Research Article

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First record of the nonindigenous parasitic copepod *Neoergasilus japonicus* (Harada, 1930) in Turkey

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Abstract: *Neoergasilus japonicus* (Harada, 1930), a parasitic copepod from the family Ergasilidae (Copepoda, Poecilostomatoida), was observed for the first time in Turkey during a parasitological examination of rudd *Scardinius erythrophthalmus* from Lake Sapanca. The investigation was performed between March 2009 and February 2010, and a total of 132 *S. erythrophthalmus* were studied at monthly intervals. *N. japonicus* infection was found from June to November, and during this period the monthly prevalences were 18.2%, 75.0%, 53.8%, 61.5%, 38.5%, and 33.3%, respectively. The average prevalence in female rudd was higher than in males. A total of 467 adult female *N. japonicus* individuals were collected, and the maximum intensity of infection, 52 specimens of *N. japonicus*, was found on a single fish in August. The preferred attachment sites of *N. japonicus* were the anal fin, with 261 individual parasites (55.9%), and the dorsal fin, with 179 (38.3%).

Key words: *Neoergasilus japonicus*, parasitic copepod, nonindigenous species, rudd, Lake Sapanca

Introduction

The genus *Neoergasilus* was first created by Yin (1956), who designated *N. japonicus* (Harada, 1930) as its type species. *Neoergasilus* now contains 10 species (Walter and Boxshall, 2010). *N. japonicus* is native to eastern Asia and was first reported by Harada in Taiwan (1930), Yin in China (1956), and Urawa et al. in Japan (1991). *N. japonicus* is a member of Ergasilidae, a large family of parasitic copepods usually classified within Poecilostomatoida, order of Copepoda (Huys and Boxshall, 1991; Abdelhalim et al., 1993). However, *N. japonicus* has spread to many countries, possibly via the aquarium trade, aquaculture, bait release, or ballast water introduction (Hudson and Bowen, 2002). It was reported in Hungary (Ponyi and Molnar, 1969), Czechoslovakia (Hanek, 1968), Great Britain (Mugridge et al., 1982), France (Lescher-Moutoue, 1979), and Finland (Tuuha et al., 1992). It has also been reported in Cuba (Prieto, 1991), and in 1994 it was found in Saginaw Bay, Lake Huron, Michigan, in 4 species of fish (Hudson and Bowen, 2002). There have been 2 recent studies on *N. japonicus* in Europe, from Germany (Knopf and Hölker, 2005) and Italy (Alfonso and Belmonte, 2010), and 1 from Mexico (Suarez-Morales et al., 2010). The purpose of this study was to investigate the extent of *N. japonicus* infection in rudd in Lake Sapanca, Turkey.

Study area

Lake Sapanca is located in the northeast Marmara region (40°41′N-40°44′N, 30°09′E-30°20′E). It has a surface area of 47 km^2 and a maximum depth of 52 m. It has 1 outlet, 13 streams flow into it, and it

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is partly fed by groundwater. It is of tectonic origin and one of the most important lakes in the region. The lake is an important source of fisheries and drinking and process water, and it is also a significant recreation area. It is naturally oligotrophic (Albay et al., 2003), but nutrient discharge from municipal wastes, industrial wastes, and agricultural runoff have made it oligomesotrophic. There are 21 fish species inhabiting in the lake (Okgerman et al., 2006).

Materials and methods

A total of 132 rudd (*Scardinius erythrophthalmus*), 74 males and 58 females of mean length 24.93 ± 3.65 cm (range: 15.2-34.0 cm), were examined each month between March 2009 and February 2010, excluding January and February. The fish were caught by local fishermen and carried live to the laboratory in water from the lake. After sacrificing them, total length and sex were recorded. The fish specimens were examined for the presence of *N. japonicus* on the dorsal, pectoral, pelvic, anal, and caudal fins and on the gills by stereomicroscope at magnifications ranging from 10× to 25×. Ergasilid specimens were removed from the fish host, fixed with 4% formalin, and transferred to 70% ethanol. The parasites were then cleared and softened in glycerin, mounted in glycerin jelly on glass microscope slides, placed under glass coverslips, and examined by light microscope at magnifications ranging from 40× to 100×. Specimens were measured by photographing slides with a Sony CCD color video camera, storing the images on CD, and displaying them on a computer screen. Unless otherwise indicated, all dimensions are presented in micrometers. As voucher specimens, 20 adult females of *N. japonicus* were deposited. The parasite was identified using the keys of Bauer (1987) as well as certain basic characteristics for species description used by Abdelhalim et al. (1993), Hayden and Rogers (1998), and Alfonso and Belmonte (2010).

