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New host and distribution records of the gill parasite *Dactylogyrus sphyrnoides* Gussev, 1976 (Platyhelminthes, Monogenoidea) on a Near Threatened Tor Barb, *Tor tor* (Hamilton, 1822) (Teleostei, Cyprinidae), in northeastern India

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During copyediting, an error in the year of publication of the Tor Barb, *Tor tor* was made. In both the title and abstract *Tor tor* (Hamilton, 1922) should be *Tor tor* (Hamilton, 1822). The editors sincerely apologize for this error.

The publication, as previously published, begins on the next page.

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New host and distribution records of the gill parasite *Dactylogyrus sphyrnoides* Gussev, 1976 (Platyhelminthes, Monogenoidea) on a Near Threatened Tor Barb, *Tor tor* (Hamilton, 1922) (Teleostei, Cyprinidae), in northeastern India

Amit Tripathi*, **Leki Wangchu** and **Dobiam Narba**

Department of Zoology, Rajiv Gandhi University, Itanagar - 791111, Arunachal Pradesh, India
* Corresponding author. E-mail: amit.tripathi@rgu.ac.in

Abstract: The parasitic monogenoid *Dactylogyrus sphyrnoides* Gussev, 1976 was recorded for the first time on the gills of the Near Threatened freshwater fish *Tor tor* (Hamilton, 1922) that was collected in northeastern India. *Dactylogyrus sphyrnoides* was originally described from specimens infecting the gills of *Barbus sarana* Hamilton, 1822 in southern India. Our specimens conform to the original description of the species in all morphometric characteristics. Our report establishes a new host and distribution records for *D. sphyrnoides* and adds to the growing list of parasitic monogenoids exhibiting low host specificity.

Key words: monogenoid, parasite, host specificity, conservation

Tor tor (Hamilton 1822), Tor Barb, (Teleostei, Cyprinidae) is an important fish in subcontinental India (Froese and Pauly 2015) that has long been utilized for food, sport, and traditional medicine purposes (IUCN 2010). Unfortunately because of rapid population declines throughout its distribution range, this species is assessed as Near Threatened in the Red Data List of Threatened Species (IUCN 2010). Despite the socio-economic importance and the Near Threatened status of the *T. tor*, the parasites of this fish are poorly known. The published parasitic records for *T. tor* include a monogenoid species, *Dactylogyrus tori* (Gusev 1976), an unidentified nematode species (Malhotra 1982), and an unidentified fungal species (Khulbe et al. 1995). This study assesses the health status of *T. tor* with respect to the monogenoids, and contributes towards baseline parasitic data, which can be used in the protection and conservation of this important fish species.

In February 2015, 19 adult live specimens of *T. tor* (total length: 11 to 28 cm) were captured using nets in the River Ichi, Arunachal Pradesh, northeastern India (27°52′ N, 094°46′ E) (Figure 1). These fish, with their parasites, were fixed in lukewarm 4% formalin and transferred to 70% ethanol. The gills were excised and examined under a stereomicroscope (Leica© EZ 4HD) for the presence of ectoparasites. All fish were infected with one or more species of Monogenoidea and sometimes also with a species of Copepoda. The procedures of staining and mounting of monogenoids followed Kritsky et al. (1986). The mounted flatworms were photographed with a digital camera (ProgRes© Capture Pro V2.8.8) attached to a microscope equipped with phase-contrast optics (Olympus© CX41). Based on these photographs, illustrations were drawn on a digitizing tablet (WACOM) using Adobe Illustrator© 6 software, and measurements (in micrometers) were obtained with the software ProExpress© 6.0 (Media Cybernetics, Inc., USA). Identifications and morphometric characteristics follow Gussev (1976). Fish nomenclature follows Froese and Pauly (2015). Voucher specimens were deposited in the British Natural History Museum, UK (NHMUK 2015.9.29.1-8.). The prevalence (percentage of infected hosts in a sample), and mean intensity (mean number of parasites per infected host in a sample) of infection were calculated according to Bush et al. (1997). Arunachal Pradesh Biodiversity Board granted the permission to collect the specimens of *T. tor*.

