Co-invasion of anchor worms *Lernaea cyprinacea* (Copepoda: Lernaeidae) in some freshwater fishes of the Kor River Basin, Southwest of Iran with some remarks on the ecological aspects of lernaeosis in the country

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Abstract

In the present investigation, co-invasion of *Lernaea* parasite is reported in some fish species, collected from the Kor River Basin (Dorudzan Reservoir and Kor River), Southwest of Iran in 2010 and 2011. *Lernaea cyprinacea* parasites were isolated from the external surface of eye, lips, gills, nostrils, fins, operculum and body of *Alburnus mossulensis*, *Capoeta aculeata*, *Capoeta saadii* (all native cyprinids), *Cyprinus carpio* and *Carassius auratus* (exotic cyprinids). The highest infestation was found in endemic fish, *C. aculeata* with 61ectoparasites in a single specimen of 348 mm TL. The greatest prevalence was found in *C. auratus* (100%) followed by *C. saadii* (80%), *C. aculeata* (69.4%), *C. carpio* (30.1%) and *A. mossulensis* (27.3%). *Lernaea* parasites may have been translocated into Dorudzan Dam by exotic species (e.g., *C. carpio* and *C. auratus*) through the four processes of introduction (transport in alien host and acting as co-introduced species), establishment (survival and reproduction in alien host, acting as co-introduced species), spreading with its original host (dispersal) and switching to a native host species to become a co-invader.

Keywords: *Lernaea cyprinacea*, Alien parasite, Invasive species, Ichthyodiversity, Iran

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Introduction

Invasive species (IS) are alien (non-native) organisms that have been introduced into an area outside of their natural range, establishing self-sustaining populations and spreading beyond their initial point of introduction, with deleterious impacts on the environment, economy and human health (Kolar and Lodge, 2001; Lymbery *et al*., 2014). Biological invasions are now considered a major environmental issue of public concern (Gozlan *et al*., 2010). Human population growth, increasing transport capacity and economic globalization have accelerated the rate of introductions of alien species throughout the world (Vitousek *et al*., 1997; Sakai *et al*., 2001; Lymbery *et al*., 2014) especially alien and invader parasites. Aquatic invasive species (AIS) and bio-invasions (BI) are global environmental issues in marine, brackish and freshwater ecosystems of the world. For the terminology of alien species see Gozlan *et al*. (2010), Esmaeili *et al*. and Lymbery *et al.* (2014). Invasive species are now recognized as a major cause of biodiversity loss and associated changes in ecosystem function, leading to biotic homogenisation as native species are replaced by widespread alien species (Pimentel, 2002; Rahel, 2002; Simberloff, 2011; Lymbery *et al*., 2014) in many parts of the world including Iran. Iran is a region of major zoogeographical interchange having remarkable biodiversity comprising more than 202 inland fish species distributed in 19 major exorheic and endorheic basins and attracting naturalists (Abdoli, 2000; Esmaeili *et al*., 2010; Coad, 2014). The Kor River Basin is one of the endorheic basins (drains to internal basin of Lake Bakhtegan) with high fish diversity (Esmaeili *et al*., 2010; Teimori *et al*., 2010). The Dorudzan Dam on the Kor River, containing 990 million m^3 of water, is 24 km long and about 9.5 km wide and can support a fish fauna (Coad, 2014).

Twenty eight confirmed fish species (Table1) belonging to 22 genera, 9 families and 6 orders have been reported from the Kor River Basin (Esmaeili *et al.*, 2010;Teimori *et al*., 2010; Gholami *et al*., 2014a; Freyhof *et al*., 2014) of which 20 and 8 species are native and exotic, respectively showing high ichthyodiversity of this small basin. However, drought, pollution, habitat destruction, exotic species and parasites (e.g., Lernaea sp.) have affected this diversity (Esmaeili *et al*., 2008, 2009, 2010, 2014; Gholami *et al.*, 2014b). With increased attention on parasitism and disease as threats to biodiversity, there is a need to identify the pathogens and parasites, which pose significant risks (Daszak *et al*., 2000; Smith *et al*., 2006) especially the globally distributed parasite *Lernaea* in highly diverse area such as the Kor River Basin.

