

## New Distribution Areas of Four Invasive Freshwater Fish Species from Turkish Thrace

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### Abstract

In order to be able to assess the impact of invasive fish on native species and ecosystems, it is important to know their existing distribution areas. The Meriç River, which is fed by some other rivers from Greece and Bulgaria, is the 'open door' where invasive species enter Turkish inland waters through European part of Turkey. Due to this need, it was aimed to determine the new distribution areas of invasive *C. gibelio*, *L. gibbosus*, *P. parva* and *G. holbrooki* in Turkish Thrace. The field surveys were conducted in a total of 135 stations in Marmara and Meriç-Ergene basins. *Carassiusgibelio* and *G. holbrooki* were the species that expanded their distribution range the most; *C. gibelio* was captured from 24 stations and it was recorded as new to 15 localities while *G. holbrooki* was captured from 17 stations and it was recorded as new to 15 localities. *Lepomisgibbosus* was collected from Rezve and Sultanbahçe streams in Marmara Basin and it was recorded as new to these localities. *Pseudorasboraparva* was collected from 10 stations and it was recorded as new to 9 localities.

### Introduction

The invasive character of exotic freshwater fish represents an important threat to native and endemic fish species in Turkey, which has a rich biodiversity. Turkey is a special geographic area in the world that has an ichthyofauna characterized by Asian and European origin. According to the last comprehensive checklist (Çiçek, Birecikligil, & Fricke, 2015), 368 species of fishes inhabited in the freshwater systems of Turkey were listed: 3 species are globally extinct, 5 species are extinct in Turkey, 153 species is endemic in Anatolia and 340 species consists of native species. The number of the non-native fish species has increased in recent years with new detection of some species, including *Heteropneustes fossilis* (Bloch, 1794), *Pterygoplichthys disjunctivus* (Weber, 1991) and *Pygocentrus nattereri* Kner, 1858 (Tarkan, 2006; Yalçın Özdilek, 2007; Ünlü,

Çiçek, Değer, & Coad, 2011). *Carassius gibelio* (Bloch, 1782), *Lepomis gibbosus* (Linnaeus, 1758), *Pseudorasbora parva* (Temminck & Schlegel, 1846) and *Gambusia holbrooki* Girard, 1859 are the most important non-native fish species with the potential to create invasive populations in Turkish inland waters. These non-native fishes adapt very well in their new environment, colonize, spread rapidly and became an invasive fish, which harms mainly endemic species (Tarkan, 2013). Detrimental impacts of the invasive fishes on ecosystems were recognized mainly with predation, food and habitat competition, hybridization, habitat degradations, and disease transfer (Copp, Kováč, Ojaveer, & Rosenthal, 2005; Kennard, Arthington, Pusey, & Harch, 2005). In a study on the predation effects of *C. gibelio* on the native fish fauna of Ömerli Reservoir (north-west of Turkey), it has been reported that the abundance of *C. gibelio* increased up

to 245%. In return, the abundance of native species such as *Vimba vimba* (L. 1758) and *Scardinius erythrophthalmus* (L. 1758) decreased by up to 52% and 44%, respectively (Gaygusuz, Tarkan & Gaygusuz, 2007). The most striking example of the effects of diseases transfer has occurred in the population of *Leucaspis delineatus* (Heckel, 1843), which is endangered in England: this fish was affected by *Sphaerothecum destruens*, a microparasitic transmitted by invasive *P. parva*. It has been reported that *L. delineatus* was affected by this disease and there was a dramatic decrease in its population (Gozlan, St-Hilaire, Feist, Martin, & Kent, 2005; Tarkan, 2013). In order to be able to assess the impact of invasive fish species on native species and ecosystems, the first step is to determine their existing distribution areas and evaluate their expansion.

The Meriç (Maritza) River, which is fed by some other rivers from Greece and Bulgaria, is the 'open door' where invasive species enter Turkish inland waters through the European part of Turkey (i. e. Turkish Thrace). Here we aimed to determine the new distribution areas of these four invasive species in Turkish Thrace.

## Materials and Methods

The field surveys were conducted in a total of 135 sampling sites in Marmara and Meriç-Ergene basins during July and August 2017 (Table 1). In the Marmara Basin, the Elmalı, Efendi, Rezve, Papuç, Bulanıkdere, Taşlı, Kazan and Sultanbahçe streams flowing to the Black Sea; the Hacımurat, Yenice, Işıklar, Kavak, Tayfur, Çınar, Abdürrahimköyü and İncirli streams flowing to the Marmara and Aegean seas were sampled. In Meriç-Ergene Basin, the streams connected to Meriç, Tunca and Ergene rivers, such as Galata, Uzunçay, Muzalı, Havsa, Teke, Kocaçay, Anaçay were sampled. Samplings were carried out over approximately 100 m stream section and fish specimens were collected using a portable electrofishing gear (SAMUS-725 MP). Collected specimens were sacrificed with a lethal solution of anaesthesia and then transferred to 5% formaldehyde solution. All specimens were stored in 70% alcohol as museum material with the museum codes of IUSHM (Istanbul University Science Faculty Hydrobiology Museum, Istanbul, Turkey).

## Results

*Carassius gibelio* was captured from 24 stations and it was recorded as new to Sultanbahçe, İncirli, Abdürrahimköyü, Kaynarlı, Seymendere, Anaçay, Kocaçay, Uzunçay, Galata, Teke, Havsa, Muzalı, Sazlıdere and Altınyazı streams. New distribution areas of the species were marked with \* in Table 2.

*Lepomis gibbosus* was collected from Rezve and

Sultanbahçe streams in Marmara Basin and it was recorded as new to these localities (Table 3).

*Pseudorasbora parva* was collected from 10 stations and it was recorded as new to Abdürrahimköyü, Seymendere, Uzunçay, Anaçay, Muzalı, Kocaçay, Kovakçeşme and Sazlıdere streams (Table 4).

