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Distribution of two closely allied gobies, *Gobius bucchichi* Steindachner, 1870 and *Gobius incognitus* Kovačić & Šanda, 2016, along the Turkish coast

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Abstract

The current status of two morphologically similar gobies, *Gobius bucchichi* Steindachner, 1870 and *G. incognitus* Kovačić & Šanda, 2016, in Türkiye is reviewed in the light of previously published and unpublished data sources. The latter species seems to be very common along the Aegean Sea coast, while its northern Levant distribution is represented by scattered records and requires further research. *Gobius bucchichi* is currently known only from Saros Bay (northern Aegean Sea) and Marmara Archipelago (Sea of Marmara), but a more comprehensive range should be suspected. This study confirms for the first time the presence of two closely allied gobies in Türkiye based on photographic evidence, filling the information gap to a great extent.

Keywords: Underwater photography, *in situ* identification, Gobiidae, New records.

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Introduction

The incognito goby, *Gobius incognitus*, was described based on specimens collected in the Adriatic Sea, in the north-western Mediterranean (France, Banyuls-sur-Mer), in the eastern Mediterranean at Crete Island, and in Israel (Kovačić and Šanda 2016). Due to its high similarity with Bucchich's goby (*G. bucchichi*), the species remained unrecognized despite its distinct morphological, meristic and genetic characteristics, resulting in a conundrum on their actual occurrences. According to recent studies, the distribution of *G. bucchichi* appears to be restricted to the East Adriatic (Italy, Slovenia, Croatia) and a few localities in Ionian (Butrint, Albania; Gulf of Arta, Greece), Aegean Sea (Kondyli Beach, Greece) and the Black Sea (Crimea) According to recent studies, while *G. incognitus* seems to be common and widespread in the Mediterranean Sea coasts, although its status throughout the northern Africa shores is currently questionable (Kovačić and Šanda 2016; Tiralongo and Pillon 2020; Tiralongo et al. 2020a; Renoult et al. 2022).

Correct identification of gobies is traditionally based on the meticulous examination of head canal pores and papillae rows of the lateral line system (Kovačić, 2008). However, several species with unique coloration can also be identified *in situ*, which is an approach receiving increased interest and successfully practiced during the last decade (Colombo and Langeneck 2013; Bilecenoglu and Yokeş 2016; Renoult et al. 2022). Cryptic lifestyles and small sizes of gobies make them almost impossible to collect with standard fishing methods, while Scuba diving and underwater photography enabled the exploration of wide coastal belts quite efficiently, resulting in observations of expanding distribution ranges of several species previously believed to be rare (Kovačić et al. 2012; Tiralongo et al. 2020b; Bilecenoglu and Çelik 2021).

Information on the occurrence of the newly described incognito goby and the narrowly distributed Bucchich's goby in Türkiye is currently scarce. By reviewing all available data sources, including the underwater photograph archives of scuba-aided biodiversity research projects and published underwater guides, it is aimed

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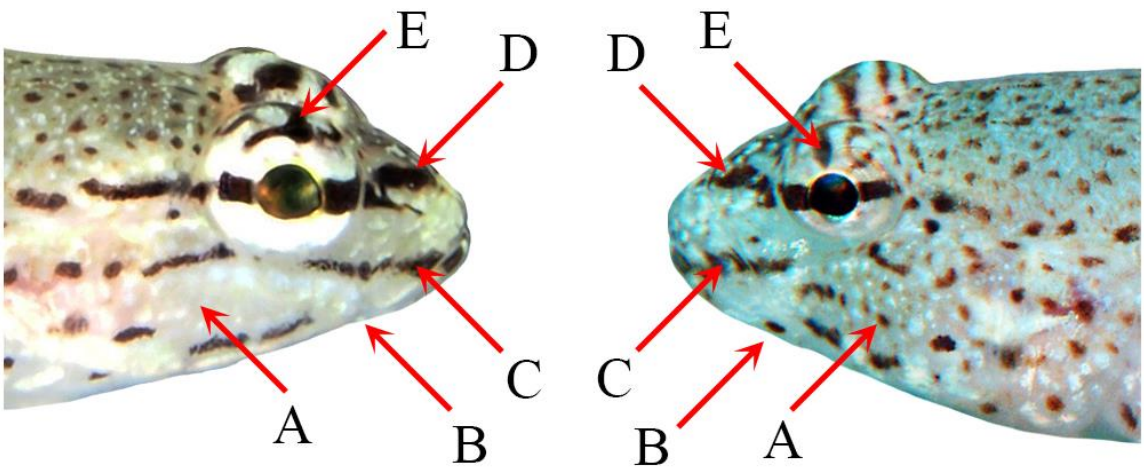

