**Diplodus levantinus** (Teleostei: Sparidae), a new species of sea bream from the southeastern Mediterranean Sea of Israel, with a checklist and a key to the species of the *Diplodus sargus* species group

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**Summary:** The sea bream *Diplodus levantinus* n. sp. is described from off the coasts of Israel in the eastern Mediterranean Sea, where it replaces *Diplodus sargus* (Linnaeus, 1758). The new species is characterized by 11-12 spines and 10-16 soft rays in the dorsal fin, 3 spines and 11-13 soft rays in the anal fin, 15-17 pectoral fin rays, 6-9 + 8-12 gill rakers on the first gill arch, upper and lower jaws with a single row of 4 incisors on each side, followed by a total of 16-19 molariform teeth in the upper jaw and 12-14 molariform teeth in the lower jaw, with the molariforms of the upper jaw separated from the incisors by a wide, toothless gap, and the sides of the body in adults with 8 vertical bars of equal width which are present even in large adults, followed by a broad bar on the caudal peduncle which usually nearly reaches the ventral margin of the caudal peduncle. An updated checklist of the species of the genus *Diplodus*, and a key to species of the *Diplodus sargus* species group from the eastern Atlantic and Mediterranean Sea, are presented.

**Keywords:** taxonomy; fishes; new species; Mediterranean Sea; neotype designation; checklist; key.

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INTRODUCTION

The spadefish genus Diplodus are distributed in tropical and warm temperate waters of the Atlantic Ocean and the western Indian Ocean including the Red Sea. They are mainly found on shallow water reefs. The genus includes a total of 22 valid subspecies and species (Paz et al. 1974, Paz 1982, Eschmeyer and Fricke 2015).

Diplodus was first described by Rafinesque (1810a: 26, 34) for Sparus annularis Linnaeus, 1758. The species of the genus have been known since ancient times; two species now assigned to the genus were described by Linnaeus (1758), namely Diplodus annularis and D. sargus. The latter species has been known since Aristotle, and its description by Linnaeus (1758) was based on multiple sources from localities in the Mediterranean Sea (Greece, France, Italy). Valenciennes in Cuvier and Valenciennes (1830: 14) unnecessarily renamed the species as Sargus rondeletii, a name that was used by many subsequent authors. Diplodus sargus may reach a total length of up to 40 cm (Man-Wai and Quignard 1982: 175), which equals a standard length of approximately 324 mm; Fischer et al. (1987) even give a maximum total length of 45 cm. Cadetan (1964) revised the genus Diplodus from West Africa, and revived the name Diplodus sargus; he described two subspecies, including the description of Diplodus sargus typicus, which included specimens from West Africa as well as the Mediterranean Sea. Partially based on his West African material, Paz et al. (1974) described a new subspecies Diplodus sargus cadenati from West Africa and the Canary Islands.

In his thesis project, Paz (1975) revised the genus Diplodus. He defined the Diplodus sargus species group as having 4-10 vertical bands along the sides of the body, plus sometimes additional smaller bands in the spaces between the main bands, 4 incisors each in the upper and lower jaws, and large molars in 2-4 rows. In the species group, he included the subspecies Diplodus sargus sargus (Linnaeus, 1758) from the Mediterranean, D. s. cadenati Paz, Bauchot and Daget, 1974 from the eastern Atlantic, D. s. capensis (Smith, 1844) from South Africa, and D. s. lineatus (Valenciennes in Cuvier and Valenciennes, 1830) from the Cape Verde Islands. These results were previously summarized in the paper of Paz et al. (1974). In addition, he reported “Diplodus X” from Israel (Paz 1975: 57-61, Fig. 27), which he thought to be a questionable hybrid between D. sargus and D. annularis. Paz (1982) expanded the Diplodus sargus species group to include two additional subspecies from the South Atlantic, four from the western Atlantic, and two from the Indian Ocean. The suspected hybrid status of the population in Israel was not mentioned again in this paper or in subsequent literature.

When we examined specimens of Diplodus from Israel, our attention was drawn to the identity of specimens previously named Diplodus sargus (non Linnaeus, 1758), which were found to be distinct from “typical” Diplodus sargus from other parts of the Mediterranean Sea. The analysis of these individuals demonstrated that the population from Israel represents a separate species, which is described in the present paper.

MATERIALS AND METHODS

Specimens were examined at the Academy of Natural Sciences of Philadelphia (ANSP); Hebrew University, Jerusalem (HUJ); Muséum National d’Histoire Naturelle, Paris (MNHN); Museo Civico di Storia Naturale “Giacomo Doria”, Genoa, Italy (MSNG); Staatliches Museum für Naturkunde, Stuttgart (SMNS); National Museum of Natural History, Washington, D.C. (USNM); and Museum für Naturkunde der Humboldt- Universität, Berlin (ZMB).

Descriptive methods follow Caldwell (1965). Proportional measurements and counts for the holotype of Diplodus levantinus n. sp. are given first, followed by those of the paratypes in parentheses. Following the method of Fricke et al. (2007), subspecies are no longer used: they are either raised to the species level or synonymized. The classification is based on Eschmeyer and Fricke (2015) and references follow Fricke (2015). The museum abbreviations follow Frick et al. (2015).