Lernaea Linnaeus, 1746 (Cyclopoida: Lernaeidae) or anchor worms are parasitic copepods that are

found on the skin and gills of freshwater fishes and cause lernaeosis disease (Marina *et al*., 2008). It has been widely translocated with cultured fish species and is now found throughout North America, Europe, Asia, southern Africa and eastern Australia with a very wide host range (Hoffman, 1970; Lester and Haywood, 2006). Although *Lernaea* is not native to Iran but it was accidentally introduced to Iran with exotic fishes and currently it can be found throughout the country, both in native and non-native fishes in different water bodies (Table 3).

In this paper, we report a significant invasion of this parasite in some native and exotic fishes from the Kor River Basin, Southwest of Iran.

Materials and methods

Fish specimens were collected during field work from January – February 2010, and from May to October 2011 in Kor River Basin (Dorudzan Reservoir, 30°12'36.92"N, 52°21'45.89"E and upstream of Kor River, 30°19'1.79"N, 52°15'24.94"E which drains to the reservoir), using electrofishing devices, hand nets and gill nets. Identification of fish specimen was carried out based on Coad (2014). The external surface of all individuals was investigated macro- and microscopically to detect lernaeid parasites that were examined under a light microscope for diagnosis of the infection. *Lernaea* parasites were carefully detached from the infected parts of skin, fins, eyes, and musculature tissues. The parasites were mounted whole for identification using a compound microscope according to Jalali (1997). Anchor worms of 4 to 8 mm lengths could be counted without the aid of magnification. Cutaneous lesions about 4 mm in diameter were assumed to be sites of parasite attachment and were included in the count because parasites were sometimes dislodged when the fish were being removed from nets. Parasite data were expressed as prevalences (proportion of infested hosts), intensities of infestation (number of parasites per infested host) and infected organs. All the collected fish specimens were stored in the Zoological Museum-Collection of Biology Department, Shiraz University (ZM-CBSU).

Results

A total of 331 fish specimens belonging to 8 species, 7 genera and 3 families were collected and examined from the Dorudzan Reservoir (locality I) and upstream of Kor River (locality II) (Table 1). Lernaeid parasites were separated from five species including *A. mossulensis*, *C. aculeata*, *C. saadii*, *C. carpio* and *C. auratus* (Cyprinidae). Parasites were detected in different body parts of fishes (Table 2, Figs. 1-4). All the isolated parasites were identified as *L. cyprinacea* (Kularatne *et al*., 1994).

Table 1: Native and exotic fishes reported from Kor River Basin of Iran. T: translocated species; E: endemic species.

Order	Family	Species	Native/Exotic
Acipenseriformes	Acipenseridae	*Acipenser persicus*	Native, T
		Acipenser stellatus	Native, T
		Huso huso	Native, T
Cypriniformes	Cyprinidae	*Acanthobrama persidis*	Native, E
		Alburnoides qanati	Native, E
		Alburnus mossulensis	Native
		Capoeta aculeate	Native, E
		Capoeta saadii	Native, E
		Carasobarbus luteus	Native
		Carassius auratus	Exotic
		Chondrostoma orientale	Native, E
		Ctenopharyngodon idella	Exotic
		Cyprinus carpio	Exotic
		Hypophthalmichthys molitrix	Exotic
		Hypophthalmichthys nobilis	Exotic
		Mesopotamichthys sharpeyi	Native, T
		Pesudorasbora parva	Exotic
	Cobitidae	*Cobitis linea*	Native, E
	Nemacheilidae	*Oxynoemacheilus farsicus*	Native, E
		Oxynoemacheilus persa	Native, E
		Oxynoemacheilus tongiorgii	Native, E
		Paracobitis persa	
Perciformes	Percidae	*Sander lucioperca*	Native, T
Mugiliformes	Mugilidae	*Chelon abu*	Native
Salmoniformes	Salmonidae	*Oncorhynchus mykiss*	Exotic
Cyprinodontiformes	Cyprinodontidae	*Aphanius shirini*	Native, E
		Aphanius sophiae	Native, E
	Poeciliidae	*Gambusia holbrooki*	Exotic

Table 2: *Lernaea* data, prevalences, intensities, infected organ and total length (mm) of fishes in two localities of Kor River Basin (Dorudzan and Kor River).

