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The first occurrence of *Neotrichoporoides nyemitawus* (Rohwer, 1921) (Hymenoptera: Eulophidae) in the West Palaearctic with a key to the known species from Iran

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Abstract. Through a survey that was conducted from 2020 to 2021, specimens were collected from wheat fields (*Triticum aestivum* L.) in West Azarbaijan province in the northwest of Iran using a sweep net. These are *Neotrichoporoides nyemitawus* (Rohwer, 1921), a new report for Iranian fauna and the West Palaearctic subregion. Illustrations of *N. nyemitawus* are provided, and its morphological characters are discussed. *Neotrichoporoides* Girault, 1913 in Iran, is represented by two species, *N. szelenyii* (Erdös, 1951) and *N. viridimaculatus* (Fullaway, 1955). Hereby, an identification key for Iranian species was provided. A worldwide distribution map of *N. nyemitawus* is also presented. Its role as the most important biocontrol agent of the shoot flies, *Atherigona* spp. (Diptera: Muscidae) was discussed.

Keywords: *Atherigona*, Biological control, new record, parasitoid, shoot flies, Tetrastichinae.

The family Eulophidae (Hym., Chalcidoidea) is the largest in the superfamily, with ca. 6000 species in 328 genera (Noyes 2019). This family in Iran has 180 species in 44 genera (Hesami et al. 2018, Jafarlu et al. 2021, 2022, Karimpour et al. 2023). The genus *Neotrichoporoides* Girault, 1913 has 73 described species worldwide, of which 27 are distributed in the Palaearctic region (Noyes 2019), and two are in Iran (Hesami et al. 2018). This genus with type-species *Neotrichoporoides uniguttatus* was described by Girault (1913). Species of *Neotrichoporoides* are generally primary parasitoids of Diptera (Bouček 1988, La Salle 1994). *Neotrichoporoides* is readily recognized from other members of the Tetrastichinae using the following morphological characters: Body with a distinct metallic lustre, and in some species, many parts of the body with mostly to entirely yellowish color; funiculars usually moderately to extremely long; propodeum distinctly longer than the dorsellum and often with a distinct reticulate sculpture; fore wing with marginal vein 5.5–9.5× as long as the length of stigmal vein; stigma is short and has a short stem (Graham 1987). Some species of the genus *Neotrichoporoides* are efficient biological control agents for several species of shoot flies, *Atherigona* spp. (Diptera: Muscidae) (Rawat & Sahu 1968, Raodeo et al. 1972, Taley & Thakare 1979, Meksongsee et al. 1981, Zongo et al. 1993, Sileshi 1997, Singh & Sharma 2002, Kalaisekar et al. 2017).

Shoot flies (*Atherigona* spp.) cause serious damage to seedlings and tender stems of the plant, which leads to dead hearts (Deeming 1971, Pont & Magpayo 1995, Chamarthi et al. 2011). The degree of importance of the mentioned pests is different, but generally, their damage is significant in the initial stages of plant growth because they attack the plant when it is still weak (Emden 2013, Baxter et al. 2014); this time generally coincides with 1–6 weeks after the plant germination (Gahukar 1987). The most damage caused by shoot flies is observed in the fields cultivated late (Barry 1972, Ameta & Sumeria 2004). So far, nine species of *Atherigona* have been reported in Iran including *A. laevigata* (Loew), *A. naqvii* Steyskal, *A. orientalis* (Schiner), *A. ponti* Deeming, *A. reversura* Villeneuve, *A. soccata* Rondani, *A. theodori* Hennig, *A. varia* (Meigen), and *A. yorki* Deeming (Kamali et al.1976, Parchami-Araghi et al. 2020), which are important pests of Barley (*Hordeum* spp.), Maize (*Zea mays* L.), Millet (*Eleusine* spp., *Panicum* spp., *Pennisetum* spp.), Oat (*Avena* spp.), Rice (*Oryza sativa* L.), Sorghum (*Sorghum* spp.), and Wheat (*Triticum aestivum* L.) (Deeming 1971, Barry 1972, Kamali et al. 1976, Zongo et al. 1993, Pont & Magpayo 1995, Chamarthi et al. 2011). The present study aims to (1) report a new record for the Iranian fauna, (2) compare the diagnostic characters of this species with the previously reported species in Iran, and provide a key to identify the Iranian species, (3) review of the efficiency of the newly reported wasp as the most effective parasitoid of shoot flies larvae.

