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Distribution and Biological Characteristics of Couch's Goby *Gobius couchi* (Gobiidae), a New Species for the Black Sea

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Abstract—Couch's goby *Gobius couchi* was found for the first time off the southwestern coast of Crimea, in the coves of Sevastopol. Earlier, this goby was not noted in the Black Sea; its range included the Atlantic coasts of England and Ireland and the northeastern part of Mediterranean and Aegean seas. The present paper provides the description of the morphological characteristics of Couch's goby, including the diagnostic features, the data on its distribution near the Crimean coasts, and some features of ecology and behavior. The data on fecundity and time of reproduction of this goby are presented for the first time. It is suggested that the appearance of Couch's goby near the Crimean coasts is determined by the process of "Mediterranization" of the Black Sea.

Keywords: Gobius couchi, morphometry, Mediterranization, Black Sea, Crimea

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INTRODUCTION

The highest species diversity is a characteristic of fam. Gobiidae, including more than 35 species in the Black Sea fish fauna. Two main groups of this family specific in their genesis prevail: brackish-water Ponto-Caspian endemics and marine allochthonous species introduced from the Mediterranean Sea during the permanent process of Mediterranization. For instance, eight new alien species of fam. Gobiidae with either Atlantic-Mediterranean or Mediterranean native ranges were found near the Crimean coasts only since the beginning of the 20th century. Three of them, *Gammogobius steinitzi* Bath, 1971, *Chromogobius zebratus* (Kolombatović, 1891) and *Millerigobius microcephalus* (Kolombatovič, 1891) are known to the present only by findings in the coastal areas of the peninsula: the two former near Cape Tarkhankut (Kovtun, 2012; Kovtun and Karpova, 2014); the latter only in Sevastopol Bay (Boltachev and Karpova, 2014). The gobies *Gobius xanthocephalus* Heymer et Zander, 1992, and *Pomatoschistus bathi* Miller, 1982, found for the first time off the coasts of Abkhazia (Vasil'eva and Bogorodskii, 2004), have become common nowadays in the region of southwestern Crimea, and the latter species occur in mass along the whole coast line of the peninsula (Boltachev et al., 2016). A goby *Gobius cruentatus* Gmelin, 1789, was simultaneously noted near the coasts of Turkey and in Sevastopol and recently constantly occurs near the Abrausskii Peninsula (Engin et al., 2007; Boltachev and Karpova, 2014; Prokof'ev, 2016). A goby *Zebrus zebrus* (Risso, 1827)—initially known from the single finding near the coasts of Turkey (Kovačić and Engin, 2009)—was found for the first time in the Sevastopol coves in 2013 and became quite numerous in the last 3 years (Karpova et al., 2015).

On the one hand, numerous findings of new gobiid species near the Crimean coasts are determined by quite close proximity to the strait of Bosporus and, on the other hand, by the diversity of habitats in the region of southwestern Crimea. In addition, regular monitoring of this area plays an important role. One result of this monitoring was finding one more gobiid species new for the Black Sea in the Sevastopol coves: Couch's goby *Gobius couchi* Miller et El-Tawil, 1974. This species was known by innumerous findings near the Atlantic coasts of England and Ireland, in the northeastern part of the Mediterranean Sea, and in the southern part of Dardanelles Strait at the exit to the Aegean Sea (Kovačić et al., 2013). Despite numerous recent catches of this species in the Mediterranean Sea, the traits of Couch's goby biology are hardly studied yet and the scarce available data concern only characteristics of size and specific features of the habitats. This is why any information on this species' ecology and behavior in the environment are of considerable scientific interest.

The goal of the present paper is to provide information on the first findings and distribution of Couch's goby in the Black Sea and to present data on the morphology and biology of this species for the first time.

