

Morphometric Characteristics of *Gambusia holbrooki* and *Gambusia affinis* (Cyprinodontiformes: Poeciliidae) Distributed on the Plains of the Chirchik River, Uzbekistan

Asqar Q. Quvatov* , Mukhayyo Sh. Atamuratova and
Ulugbek T. Mirzaev

Institute of Zoology, Academic Sciences of the Republic of Uzbekistan, Tashkent 100053,
Uzbekistan

*Corresponding Author: asqarquvatovxabb@mail.ru

ARTICLE INFO

Article History:

Received: Sept. 6, 2021
Accepted: Dec. 28, 2021
Online: Jan. 19, 2022

Keywords:

River Chirchik,
Gambusia holbrooki,
Gambusia affinis,
Morphologic features,
Meristic characters

ABSTRACT

This article presents the results of comparative analysis and the morphological as well as morphometric characteristics of two species, *Gambusia affinis*, and *Gambusia holbrooki* of the family Poeciliidae commonly found on the plains of the republic's water bodies; in the shallow coastal regions of rivers and lakes. During the research, 44 fish specimens were used, with body lengths ranging from 21 to 55 mm. Their dominance over other species was monitored. The morphometric analysis of the samples provided data on the plastic and meristic characteristics of the studied species. Differences between species were mainly observed among male individuals in terms of meristematic characteristics. At the same time, the number of fin rays in *Gambusia affinis* was detected in the following order: on the dorsal – II 5, anal – 10, on the ventral – I 5, on the thoracic – III 8, and on the caudal – 23-24, and the number of scales on the lateral line was 32-33. The number of fin rays in *Gambusia holbrooki* was determined in the following order: on the dorsal – II 6 (5), anal – 10, on the ventral – I 5, on the chest – III 8, and on the caudal – 22-23, and the number of scales on the lateral line was 31-32. The coefficient of variation for plastic characteristics in the male *Gambusia affinis* varied from 3.9% to 38.1% (4.0% on average), while that of the male *Gambusia holbrooki*, the recorded variation was from 2.2% to 23.7% (on average 5.2%).

INTRODUCTION

The natural range of *Gambusia holbrooki* (Girard, 1859) is the Atlantic states of North America from New Jersey to Florida and the Gulf of Mexico basin in Florida and Georgia (Berg, 1949). These insectivorous fish are one of many representatives of the same family (Poeciliidae) that are widespread (Lindberg, 1947) and acclimatized in Europe and Uzbekistan (Mirabdullaev *et al.*, 2011). This species inhabits lowland water bodies throughout Uzbekistan (Mirabdullaev *et al.*, 2002).

Gambusia holbrooki was introduced to Europe and from there to Uzbekistan, which also received this species from North America. This species inhabits lowland water

bodies throughout Uzbekistan, inhabiting their shallow coastal part (Mirabdullaev *et al.*, 2002). In addition to *Gambusia holbrooki*, the closely related species is *Gambusia affinis*, which is similar to the former species in size, appearance, and biology and has been introduced to many parts of the world, including Europe (Reshetnikov, 2018).

In 1925, the mosquito fish was brought from Italy to Abkhazia, and in the 1930s, it was found in the reservoirs of the countries of Central Asia, where they adapted well to local conditions and began to spread widely (Nuriev, 1985).

According to Nuriev (1985), in the USSR, two forms of mosquito fish are considered acclimatized – *Gambusia affinis* and *Gambusia holbrooki*. At present, in addition to natural reservoirs, mosquito fish can be found in artificially irrigated lands, including rice fields (Davey & Meisch, 1977).

Mirabdullaev *et al.* (2011) noted that the mouth of *Gambusia affinis* is directed upwards. They confirmed the presence of 6- 9 rays in the dorsal fin and 8-11 in the anal fin. *Gambusia* individuals are widely spread in the Chirchik River. They usually live along the river banks and in accumulated water. When viewed from above, a mosquito fish floating in the water has a yellowish-green tint that appears on the upper body. It is most active at a water temperature of 18- 20°C.

