ZANCO Journal of Pure and Applied Sciences

TYPE Original article
DOI http://dx.doi.org/10.21271/ZJPAS.37.6.6

OPEN ACCESS

*Corresponding author
Safeen Othman Sediq
Hussein Hasan Mala
safeen.sediq@su.edu.krd
hussein.mala@su.edu.krd

RECEIVED :10 /05 /2025
ACCEPTED :31/07/ 2025
PUBLISHED :31/ 12/ 2025

KEYWORDS:
Argulus foliaceus,
C. carpio,
Seasonal Fluctuation,
Taq Taq District, Iraq.

Impact of changes in water quality on the infestation of the common carp *Cyprinus carpio* with fish lice *Argulus foliaceus* in aquaculture in Erbil province, Iraq

Safeen Othman Sediq, Hussein Hasan Mala, Shamall Muhammad Amin

Department of Fish Health and Production, College of Agriculture Engineering Science, Salahaddin University-Erbil, Erbil, Kurdistan Region, Iraq

ABSTRACT

The present study investigates that seasonal distribution and intensity of infestation of *Argulus foliaceus* in common carp (*Cyprinus carpio*) in Taq Taq, Kurdistan Region, Iraq, in relation to ecological factors such as temperature, pH, electrical conductivity (EC), and salinity. A total of 90 fish were taken throughout 2024, and parasitological examinations were conducted to assess infestation rates. The results revealed a clear seasonality, with the highest infestation rates (0.667) in summer and early autumn (June–September) when water temperature rise (8.3–19.2°C) and pH levels were slightly alkaline (pH 8–9). Infestation was lowest in winter (December–February), this was due to the reduced temperatures (3.4–5.3°C), which was not favorable to parasite metabolism and reproduction. Statistical analysis revealed that there was a high correlation ($p < 0.01$) between intensity of parasite infestation and water temperature. This study indicates the impact of ecology on *A. foliaceus* distribution and also the potential economic threat it poses to aquaculture. Proper environmental management, regular monitoring, and targeted interventions are essential to mitigate infestations and safeguard fish health in aquaculture settings.

1. Introduction

Fish recognized as an excellent food source for humans and preferred as the perfect diet because of their higher proportions of unsaturated fatty content. Thus, this makes fish the source of basic income for millions of people worldwide (Obaid *et al*., 2021). Aquatic environmental conditions change naturally throughout the year, affecting life cycles of hosts as well as parasites. In particular, water temperature is positively affecting the development of many parasites, increasing the risk of infection and diseases during summer season. Inter-annual temperature fluctuations are likely to alter host–parasite interactions, which may result in profound impacts on sensitive ecosystems (Schade *et al*., 2016). Fish lice (*Crustacea: Argulidae*) is a significant group of ectoparasites that infect various fish and amphibian's species (Wafer et al., 2015); (Poly, 2008). These parasites are harmful to fish breeding and the major constraint to fish cultivation (Khodadadi *et al*., 2013).

Fish lice induce instability, body pigmentation, deformity, weight loss and decrease fish growth (Mirzaei and Khovand, 2015; Shinn *et al.*, 2015). Argulus is a significant fish ectoparasite that can inflict serious economic loss due to disease outbreaks and therefore is a major problem for global aquaculture. Disease intensity and prevalence influenced by host-parasite-environmental interactions, specifically temperature. Among the significant impacts of thermal alteration regimes are the change in the spatiotemporal structure of Argulus in response to their fast life-history traits. As a result of faster in progressing their life cycle, farmed fish will become more susceptible to other infectious and hence this increases the mortality rate. Moreover, these climatic changes are bound to influence the physiology, immune system, behavior, and parasite avoidance of fish, which can lead to ecosystem-level changes (Brahmchari *et al*., 2023). Foliaceus females release approximately 250–300 eggs into substrates like water plants or rocks when water temperature rises above10 °C. Eggs were hatch in 15–55 days, and the parasitic larvae need to locate a host within three days to survive.