Results

Neoergasilus japonicus were found on 31 of the 132 *S. erythrophthalmus* specimens examined between March 2009 and February 2010. They were found only between June and November. Of the total 467 adult female *N. japonicus* specimens recorded on the fish host, 261 (55.9%) were on the anal, 179 (38.3%) on the dorsal, 9 (1.9%) on the pectoral, 7 (1.6%) on the pelvic, and 8 (1.7%) on the caudal fins; 3 (0.6%) were on the gills. Table 1 shows these distributions for each month. The majority of the parasites were attached to the base of the fins. In November only, all of the *N. japonicus* specimens lacked egg sacs. Parasite prevalences for the months of June-November were 18.2%, 75.0%, 53.8%, 61.5%, 38.5%, and 33.3%, respectively. Table 2 shows the number of fish examined and infected, and the prevalence, mean intensity, and mean abundance of parasites for each month. Figure 1 shows the monthly prevalence of *N. japonicus* infection according to sex. This was highest at around 80% in females during July, September, and October; in males during the same period, the infection rate decreased from 66.6% in July to 12.5% in October.

Table 1. Preferred sites of attachment of *Neoergasilus japonicus* on rudd in Lake Sapanca.

	Anal fin	Dorsal fin	Pectoral fin	Pelvic fin	Caudal fin	Gill
June	17	1	-	-	-	-
July	43	91	-	1	-	-
August	81	23	3	2	3	2
September	68	43	5	2	4	1
October	27	4	1	-	1	-
November	25	17	-	2	-	-
Total	261	179	9	7	8	3
%	55.9%	38.3%	1.9%	1.6%	1.7%	0.6%

Table 2. Infection parameters of rudd by *Neoergasilus japonicus* between June and November in Lake Sapanca.

Months	EFN	IFN	P (%)	TPN	MI	MA
June	11	2	18.2	18	9.0	1.6
July	8	6	75.0	135	22.5	16.9
August	13	7	53.8	114	16.3	8.8
September	13	8	61.5	123	15.4	9.5
October	13	5	38.5	33	6.6	2.5
November	9	3	33.3	44	14.7	4.9

EFN: examined fish number, IFN: infected fish number, P: prevalence, TPN: total parasite number, MI: mean intensity, MA: mean abundance.

Description

Average overall length of *Neoergasilus japonicus* from cephalosome to uropods was 759 µm (746-793 µm). Ergasiliform body, 4 free thoracic segments, and reduced fifth segment (Figure 2a). Each uropod has 1 small and naked ventrolateral seta, 1 small ventrodistal seta, and 2 long naked terminal setae (Figure 2b). First antenna 6-segmented (Figure 2c). Second antenna 4-segmented with 1 well-developed spine at distal end of basal segment, 1 small spiniform seta on the inner margin of second segment, third segment strongly recurved, and fourth segment pointed claw (Figure 2d). Mouth parts located ventrally, mandible 2-segmented with terminal sickle of denticle on distal end (Figure 2e). First maxilla unsegmented lobe with 2 setae on posterior margin and on medial margin with a spiniform seta (Figure 2f). Second maxilla 2-segmented; first segment becomes thinner distally with an apical process containing a great number of teeth (Figure 2g). Both rami (exopod-endopod) of swimming legs 1-3 are 3-segmented. Basis of legs 1-4 with single, naked seta (Figures 3a-3c). Swimming legs 1-4 bear pinnate seta on rami. Triangular process between 2 rami on the second basic segment of leg 1, first segment of exopod with pectinate spine, and second segment of exopod modified to a paddle-shaped spine. Third segment with 2 pectinate spines and 5 setae, first and second segment of endopod with 1 medial seta, and third segment with 2 pectinate spines and 4 setae (Figure 3a). Second leg with pectinate spine on first segment of exopod, 1 medial seta on second segment, 1 terminal spine, and 6 setae on third segment. First segment of endopod with 1 medial seta, second segment with 2 medial seta, and third segment with 1 terminal spine and 4 setae (Figure 3b). Third leg with 1 pectinate spine on first segment of exopod, second and third segment with 1 medial seta, and third segment with 5 terminal setae. First segment of endopod with 1 and second segment with 2 setae, third segment with 1 pectinate spine and 4 setae (Figure 3c). Fourth leg biramous with 1-segmented rami, exopod with 4 setae and endopod with 2 setae, basipodite bears a seta on external margin (Figure 3d). Fifth leg uniramous with 3 naked setae (Figure 3e).

