trachurus* (L.) in the North-East Atlantic Ocean and Mediterranean Sea

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Abstract

As part of a multidisciplinary stock identification study 1002 horse mackerel *Trachurus trachurus* (L.) from 12 sites in the North-East Atlantic and Mediterranean Sea were examined for the presence of myxosporean parasites, with the aim of identifying species that could be used as biological tags. Five species of myxosporean parasites were found. Examination of gall bladders revealed infections with *Alataspora serenum*, *A. solomoni* and an unidentified *Kudoa* sp., while *Kudoa nova* was found in the red muscles. The liver of a single fish was found to be infected with *Myxobolus spinacurvatura*. Infection with *A. solomoni* and *M. spinacurvatura* represents new host records. *Kudoa* sp. is likely to be a previously undescribed species. *A. serenum*, *A. solomoni* and *K. nova* are shown to be potentially useful tags for stock identification.

Key words

Myxosporean parasites, fish, *Trachurus trachurus*, Atlantic Ocean, Mediterranean Sea

Introduction

The horse mackerel (*Trachurus trachurus*) is a small pelagic fish, common in the North Atlantic and Mediterranean Sea. It is the most northerly representative of the genus *Trachurus* and is distributed from West Africa to the Norwegian Sea, including Iceland, and throughout the North Sea, the Mediterranean and Black Seas (Smith-Vaniz 1986).

There has been uncertainty for several years about the validity of stock definitions for this species in the North-East Atlantic (Murta 2000). Currently, ICES considers there to be three stocks in this area, the North Sea Stock, the Western Stock, in waters to the west of the British Isles, extending into the Bay of Biscay, and the Southern Stock, in waters around the Iberian Peninsula (ICES 1998). There are no stocks defined in the African coastal area, or the Mediterranean Sea.

To support the possible use of parasites as biological tags for this species, a study was made of the parasite fauna of the horse mackerel throughout European waters. Sixty-eight different parasite taxa have been recorded by this study (MacKenzie *et al.* 2004).

Three myxosporeans have been described from the horse mackerel in the North Atlantic; *Alataspora serenum* Gaevskaya et Kovaleva, 1979, *Kudoa nova* Naidenova, 1975 and *Kudoa quadratum* (Thélohan, 1892) (Gaevskaya and Kovaleva 1979a, Gaevskaya and Kovaleva 1980).

A number of species of myxosporeans have been described from other members of the genus *Trachurus*. *Alataspora solomoni* Yurakhno, 1988 was described from the Mediterranean horse mackerel, *T. mediterraneus*, from the Black Sea, near Sevastopol (Yurakhno 1988). *Davisia donecae* Gaevskaya et Kovaleva, 1979 and *Ceratomyxa australis* Gaevskaya et Kovaleva, 1979 have been described from the Cape horse mackerel, *T. capensis* from Namibian waters (Gaevskaya and Kovaleva 1979b).

Materials and methods

Samples of horse mackerel were collected by a combination of commercial and research vessels at 19 sites in the North Atlantic and Mediterranean Sea during both 2000 and 2001,