Figure 1. Comparison between *Gobius bucchicchi* vs. *G. incognitus*, respectively. A) unpatterned cheek between two longitudinal dot rows vs. a third row in between; B) mouth corner without dot vs. a single well-defined dark dot; C) preorbital bar reaches the level of orbit vs. stops well before the anteroventral border of the orbit; D) snout with M-shaped line vs. V-shaped line; E) longitudinal marking along the upper iris vs. simple upper vertical eye-bar (also note the large vs. smaller eye diameter) (*G. bucchichi*, Sea of Marmara, M.Bilecenoglu; *G. incognitus*, Hisarönü Bay, southern Aegean Sea, A.Can)

to shed light on the status of both species in Türkiye, which will serve to fill the current knowledge gap to a great extent.

Material and Methods

The study is mainly based on examining a wide array of underwater photographs taken from the Turkish coastline during the last two decades and considering all published data. Data sources are grouped into five categories: (1) published research papers on the occurrence of *G. bucchichi* and *G. incognitus*, (2) photographic inventories obtained during scientific research projects supported by TÜBİTAK (The Scientific and Technological Research Council of Türkiye) including two baseline studies by Can et al. (2003) and Çınar et al. (2008), (3) underwater guides concentrating on Turkish marine fauna, (4) previously unpublished underwater photographs taken by during recreational scuba dives, and (5) GenBank records. Since the present study is focused on determining the actual distribution range of *G. bucchichi* and *G. incognitus* in Türkiye, an evidence-based approach is followed (see Kovačić et al. 2020) and only underwater photographs enabling a positive species identification were used. Those that do not include details on the exact locality are not considered. Identification of the two similar gobies based on underwater photographs of *in situ* individuals was made according to distinguishing characteristics (such as dots on cheeks, body coloration; Fig. 1) presented by Kovačić and Sanda (2016), Tiralongo and Pillon (2020), Renault et al. (2022) and Kovačić et al. (2022). Bucchich's goby is characterized by a uniformly pale yellowish/pale gray color dorsally; faint but well-aligned midlateral dashes; two longitudinal rows of dots on the cheek (one on the ventral edge of the cheek and another one starting with the oblique preorbital bar); the mouth unmarked at the corner; an irregular longitudinal curved marking along with the upper iris; snout with dark dashes forming a typical M-shaped line. Incognito goby is characterized by a uniformly pale gray, greenish-gray, or light brown color dorsally, covered with longitudinal lines of brown dots; mid-lateral blotches obvious, often fused to form larger dark blotches separated by spaces; three longitudinal rows of dots on the cheek (one on the ventral edge of the cheek and another one starting with the oblique preorbital bar, plus a third row in between, in the center of the cheek); a well-defined dark dot at the posterior angle of mouth; upper iris with separate brown dots or radiating stripes, without longitudinally curved mark; the snout is patterned with a V-shaped line.

Table 1. Compilation of occurrence data of *Gobius bucchicchi* vs. *G. incognitus*. Localities associated with letters and numbers are also plotted in Figure 2 for a better presentation of their distribution. Locality abbreviations as follows: SM – Sea of Marmara, nAS – northern Aegean Sea, cAS – central Aegean Sea, sAS – southern Aegean Sea, nwL – northwestern Levant, nL – northern Levant, neL – northeastern Levant.