*Gambusia holbrooki* was captured from 17 stations and it was recorded as new to Papuç, Kavak, Çınar, Uzunçay, Anaçay, Ergene, Havsa, Kovakçeşme, Sazlıdere, Teke, Yenikarpuzlu, Çamlıca and Altınyazı streams. New distribution areas of the species were marked with \* in Table 5.

## Discussion

Fish can expand their distribution boundaries naturally through lotic and lentic systems connected to each other. But the human effect (such as stocking, recreational fishing or biological control) is an essential part in the expansion of the distribution of fishes in independent systems (Tarkan, 2013). In Turkish Thrace, while the streams/canals and lakes/ponds in Meriç-Ergene River Basin are connected to each other, the most of the lotic and lentic systems in Marmara Basin are independent of each other. When the past and present distribution of these four invasive species are analysed (Figure 1, Tables 2 to 6), it is thought that besides the interconnected systems, the human factor is also effective in expanding the distribution area of fishes. *Carassius gibelio* was first reported in the Gala Lake in 1988, but it is seen that it had spread to a large part of the Thrace in 2004 (Baran & Ongan, 1988; Özuluğ, Meriç, & Freyhof, 2004). The most of the stations sampled in this study are in the distribution area of *C. gibelio* in the Turkish Thrace, however, with 5 specimens captured from Sultanbahçe Stream, its distribution range has been expanded to the streams flowing to the Black Sea.

Due to its geographical location and cross-border river systems, the Turkish Thrace is an important corridor for the crossing of alien fish species spreading in Europe and especially in the Balkans. Now, freshwater habitats in Turkish Thrace are also under threat of these four invasive species besides water pollution, which occurs a result of industrialization, domestic waste or agricultural activities (Sakcali, Yilmaz, Guçel, Yarci, & Ozturk, 2009; Yılmaz & Sivri, 2014; Özkahya & Çamur-Elipek, 2016). The first entry of *G. holbrooki* into Turkish inland waters occurred via Lake Amik (southern Anatolian part of Turkey) in 1920s for mosquito control purpose (İnnal & Erk'akan, 2006). However, the first appearance of the species in the Turkish Thrace (European part of Turkey) was reported from marsh areas in Meriç River basin (Balık, 1985). This species entered Bulgarian inland waters in 1924;

