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The key for identification of Gobiidae (Pisces: Perciformes) in the Adriatic Sea

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The key covers 46 gobiid species presently known in the Adriatic Sea. For the present key the standard form of dichotomous bracket key was used. The new characters (like the second dorsal fin base naked, at least along first three rays; less than 4 suborbital transverse rows with 4 or more papillae present; suborbital row b anteriorly not reaching below suborbital row a; anterior dorsal row g reaching anteriorly row o) in the key are based on data from checked material, original species descriptions, short descriptions in reviews and published morphological works. This key should be able to identify adults of both sexes as well as late juveniles.

Key words: identification key, Gobiidae, Adriatic Sea

INTRODUCTION

The recognition of gobiid fishes in the Adriatic Sea started in the second half of the 19th century with four species descriptions (VERGA 1841; STEINDACHNER, 1861, 1863, 1870) followed by the preparation of two local checklists: A.P. NINNI (1882) prepared one for the Venice area and KOLOMBATOVIĆ (1891) wrote another one for the Split area. The work of KOLOMBATOVIĆ (1891) listed 25 species, several of them as new species. The type specimens preserved in some European museums served as source for generic and species descriptions and re-descriptions of Mediterranean Gobiidae in the following century. This work specifically had much longer and greater influence on entire Mediterranean taxonomy of gobiid fishes than any other works. However, the first published data on gobies of the Adriatic Sea appeared much earlier. The record of *Gobius jozo* for the Split and Trogir areas (the synonym of *Gobius niger* Linnaeus, 1758) was published

in the book «Ichthyologia massiliensis» BRÜNNICH (1765). The numerous lists of the Adriatic fish species that included gobies after the publication of BRÜNNICH (1765) to until the works of A. P. NINNI (1882) and KOLOMBATOVIĆ (1891) contained just the species name cited by rote from one list to another, while some, in addition, contained general comments on the species (see references and details in KOVAČIĆ, 2005). Regarding the documented knowledge on gobiid diversity in the lists of Adriatic fish species, the situation was not much better during the 20th century. The status changed when the synonymy of Mediterranean gobies was clarified by MILLER (1973). Following MILLER's (1973) synonymy, ŠTEVČIĆ (1977) listed 40 gobiid species, followed by further work of KOVAČIĆ (1994): 42 gobiid species, JARDAS (1996): 44 gobiid species, and LIPEJ & DULČIĆ (2004): 50 gobiid species. However, all these authors avoided critical reconsideration of the actual presence of these species that were previously included in the listings of the Adriatic

fauna. KOVAČIĆ (2005) listed a total of 46 gobiid species in the Adriatic Sea and based this list on a critical re-assessment of all available data on gobiid species in the Adriatic Sea.

Many ichthyologists agree that the family Gobiidae is not only a very specious fish family in the Adriatic Sea, but also one which faces large difficulties in species identification. The first identification key that included gobiid species for the entire Adriatic Sea was published by ŠOLJAN (1948). Unfortunately, this great book hardly provided proper identification keys for Gobiidae, except for the most common and well-known species. It lists just one species more than KOLOMBATOVIĆ's (1891) local checklist half a century before, but also ignored the very important characters of the lateral line system in the key diagnosis. Everything changed after MILLER (1986) published the identification key for the entire clofnam area. This work was the basis for any later gobiid identification during the following 20 years. JARDAS (1996) published another great book on Adriatic fishes because the work of ŠOLJAN (1948), as well as the later editions was at that time quite out of date. However, JARDAS (1996) provided more or less a translation into Croatian of MILLER'S (1986) identification key restricted to Adriatic species and with minor rearrangements.

The need for a new identification key on gobiids arises firstly from the updated checklist (KOVAČIĆ, 2005), and secondly to improve and correct the diagnostic characters in the MILLER'S key (1986) in an attempt to improve precision and accuracy in the identification of Gobiidae. The new key followed several principles in constructing the key that should lead to undoubtful and as simple as possible identification of specimens (parts of these recommendations were listed in MAYR & ASHLOCK, 1991). The principles are described in detail in Material and Methods.

MATERIAL AND METHODS

The present key is based on data from checked material, original species descriptions,

short descriptions in reviews (MILLER, 1986), and published morphological works (see KOVAČIĆ, 2005). The characters were examined and checked on material of Adriatic gobiid species kept in the ichthyological collection of Prirodoslovni muzej Rijeka.