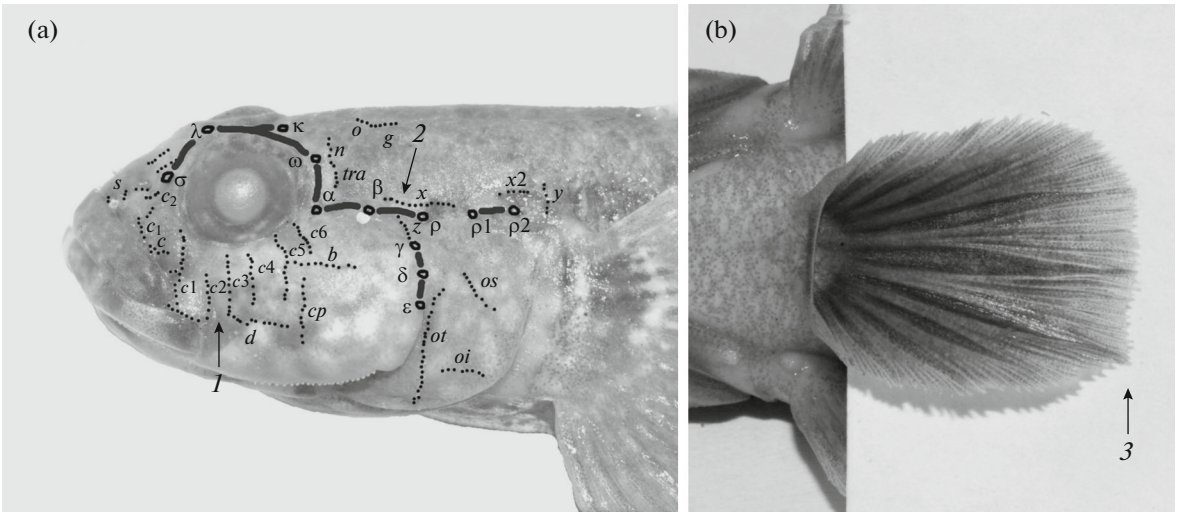

Fig. 1. Structures of (a) seismosnesoric system and (b) abdominal surculus of Couch's goby *Gobius couchi*. Canal pores: σ, λ, κ, ω, α, β, ρ—of the anterior oculocapsular canal; ρ1, ρ2—of the posterior oculocapsular canal; γ, δ, ε—of the preopercular canal. Rows of genipores: *r*, *s*, *c*, c_1, c_2—preorbital; *b*, *c*1–*c*6, *d*—suborbital; *x*, *x*2, *tra*, *z*, *y*—oculocapsular; *ot*, *os*, *oi*—opercular; *n*, *o*, *g*—parietal. Key identification characters (⇨): *1*—structure of subocular row of genipores *d*; *2*—position of oculocapsular row of genipores *x*; 3—shape of the posterior edge of abdominal surculus.

MATERIALS AND METHODS

The materials were sampled near Sevastopol (southwestern Crimea) in the Kazach'ya Bay (44.57° N, 33.40° E; 98 individuals) and Karantinnaya Bay (44.62° N, 33.50° E; 2 individuals). The fish were sampled with hand net in the coastal zone at depths of 0.5–6.0 m in August–September 2015 and every month from May to September 2016. In total, 100 ind. of Couch's goby (65 females and 35 males) were sampled. For the species identification, the identification tables were used (Miller, 1986; Kovačić, 2008).

In all individuals, total body (*TL*) and standard (*SL*, from the top of snout to the end of urostyle) lengths were measured to 0.1 mm using a slide caliper; the weight was determined to 0.01 g using electronic balances; sex and stage of gonads maturity were determined. For the age determination, the otoliths (15 fish) were analyzed; the number of oocytes in the gonads of IV maturity stage were directly counted (five females). The morphometric analysis of the materials (51 ind.) preserved in 4% formaldehyde followed common methods (Pravdin, 1966). In total, 34 indices of the plastic characters were analyzed: 22 are expressed as % *SL*; 12 as % of the head length (*c*). The significance of differences in the plastic and meristic features between the males and females was assessed applying Student's test (t_{st}). The terminology of the genipore rows and of the seismosensory system canals is given according to Miller (1986). To study the features of the goby's behavior, the observations and filming were carried out in the natural and aquarium conditions.