Comparative material: Diplodus annularis: HUJ 7149 (5, Haifa, Israel); HUJ 7814 (2, Jaffa, Israel); HUJ 9616 (1, Bardawil Lagoon, Egypt); HUJ 9757 (1, Jaffa, Israel); HUJ 12237 (1, Haifa, Israel); HUJ 18383 (1, Haifa, Israel); HUJ 19056 (2, Istanbul, Turkey); SMNS 995 (3, Italy, Trieste); SMNS 1009 (1, France Nice); SMNS 4809 (3, France, Alpes Maritimes); SMNS 9198 (4, Croatia, Istria); SMNS 9193 (2, Italy, Genova); SMNS 9188 (1, Italy, Genova); SMNS 9438 (4, Croatia, Cres Island); SMNS 9591 (1, Greece, Varkiza); SMNS 9629 (1, Greece, Varkiza); SMNS 9868 (1, Greece, Varkiza); SMNS 11186 (1, Greece, Gulf of Laconia); SMNS 11539 (2, Turkey, Mugla); SMNS 11597 (2, Greece, Varkiza); SMNS 12478 (1, Spain, Balearic Islands, Formentera); SMNS 15570 (1, Italy, Sardinia); SMNS 23470 (1, Canary Islands, El Hierro); SMNS 23474 (1, Canary Islands, El Hierro); SMNS 23478 (1, Canary Islands, El Hierro); SMNS 23490 (1, Canary Islands, El Hierro); SMNS 24260 (1, Canary Islands, Tenerife); SMNS 24294 (3, Canary Islands, Tenerife); SMNS 24299 (1, Spain, Cadiz); SMNS 24308 (1, Spain, Cadiz); SMNS 25294 (4, Turkey, Antalya); SMNS 25735 (2, Italy, Venice); SMNS 25736 (1, Monaco); SMNS 33511 (1, Turkey, Alanya). Diplodus argenteus: MSNG 40167 (1, USA, Florida); MSNG 42500 (1, Uruguay, Montevideo); MSNG 45730 (2, Uruguay, Montevideo); USNM 375532 (1, Brazil, Santa Catarina); USNM 384179 (1, Brazil, Santa Catarina). Diplodus ascensionis: ANSP 158788 (1, Ascension Island). Diplodus bellottii: SMNS 10301 (3, Canary Islands, Lanzarote); SMNS 16722 (2, Canary Islands, Fuerteventura); ZMB 33614 (1, Western Sahara). Diplodus bernardensis: USNM 351263 (1, Bermuda). Diplodus cadenati: HUJ 19258 (1, Canary Islands, Tenerife); HUJ 20532 (3, jaws, Canary Islands, Tenerife); HUJ 20533 (3 jaws, Canary Islands, Tenerife); HUJ 20534 (3 jaws, Senegal, Dakar); MSNG 42382 (1, Canary Islands); MSNG 42885 (1, Portugal, Sesimbra); SMNS 11921 (1, Senegal, Dakar); SMNS 16738 (1, Canary Islands, Fuerteventura); ZMB 13819 (1, Azores); ZMB 13833 (2, Azores); ZMB 19185 (2, Azores, São Miguel). Diplodus capensis: MSNG 26649 (2, South Africa, Cape Province); SMNS 25672 (1, South Africa); ZMB 1071 (1, South Africa, Cape Province); ZMB 1072 (1, South Africa, Cape Province). Diplodus cadieniaca: USNM 53152 (1, Bahamas, New Providence); USMN 131278 (1, Venezuela, Estanques Bay). Diplodus cervinus: HUJ 14171 (3, Bardawil Lagoon, Egypt); HUJ 18928 (2, Mikhmoret, Israel); MSNG 13110 (1, Canary Islands, Tenerife); MSNG 13112 (1, Italy, Palermo); MSNG 39811 (1, Bivala, Genoa). Diplodus didactylus: SMNS 10329 (1, Canary Islands); SMNS 10355 (2, Canary Islands, Lanzarote); SMNS 11791 (1, Canary Islands, Gomera); SMNS 16779 (1, Canary Islands, Fuerteventura); SMNS 24310 (6, Spain, Cadiz). Diplodus fasciatus: HUJ 20369 (2 jaws, Cape Verde Islands, Boa Vista); MSNG 13111 (2, Cape Verde Islands).
New Diplodus from southeastern Mediterranean • 307

Diplodus levantinus new species (Figs 1-4, Table 1)

Sargus Rondeletii (non Valenciennes in Cuvier and Valenciennes, 1830): Steinitz 1927: 338 (Haifa, Israel).

Sargus sargus (non Linnaeus, 1758): Liebnan 1934: 323 (Palestine/Israel; most frequent and abundant species).

Diplodus sargus (non Linnaeus, 1758): Hornell 1935: 83 (Palestine/Israel). Bodenheimer 1937: 273 (Palestine/Israel). Ben-Tuvia 1953a: 273 (off Caesarea, Israel). Ben-Tuvia 1953b: 439 (off Caesarea, Israel). Ben-Tuvia 1971: 32 (Israel). Golani 1996: 39 (Israel). Golani 2006: 182 (Israel). Golani et al. 2006: 163.

Sargus rondeletii (non Valenciennes in Cuvier and Valenciennes, 1830): Bodenheimer 1935: 462 (Palestine/Israel).

Diplodus X (probably a hybrid of Diplodus annularis × Diplodus sargus): Paz et al. 1974: 126. Paz 1975: 57-61 (Tantoura Bay, Israel).

Diplodus sargus sargus (non Linnaeus, 1758): Whitehead et al. 1986: 894-895 (part. Israel).

Fig 1. – Diplodus levantinus n. sp., HUJ 20555, holotype, 184.1 mm SL, off Jaffa, Israel, 30 Oct. 2015. Leftateral view; photograph of the fresh colouration taken a few hours after collection (Photograph: D. Golani).
Holotype: HUJ 20535, 184.1 mm SL, eastern Mediterranean Sea, Israel, off Jaffa, ca. 32°03’N 34°45’E, collected by local fishermen, 30 Oct. 2015.

Paratypes: Eastern Mediterranean Sea, Israel: HUJ 2134, 6399, 6402, 6403, 7462, 14441, 19859, 20257, 20344, MSNG 58305, 50-176 mm SL.