The following principles were the criteria for choice of characters whenever it was possible: (I) avoid a character present only in specific state of specimens, for example body transparent in life. (II) avoid easily damaged character, if possible. Caudal fin rounded or truncate to slightly emarginate is a great character for *Pomatoschistus* species, but also the first character that would be destroyed with unskilled collecting or handling of specimens. (III) use constant characters, without excessive individual variations, avoid characters with published examples of aberrations. I also excluded characters with which I had my personal experience on unpublished character variations. (IV) avoid a character present only in specific development stage or sex of specimens, for example the first dorsal fin elongate in adult males. (V) use only external characters, for example unskilled checking of mouth for dentition characters in mostly small and fragile species could destroy specimen as well as the patience of the investigator. (VI) use absolute characters or use relative characters with a clear numeric ratio, avoid relative descriptive characters, for example, characters eye lateral, interorbit wide *versus* eye dorsolateral, interorbit narrow between species are useless for species identification without comparative material of all species of that genus. In the particular case, in two species of genus *Pomatoschistus*, lateral position of eye is still relatively dorsolateral and wide interorbit is still quite narrow. (VII) I tried to use simple characters, for example head naked-scaled, scale count along lateral midline, whenever it was possible, and to construct the dichotomous key with simple characters as close to the beginning of the key as possible. (VIII) do not use overlapping characters, for example: second dorsal branched rays usually 14 or 15 *versus* second dorsal branched rays usually more than 14 (14-18).

Table 1. List of recorded gobiid species in the Adriatic Sea

1. <i>Aphia minuta mediterranea</i> De Buen, 1931	24. <i>Gobius vittatus</i> Vinciguerra, 1883
2. <i>Buenia affinis</i> Iljin, 1930	25. <i>Knipowitschia caucasica</i> (Kawrajsky, 1916)
3. <i>Chromogobius quadrivittatus</i> (Steindachner, 1863)	26. <i>Knipowitschia panizzae</i> (Verga, 1841)
4. <i>Chromogobius zebratus zebratus</i> (Kolombatović, 1891)	27. <i>Lebetus guileti</i> (Le Danois, 1913)
5. <i>Corcyrogobius liechtensteini</i> (Kolombatović, 1891)	28. <i>Lesueurigobius friesii</i> (Malm, 1874)
6. <i>Crystallogobius linearis</i> (Von Duben, 1845)	29. <i>Lesueurigobius suerii</i> (Risso, 1810)
7. <i>Deltentosteus colonianus</i> (Risso, 1826)	30. <i>Millerigobius macrocephalus</i> (Kolombatović, 1891)
8. <i>Deltentosteus quadrimaculatus</i> (Valenciennes, 1837)	31. <i>Odondebuena balearica</i> (Pellegrin & Fage, 1907)
9. <i>Didogobius schlieweni</i> Miller, 1992	32. <i>Pomatoschistus bathi</i> Miller, 1982
10. <i>Didogobius splechnai</i> Ahnelt & Patzner, 1995	33. <i>Pomatoschistus canestrini</i> (Ninni, 1883)
11. <i>Gammogobius steinitzi</i> Bath, 1971	34. <i>Pomatoschistus knerii</i> (Steindachner, 1861)
12. <i>Gobius ater</i> Bellotti, 1888	35. <i>Pomatoschistus marmoratus</i> (Risso, 1810)
13. <i>Gobius auratus</i> Risso, 1810	36. <i>Pomatoschistus minutus</i> (Pallas, 1770)
14. <i>Gobius bucchichi</i> Steindachner, 1870	37. <i>Pomatoschistus norvegicus</i> (Collett, 1903)
15. <i>Gobius cobitis</i> Pallas, 1811	38. <i>Pomatoschistus pictus</i> (Malm, 1865)
16. <i>Gobius couchi</i> Miller & El-Tawil, 1974	39. <i>Pomatoschistus quagga</i> (Heckel, 1840)
17. <i>Gobius cruentatus</i> Gmelin, 1789	40. <i>Pseudaphya ferreri</i> (De Buen & Fage, 1908)
18. <i>Gobius fallax</i> Sarato, 1889	41. <i>Speleogobius trigloides</i> (Zander & Jelinek, 1976)
19. <i>Gobius geniporus</i> Valenciennes, 1837	42. <i>Thorogobius ephippiatus</i> (Lowe, 1839)
20. <i>Gobius kolombatovici</i> Kovačić & Miller, 2000	43. <i>Thorogobius macrolepis</i> (Kolombatović, 1891)
21. <i>Gobius niger</i> Linnaeus, 1758	44. <i>Vanneaugobius dollfusi</i> (Brownell, 1978)
22. <i>Gobius paganellus</i> Linnaeus, 1758	45. <i>Zebrus zebrus</i> (Risso, 1826)
23. <i>Gobius roulei</i> De Buen, 1928	46. <i>Zosterisessor ophiocephalus</i> (Pallas, 1811)