Recently, 23 individuals of this species were archived in the collection of the Azov-Black seas' basin fish of the Institute of Marine Biological Research, Russian Academy of Sciences (nos. AB-1227–1230, AB-1291, AB-1293, AB-1296).

RESULTS AND DISCUSSION

Morphological characteristics. The species of the goby was identified based on the set of the following diagnostic features: longitudinal row of lateral-line system α genipores absent; anterior longitudinal oculocapsular row of genipores *x* in front part does not reach β pore; all three head canals of seismosensory systems present; row of *d* genipores split into two parts; behind orbit, oculocapsular canal with α pore present (Fig. 1a); head and occiput covered with scales; number of scales along middle of body side less than 50 (usually 36–44); solid uninterrupted black stripe along body and head absent; abdominal surculus weakly truncated (Fig. 1b). Main morphometric characteristics of Couch's goby males and females are given in Table 1.

Body teretial, covered with ctenoid scales, cheeks and bases of pectoral fins bare. Head not impressed; upper lip not widened at sides. Posterior nostrils not elongated to tubule; short triangle-shaped tentaculum branches from anterior nostrils. Head seismosensory systems with six transverse rows of genipores; all three head canals present: anterior oculocapsular (with σ, λ, κ, ω, α, β, and ρ pores), posterior oculocapsular (with ρ1 and ρ2 pores) and preopercular (with γ, δ and ε pores) (Fig. 1a).

In first dorsal fin (*D*1), usually 6 (6.0 ± 0.03) spiny rays (rarely 5 or 7); in second fin (*D*2), one spiny (rarely two) and 12–13 (12.6 ± 0.11) (rarely 11) branched rays. In adult males, upper part of *D*1 rays

Table 1. Plastic characters of Couch's goby *Gobius couchi* males and females

Character	Males ($n = 25$)	Females ($n = 26$)	t_{st}
Total length (*TL*), mm	71.7 ± 1.52 61.7–80.6	63.5 ± 0.74 56.4–70.4	4.85**
Standard length (*SL*), mm	57.3 ± 1.16 50.2–64.8	51.6 ± 0.63 45.6–56.7	4.28**
Weight, g	4.1 ± 0.24 2.8–5.7	2.9 ± 0.12 1.94–4.06	4.24**
	As % *SL*		
Maximal body depth	17.9 ± 0.37 15.5–21.5	19.0 ± 0.29 16.3–22.1	2.39*
Minimal body depth	11.0 ± 0.10 10.3–11.5	10.4 ± 0.07 9.8–11.1	5.49**
Maximal body width	15.6 ± 0.23 13.9–17.0	16.5 ± 0.34 13.5–19.7	2.28*
Minimal body width	8.3 ± 0.17 7.2–9.5	8.3 ± 0.12 7.1–9.6	0.33
Predorsal distance	33.2 ± 0.33 31.5–35.9	34.8 ± 0.21 33.0–36.7	4.08**
Postdorsal distance	16.8 ± 0.29 14.6–18.8	16.0 ± 0.40 13.8–20.3	1.58
Antepectoral distance	30.4 ± 0.27 28.6–32.1	30.8 ± 0.22 28.6–33.1	1.10
Anteventral distance	30.1 ± 0.23 28.8–32.0	30.9 ± 0.20 28.5–32.5	2.50*
Anteanal distance	57.1 ± 0.27 55.6–58.4	59.1 ± 0.25 56.9–62.4	5.50**
Pectoventral distance	14.2 ± 0.22 12.2–15.9	14.4 ± 0.14 13.2–15.8	0.87
Ventroanal distance	25.8 ± 0.28 23.8–26.9	27.2 ± 0.25 25.1–29.4	3.95**
Length of caudal peduncle	19.2 ± 0.30 17.6–21.8	18.3 ± 0.21 16.4–20.3	2.42*
Length of first dorsal fin base	18.8 ± 0.23 17.4–20.6	18.8 ± 0.18 17.0–20.5	0.22
Height of first dorsal fin	18.5 ± 0.51 16.3–23.4	14.3 ± 0.21 12.1–16.7	7.73**
Length of second dorsal fin base	33.1 ± 0.17 32.1–34.7	31.6 ± 0.22 29.1–33.6	5.47**
Height of second dorsal fin	19.6 ± 0.92 14.4–26.0	14.2 ± 0.21 11.8–16.6	5.63**
Length of anal fin base	25.1 ± 0.35 22.9–27.4	23.4 ± 0.20 20.8–25.1	4.43**

Table 1. (Contd.)