Table 1. – Selected body proportions of the holotype and selected paratypes of Diplodus levantinus n. sp., expressed in percentage of standard length.

|                     | Holotype (HUJ 20535, 184.1 mm SL) | Paratypes (n = 27; HUJ 2134, 6399, 6402, 6403, 7462, 14441, 19859, 20257, 20344, MSNG 58305, 50-176 mm SL) |
|---------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------|
| Body depth          | 44                                | 45-50                                                               |
| Head length         | 32                                | 32-37                                                               |
| Horizontal eye diameter | 8                                  | 8-13                                                               |
| Tip of snout to dorsal fin origin | 44                              | 44-48                                                               |
| Tip of snout to anal fin origin | 69                              | 67-73                                                               |
| Tip of snout to dorsal fin insertion | 73                              | 69-78                                                               |
| Tip of snout to anal fin insertion | 73                              | 70-79                                                               |
| Tip of snout to pectoral fin origin | 33                              | 32-38                                                               |
| Tip of snout to pelvic fin origin | 39                              | 39-45                                                               |
| Dorsal fin origin to caudal fin base | 72                              | 65-72                                                               |
| Anal fin origin to caudal fin base | 39                              | 38-43                                                               |
| Pectoral fin origin to caudal fin base | 68                              | 64-70                                                               |
| Length of dorsal fin base | 57                              | 52-56                                                               |
| Length of anal fin base | 24                              | 22-26                                                               |
| Length of pectoral fin base | 7                               | 7-8                                                                |
| Length of pectoral fin | 33                               | 34-39                                                               |
| Length of pelvic fin | 23                               | 23-25                                                               |
| Length of pelvic fin spine | 15                              | 13-16                                                               |
| Dorsal fin insertion to caudal fin base | 40                              | 30-40                                                               |
| Anal fin insertion to caudal fin base | 35                              | 31-35                                                               |
| Least depth of caudal peduncle | 11                              | 9-12                                                                |

Fig. 2. – Diplodus levantinus n. sp., HUJ 20257, paratype, specimen 1, 95 mm SL, Sdot Yam, Israel, 21 Jan. 2014. Lateral view; photograph of the fresh colouration taken a few hours after collection (Photograph: D. Golani).

Diagnosis. A species of Diplodus Rafinesque 1810 with 11-12 spines and 10-16 soft rays in the dorsal fin, 3 spines and 11-13 soft rays in the anal fin, 15-17 pectoral fin rays, 6-9 + 8-12 gill rakers on the first gill arch, upper and lower jaws with a single row of 4 incisors on each side, followed by a total of 16-19 molariform teeth in the upper jaw and 12-14 molariform teeth in the lower jaw, with the molariforms of the upper jaw separated from the incisors by a wide gap, and the sides of the body in adults with 8 vertical bars of equal width, which are present even in large adults, followed by a broad bar on caudal peduncle, which usually nearly reaches the ventral margin of the caudal peduncle.
Description. Dorsal fin-ray formula XII, 13 (XI to XII, 10 to 16, usually XII, 13 to 14). Anal fin ray formula III, 13 (III, 11 to 13). Pectoral fin ray formula, all elements, 16-16 (15 to 17). Gill rakers 6+9 (6-9+8-12) on first gill arch.

Selected body proportions, included in Table 1, are part of the description.

Body completely scaled; scales ctenoid. Predorsal scales extending to a point above about centre of eye. Cheeks scaled. Snout scaleless. A long ventral axillary scale. Inter-ray membranes of dorsal, anal, pelvic and pectoral fins scaleless. Small scales extending about three-fourths the way out from base of caudal fin. Lateral line a smooth shallow convex curve from its origin to just beyond end of dorsal fin, then nearly straight to fold formed when tail is bent upward. Four scales (two to four) in a line angling upward, extending onto basal portion of caudal fin. Lateral line scales 68 (59-72). Eight (eight or nine) scales above lateral line to origin of dorsal fin, 16 (16-17) below to origin of anal fin, and seven (seven) above highest curve of lateral line to base of dorsal fin. Maximum observed standard length 231 mm.

Fig. 3. – Diplodus levantinus n. sp., HUJ 2134, paratype, 176.3 mm SL, near mouth of Wadi Hadera, Israel, 24 Oct. 1955. Lateral view; photograph of the colouration in preservative taken 60 years after preservation (Photograph: D. Golani).

Fig. 4. – Diplodus levantinus n. sp., HUJ 20535, holotype, 184.1 mm SL, off Jaffa, Israel, 30 Oct. 2015. Lateral view; x-ray (Photograph: I. Aizenberg).
Dorsal outline a regular curve from tip of snout to end (insertion) of dorsal fin, with only a slight concavity above eye and a slight convexity in front of eye. Snout slightly pointed. Ventral outline slightly convex (nearly straight) from tip of snout to pelvic fin origin, thence nearly straight to anal fin origin, and after angling upward at an angle of about 40°, convex to end (insertion) of anal fin. Dorsal and anal fins low. Pectoral fin long, reaching nearly to or past origin of anal fin, and increasing in relative length with increase in body length. Caudal fin forked. Mouth small, maxillary not reaching anterior margin of orbit in small specimens. Anterior nostril round; posterior nostril an elongate oval, the opening slit-like.

A single outer row of incisor teeth, four on each side both upper and lower, and none notched; upper portion of each tooth essentially rectangular in outline above a narrowed base bearing a posterior buttress on inner surface; teeth protrude and are rather strongly incurved towards cutting edge; anterior corner of each lateral tooth elevated. A mosaic of small molariform teeth in posterior part of mouth, 16 (16-19) in upper jaw, 12 (12-14) in lower jaw; anterior part immediately behind incisor teeth is naked; behind these, in lateral posterior part of mouth, there are three (two or three) rows of molariform teeth above, and three (two or three) rows below.