In the present study, sampling was done using a sweep net on wheat fields during 2020–2021 in the Khoy region in West Azerbaijan province. These collected specimens were captured by an aspirator and then killed by sub-zero temperature. Afterward, these specimens were transferred to 75% ethanol. During the examination of the samples using a ZEISS-Stemi SV8 stereomicroscope, species belonging to the Eulophidae family were found, which were treated in the same way as the Noyes (1982). The morphological characteristics of the specimens were studied using an Olympus SZH stereomicroscope. To identify the specimens at the genus and species level, Graham (1987) was used. Subsequently, the identified specimens were confirmed at the genus level by Dr. Christer Hansson and at the species level by the third author. For imaging, an Olympus SZH stereomicroscope and a mobile phone camera (with 13 megapixels resolution) were used. Then, assembling and editing photos in the plates was done with Adobe Photoshop CC software (2015.0.0 Release). Morphological terminology follows Yoder et al. (2010). Identified specimens were deposited in the Plant Protection Department of Urmia University (PPDUU).

During the present research, 10 specimens were collected from the wheat fields of the Khoy region in West Azerbaijan province. These specimens were identified as *Neotrichoporoides nyemitawus* (Rohwer, 1921), a new record

for Iranian fauna and the West Palaearctic subregion. Including the new record for Iranian fauna, the number of *Neotrichoporoides* species in Iran increased to three.

Taxonomic account

Order: Hymenoptera Linneaus 1758
Superfamily: Chalcidoidea Latreille, 1817
Family: Eulophidae Westwood, 1829
Subfamily: Tetrastichinae Foerster, 1856
Genus: *Neotrichoporoides* Girault, 1913

Neotrichoporoides nyemitawus
(Rohwer, 1921) (Fig. 1)

Tetrastichus nyemitawus Rohwer, 1921
Tetrastichus agarwali Shafee, Fatma and Kishore, 1984

Material examined. IRAN - West Azarbaijan province • 4 ♀♀ (PPDUU): Khoy; 38° 26′41.316″ N, 45°1′47.498‴ E; 1194 m a.s.l. July 18, 2020; swept on Wheat (*Triticum aestivum* L.); M. jafarlu leg. • 6 ♀♀ (PPDUU): Khoy; 38°33′20.798″ N, 44°53′25.079″ E; 1218 m a.s.l.; September 13, 2021; same data as for preceding.

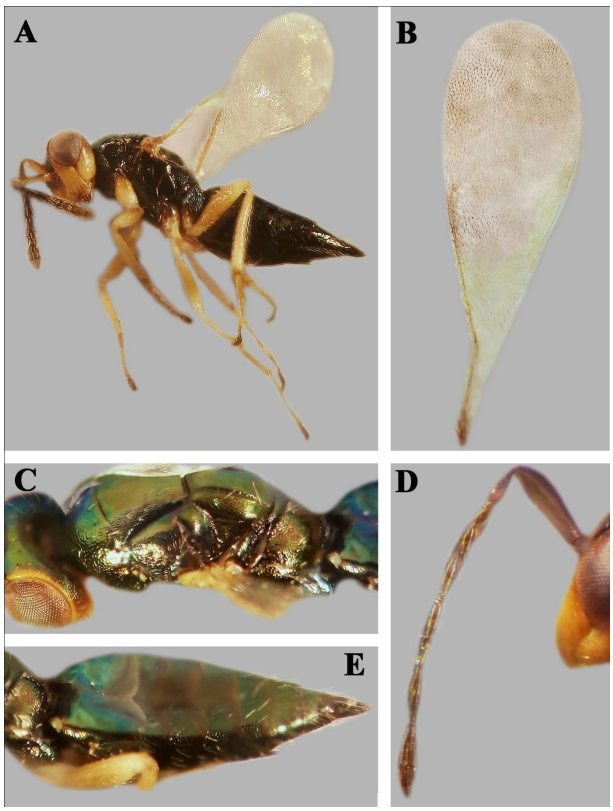

Figure 1. *Neotrichoporoides nyemitawus*, female: A. Habitus, lateral view; B. Fore wing; C. Head and mesosoma, dorsal view; D. Head and antenna, latero-dorsal view; E. Propodeum and metasoma, latero-dorsal view.

Diagnosis. Female. Body generally metallic green with yellow markings in some parts (Figs 1A, C, D, E); thorax mostly metallic green (Fig. 1C); lower half of face yellow (Figs 1A, D); gaster metallic green to light brownish green (Fig. 1E); legs yellow, hind coxa distinctly reticulate and metallic green (Fig. 1A). Malar groove below the compound eye with a medium-sized cavity, the size of which approximately 0.3× as long as the length of the malar space. Antennal scape 0.97× as long as the length of the compound eye; flagellum narrow and almost filiform; first funicular 2.2× as long as the length of pedicel and 5.3× as long as broad (Figs 1A, D). Forewing 3× as long as broad; submarginal vein with 5 dorsal setae (Figs 1A, B).