Fish Species	Locality	N	Charactristics	Mean (SD)	Infected organs
Alburnus mossulensis	Dorudzan	11	Total length	180.42	Skin (fins)
			Intensity	0.64 (1.12)	
			Prevalence	27.3%	
	Kor River	57	Total length	116.9	-
			Intensity	0	
			Prevalence	0	
Capoeta aculeata	Dorudzan	121	Total length	299.5	Skin, Nostril, Eye, Lip, Rostrum
			Intensity	8.82 (11.6)	
			Prevalence	69.4%	
	Kor River	22	Total length	145.7	Skin (fins)
			Intensity	0.14 (0.47)	
			Prevalence	9.1%	
Cyprinus carpio	Dorudzan	83	Total length	241	Skin including fins, Gill
			Intensity	1.35 (3.22)	
			Prevalence	30.1%	
Capoeta saadii	Dorudzan	10	Total length	357.5	Skin including fins, Gill
			Intensity	6.5 (8.75)	
			Prevalence	80%	
	Kor River	3	Total length	104.2	-
			Intensity	0	
			Prevalence	0	
Carasobarbus luteus	Dorudzan	7	Total length	230.3	-
			Intensity	0	
			Prevalence	0	
Carassius auratus	Dorudzan	4	Total length	194.65	Skin including fins and head
			Intensity	7 (2.5)	
			Prevalence	100%	
Cobitis linea	Kor River	1	Total length	36.97	-
			Intensity	0	
			Prevalence	0	
Oxynoemacheilus persa	Kor River	12	Total length	55.83	-
			Intensity	0	
			Prevalence	0	

Table 3: *Lernaea* parasites recorded from freshwater fishes of Iran.

Order	Family	Species	Native /Exotic	Locality	Region	Reference
Cypriniformes	Cyprinidae	*Abramis brama*	Native	North of Iran	Caspian	Jalali, (1998)
		Abramis bjoerkna	Native	Boojagh Lagoon	Caspian	Khara *et al*., (2011)
		Acanthalburnus urmianus	Native	Mahabad Reservoir	Urmia	Mirhashemi Nasab and Pazooki, (2003)
		Alburnus hohenakeri	Native	Choghakhour Lagoon	Tigris	Raissy *et al*., (2011,2013)
		Aspidoparia morar	Native	Mashkid River	Mashkid	Malekzehi *et al*., (2014)
		Aspius vorax	Native	Karun River	Karun	Molnar and Baska ,(1993)
		Bangana dero	Native	Mashkid River	Mashkid	Malekzehi *et al*., (2014)
		Lucuibarbus barbulus	Native	Armand River	Tigris	Raissy and Ansari, (2012)
		Barbus lacerta	Native	Vahdat Reservoir	Tigris	Jalali and Barzegar, (2005)
				Mahabad Reservoir	Urmia	Mirhashemi nasab and Pazooki, (2003)
		Carasobarbus luteus	Native	Karun River Zarineh-rud River	Karun	Molnar and Baska, (1993) Jalali, (1998)
		Barbus sp.	Native	Doghab River Vahdat Reservoir	Caspian	Mokhayyer (1985)
		Blicca bejoerkna	Native	Boojagh Lagoon	Caspian	Khara *et al*., (2004)

Continued Table 3

Order	Family	Species	Native /Exotic	Locality	Region	Reference
Cypriniformes	Cyprinidae	*Capoeta aculeata*	Native	Kaftar Lake	Kor	Barzegar and Jalali, (2000)
				Behesht abad River	Karun	Barzegar *et al*., (2004)
				Choghakhour Lag	Tigris	Raissy *et al*., (2011, 2013)
				Doghab River	Caspian	Mokhayyer, (1985)
		Capoeta capoeta	Native	Mahabad Reservoir	Urmia	Mirhashemi nasab and Pazooki, (2003)
		Capoeta damascina	Native	Chaghakhour Lagoon	Tigris	FadaeiFard *et al*., (2001)
				Gandoman Lagoon		Raissy *et al.*, (2010,2011)
				Kaftar Lake	Kor	Barzegar and Jalali (2000)
		Capoeta trutta	Native	Vahdat Reservoir	Tigris	Jalali and Barzegar, (2005)
		Carassius auratus gibelio	Exotic	Anzali Lagoon	Caspian	Jalali, (1998)
				Choghakhor Lag	Tigris	Raissy *et al*., (2011,2013)
		Carassius aurarus auratus	Exotic	All regions of Iran	All basins	Jalali, (1998) Sharif Rohani, (1994)
		Carassius sp.	Exotic	Anzali Lagoon	Caspian	Asadzadeh Mangili *et al*., (2000)
		Chalcalburnus mossulensis	Native	Kaftar Lagoon	Kor	Barzegar and Jalali, (2000)
		Chondrostoma regium	Native	Kaftar Lake	Kor	Barzegar and Jalali, (2000)