Vertebræ (Fig. 4): 10 precaudal plus 13 caudal plus one hypural, equalling 10 plus 14 as usually recorded. Three predorsal bones. Two dorsal spines situated on first pterygiophore, thereafter one spine on each pterygiophore (a count of 0-0-0-2 as discussed by Smith and Bailey, 1961).

Table 2. – Comparison of eastern Atlantic and Mediterranean species of the Diplodus sargus species group.

|                          | D. levantinus n. sp. | D. sargus | D. cadenati | D. lineatus | D. capensis |
|--------------------------|----------------------|-----------|-------------|-------------|-------------|
| Dorsal fin rays          | XI-XII, 10-16        | XI-XIII, 12-15 | XI-XIII, 12-15 | XI-XIII, 12-15 | XI-XIII, 13-16 |
| Anal fin rays            | III, 11-13           | III, 12-14 | III, 12-14  | III, 12-14  | XII, 14-17   |
| Pectoral fin rays        | 15-17                | 15-17     | 16-17       | 15-18       | 15-17       |
| Lateral line scales      | 59-72                | 57-68     | 58-67       | 57-66       | 61-69       |
| Number of molariform teeth in upper jaw | 16-19            | 28-32     | 39-43       | 8-10        | 36-41       |
| Rows of molariform teeth in upper jaw | 2-3               | 4         | 4-5         | 1-2         | 4-5         |
| Number of molariform teeth in lower jaw | 12-14            | 20-28     | 27-31       | 3-4         | 19-22       |
| Rows of molariform teeth in lower jaw | 2-3               | 4-5       | 4-6         | 2           | 3-4         |
| Extent of molariforms towards incisors in upper jaw | Not reaching to base of incisors, leaving a wide gap | Nearly reaching to base of incisors | Reaching to base of incisors | Not reaching to base of incisors, leaving a wide gap | Reaching to base of incisors |
| Extent of molariforms towards incisors in lower jaw | Not reaching to base of incisors, leaving a narrow gap | Nearly reaching to base of incisors | Reaching to base of incisors | Not reaching to base of incisors, leaving a wide gap | Reaching to base of incisors |
| Large adults: vertical bars on body | 8 of equal width | None | Alternatingly 5 wide, 3-4 narrow, total 8-9 | 4 of equal width, 1 narrow | None |
| Medium-sized adults: vertical bars on body | 8 of equal width | Alternatingly 4-5 wide, 3-4 narrow, total 8-10 | Alternatingly 4-5 wide, 3-4 narrow, total 7-9 | 4 of equal width, 1 narrow | 9 of equal width |
| Small adults: vertical bars on body | 8 of equal width | Alternatingly 4-5 wide, 3-4 narrow, total 9-10 | 5 of equal width | 4-5 of equal width | 9 of equal width |
| Extent of dark blotch on caudal peduncle | Nearly reaching ventral margin | Usually only on upper three-fourths | Only on upper four-thirds | Only on upper half to upper three-fourths | Only on upper three-fourths |

Colour in alcohol. For pigmentation of body refer to Figures 1-2, which are part of the description.

Head and body silver, scales with horizontal rows of dark pigment. Head dorsally dark grey between the eyes, and a vertical dark streak below the eye. Posterior edge of opercle dark. A dark pectoral axillary blotch. Caudal peduncle with a broad dark grey streak that often reaches to the lower midline. Sides of body with
about eight narrow vertical bars that extend across the upper three-fourths of the body; the posterior two bars are present but not very well visible on the photograph of the holotype due to light reflections (Fig. 1). Pectoral fins immaculate. Inter-spine and inter-ray membranes of dorsal, anal and caudal fins tinged with dark pigment, which is more intense towards bases of fins. Anterior inter-ray membranes of pelvic fins dark, more so than those of dorsal, anal and caudal fins; the spine and the first membrane are white, however, as are the posterior membranes. Caudal fin distally dark grey.

**Etymology.** The name of the new species, levantinus, refers to the Levant, a historical name for the coasts of the eastern Mediterranean.

**Distribution and habitat.** Known only from the coast of Israel, eastern Mediterranean Sea, between Haifa and Jaffa (Fig. 5). The species is found from shallow water to 50 m depth, usually on sand bottom near rocks; juveniles are found above sandy substrate near rocks at depths of 0.2-2 m.