Gobius bucchichi					
Locality	Observation (year)	Number of Individuals	Depth	Habitat	Source/Reference
A) Paşalimanı Island (SM)	2020	10	2-8	Sand, gravel, dead bivalve shells, algae covered rocks	Figure 3A
B) Saros Bay (nAS)	-	1	-	-	KY176485, Yokes (unpublished)
Gobius incognitus					
1) Saros Bay*(nAS)	2004	1	12	*Anemonia viridis*	Gözcelioğlu (2011, p.391)
2) Gökçeada (nAS)	2018	39	3	Sandy	Kesici and Dalyan (2018, p.3)
3) Karaburun (cAS)	2014	2	12	Coarse sand, stone	Figure 3B
4) Urla (cAS)	1986	3	1	*Anemonia viridis*	Kaya and Mater, 1987 (p.124)
5) Seferihisar (cAS)	2015	1	6	Coarse sand, gravel, stone	Figure 3C
6) Bodrum (sAS)	-	4	1-3	Coarse sand	Gökalp (2011, p.243,245)
7) Datça (sAS)	2004	1	8	*Anemonia viridis*	Can and Bilecenoğlu (2005, p.147)
8) Hisarönü (sAS)	2001	9	3-10	Sandy, rocky, coarse sand	Figure 3D, Can et al. 2003 (unpublished)
9) Fethiye (nwL)	2015	2	2-3	Algae covered rocks	Figure 3E
10) Kaş (nL)	2001	1	10	Algae covered rocks	Can and Bilecenoğlu (2005, p.147)
11) İskenderun (neL)	2005	2	4-5	Algae covered rocks	Figure 3F, Çınar et al. 2008 (unpublished)

* Locality and depth given by Gözcelioğlu (2011) as Ayvalık Islands, 18 m is erroneous but corrected herein, based on pers.comm. with the underwater photographer T. Ceylan.

Results and Discussion

We have thoroughly examined the entire records of *G. bucchichi*/*G. incognitus* from Türkiye, following the dichotomous key provided based on photographs of live individuals by Kovačić et al. (2022) and the *in situ* identification guide by Renault et al. (2022). The incognito goby is observed and/or documented from 11 different localities along the Aegean and northern Levant shores of Türkiye (Table 1, Fig. 2), while Bucchich's goby is currently known only from two localities, Saros Bay in the northern Aegean Sea and Marmara Archipelago in the southern part of Sea of Marmara.

The presence of *G. incognitus* (misidentified as *G. bucchichi*) based on collected and morphologically described specimens in Türkiye was given by Kaya and Mater (1987), and currently appears to be the single available published research. A total of three individuals were collected from Urla (İzmir Bay, Aegean Sea) under *Anemonia viridis* at a depth of 1 m. The authors have included a black and white photograph and an original illustration of the examined material, in which a well-defined dark dot at the posterior angle of the mouth is apparent. Although no information was given on cheek dots, the body coloration was defined as light brown/yellow/green, associated with typical distinct dark mid-lateral blotches. Above mentioned habitat and coloration characteristics indicate that the İzmir Bay samples are merely a misidentification of *G. incognitus*, recognized herein as the first valid record of the species in Türkiye.

Photographic documentation of Turkish marine fish was carried out at 91 different localities along the entire Turkish coastline between 2001 and 2003, in which over 5000 underwater photographs were taken during 237 scuba dives. The project results were presented by Can et al. (2003) and an updated version was later published as an underwater fish guide (Can and Bilecenoğlu 2005). Recent analyses of the entire set of photographs labeled as *G. bucchichi* turned out to be *G. incognitus* without any exception. The situation was similar in other

