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New insights into the monogenean fauna and host-parasite associations of cyprinoid fishes from the Karakaya Dam Lake on the Euphrates river, Türkiye: First records

Nuevas perspectivas sobre la fauna de monogéneo y las asociaciones hospedador-parásito en peces cyprinoid de la Presa Karakaya en el río Éufrates, Turquía: Primeros registros

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ABSTRACT

This is the first study on monogenean ectoparasites of five cyprinoid fish species *Cyprinus carpio, Carassius gibelio, Carassius auratus, Acanthobrama marmid* and *Chondrostoma regium* in the Karakaya Dam Lake, on the Euphrates river. Fish species were obtained from a commercial fisherman in the period from December 2024 to June 2025. Ten gill monogenean parasites belonging to three different genera (*Dactylogyrus, Gyrodactylus, Eudiplozoon*) were identified. These are *Dactylogyrus anchoratus, D. anoigeus D. achmerowi D. extensus, D. elegantis, D. sphyrna, D. vistulae, Eudiplozoon nipponicum, Gyrodactylus sprostonae* and *Gyrodactylus* sp. The percentage of occurrence, mean intensity and abundance values of the identified monogenean species in their hosts were calculated. The similarity of the monogenean parasite fauna of five cyprinoid fish species was compared. The most common monogenean species is *D. anchoratus*, which has been identified in *Carasius auratus, C. gibelio* and *C. carpio*. All the monogenean species were recorded for the first time in the Karakaya Dam Lake. *Dactylogyrus anoigeus* and *D. achmerowi* are new records for Turkish fish parasite fauna, while *E. nipponicum* for *A. marmid* and *C. gibelio, D. sphyrna* for *A. marmid* are a new parasite records. Furthermore, the *D. extensus* and *G. sprostonae* on *C. auratus* is reported for the first time in Türkiye.

Key words: Ectoparasites, cyprinoid fishes, *Dactylogyrus*, *Gyrodactylus*, *Eudiplozoon*

RESUMEN

Este es el primer estudio sobre ectoparásitos monogéneos en cinco especies de peces cyprinoid *Cyprinus carpio*, *Carassius gibelio*, *Carassius auratus*, *Acanthobrama marmid* y *Chondrostoma regium* en el Lago de la Presa Karakaya, en el río Éufrates. Los especímenes de peces fueron obtenidos de un pescador comercial en el período de diciembre de 2024 a junio de 2025. Se identificaron diez especies de monogéneos branquiales pertenecientes a tres géneros diferentes (*Dactylogyrus*, *Gyrodactylus*, *Eudiplozoon*). que fueron *Dactylogyrus anchoratus*, *D. anoigeus*, *D. achmerowi*, *D. extensus*, *D. elegantis*, *D. sphyrna*, *D. vistulae*, *Eudiplozoon nipponicum*, *Gyrodactylus sprostonae* y *Gyrodactylus* sp. Se calcularon el porcentaje de ocurrencia, la intensidad media y la abundancia de las especies de monogeneos identificadas en sus hospedadores. Se comparó la similitud de la fauna de parásitos monogéneos entre las cinco especies de peces ciprinoides. La especie de monogéneos más común fue *D. anchoratus*, identificada en *Carassius auratus*, *C. gibelio* y *C. carpio*. Todas las especies de monogéneos fueron registradas por primera vez en el Lago de la Presa Karakaya. *Dactylogyrus anoigeus* y *D. achmerowi* constituyen nuevos registros para la fauna parasitaria de peces en Turquía, mientras que *E. nipponicum* en *A. marmid* y *C. gibelio*, y *D. sphyrna* en *A. marmid* representan nuevos registros parasitarios. Además, la presencia de *D. extensus* y *G. sprostonae* en *C. auratus* se reporta por primera vez en Turquía.

Palabras clave: Ectoparásitos, peces cyprinoid, *Dactylogyrus*, *Gyrodactylus*, *Eudiplozoon*

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INTRODUCTION

Monogenean parasites are the most extensive, with more than 7,000 identified species found worldwide. They primarily parasitize fish but occasionally infect aquatic invertebrates, amphibians, reptiles and even a single mammalian species (the hippopotamus). Many these species present a serious risk to fish hosts, especially in aquaculture settings [1, 2].