**Comparisons.** The dentition and colouration of the eastern Atlantic and Mediterranean species are compared in Figs 6-7 and Table 2. The new species is distinguished from *D. sargus* (Mediterranean Sea except Israel; Figs 8, 6A, 7A-C) by the number of molariform teeth in the upper and lower jaws in juveniles and adults (*D. sargus*: upper jaw 28-32, 4 rows; lower jaw 20-28, 4-5 rows. *D. levantinus* n. sp.: upper jaw 16-19, 2-3 rows; lower jaw: 12-14, 2-3 rows), the molariform teeth which do not extend to the base of the incisors in the upper jaw but leave a wide gap (nearly extending to the base of the incisors in *D. sargus*), the presence of vertical bars on the sides of the body in large specimens (usually absent in *D. sargus*), and sides of body in moderate and small adults with bars of equal width (usually alternating wide and narrow bars in *D. sargus*). It differs from *D. cadenati* (eastern Atlantic; Figs 9, 6C, 7G-I) in the number of molariform teeth in the upper and lower jaws in juveniles and adults (*D. cadenati*: upper jaw 39-43, 4-5 rows; lower jaw 28-32, 4-5 rows. *D. levantinus* n. sp.: upper jaw 16-19, 2-3 rows; lower jaw: 12-14, 2-3 rows), the molariform teeth...
which do not extend to the base of the incisors in the upper jaw but leave a wide gap (extending to the base of the incisors in *D. cadenati*), sides of body in large and moderate adults with bars of equal width (usually alternating wide and narrow bars in *D. cadenati*), sides of body in small adults with 8 vertical bars (with about 5 vertical bars in *D. lineatus*), and the black blotch on the caudal peduncle usually reaching the ventral margin (usually only covering the upper three-fourths in *D. lineatus*). It is distinguished from *D. capensis* (South Africa; Figs 6B, 7D-F) in the number of molariform teeth in the upper and lower jaws in juveniles and adults (*D. capensis*: upper jaw 36-41, 4-5 rows; lower jaw: 19-22, 3-4 rows. *D. levantinus* n. sp.: upper jaw 16-19, 2-3 rows; lower jaw: 12-14, 2-3 rows), sides of body in small adults with 8 vertical bars (with 4-5 vertical bars in *D. lineatus*), and the black blotch on the caudal peduncle usually nearly reaching the ventral margin (usually only covering the upper half to upper three-fourths in *D. lineatus*). It differs from *D. capensis* (South Africa; Figs 6B, 7D-F) in the number of molariform teeth in the upper and lower jaws in juveniles and adults (*D. capensis*: upper jaw 36-41, 4-5 rows; lower jaw: 19-22, 3-4 rows. *D. levantinus* n. sp.: up-
New Diplodus from southeastern Mediterranean

per jaw 16-19, 2-3 rows; lower jaw: 12-14, 2-3 rows), the molariform teeth, which do not extend to the base of the incisors in the upper jaw but leave a wide gap (extending to the base of the incisors in D. capensis), the presence of vertical bars on the sides of the body in large specimens (absent in D. capensis), and sides of body in moderate and small adults with 8 vertical bars (with 9 vertical bars in D. capensis). The new species is distinguished from D. argenteus (western Atlantic), D. ascensionis (Ascension Island), D. bermudensis (western Atlantic), D. caudimacula (western Atlantic), D. helenae (St. Helena), D. holbrooki (western Atlantic), D. kotschyi (northwestern Indian Ocean) and D. noct (Red Sea) by the presence of vertical bars on the sides of the body in large specimens (absent in D. argenteus, D. ascensionis, D. bermudensis, D. caudimacula, D. helenae, D. holbrooki, D. kotschyi and D. noct), sides of body in moderate and small adults with 8 vertical bars (with 9 vertical bars in D. argenteus, D. bermudensis, D. caudimacula, D. helenae, D. kotschyi, and D. noct), and the black blotch on the caudal peduncle usually nearly reaching the ventral margin (usually only covering the upper three-fourths in D. argenteus, D. ascensionis, D. bermudensis, D. caudimacula, D. holbrooki, D. noct and D. kotschyi, in large specimens restricted to a round blotch in the middle in D. kotschyi and D. noct).

DISCUSSION

The southeastern Mediterranean (Levantine) populations previously attributed to Diplodus sargus clearly belong to a different species, based on differences in the dentition and colouration. The only junior synonym of D. sargus listed in the Catalogue of Fishes online (Eschmeyer and Fricke 2015) that was described from the eastern Mediterranean, Sargus raucus Geoffroy Saint-Hilaire, 1809, was first considered as the valid name for these; the species was illustrated from Egypt by Geoffroy Saint-Hilaire (1809: pl. 18, Fig. 1), and no type material is available. The material was collected in Alexandria, Egypt in 1798-1799, and when Alexandria was conquered by Britain, Geoffroy Saint-Hilaire refused to hand over the materials and documents to the British general Hutchinson, and later sent the material to Paris (Baufchot et al. 1990: 88). However, Bauchot and
Daget (1971: 322) found two specimens of *Sargus rau- cus* from Alexandria (MNHN 0000-5740), which were used for the description of Geoffroy Saint-Hilaire (1827: 340), and identified them as *Diplodus cervinus* (Lowe 1838). None of the specimens agrees with the holotype illustrated by Geoffroy Saint-Hilaire (1809: Pl. 38, Fig. 1), which is a smaller specimen and clearly belongs to the *Diplodus sargus* species group, so the holotype is not included in MNHN 0000-5740. The material collected by E. Geoffroy Saint-Hilaire in Egypt was exclusively sent to Paris, but no other material of the *Diplodus sar- gus* species group collected during the Egyptian mission is extant in the MNHN collection (see also Bauchot and Daget 1972: 69). We therefore conclude that the holotype is lost. A specimen from Bardawil Lagoon, Egypt (HUJ 6047), very similar in colouration to the one illustrated by Geoffroy Saint-Hilaire (1809), turned out to have the typical dentition of *Diplodus sargus* with irregularly grouped small molars reaching right to the front teeth, without a naked area in between. The specimen has a dorsal fin count of XII+13, an anal fin count of III+13, pectoral fin rays 16, gill rakers 5+8. In

Fig. 9. – *Diplodus cadenati*, HUJ 20532, 3 spec (upper to lower: 151, 149, 140 mm SL), Tenerife, Canary Islands, 25 July 2015. Lateral view; photograph of the fresh colouration taken a few hours after collection (Photograph: R. Fricke).
order to avoid nomenclatural confusion, and to fix the classification of southeastern Mediterranean species in the *Diplodus sargus* group, the specimen (HJU 6047) is hereby designated as the neotype of *Sargus raurus* Geoffroy Saint-Hilaire, 1809 (Fig. 11), which is thus a junior synonym of *Diplodus sargus* (Linnaeus, 1758). The neotype originates from Bardawil Lagoon, northern Sinai, Egypt, which is as close as possible to the original type locality (Egypt). A second specimen from Bardawil Lagoon (HJU 6057) also agrees in the dentition and general characters with *Diplodus sargus*. A third specimen, ZMB 1055 (70.5 mm SL) from Alexandria, Egypt, collected during the expedition of Hemprich and Ehrenberg, has likewise a dentition typical of *Diplodus sargus*. It can be concluded that *Diplodus sargus* is found along the Mediterranean coast of Egypt, while the species is replaced by *D. levantinus* n. sp. in Israel.