MATERIALS AND METHODS

This article provides informative data on the morphological characteristics of the *Gambusia* inhabiting the Chirchik River and its basins (Fig. 1). During the research, 44 fish specimens (Fig. 2) were caught from the middle and lower reaches of the Chirchik River in the summer of 2019 and the fall of 2020 at the coordinates of 41°15'33.77"N, 69°22'4.63"E. Their body lengths ranged from 21 to 55 mm. The measurements were carried out according to the generally accepted method for determining 25 plastic (measured) and 5 meristic (calculated) characteristics of fish (Pravdin, 1966).

During statistical process (for morphometric analysis) of the material, the mean value of the signs (M), its error (m), standard deviation (σ), and coefficient of variation ($Cv, \%$) were calculated (Lakin, 1990).

The accepted Latin abbreviations of the symbols used are as follows: SL – standard body length; c – length of the head; ao – length of the snout; o – horizontal diameter of the eye; po – postorbital distance; hc – head height; io – width of the interorbital space; H – highest body height; h – the height of the caudal stem; aD – antedorsal distance; pD – postdorsal distance; lca – caudal stem length; ID – length of the base of the dorsal fin; hD – the height of the dorsal fin; lA – length of the anal fin; hA – the height of the anal fin; IP – pectoral fin length; IV – length of the ventral fin; PV – pectoventral distance; and VA – ventroanal distance (Pravdin, 1966).

RESULTS AND ITS DISCUSSION

Nowadays, 2 species of mosquito fish are widespread in the Chirchik River basins; namely, *Gambusia affinis* and *Gambusia holbrooki*.

Taxonomic classification:

Class **Osteichthyes** - Bony fish

Subclass **Actinopterygii** Klein, 1885 - Ray-finned fish

Infraclass **Neopterygii** – New flies (modern ray-finned)

Division **Teleostei** Division - Bony fish

Subdivision **Euteleostei** - True bony fish

Superorder **Acanthopterygii** - Spiny feathers

Order **Cyprinodontiformes** – Carp - toothed

Suborder **Cyprinodontoidei** – Carp - toothed

Family **Poeciliidae** Swainson, 1839 - Peciliaceae

Genus **Gambusia** Poey, 1854 - mosquitoes.

1. *Gambusia holbrooki* Girard, 1859 – Holbrook (eastern) mosquito (alien species, acclimatized) (Mirzaev & Kuvatov, 2020; Froese & Pauly, 2020).

2. *Gambusia affinis* Baird and Girard, 1853 – common mosquito (alien species, acclimatized) (Mirabdullaev et al., 2002; Froese & Pauly, 2020).

These two species differ markedly in their morphometric and diagnostic characteristics. The division of species can be determined mainly by the presence or absence of small teeth on the first and second rays of the anal fin in males.

The meristic characteristics of the two species of the genus *Gambusia* from the Chirchik River are presented in Table (1).

The plastic characteristics of the two species of *Gambusia* from the Chirchik River are presented in Tables (2, 3, 4).

The coefficient of variation for plastic traits in male *Gambusia affinis* varied from 3.9% to 38.1% (4.0% on average), among which the traits of *po*, *VA*, *po/c* had high variability; the traits of *pD*, *hD*, *hA*, *lP*, *PV* had moderate variability, whereas the remaining traits had low variability. The coefficient of variation in male *Gambusia holbrooki* for plastic traits varied from 2.2% to 23.7% (average 5.2%). For the traits *lD*, *lV*, *VA*, they had high variability; the traits *hc*, *io*, *hc/c*, *io/c* had moderate variability, while the remaining traits had low variability. The coefficient of variation for female individuals varied from 2.9% to 17.1% (on average 10.6%). Among these, the traits *ao*, *o*, *po*, *lD*, *lA*, *ao/c*, *o/c*, *po/c* had moderate variability, and the remaining traits had low variability. In female individuals, high variability was not observed.