**Table 1.** Sampling sites in the study region (Turkish Thrace)

| No | Streams              | Basin, Province           | Coordinate                | No | Streams               | Basin, Province                | Coordinate                |
|----|----------------------|---------------------------|---------------------------|----|-----------------------|--------------------------------|---------------------------|
| 1  | Bulanık Stream-1     | Marmara Basin, Kırklareli | 41.820316°N 27.953779°E   | 36 | Doğancı Stream-2      | Marmara Basin, Tekirdağ        | 41.0148501°N 27.5650490°E |
| 2  | Bulanık Stream-2     | Marmara Basin, Kırklareli | 41.80270°N 27.817034°E    | 37 | Hacımurat Stream-1    | Marmara Basin, Tekirdağ        | 41.0504632°N 27.7343011°E |
| 3  | Bulanık Stream-3     | Marmara Basin, Kırklareli | 41.812102°N 27.798522°E   | 38 | Çilingöz Stream       | Marmara Basin, İstanbul        | 41.5319444°N 28.1808333°E |
| 4  | Rezve Stream-1       | Marmara Basin, Kırklareli | 41.909917°N 27.675432°E   | 39 | Kumdere Stream        | Marmara Basin, Tekirdağ        | 41.0621778°N 27.9062769°E |
| 5  | Rezve Stream-2       | Marmara Basin, Kırklareli | 41.949369°N 27.674070°E   | 40 | İncirli Stream-1      | Marmara Basin, Edirne          | 40.6275812°N 26.1565345°E |
| 6  | Rezve Stream-3       | Marmara Basin, Kırklareli | 41.897764°N 27.557869°E   | 41 | İncirli Stream-2      | Marmara Basin, Edirne          | 40.6736410°N 26.1878198°E |
| 7  | Rezve Stream-4       | Marmara Basin, Kırklareli | 41.924878°N 27.385859°E   | 42 | Bağ Stream            | Marmara Basin, Edirne          | 40.6144859°N 26.1947959°E |
| 8  | Rezve Stream-5       | Marmara Basin, Kırklareli | 41.833843°N 27.664316°E   | 43 | Abdürrahimköyü Stream | Marmara Basin, Edirne          | 40.6437143°N 26.2643402°E |
| 9  | Veleka Stream        | Marmara Basin, Kırklareli | 42.043504°N 27.328979°E   | 44 | Sulucak Stream-1      | Meriç-Ergene Basin, Kırklareli | 41.626412°N 27.646475°E   |
| 10 | Efendi Stream-1      | Marmara Basin, Kırklareli | 41.908269°N 27.943145°E   | 45 | Sulucak Stream-2      | Meriç-Ergene Basin, Kırklareli | 41.521258°N 27.574575°E   |
| 11 | Efendi Stream-2      | Marmara Basin, Kırklareli | 41.927050°N 27.908495°E   | 46 | Sulucak Stream-3      | Meriç-Ergene Basin, Kırklareli | 41.417756°N 27.558481°E   |
| 12 | Taşlı Stream-1       | Marmara Basin, Kırklareli | 41.875240°N 27.937356°E   | 47 | Kaynarlı Stream-1     | Meriç-Ergene Basin, Kırklareli | 41.755079°N 27.545256°E   |
| 13 | Taşlı Stream-2       | Marmara Basin, Kırklareli | 41.898141°N 27.858676°E   | 48 | Kaynarlı Stream-2     | Meriç-Ergene Basin, Kırklareli | 41.706938°N 27.530010°E   |
| 14 | Taşlı Stream-3       | Marmara Basin, Kırklareli | 41.914850°N 27.851990°E   | 49 | Kaynarlı Stream-3     | Meriç-Ergene Basin, Kırklareli | 41.704283°N 27.605290°E   |
| 15 | Papuç Stream-1       | Marmara Basin, Kırklareli | 41.636520°N 28.068942°E   | 50 | Kaynarlı Stream-4     | Meriç-Ergene Basin, Kırklareli | 41.585085°N 27.566569°E   |
| 16 | Papuç Stream-2       | Marmara Basin, Kırklareli | 41.663295°N 27.977579°E   | 51 | Kaynarlı Stream-5     | Meriç-Ergene Basin, Kırklareli | 41.461990°N 27.397470°E   |
| 17 | Papuç Stream-3       | Marmara Basin, Kırklareli | 41.684083°N 27.882019°E   | 52 | Kaynarlı Stream-6     | Meriç-Ergene Basin, Kırklareli | 41.414839°N 27.350709°E   |
| 18 | Elmalı Stream        | Marmara Basin, Kırklareli | 41.576957°N 28.128217°E   | 53 | Galata Stream         | Meriç-Ergene Basin, Tekirdağ   | 41.401847°N 27.957269°E   |
| 19 | Sultanbahçe Stream-1 | Marmara Basin, Kırklareli | 41.575560°N 28.097706°E   | 54 | Pınarbaşı Stream-1    | Meriç-Ergene Basin, Tekirdağ   | 41.389793°N 27.622586°E   |
| 20 | Sultanbahçe Stream-2 | Marmara Basin, Kırklareli | 41.532678°N 28.039940°E   | 55 | Pınarbaşı Stream-2    | Meriç-Ergene Basin, Kırklareli | 41.307022°N 27.538586°E   |
| 21 | Kazan Stream-1       | Marmara Basin, Kırklareli | 41.615722°N 28.076480°E   | 56 | Pınarbaşı Stream-3    | Meriç-Ergene Basin, Kırklareli | 41.515885°N 27.847191°E   |
| 22 | Kazan Stream-2       | Marmara Basin, Kırklareli | 41.611327°N 27.990940°E   | 57 | Pınarbaşı Stream-4    | Meriç-Ergene Basin, Kırklareli | 41.349043°N 27.713974°E   |
| 23 | Kazan Stream-3       | Marmara Basin, Kırklareli | 41.635270°N 27.840137°E   | 58 | Ergene River-1        | Meriç-Ergene Basin, Tekirdağ   | 41.449930°N 27.905937°E   |
| 24 | Suvat Stream         | Marmara Basin, Edirne     | 40.6365910°N 26.3752291°E | 59 | Ergene River-2        | Meriç-Ergene Basin, Tekirdağ   | 41.311908°N 27.803817°E   |
| 25 | Çınar Stream-1       | Marmara Basin, Edirne     | 40.6604077°N 26.5156142°E | 60 | Ergene River-3        | Meriç-Ergene Basin, Tekirdağ   | 41.1943416°N 27.4762896°E |
| 26 | Çınar Stream-2       | Marmara Basin, Edirne     | 40.6585876°N 26.5472884°E | 61 | Ergene River-4        | Meriç-Ergene Basin, Tekirdağ   | 41.2023569°N 27.4763185°E |
| 27 | Tayfur Stream-1      | Marmara Basin, Çanakkale  | 40.3424502°N 26.5684105°E | 62 | Ergene River-5        | Meriç-Ergene Basin, Kırklareli | 41.273479°N 27.457547°E   |
| 28 | Tayfur Stream-2      | Marmara Basin, Çanakkale  | 40.3810278°N 26.4911333°E | 63 | Ergene River-6        | Meriç-Ergene Basin, Kırklareli | 41.360378°N 27.224135°E   |
| 29 | Tayfur Stream-3      | Marmara Basin, Çanakkale  | 40.3975667°N 26.480097°E  | 64 | Ergene River-7        | Meriç-Ergene Basin, Kırklareli | 41.3527859°N 27.0798944°E |
| 30 | Ilgar Stream         | Marmara Basin, Çanakkale  | 40.2819348°N 26.4791603°E | 65 | Ergene River-8        | Meriç-Ergene Basin, Kırklareli | 41.3350833°N 26.9217999°E |
| 31 | Kavak Stream-1       | Marmara Basin, Tekirdağ   | 40.6230170°N 26.8866744°E | 66 | Ergene River-9        | Meriç-Ergene Basin, Edirne     | 41.244561°N 26.616462°E   |
| 32 | Kavak Stream-2       | Marmara Basin, Tekirdağ   | 40.6916002°N 27.0958022°E | 67 | Anaçay Stream-1       | Meriç-Ergene Basin, Kırklareli | 41.710965°N 27.262584°E   |
| 33 | Kavak Stream-3       | Marmara Basin, Tekirdağ   | 40.7756653°N 27.0667066°E | 68 | Anaçay Stream-2       | Meriç-Ergene Basin, Kırklareli | 41.659340°N 27.231832°E   |
| 34 | Işıklar Stream       | Marmara Basin, Tekirdağ   | 40.8769638°N 27.4102014°E | 69 | Anaçay Stream-3       | Meriç-Ergene Basin, Kırklareli | 41.5391314°N 27.1605189°E |
| 35 | Doğancı Stream-1     | Marmara Basin, Tekirdağ   | 41.0053538°N 27.5640572°E | 70 | Anaçay Stream-4       | Meriç-Ergene Basin, Kırklareli | 41.4298498°N 27.0980657°E |