Primary hosts. Several species of *Atherigona* (Dip.: Muscidae), including *Atherigona conigera*, *A. hyalinipennis*, *A. naqvii*, *A. soccata*, *A. varia* (Noyes 2019). Of which, the last three species were known from Iran (Kamali et al. 1976, Parchami-Araghi et al. 2020).

Distribution. AFROTROPICAL: Burkina Faso (Zongo et al. 1993), Ethiopia (Sileshi 1997), Kenya (Graham 1987); ORIENTAL: India (Rohwer 1921), Thailand (Graham 1987); PALAEARCTIC: China (Zhu & Huang 2001, Li & Li 2021), and Iran (new record) (Fig. 2).

Figure 2. Worldwide distribution map of *Neotrichoporoides nyemitawus*

Key to the Iranian species of the genus *Neotrichoporoides* Girault, 1913 (based on female).

1. Body predominantly yellow with dark longitudinal marks in its different parts; marginal vein more than 8× as long as stigmal vein; scape with the same length as the eye or 1.1× it; malar sulcus with a small fovea under the eye; propodeum surface relatively dull ..... ……. ***Neotrichoporoides viridimaculatus*** **(Fullaway, 1955)**

- Body mostly metallic green to black with yellow marks in some parts or not; marginal vein at most 7× as long as stigmal vein; scape at most 0.97× as long as the length of the eye, and never exceeds the length of the latter; malar sulcus with a larger fovea under the eye; propodeum surface more shiny **2**

2. Lower half of face yellow; first funicular 2.2–2.4× as long as the length of the pedicel, and with the same length as clava or only slightly longer; gaster 3× as long as broad ..... ***Neotrichoporoides nyemitawus*** **(Rohwer, 1921)**

- The lower half of face green; first funicular at most 2× as long as the length of the pedicel, and a little shorter than the clava; gaster 2–2.7× as long as broad **……**..... **…… ……** ***Neotrichoporoides szelenyii*** **(Erdos, 1951)**

Different control methods are used to reduce the damage of shoot flies (Kamatar & Salimath 2003, Chamarthi et al. 2011, Baxter et al. 2014). Seasonal precipitation can affect time-scheduled planting (Chamarthi et al. 2011), and the chemical measure doesn't fully control shoot fly populations (Talati & Upadhyay 1978, Baxter et al. 2014). In addition, the larvae of shoot flies tend to feed deep in the canopy; therefore, the pesticides are less effective (Baxter et al. 2014). While parasitic wasps such as *N. nyemitawus* and three braconids *Apanteles* sp., *Bobekia* sp., and *Phaedrotoma* sp. were reported on *Atherigona* species, *N. nyemitawus* was significantly the dominant parasitoid (Sileshi 1997). Similarly, in the study of the effect of several species of hymenopterous parasitoids, including *Bracon* sp. (Braconidae), *Hockeria* sp. (Chalcididae), *Spalangia endius* Walker, 1839 (Pteromalidae), and *Trichogrammatoidea simmondsi* Nagaraja, 1979 (Trichogrammatidae), in regulating the population of *Atherigona soccata* Rondani, the highest parasitism rate belonged to *N. nyemitawus* with a mortality rate of 21% (Kalaisekar et al. 2017). Furthermore, Zongo et al. (1993) considered *N. nyemitawus* as the most effective parasitoid of *Atherigona* larvae in field conditions, and it was introduced as a potential biological agent to control shoot fly populations. Singh and Sharma (2002) have also introduced *N. nyemitawus* as the most important parasitoid of *Atherigona* larvae.

We will further realize the importance of *N. nyemitawus* when it was a candidate for mass rearing within larval parasitoids of shoot flies in 11 families of Diptera and Hymenoptera (Taley & Thakare 1979, Zongo et al. 1993, Sileshi 1997, Singh & Sharma 2002, Kalaisekar et al. 2017). Due to its high parasitism potential on shoot flies larvae (Singh & Sharma 2002), relatively short egg-to-adult developmental time and high fecundity potential (168 eggs/female at 27°C) (Taley & Thakare 1979), high searching ability and finding host larvae in the canopy (Zongo et al. 1993), *N. nyemitawus* was evaluated as the most effective parasitoid of *Atherigona* larvae (Rawat & Sahu 1968, Raodeo et al. 1972, Taley & Thakare 1979, Meksongsee et al. 1981, Zongo et al. 1993, Sileshi 1997, Singh & Sharma 2002, Kalaisekar et al. 2017). Consequently, it has a good potential to be used in integrated pest management programs.

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