Males: *Gambusia affinis* and *Gambusia holbrooki* have 10-11 rays in the anal fins, of which the first and second are short, approximately 0.1-0.2 mm. In addition, the next third-fourth-fifth rays are elongated, divided into segments. These segments consist of radicle denticles (on gonopodium) that serve to fertilize females during reproduction, whereas the remaining five rays have the shape of the first and second ray. The main

difference between the species is manifested in the form of the third-fourth-fifth elongated rays in the anal canal and the presence or absence of teeth, as well as the variety in their shapes. L.S. Berg and others have summarized such information in the literature (Berg, 1949; Jiancao *et al.*, 2017).

The first long ray on the anal fin of *Gambusia affinis* is divided into segments, on which teeth are completely absent or poorly developed. The second long ray is divided into segments for almost half its length. In this case, the upper part is divided into toothless segments. Closer to the middle, the underdeveloped hook occurs; the lower second part has 5 or 6 well-developed denticles, outwardly similar to the roots of mammalian teeth, the 1-2-3 molars, and in some cases including the base, the first dentition can be four molars. Here, the base of the denticles is one segment, and the roots freely emerge in two rows. The second ray, closer to the end of the second half, forms a hook towards the third ray. The long third ray is divided into segments and does not form denticles, and the last segment, changing its shape, forms a hook facing the outside (Fig. 3).

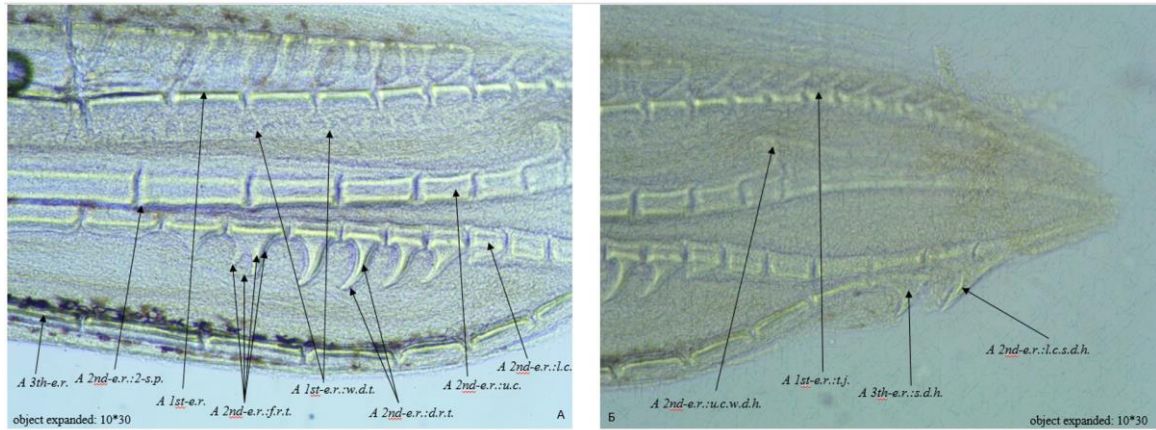
The first long ray on the anal fin of *Gambusia holbrooki* is divided into segments with well-developed denticles. The denticles, emerging from each segment, are directed to the second ray, two-row, and 1-2-3-4 molars and are also located freely. There are no such denticles on the last 13-14 segments of the ray. The second elongated ray, similar to that in *Gambusia affinis*, is divided into segments for almost half its length. In this case, the upper part is toothless and divided into segments, and closer to the middle, it displays an underdeveloped hook directed to the first ray. The lower second part has 5 or 6 well-developed teeth, externally similar to those in *Gambusia affinis*, that form two rows of 1-2-3-4 molars: the first and second denticles are well developed and 3-4 molars. In this case, the base of the teeth has one base and comes out in a free state. Closer to the end, the lower part of the second ray forms a hook directed towards the third ray. The long third ray is divided into segments and does not form denticles, and the terminal segment, changing its shape, forms a hook facing the outside (Fig. 4).