Table 1. Continued

| No  | Streams             | Basin, Province                | Coordinate                | No  | Streams                  | Basin, Province              | Coordinate                |
|-----|---------------------|--------------------------------|---------------------------|-----|--------------------------|------------------------------|---------------------------|
| 71  | Anaçay Stream-5     | Meriç-Ergene Basin, Kırklareli | 41.3475211°N 27.0416065°E | 104 | Meriç River-2            | Meriç-Ergene Basin, Edirne   | 41.625704°N 26.580198°E   |
| 72  | Teke Stream-1       | Meriç-Ergene Basin, Kırklareli | 41.833316°N 27.180784°E   | 105 | Üyükütatar Stream        | Meriç-Ergene Basin, Edirne   | 41.553010°N 26.605086°E   |
| 73  | Teke Stream-2       | Meriç-Ergene Basin, Kırklareli | 41.892157°N 27.102999°E   | 106 | Çakmakköy Stream         | Meriç-Ergene Basin, Edirne   | 41.370297°N 26.675231°E   |
| 74  | Teke Stream-3       | Meriç-Ergene Basin, Kırklareli | 41.877278°N 27.048004°E   | 107 | Meriç Stream             | Meriç-Ergene Basin, Edirne   | 41.187332°N 26.414549°E   |
| 75  | Teke Stream-4       | Meriç-Ergene Basin, Kırklareli | 41.719303°N 27.104992°E   | 108 | Hasırçıarnavutköy Stream | Meriç-Ergene Basin, Edirne   | 41.284148°N 26.468537°E   |
| 76  | Teke Stream-5       | Meriç-Ergene Basin, Kırklareli | 41.659340°N 27.231832°E   | 109 | Rahmanca Stream          | Meriç-Ergene Basin, Edirne   | 41.286973°N 26.496818°E   |
| 77  | Teke Stream-6       | Meriç-Ergene Basin, Kırklareli | 41.4599153°N 26.9140068°E | 110 | Uzunçay Stream-1         | Meriç-Ergene Basin, Tekirdağ | 41.0862890°N 26.9819656°E |
| 78  | Teke Stream-7       | Meriç-Ergene Basin, Kırklareli | 41.3428907°N 26.9245294°E | 111 | Uzunçay Stream-2         | Meriç-Ergene Basin, Tekirdağ | 41.0536507°N 26.9729205°E |
| 79  | Havsa Stream-1      | Meriç-Ergene Basin, Edirne     | 41.778918°N 26.915071°E   | 112 | Uzunçay Stream-3         | Meriç-Ergene Basin, Tekirdağ | 41.0020124°N 26.9426994°E |
| 80  | Havsa Stream-2      | Meriç-Ergene Basin, Edirne     | 41.642338°N 26.864454°E   | 113 | Uzunçay Stream-4         | Meriç-Ergene Basin, Tekirdağ | 40.9450157°N 26.8849880°E |
| 81  | Havsa Stream-3      | Meriç-Ergene Basin, Edirne     | 41.5485743°N 26.8244217°E | 114 | Uzunçay Stream-5         | Meriç-Ergene Basin, Tekirdağ | 40.9527876°N 27.0315214°E |
| 82  | Seymendere Stream-1 | Meriç-Ergene Basin, Edirne     | 41.638614°N 26.802949°E   | 115 | Uzunçay Stream-6         | Meriç-Ergene Basin, Tekirdağ | 41.0422124°N 27.0888878°E |
| 83  | Seymendere Stream-2 | Meriç-Ergene Basin, Edirne     | 41.4120957°N 26.8304268°E | 116 | Uzunçay Stream-7         | Meriç-Ergene Basin, Tekirdağ | 41.2094974°N 27.1172066°E |
| 84  | Susam Stream        | Meriç-Ergene Basin, Kırklareli | 41.569485°N 27.067466°E   | 117 | Çorlu Stream             | Meriç-Ergene Basin, Tekirdağ | 41.245414°N 27.882368°E   |
| 85  | Kuruçeşme Stream-1  | Meriç-Ergene Basin, Kırklareli | 41.427846°N 27.181201°E   | 118 | Çamlıca Stream -1        | Meriç-Ergene Basin, Edirne   | 40.7714723°N 26.6773484°E |
| 86  | Kuruçeşme Stream-2  | Meriç-Ergene Basin, Kırklareli | 41.4008870°N 27.1638743°E | 119 | Çamlıca Stream -2        | Meriç-Ergene Basin, Edirne   | 40.8092748°N 26.5125686°E |
| 87  | Düğüncülü Stream    | Meriç-Ergene Basin, Kırklareli | 41.376114°N 27.178414°E   | 120 | Çamlıca Stream -3        | Meriç-Ergene Basin, Edirne   | 40.7686170°N 26.5144431°E |
| 88  | Tunca River-1       | Meriç-Ergene Basin, Edirne     | 41.759217°N 26.559570°E   | 121 | Muzalı Stream-1          | Meriç-Ergene Basin, Edirne   | 40.9378226°N 26.7096553°E |
| 89  | Tunca River-2       | Meriç-Ergene Basin, Edirne     | 41.888001°N 26.591901°E   | 122 | Muzalı Stream-2          | Meriç-Ergene Basin, Edirne   | 40.9097408°N 26.6006430°E |
| 90  | Tunca River-3       | Meriç-Ergene Basin, Edirne     | 41.840221°N 26.584588°E   | 123 | Muzalı Stream-3          | Meriç-Ergene Basin, Edirne   | 40.8582130°N 26.7014729°E |
| 91  | Çoban Stream-1      | Meriç-Ergene Basin, Edirne     | 41.880558°N 26.668745°E   | 124 | Muzalı Stream-4          | Meriç-Ergene Basin, Edirne   | 40.8703195°N 26.6393244°E |
| 92  | Çoban Stream-2      | Meriç-Ergene Basin, Edirne     | 41.797344°N 26.575782°E   | 125 | Muzalı Stream-5          | Meriç-Ergene Basin, Edirne   | 40.8621405°N 26.6101272°E |
| 93  | Kovakçeşme Stream-1 | Meriç-Ergene Basin, Edirne     | 41.81268°N 26.699621°E    | 126 | Muzalı Stream-6          | Meriç-Ergene Basin, Edirne   | 40.7714723°N 26.6773484°E |
| 94  | Kovakçeşme Stream-2 | Meriç-Ergene Basin, Edirne     | 41.776263°N 26.681876°E   | 127 | Esetçe Stream            | Meriç-Ergene Basin, Edirne   | 40.8301984°N 26.3688572°E |
| 95  | Kovakçeşme Stream-3 | Meriç-Ergene Basin, Edirne     | 41.761889°N 26.643432°E   | 128 | Yenikarpuzlu Stream      | Meriç-Ergene Basin, Edirne   | 40.8337608°N 26.2907442°E |
| 96  | Kovakçeşme Stream-4 | Meriç-Ergene Basin, Edirne     | 41.760417°N 26.617718°E   | 129 | İbriktepe Stream         | Meriç-Ergene Basin, Edirne   | 40.9855207°N 26.4908021°E |
| 97  | Kovakçeşme Stream-5 | Meriç-Ergene Basin, Edirne     | 41.723616°N 26.624961°E   | 130 | Balabancık Stream        | Meriç-Ergene Basin, Edirne   | 41.0331068°N 26.4097897°E |
| 98  | Kovakçeşme Stream-6 | Meriç-Ergene Basin, Edirne     | 41.721705°N 26.564859°E   | 131 | Altınyazı Stream         | Meriç-Ergene Basin, Edirne   | 41.0773108°N 26.5742819°E |
| 99  | Sazlıdere Stream-1  | Meriç-Ergene Basin, Edirne     | 41.6958056°N 26.7261472°E | 132 | Kocaçay Stream-1         | Meriç-Ergene Basin, Edirne   | 41.3071346°N 26.9027281°E |
| 100 | Sazlıdere Stream-2  | Meriç-Ergene Basin, Edirne     | 41.631545°N 26.679654°E   | 133 | Kocaçay Stream-2         | Meriç-Ergene Basin, Edirne   | 41.2691340°N 26.8401800°E |
| 101 | Sazlıdere Stream-3  | Meriç-Ergene Basin, Edirne     | 41.571419°N 26.665654°E   | 134 | Ana Stream-1             | Meriç-Ergene Basin, Tekirdağ | 41.0861326°N 27.2436311°E |
| 102 | Sazlıdere Stream-4  | Meriç-Ergene Basin, Edirne     | 41.482741°N 26.627084°E   | 135 | Ana Stream-2             | Meriç-Ergene Basin, Tekirdağ | 41.2177516°N 27.2044927°E |
| 103 | Meriç River-1       | Meriç-Ergene Basin, Edirne     | 41.666176°N 26.532333°E   |     |                          |                              |                           |

