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# Description of the Native Hybrid Population Between *Squalius semae* and *Alburnus sellal* Distributed in the Upper Euphrates River

**Davut TURAN[1*], Cüneyt KAYA[1], Esra BAYÇELEBİ[1]**

[1]Recep Tayyip Erdogan University, Faculty of Fisheries, 53100 Rize, Turkey

[*]Sorumlu Yazar/Corresponding Author
E-mail: dvtturan@yahoo.com
Orcid ID: 0000-0002-9586-6223

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**ABSTRACT**

In the scope of this study, the first description of the hybrid population of *Squalius semae* and *Alburnus sellal* from the upper Euphrates River is presented. The description was made based on museum material which collected in July 2006 by electrofishing equipment. The Principal Component Analysis was performed using 24 morphometric characters to compare the relationship between ancestors and hybrid individuals. The hybrid population was characterized by a terminal mouth, a long and slender caudal peduncle (its length 1.9-2.8 times its depth), 8½ branched dorsal-fin ray, 9½-10½ (mode 10½) branched anal-fin rays, 54-60 lateral line scales, 10-11 scale rows between dorsal-fin origin and lateral line, 5-6 scale rows between anal-fin origin and lateral line and 9-10+3-4 gill rakers on the outer side of the first-gill arch. According to the data obtained as a result of this study, most of the metric and meristic data belonging to hybrid individuals placed between the data of *Squalius semae* and *Alburnus sellal*.

**Keywords:** Anatolia, Hybridization, Bleak, Chub

# Yukarı Fırat Nehri'nde Yayılış Gösteren *Squalius semae* ve *Alburnus sellal* arasındaki Yerli Hibrit Populasyonunun Tanımlanması

**ÖZET**

Bu çalışmada, yukarı Fırat Nehri'nden *Squalius semae* ve *Alburnus sellal* hibrit popülasyonunun ilk tanımlaması yapılmıştır. Tanımlama, Temmuz 2006'da elektroşoker avlama ekipmanı ile toplanan müze materyallerine dayanılarak yapılmıştır. Atalar ve hibrit bireyler arasındaki ilişkiyi karşılaştırmak için 24 morfometrik karakter kullanılarak Temel Bileşenler Analizi gerçekleştirildi. Hibrit populasyon terminal konumlu bir ağzının, uzun ve ince bir kuyruk sapının (uzunluğu derinliğinin 1.9-2.8 katı), dorsal yüzgeçte 8½ dallanmış ışının, anal yüzgeçte 9½-10½ (mod 10½) dallanmış ışının, ligne lateralde 54-60 yanal pulun, dorsal yüzgeç orijini ile yan çizgi arasında 10-11, anal yüzgeç orijini ile yanal çizgi arasında ise 5-6 pul sırasının ve ilk solungaç yayının dış tarafında 9-10 + 3-4 solungaç dikeninin olması ile karakterize edildi. Bu çalışma sonucunda elde edilen verilere göre, melez bireylere ait metrik ve meristik verilerin çoğu, *Squalius semae* ve *Alburnus sellal* verilerinin arasına yerleşmiştir.

**Anahtar Kelimeler:** Anadolu, Hibriditasyon, İnci balığı, Tatlısu kefali

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## 1. Introduction

Hybridization is a well-known phenomenon in closely related fish species sharing similar environments (Costedoat et al., 2005). Although many parameters have been put forwarded to explain the occurrence of hybrids in closely related species such as unbalanced quantities of two parental species in given time, external fertilization and spawning habitat competition, the main parameter driving hybridization has been suggested as habitat loss (Hubbs, 1955; Campton, 1987). For example, Scribner et al., (2001) reported that habitat loss as the most critical parameter, being responsible for 50% of the cases observed. Similarly, the same authors declared Cyprinids account for 40% of all hybrids of which the bleak, *Alburnus alburnus* (Linnaeus 1758), consisted of the largest number of hybrids represented.

The bleak in the Euphrates and Tigris rivers had been known as *Alburnus mossulensis* Heckel 1843 for a long time (Kaya et al., 2016). Later, this species synonymized with *Alburnus sellal* Heckel 1843 from Queiq River (Mohammadian-Kalat et al., 2017), and this aspect followed by the other studies (Freyhof et al., 2018a, 2018b; Bektaş et al., 2020). The chub *Squalius semae* Turan, Kottelat & Bayçelebi 2017 is distributed in the upper Euphrates drainages around the Erzurum province (Turan et al., 2017). There is not any record of a hybrid individual between these two species mentioned above. They often share the same habitat. Naturally, hybrids of these species also occur, however, hybrids are very common in degraded habitats, especially in dam lakes. Thus, in degraded habitats, hybrid individuals become more dominant than their ancestors. Therefore, it is of prime interest to carry out detailed biological and genetic studies to elucidate the occurrence of hybrids. In this study, a hybrid population of *Squalius semae* and *Alburnus sellal* inhabiting Kuzgun Dam Lake (Euphrates River drainage) has been described for the first time.