Continued Table 3

Order	Family	Species	Native /Exotic	Locality	Region	Reference
				North of Iran and Khuzestan	Caspian and Karun	Jalali, (1998)
				Sefid-rud River	Caspian	Naem, *et al* ., (2000)
				Mahabad Reservoir	Urmia	Mirhashemi nasab and Pazooki, (2003)
				All region of Iran	All basins	Jalali, (1998)
		Ctenopharyngodon idella	Exotic	Sefid-rud River	Caspian	Naem, *et al*., (2000)
				Zarineh-rud River	Urmia	Jalali, (1998)
				Hamoon Lagoon	Sistan	Molnar and Baska, (1993)
Cypriniformes	Cyprinidae					Molnar, (1990)
				Zarivar Lake	Tigris	Jalali and Barzegar, (2006)
		Cyprinion microphthalmum	Native	Mashkid River	Mashkid	Malekzehi *et al*., (2014)
					Caspian	Asadzadeh Mangili *et al*., (2000)
				Anzali Lagoon	Sistan	Sharif Rohani, (1994)
				Hamoon Lag	Kor	Barzegar and Jalali, (2000)
				Kaftar Lake	Tigris	Jalali and Barzegar, (2006)
				Zarivar Lake	Tajan (Tedzhen)	Borji *et al*., (2012)
		Cyprinus carpio	Exotic	ponds around Mashhad	Tigris	Raissy *et al*., (2011,2013)
				Choghakhor Lagoon	Tajan (Tedzhen)	Nematollahi *et al*., (2013)
				Mashhad		

Continued Table 3

Order	Family	Species	Native /Exotic	Locality	Region	Reference
		Gobio sp.	Native	Hamoon Lagoon	Sistan	Molnar, (1990)
		Gonorhynchus diplocheilus	Native	Mashkid River	Mashkid	Malekzehi *et al* (2014)
		Hypophthalmichthys molitrix	Exotic	All area of Iran	All basins	Jalali, (1998)
				Anzali Lagoon	Caspian	Asadzadeh Mangili *et al*.,(2000)
				Choghakhour Lagoon	Tigris	Sharif Rohani, (1994)
				Mashhad	Tajan (Tedzhen)	Raissy *et al*., (2011) Nematollahi *et al*., (2013)
Cypriniformes	Cyprinidae	*Hypophthalmichthys nobilis*	Exotic	North of Iran and Khuzestan	Caspian and Karun	Jalali, (1998)
		Squalius cephalus	Native	Mahabad Reservoir	Uromia	Mirhashemi nasab and Pazooki, (2003) Pazooki, *et al*., (2005)
				Khandaghloo River	Caspian	
		Acanthobrama persidis	Native	Kaftar Lake	Kor	Barzegar and Jalali, (2000)
		Pseudorasbora parva	Exotic	Kaftar Lake	Kor	Barzegar and Jalali, (2000)
		Rutilus rutilus	Native	Boojagh Lagoon	Caspian	Khara *et al.*, (2004,2011)
		Schizocypris altidorsalis	Native	Hamoon Lagoon	Sistan	Sharif Rohani, (1994)
		Schizothorax zarudnyi	Native	Hamoon Lagoon	Sistan	Sharif Rohani, (1994)