Fig. 1. Hydrological map of the Tashkent region of the Republic of Uzbekistan



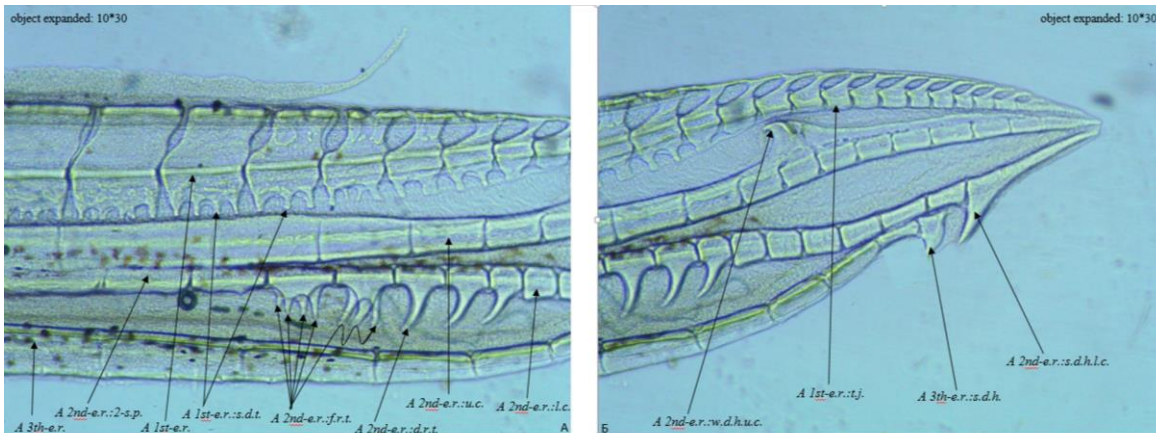
Fig. 2. The appearance of *Gambusia holbrooki* (in the photo: male on the left, female on the right) (photo by the author: A. Quvatov)



A: *A 1st-er.* - the first anal elongated ray, *A 1st-er.:w.d.t.* - weak developed teeth in the first elongated anal ray, *A 2nd-er.:2-s.p.* - the separated part of the second anal elongated ray, *A 2nd-er.:u.c.* - the upper contour of the second anal elongated ray, *A 2nd-er.:l.c.* - the lower contour of the second anal elongated ray, *A 2nd-er.:d.r.t.* - double-row teeth in the second anal elongated ray, *A 2nd-er.:f.r.t.* - four root teeth in the second lengthened anal ray, *A 3th-er.* - the third anal elongated ray.

B: *A 1st-er.:t.j.* - toothless joints on the first anal elongated ray, *A 2nd-er.:u.c.w.d.h.* - a weakly developed hook into the upper contour of the second elongated anal ray, *A 2nd-er.:l.c.s.d.h.* - a strong developed hook in the lower contour of the second anal lengthened ray, *A 3th-er.:s.d.h.* - strong developed hook in the third anal elongated ray.

Fig. 3 (A: B). Elongated anal-fin ray in *Gambusia affinis* (Photo by the author: A. Quvatov)



A: *A 1st-er.* - the first anal elongated ray, *A 1st-er.:s.d.t.* - strong developed teeth in the first elongated anal ray, *A 2nd-er.:2-s.p.* - the separated part of the second anal elongated ray, *A 2nd-er.:u.c.* - the upper contour of the second anal elongated ray, *A 2nd-er.:l.c.* - the lower contour of the second anal elongated ray, *A 2nd-er.:d.r.t.* - double-row teeth in the second anal elongated ray, *A 2nd-er.:f.r.t.* - four root teeth in the second lengthened anal ray, *A 3th-er.* - the third anal elongated ray.