Character	Males ($n = 25$)	Females ($n = 26$)	t_{st}
Height of anal fin	19.0 ± 0.75 10.9–23.2	15.0 ± 0.28 12.4–18.4	5.00**
Length of pectoral fin	23.9 ± 0.32 22.1–26.0	23.0 ± 0.29 19.3–26.0	2.08*
Length of pelvic disc	22.8 ± 0.32 19.7–25.0	22.5 ± 0.24 20.3–24.2	0.75
Length of caudal fin	25.3 ± 0.43 22.0–27.3	23.4 ± 0.28 20.3–26.2	3.86**
Length of head (*c*)	26.5 ± 0.28 24.9–28.3	26.9 ± 0.18 25.7–29.2	1.12
	As % *c*		
Head depth at occiput	66.0 ± 1.01 58.5–71.8	66.5 ± 0.78 59.4–74.0	0.37
Head depth through middle of eye	53.0 ± 1.01 44.9–59.3	52.7 ± 0.73 44.9–59.8	0.27
Head width	49.5 ± 0.51 45.3–52.8	48.5 ± 0.44 43.5–52.4	1.50
Preorbital distance	25.4 ± 0.94 21.5–34.3	24.6 ± 0.66 18.7–30.9	0.69
Length of mandible	35.3 ± 1.46 27.0–44.0	31.9 ± 0.64 25.4–39.1	2.16*
Length of maxilla	35.2 ± 0.78 31.7–43.3	34.9 ± 0.81 28.5–42.6	0.31
Horizontal diameter of eye	25.8 ± 0.57 22.7–31.9	26.9 ± 0.32 23.2–30.87	1.72
Postorbital distance	52.0 ± 0.56 47.9–54.9	51.6 ± 0.48 46.1–55.3	0.51
Distance between eye and angle of mouth	19.7 ± 0.79 16.0–26.1	19.1 ± 0.49 14.4–23.6	0.58
Distance between angles of mouth	46.5 ± 0.97 40.8–52.9	43.4 ± 0.68 35.9–48.9	2.62*
Interorbital distance	10.5 ± 0.66 8.0–17.7	10.3 ± 0.43 6.8–11.6	2.15*
Depth of cheek	38.7 ± 0.72 32.6–43.5	37.0 ± 0.46 31.9–40.8	2.01

Top—mean; bottom—limits of character variation; differences are significant at p: * < 0.05–0.01, ** < 0.001.

free of membrane and their ends protrude over membrane limits (Fig. 2a). In anal fin, one (rarely two) spiny ray and 11–12 (11.5 ± 0.12) (rarely 10) branched rays. In pectoral fins, there 16–17 (16.2 ± 0.14) rays; capilliform rays absent, but upper rays at ends free of membrane. In caudal fin, 13–14 (rarely 16) branched rays (14.0 ± 0.15). Posterior edge of pelvic disc truncated, lacks incisure, membrane developed, lateral lobes absent (Fig. 1b). Number of scales along middle of body side usually 36–44 (39.9 ± 0.15).