## 2. Material and Method

Fish were caught by pulsed DC electrofishing equipment. Material is deposited in: Recep Tayyip Erdogan University Zoology Museum of the Faculty of Fisheries. Counts and measurements follow Kottelat and Freyhof (2007) except as follows. Head width: head width at the operculum; Head depth: head depth at occiput (posteriormost extent of the head on the dorsal midline); snout width: at level of nostrils. The lateral line scale count includes the scales on the base of the caudal fin. Vertebrae counts were obtained from radiographs, and include the four weberian vertebrae and the hypural complex. The first caudal vertebra is that with its haemal spine posterior to the anteriormost anal ray**.** The count of caudal vertebrae includes the hypural complex. The last two branched dorsal and anal rays articulating on a single pterygiophore are counted as "1½". Numbers in parentheses after a count indicates the number of specimens in which this count is observed.

The morphometric characters of the two species of *Squalius semae*, *Alburnus sellal* and *Squalius semae* x *Alburnus sellal* (hybrid) from Kuzgun Dam Lake (Euphrates River drainage) were compared by Principal Component Analysis (PCA) using a covariance matrix on log-transformed measurements with the software package PAST version 1.8 (Hammer et al., 2001).

## 3. 3. Results

### 3.1. Description of the hybrid of *Squalius semae* and *Alburnus sellal*

***Squalius semae* x *Alburnus sellal*** (Figure 1), FFR 1566, 25, 130-180 mm SL, Turkey: Erzurum Prov.: Kuzgun Dam Lake, Euphrates River, Ilıca, 30 km northern of Erzurum, Leg. D. Turan, S. Engin, 15 July 2006.

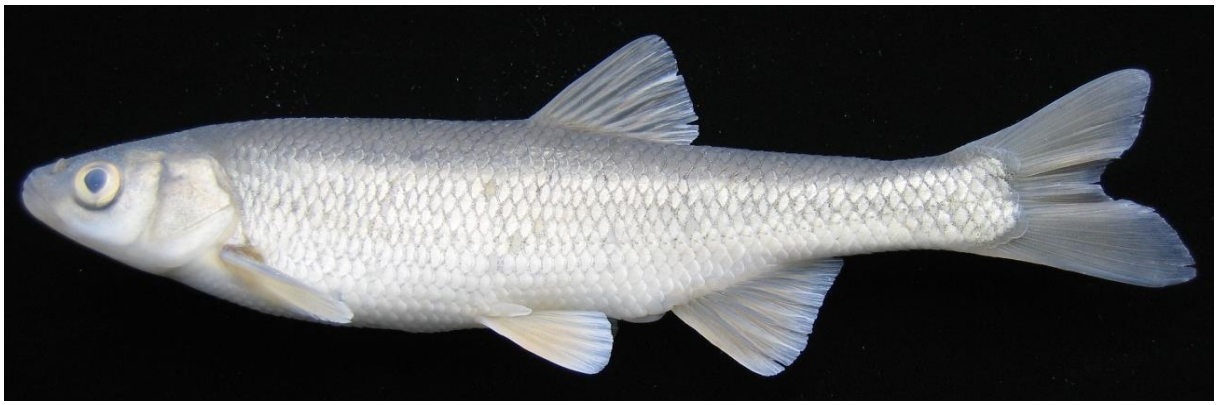

**Figure 1.** *S. semae* x *A. sellal* (Hybrid), FFR 1566, 165 mm SL, Turkey: Euphrates River drainage

***Squalius semae*** (Figure 2) FFR 1568, 15, 138-198 mm SL, Turkey: Ezurum Prov.: Kuzgun Dam Lake, Euphrates River, Ilıca, 30 km northern of Erzurum, Leg. D. Turan, S. Engin, 15 July 2006.