Using morphometric characteristics, one of the monogenoid species was identified as *Dactylogyrus sphyrnoides* Gussev, 1976 [prevalence 100% (19/19); mean intensity 7]. Gussev (1976) originally described *D. sphyrnoides* from the gills of *Barbus sarana,* now *Systomus sarana* (Hamilton, 1822), collected in Tamil Nadu, southern India. *Dactylogyrus sphyrnoides* has not been reported since then. This species of monogenoid

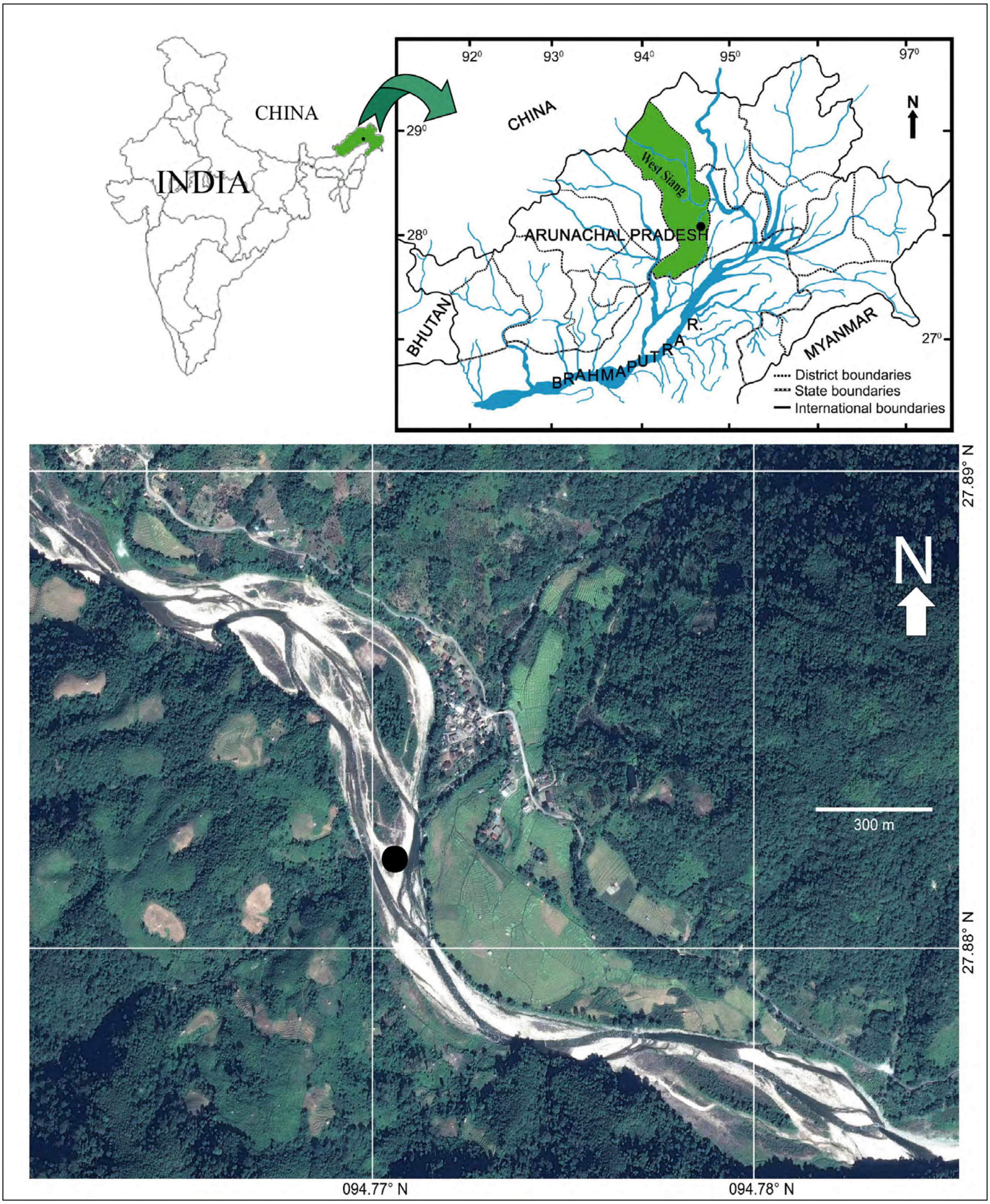

Figure 1. Collection site of *Tor tor* in Arunachal Pradesh, India (satellite image from Google Earth™).