B: *A 1st-er.:t.j.* - toothless joints in the first anal elongated ray, *A 2nd-er.:w.d.h.u.c.* - a weakly developed hook into the upper contour of the second elongated anal ray, *A 2nd-er.:s.d.h.l.c.* - a strong developed hook in the lower contour of the second elongated anal ray, *A 3th-er.:s.d.h.* - strong developed hook into the third anal elongated ray.

Fig. 4 (A: B). Elongated anal-fin ray in *Gambusia holbrooki* (Photo by the author: A. Quvatov)

Table 1. Meristic signs

Characteristics	<i>Gambusia holbrooki</i>		<i>Gambusia affinis</i>	
	Males $n = 15$	Females $n = 10$	Males $n = 10$	Females $n = 9$
<i>D</i>	II 6 (5)	II 6	II 5	II 5 (6)
<i>V</i>	I 5	I 5	I 5	I 5
<i>P</i>	III 8	III-IV 8	III 8	III-IV 8
<i>A</i>	11	11	10	11
<i>C</i>	22-23	22-23	23-24	23-24
Number of scales in the lateral line	31-32	31-33	32-33	31-32

Note: *D* – dorsal fin, *V* – abdominal fin, *P* – pectoral fin, *A* – anal fin, and *C* – caudal fin.

Table 2. Plastic characteristics of female *Gambusia holbrooki* from the Chirchik River ($n=15$)

Characteristics	Min-Max	M±m	σ	C_v , %
<i>l</i> , mm	30-46	38.6±1.1	4.1	10.6
In % of body length (<i>l</i>)				
<i>c</i>	23.1-26.3	24.5± 0.3	1.1	4.6
<i>ao</i>	6.5-10.0	7.9±0.2	0.9	11.8
<i>o</i>	5.0-8.1	6.4±0.3	1.1	17.1
<i>po</i>	8.1-13.2	10.4±0.3	1.3	12.7
<i>hc</i>	14.0-16.7	15.6±0.2	0.8	4.9
<i>io</i>	11.6-13.5	12.8±0.2	0.6	4.5
<i>H</i>	25.0-30.8	27.9±0.4	1.6	5.9
<i>h</i>	11.9-14.0	13.0±0.1	0.6	4.3
<i>aD</i>	57.9-65.2	61.9±0.5	1.8	2.9
<i>pD</i>	18.9-25.8	21.7±0.4	1.7	8.0
<i>lca</i>	30.4-36.8	34.4±0.5	1.8	5.2
<i>lD</i>	6.5-11.6	8.1±0.3	1.4	16.8
<i>hD</i>	14.3-17.9	15.9±0.2	0.8	5.2
<i>lA</i>	7.9-13.3	9.9±0.3	1.3	13.2
<i>hA</i>	17.4-22.6	18.9±0.4	1.4	7.4
<i>lP</i>	15.2-20.0	18.0±0.4	1.4	7.7
<i>lV</i>	10.5-16.2	12.8±0.3	1.2	9.5
<i>PV</i>	21.1-23.9	23.1±0.2	0.8	3.7
<i>VA</i>	12.5-167	14.2±0.4	1.4	9.8

In % of head length (c)				
<i>ao/c</i>	27.3-42.9	32.1±1.0	4.0	12.5
<i>o/c</i>	20.0-33.3	26.0±1.1	4.3	16.5
<i>po/c</i>	33.3-50.0	42.2±1.2	4.7	11.1
<i>hc/c</i>	54.5-71.4	63.7±1.2	4.6	7.2
<i>io/c</i>	45.5-57.1	52.3±1.9	3.4	6.6

Table 3. Plastic characteristics of male *Gambusia holbrooki* from the Chirchik River (*n*-10)