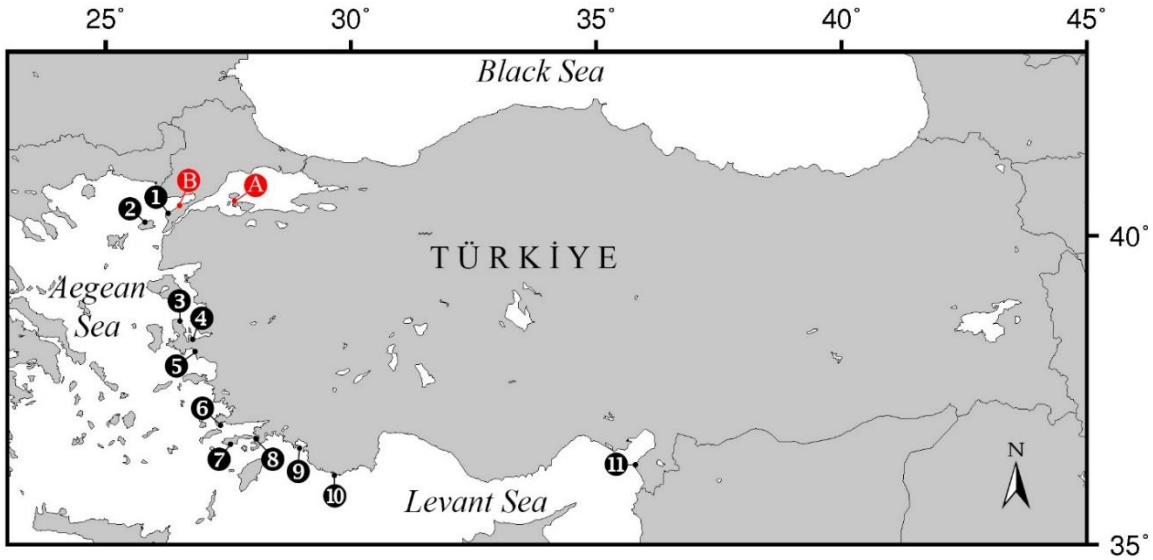

Figure 2. Distribution of *G. bucchichi* and *G. incognitus* along the Turkish coastline. See Table 1 for details. *G. bucchichi*: A) Marmara Archipelago, B) Saros Bay. *G. incognitus*: 1) Saros Bay (Gözcelioğlu 2011), 2) Gökçeada (Kesici and Dalyan 2018), 3) Karaburun, 4) Urla (Kaya and Mater 1987), 5) Seferihisar, 6) Bodrum (Gökalp 2011), 7) Datça (Can and Bilecenoğlu 2005), 8) Hisarönü Bay (Can et al. 2003), 9) Fethiye Bay, 10) Kaş (Can and Bilecenoğlu 2005), 11) İskenderun Bay (Çınar et al. 2008).

underwater guides relating to Turkish marine fauna. The two gobies observed from the vicinity of Bodrum (southern Aegean Sea) cited discretely as *G. bucchichi* and *G. fallax* (Gökalp 2011) are indeed typical individuals of *G. incognitus*, so as the Saros Bay individual associated by *A. viridis* (Gözcelioğlu 2011). Apart from the regions mentioned above, we could photograph the species in additional localities between Karaburun in the central Aegean Sea as far as Iskenderun Bay in the northeastern Levant (Fig. 3), improving the available knowledge of its actual distribution range. The incognito goby prefers shallow waters of up to 10 m, while only two observations were made at a depth of 12 m (Table 1). The species is found in a variety of habitats, including *A. viridis*, sand, coarse sand, stone and algae-covered rocky substratum in agreement with Kovačić and Šanda (2016) and Tiralongo et al. (2020b), and some individuals were even sighted in association with the invasive sea urchin *Diadema setosum* at shallow depths of 5 m (see Bilecenoglu et al. 2019, the species was misidentified as *G. bucchichi*) (Fig. 4).

As for the rare occurring *G. bucchichi*, we were able to identify only a single published material revealing its presence in Türkiye, given by Engin et al. (2018, p.1080). Underwater photographs of three life stages (juvenile, pre-adult and adult) of *G. bucchichi* was presented by the authors, in which the adult form is a typical *G. incongitus*, the juvenile has a bucchichi-like form with large eyes (larger than the snout length) but without the typical longitudinal marking on the upper eye, so requiring confirmation on the correct species identification, while the pre-adult is a *G. bucchichi* without any doubt. Since the photograph given was not associated with an exact locality, relevant data was not included in Table 1, but provides concrete proof of the occurrence of the species on the Turkish Aegean Sea coast. The only available photographic evidence with valid locality is from the Paşalimanı Island, Marmara Archipelago (Fig. 3A) and there is also genetic data of an individual captured from Saros Bay (GenBank accession no. KY176485, M.B. Yokes, unpublished). The NCBI Blast analysis revealed that the generated sequence is 100% identical with *G. bucchichi* from Ostro Peninsula, Croatia (MT670195) and with Krk Island, Croatia (MT670192), 99.84% with Selce, Croatia (MT670193) and Butrint Lagoon, Albania (MT670191), supporting the correct identification. Habitat of *G. bucchici* includes all kinds of rocky substrate (gravel, cobbles, boulders and bedrock) and sandy bottoms mixed with a hard substratum, to a maximum depth of 8 m (Kovačić and Šanda 2016), in accordance with our observation from the Sea of Marmara.