Temperature-dependent reproduction influences parasite population dynamics (Haridevamuthu *et al.,* 2024). This study highlights the investigation of seasonal patterns of distribution and infestation intensity of *A. foliaceus* relative to certain ecological factors, including water temperature, pH, EC and salinity.

2. Materials and Methods

2.1. Study Location

The study was conducted in Taq Taq is a district located within the Koysinjaq District of Erbil Governorate, Kurdistan Region-Iraq (Fig. 1). Geographically, it is situated at approximately 35.8857°N latitude and 44.5932°E longitude. The sampling was done during the period started from January to December 2024.

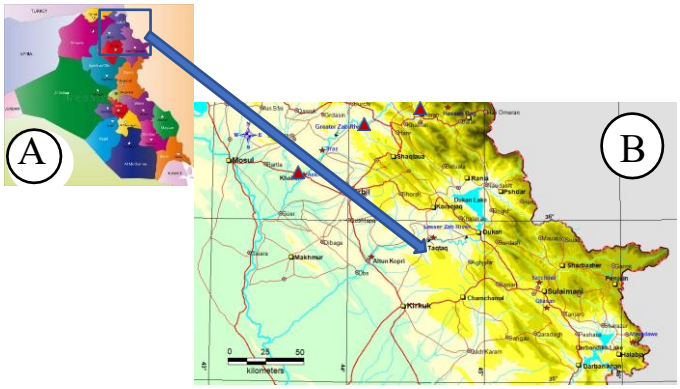

Figure 1: A- Iraq Map. **B-** Showing study site and sampling stations. Designed with MapInfo Professional. Version 19.0. Des. 07, 2024.

2.2. Fish Sampling

Fish samples were taken monthly during the study period, a total of 90 fish collected during the year. Fish were captured using fish nets. The specimens were transported to the laboratory in aerated containers to minimize stress and maintain physiological conditions.

2.3. Parasitological Examination

Fish was carefully examined for the presence of *A. foliaceus* infestation. External body surfaces, including fins, gills, and skin, were thoroughly inspected. The intensity of infestation was recorded as the number of parasites per fish (Öztürk, 2022). The seasonal distribution of infestation was classified according to the number of parasites observed during each season (spring,

summer, autumn, and winter).

2.4. Chemical characteristics of the aquatic environment

Aquatic parameters were monitored throughout the study period to determine their relationship with parasite infestation. These parameters were measured at each sampling site, and data were recorded monthly as follows:

- Temperature: Water temperature was measured using a thermometer in degrees Celsius at each sampling site.
- pH: pH levels were recorded using a pH meter.
- Electrical Conductivity (EC): EC was measured using a conductivity meter to assess the water's ion content.
- Salinity: Salinity was determined using a refractometer and expressed in practical salinity units (PSU).

5.2. Data Analysis

Data were analyzed using descriptive statistics to summarize the seasonal variation in A. foliaceus infestation intensity. The correlation between water parameters (temperature, pH, EC, and salinity) and infestation intensity was assessed using (Duncan Multiple Test and Statistical analysis system SAS) to determine significant relationships. The significance level was set at $p < 0.01$ for all analyses.

3. Result and discussion

The result indicates (Table 1) indicate that a clear seasonal pattern in infestation intensity, with significant variations across different months of *A. foliaceus* in (*C. carpio*)**,** recorded monthly over a one-year period. It includes the proportion of infected fish was 38 and the number of parasites collected each month.