Continued Table 3

Order	Family	Species	Native /Exotic	Locality	Region	Reference
		Schizothorax zarudnyi	Native	Chah nimeh and Zahak Dam	Sistan	Elahi Moghadam, (2010)
		Schizothorax sp.	Native	Hamoon Lagoon	Sistan	Molnar, (1990)
		Tinca tinca	Native	Anzali Lagoon	Caspian	Asadzadeh Mangili *et al*., (2000)
				Boojagh Wetland		Khara *et al*., (2011)
Siluriformes	Siluridae	*Silurus glanis*	Native	Zarineh-rud River	Uromia	Jalali, 1998
				Anzali Lagoon	Caspian	Roohi *et al*., (2014)
	Sisoridae	*Glyptothorax silviae*	Native	Saimareh River	Tigris	Sayyadzadeh *et al*., (2014)
Salmoniformes	Salmonidae	*Oncorhynchus mykiss*	Exotic	Sistan Chah nimeh	Sistan	Sharif Rohani., (1994)
Esociformes	Esocidae	*Esox lucius*	Native	Anzali Lagoon	Caspian	Asadzadeh Mangili *et al.*, (2000)
	Cyprinodontidae	*Aphanius dispar*	Native	Mashkid River	Mashkid	Malekzehi *et al*., (2014)
		Aphanius sophiae	Native	Ghadamgah Spring	Kor	Rahimi et al., (2013)
Cyprinodontiformes		*Aphanius vladykovi*	Native	Behesht abad River	Karun	Barzegar *et al*., (2004)
	Poeciliida	*Gambusia holbrooki*	Exotic	Fish pond in north of Iran	Caspian	Mokhayyer, (1985)
Synbranchiformes	Mastacembelidae	*Mastacembelus mastacembelus*	Native	Zarivar Lake	Tigris	Jalali *et al*., 2008
			Native	Zarivar Lake	Tigris	Jalali and Barzegar, (2006)
Perciformes	Channidae	*Channa gachua*	Native	Mashkid River	Mashkid	Malekzehi *et a*l., (2014)

Figure 1: *Cyprinus carpio* infested by *Lernaea cyprinacea* in Kor River Basin.

Figure 2: *Capoeta aculeata* infested by *Lernaea cyprinacea* in Kor River Basin.

Figure 3: *Capoeta saadii* infested by *Lernaea cyprinacea* in Kor River Basin.

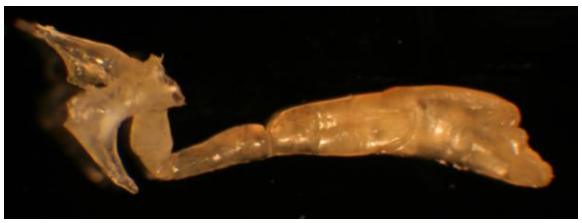

Figure 4: *Lernaea cyprinacea* from *Capoeta aculeata* in Kor River Basin.

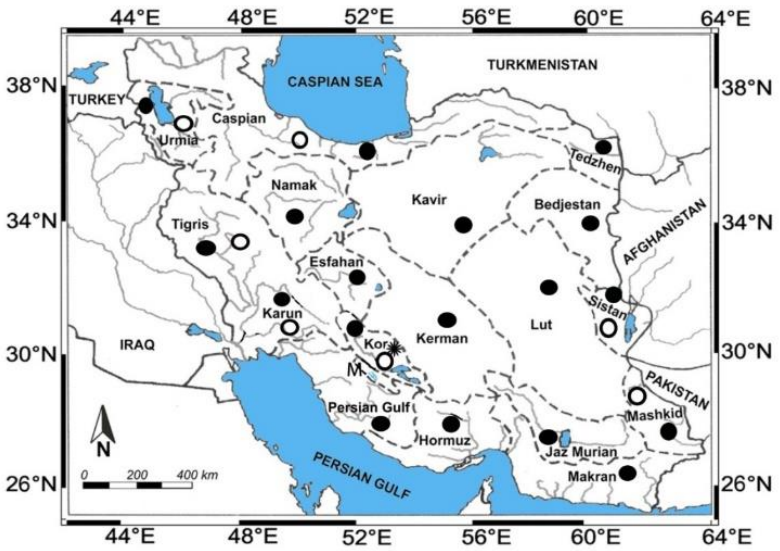

Figure 5: Distribution map of *Lernaea* in Iran, ● exotic fishes, ○ native fishes, ✹ new records from Kor River Basin.