The key covers 46 gobiid species presently known in the Adriatic Sea (KOVAČIĆ, 2005) (Table 1). The terminology of papillae rows, and of head canal pores of lateral-line system follows SANZO (1911) and MILLER (1986) (Fig. 1). Suborbital transverse rows *c* are usually marked just with numbers. In the species without row *a* suborbital transverse rows could begin upwards near the orbit. The last transverse suborbital row near pore α could be

present just as single papilla in some species. Scales in lateral series are counted from axilla along lateral midline, including scales over the origin of caudal fin. Last bifid ray is counted as one in the second dorsal fin and the anal fin. Pelvic disc details are presented on Fig. 2. Pelvic disc emargination is the difference between the longest branches of fourth branched rays and the shortest branches of fifth branched ray (Fig. 2b).

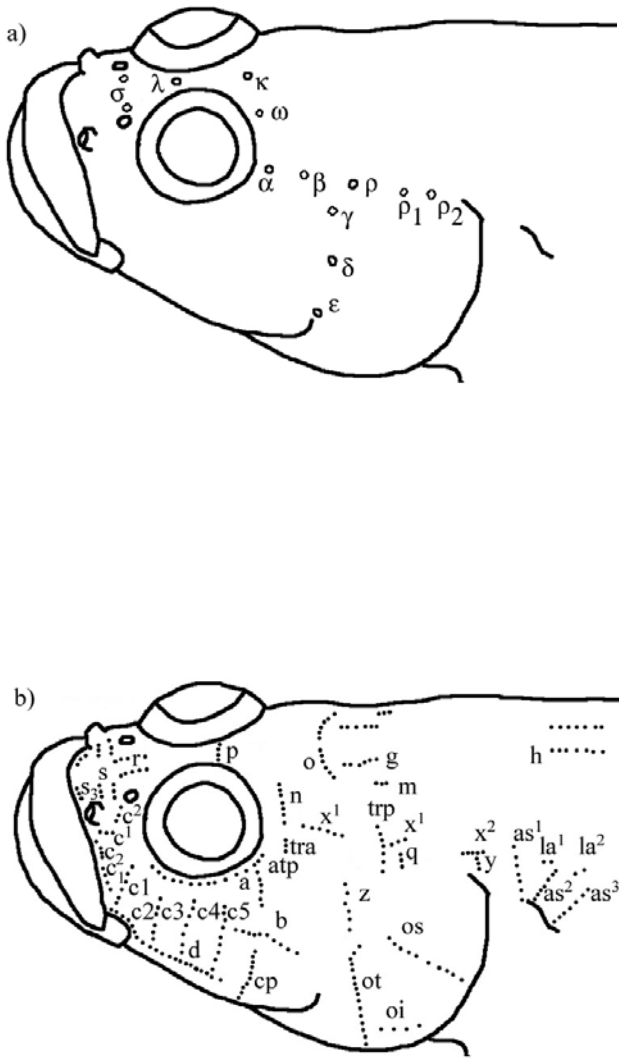


Fig. 1. The terminology and position of (a) head canal pores and of (b) papillae rows of lateral-line system in the present keys. Head anterior oculoscapular canal pores λ , κ , ω , α , β , ρ ; posterior oculoscapular canal pores ρ^1 , ρ^2 ; preopercular canal pores γ , δ , ε . Rows of sensory papillae: preorbital: r , s^1 , s^2 , s^3 , c^1 , c^2 , c_1 , c_2 ; suborbital: a , b , c (if more transversal c rows present: c_1 , c_2 , c_3 , c_4 , c_5 or just marked with numbers: 1, 2, 3, 4, 5, 6, 7), d ; preoperculo-mandibular: e , i , f ; oculoscapular: x^1 , x^2 , tra , trp , z , q , y , as^1 , as^2 , as^3 , la^1 , la^2 ; opercular: ot , os , oi ; anterior dorsal: n , o , g , m , h ; interorbital: p .