Their presence has been shown to negatively affect fish health by reducing growth rates, increasing susceptibility to disease, and raising mortality, thereby causing economic damage [3, 4].

This group of parasites has high host specificity and is widely used as model organisms in the study of host-parasite coevolution, particularly for disentangling geographic and phylogenetic patterns of parasite diversification [5, 6].

These parasites, which have a direct life cycle, transmit to various hosts through the release of eggs and free-swimming infectious larvae, by encountering detached drifting parasites, or through interactions between live fish and infected dead fish [7].

The spread of monogenean parasites from one region to another can occur naturally through fish migration, as well as indirectly through human-influenced factors such as global fish trade [8].

Cypriniformes, known for their broad geographic range, represent the freshwater fish group with the highest species diversity and extensive research has been conducted on their parasites. Monogeneans are the most commonly known parasites. The health and diversity of Cypriniformes populations, which are widespread in freshwater ecosystems and inhabit lakes, rivers, and dam reservoirs, as well as their parasite communities, are greatly influenced by the dynamic and often fragile nature of freshwater habitats [9, 10].

Freshwater sources such as lakes and dam reservoirs are not stable systems and are significantly affected not only by ecological changes like climate change but also by pollution from agricultural and domestic waste [11, 12].

Monogenean parasites found on fish living in these lakes provide important information about water quality and ecosystem balance. Numerous studies have shown that especially when water quality deteriorates, there is a decrease in the abundance and species diversity of monogeneans [13].

To date, there have been many studies on monogenean parasites of Cyprinoid fish in several localities in Türkiye [1, 14, 15, 16, 17, 18, 19]. On the other hand, no specific investigations have been conducted regarding monogenean parasite fauna in the Karakaya Dam Lake in Türkiye. A few studies in the Karakaya Dam Lake have predominantly focused on endo helminths [20, 21, 22]. The aim of this research study is to identify the monogenean parasite species present in five cyprinoid fish species collected from the Karakaya Dam Lake, at this peculiar part of Türkiye.

MATERIALS AND METHODS

Fish specimens were collected from the Karakaya Dam Lake (38°26' N–38°37' E) situated on the Euphrates River (FIG. 1). This river that defines the boundaries of Mesopotamia, originating in Türkiye and flowing into the Persian Gulf, is one of the most significant rivers in the Middle East, both ecologically and economically. Karakaya Dam Lake, situated on this river, serves as a crucial freshwater resource for the region. Despite the ecological importance of this aquatic system, limited research has been conducted on parasites in its ichthyofauna. Fish samples were collected in the period from December 2024 to June 2025 in the Boran and Hasircilar regions of the Karakaya Dam Lake, where domestic and industrial waste concentration is higher (FIG. 1).

FIGURE 1. Map of the Karakaya Dam Lake from which the fish specimens examined in the study were obtained

A total of 48 *Acanthobrama marmid*, 19 *Cyprinus carpio*, 16 *Carassius gibelio*, 13 *Chondrostoma regium*, and 5 *Carassius auratus* specimens were obtained from a commercial fisherman and transported to Malatya Turgut Özal University Aquaculture Department Laboratory in an ice-filled box. Total length (Ichthyometer) and weight (OHAUS SPX223, Compact Bench Scale, USA) of each fish were accurately measured to the nearest 0.1 cm and 0.1 g, respectively.

To detect monogenean parasites, the gills of the fish were removed, and slide preparations were made, and parasites were identified and counted by screening whole smears of the gills examined under a trinocular light microscope (Olympus, CX31, Japan). Parasite microphotographs were taken using Olympus BX53F digital camera. Counted monogenean parasites fixed with 70% ethaol for re-examination at a later time.

Species identification for was performed based on the morphological characteristics of the sclerotized attachment structures, the arrangement of clamps, haptor and copulatory organs. The taxonomic classification and identification of the parasites observed were done on the basis of some research [15, 21, 22, 23, 24, 25]. The percentage of occurrence (%) indicates how frequently a given parasite species is observed among the examined hosts. Mean intensity, and abundance were calculated following Bush *et al.* [26]. Mean intensity was defined as the average number of parasites per infected host, whereas abundance was calculated as the average number of parasites per examined host, regardless of infection status.