**Table 2.** Records of *C. gibelio* in Turkish Thrace. Asterisks indicate newly recorded localities

| Basin                                  | Locality                                  | Coordinate                | Station No     | Date           | Number of Specimens | Mean Length (SL±SD, min.-max., cm) |
|--|---|---------------------------|----------------|----------------|---------------------|------------------------------------|
| Marmara Basin                          | Sultanbahçe Stream-1*                     | 41.575560°N 28.097706°E   | 19             | 4 August 2017  | 5                   | 10.9±1.5 (9.0-12.8)                |
|  | İncirli Stream-1*                         | 40.6275812°N 26.1565345°E | 40             | 27 July 2017   | 7                   | 6.7±4.4 (2.9-14.7)                 |
|  | Abdürrahimköyü Stream*                    | 40.6437143°N 26.2643402°E | 43             | 27 July 2017   | 145                 | 3.7±3.4 (1.7-4.2)                  |
|  | Kavak Stream-1 (Özuluğ et al., 2004)      | 40.6230170°N 26.8866744°E | 31             | 24 July 2017   | 45                  | 4.3±1.2 (2.7-7.5)                  |
|  | Kavak Stream-2 (Özuluğ et al., 2004)      | 40.6916002°N 27.0958022°E | 32             | 24 July 2017   | 16                  | 9.7±5.7 (1.7-20.3)                 |
|  | Kavak Stream-3 (Özuluğ et al., 2004)      | 40.7756653°N 27.0667066°E | 33             | 24 July 2017   | 1                   | 12.0                               |
| Meriç-Ergene Basin                     | Kaynarlı Stream-6*                        | 41.414839°N 27.350709°E   | 52             | 7 August 2017  | 13                  | 3.4±1.2 (1.9-5.4)                  |
|  | Seymendere Stream-1*                      | 41.638614°N 26.802949°E   | 82             | 8 August 2017  | 2                   | 2.9±1.8 (1.6-4.2)                  |
|  | Anaçay Stream-5*                          | 41.3475211°N 27.0416065°E | 71             | 26 July 2017   | 4                   | 4.6±0.7 (3.7-5.5)                  |
|  | Kocaçay Stream*                           | 41.3071346°N 26.9027281°E | 132            | 10 August 2017 | 6                   | 7.8±1.3 (6.1-9.3)                  |
|  | Altınyazı Stream*                         | 41.0773108°N 26.5742819°E | 131            | 9 August 2017  | 3                   | 6.7±2.2 (5.1-9.2)                  |
|  | Uzunçay Stream-4*                         | 40.9450157°N 26.8849880°E | 113            | 26 July 2017   | 1                   | 19.5                               |
|  | Galata Stream*                            | 41.311908°N 27.803817°E   | 53             | 17 August 2017 | 1                   | 10.3                               |
|  | Teke Stream-2*                            | 41.892157°N 27.102999°E   | 73             | 8 August 2017  | 2                   | 9.2±0.8 (8.6-9.8)                  |
|  | Teke Stream-7*                            | 41.3428907°N 26.9245294°E | 78             | 10 August 2017 | 13                  | 5.5±2.5 (1.6-10.8)                 |
|  | Havsa Stream-3*                           | 41.5485743°N 26.8244217°E | 81             | 14 August 2017 | 4                   | 6.5±0.7 (5.5-7.1)                  |
|  | Muzalı Stream-4*                          | 40.8703195°N 26.6393244°E | 124            | 17 August 2017 | 14                  | 2.9±1.3 (1.4-5.9)                  |
|  | Sazlıdere Stream-4*                       | 41.482741°N 26.627084°E   | 102            | 16 August 2017 | 34                  | 4.6±1.6 (2.4-8.3)                  |
|  | Yenikarpuzlu Stream                       | 41.0422111°N 27.0888889°E | 28             | 8 August 2017  | 21                  | 9.4±2.9 (4.8-13.3)                 |
|  | Tunca River-1 (Özuluğ et al., 2004)       | 41.759217°N 26.559570°E   | 88             | 15 August 2017 | 4                   | 8.5±1.1 (7.2-9.6)                  |
|  | Kovakçeşme Stream-6 (Özuluğ et al., 2004) | 41.721705°N 26.564859°E   | 98             | 15 August 2017 | 1                   | 12.4                               |
|  | Üyükütatar Stream (Özuluğ et al., 2004)   | 41.553010°N 26.605086°E   | 105            | 16 August 2017 | 5                   | 6.26±2.8 (3.3-8.9)                 |
| Meriç River-2 (Özuluğ et al., 2004)    | 41.625704°N 26.580198°E                   | 104                       | 16 August 2017 | 3              | 9.9±4.8 (6.0-15.2)  |                                    |
| İbriktepe Stream (Özuluğ et al., 2004) | 40.9855207°N 26.4908021°E                 | 129                       | 9 August 2017  | 9              | 6.6±2.0 (4.4-9.8)   |                                    |