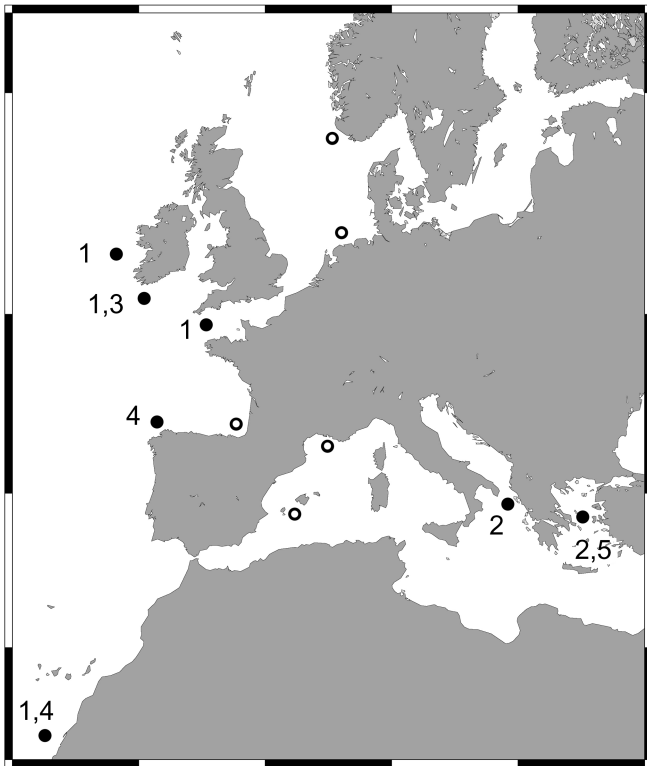


Fig. 1. Locations of sampling sites in European waters. Sites where myxosporeans were recorded are signified by filled circles and denoted as follows: **1.** *Alataspora serenum*. **2.** *Alataspora solomoni*. **3.** *Kudoa* sp. **4.** *Kudoa nova*. **5.** *Myxobolus spinacurvatura*. Sites where myxosporeans were not present are shown as empty circles

as part of the multidisciplinary stock identification project “HOMSIR”. For a detailed description of sampling procedures, see Abaunza *et al.* (in press).

One thousand and two fishes from 12 sites over both years were deep-frozen and transported to the University of Aberdeen for complete parasitological examination. These sites are shown in Figure 1.

Wet smears of gall bladder and liver tissue were examined under phase contrast microscopy at a magnification of $\times 325$, using a Zeiss Photomicroscope II, for the presence of myxosporean parasites. Fish were then filleted and “candled” and the musculature examined for the presence of cysts.

For descriptive purposes, spores were examined at magnifications of up to $\times 2000$, using an agar monolayer and oil immersion microscopy. Air-dried smears were fixed in methyl alcohol and stained with Giemsa to enhance spore morphology. For electron microscopy, gall bladders containing spores of *A. solomoni* were fixed in glutaraldehyde, opened longitudinally, attached to a stub, sputter-coated with gold and examined using a Jeol 35CF scanning electron microscope.

As far as is possible when dealing with frozen material, the guidelines of Lom and Arthur (1989) were adhered to. All measurements of dimensions are given in micrometres (μm), as ranges followed, in parentheses, by means \pm standard deviation. Date and location of capture and prevalence refer to the

site where the species was most common. Other sites where the parasite was recorded are shown on Figure 1.

Results

Five myxosporean parasites from three families were recorded infecting the horse mackerel in the Atlantic Ocean and Mediterranean Sea. *A. serenum*, *A. solomoni* and *Kudoa* sp. were found to be coelozoic in the gall bladder. *K. nova* was found in the red musculature. *M. spinacurvatura* was found in the liver of one fish from the Aegean Sea.

Alataspora serenum Gaevskaya et Kovaleva, 1979 (Fig. 2)

Order: Bivalvulida Shulman, 1959

Family: Alatasporidae Schulman, Kovaleva et Dubina, 1979

Genus: *Alataspora* Schulman, Kovaleva et Dubina, 1979

Description: No pathological changes in host noted. Trophozoite stage not observed. Spores transparent, crescent shaped, anterior end convex, posterior end concave. Spore valves equally sized. Suture straight and distinct. Triangular body containing polar capsules, with alate projections extending laterally from the anterior of the body. Polar capsules spherical. Spore dimensions, based on observations of 50 spores: length 3.8–7.7 (5.80 ± 0.83), width 11.5–19.2 (14.40 ± 1.56). Spore length:width ratio, 1:1.67–3.50. Polar capsules equally sized, opening to anterior of spore. Polar capsule dimensions, based on 40 measurements, diameter 1.3–2.6 (1.87 ± 0.39).

Host: *Trachurus trachurus* (L.).

Site of infection: Gall bladder.

Location of capture: West of Ireland, $52^{\circ}52.8'N$ $12^{\circ}03.6'W$.

Date: March 25, 2001.

Prevalence: 6/25 (24%).

Host length range: 19.6–43.1 cm.