**Figure 2.** *S. semae* FFR 1568, 174 mm SL, Turkey: Euphrates River drainage

***Alburnus sellal*** (Figure 3), FFR 0905, 15, 80-160 mm SL, Turkey: Ezurum Prov.: Kuzgun Dam Lake, Euphrates River, Ilıca, 30 km northern of Erzurum, Leg. D. Turan, S. Engin, 15 July 2006.

**Figure 3.** *A. sellal* FFR 0905, 133 mm SL, Turkey: Euphrates River drainage

General appearance is shown in Figure 1; morphometric and meristic data are given in Tables 1 and 2 respectively. Body slender and slightly compressed laterally. Upper profile slightly arched; ventral profile more arched than dorsal profile. Head slender and narrower, markedly longer than body depth, dorsal profile slightly convex. Snout short, its length 25.9-31.0% HL, slender and narrower, its tip rounded. Mouth small and narrower, terminal, oblique, the corner of mouth not reaching vertical through anterior margin of eye. Lips

thin and slightly the upper lip thickening at the middle part. Interorbital area narrower, its width 28.5-31.4% SL. The caudal peduncle long and slender (its length 1.9-2.8 times its depth).

Dorsal fin with 3 simple and 8½ branched rays; its height smaller than pectoral fin length, outer margin slightly convex; origin markedly behind vertical through pelvic-fin origin; Pectoral fin rounded, with 14-16 branched rays. Pelvic fin rounded, with 1 simple and 8 branched rays. Anal fin with 3 simple and 9-10½ branched rays; outer margin convex anteriorly. Caudal fin markedly forked, lobes pointed. Lateral line with 54 (2), 55 (4), 56 (2), 57 (1), 58 (1), 59 (3) and 60 (2) scales; 10 (11) and 11 (4) scales rows between lateral line and dorsal-fin origin; 5 (13) and 6 (2) scale rows between lateral line and anal-fin origin. Gill rakers 3-4 + 9-10 = 12-13 on outer side of first gill arch. Total vertebrae 24 + 19 = 43 (6), 25 + 18 = 43 (4), 24 + 18 = 42 (5). Pharyngeal teeth 5.2-2.5 markedly hooked and serrated.

**Coloration.** Formalin preserved adults and juveniles dark grey on back and greyish on flank, whitish on belly. Dorsal and caudal fins dark grey; pectoral, pelvic and anal fins yellowish, orange pigments on pelvic and anal fins membrane, scales above lateral line with much faintly marked to distinct dark edge along posterior margin, usually with one row of large black pigments on posterior margin of flank and back scales, without pigments against rest of scale.

**Table 1.** Morphometry of *Squalius samae*, *S. semae* x *A. sellal* (Hybrid) and *Alburnus sellal* distributed in Euphrates River.