**Table 3.** Records of *L. gibbosus* in Turkish Thrace. Asterisks indicate newly recorded localities

| Basin         | Locality              | Coordinate              | Station No | Date          | Number of Specimens | Mean Length (SL±SD, min.-max., cm) |
|---------------|-----------------------|-------------------------|------------|---------------|---------------------|------------------------------------|
| Marmara Basin | Rezve Stream-4*       | 41.924878°N 27.385859°E | 7          | 2 August 2017 | 2                   | 7.3±0.3 (7.1-7.5)                  |
|               | Sultanbahçe Stream-1* | 41.575560°N 28.097706°E | 19         | 4 August 2017 | 4                   | 6.2±0.5 (5.6-6.7)                  |

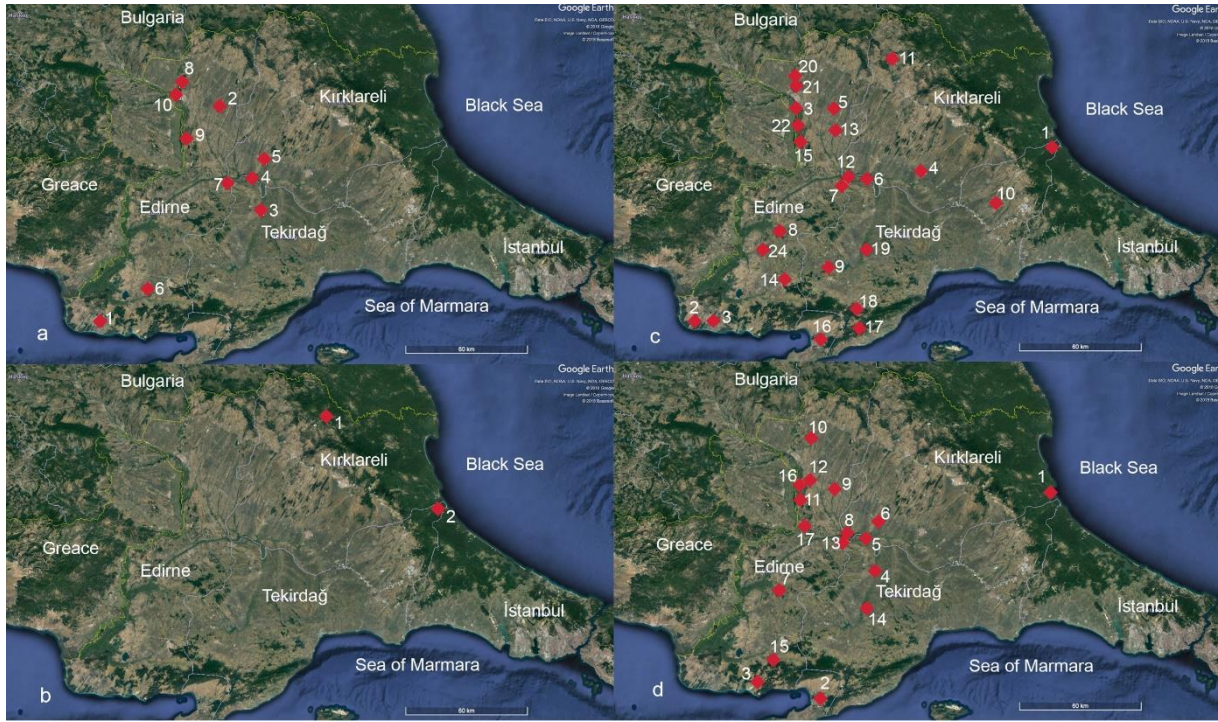
**Table 4.** Records of *P. parva* in Turkish Thrace. Asterisks indicate newly recorded localities