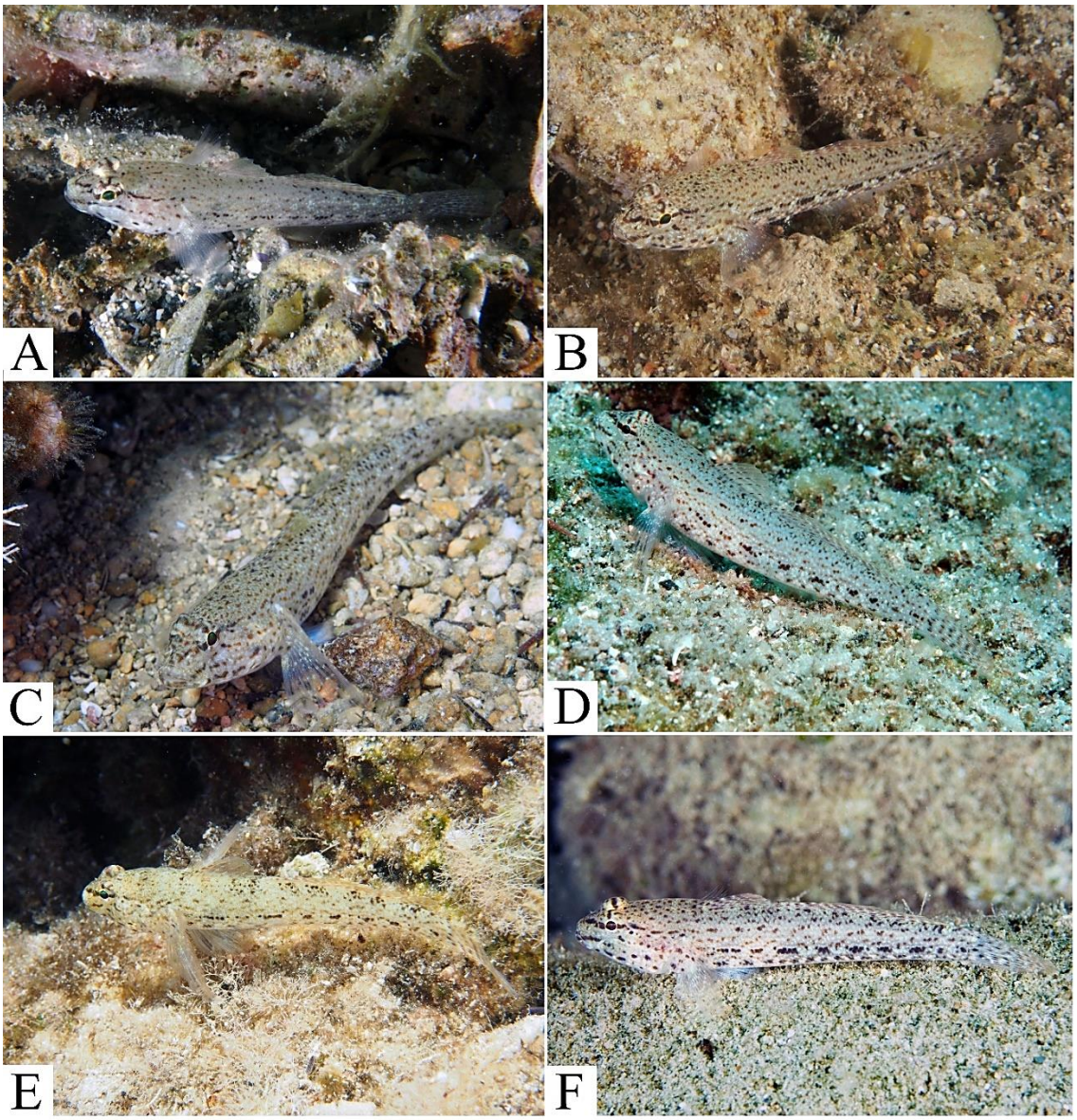

Figure 3. A) *Gobius bucchichi*, Paşalimanı Island, Sea of Marmara (M.Bilecenoglu); B) *G. incognitus*, Karaburun, Aegean Sea (M.Bilecenoglu); C) *G. incognitus*, Seferihisar, Aegean Sea (M.Bilecenoglu); D) *G. incognitus*, Hisarönü Bay, Aegean Sea (A.Can); E) *G. ncognitus*, Fethiye Bay, northwestern Levant (M.Bilecenoglu); F) *G. incognitus*, Iskenderun Bay, northeastern Levant (A.Can).