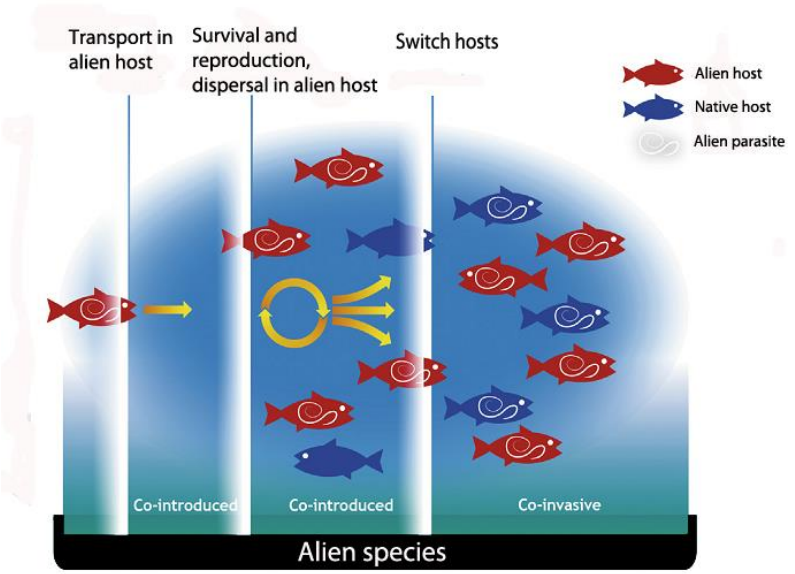

Figure 6: Parasitic aliens. The alien host species (in red) contains an alien parasite species. The alien parasite goes through the processes of introduction, establishment and spread with its original host and then switches to a native host species (in blue) to become a co-invader (main source, Lymbery *et al.*, 2014).

The overall prevalences (for all fish species) at the two localities were 52.5% (n = 236 fishes) at the Dorudzan Reservoir and 2.1% (n = 95 fishes) at the Kor River. Other parasite data such as prevalences, intensities, infected organs and total length of fishes based on the fish species and locality are given in Table 2. The greatest prevalence was observed for *Carassius auratus* (100%) followed by *C. saadii* (80%), *C. aculeata* (69.4%), *C. carpio* (30.1%) and *A. mossulensis* (27.3%). The highest intensity was observed in *C. aculeata* in Dorudzan Reservoir being 8.82. In general the infestation was much high in reservoir (with warm and stagnant water) than the Kor River (having cold and running water). None of the examined specimens of *Carasobarbus luteus* (Cyprinidae), *Cobitis linea* (Cobitidae) and *Oxynoemacheilus persa* (Nemacheilidae) were infected with the parasite.

Discussion

Lernaea is a copepod, which is parasitic on many species of freshwater fishes and is extremely common among the cyprinid fishes feeding on the host's blood and tissue. Invasion destroys scales, skin, muscles, and penetration of the fish body results in deep ulcers, abscesses or fistulas accommodating serious economic loss. Heavy parasitosis could be the cause of mass mortalities of wild and cultured fish and also secondary bacterial or fungal infections (Lester and Haywood, 2006). They are highly adapted to a parasitic way of life. The majority of lernaeids have undergone extensive morphological adaptations (Piasecki *et al.,* 2004).

The data reported here are concerned with the occurrence of *Lernaea* parasites in five native and exotic cyprinids collected from the two localities from Kor River Basin in Iran for the first time. Usually, it is believed that *Lernaea* is a common parasite of the cyprinid fishes, although it has been also reported from other fishes. It is in agreement with our data reported here.

Lernaea spp. (commonly *L. cyprinacea*) has been widely distributed throughout the world, presumably through the translocation of cyprinid hosts such as goldfish, *C. auratus* and European carp, *C. carpio* (Piasecki *et al*., 2004; Marina *et al*., 2008). The *Lernaea* parasite was reported for the first time in *Gambusia* sp. (probably *Gambusia holbrooki*) in 1981 and in common carp and Chinese carps in 1981 and 1982 (Jalali, 1997) from north of Iran and now it has been widely distributed throughout Iran presumably through the translocation of exotic cyprinid hosts (Fig. 5, Table 3) and has infested many native freshwater fishes of Iran (Table 3).

Both species of *C. auratus* and *C. carpio* which are supposed to be involved in translocation of *Lernaea* parasite are present in the area under study as exotic cyprinid fishes and hence they might have a significant role in the translocation of *Lernaea* during