Characteristics	Min-Max	M±m	σ	Cv, %
<i>Sl, mm</i>	21-24	22.6±0.4	1.2	5.2
In % of body length (l)				
<i>C</i>	23.8-27.3	25.7±0.4	1.4	5.3
<i>Ao</i>	8.3-9.5	8.9±0.1	0.5	5.3
<i>O</i>	8.3-9.5	8.9±0.1	0.5	5.3
<i>Po</i>	8.3-9.5	8.9±0.1	0.5	5.3
<i>Hc</i>	12.5-17.4	14.6±0.6	1.9	12.9
<i>Io</i>	8.3-13.0	10.6±0.6	1.9	18.2
<i>H</i>	18.2-21.7	19.8±0.5	1.5	7.4
<i>H</i>	12.5-14.3	13.3±0.2	0.7	5.2
<i>aD</i>	56.5-60.9	58.4±0.4	1.3	2.2
<i>pD</i>	25.0-29.2	27.5±0.5	1.4	5.2
<i>Lca</i>	43.5-50.0	48.2±0.7	2.2	4.6
<i>lD</i>	8.3-14.3	10.7±0.8	2.5	23.7
<i>hD</i>	16.7-19.0	17.8±0.3	0.9	5.1
<i>lA</i>	8.3-9.5	8.9±0.1	0.5	5.3
<i>hA</i>	30.4-36.4	33.2±0.5	1.7	5.0
<i>lP</i>	20.8-23.8	22.2±0.4	1.2	5.3
<i>lV</i>	8.3-14.3	10.6±0.8	2.4	22.6
<i>PV</i>	12.5-14.3	13.3±0.2	0.7	5.2
<i>VA</i>	8.3-13.6	10.2±0.6	2.0	20.1
In % of head length (c)				
<i>ao/c</i>	33.3-41.1	34.6±0.9	2.8	8.2
<i>o/c</i>	33.3-49.8	34.6±0.9	2.8	8.2
<i>po/c</i>	33.3-49.9	34.6±0.9	2.8	8.2
<i>hc/c</i>	50.2-66.7	57.0±2.5	7.8	13.7
<i>io/c</i>	33.3-51.1	41.3±2.5	7.9	19.1

Table 4. Plastic characteristics of male *Gambusia affinis* from the Chirchik River (*n*-10)

Characteristics	Min-Max	M±m	σ	Cv, %
<i>Sl, mm</i>	21-23	22.1±0.3	0.9	4.0
In % of body length (<i>l</i>)				
<i>C</i>	21.7-28.6	25.8±0.8	2.4	9.2
<i>Ao</i>	8.7-9.5	9.1±0.1	0.4	3.9
<i>O</i>	8.7-9.5	9.1±0.1	0.4	3.9
<i>Po</i>	8.7-14.3	10.8±0.7	2.2	20.2
<i>Hc</i>	13.0-14.3	13.6±0.2	0.6	4.2
<i>Io</i>	13.0-14.3	13.6±0.2	0.6	4.2
<i>H</i>	18.2-23.8	22.2±0.5	1.7	7.5
<i>H</i>	13.0-14.3	13.6±0.2	0.6	4.2
<i>aD</i>	54.5-61.9	56.6±0.7	2.2	3.8
<i>pD</i>	21.7-34.8	26.3±1.3	4.0	15.4
<i>Lca</i>	39.1-47.6	42.6±1.1	3.4	7.9
<i>lD</i>	8.7-9.5	9.1±0.1	0.4	3.9
<i>hD</i>	17.4-23.8	19.5±0.9	2.8	14.1
<i>lA</i>	8.7-9.5	9.1±0.1	0.4	3.9
<i>hA</i>	21.7-36.4	30.7±1.5	4.8	15.7
<i>lP</i>	17.4-23.8	19.0±0.7	2.1	11.1
<i>lV</i>	8.7-9.5	9.1±0.1	0.4	3.9
<i>PV</i>	13.0-19.0	14.9±0.7	2.2	14.5
<i>VA</i>	4.3-9.5	5.9±0.7	2.2	38.1
In % of head length (<i>c</i>)				
<i>ao/c</i>	33.3-40.9	35.3±1.0	3.2	9.2
<i>o/c</i>	33.3-40.2	35.3±1.0	3.2	9.2
<i>po/c</i>	33.3-60.4	42.3±3.0	9.6	22.6
<i>hc/c</i>	50.0-60.3	53.0±1.5	4.8	9.1
<i>io/c</i>	50.0-60.4	53.0±1.5	4.8	9.1