Month (Year)	Fish infected	Parasite collected
January	0.000 d	0.000 d
February	0.333 abc	0.166 cd
March	0.375 abc	0.375 bcd
April	0.555 abc	0.444 abcd
May	0.428 abc	0.571 abc
June	0.555 abc	0.777 ab
July	0.545 abc	0.818 ab
August	0.416 abc	0.833 ab
September	0.667 a	0.888 a
October	0.571 ab	0.714 ab
November	0.375 abc	0.250 cd
December	0.100 bc	0.100 d
P. value	1.37 NS 0.203	4.83 ** 0.01

Table 1: Monthly fluctuations of the infection of *A. foliaceus* from Taq Taq province

3.1. Seasonal Variation in Infestation Rates

The lowest infestation rates were observed in January, where the fish were not affected and the parasite were not observed. During December only 5 were infected from 50 fish (10%) were infected with *A. foliaceus*, and the parasite numbers were minimal (0.100 per fish). This may be due to that *A. foliaceus* is less active in winter, which may negatively impact its reproductive cycle and overall survival. Fish have stronger immune responses at lower temperatures, which makes it harder for parasites to settle on them (Islam *et al*., 2022). During early spring (March-April), the infection intensity increases with increasing water temperature and reached 0.375 in March and 0.555 in April. The parasites collected also began to rise stepwise during the

period. It indicates that the favorability of environmental conditions also increases amount of *A. foliaceus* resumes active reproduction and host attachment, leading to a rising infestation rate

Maximum infection was record during the Summer and Autumn seasons of the year (June–September). During the months of June and July, infection rate was 0.555 and 0.545 and the rate of parasite collected was 0.777 and 0.818. In September, infection rate was highest (0.667) and maximum parasites collection was 0.888. This shows that *A. foliaceus* reproduces and transmits best in warmer months, perhaps due to increased metabolic activity, increased egg hatching rates, and increased host populations. Increasing the infestation rate during these months might also result from increased stocking densities of fish and reduced water quality. So, this lead to facilitate the spread of parasite among the fish. Following its peak in September, the infestation rate exhibited a gradual decline in October (0.571) and further decreased in November (0.375).

In December, the numbers declined significantly again. The observed decline corresponds with decreasing temperatures during autumn and winter, which likely contribute to reduced reproductive activity and increased natural mortality within the parasite population.

Principal component analysis illustrates that water temperature is positively correlated with *A. foliaceus* distribution. These parasites occurred more in summer and autumn seasons when suspended matter and water temperature provide the highest values. Temperature is a key environmental factor that affects the parasite as well as the host. Statistical analysis proved that parasite distribution is related to season and fish size (Sara *et al*., 2016).

Table (2) indicate that the seasonal variations in water pH and temperature, the water pH readings were 7,8,8,9 in Winter 2023-2024, Spring 2024, Summer 2024, Autumn 2024 respectively. Minimum water temperature values were recorded 3.4, 5.3, 8.3, 5.1 during Winter 2023-2024, Spring 2024, Summer 2024 and Autumn 2024 respectively, while maximum water temperature values were recorded 5.3, 8.9, 19.2, 9.2 during Winter 2023-2024, Spring 2024, Summer 2024, Autumn 2024 respectively. Which are contributing factors in controlling the infestation intensity of *A. foliaceus* in Common carp. The data suggest significant fluctuations in temperature and pH levels throughout the year, which influence the parasite's life cycle, reproductive processes, and overall activity.
Many recent studies confirm that increased water temperature support growth and reproduction of Argulus species among freshwater fishes, particularly common carp (*C. carpio*). Sahoo *et al*., 2013 found that 28°C is the optimum temperature for Argulus sp. egg hatching, with the highest hatching rate in 15 days. Similarly, (Brazenor *et al*. 2020) found that improved reproductive performance and shorter life cycles of *Argulus foliaceus* are enhanced by warm temperatures, thereby resulting in increased parasite loads in aquaculture systems. *Argulus foliaceus* prevalence was greater during the summer season in the Kunduzlar Dam Lake, Turkey, suggesting that elevated temperatures are favorable for parasitic outbreaks (Öztürk, 2022). A study conducted in Indonesia by Bahtiar et al. (2024) reported acute *Argulus japonicus* infection in carp at a water temperature of 28°C, thereby supporting the role of elevated temperatures in facilitating increased infection rates. These findings underpin the assumption that high temperature is a key environmental parameter facilitating Argulus outbreaks during summer or in poorly controlled fish farms.