the process which has been illustrated in Fig. 6 and has well been explained and discussed by Lymbery *et al*. (2014). Based on Lymbery *et al*. (2014), the alien host species that contains an alien parasite species must overcome 4 barriers. The alien parasite goes through the processes of: I) introduction (transport in alien host and acting as co-introduced species), II) establishment (survival and reproduction in alien host, acting as co-introduced species), III) spreading with its original host (dispersal) and IV) switching to a native host species to become a co-invader (Fig. 5). The same process is suggested for the alien and invader host species of Iran. To date more than 32 alien (exotic) fish species belonging to 10 orders and 12 families (Cyprinidae, Gobiidae, Salmonidae, Anguilidae, Mugilidae, Centrarchidae, Heteropneustidae, Gasterosteidae, Cichlidae, Poecilidae, Adrianichthyidae and Pleuronectidae) have been reported from inland water bodies of Iran of which 25 species are confirmed by specimens Esmaeili *et al*., (2010, 2014) of which six species are found in the Kor River Basin (Table 1). Introduced fishes may impact on native and endemic species in freshwater of Iran, through predation, competition, habitat alteration, and transfer of exotic (alien) parasites and diseases and this has been an increasing cause of concern for the health of freshwater environments throughout the world (Levy, 2004).

We found *L. cyprinacea* infestations on five different species of fish, with the greatest prevalence on *C. auratus* (100%) followed by *C. saadii* (80%), *C. aculeate* (69.4%), *C. carpio* (30.1%) and *A. mossulensis* (27.3%). Differences in infestation levels among different host species have also been reported in many other studies (e.g., Marcogliese, 1991; Bond, 2004). It may result from different encounter frequencies between host and parasite, from differences in the rate of attachment of parasite to different host species or from differences in the immature response different host species to the parasite. Introduced alien hosts often have fewer parasite species and a lower prevalence of parasites than native hosts, which may provide them with a competitive advantage (enemy release; Mitchell and Power, 2003; Torchin *et al*., 2003). Once introduction has occurred, parasite transmission may occur from native hosts to alien hosts, leading to an increase in infection of natives if aliens amplify transmission (spillback; Kelly *et al*., 2009; Mastisky and Veres, 2010) or a decrease in infection of natives if aliens reduce transmission (dilution; Paterson *et al*., 2011; Poulin *et al*., 2011). If alien hosts introduce new parasites, then these may be transmitted to native hosts, leading to the emergence of new disease in the natives (spillover or pathogen pollution; Daszak *et al*., 2000; Taraschewski, 2006; Lymbery *et al*., 2014).

The prevalence of this parasite in Dorudzan Reservoir was much higher than that in the Kor River. It might be due to: I) Absence of *C. auratus* and *C.*

carpio which do not act as alien host parasites in the Kor River (reducing infection of other fishes) because the most likely route of introduction of *Lernaea* is these exotic Carps. II) Different habitat condition in the Dorudzan Reservoir and the Kor River including water depth, water current, water temperature and oxygen level. It seems that the Dorudzan Reservoir with its high water depth and temperature and low water currents and oxygen level provides a suitable condition for the survival, reproduction and establishment of *Lernaea* parasite both in exotic and native fishes. A positive relationship between both prevalence and intensity of infection of *L. cyprinacea* and water temperature has already been reported in some fishes (see Marcogliese, 1991; Lester and Haywood, 2006). Water temperature is known as the significant factor influencing the duration of life cycle of *Lernaea*. It is reported that the development of the parasite increases with increasing water temperature. Female anchor worms attach to the body of their hosts, produce eggs which hatch into free-living naupliar larvae. After about 4 days, the naupliar larvae molt into the infective copepodid larvae which usually attach to the gills of the host fish. Copepod larvae molt to adults after a week or more depending on the water temperature, with optimal development at 28-36°C and little development below 20°C (Marcogliese, 1991; Lester and Haywood, 2006).

Lernaea infestations can have serious pathogenic effects on their fish hosts. Copepodites may cause disruption and necrosis of gill epithelium, while attachment of adult females usually causes hemorrhages, muscle necrosis and an intense inflammatory response, sometimes associated with secondary bacterial infections (Khalifa and Post, 1976; Berry *et al*., 1991). The infected fishes are not eliminated directly by the parasite, however, it may open routes for secondary infection and finally, related growth retardation, behavioral changes and associated secondary invaders may lead to death of the infected individuals (Robinson and Avenat-Oldewage, 1996). Due to these sever impacts and usage of reservoir water as drinking water for a big city as Shiraz, a long term monitoring of the parasites and fishes is highly recommended in the Kor River Basin which is a highly diverse basin in terms of native, especially endemic fishes. Finally, further parasitological investigations on these fishes during different seasons of the year are highly suggested to clarify the role of temperature and environmental conditions on infection of fish.

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