Note: *M* represents the mean, *m* represents the error of the mean, σ represents the standard deviation, and *Cv* represents the coefficient of variation in %

CONCLUSION

The species *Gambusia affinis* and *Gambusia holbrooki* were recorded present in the ichthyofauna of the Chirchik River. In terms of meristic characteristics, the male *Gambusia affinis* differs from individual male *Gambusia holbrooki* by one smaller branching ray on the dorsal (*D*) fin and one smaller ray in the anal (*A*) fin, as well as one larger ray in the caudal (*C*) fin and one scale on the sideline. Among female individuals,

the species *Gambusia affinis* is partially distinguished by one ray that is larger in the caudal (C) fin and one smaller scale on the lateral line. Diagnostic and morphometric characteristics also confirm the differences between the species.

ACKNOWLEDGEMENTS

I express my sincere gratitude to the staff of the laboratories of Ichthyology and Hydrobiology and to a staff member at the laboratory at the Molecular Zoology Institute of Zoology (O.O. Amirov and E.E. Ikhromov) who helped me to develop the color photos.

REFERENCES

- Davey R.B. and Meisch M.V.** (1977). Dispersal of mosquitofish, *Gambusia affinis*, in Arkansas rice field. *Mosquito news* 37: 777-778.
- Jiancao G.; Xu Ouyang.; Bojian Chen.; Jonas Jourdan and Martin Plath.** (2017). Molecular and morphometric evidence for the widespread introduction of Western mosquitofish *Gambusia affinis* (Baird and Girard, 1853) into freshwaters of mainland China. DOI: <https://doi.org/10.3391/bir.2017.6.3.14>.
- Froese, R. and Pauly, D.** (Editors 2020). Fish base. World Wide Web electronic publication. www.fishbase.org version (12/2020). <https://www.fishbase.se/summary/Gambusia-holbrooki.html>.
- Froese, R. and Pauly, D.** (Editors 2020). Fish base. World Wide Web electronic publication. www.fishbase.org, version (12/2020). <https://www.fishbase.se/summary/Gambusia-affinis.html>.
- Mirzaev U.T. and Kuvatov A.K.** (2020). Annotated list of fish of the Chirchik River // Science of zoology of Uzbekistan: Current issues and development prospects. pp. 184-188.
- Reshetnikov A.N.** (2018). *Gambusia holbrooki* // the most dangerous invasive species in Russia (Top-100). <https://www.researchgate.net/publication/332496218>. 538 pp.
- Berg L.S.** (1949). Fish of fresh waters of the USSR and neighboring countries III // Publ: Academy of Sciences of the USSR. pp. 988-989.
- Lakin G.F.** (1990). Biometrics: A Textbook for Biol. specialist. Universities. 4 th ed. 352 pp.
- Lindberg G.U.** (1947). Larva-eating fish of Central Asia // Publishing house of the USSR Academy of Sciences. 52 pp.
- Mirabdullaev I.M.; Mirzaev U.T.; Kuzmetov A.R.; Kimsanov Z.O.** (2011). Fish identifier of Uzbekistan and neighboring regions. 80 pp.
- Mirabdullaev I.M.; Mirzaev U.T.; Khegay V.N.** (2002). Determinant of fish of Uzbekistan // Second edition revised and supplemented. pp. 72-73.
- Nuriev H.N.** (1985). Acclimatized fish of reservoirs of the Zeravshan River basin. pp. 59-63.
- Pravdin I.F.** (1966). Guide to the study of fish. 4th ed. Food industry. 376 pp.