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New record of a biological control agent, *Cybocephalus nipponicus* Endrödy-Younga, 1971 (Coleoptera: Cybocephalidae) from Iran

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ABSTRACT. Here we report the presence of *Cybocephalus nipponicus* Endrödy-Younga, 1971 from Iran, which has been collected on mulberry in Gilan province, as well as on bitter orange and Japanese spindle in Mazandaran province, northern Iran. The specimens were collected while feeding on scale insects, *Pseudaulacaspis pentagona* (Targioni Tozzetti, 1886), *Unaspis euonymi* (Comstock, 1881) and *Lepidosaphes gloveri* (Packard, 1869) (Hemiptera: Diaspididae). Photos of habitus and genitalia with some taxonomic comments are presented.

Keywords: biocontrol, conservation, new record, predator, scale insects

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INTRODUCTION

Like other cybocephalid beetles, *Cybocephalus nipponicus* Endrödy-Younga, 1971 is a ravenous predator of pre-imaginal and adult stages of scale insects, which acts as an effective biological control agent. The biology and rearing process of *C. nipponicus* have been studied in detail by some specialists (Alvarez &

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Van Driesche, 1998a, 1998b; Smith & Cave, 2006). This species is native to Asia and the South Pacific but it has been released in the United States and established successfully. The reported hosts from the USA and West Indies include 17 Diaspididae and one Tetranychid species (Smith, 2022). The females of *C. nipponicus* usually lay three eggs per day under an armoured scale, which averages 288 eggs in its lifetime. It takes about seven weeks from egg to adult, and the total lifetime is between 11 to 14 weeks. The study showed that if the populations of scale insects survive all year, *C. nipponicus* could have three generations (Alvarez & Van Driesche, 1998a, 1998b).

Cybocephalus Erichson, 1844 comprises 178 species worldwide (Smith, 2021). In Iran, more than 10 species have been reported as recognized predators of scale insects (Gharib, 1973; Lachinani & Ahmadi, 1993; Yazdani & Ebrahimi, 1993; Kolahdooz Shahroodi et al., 2002; Jelínek & Audisio, 2007; Kirejtshuk & Fallahzadeh, 2008, 2010; Jalilvand et al., 2012). Among the reported species, *Cybocephalus assiduus* Kirejtshuk & Fallahzadeh was collected on fig wax scale, *Ceroplastes rusci* (Linnaeus) (Kirejtshuk & Fallahzadeh, 2008); *Cybocephalus aonidiellae* Kirejtshuk & Fallahzadeh on oriental yellow scale, *Aonidiella orientalis* (Newstead) (Kirejtshuk & Fallahzadeh, 2010); *Cybocephalus fodori minor* Endrödy - Younga on yellow pistachio hard scale, *Lepidosaphes pistaciae* Archangelskaya, Mediterranean fig scale *L. conchiformis* (Gemelin) and also on oystershell scale *L. malicola* (Borchsenius) (Kolahdooz Shahroodi et al., 2012). In this paper, we report the presence of a new biocontrol agent, *C. nipponicus*, for the fauna of Iran, which can be reared and released as an effective predator of armoured scale insects in this country.

MATERIAL AND METHODS

The specimens of *Cybocephalus nipponicus* were collected on branches of mulberry (*Morus alba*), and Japanese spindle (*Euonymus japonicus*) while feeding on scale insects in Rasht, Salman Shahr and Nashtarud districts, northern Iran. Specimens were studied using a stereomicroscope Zeiss® Stemi SV8. The morphological characters including genitalia were studied according to the methods described in Smith and Cave (2006). The photos of habitus were taken using a 650D Canon® digital camera through an Olympus® SZH stereomicroscope. The photos of male genitalia were taken by the same camera, through an Olympus® SZH microscope. The images were combined by the Helicon Focus 7 software. The classification of the family Cybocephalidae was confirmed according to the molecular phylogeny done by Cline et al. (2014). All specimens are preserved in Hayk Mirzayans Insect Museum (HMIM), Iranian Research Institute of Plant Protection, Tehran, Iran.