Beside the water temperature, pH is also critical in the interaction between fish and parasites. Deviations from the optimal pH range of 6.5 to 8.5 have been shown to not only induce stress in *Cyprinus carpio* but also impair their immune responses, thereby facilitating parasite attachment and survival. Extremes in pH have been linked to damage in gill and skin tissues, creating favorable conditions for *Argulus* anchorage (Latief *et al*., 2024).

Table 2: Showing the parameters being studied influencing, Temperature, pH of infection *C. carpio* by *A. foliaceus*

Season	Winter	Spring	Summer	Autumn
Months	Dec - Feb	Mar - May	Jun- Aug	Sep - Nov
Water pH	7	8	8	9
Lower Water Temp. (°C)	3.4	5.3	8.3	5.1
Higher Water Temp. (°C)	5.3	8.9	19.2	9.2

3.2. Seasonal Changes in Water Parameters

A. foliaceus, is a large ectoparasitic group of Branchiura crustaceans, poses a serious threat to freshwater aquaculture, particularly to food and ornamental fish species such as *C. carpio*. Water environment and seasonal changes mainly water quality and temperature are key determinant factors for intensity and degree of infestation. Mirzaei and Khovand (2015) documented a high prevalence of *A. foliaceus* in ornamental fish, including *C. carpio,* in southeastern Iran. they indicate that water temperature and sanitation in ornamental fish farms have a major influence on infestation rates, where stagnant and warm conditions are conducive for parasite reproduction. Pekmezci *et al*. (2011) demonstrated that high infestations of *A. foliaceus* in pond-reared *C. carpio* can result in severe mortality. It was shown in their study that low water quality and lack of parasite control were the major reasons for high mortality, highlighting once again, the importance of environmental monitoring and preventive health in aquaculture systems.

Safir Khan *et al*. (2017) similarly reported the presence of *Argulus* species in carp from Dera Ismail Khan, Pakistan. Prevalence was higher in warmer times, as is well established in the biology of *Argulus*, where development and reproduction are more rapid at higher temperatures, typically above 20°C and,

the water is highest (8.3–19.2°C) and pH reach to Rayamajhi and Kunwor (2017) also identified the presence of *Argulus japonicus*, a member of the *Argulus* genus, on *C. carpio* in Nepal. They observed that prevalence of parasites was positively correlated with warmer climatic conditions and quiet pond habitats, both of which favor development of eggs as well as larval survival.

Aalberg *et al*., (2016) conducted a study on *Argulus* species affecting various freshwater food fish, observing that infestations by *A. foliaceus* were commonly linked to environmental stressors such as overcrowding, elevated organic load, and temperature fluctuations. Their findings underscore the importance of regular water quality monitoring and seasonal risk assessment as integral components of sustainable aquaculture practices.

These studies emphasize that *Argulus foliaceus* infestations are influenced not only by biological compatibility with the host *Cyprinus carpio* but also by high sensitivity to environmental variables, particularly temperature and water quality. Careful monitoring of these factors is essential for preventing outbreaks and maintaining the sustainability of aquaculture systems.

3.3. Correlation Between Water Conditions and Parasite Infestation

During winter season, when temperature decline to its lowest level (3.4–5.3°C) and pH is neutral (7) The activity of *A. foliaceus* decrease to minimal at low temperatures, as cold conditions reduce its metabolic rate, reproductive capacity, and ability to attach to the host, resulting in low or absent infestations. This explains infection rates being lowest during December to February. As spring sets in and temperatures rise (5.3–8.9°C) parasite activity slowly increases. Infestation rates start to increase in March–April as conditions for reproduction improve. The pH of water also increases to 8 which is still supportive of parasite survival. This is the onset of infestation increase during this seasonal shift. The highest infestation is in summer (June–August) when temperatures of

8. The high temperatures favor the reproduction egg hatching and attachment to fish hosts of the parasite resulting in the highest recorded parasite loads.