Statistical analysis

Kruskal-Wallis test (Non-parametric ANOVA) was applied to determine significant differences in the mean intensity values of identified monogenean parasites in five cyprinoid fishes. The significance of the host-parasite relationship was conducted according to the abundance (A) index by presented in Zander *et al.* [27]. The scales used for species were A > 2 for core species, A = 0.6–2 for secondary species, A = 0.2 – 0.6 for satellite species, and A < 0.2 for rare species. The Czekanowski-Sørensen Index (ICS, %) was used to compare the monogenea faunas of five Cypriniformes.

RESULTS AND DISCUSSION

In the present study, the total length and body weight ranges of the fish species examined in the present study varied among species. Total length ranged from 21.8 to 30.1 cm and body weight from 110.22 to 363 g in *A. marmid*; from 33.5 to 45.5 cm and 547 to 1284 g in *C. carpio*; from 19.3 to 33.4 cm and 130 to 634 g in *C. gibelio*; from 29.8 to 39.0 cm and 262 to 460 g in *C. regium*; and from 24.5 to 31.0 cm and 184 to 268 g in *C. auratus.* Total of 10 monogenean parasite species including *Dactylogyrus anchoratus, D. anoigeus, D. achmerowi, D. extensus, D. elegantis, D. sphyrna, D. vistulae, Eudiplozoon nipponicum, Gyrodactylus sprostonae* and *Gyrodactylus* sp. were determined in five cyprinoid fish (TABLE I and FIGS. 2, 3, and 4). It was determined that the highest monogenean species diversity was observed in *C. carpio* with five species, while the lowest diversity was found in *C. regium* and *C. auratus*, each infected with only two species (TABLES I and II). The identified monogenean parasite species, along with their percentage of occurrence (%), mean intensity (MI), number of infected hosts, abundance (A), and the minimum and maximum parasite counts per host, are summarized in TABLE II.

TABLE I
List of monogenean species found in five cyprinoid fishes in the Karakaya Dam Lake

Host Family	Fish species	Parasite Species
Cyprinidae	*Cyprinus carpio*	*Dactylogyrus achmerowi* Gusev, 1955
		Dactylogyrus anchoratus (Dujardin, 1845)
		Dactylogyrus extensus Mueller & Van Cleave, 1932
		Eudiplozoon nipponicum (Goto, 1891)
		Gyrodactylus sp.
	Carassius gibelio	*Dactylogyrus anchoratus* (Dujardin, 1845)
		Dactylogyrus extensus Mueller & Van Cleave, 1932
		Gyrodactylus sprostonae Ling, 1962
		Eudiplozoon nipponicum (Goto, 1891)
	Carassius auratus	*Dactylogyrus anchoratus* (Dujardin, 1845)
		Gyrodactylus sprostonae Ling, 1962
Leuciscidae	*Acanthobrama marmid*	*Dactylogyrus anoigeus* Řehulková, 2024
		Dactylogyrus sphyrna Linstow, 1878
		Eudiplozoon nipponicum (Goto, 1891)
	Chondrostoma regium	*Dactylogyrus elegantis* Gusev, 1966
		Dactylogyrus vistulae Prost, 1957

The levels of monogenean infection in the cyprinoid fishes were evaluated, ranging from 20% to 100%, MI was determined to be between 5.90 and 56.95, and mean A was between 2.20 and 56.95. The highest percentage of occurrence and MI values (100% and 56.95) were found in *C. carpio*. The lowest mean percentage of occurrence and MI values were found in *C. auratus* (20%) and *C. regium* (5.90) respectively (TABLE II).

TABLE II
Overall infection percentage of occurrence (%), mean intensity, and abundance values of monogenean parasite species detected in cyprinoid fishes in the present study

Fish species	$N_{parasites}$	N_{in}/N_{ex}	Occu (%)	MI ± SE	A	Min-Max
Cyprinus carpio	5	19/19	100.00	56.95 ± 7.20[a]	56.95	1 – 314
Carassius gibelio	4	10/16	62.50	26.60 ± 9.27[ab]	16.62	1 – 88
Carassius auratus	2	1/5	20.00	11.00 ± 0.00[ab]	2.20	1 – 11
Acanthobrama marmid	3	31/48	64.58	6.61 ± 1.21[b]	4.27	1 – 28
Chondrostoma regium	2	10/13	76.92	5.90 ± 0.98[ab]	4.53	1 – 13

N_{in}: Number of infected specimens, N_{ex}: Number of specimens examined, Occu: Percentage of occurrence, MI: Mean intensity, SE: Standard error, A: Abundance

The overall MI values of monogenean parasite species varied significantly among the five fish species ($P<0.05$). The percentage of occurrence (%), MI and A values of each monogenean parasite species detected in this study in their respective hosts, along with category indicators depending on abundance status, are presented in TABLE III. In the present study, seven *Dactylogyrus*, two *Gyrodactylus* and one diplozoid species were identified (TABLE III, FIGS. 2, 3, and 4).