The difference of the Israeli population from other species of the *Diplodus sargus* species group were first recognized in the doctoral dissertation of Paz (1975: 57), who provisionally named the specimens from Israel “*Diplodus X*” and assumed that they were hybrids between *D. annularis* × *D. sargus*, due to the dentition, which seemed intermediate between those species. However, the hybrid theory can be ruled out, as no true *Diplodus sargus* is found in Israel, and genetically they are clearly part of the *Diplodus sargus* species group, without a component of another species of *Diplodus* (Yaron Tikochinski, personal communication). Except in the work of Paz (1975), the distinctiveness of Israeli populations previously misidentified as *D. sargus* was neither mentioned nor discussed again in the literature, including the later paper of Paz (1982).

The body shape and colouration changes during growth in *Diplodus* spp.; juveniles are more slender, adults more high-bodied, and in some species the number of stripes along the sides of the body increases. Allometric growth in *Diplodus* compared with

Fig. 10. – *Diplodus lineatus*, HJU 20368, 4 spec (Upper to lower: 222, 176, 166, 162 mm SL), Boa Vista, Cape Verde Islands, 9 Sept. 2014. Lateral view; photograph of the fresh colouration taken a few hours after collection (Photograph: R. Fricke).
two other species of the genus was analysed by Loy et al. (2001). Allometric growth is also obvious in *Diplo- dus levantinus* n. sp., but the number of stripes along the sides of the body does not change from juveniles to adults in this species.

Considering the genetics of species in the *Diplo- dus sargus* species group, no genetic differences were found between *Diplo dus sargus* and *D. cadenati* by Domingues et al. (2007). They agreed with Bargelloni et al. (2005) who considered two hypotheses to explain this lack of differentiation. Either *D. sargus* is a recent immigrant in the Mediterranean or historical bottlenecks and recolonization processes prevented strong differentiation of Atlantic and Mediterranean basins. In a genetic study of several species of *Diplo dus*, including *D. levantinus* n. sp., *D. sargus* and *D. lineatus*, no significant differences were found among these species (Yaron Tikochinski, personal communication). On the other hand, the *Diplo dus sargus* species group is well distinguished from other species of *Diplo dus* (see Summerer et al. 2001, Casu et al. 2009). However, González-Wangüemert et al. (2006) detected diagnostic alleles differentiating between *Diplo dus sargus* and *D. cadenati*; additional molecular analyses should be performed for the species group. Apart from potential genetical differences, the species in the *Diplo dus sargus* species group are sufficiently distinguished by their dentition and colouration.

The restricted range of *Diplodus levantinus* n. sp. appears to represent a relict distribution; its particular dentition recalls that of *D. lineatus* from the Cape Verde Islands, which is also considered a relict distribution. Species with a stronger dentition (including *D. sargus* in the Mediterranean) seem to have spread over most of the range of the species group, leaving the species with weaker dentition in such small, restricted areas at the margin. The range of *D. levantinus* is separated from that of *D. sargus* by wide stretches of sandy shore without suitable habitat in the south; the situation in the north of its distribution range remains unknown.

CHECKLIST OF SPECIES OF THE GENUS *DIPLODUS*

*Diplodus annularis* (Linnaeus, 1758)

*Sparus unicolor flavescens*, macula nigra annulari ad caudam Artedi 1738a: 37, No. 12 (based on Artedi 1738b; Sparus of authors).

*Sparus unicolor flavescens*, macula nigra annulari ad caudam Artedi 1738b: 57, No. 1 (based on Ruás of Aristoteles and Aelianus; Sparos of Athineus, Oppianus and Eustathiou; Sparus of Plinius, Albertinus, Cubae, Bellonius, Rondeletius, Salviani, Aldrovandi, Jonston, Charleton, Willughby, Rajus; Marinus of Gesner; Sparulus of Ovidius; Fluta and Sargus of Gaza; Caspargus of Aelianus).

*Sparus annularis* Linnaeus, 1758: 278 (in mari Adriatico, infero/Adriatic Sea; no types known; based on *Art. gen. 37, syn. 57, Sparus unicolor flavescens* ...).

*Sparus sparulus* Lacepède, 1802: 26, 76 [part: Mediterranean Sea; syntypes: MNHN A.125 (2)].

*Sparus sparlotus* Rafinesque, 1810b: 49 (Toscana, Italy; no types known).

*Sciaena melanura* Pallas, 1814: 254 (Eupatoria/Samsun, Turkey, Black Sea; no types known).

Distribution: Mediterranean Sea, Black Sea and Sea of Azov; eastern Atlantic from Canary Islands north to Bay of Biscay.

*Diplodus argenteus* (Valenciennes in Cuvier and Valenciennes, 1830)

*Sargus argenteus* Valenciennes in Cuvier and Valenciennes, 1830: 60 [Brazil; syntypes: MNHN 8555 (3), A-8105 (1)].

*Sparus sargo* Larrañaga, 1923: 379 (Uruguay; no types known).

Distribution: western Atlantic from Brazil to Argentina.