Alataspora solomoni Yurakhno, 1988 (Fig. 3)

Order: Bivalvulida Shulman, 1959

Family: Alatasporidae Schulman, Kovaleva et Dubina, 1979

Genus: *Alataspora* Schulman, Kovaleva et Dubina, 1979

Description: No pathological changes noted. Vegetative stages not observed. Spores transparent, crescent shaped,

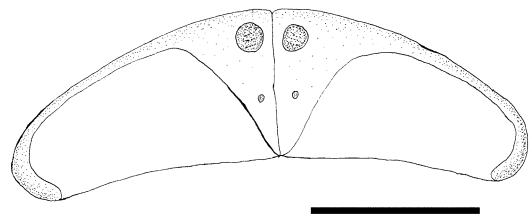


Fig. 2. *Alataspora serenum*. Scale bar = 5 μm

anterior end convex, posterior end concave. Spore valves equally sized. Suture straight and distinct. Triangular body, with slight thickening around suture, containing polar capsules. Polar capsules opening onto different sides of anterior side of the spore. Spore dimensions, based on observations of 50 spores: length 5.1–9.0 (6.7 ± 0.8), width 17.9–33.3 (24.3 ± 3.2). Spore length:width ratio, 1:2.67–1:5.75. Polar capsules spherical, unequal in size. Dimensions of polar capsules, based on 40 observations, diameter of larger polar capsule, 1.6–2.88 (2.24 ± 0.39), diameter of smaller polar capsule 0.96–2.56 (1.94 ± 0.4).

Host: *Trachurus trachurus* (L.).

Site of infection: Gall bladder.

Location of capture: Ionian Sea, 40°28'N 24°55'E.

Date: June 7, 2001.

Prevalence: 11/50 (22%).

Host length range: 12.4–30.3 cm.

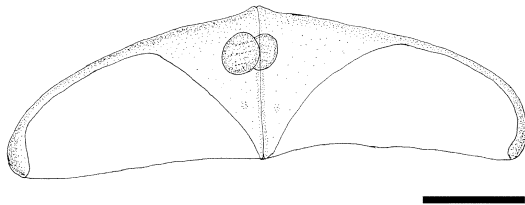


Fig. 3. *Alataspora solomoni*. Scale bar = 5 μ m

Kudoa sp. (Fig. 4)

Order: Multivalvulida Shulman, 1959

Family: Kudoidae Meglitsch, 1960

Genus: *Kudoa* Meglitsch, 1947

Description: No pathological changes noted. Vegetative stages not observed. Spore transparent, subquadrate in apical view, with rounded valves. Sutural line thin and indistinct. Anterior side of spore convex, posterior side “bell” shaped. Polar capsules large, pyriform. Spore dimensions, based on 17 measurements: length 5.1–7.7 (5.97 ± 0.79), spore width 5.3–7.3 (6.11 ± 0.53), polar capsule length 2.6–3.8 (3.10 ± 0.45).

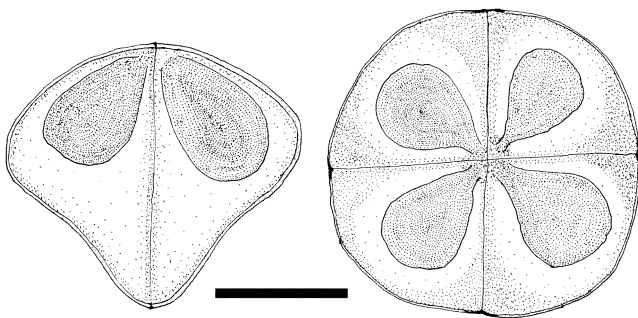


Fig. 4. Unidentified *Kudoa* sp. in apical (left) and lateral (right) views. Scale bar = 2 μ m

Host: *Trachurus trachurus* (L.).

Site of infection: Coelozoic in the gall bladder.

Location of capture: South of Ireland, 48°45'N 09°29'W.

Date: April 2001.

Prevalence: 3/46 (6.5%).

Host length range: 26.4–31.8 cm.

Kudoa nova Naidenova, 1975 (Fig. 5)

Order: Multivalvulida Shulman, 1959

Family: Kudoidae Meglitsch, 1960

Genus: *Kudoa* Meglitsch, 1947

Description: Pseudocysts macroscopic, white, spherical, up to 3 mm in diameter, found in clusters in the dorsal, ventral and lateral red muscles. Vegetative state of spore not observed. Spore subquadrate in apical view, with rounded valves. Sutural line thin and indistinct. Slightly elongate, ventrally flattened, in lateral view. Polar capsules large, pyriform. Spore dimensions based on 30 spores: length 5.1–7.7 (6.2 ± 0.9), width 5.1–7.7 (6.2 ± 0.9), polar capsule length 1.3–2.6 (1.8 ± 0.4).