While some monogenean parasite species were observed in more than one cyprinoid fish, some species were recorded in only one cyprinoid fish species. The most common monogenean species were *D. anchoratus* and *E. nipponicum*, which infect three cyprinoid fish, while *D. extensus* and *G. sprostonae* were found to be infect two fish species. *D. achmerowi* was recorded only in *C. carpio, D. elegantis* and *D. vistulae* were found only in *C. regium*, and *D. anoigeus* and *D. sphyrna* were observed only in *A. marmid* (TABLE III).

The highest percentage of occurrence values were observed in *D. achmerowi* (94.74%) and *D. extensus* (84.21%) detected in *C. carpio*, while the lowest value was observed in *E. nipponicum* (2.08%) detected in *A. marmid*. The highest MI value was obtained in *Gyrodactylus* sp. (86.33) infecting *C. carpio*, while the lowest value was observed in *E. nipponicum* (1.00) infecting *A. marmid* (TABLE III).

Dactylogyrus anoigeus, D. achmerowi, D. extensus, D. sprostonae D. vistulae and *Gyrodactylus* sp. were observed as core species, while *D. sphyrna* was observed as satellite species. *D. anchoratus* played the role of core and rare parasite depending on the host species. *E. nipponicum* played the rol of secondary in *C. carpio*, but rare in *C. gibelio* and *A. marmid* (TABLE III).

TABLE III
Infection values of monogenean parasite species detected in cyprinoid fishes in the Karakaya Dam Lake

Monogenean species	Host	N_{in}/N_{ex}	Occu (%)	MI ± SE	A	Category
Dactylogyrus anchoratus	*Carassius gibelio*	7/16	43.75	7.14 ± 3.78	3.12	core
	Carassius auratus	2/5	40.00	5.50 ± 4.50	2.20	core
	Cyprinus carpio	1/19	5.26	1.00 ± 0.00	0.05	rare
Dactylogyrus extensus	*Cyprinus carpio*	16/19	84.21	22.00 ± 5.51	18.53	core
	Carassius gibelio	7/16	6.25	78.00 ± 0.00	4.87	core
Dactylogyrus anoigeus	*Acanthobrama marmid*	26/48	54.17	6.96 ± 1.32	3.77	core
Dactylogyrus sphyrna	*Acanthobrama marmid*	16/48	33.33	1.43 ± 0.18	0.48	satellite
Dactylogyrus achmerowi	*Cyprinus carpio*	18/19	94.74	25.00 ± 7.91	23.68	core
Dactylogyrus elegantis	*Chondrostoma regium*	6/13	46.16	2.83 ± 0.60	1.31	secondary
Dactylogyrus vistulae	*Chondrostoma regium*	9/13	69.23	4.67 ± 0.81	3.23	core
Gyrodactylus sprostonae	*Carassius gibelio*	7/16	43.75	19.57 ± 7.01	8.56	core
	Carassius auratus	1/5	20.00	11.00 ± 0.00	2.20	core
Gyrodactylus sp.	*Cyprinus carpio*	3/19	15.79	86.33 ± 84.33	13.63	core
Eudiplozoon nipponicum	*Cyprinus carpio*	6/19	31.57	3.33 ± 0.95	1.05	secondary
	Carassius gibelio	1/16	6.25	6.25 ± 1.00	0.06	rare
	Acanthobrama marmid	2/48	2.08	1.00 ± 0.00	0.02	rare

N_{in}: Number of infected specimens, N_{ex}: Number of specimens examined, Occu: Percentage of occurrence, MI: Mean intensity, SE: Standard error, A: Abundance

The monogenean parasite faunas of the five cyprinoid fishes examined in this study differed from each other. The monogenean parasite fauna of *C. gibelio* was observed to be closely similar to the faunas of both species, *C. carpio* and *C. auratus* (ICS = 66.67%). No similarity was detected between *C. regium* and the other 4 cyprinoid fish species, and both between *C. auratus* and *A. marmid* and *C. auratus* and *C. regium* (TABLE IV).