Body coloration marbled, with alternating brownish and buff scales on back and upper part of body

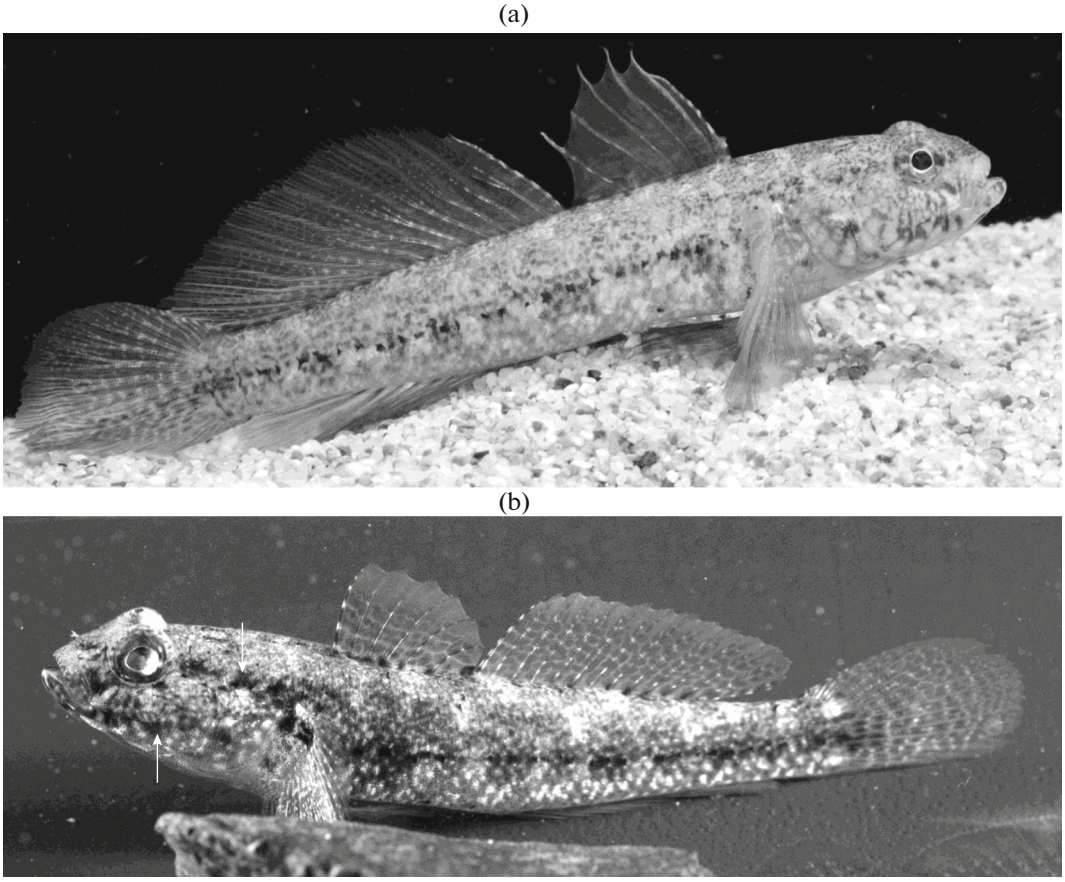

Fig. 2. External view of Couch's goby *Gobius couchi* (a) male and of (b) female at the stress-induced coloration; (⇨) positions of dark spots in the majority of specimens.

sides; buff and orange-yellowish, on lower sides. Abdominal side yellowish-white. Along middle of body side, a row of black–brown points and nine fuzzy brownish spots weakly expressed especially on body anterior part (Fig. 2a). At stress and aggression, coloration darkens but marbled pattern remains (Fig. 2b). Head also of marbled brownish-buff coloration. Three brownish, fuzzy, more or less intensively colored spots on cheeks behind mouth angles and on head above opercula; these spots most clearly visible at stress (Fig. 2b). Dark spot, consisting of two parts at upper part of pectoral fin bases and sometimes protrudes to bases of upper rays. Fins yellowish, with four to five irregular reddish-brown stripes on unpaired fins and rows of pinkish points on pectoral fins.

The specimens of different sexes significantly differ in 18 plastic characters (Table 1). In the females, the values of the following characters are larger: maximal body height and width; predorsal, anteventral, anteanal and ventroanal distances. In the males, minimal body height, length of caudal peduncle, length of the base of second dorsal and anal fins, height of unpaired fins, length of pectoral and caudal fins, length of mandible, distance between mouth angles, and interorbital distance are larger. No differences between males and females in the meristic characters were revealed.