Host: *Trachurus trachurus* (L.).

Site of infection: Dorsal, ventral and lateral red muscles.

Location of capture: North African Coast, 19°58'N 17°28'W.

Date: January 2001.

Prevalence: 3/46 (6.5%).

Host length range: 21.3–24.6 cm.

Myxobolus spinacurvatura Maeno, Sorimachi, Ogawa et Egusa, 1990 (Fig. 6)

Order: Bivalvulida Shulman, 1959

Family: Myxobolidae Thélohan, 1892

Genus: *Myxobolus* Butschli, 1882

Description: No pathological changes noted in host. Spore oviform in lateral view, flattened perpendicular to sutural line. Two polar capsules, opening separately on the apical side of spore. Polar filaments coiled in three or four turns. Spore dimensions, based on measurements of 40 spores: length 8.9–11.5 (9.97 ± 0.90), thickness 3.8–6.4 (4.92 ± 0.82), width

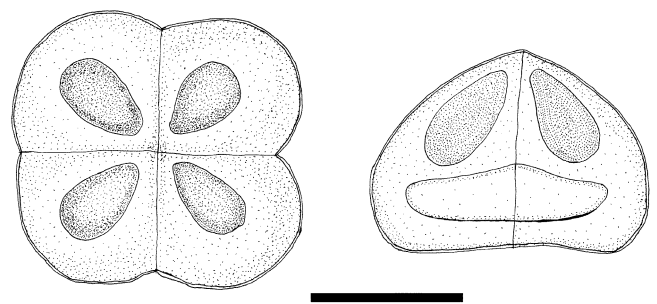


Fig. 5. *Kudoa nova* in lateral (left) and apical (right) views. Scale bar = 5 μ m

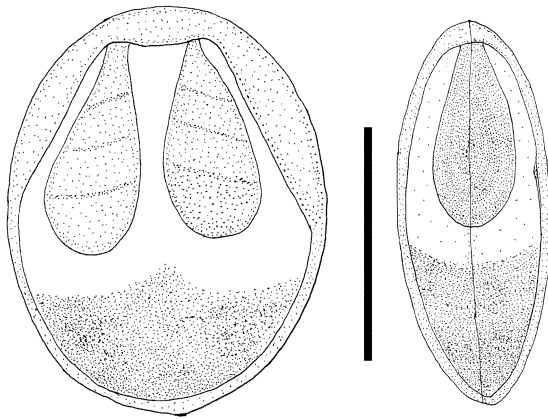


Fig. 6. *Myxobolus spinacurvatura* viewed in lateral (left) and sutural (right) planes. Scale bar = 5 μ m

7.1–9.2 (8.56 ± 0.61). Length of polar capsule 3.8–5.1 (4.24 ± 0.60), width of polar capsule 2.3–2.9 (2.78 ± 0.26). This species has been comprehensively described by Maeno *et al.* (1990) and Bahri and Marques (1996).

Host: *Trachurus trachurus* (L.).

Site of infection: Liver.

Location of capture: Ionian Sea, 40°28'N 24°55'E.

Date: June 7, 2001.

Prevalence: 1/43 (2.3%).

Host length range: 23.8 cm.

Discussion

This is the first comprehensive study of the myxosporean parasites of *T. trachurus* throughout its geographic range, and reveals a diverse community.

Several of the myxosporean species that infect horse mackerel show potential for use as biological tags.

Alataspora serenum was originally described from *T. trachurus* in the Celtic Sea, infecting around 15% of fish (Gaevskaya and Kovaleva 1979a). It was recorded in the present study in three samples, one site to the north-west of Ireland, one in the Celtic Sea and one in the western English Channel, in both 2000 and 2001. Prevalence in all samples was around 15–20%. It was not recorded in samples from the adjacent waters of the North Sea and Bay of Biscay. This finding supports the current management system by suggesting that movements between the Western stock and the Southern and North Sea stocks are limited. *A. serenum* was also recorded from a single fish (1/46) from the Atlantic coast of North Africa (19°58'N 17°28'W), suggesting that some horse mackerel may be highly migratory. This species was not recorded in the Mediterranean Sea. It could be useful as a tag, indicating mixing of stocks in the North-East Atlantic.