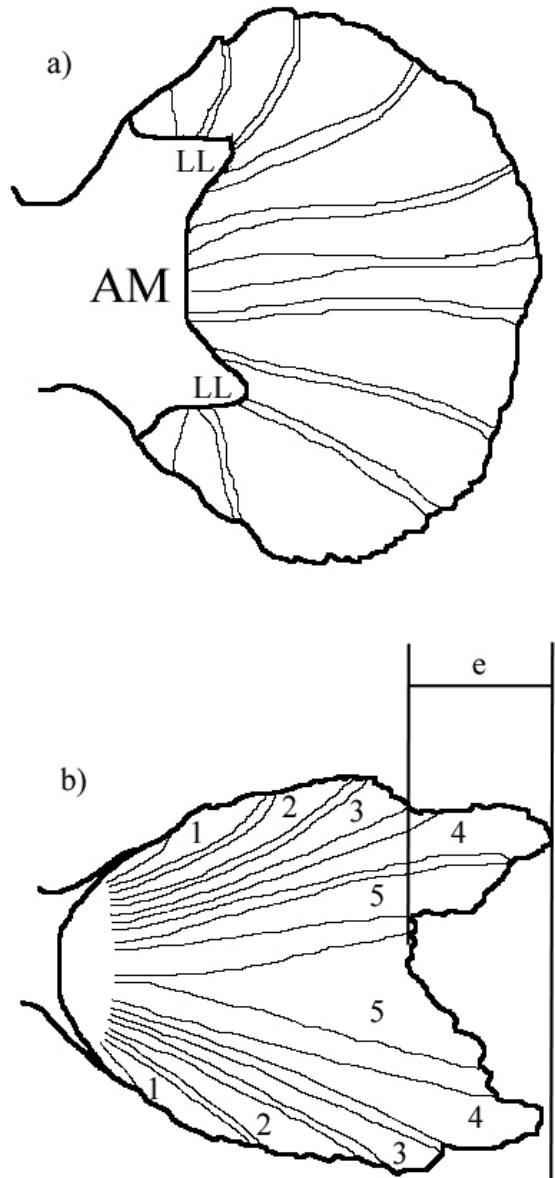


Fig. 2. (a) pelvic fin with anterior membrane (AM) and lateral lobes (LL) on anterior membrane, (b) pelvic disc emargination (e) is the difference between the longest branches of fourth branched rays and the shortest branches of fifth branched ray

IDENTIFICATION KEY

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|--|--------------------------------------|-----|
| 1. First dorsal fin with 3 or less spines | <i>Crystallogobius linearis</i> | |
| First dorsal fin with 4 or more spines | | 2. |
| 2. Suborbital row <i>a</i> present (Fig. 1) | | 3. |
| Suborbital row <i>a</i> absent | | 21. |
| 3. Pelvic disc without anterior transverse membrane (Fig. 2a) | | 4. |
| Pelvic disc with anterior transverse membrane | | 5. |
| 4. Head canals absent (Fig. 1) | <i>Lebetus guilleti</i> | |
| Head canals present | <i>Speleogobius trigloides</i> | |
| 5. Head canals absent (Fig. 1) | | 6. |
| Head canals present | | 8. |
| 6. Suborbital transverse rows present (Fig. 1) | <i>Aphia minuta</i> | |
| Suborbital transverse rows absent | | 7. |
| 7. Nape naked | <i>Lesueurigobius suerii</i> | |
| Nape scaled | <i>Lesueurigobius friesii</i> | |
| 8. Head canals with numerous extra pores (Fig. 1) | | 9. |
| Head canals with usual (22 or less) number of pores | | 10. |
| 9. Second dorsal fin branched rays 8-9, anal fin branched rays 9 | <i>Deltentosteus quadrimaculatus</i> | |
| Second dorsal fin branched rays 10-11, anal fin branched rays 10 | <i>Deltentosteus colonianus</i> | |
| 10. Suborbital transverse rows absent (Fig. 1) | <i>Buenia affinis</i> | |
| Suborbital transverse rows present | | 11. |
| 11. Anterior oculoscapular canal ends in interorbit, with paired pores λ (Fig. 1) | | 12. |
| Anterior oculoscapular canal extends on to snout, to pores σ | | 14. |
| 12. Scales in lateral series 30 or less | <i>Pseudaphya ferreri</i> | |
| Scales in lateral series more than 30 | | 13. |
| 13. Posterior oculoscapular canal present (Fig. 1) | <i>Knipowitschia caucasica</i> | |
| Posterior oculoscapular canal absent | <i>Knipowitschia panizzae</i> | |
| 14. Scales in lateral series 29-52 | | 15. |
| Scales in lateral series 55-75 | | 20. |
| 15. Second dorsal fin base naked, at least along first three rays | <i>Pomatoschistus canestrinii</i> | |
| Second dorsal fin base completely scaled | | 16. |
| 16. Suborbital row <i>b</i> anteriorly not reaching below suborbital row <i>a</i> (Fig. 1) | <i>Pomatoschistus quagga</i> | |
| Suborbital row <i>b</i> ending anteriorly below suborbital row <i>a</i> | | 17. |