The males are significantly larger than the same-age females but, the power coefficient values in the equations describing dependence of body weight on the standard body length are close to each other in the males and females (Fig. 3). The results of the present study may serve as a basis for the comparative analysis of the characteristics of the goby populations.

The data on the maximal sizes of Couch's goby are quite contradictory. The authors of the original description of this species indicate its maximal *TL* of 90 mm (Miller and El-Tawil, 1974; Miller, 1986). Further, the gobies found in the Eastern Atlantic have *SL* of not more than 72 mm (Minchin, 1988), which roughly corresponds to the *TL* noted above. According to our data, the dependence between the total and standard lengths in these gobies exhibits the linear pattern and is described by the following equation: $TL = 1.2605SL - 1.0723$. Slightly smaller sizes are noted in the Couch's goby of the Mediterranean Sea: *TL* 67 mm (Özen et al., 2009). The Fishbase database (*FishBase*..., 2016) indicates maximal *TL* of 170 mm referring to the generalized paper (Bauchot et al., 1989).

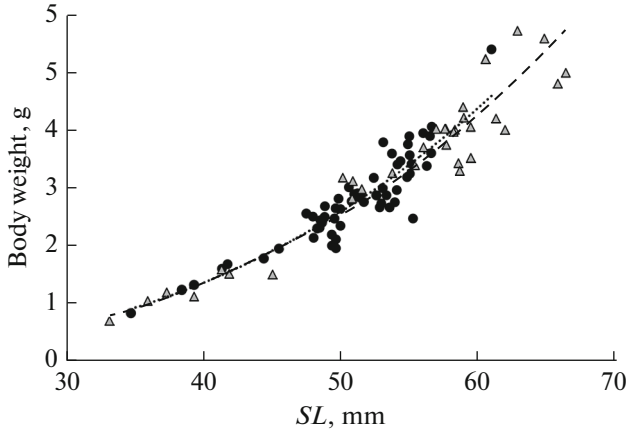

Fig. 3. Correlation between the length (*SL*) and weight (*W*) of Couch's goby *Gobius couchi*: (●) females, $W = 0.00003SL^{2.9228}$, $R^2 = 0.8833$; (▲) males, $W = 0.00003SL^{2.8906}$, $R^2 = 0.9520$.

However, in this publication, another value of maximal body length (*TL* 150 mm) is given, but the source of this data is not indicated. In our samples, the biggest male has *TL* of 83.1 mm, *SL* of 66.4 mm, body weight of 5.72 g; the biggest female, 77.9 mm, 61.0 mm, 5.4 g, respectively.

Ecology. As the majority of other species of the family, Couch's goby is a bottom-dwelling, nonmigrating fish. This suggests that its migration at the stage of pelagic larva typical for the gobies of g. *Gobius* at a natural process of Mediterranization is the most likely way of its invasion into the Black Sea. Apparently, this goby fully adapted to the conditions of the southwestern coast of Crimea. In general, the thermal regime near Sevastopol, in the Kazach'ya and Karantinnaya bays is normal for this species. In winter, the temperature at the water surface is approximately 7°C, which corresponds to the coastal waters of Ireland and England. In summer, the water temperatures rises to 26.8°C on average and reaches 30°C at shallows, which corresponds to the Mediterranean seas. The water salinity over the greater part of the coves varies within the 17.43–18.25‰ limit that is approximately twofold lower than in the native range of this species. Couch's goby was not previously found at such low water salinities, and our finding of this species evidences to its high tolerance to this condition.

The age of studied fish was not more than 2+, while the age of 6 years is indicated as maximal for this species in the published papers (Miller, 1986). The yearlings had *SL* 41.4–45.6 mm; 2-years-old fish, 48.9–65.8 mm. The effect of ecological conditions in the Black Sea may be one of the possible reasons for high growth rate and lack of elder fish. In our samples, 2- year-olds prevail (Fig. 4). Presumably, this is because these fish are more open (less secretive) and are much easier to catch.