is characterised by the presence of a uniquely shaped sphyrnoid anchor and a large 5th pair of hooks, which is almost the size of the dorsal anchor. The morphometric data of our specimens of *D. sphyrnoides* are summarised and compared with Gussev's (1976) data in Table 1, and our specimens correspond with those data. Gussev (1976) could not locate the vagina and egg of *D. sphyrnoides*, which we observed in our specimens (Figures 2–9). The vagina is a lightly sclerotised tube, 36 µm (35–37 µm; n = 6) long with slightly funnel-shaped

Table 1. A comparison of measurements (mean values, in micrometers, followed by range in the parentheses) of *Dactylogyrus shyrnoides* from *Tor tor* in northeastern India (present study) and *Systoma sarana* in southern India (Gussev 1976).

	Present study	Gussev (1976)
Body		
Total body length	514 (439–601)	700
Total body width	156 (118–177)	150
Pharynx diameter	28 (27–29)	32
Male organs		
Copulatory tube	144 (138–157)	11–142
Accessory piece	67 (61–79)	52–60
Testis length	—	—
Female organs		
Vagina length	36 (35–38)	—
Ovary length	54	—
Ovary width	31	—
Haptoral parts		
Dorsal anchor length	38 (37–42)	37–41
Point	13 (12–15)	12–13
Dorsal bar length	35 (35–36)	37–40
Hooks (5)	37 (31–44)	45–52
Hooks (1–4, 6 and 7)	12–22	19–30
Egg		
Egg length	120	—
Egg width	61	—

expansion at the body margin. The egg is oval, with a very short knob-like filament at its posterior end, 120 μm (118–121 μm; $n = 6$) long × 61 μm (59–62 μm; $n = 6$) wide.

The monogenoid species, other than *D. tori* and *D. sphyrnoides*, observed on *T. tor* are apparently new species, and will be published on separately.

The high prevalence rate reported herein indicates that the *T. tor* is a favoured host for *D. sphyrnoides*. The finding of eggs, both inside the parasite's body and on the gills of the fish host, further confirms that *D. sphyrnoides* lives and reproduces successfully on *T. tor*. This fish host is, therefore, more than just an occasional or accidental host. Our report establishes *T. tor* as a new host record for *D. sphyrnoides* and extends the geographic distribution of this monogenoid northeast to Arunachal Pradesh.

Host specificity is the restriction of a parasite to certain host species for maximizing its reproductive success (Kennedy 1975). Monogenoids have long been considered the most host-specific of all fish parasites (Llewellyn 1956; Rohde 1978). However, many authors recently believe that monogenoids are probably less host-specific than previously thought (see Bakke et al.