*Diplodus ascensionis* (Valenciennes in Cuvier and Valenciennes, 1830)

*Sargus ascensionis* Valenciennes in Cuvier and Valenciennes, 1830.
Diplodus bellottii (Steindachner, 1882)
*Sargus bellottii* Steindachner, 1882: 42 (Arglim Bank, Canary Islands; holotype: not found).

Diplodus senegalensis Cadenat, 1964: 968, Figs 6, 7, 25 [Port-Étienne, Mauritania; Senegal; syntypes: IFAN uncat. (15)].

Diplodus sargus typicus Cadenat, 1964: 960 (part: West Africa).

Diplodus cadenati Paz, Bauchot and Daget, 1974
*Diplodus sargus typicus* Cadenat, 1964: 960 (part: West Africa).

Diplodus capensis (Smith, 1844)
*Sargus capensis* Smith, 1844: unpaginated, pl. 23, Fig. 2 (East Cape, South Africa; holotype: BMNH 1845.7.3.52).

Diplodus caudimacula (Poey, 1860)
*Sargus caudimacula* Poey, 1860: 198 [Cuba; syntypes: MCZ 21715 (1), USNM 100938 (1, ex 4693)].

Diplodus cervinus (Lowe, 1838)
*Sparus trifasciatus* Rafinesque, 1810b: 50, No. 135 (Sicily, Italy; no types known).

Diplodus fasciatus (Valenciennes in Cuvier and Valenciennes, 1830)
*Sargus fasciatus* Valenciennes in Cuvier and Valenciennes, 1830: 59 [Cape Verde Islands; syntypes: MNHN A.8099 (1), A.8100 (1)].

Diplodus helenae (Sauvage, 1879)
*Sargus helenae* Sauvage, 1879: 205 (Saint Helena Island; holotype: MNHN A.0952).

Diplodus holbrookii (Bean, 1878)
*Sargus holbrookii* Bean, 1878: 198 [Savannah Bank, Charleston, South Carolina, USA; syntypes: USNM; 20979 (4)].

Diplodus hottentotus (Smith, 1844)
*Sargus hottentotus* Smith, 1844: unpaginated, Pl. 23, Fig. 1 (SE coast of South Africa; holotype: BMNH 1845.7.3.51).

Diplodus levantinus new species
Distribution: Israel, eastern Mediterranean Sea.

Diplodus lineatus (Valenciennes in Cuvier and Valenciennes, 1830)
*Sargus lineatus* Valenciennes in Cuvier and Valenciennes, 1830: 59 (no locality; holotype: MNHN A-8102).

Diplodus omanensis Bauchot and Bianchi, 1984
*Diplodus cervinus omanensis* Bauchot and Bianchi, 1984: 103, Fig. A (Kuria Maria Bay, Oman, Arabian Sea; holotype: MNHN 1984-0358).

Diplodus prayensis Cadenat, 1964
*Diplodus prayensis* Cadenat, 1964: 955, 965, Figs 8, 14, 20 (Port of Praia, Sao Tiago Island, Cape Verde Islands; holotype: MNHN 1964-0579).

Diplodus puntazzo (Walbaum [ex Cetti], 1792)
*Sparus puntazzo* Cetti, 1777: 115 (Sardinia, Italy; no types known; not available, used as vernacular name only).

* Sparus puntazzo* Walbaum [ex Cetti], 1792: 282 (Sar-
Diplodus sargus (Linnaeus, 1758)
Sparus lineis transversis varius, macula nigra insigni ad caudam Artedi 1738a: 37, No. 13 (based on Artedi 1738b, No. 58; Sergus of authors).
Sparus lineis transversis varius, macula nigra insigni ad caudam Artedi 1738b: 58, No. 2 (Greece, France, Italy, Venice; based on O’Sargus of Aristotlestes, Aelianus, Oppianus and Atheneus; Sargus of Ennius, Ovidius, Plinius, Juvenal, Bellonius, Rondeletius, Salviani, Gesner, Aldrovandius, Jonston, Charleton, Willughby and Raujus).
Sparus sargus Linnaeus, 1758: 278 (in M. infero, Adriatic Sea; no types known; based on ‘Art. gen. 37, syn. 58, Sparus lineis transversis varius ...').
Sparus cinctus Walbaum, 1792: 282 (Marseille, France; no types known; based on Sparus sp., ‘Sparus fascia subcaudal ...’ of Brünnich 1768: 39, No. 58).
Sargus rauschi Geoffroy Saint-Hilaire 1809: Pl. 18, Fig. 1 (Alexandria, Egypt; neotype: HUJ 6047, as designated above.)
Sparus sargus: Rafinesque, 1810a: 24, No. 151 (Messina, Sicily, Italy).
Sparus varutalus Rafinesque, 1810b: 48 (Sicily, Italy; no types known).
Sargus rondeletii Valenciennes in Cuvier and Valenciennes, 1830: 14, pl. 141 [Naples, Italy; Marseille and Toulon, France; Malta; Alexandria, Egypt; Bizerte, Tunisia; syntypes: MNHN 8529–8530 (2), 8602 (1), A.8098 (1)].
Sargus vetula Valenciennes in Cuvier and Valenciennes, 1830: 48 [Martigues, France; Naples, Italy; syntypes: MNHN 8543 (2), 8544 (1)].
Diplodus sargus typicus Cadenat, 1964: 960 (part: Mediterranean Sea).
Distribution: Mediterranean Sea (except Israel), Black Sea.
Diplodus striatus (Bliss 1883)
Sargus striatus Bliss, 1883: 50 (Mauritius; holotype: MCZ 5731).
Distribution: southwestern Indian Ocean: Mauritius, Rodrigues.
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)
Sargus noster primus ... Aldrovandi, 1638: Fig. [p. 174].