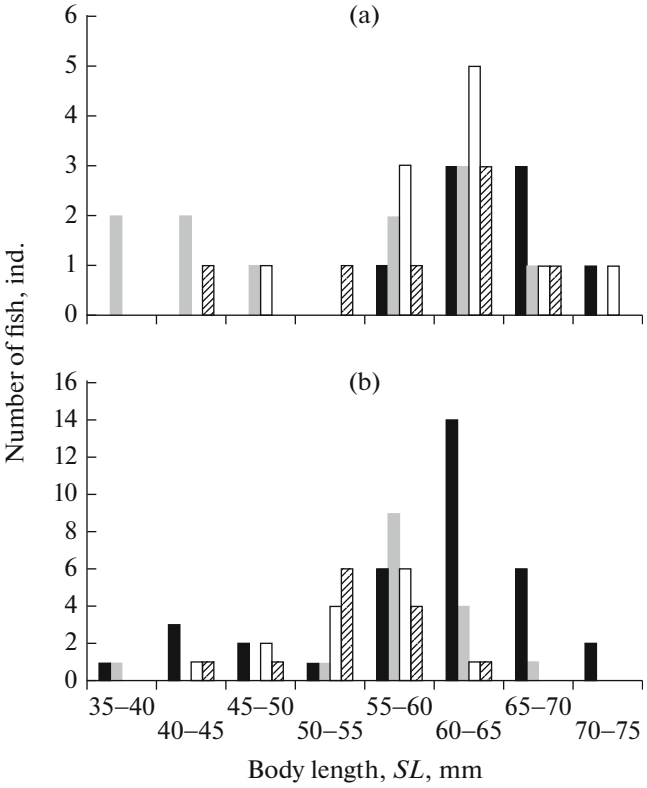

Fig. 4. Size composition of (a) males and (b) females of Couch's goby *Gobius couchi* in various months: (■) June, (■) July, (□) August, (▨) September.

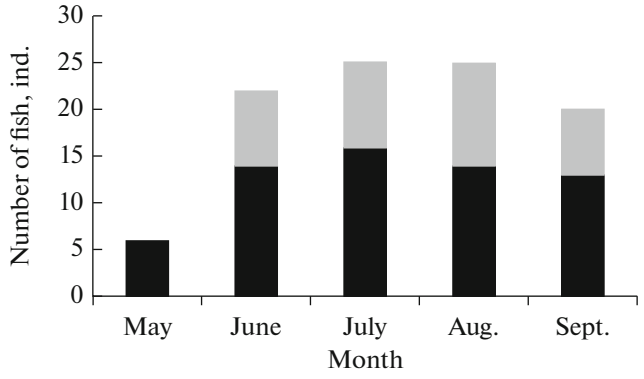

Fig. 5. Sexual structure of group samples of Couch's goby *Gobius couchi* in various months: (■) males, (■) females.

The females are more numerous than males and the former approach the coast earlier at spring rise of water temperature (Fig. 5). The females at the prespawning state with the oocytes of IV stage maturity prevailed in the samples from mid-May; the mature females were observed during 2 months, from the end of May to the end of June. In August and September, the fish were spawned with resorbing eggs in the ovaries. That is, as judged by the status of gonads, the

(a)

(b)

Fig. 6. Typical position of Couch's goby *Gobius couchi* on sandy site near the (a) burrow and (b) territorial behavior of male at approaching of the rival specimen.

spawning continues from the end of May to the end of July. The fish start reproduction at the second year of life. The spawning is fractional; the number of oocytes at IV stage of maturity in the gonads of females with *SL* 47.6–56.5 mm was 7920–9180. Considerable fecundity for the fish of these sizes, in combination with active protection of the eggs by the male, determine the relatively high reproductive potential of Couch's goby.