From a total of 10 individuals encountered, they were almost exclusively found at the mixed habitats bearing sand, gravel, dead bivalve shells (*Mytilus galloprovincialis*) and algae-covered rocks. Such a specialized habitat also exists on the Turkish Black Sea coast, so its possible presence therein should not be neglected and investigated by further research. Currently, only the Crimean population of *G. bucchichi* was validated in the northern Black Sea (Renoult et al. 2022).

Goby identification following the traditional way is an unrivaled challenge for ichthyologists, which is also valid for the underwater photograph-based approaches, both requiring specialized experience. In a few cases, we were unable to identify the individuals either as *G. bucchichi* or *G. incognitus*, since several diagnostic

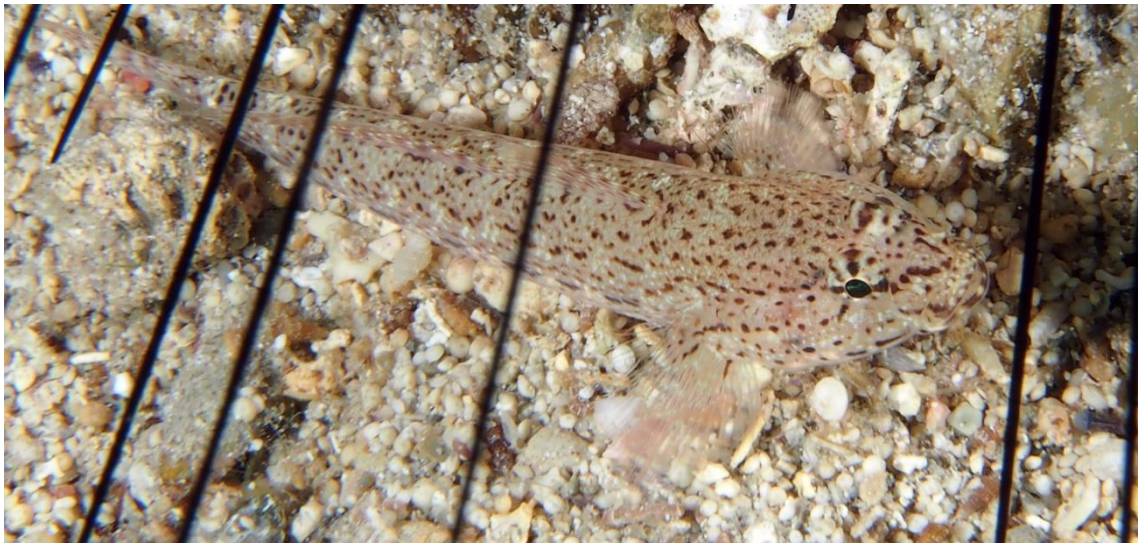

Figure 4. A *Gobius incognitus* individual observed under long spines of the invasive sea urchin, *Diadema setosum* (Bodrum, southern Aegean Sea, M.Bilecenoglu).

Figure 5. Two examples of *Gobius* "*problematicus*". Upper photo: Despite of the large eyes, absence of dark dot at the mouth corner, lack of third row of dots on cheek and the presence of distinct M-shaped line on the snout (typical for *G. bucchichi*), lateral dots fused to form blotches and the lack of horizontal marking on the upper eye (typical for *G. incognitus*) hinders precise identification (Marmaris, depth < 1m, south Aegean Sea, M.Bilecenoğlu). Lower photo: Mid-lateral dash formation, more or less obvious M-shaped line on the snout and large eyes are typical for *G. bucchichi*, yet the dot pattern on the cheek is faint, with an indistinct gray dot at the corner of mouth and the pattern on upper eye, making it difficult to assign a correct species identification (Bodrum, depth 1 m, south Aegean Sea, M.Bilecenoğlu).

characters were missing or not well visible (therefore they were omitted from the current analysis, Fig. 5). Such circumstances certainly require the individual to be sampled, underlining the fact that *in situ* identification has limitations. Anyhow, there is no doubt that underwater photography is a powerful tool in clarifying the geographic and ecological distribution of certain gobies, which will shed light on their real diversity and contribution to the species richness in the littoral Mediterranean fish assemblages that has probably remained underestimated until now (Kovačić et al. 2022).

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