The optimal combination of hot temperatures and alkaline pH favors *A. foliaceus* the most, which results in the highest infestation rates. As autumn approaches (September–November), water temperatures decline to between 5.1 and 9.2°C, corresponding with a gradual decrease in infestation levels. Although the pH remains at 9, which is still optimal for parasite survival, the reduced temperatures inhibit reproductive and metabolic activity, leading to a decline in parasite populations. By late autumn, infestation levels begin to diminish in anticipation of the reduced activity period during winter. Change in water temperature, salinity, pH, water depth, and stoking density dictate the occurrence of parasitic diseases in fish food residues and feces can significantly contribute to the spread of parasitic diseases by creating a favorable environment for the development of parasites in fish breeding areas (Suliman and Al-Harbi, 2016). Parasitic infections can result in fish mortality, thereby causing significant economic losses for aquaculture producers (Cable *et al*., 2017).

Water temperatures extremes and acid change can stress the fish and weaken the immune system facilitating the infections. The elevated temperatures can induce stress and increase carp metabolism making them more vulnerable to parasitic damage. Low temperatures may slow the parasite's activity but can also suppress the fish's immune response (Fast, 2014). Parasitic organisms, especially fish lice, significantly affect global freshwater fisheries, leading to major economic impacts, particularly in aquaculture. Can damage the fish's skin and mucus layer, which are the first lines of defense against parasites (Holm *et al*., 2015).

Argulus is flattened from top to bottom (Fig. 2), featuring an oval to round body covered by a broad carapace (outer protective shell) and two compound eyes. A slender, needle-shaped "stylet" situated in front of the mouth tube is used to puncture the host and assist the parasite in consuming bodily fluids. These suckers originate from hook-shaped structures in the earlier stages. Spines and hooks on their appendages ("legs") aid in movement (Fig. 3). Advance juveniles and adult *Argulus foliaceus* typically measure around 3–7 mm in length and 2–4 mm in width. The reproductive anatomy of *Argulus foliaceus* is comprehensively described in the fact sheet titled *"Argulus (Fish Louse) Infections in Fish"* by Steckler and Yanong (2013). They describe that the females are larger than males and can be identified by short, paired structures at their posterior end known as seminal receptacles (spermathecae), which receive sperm from the male. Argulus infestation leads to significant immunomodulatory effects on its hosts by triggering argulosis, which results in inflammation, widespread tissue damage, and mortality (Andrade *et al*., 2024). Understanding the impact of host-parasite interaction on the host's immune system is crucial in developing means to prevent, control, and manage argulosis. Such interactions offer valuable insights into the co-evolutionary dynamics between hosts and parasites (Haridevamuthu *et al*., 2024). In the present study represented temperature and pH played a major role in the ecology of *A. foliaceus* and carp health. Optimal environmental conditions have to be regulated in order to manage parasite infestations as well as overall fish population health. Management and monitoring should be done in advance to mitigate the effects of this parasitic crustacean (Aly and Fathi, 2024). In addition, *A. foliaceus* exhibits strong seasonal variation in infestation intensity and reproductive activity, with most activity during warm months. A combination of environmental control, monitoring, and use suitable treatments is effective management. An Experiment have shown that infestation intensities of *A. foliaceus* are significantly greater during summer months due to warmer water temperatures. For instance, a study conducted in Kunduzlar Dam Lake in Turkey reported high levels of infestation during the summer, highlighting the influence of temperature on parasite prevalence (Öztürk, 2022).

Figure 2: *A. foliaceus* on the skin and caudal fin of *C. carpio*.

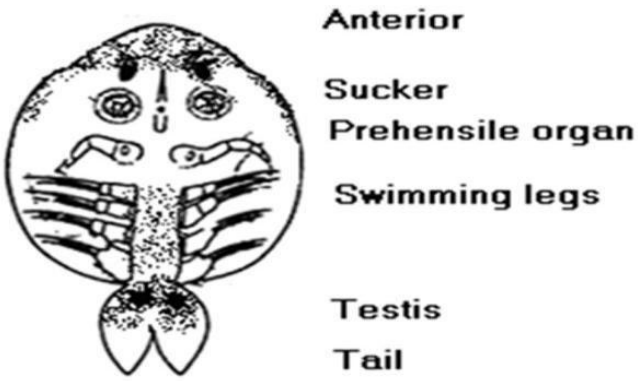

Figure 3: *A. foliaceus* by camera Lucida.