RESULTS

Taxonomic hierarchy

Class Insecta Linnaeus, 1758

Order Coleoptera Linnaeus, 1758

Family Cybocephalidae Jaquelin Du Val, 1858

Genus *Cybocephalus* Erichson, 1844

***Cybocephalus nipponicus* Endrödy-Younga, 1971** (Figs 1–2)

Material examined. 11♂♂ 10♀♀ (HMIM), IRAN, Gilan province, Rasht, Pasikhan, 37°16'52"N, 49°27'10"E, 23.VII.2023, Mulberry Garden, leg. B. Rafiei; 1♂ 1♀ (HMIM), IRAN, Mazandaran province, Salman-Shahr, 36°42'9"N, 51°11'42"E, VII.2023; 1♂ 2♀♀ Nashtarud, 36°45'5"N, 51°1'30"E, XII.2023, leg.: Chitgar.

Diagnostic characters. Length 1.0–12 mm. Male with yellow to orange head, pronotum, prosternum, mesosternum and legs. Females black with brownish legs. Dorsum glabrous with fine punctation, which is more visible on elytra. Antennal club truncate. Aedeagus with parallel sides basally, triangular apically (Fig. 2). According to Kirejtshuk and Fallahzadeh (2010), it differs from *Cybocephalus aonidiellae* Kirejtshuk & Fallahzadeh by lighter head and pronotum of males, coarser punctation and apically triangular tegmen.

Biological note. The beetles were reared with a colony of white peach scale, *Pseudaulacaspis pentagona*, kept in the laboratory of Gilan Agricultural and Natural Resources Research and Education Center, and the Biological Control Research Department, Iranian Research Institute of Plant Protection, Tehran. In the laboratory, *C. nipponicus* actively fed on the colonies of white peach scale, that were reared on Kiwifruit (*Actinida delicious* C.F. Liang & A.R. Ferguson) and pumpkin species (*Cucurbita moschata* Duchesne and *Cucurbita maxima* Duchesne) under controlled conditions of 25 ± 1°C and 70 ± 5% relative humidity in Gilan. In Tehran, it was active for about two weeks feeding on white peach scale at room temperature.

DISCUSSION

Although *Cybocephalus nipponicus* is native to Southeast Asia and the South Pacific (Endrödy-Younga, 1971; Tian, 2006), it has been recently introduced and dispersed in many countries. This biological control agent has been intentionally introduced to Korea, Thailand, Taiwan, South Africa and the United States (Smith & Cave, 2006; Smith & Bailey, 2007; Song et al., 2012; Labuschagne et al., 1996), but it seems to have accidentally dispersed in the Hawaiian Islands (Ewing, 2004), as well as in Europe, Italy (Lupi, 2002), Hungary (Merkl et al., 2017), Spain (Viñolas et al., 2017) and Romania (Pintilioaie & Mate, 2023). The introduction pathway of this species in Iran is not clear but due to its distribution in the Middle East, it is likely it has passively reached Iran with armoured scale on imported plants from East Asia, subsequently spreading with the host plants of the scale insects. Tanaka & Inoue (1980) mentioned that adults of *C. nipponicus* can feed on *Panonychus citri* (McGregor), but the females were unable to lay eggs. We observed *C. nipponicus* on *Morus alba* (mulberry trees) while feeding on *Pseudaulacaspis pentagona*, on *Citrus aurantium* trees feeding on *Lepidosaphes gloveri*, and on *Euonymus japonicus* (Japanese spindle) while feeding on *Unaspis euonymi*. This is the first report of the presence and activity of this effective biocontrol agent in Iran.