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|--|------------------------------------|
| 17. Less than 4 suborbital transverse rows with 4 or more papillae present (Fig. 1) | 18. |
| 4 or more suborbital transverse rows with 4 or more papillae present | 19. |
| 18. Pectoral fin rays 14-16 | <i>Pomatoschistus bathi</i> |
| Pectoral fin rays 17-20 | <i>Pomatoschistus knerii</i> |
| 19. First dorsal fin base and breast scaled, spots along lateral midline single, first dorsal fin without two longitudinal rows of black spots | <i>Pomatoschistus marmoratus</i> |
| Breast and first dorsal fin base to third or fourth spine naked, spots along lateral midline doubled, first dorsal fin with two longitudinal rows of black spots | <i>Pomatoschistus pictus</i> |
| 20. Only suborbital transverse row <i>cp</i> extending below suborbital row <i>d</i> , suborbital row <i>b</i> ending anteriorly below anterior half of eye, breast scaled (Fig. 1) | <i>Pomatoschistus minutus</i> |
| Three suborbital transverse row <i>c</i> including <i>cp</i> extending below suborbital row <i>d</i> , suborbital row <i>b</i> ending anteriorly below posterior half of eye, breast naked | <i>Pomatoschistus norvegicus</i> |
| 21. All three head canals present (Fig 1.) | 22. |
| At least one head canal absent | 38. |
| 22. Head and nape naked | 23. |
| Head and nape scaled | 26. |
| 23. Anterior dorsal row <i>g</i> ends anterior to lateral end of row <i>o</i> (Fig. 1) | 24. |
| Anterior dorsal row <i>g</i> ends behind or on lateral end of row <i>o</i> | 25. |
| 24. Scales in lateral series 27-31 | <i>Thorogobius macrolepis</i> |
| Scales in lateral series 33-42 | <i>Thorogobius ephippiatus</i> |
| 25. Transverse suborbital rows 7 (Fig. 1) | <i>Zebrus zebrus</i> |
| Transverse suborbital rows 6 | <i>Gobius roulei</i> |
| 26. Anterior oculoscapular canal with short side branch to pore α below eye (Fig. 1) | 27. |
| Anterior oculoscapular canal with pore α at rear of orbit | 28. |
| 27. Scales in lateral series 50-57 | <i>Gobius paganellus</i> |
| Scales in lateral series 38-40 | <i>Gobius ater</i> |
| 28. Oculoscapular row x^l extending forward to, or before, pore β (Fig. 1) | 29. |
| Oculoscapular row x^l ending forward behind pore β | 30. |
| 29. Transverse suborbital rows 7 (Fig. 1) | <i>Zosterisessor ophiocephalus</i> |
| Transverse suborbital rows 6 | <i>Gobius cruentatus</i> |
| 30. Scales in lateral series 50 or mor | 31. |
| Scales in lateral series less than 50 | 34. |