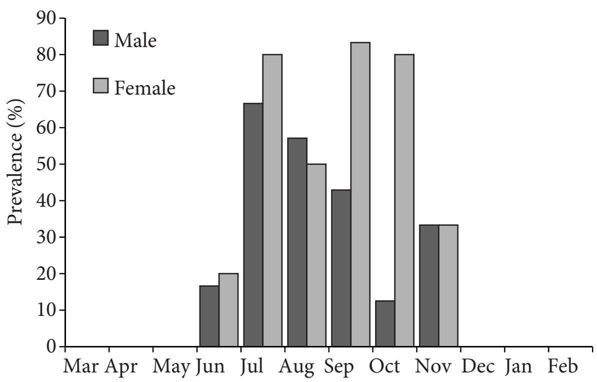

Figure 1. Monthly prevalence of infection of rudd by *Neoergasilus japonicus* in Lake Sapanca according to sex.

Discussion

Globalization of aquaculture (marine and freshwater) and inadequate quarantine standards

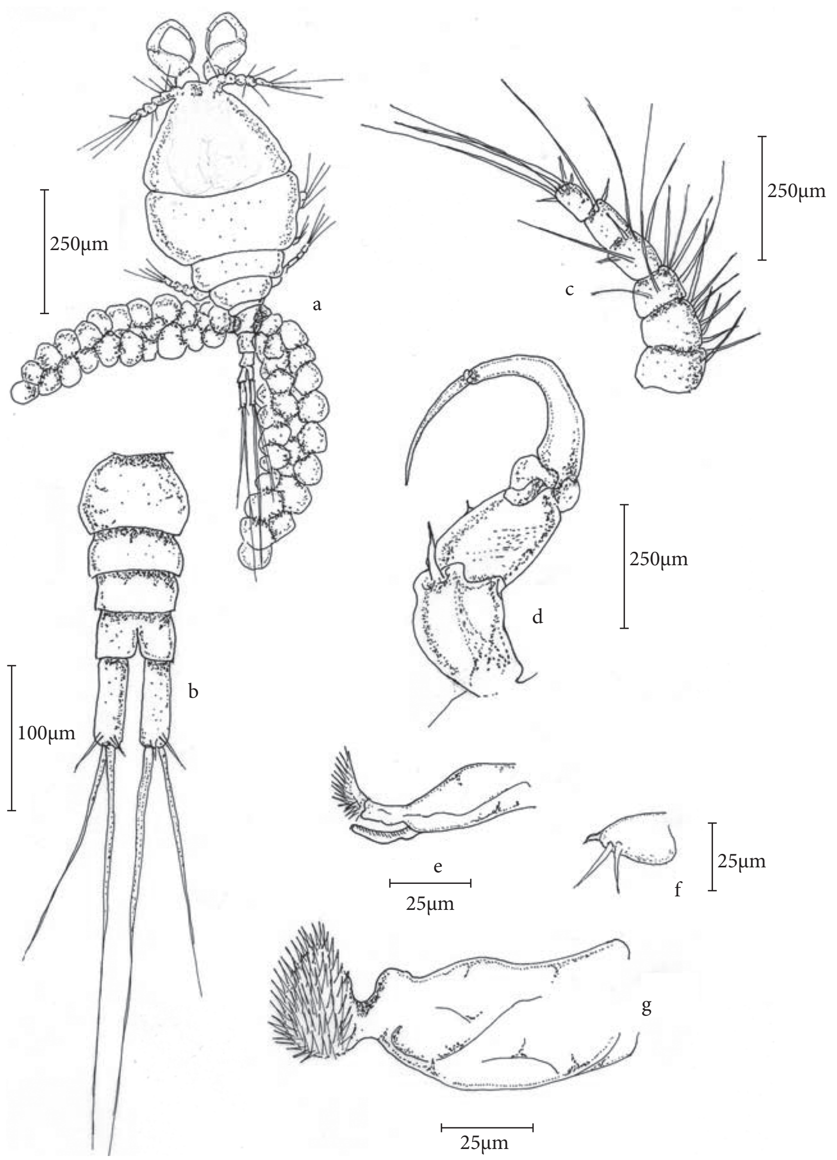

Figure 2. *Neoergasilus japonicus*: a) dorsal view, b) ventral view of genital complex (without egg sacs), c) first antenna, d) second antenna, e) mandible, f) first maxilla, g) second maxilla.

have facilitated the introduction of parasites into new environments; this has harmed native aquatic organisms. The routes of *N. japonicus* invasion have been linked to unintentional releases from sources such as the worldwide live fish trade and ballast water introduction (Knopf and Hölker, 2005). Over 1000 nonindigenous species have been reported in marine estuaries and freshwater habitats in North America, Europe, and Australia (Grigorovich et al., 2003). *N. japonicus* is one such nonindigenous species. It has little host specificity and is found on various fish species. It has been introduced into other countries, transported on exotic fish hosts associated with aquaculture, and it is found only in freshwater (Hayden and Roger, 1998). Adult males and larvae of ergasilids are free-living, and only adult females are parasitic (Kabata, 1979). Most investigations of *N. japonicus* have been connected with fish