The study is the first to report on the monogenean parasite fauna of five cyprinoid fish in the Karakaya Dam Lake. A total of 10 gill monogenean parasites belonging to the genera *Dactylogyrus* (7), *Gyrodactylus* (2), and *Eudiplozoon* (1), were identified in the study. *Dactylogyrus* is known as one of the largest genera of parasitic helminths, 95% of which are gill parasites in fish of the family Cyprinidae. In general, most species of the genus *Dactylogyrus* are strictly host-specific, or limited to one or more closely related hosts [22]. *D. anchoratus* [28], *D. extensus* [15, 29, 30, 31, 32], *D. minitus* [14, 28, 33, 34, 35], *D. vastator* and *D. elegantis* are known as species-specific for *C. carpio*. Although these monogenean species (except *D. elegantis*) have been also reported as hosts of *C. gibelio* [16, 29, 36, 37, 38] none have been reported in *A. marmid*.

TABLE IV
Czekanowski-Sorensen Index (%) in monogenean fauna of five cyprinoid fish in the study

	C. carpio	*C. gibelio*	*C. auratus*	*A. marmid*	*C. regium*
C. carpio	100				
C. gibelio	66.67	100			
C. auratus	28.57	66.67	100		
A. marmid	25.00	28.57	0.00	100	
C. regium	0.00	0.00	0.00	0.00	100

Cyprinus carpio, Carassius gibelio, Acanthobrama marmid, Chondrostoma regium, Carassius auratus

D. sphyrna has been frequently reported in many cyprinoid fish species, particularly members of the Leuciscidae [14, 15, 16, 33]. However, the existence of this monogenean in *A. marmid* has not been previously reported. Thus, *A. marmid* is also added to the list of hosts of *D. sphryna* with this study.

Gyrodactylus sprostonae is a relatively little known species. This species originally described from *C. auratus* and *C. carpio*, it has only been reported in *C. gibelio* in Türkiye [39]. This study reports the presence of *G. sprostonae* on *C. auratus* in Türkiye for the first time.

Eudiplozoon nipponicum is a monoxenous blood-feeding ectoparasite that lives on the gills of *C. carpio*. The species presence in *C. carpio* is first reported by Kircalar *et al*. [40] in Türkiye, has not been reported previously in *C. gibelio* and *A. marmid*.

So far, according to previous studies, two of the listed species, *D. anchoratus* [29, 41] and *Gyrodactylus katharineri* [29, 41] have been reported in presence in *C. auratus* different from localities of Türkiye.

The number of studies on monogenean parasites of members of the Leuciscidae family living in Turkish waters is limited [14, 42, 43, 44, 45].

Monogenean parasites of cyprinoid fish exhibit a high degree of host specificity, leading to most fish species being infected by one or more specific parasites [7]. When the specificity of the