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|---|-------------------------------------|
| 31. Pelvic disc complete (Fig. 2b) | 32. |
| Pelvic disc truncate | 33. |
| 32. Pelvic disc anterior membrane with lateral lobes (Fig. 2a) | <i>Gobius cobitis</i> |
| Pelvic disc anterior membrane without lateral lobes | <i>Gobius bucchichi</i> |
| 33. Anterior dorsal row <i>g</i> reaching anteriorly row <i>o</i> (Fig. 1) | <i>Gobius kolombatovici</i> |
| Anterior dorsal row <i>g</i> ending anteriorly behind row <i>o</i> | <i>Gobius geniporus</i> |
| 34. Suborbital row <i>d</i> continuous (Fig. 1) | <i>Gobius niger</i> |
| Suborbital row <i>d</i> divided | 35. |
| 35. Scales in lateral series 32-36, black longitudinal band along body and head | <i>Gobius vittatus</i> |
| Scales in lateral series 38-48, without black longitudinal band along body and head | 36. |
| 36. Pelvic disc complete or no more than 1/8 emarginate (Fig. 2b) | <i>Gobius couchi</i> |
| Pelvic disc emarginate more than 1/8 | 37. |
| 37. Pelvic disc emarginate more than 1/3 (Fig. 2b) | <i>Gobius auratus</i> |
| Pelvic disc emarginate less than 1/3 | <i>Gobius fallax</i> |
| 38. Preopercular canal absent (Fig. 1) | 39. |
| Preopercular canal present | 40. |
| 39. Transverse suborbital rows 6 (last one with 1 papilla) (Fig. 1) | <i>Corcyrogobius liechtensteini</i> |
| Transverse suborbital rows 7 (last one with 1 papilla) | <i>Gammogobius steinitzi</i> |
| 40. Pelvic fins almost separate (Fig. 2b) | 41. |
| Pelvic fins forming disc | 42. |
| 41. Transverse suborbital rows 6 (last one with 1 papilla) (Fig. 1) | <i>Odondebuenia balearica</i> |
| Transverse suborbital rows 7 (last one with 1 papilla) | <i>Vanneaugobius dollfusi</i> |
| 42. Interorbital papillae present (Fig. 1) | <i>Millerigobius macrocephalus</i> |
| Interorbital papillae absent | 43. |
| 43. Transverse suborbital rows 6 (last one with 1 papilla) (Fig. 1) | 44. |
| Transverse suborbital rows 7 | 45. |
| 44. Scales in lateral series 55-56 | <i>Didogobius schlieveni</i> |
| Scales in lateral series 28-31 | <i>Didogobius splechnai</i> |
| 45. Scales in lateral series 56-72 | <i>Chromogobius quadrivittatus</i> |
| Scales in lateral series 40-52 | <i>Chromogobius zebratus</i> |

DISCUSSION

For the present key the standard format of a dichotomous bracket key was used. Between utilitarian and phylogenetic approaches, the functionality of the key was the main goal in the construction of the key i.e. to ensure proper species identification. In addition, phylogenetic relationship among Mediterranean gobies above generic level are still unclear, and some present genera of Mediterranean gobies are probably paraphyletic. In each couplet I used a single pair of contrasting character states without supplemental characters. It appears to be much better to provide a good single character following the principles outlined in Material and Methods, than to add confusion to the process of identification by proposing several overlapping characters or characters which appear to be highly variable within a single species. However, it is always good to confirm species identification comparing data from short descriptions in reviews, original species descriptions and published morphological works. The exceptions with inclusion of supplemental characters in the key are identifications of *P. pictus* and *P. norvegicus*, for which I haven't had the opportunity to check a larger number of specimens and therefore to choose the best character presently available. Recognizing the described high variability in morphological characters of Adriatic

populations of *K. caucasica* (KOVAČIĆ & PALLAORO, 2003) it is no longer possible to distinguish clearly specimens of *K. caucasica* and *K. panizzae* and the validity of the taxonomic status of these species has to be questioned. Within a single sample of *K. caucasica* it is possible to find specimens with or without posterior oculoscapular canal. Therefore, the positive identification of these two species is limited until this taxonomic dilemma has been resolved.

This key should be able to identify adults of both sexes as well as late juveniles of all gobiid species recognized in the Adriatic so far. The early juveniles, with not completely developed characters used in this key, could not be identified (KOVAČIĆ, 2004). Experience has shown that the lateral line system provides still the most important and non-substitutable set of characters for positive identification of gobies. This makes any attempt of precise and reliable identification of most Mediterranean gobies in their habitat a most difficult task for non-experts. It should be noted that this difficulty in itself poses a significant limitation for studying fish assemblages by non-destructive techniques, such as visual census.

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Ključ za određivanje porodice Gobiidae (Pisces: Perciformes) u Jadranu

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SAŽETAK

Ovaj ključ uključuje 46 vrsta glavoča do sada zabilježenih u Jadranu. Za ključ je uzeta standardna forma dihotomskog ključa sa zgradama. Novi karakteri u ključu (kao osnova druge leđne peraje bez ljustaka, barem uz prve tri šipčice; manje od 4 suborbitalna transversna reda s 4 ili više papila; suborbitalni red *b* naprijed ne dolazi pod suborbitalni red *a*; anteriorno dorsalni red *g* dolazi do anteriornog reda *o*) zasnovani su na podacima s pregledanog materijala, izvornih opisa vrsta, kratkih opisa u preglednim djelima i objavljenim morfološkim radovima. Ovaj ključ trebao bi omogućiti određivanje odraslih jedinki oba spola, kao i kasnih nezrelih primjeraka.

Ključne riječi: ključ za određivanje, Gobiidae, Jadran