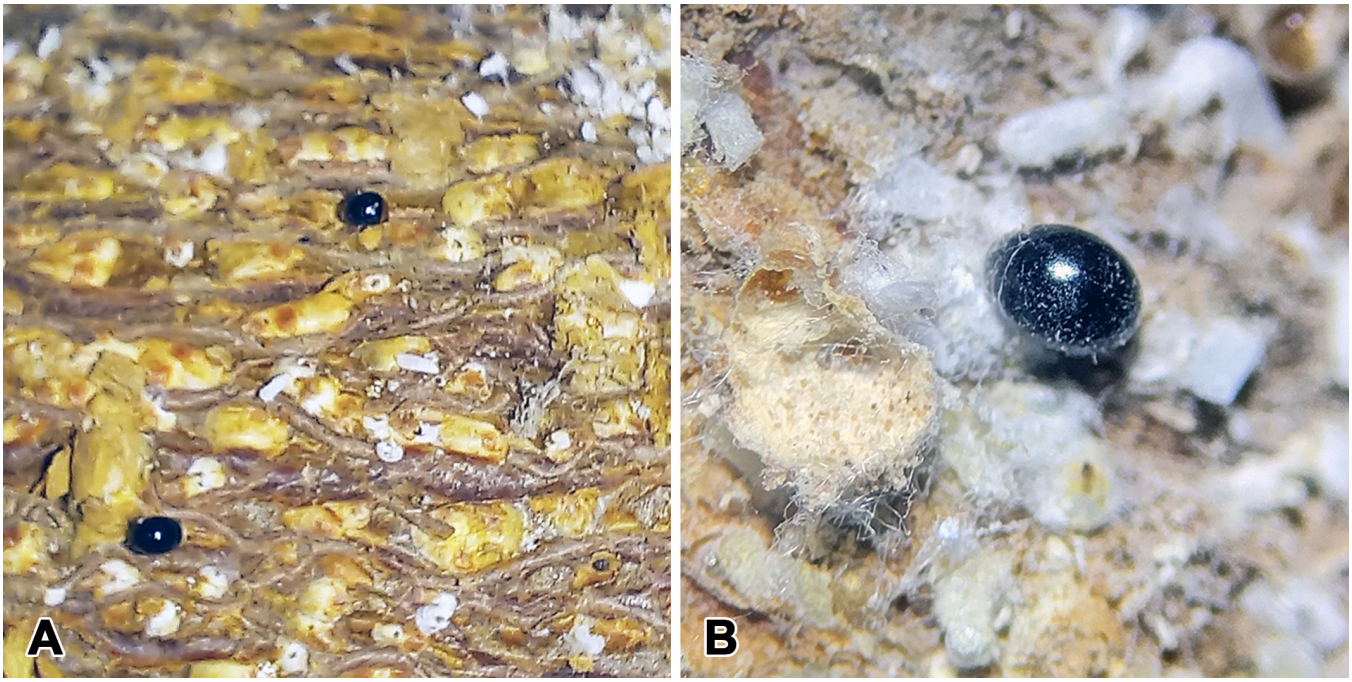

Figure 1. Activity of *Cybocephalus nipponicus* Endrödy-Younga, 1971 on *Pseudaulacaspis pentagona* (Targioni Tozzetti, 1886). **A.** Adult beetles among the colony; **B.** Close up view.

Figure 2. *Cybocephalus nipponicus* male: **A.** Dorsal view; **B.** Ventral view; **C.** Lateral view of habitus (Scale bar: 0.5 mm); **D.** Aedeagus, ventral view; **E.** Aedeagus, lateral view; **F.** Spermatheca.

AUTHOR'S CONTRIBUTION

The authors confirm their contribution to the paper as follows: S. Serri: Identifying the specimens, preparing the photograph of the mounted specimen, writing the manuscript and correspondence; S. Manzari, Sh. Farrokhi and B. Rafiee: Collecting the specimens and preparing the photographs of the live specimens; M. Gholamzadeh Chitgar: Collecting the specimens; P. Audisio: Confirming the identification of the specimens and revising the manuscript. All authors read and approved the final version of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

The specimens listed in this study are deposited in Hayk Mirzayans Insect Museum (HMIM), Iranian Research Institute of Plant Protection, Tehran, Iran and are available from the curator, upon request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study only included plants and arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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گزارش جدید از یک عامل مهار زیستی *Cybocephalus nipponicus* Endrödy-Younga, 1971 (Coleoptera: Cybocephalidae) از ایران

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چکیـده: گونهٔ *Cybocephalus nipponicus* Endrödy-Younga, 1971 برای اولین بار از ایران گزارش می‌شود. این گونه از باغ‌های توت استان گیلان و همچنین از روی درختان مرکبات و شمشاد طلایی استان مازندران در حال تغذیه از شپشک‌های سپردار *Pseudaulacaspis pentagona* (Targioni Tozzetti, 1886)، *Unaspis euonymi* (Comstock, 1881) و *Lepidosaphes gloveri* (Packard, 1869) جمع‌آوری شد. در این مقاله تصاویر حشره و نکات تاکسونومیک این گونه ارایه شد.

واژگـان کلیدی: مهار زیستی، حفاظت، گزارش جدید، شکارگر، شپشک سپردار