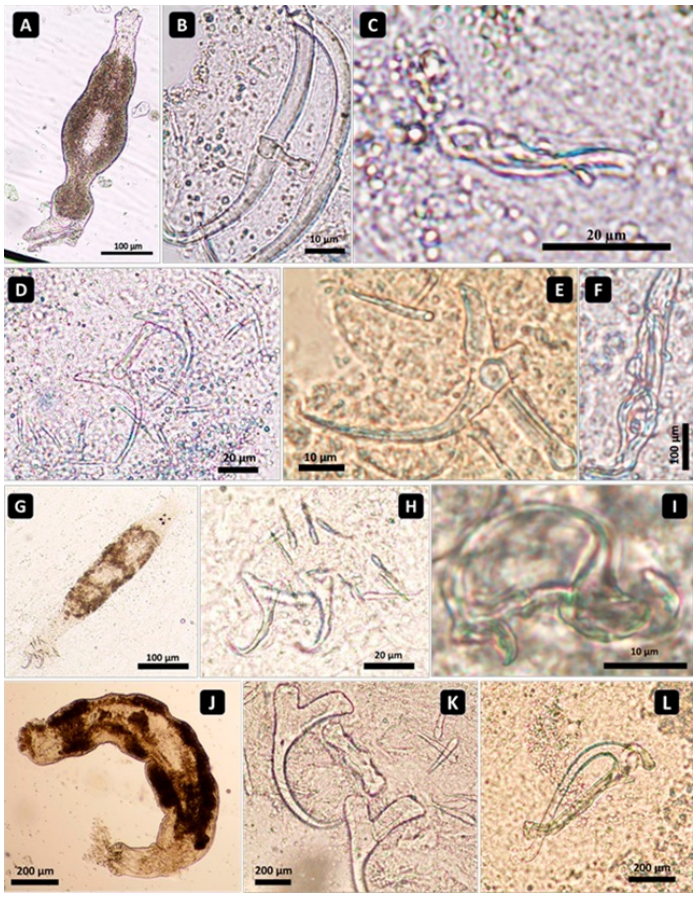

FIGURE 2. Photomicrographs of *Dactylogyrus anchoratus, Dactylogyrus achmerowi, Dactylogyrus anoigenus* and *Dactylogyrus extensus*. A: *D. anchoratus* specimen total view, B: Haptor of *D. anchoratus*, C: Copulatory organ of *D. anchoratus.* D: Haptor of *D. achmerowi,* E: Dorsal bar and median hook of *D. achmerowi*, F: Copulatory organ of *D. achmerowi*, G. *D. anoigenus* specimen total view, H: Haptor of *D. anoigenus*, I. Copulatory organ of *D. anoigenus*, J: *D. extensus* specimen total view, K. Haptor (dorsal bar and median hooks) of *D. extensus*, L: Copulatory organ of *D. extensus*

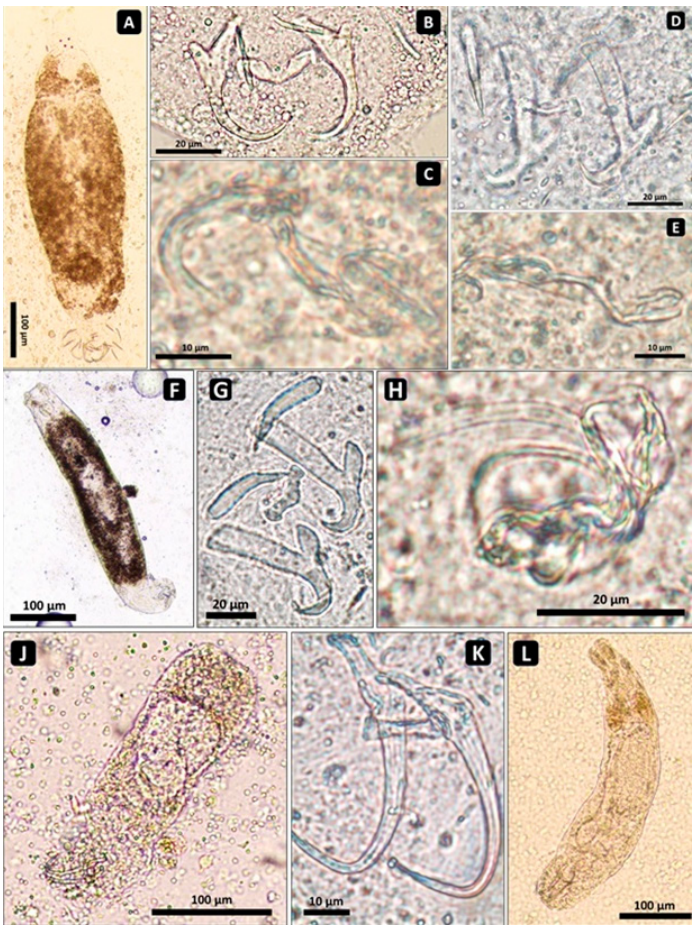

FIGURE 3. Photomicrographs of *Dactylogyrus elegantis, Dactylogyrus vistulae, Dactylogyrus sphyrna, Gyrodactylus sprostonae* and *Gyrodactylus* sp. A: *D. elegantis* specimen total view, B: Haptor of *D. elegantis*, C. Copulatory organ of *D. elegantis*. D: Haptor of *D. vistulae*, E. Copulatory organ of *D. vistulae*, F: *D. sphyrna* specimen total view, G. Haptor of *D. sphyrna*, H: Copulatory organ of *D. sphyrna*, J: *G. sprostonae* specimen total view, K. Dorsal bar and median hooks of *G. sprostonae*, L. *Gyrodactylus* sp. specimen total view