| | ***Squalius semae*** | ***S. semae* x *A. sellal*** | ***Alburnus sellal*** |
|---|---|---|---|
| n | 15 | 15 | 15 |
| Standard Length (mm) | 138-198 | 126-180 | 101-125 |
| **In percent of standard length** | Range (mean) | Range (mean) | Range (mean) |
| Head length | 26.0-28.7 (26.9) | 24.5-27.2 (26.0) | 23.0-24.6 (23.8) |
| Body depth of dorsal-fin origin | 20.7-23.8 (21.9) | 19.9-22.8 (21.5) | 18.0-20.9 (19.6) |
| Predorsal length | 52.6-55.8 (53.9) | 52.3-55.2 (53.6) | 51.3-54.0 (52.0) |
| Prepelvic length | 49.3-53.4 (51.0) | 47.0-50.2 (48.8) | 46.2-48.9 (47.5) |
| Preanal length | 68.9-72.6 (70.9) | 66.7-72.8 (69.1) | 64.7-67.4 (66.3) |
| Pectoral-fin origin to anal fin | 46.4-51.4 (48.1) | 43.7-47.7 (45.2) | 42.0-45.0 (43.5) |
| Pectoral-fin origin to pelvic fin | 25.3-30.1 (27.1) | 23.4-25.8 (24.9) | 22.4-25.4 (24.2) |
| Pelvic-fin origin to anal fin | 19.1-22.5 (21.1) | 18.3-22.7 (20.0) | 18.7-21.5 (19.7) |
| Dorsal-fin height | 15.3-18.6 (17.0) | 15.4-20.4 (17.7) | 16.9-20.5 (18.6) |
| Anal-fin length | 14.3-16.9 (15.8) | 13.2-16.6 (14.8) | 13.1-17.0 (15.4) |
| Pectoral-fin length | 16.8-18.6 (17.7) | 16.4-20.5 (18.7) | 16.9-20.3 (18.9) |
| Pelvic-fin length | 13.7-15.2 (14.3) | 13.3-16.0 (14.8) | 13.2-16.1 (15.0) |
| Upper caudal-fin lobe | 15.9-18.8 (17.9) | 15.9-20.3 (18.6) | 22.1-25.2 (23.3) |
| Length of middle caudal-fin ray | 11.1-13.4 (12.6) | 9.5-12.1 (11.2) | 10.7-14.6 (12.3) |
| Length of caudal peduncule | 19.1-22.1 (20.4) | 21.0-23.8 (22.4) | 22.0-25.3 (23.4) |
| Depth of caudal peduncle | 10.5-12.2 (11.3) | 9.5-10.5 (10.1) | 8.0-9.2 (8.6) |
| **In percent of head length** | | | |
| Snout length | 29.5-33.6 (33.3) | 25.8-30.9 (29.2) | 26.7-30.4 (28.7) |
| Eye diameter | 16.0-19.6 (18.0) | 17.5-20.7 (19.5) | 23.2-27.3 (25.2) |
| Interorbital width | 33.3-38.4 (36.3) | 28.5-31.3 (30.5) | 25.7-29.8 (28.3) |
| Head width at middle of post opercule | 55.4-63.2 (59.6) | 49.0-56.9 (52.1) | 48.0-50.2 (48.9) |
| Head depth at nape | 58.0-64.7 (62.0) | 57.2-66.6 (61.7) | 59.0-64.5 (62.4) |
| Snout width at nostrils | 35.4-41.8 (38.3) | 30.9-33.4 (32.2) | 28.1-33.6 (29.9) |
| Snout depth at nostrils | 30.9-34.7 (32.4) | 27.1-32.1 (29.7) | 34.0-37.8 (35.7) |
| Mouth width | 28.4-34.3 (30.2) | 21.3-26.0 (24.1) | 19.3-23.8 (21.9) |

**Table 2.** Frequency distribution of meristic features of *Squalius semae*, *S. semae* x *A. sellal* and *Alburnus sellal* distributed in Euphrates River

**Lateral line scales**

| | N | 42 | 43 | 44 | 45 | 46 | … | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | … | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Squalius semae* | 15 | 3 | 3 | 6 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *S. semae* x *A. sellal* | 15 | - | - | - | - | - | - | 1 | - | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Alburnus sellal* | 15 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | - | 1 | - | 1 |

**Transversal scales**

| | | Above lateral line | | | | | | | | | Below lateral line | | | | | Branched anal-fin rays | | | | | Gill rakers | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| *Squalius semae* | 15 | 5 | 10 | - | - | - | - | - | - | - | 1 | 14 | - | - | - | 15 | - | - | - | - | 2 | 7 | 5 | 1 | - | - | - | - | - | - | - | - |
| *S. semae* x *A. sellal* | 15 | - | - | - | 11 | 4 | - | - | - | - | - | - | 13 | 2 | - | - | 5 | 10 | - | - | - | - | - | - | - | - | 7 | 8 | - | - | - | - |
| *Alburnus sellal* | 15 | - | - | - | - | - | - | 4 | 7 | 3 | - | - | - | 7 | 8 | - | - | - | 8 | 7 | - | - | - | - | - | - | - | - | 3 | 5 | 5 | 2 |

## 4. Discussion

*Squalius semae* and *Alburnus sellal* prefer slightly flowing or stagnant and deep waters, and generally live as syntopic in both lentic and lotic habitats. These two species are known to propagate many hybrids, however, so far no hybrid has been described. Often these hybrids are thought to be a separate species and they reproduce but this has not been recorded/proved, yet. Sometimes hybrids of these two species do not exceed a few examples in their natural habitats, but they create considerable stocks in degraded habitat such as dam lakes. This strengthens the idea that hybrids are able to breed.

When the meristic characters of this hybrid are examined, it is observed that the majority of the characters, especially the diagnostic characters of the both genus, are intermediate forms between the two species (Table 2). For example, lateral line scales are 42-46 in *Squalius semae*, 77-89 in *Alburnus sellal*, whereas in the hybrid population is 53-60. Ligne transversal scale rows are 7-8/3-4 in *S. semae*, 13-15/6-7 in *A. sellal* and 10-11/5-6 in the hybrid individuals. Number of gill rakers 6-9 in *S. semae*, 14-17 in *A. sellal* and 12-13 in the hybrid population (Table 1). Also, *Squalius semae*, *Alburnus sellal* and their hybrids (*Squalius semae* x *Alburnus sellal*) were compared using Principal Component Analysis (PCA). The PCA was performed using 24 morphometric characters. The PCA shows that a hybrid population places intermediate form between two species (Figure 4). Variables loading on the first metric PC I–II are given in Table 3.