Conclusions

This study confirms that *A. foliaceus* infestation in common carp exhibits seasonal variation, with peak infestations occurring during the warmer months (June–September) and minimum levels observed during winter (December–February). Water temperature and pH significantly influence reproduction and parasite survival, underscoring the necessity of effective environmental monitoring and management. Routine water quality assessments and targeted interventions are essential to prevent infestations, promote fish welfare, and support sustainable, environmentally friendly aquaculture practices.

Acknowledgment: Not applicable.

Financial support: No financial support.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article.

References

AALBERG, K., KOŠČOVÁ, L., ŠMIGA, Ľ., KOŠUTH, P., KOŠČO, J., OROS, M., BARČÁK, D. & LAZAR, P. 2016. A study of fish lice (Argulus sp.) infection in freshwater food fish. *Folia Veterinaria,* 60**,** 54-59.

ALY, S. M. & FATHI, M. 2024. Advancing aquaculture biosecurity: a scientometric analysis and future outlook for disease prevention and environmental sustainability. *Aquaculture International,* 32**,** 8763-8789.

ANDRADE, J., PEREIRA, M., SILVA, L., FIGUEIREDO, H. & JATOBÁ, A. 2024. Infestation of Argulus sp. associated with bacteriosis in ornamental carp-case report. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia,* 76**,** e13240.

BRAHMCHARI, R. K., KUMAR, S., KUMARI, P. & KUMAR, K. 2023. Argulus parasitism in aquaculture: an elevated temperature scenario. *Outlook of climate change and fish nutrition.* Springer.

BRAZENOR, A. K., FRANCIS, D. S., CONLAN, J. A., CARTON, A. G. & HUTSON, K. S. 2020. Temperature alters reproduction and maternal provisioning in a fish ectoparasite. *International Journal for Parasitology,* 50**,** 839-849.

CABLE, J., BARBER, I., BOAG, B., ELLISON, A. R., MORGAN, E. R., MURRAY, K., PASCOE, E. L., SAIT, S. M., WILSON, A. J. & BOOTH, M. 2017. Global change, parasite transmission and disease control: lessons from ecology. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 372**,** 20160088.

FAST, M. D. 2014. Fish immune responses to parasitic copepod (namely sea lice) infection. *Developmental & Comparative Immunology,* 43**,** 300-312.

HARIDEVAMUTHU, B., RAJ, D., ARSHAD, A. & AROCKIARAJ, J. 2024. Comprehensive review of Argulus infestations in aquaculture: Biological impacts and advanced management strategies. *Fish & Shellfish Immunology***,** 109851.

HOLM, H., SANTI, N., KJØGLUM, S., PERISIC, N., SKUGOR, S. & EVENSEN, Ø. 2015. Difference in skin immune responses to infection with salmon louse (Lepeophtheirus salmonis) in Atlantic salmon (Salmo salar L.) of families selected for resistance and susceptibility. *Fish & shellfish immunology,* 42**,** 384-394.

ISLAM, M. J., KUNZMANN, A. & SLATER, M. J. 2022. Responses of aquaculture fish to climate change-induced extreme temperatures: A review. *Journal of the World Aquaculture Society,* 53**,** 314-366.

KHODADADI, A., RASULI, S., ABDI, K. & AZIZI, R. 2013. determination of abundance of external parasites of goldfish (carassius auratus linnaeus, 1785) in fish breeding and pisciculture centers in urmia city.

LATIEF, L., GILBERT, B. M. & AVENANT-OLDEWAGE, A. 2024. Effects of water quality on fish parasite biodiversity and physiological responses in the host fish Clarias gariepinus from a eutrophic lake subjected to acid mine drainage in South Africa. *Integrated Environmental Assessment and Management,* 20**,** 1539-1553.