Alataspora solomoni was originally described infecting the Mediterranean horse mackerel, *T. mediterraneus*, from Quarantine Bay, near Sevastopol, in the Black Sea (Yurakhno

1988). This is the first record of *A. solomoni* infecting the Atlantic horse mackerel (*T. trachurus*), and the first record of infection outside the area of the Black Sea. *A. solomoni* was only recorded in fish from the samples taken in the eastern part of the Mediterranean Sea. It was not recorded in any of the samples taken in the western part of the Mediterranean, and suggests the existence of discrete stocks in this body of water.

Over 450 species of *Myxobolus* have been described from fish hosts. Of these, the majority have been described from freshwater fishes (Landsberg and Lom 1991). This is the first record of *Myxobolus spinacurvatura* infecting *T. trachurus*, and the first record of this species from the European coast of the Mediterranean Sea. The rarity of this finding suggests that this was an accidental infection. This species does not provide any useful information on stock identity or distribution.

An unidentified *Myxobolus* sp. has been previously recorded in the Adriatic Sea, infecting the livers of mullet, *Mugil cephalus*, in aquaculture facilities in Italy (Fioravanti *et al.* 2001). It is unknown whether this was the same species which has been recorded here, but the geographical proximity of this record to our finding and the fact that this species was first described from an infection of *M. cephalus* (Maeno *et al.* 1990) would suggest that this is possible.

The genus *Kudoa* (Myxozoa, Myxosporea) comprises of species which are typically histozoic parasites (Moran *et al.* 1999). This is only the third report of a *Kudoa* species being found free in the gall bladder, the other two being *Kudoa tachysuriae* Sarkar *et Mazumder*, 1983, reported from the three-spined catfish, *Arius tenuispinis* Day, 1877, and *Kudoa haridasae* Sarkar *et Ghosh*, 1991, from the gold-spot mullet, *Liza parisa* (Hamilton, 1822), both from the Bay of Bengal (Sarkar and Mazumder 1983, Sarkar and Ghosh 1991). This species was found infecting horse mackerel from one site to the south-west of Ireland only. Where present, infections were of a very low intensity, which made a detailed description or electron microscopy impossible. It is likely that this finding represents the discovery of a previously undescribed species. This species needs further study and description before any useful information can be extracted from its distribution.

Despite examining samples from the Bay of Biscay, where it had previously been recorded (Gaevskaya and Kovaleva 1980), no fish infected with *Kudoa quadratum* were encountered.

Kudoa nova has been reported from *T. trachurus*, *T. mediterraneus* and *T. capensis*, from the Atlantic Ocean, Black and Mediterranean Seas (Kovaleva *et al.* 1979). In this study, it was most frequently recorded in the sample collected from the African coast, at a prevalence of 6.5%. This agrees with the southerly distribution proposed by Kovaleva *et al.* (1979) who found infected *T. trachurus* only along the Morocco-Saharan coast. This species could prove a useful biological tag to study migration of fish from African waters into European seas. A single fish from a sample collected off the Galician coast was found to be infected with *K. nova*. Again, this supports the idea that some horse mackerel are highly migratory.

Cruz *et al.* (2003) reported a number of horse mackerel from the coast of Portugal as being infected with a *Kudoa* sp. Further sampling should be carried out in this area to determine the identity of this species. If found to be *K. nova*, it would support the findings of Murta (2000), who proposed a degree of mixing between North African and European horse mackerel stocks.

Alataspora serenum, *A. solomoni* and *K. nova* all show potential as useful biological tags for stock identification in different areas. *A. serenum* is most commonly found in fish from the Western stock, *A. solomoni* has only been found in fish from the eastern Mediterranean, and *K. nova* shows a more southerly distribution. It is a simple procedure to examine a fish for infections with these species, and examination of greater numbers or of further samples from areas that have not been covered in this study would be a simple and useful contribution to understanding the stock distribution of this species.