**Table 3.** Character loading on principal components I–II for 24 measurements taken on 45 specimens of *Squalius semae*, *S. semae* x *A. sellal* (hybrid) and *A. sellal*.

| | **PCA 1** | **PCA2** |
|---|---|---|
| Head length | -0.16 | 0.11 |
| Body depth of dorsal-fin origin | -0.10 | 0.05 |
| Predorsal length | -0.03 | 0.01 |
| Prepelvic length | -0.10 | -0.01 |
| Preanal length | -0.09 | 0.02 |
| Pectoral-fin orgin to anal fin | -0.13 | -0.05 |
| Pectoral-fin orgin to pelvic fin | -0.16 | -0.09 |
| Pelvic-fin orgin to anal fin | -0.09 | -0.07 |
| Dorsal-fin heigth | 0.12 | -0.08 |
| Anal-fin length | -0.05 | -0.15 |
| Pectoral-fin length | 0.07 | 0.01 |
| Pelvic-fin length | 0.05 | -0.04 |
| Upper caudal-fin lobe | 0.33 | -0.33 |
| Length of middle caudal-fin ray | -0.02 | -0.30 |
| Length of caudal peduncule | 0.17 | 0.10 |
| Depth of caudal peduncle | -0.31 | -0.02 |
| Snout length | -0.08 | -0.11 |
| Eye diameter | 0.40 | -0.28 |
| Interorbital width | -0.28 | -0.16 |
| Head width at middle of post opercule | -0.14 | -0.32 |
| Head depth at nape | 0.02 | -0.07 |
| Snout width at nostrils | -0.29 | -0.17 |
| Snout depth at nostrils | 0.10 | -0.41 |
| Mouth width | -0.38 | -0.27 |

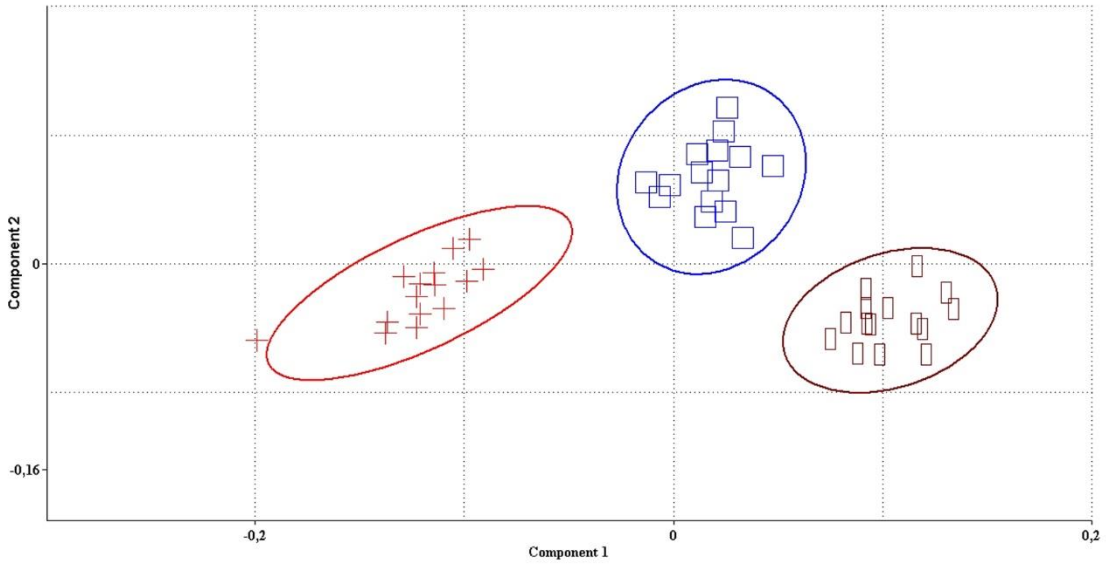


**Figure 4.** A scatter plot of the scores of the first two principal components (PC I, PC II) for 45 specimens of two species and hybrid: *Squalius semae* (+), *Squalius semae* x *Alburnus sellal* (□) and *Alburnus sellal* (▯), based on 24 morphometric characters.

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