| Basin              | Locality                       | Coordinate                | Station No | Date           | Number of Specimens | Mean Length (SL±SD, min.-max., cm) |
|--------------------|--------------------------------|---------------------------|------------|----------------|---------------------|------------------------------------|
| Marmara Basin      | Abdürrahimköyü Stream*         | 40.6437143°N 26.2643402°E | 43         | 27 July 2017   | 11                  | 2.3±0.5 (1.7-3.3)                  |
| Meriç-Ergene Basin | Seymendere Stream-1*           | 41.638614°N 26.802949°E   | 82         | 8 August 2017  | 1                   | 4.5                                |
|                    | Uzunçay Stream-7*              | 41.2094974°N 27.1172066°E | 116        | 26 July 2017   | 1                   | 2.7                                |
|                    | Anaçay Stream-5*               | 41.3475211°N 27.0416065°E | 65         | 26 July 2017   | 1                   | 3.4                                |
|                    | Anaçay Stream-4*               | 41.4298498°N 27.0980657°E | 70         | 26 July 2017   | 1                   | 3.9                                |
|                    | Muzalı Stream-6*               | 40.8092748°N 26.5125686°E | 126        | 8 August 2017  | 1                   | 5.7                                |
|                    | Kocaçay Stream-1*              | 41.3071346°N 26.9027281°E | 132        | 10 August 2017 | 1                   | 5.7                                |
|                    | Kovakçeşme Stream-6*           | 41.721705°N 26.564859°E   | 98         | 15 August 2017 | 1                   | 4.1                                |
|                    | Sazlıdere Stream-4*            | 41.482741°N 26.627084°E   | 102        | 16 August 2017 | 10                  | 3.7±1.2 (1.8-5.5)                  |
|                    | Meriç River-1 (Erk'akan, 1984) | 41.666176°N 26.532333°E   | 103        | 17 August 2017 | 2                   | 5.3 (5.3-5.3)                      |

**Table 5.** Records of *G. holbrooki* in Turkish Thrace. Asterisks indicate newly recorded localities

| Basin                          | Locality                        | Coordinate                | Station No     | Date           | Number of Specimens | Mean Length (SL±SD, min.-max., cm) |
|--------------------------------|---------------------------------|---------------------------|----------------|----------------|---------------------|------------------------------------|
| Marmara Basin                  | Papuçdere Stream-1*             | 41.636520°N 28.068942°E   | 15             | 4 August 2017  | 2                   | 1.7±0.1 (1.6-.17)                  |
|                                | Kavak Stream-1*                 | 40.6230170°N 26.8866744°E | 31             | 24 July 2017   | 2                   | 1.8±0.4 (1.5-2.1)                  |
|                                | Çınar Stream-1*                 | 40.6604077°N 26.5156142°E | 25             | 11 August 2017 | 3                   | 2.2±0.3 (1.9-2.4)                  |
| Meriç-Ergene Basin             | Uzundere Stream-7*              | 41.2094974°N 27.1172066°E | 116            | 26 July 2017   | 3                   | 2.8±0.4 (2.4-3.1)                  |
|                                | Anaçay Stream-5*                | 41.3475211°N 27.0416065°E | 71             | 26 July 2017   | 4                   | 2.2±0.3 (1.9-2.6)                  |
|                                | Anaçay Stream-4*                | 41.4298498°N 27.0980657°E | 70             | 26 July 2017   | 2                   | 2.3±0.5 (1.9-2.6)                  |
|                                | Altinyazı Stream*               | 41.0773108°N 26.5742819°E | 131            | 9 August 2017  | 10                  | 2.2±0.5 (1.7-3.3)                  |
|                                | Ergene River-8*                 | 41.3350833°N 26.9217999°E | 62             | 10 August 2017 | 2                   | 1.9±0.2 (1.7-2.0)                  |
|                                | Havsa Stream-3*                 | 41.5485743°N 26.8244217°E | 81             | 14 August 2017 | 1                   | 2.3                                |
|                                | Kovakçeşme Stream-3*            | 41.761889°N 26.643432°E   | 95             | 15 August 2017 | 1                   | 2.3                                |
|                                | Sazlıdere Stream-4*             | 41.482741°N 26.627084°E   | 102            | 16 August 2017 | 15                  | 2.4±0.7 (1.8-3.6)                  |
|                                | Sazlıdere Stream-3*             | 41.571419°N 26.665654°E   | 101            | 15 August 2017 | 30                  | 2.3±0.9 (1.2-4.2)                  |
|                                | Teke Stream-7*                  | 41.3428907°N 26.9245294°E | 78             | 10 August 2017 | 1                   | 3.1                                |
|                                | Yenikarpuzlu Stream*            | 41.0422111°N 27.0888889°E | 128            | 8 August 2017  | 25                  | 2.5±0.7 (1.5-4.2)                  |
|                                | Çamlıca Stream-2*               | 40.7674802°N 26.5839040°E | 119            | 11 August 2017 | 2                   | 3.0±1.9 (1.7-4.4)                  |
|                                | Üyükütatar Stream (Zarev, 2012) | 41.553010°N 26.605086°E   | 105            | 16 August 2017 | 17                  | 1.7±0.2 (1.5-2.5)                  |
| Çakmakköy Stream (Zarev, 2012) | 41.370297°N 26.675231°E         | 106                       | 16 August 2017 | 80             | 2.7±0.7 (1.4-4.8)   |                                    |





**Figure 1.** The distribution areas of the invasive fish species in Turkish Thrace (a: *Pseudorasbora parva*, 1: Abdürrahimköyü Stream, 2: Seymendere S.-1, 3: Uzunçay S.-7, 4: Anaçay S.-5, 5: Anaçay S.-4, 6: Muzalı S.-6, 7: Kocaçay S.-1, 8: Kovakçeşme S.-6, 9: Sazlıdere S.-4, 10: Meriç R.-1 – b: *Lepomis gibbosus*, 1: Rezve S.-4, 2: Sultanbahçe S.-1 – c: *Carassius gibelio*, 1: Sultanbahçe S.-1, 2: İncirli S.-1, 3: Abdürrahimköyü S., 4: Kaynarlı S.-6, 5: Seymendere S.-1, 6: Anaçay S.-5, 7: Kocaçay S.-1, 8: Altınyazı S., 9: Uzunçay S.-4, 10: Galata S.; 11: Teke S.-2, 12: Teke S.-7, 13: Havsa S.-3, 14: Muzalı S.-4, 15: Sazlıdere S.-1, 16: Kavak S.-1, 17: Kavak S.-2, 18: Kavak S.-3, 19: Yenikarpuzlu S., 20: Tunca R.-1, 21: Kovakçeşme S.-6, 22: Meriç R.-1, 23: Meriç R.-2, 24: İbriktepe S. – d: *Gambusia holbrooki*, 1: Papuçdere S.-1, 2: Kavak S.-1, 3: Çınar S.-1, 4: Uzundere S.-7, 5: Anaçay S.-5, 6: Anaçay S.-4, 7: Altınyazı S., 8: Ergene S.-5, 9: Havsa S.-3, 10: Kovakçeşme S.-3, 11: Sazlıdere S.-4, 12: Sazlıdere S.-3, 13: Teke S.-7, 14: Yenikarpuzlu S., 15: Çamlıca S., 16: Üyüklütatar S., 17: Çakmakköy S.