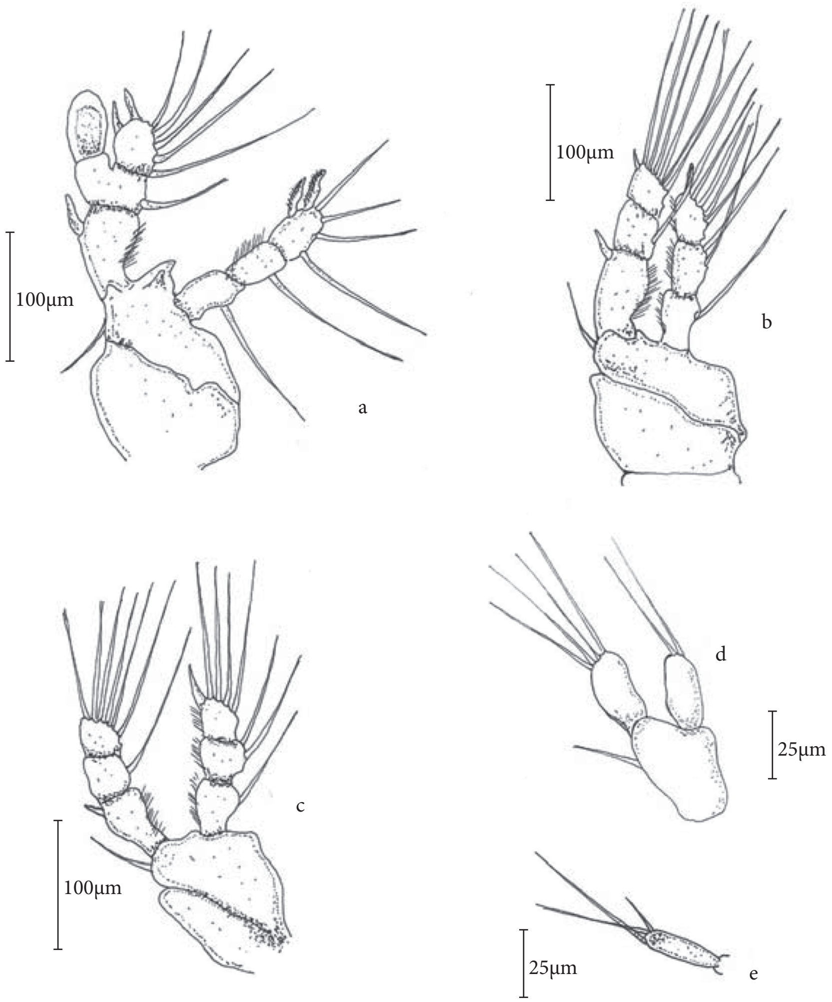

Figure 3. *Neoergasilus japonicus*: a) leg 1, b) leg 2, c) leg 3, d) leg 4, e) leg 5.

infection (Tuuha et al., 1992; Hayden and Roger, 1998; Hudson and Bowen, 2002; Knopf and Hölker, 2005), although a few have been connected with free-living zooplankton (Baud et al., 2004; Alfonso and Belmonte, 2010).

The present study determined infection parameters and morphological characteristics of *N. japonicus.* We observed 2 spines and 4 setae on the third segment of the endopod of the first swimming leg (Figure 3a), and this description is in accordance with the findings of Harada (1930), Urawa et al. (1980), Mugridge et al. (1982), Hayden and Rogers (1998), and Alfonso and Belmonte (2010). Consistent with Alfonso and Belmonte (2010), but not with Hayden and Rogers (1998), we observed a seta on the external margin of the basipodite of the fourth swimming leg (Figure 3d).

N. japonicus is mainly found loosely attached to the fins of the host (Tuuha et al., 1992; Knopf and Hölker, 2005). We found *N. japonicus* on all fins, but mainly on the anal and dorsal fins and only in limited numbers on the gills of the rudd (Table 1). The following site preferences have been reported by others: dorsal fins and base of the anal fins (Hayden and Rogers, 1998); dorsal, pelvic, anal, and caudal fins (Hudson and Bowen, 2002); anal fin only (Knopf and Hölker, 2005); and occasionally on the gills (Baud et al., 2004). *N. japonicus* was found between June and November, which may be related to the thermal regime of the oligomesotrophic Lake Sapanca and the migration of the fish host to deep water after November. Tuuha et al. (1992) stated that seasonal variation in the prevalence of *N. japonicus* infection can vary between lakes. In Lake Sapanca, we also found *N. japonicus* on the anal fins of *Tinca tinca*. Our future studies will investigate the extent to which this copepod parasite has infected other fish species, especially cyprinids, in Lake Sapanca.

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