In the eastern Atlantic and Mediterranean basin, Couch's goby was found mainly at the habitats with sandy grounds and overgrowths of sea grasses (Stefanni and Mazzoldi, 1999; Liu et al., 2009; Özen et al., 2009; Kovačić et al., 2011) as well as at the sandy grounds alternating with exposed rocks or screes of pebbles, stones, and boulders (Miller, 1986; Kovačić, 2001; Kovačić et al., 2013). The features of bottom geomorphology in the Kazach'ya and Karantinnaya (Sevastopol) where this species was found are similar. At the shallows along the shores between the places with limestone rocks, there are areas covered by sand and coarse-debris grounds. At the depths of 4–6 m,

soft sandy and silty-sandy grounds with some spots of coquina substitute the solid grounds; at the depths of more than 8 m, the bottom is sand with various extents of siltation with admixture of coquina covered in some places with dense stands of sea grasses, zostera, and ruppia.

According to our observations, Couch's goby exhibits relatively narrow biotopic confinedness: it inhabits small stony screes and discrete stone debris on the sandy grounds covered in some places by sea grasses (mainly zostera). The gobies very seldom occur in the stands of sea grasses situated at considerable distance from the stone debris and exposed limestone rocks; the fish was noted neither at the stony substrates lacking sandy spots nor at the bare sandy bottoms. Usually, the gobies set in the burrows dug in the sand under the stones, under the roots of zostera, or near the shelters at the open sites (Fig. 6a). The gobies exhibit moderate territorial behavior and aggression towards conspecific individuals (Fig. 6b); often groups of three or four fish were observed near one shelter; as judged by the size and external features, several females gathered at the male's burrow. Maximal depths at which the gobies were noted in warm seasons, was approximately 6 m.

Distribution. The Couch's goby is a quite rare Atlantic–Mediterranean species. For the first time, it was found in the coastal waters of Great Britain (Cornwall), southwestern and Northern Ireland (Miller and El-Tawin, 1974; Minchin, 1987, 1988; Costello, 1992). Later, this species was found in the Mediterranean basin: in 1996–1997 off the Croatian coasts (Kovačić, 2001); in 1999, in Tyrrhenian Sea near Ischia Island (Stefanni and Mazzoldi, 1999); in 2004, in the Ionian Sea near Corfu Island (Šanda and Kovačić, 2009); in 2007, in the Aegean Sea, southern part of the Dardanelles Strait (Özen et al., 2009); in 2009, in the Ligurian Sea (Liu et al., 2009); in 2010, in the Libian Sea, near Crete (Kovačić et al., 2011); in 2011, near Malta (Kovačić et al., 2013).

In the Black Sea, Couch's goby was not recorded earlier; the closest to the Black Sea location of its finding was the southern part of the Dardanelles Strait. Near the Crimean coasts, we found this species in only two coves, Kazach'ya and Karantinnaya, and the fish was not found in these coves near the open coasts. The results of the present study have shown that Couch's goby is a common and quite numerous species. Indirectly, the high population is proven by the fact that we caught 90 individuals during the summer 2016 at the 100 m-long part of the coastal zone, but their number and occurrence frequency was not decreased at this site according to visual observations.

It is hard to identify the time when Couch's goby appeared in the Sevastopol coves. However, we suggest that we first found this species back in the end of the 1990: at that time, it was erroneously identified as juvenile black goby *Gobius niger*. Recent high abundance of Couch's goby may also confirm that this species has lived in Kazach'ya bay for several decades. The version on the relatively recent introduction of this species into the Black Sea is confirmed to a certain extent by its narrowly-local occurrence in the Sevastopol bays. We tried to find this goby at other parts of the Crimean coasts considering the traits of its behavior and biotopic preferences but failed to find it. However, it is not completely impossible that this species is native for the Black Sea and it was not found earlier because it is relatively small, is a bottom-dweller, and exhibits a quite secretive mode of life.

The present study suggests that Couch's goby is a quite common and numerous species; high fecundity may explain successful establishing of its population but wide spread of this species is limited by such a factor as confinedness to specific biotopes. It is likely that the penetration of this species into the Black Sea relates to the process of Mediterranization and may have occurred several decades earlier.

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