**Table 6.** Summary of invasive *C. gibelio*, *L. gibbosus*, *P. parva* and *G. holbrooki* introductions in Turkish Thrace (MB: Marmara Basin; MEB: Meriç-Ergene Basin)

| Species             | Distribution Area   | Basin | Reference                   |
|---------------------|---|-------|-----------------------------|
| <i>C. gibelio</i>   | Gala Lake   | MEB   | Baran and Ongan, 1988       |
|                     | Büyükçekmece Reservoir  | MB    | Özuluğ, 1999                |
|                     | Kayalı Dam, Tunca River, Sarıcaali Pond, Çöpköy Pond, Bülbüldere Pond, İbriktepe Dam, Meriç River, Gala Lake, Çamlıca Creek, Kavaklı Stream | MEB   | Özuluğ <i>et al.</i> , 2004 |
|                     | Kınıklı Stream, Büyükçekmece Reservoir, Pond of Istanbul Technical University   | MB    | Özuluğ <i>et al.</i> , 2004 |
|                     | Tunca River   | MEB   | İlhan <i>et al.</i> , 2005  |
|                     | Arnavut Stream, Bulanıkdere Stream, Saka Lake   | MB    | İlhan <i>et al.</i> , 2005  |
|                     | Karpuzlu Reservoir  | MEB   | Aydın <i>et al.</i> , 2011  |
|                     | İpsala Canal  | MEB   | Keskin <i>et al.</i> , 2013 |
|                     | Topaçlı Reservoir   | MB    | Tarkan <i>et al.</i> , 2012 |
|                     | Istranca Stream   | MB    | Saç and Özuluğ, 2014        |
|                     | Kula Stream, Sinekli Pond, Çakıl Pond, Küçükkokmuş Pond, Büyükkokmuş Pond, Çayırdere Pond, Sungurlu Stream                                  | MB    | Saç and Özuluğ, 2017        |
| <i>L. gibbosus</i>  | İpsala Canal  | MEB   | Erk'akan, 1983              |
|                     | Gala Lake   | MEB   | Baran and Ongan, 1988       |
|                     | Değirmenköy Pond  | MB    | Saç and Özuluğ, 2017        |
| <i>P. parva</i>     | Meriç River   | MEB   | Erk'akan, 1984              |
| <i>G. holbrooki</i> | Meriç River   | MEB   | Balık, 1985                 |
|                     | Büyükçekmece Reservoir  | MB    | Özuluğ, 1999                |
|                     | Durusu Lake   | MB    | Özuluğ, 2008                |
|                     | Güllapoğlu Lake   | MEB   | Güner, 2010                 |
|                     | Kurfalı Stream, Sinekli Pond, İzzettin Stream, Küçükkokmuş Pond, Büyükkokmuş Pond, Çilingöz Stream, Ormanlı Stream, Celepköy Pond           | MB    | Saç and Özuluğ, 2017        |

the first successful attempts for breeding were made near Tunca River and its distribution range has covered Meriç River (cross-border river system) (Georgiev, 2006; Zarev, 2012). It is thought that *G. holbrooki* entered the Meriç-Ergene Basin in Turkish Thrace via this boundary water (Meriç River) and since then its distribution range expanded in the basin. Similarly, it was thought that *C. gibelio* might naturally disperse through river systems from Greece and Bulgaria to Turkish Thrace (Özuluğ *et al.*, 2004).

The distribution of *L. gibbosus* was limited to Edirne (İpsala Canal and Gala Lake) and İstanbul (Değirmenköy Pond) (Erk'akan, 1983; Baran & Ongan, 1988; Saç & Özuluğ, 2017); but, it was determined that the distribution range of the species has been expanded to the streams (Rezve and Sultanbahçe) flowing to the Black Sea in the north. Similarly, previously known only from the Meriç River (Erk'akan, 1984), *P. parva* was also collected from the Abdürrahimköyü Stream in the Marmara Basin besides the many of the streams in the Meriç-Ergene Basin. It is thought that the expansion of the range of these fishes is probably originated from human activities such as recreational fishing, accidental, etc.

In conclusion, besides the human activities, the streams connected with each other and the transboundary waters are effective on the expansion of the distribution range of these four non-native fish species. However, other alien fish species such as *Gymnocephalus cernua* (Linnaeus, 1758), *Percottus glenii* Dybowski, 1877, *Ameiurus nebulosus* (Lesueur 1819), that have spread in neighbouring countries (Bulgaria and Greece) have not yet been observed in Turkish Thrace (Jurajda, Vassilev, Polačik, & Trichkova, 2006; Uzunova & Zlatanova, 2007; Petriki, Naziridis, Apostolou, Koutrakis, & Bobori, 2014). These fishes have a large habitat tolerance, including ponds, lakes, backwaters, marshes and small to large rivers and they prefer still or slow-flowing waters with soft substrate. They also occur in vegetated shallows over sand, rock, mud, or silt, in clear to turbid water (Kottelat & Freyhof, 2007; Freyhof & Kottelat, 2008; NatureServe, 2013). The inland waters of Thrace have different habitats and suitable conditions in such a way that these species prefer, so, these species are potential invaders for Turkish waters.

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