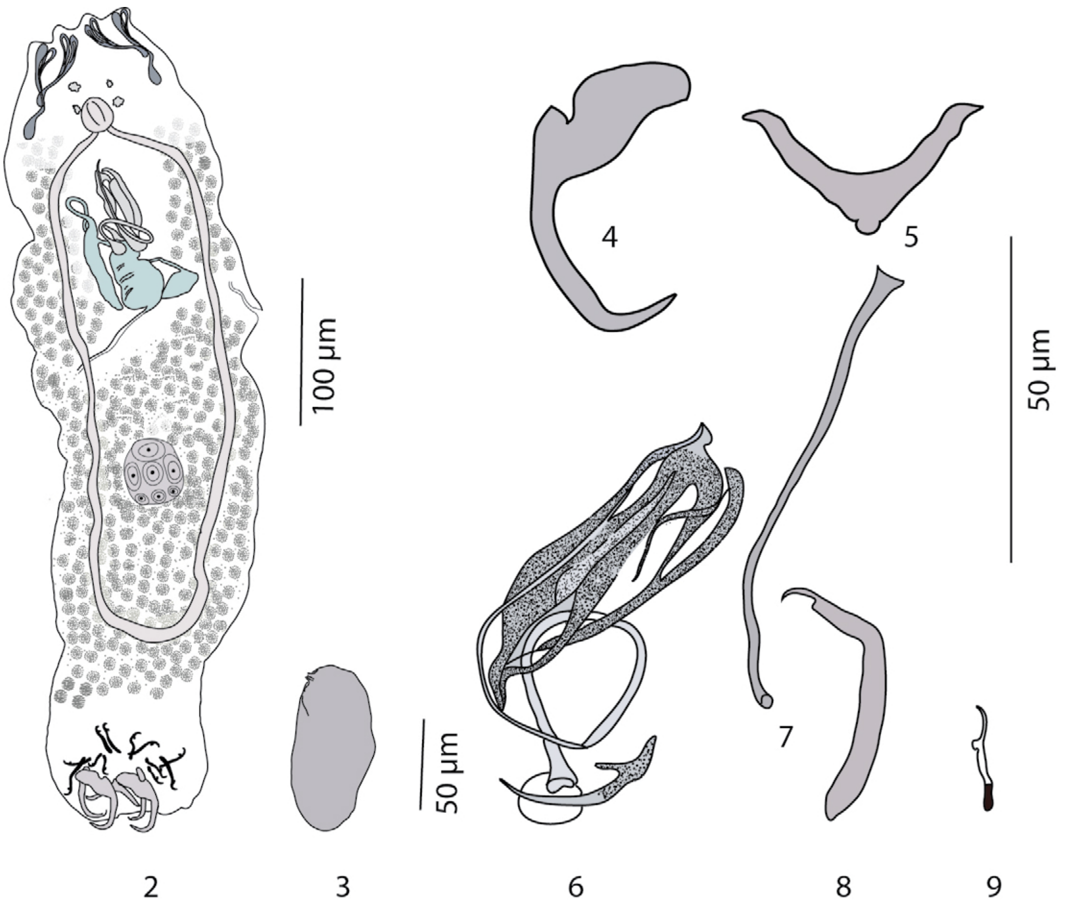

Figure 2–9. *Dactylogyrus sphyrnoides* Gussev, 1976 from *Tor tor.* **2:** Whole mount (dorsal view). **3:** Egg. **4:** Dorsal anchor. **5:** Dorsal bar. **6:** Copulatory complex. **7:** Vagina. **8:** Hook pair 5. **9:** Hook pair 1–4, 6 and 7.

1992; Rohde 1993; Whittington 1998). The apparent high host specificity of many monogenoids could be an artefact based on limited sampling of host fish and a corresponding knowledge of their parasites (Whittington 2000). Some of the well-documented monogenoids demonstrating low host specificity have recently been appraised by Tripathi (2014), and our finding of *D. sphyrnoides* infecting *T. tor* adds to the growing list of parasitic monogenoids with low host specificity.

The eggs of oviparous monogenoids, including *D. sphyrnoides*, have a short polar filament at their posterior end that keeps them suspended in the water column. These suspended eggs, and sometimes their free-swimming ciliated larvae that emerge from them, are then carried to a new host by currents. Considering that the transmission of monogenoids to new hosts is direct and depends primarily on water currents, the ability of *D. sphyrnoides* to exploit two non-congeneric hosts may be explained by the shared ecologies of its hosts. For example, both *S. sarana* and *T. tor* are freshwater, benthopelagic, potamodromous, and bottom-feeding fish, in addition to being omnivores (see Froese and Pauly 2015). However, it unknown whether *T. tor* or *S. sarana* is the optimal host for *D. sphyrnoides*. We hypothesise that *T. tor* is the optimal host. Bagge et al. (2004) suggested that a minimum fish population size is necessary for the proliferation of monogenoids. Because the population size of *T. tor* is declining throughout its range, the availability of new host individuals may be a limiting factor for *D. sphyrnoides* populations. Thus, a part of the *D. sphyrnoides* population may have found an alternative host population (*S. sarana,* a common, widespread species with no known major threats) that represents a more stable host environment with a similar and/or overlapping ecology.

The high infection rate of *T. tor* by multiple monogenoid species and at least one unidentified copepod species is of great concern, considering the Near Threatened status of this fish. A heavy infection rate of parasitic monogenoids can be lethal, especially to younger fish and those in intensive culture/captive conditions (Thoney and Hargis 1991). Here, we do not intend to establish parasitic aetiology as a cause of the declining rate of *T. tor* because the mortalities in natural populations are affected by a combination of factors that are not easily determined. However, because parasitic infections play a key role in conservation biology by regulating the abundance of their host populations, a more comprehensive parasitological study of *T. tor* involving multiple parasites, from viruses to bacteria to fungi to metazoans, is urgently required. The baseline data generated will help implementing any future control and management strategies to recover and conserve *T. tor*.

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