Key to eastern Atlantic and Mediterranean species of the Diplodus sargus group
1– Each side of upper jaw with a total of 28-43 molariform teeth in 4-5 principal rows; each side of lower jaw with a total of 20-31 molariform teeth in 3-6 principal rows; molariform teeth in upper jaw reaching to base of incisors ........................................ 2
2– Each side of upper jaw with a total of 8-19 molariform teeth in 1-3 principal rows; each side of lower jaw with a total of 3-14 molariform teeth in 2-3 principal rows; molariform teeth in upper jaw not reaching to base of incisors, separated by a distance of at least 2 lengths of the largest molariform tooth ........................................ 4
3– Each side of upper jaw with a total of 28-32 molariform teeth........................................... Diplodus sargus
4– Each side of upper jaw with a total of 8-10 molariform teeth in 1-2 principal rows; each side of lower jaw with a total of 3-4 molariform teeth in 2 principal rows; molariform teeth in lower jaw not reaching to base of incisors, separated by a distance of at least 2 lengths of the largest molariform tooth; sides of body with 4 broad and one narrow vertical dark bars, in addition to dark blotch on dorsal half of caudal peduncle........................................... Diplodus striatus
5– Each side of upper jaw with a total of 16-19 molariform teeth in 2-3 principal rows; each side of lower jaw with a total of 12-14 molariform teeth in 2-3 principal rows; molariform teeth in lower jaw nearly reaching to base of incisors; sides of body
with about 8 narrow vertical dark bars of even width, in addition to dark blotch nearly all across caudal peduncle. . . . . . . . Diplodus levantinus n. sp.

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REFERENCES

Aldrovandi U. 1638. De piscibus libri V et de cetis lib. unus. I. B. Bellagamba, Bononiae [Bologna]: 6 [unnumbered] + (372)732 + 27 [unnumbered] pp.

Artedi P. 1738a. Genera piscium. In quibus systema totum ichthyologiae proponitus cum classibus, generum characteribus, specierum differentiis, observationibus plurimis. Redactis speciebus 242 ad genera 52. Ichthyologiae pars 3. Conradus Wishhoff, Lugduni Batavorum (Leiden), 84 + ii pp.

Artedi P. 1738b. Synonyma nominum piscium fere omnium; in qua recensitio fite nominum piscium, omnium facilie authorum, qui undam de piscibus scripserit: uti Graecorum, Romanorum, Barbarorum, nec non omnium sequentium ichthyologorum, una cum nominibus iniquilin variarum nationum. Ichthyologiae pars 4. Conradus Wishhoff, Lugduni Batavorum (Leiden), i + 118 + xxi pp.

Barbey R. 1850. Description de Poissons de la mer Rouge et de la Méditerranée. In: Description de l'Egypte ou recueil d'observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'Armée française, publié par les ordres de sa Majesté-L'Empereur Napoléon le Grand. Tome I, (pt. 1). Imprimerie Impériale, Paris: 1-52 [141-338], Poissons Pls. 1-17.

Bauchot M.-L. 1979. Les Diplodus (Pisces, Sparidae) de la mer Rouge. Zone de pêche 37. Révision 1. Volume II Vertébrés. FAO, Rome.

Bauchot M.-L., Bianchi G. 1984. Les Sparidae de l'océan Indien est de l'Indonésie. Cah. ORSTOM, Sér. Océanogr. 3(3): 319-338.

Bauchot M.-L., Daget J. 1971. Les Diplodus (Pisces, Sparidae) du groupe cervinus-fasciatus. Cah. ORSTOM, Sér. Océanogr. 9(3): 139-178.

Bauchot M.-L., Daget J. 1972. Catalogue critique des types de poissons du Muséum national d’Histoire naturelle. (Suite.) (Famille des Sparidae). Bull. Mus. Nat. Hist. Nat. (Sér. 3: Zool.) 24(Zool. 18): 33-100.

Bauchot M.-L., Daget J., Bauchot R. 1990. L’ichthyologie en France au début du XIXe siècle. L’Histoire naturelle des poissons de Cuvier et Valenciennes. Bull. Mus. Nat. Hist. Nat. A (Zool.) 41(21), Suppl. 1-142.

Bauchot M.-L., Daget J., Bauchot R. 1990. L’ichthyologie en France au début du XIXe siècle. L’Histoire naturelle des poissons de Cuvier et Valenciennes. Bull. Mus. Nat. Hist. Nat. A (Zool.) 41(21), Suppl. 1-142.

Bean T.H. 1878. Description of a new sparid fish, Sargus holbrookii, from Savannah Bank. Proc. U. S. Nat. Mus. 1(28): 198-200.

Ben-Tuvia A. 1953a. Mediterranean fishes of Israel. Sea Fish. Res. Stat., Bull. 8: 1-40.

Ben-Tuvia A. 1953b. Mediterranean fishes of Israel. Sea Fish. Res. Stat., Bull. 8: 1-40.

Ben-Tuvia A. 1953b. Mediterranean fishes of Israel. Sea Fish. Res. Stat., Bull. 8: 1-40.

Ben-Tuvia A. 1953b. Mediterranean fishes of Israel. Sea Fish. Res. Stat., Bull. 8: 1-40.

Ben-Tuvia A. 1953b. Mediterranean fishes of Israel. Sea Fish. Res. Stat., Bull. 8: 1-40.

Ben-Tuvia A. 1971. Revised list of the Mediterranean fishes of Israel. Isr. J. Zool. 20: 1-39.

Bleeker P. 1876. Systema Percarum revisum. Pars Ia. Percae. Arch. Nat. Néerl. Sci. Exact. Nat. 11: 247-288.

Bliss R. 1883. Descriptions of new species of Mauritius fishes. Trans. Roy. Soc. Arts Sci. Mauritius (N. S.) 13: 45-63.