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References

- Abaunza P., Murta A., Campbell N., Cimmaruta R., Comesaña S., Dahle G., Gallo E., García Santamaría M.T., Gordo L., Iversen S., MacKenzie K., Magoulas A., Mattiucci S., Molloy J., Nascetti G., Pinto A.L., Quinta R., Ramos P., Ruggi A., Sanjuan A., Santos A.T., Stransky C., Zimmermann C. Considerations on sampling strategies for an holistic approach to stock identification: the example of the HOMSIR project. *Fisheries Research*, in press.
- Bahri S., Marques A. 1996. Myxosporean parasites of the genus *Myxobolus* from *Mugil cephalus* in Ichkeul lagoon, Tunisia: Description of two new species. *Diseases of Aquatic Organisms*, 27, 115–122.
- Cruz C., Vas A., Saraiva A. 2003. Occurrence of *Kudoa* sp. (Myxozoa) in *Trachurus trachurus* L. (Osteichthyes) in Portugal. *Parasite*, 10, 69–79.
- Fioravanti M.L., Caffara M., Delgado M.L., Florio D., Marcer F., Quaglio F., Restani R. 2001. Indagine sulla diffusione di myxosporidi (Myxozoa) in pesci marini allevati in Italia. *Bollettino Società Italiana di Patologia Ittica*, 13, 12–25.
- Gaevskaya A.V., Kovaleva A.A. 1979a. New and rarely encountered forms of myxosporidia from fishes of the Celtic Sea. *Parazitologiya*, 13, 159–165 (In Russian).
- Gaevskaya A.V., Kovaleva A.A. 1979b. Two new species of myxosporidia from horse mackerel in the south eastern Atlantic. *Biologiya Morya*, 3, 80–83 (In Russian).
- Gaevskaya A.V., Kovaleva A.A. 1980. Eco-geographical characteristics of the parasite fauna of Atlantic Ocean scad. In: *Investigations on the biological resources of the Atlantic Ocean*. IBSS, Sevastopol (In Russian).
- ICES 1998. Working group on the assessment of mackerel, horse mackerel, sardine and anchovy. *ICES CM 1998/ACFM*, 6.
- Kovaleva A.A., Shulman S.S., Yakovlev V.N. 1979. Myxosporidia of the genus *Kudoa* (Myxosporidia: Multivalvulida) of the Atlantic Ocean basin. *Trudy Zoologicheskogo Instituta AN SSSR*, 87, 42–64 (In Russian).
- Landsberg J.H., Lom J. 1991. Taxonomy of the genera of the *Myxobolus/Myxosoma* group (Myxobolidae: Myxosporea), current listing of species and revision of synonyms. *Systematic Parasitology*, 18, 165–186.
- Lom J., Arthur J.R. 1989. A guideline for the preparation of species descriptions in the Myxosporea. *Journal of Fish Diseases*, 12, 151–156.
- MacKenzie K., Campbell N., Mattiucci S., Ramos P., Pereira A.L., Abaunza P. 2004. A checklist of the protozoan and metazoan parasites reported from the Atlantic horse mackerel, *Trachurus trachurus* L. *Bulletin of the European Association of Fish Pathologists*, 24, 180–184.
- Maeno Y., Sorimachi M., Ogawa K., Egusa S. 1990. *Myxobolus spinacurvatura* sp. n. (Myxosporea: Bilvalvulida) parasitic in deformed mullet, *Mugil cephalus*. *Fish Pathology*, 25, 37–41.
- Moran J.D.W., Whitaker D.J., Kent M.L. 1999. A review of the myxosporean genus *Kudoa* Meglitsch, 1947, and its impact on the international aquaculture industry and commercial fisheries. *Aquaculture*, 172, 163–196.
- Murta A. 2000. Morphological variation of horse mackerel (*Trachurus trachurus*) in the Iberian and North African Atlantic: implications for stock identification. *ICES Journal of Marine Science*, 57, 1240–1248.
- Sarkar N., Ghosh S. 1991. Two new coelozoic Myxosporidia (Myxozoa: Myxosporea) from estuarine teleost fishes (Mugilidae) of West Bengal, India. *Proceedings of the Zoological Society of Calcutta*, 44, 131–135.
- Sarkar N., Mazumder S.K. 1983. Studies on myxosporean parasites (Myxozoa: Myxosporea) from marine fishes in West Bengal, India: I. Description of three new species from *Tachysurus* spp. *Archiv für Protistenkunde*, 127, 59–63.
- Smith-Vaniz W.F. 1986. The Carangidae. In: *Fishes of the North-Eastern Atlantic and the Mediterranean*. Vol. II (Eds. P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese). UNESCO, Paris, 815–844.
- Yurakhno V.M. 1988. On new myxosporidia of Black Sea fishes. *Parazitologiya*, 22, 521–524 (In Russian).