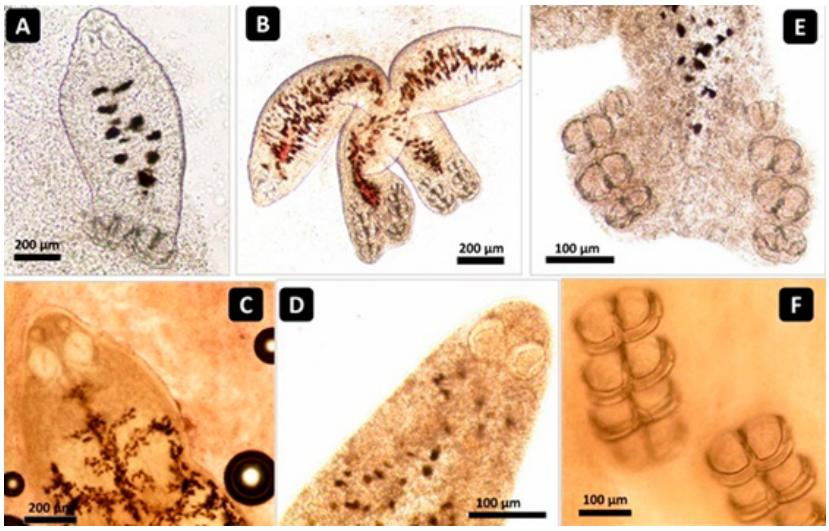

FIGURE 4. Photomicrographs of *Eudiplozoon nipponicum*. A: diporpa larval stadium, B: general view of *E. nipponicum*, C-D. anterior end of body, E-F. clamps

monogenean parasites identified in the cyprinoid fish species examined in this study was evaluated, it can be said that *G. elegantis* and *D. vistulae* parasites only infect *C. regium*, while *G. sprostonae* infects *C. auratus* and *C. gibelio*. Additionally, *D. achmerowi* was detected only in *C. carpio*, and *D. sphryna* and *D. anoigeus* were detected only in *A. marmid*.

So far, 24 nominal monogenean species have been reported in these five Cyprinoid fishes in the Turkish freshwaters according to data of various authors. Considering the number of monogenea species reported in the five cyprinoid fishes, it is noteworthy that the species diversity in *C. carpio* (12 species) is higher than from the other four cyprinoid fish. So far, *D. achmerowi* and *D. anoigeus* has not been previously recorded in cyprinoid fishes from Türkiye. It is remarkable that these monogenean parasites are reported for the first time in cyprinoid fish in the present investigation. With this study, the number of monogenean parasite species in the Turkish parasitic fauna for the species *Cyprinus carpio, Carassius gibelio, Carassius auratus, Acanthobrama marmid*, and *Chondrostoma regium* increased to 26 with the addition of *D. achmerowi* and *D. anoigeus*. When the other studies on the monogenean species detected in this study are considered, *D. anchoratus* and *D. extensus* were reported more frequently compared to the other monogenean species.

CONCLUSIONS

In conclusion, the study determined 10 monogenean gills parasite species present in 5 cyprinoid fish from the Karakaya Dam Lake. These monogenean parasites are new records for the Karakaya Dam Lake, and *Dactylogyrus achmerowi* and *Dactylogyrus anoigeus* are also new records for Türkiye. *Acanthobrama marmid* is a new host record for *D. sphyrna*. It was determined that the monogenean parasite faunas of *C. carpio* and *C. gibelio* were similar to each other (66.67%), but the monogenean parasite fauna of *A. regium* was quite different from the monogenean fauna of the other four species studied. The fact that no prior studies on monogenean parasites have been conducted in the region, and that species diversity is being reported for the first time through this study, underscores the scientific significance and contribution of the present research to existing literature. Findings in this study indicate that the region harbors a rich diversity of monogenean species. The findings of this study will provide an important foundation for future research aimed at a more comprehensive understanding of monogenean diversity, addressing current knowledge gaps, the evolutionary dynamics of host-parasite interactions, and the identification of biogeographic patterns.

Conflicts of interest

The author(s) declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

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