MIRZAEI, M. & KHOVAND, H. 2015. Prevalence of Argulus foliaceus in ornamental fishes [goldfish (Carassius auratus) and Koi (Cyprinus carpio)] in Kerman, southeast of Iran. *Journal of parasitic diseases,* 39**,** 780-782.

OBAID, H. M., HUSSEIN, N. F., OBED, T. M. & BOUNDENGA, L. 2021. Common Carp (Cyprinus carpio) parasites diversity and prevalence in Erbil aquacultures: gills, skin and intestinal infections. *Iranian Journal of Veterinary Science and Technology,* 13**,** 34-41.

ÖZTÜRK, M. O. 2022. An Investigation on Argulus foliaceus (Crustacea) Infestation of Fishes in the Kunduzlar Dam Lake. *Journal of Limnology and Freshwater Fisheries Research,* 8**,** 282-288.

PEKMEZCI, G., YARDIMCI, B., BOLUKBAS, C., BEYHAN, Y. & UMUR, S. 2011. Mortality due to heavy infestation of Argulus foliaceus (Linnaeus, 1758)(Branchiura) in pond-reared carp, Cyprinus carpio L., 1758 (Pisces). *Crustaceana,* 84**,** 553-557.

POLY, W. J. 2008. Global diversity of fishlice (Crustacea: Branchiura: Argulidae) in freshwater. *Hydrobiologia,* 595**,** 209-212.

RAYAMAJHI, A. & KUNWOR, P. 2017. First Record of Argulus japonicus (Crustacea: Branchiura) on Cyprinus carpio in Nepal, with Additional Notes on Morphology and Prevalence of A. Japonicus and Its Treatment. *Nepalese Veterinary Journal,* 34**,** 119-127.

SAFIR KHAN, W. A., JAVID, M., ULLAH, I., HUSSAIN, G., SHAHNAZ, Z., ULLAH, I. & ULLAH, I. 2017. Prevalence of Argulus in Common Carp (Cyprinus carpio) From DI Khan (Khyber Pakhtunkhwa) Pakistan.

SAHOO, P. K., MOHANTY, J., HEMAPRASANTH, KAR, B., MOHANTY, B. R., GARNAYAK, S. K. & JENA, J. K. 2013. Egg laying strategies and effect of temperature on egg development of Argulus siamensis. *Journal of Parasitic Diseases,* 37**,** 158-162.

SARA, B., BAROUR, C., SAMEH, A., BOUALLEG, C. & MOURAD, B. 2016. Environmental parameters and parasitism in common carp (Cyprinus carpio Linnaeus, 1758) caught from Oubeira Lake (North-East of Algeria). *Research journal of fisheries and hydrobiology,* 11.

SCHADE, F. M., RAUPACH, M. J. & WEGNER, K. M. 2016. Seasonal variation in parasite infection patterns of marine fish species from the Northern Wadden Sea in relation to interannual temperature fluctuations. *Journal of Sea Research,* 113**,** 73-84.

SHINN, A., PRATOOMYOT, J., BRON, J., PALADINI, G., BROOKER, E. & BROOKER, A. 2015. Economic impacts of aquatic parasites on global finfish production. *Global Aquaculture Advocate,* 2015**,** 58-61.

STECKLER, N. & YANONG, R. P. 2013. Argulus (Fish Louse) infections in fish: FA184, 11/2012. *Edis,* 2013.

SULIMAN, E. A. M. & AL-HARBI, A. H. 2016. Prevalence and seasonal variation of ectoparasites in cultured Nile tilapia Oreochromis niloticus in Saudi Arabia. *Journal of parasitic diseases,* 40**,** 1487-1493.

WAFER, L. N., WHITNEY, J. C. & JENSEN, V. B. 2015. Fish lice (Argulus japonicus) in goldfish (Carassius auratus). *Comparative medicine,* 65**,** 93-95.