

Egg Parasitoids from Pakistan as Possible Classical Biological Control Agents of the Invasive Pest *Bagrada hilaris* (Heteroptera: Pentatomidae)¹

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The painted bug, *Bagrada hilaris* (Burmeister) (Heteroptera: Pentatomidae), has been found in the United States. Without its coevolved natural enemies it has become a serious threat to cole and other crops. The painted bug is native to eastern and southern Africa through western Asia (Map 417 1981, Distribution Maps of Pests, Commonwealth Agricultural Bureau). In the United States, it was first documented in coastal southern California in 2008 and, by 2012, it had dispersed to areas within Arizona, Nevada, Utah, New Mexico, and west Texas (Palumbo and Natwick 2010, Plant Health Progr. doi:10.1094/PHP-2010-0621-01-BR; Bundy et al. 2012, Southwest. Entomol. 37: 411–414; Reed et al. 2013, J. Integrated Pest Manag. 4: doi: <http://dx.doi.org/10.1603/IPM13007>). More recently, it was reported from cole crops in Coahuila, Mexico (Sánchez-Peña 2014, Southwest. Entomol. 39: 375–376). It is expected to continue to spread, threatening the commercial cole crop industry and ornamentals east of the Mississippi River. A classical biological control project was initiated in 2014 to discover and import key natural enemies within the area of origin of *B. hilaris* for quarantine evaluation in the United States. This is a report on initial results.

Surveys were conducted in 2014 throughout Pakistan for natural enemies of this pest pentatomid, focused on parasitoids associated with their eggs. Although well known as a pest of *Brassica* crops, this insect is highly polyphagous and has been previously reported in Pakistan from a wide range of plants including *Brassica oleracea* L., *Brassica rapa* L. (as *Brassica campestris* L.), *Brassica napus* L.,

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Raphanus sativus L., *Triticum aestivum* L., *Zea mays* L., *Cynodon dactylon* (L.) Persoon, *Sorghum sudanense* (Piper) Stapf, *Medicago sativa* L., *Ricinus communis* L., *Descurainia sophia* (L.) Webb ex Prantl (as *Sisymbrium sophia* L.), *Trifolium alexandrinum* L., *Chloris gayana* Kunth, *Cymbopogon distans* (Nees) J.F. Watson, *Cynodon plectostachyus* (K. Schumann) Pilger, napier hybrid *Pennisetum glaucum* (L.) Leeke ($\times$ *Pennisetum purpureum* Schumacher), and *Chenopodium album* L. (Cheema et al. 1973, Commonwealth Inst. Biol. Control Tech. Bull. 16: 47–67; Commonwealth Institute of Biological Control Pakistan Station, Rawalpindi 1969, Final Report 1959–69). Little is known of natural enemies associated with this insect in Pakistan. Among parasitoids, the tachinids *Alophora* (*Hyalomya*) *pusilla* Meigen from the western hills and *Parellophora indica* Mesnil from the northern foothills were reported; predators included the chrysopid *Chrysoperla carnea* Stephens and an unidentified spider attacking *B. hilaris* in Pakistan (Cheema et al. 1973). Past surveys of natural enemies were confined to pentatomids on Gramineae, and little effort was made to look for natural enemies of *B. hilaris* on other crops. Because the bug was reported to be highly invasive on cole crops in the United States, the current surveys in Pakistan concentrated on *Brassica* crops.

Exploration for egg parasitoids was greatly facilitated by the recent confirmation of the unique oviposition behavior of *B. hilaris*. Unlike most pentatomids that glue masses of eggs together onto plant material, *B. hilaris* normally deposits eggs singly into the soil (Taylor et al. 2014, Ann. Entomol. Soc. Am. 107: 872–877). Thus, sampling for eggs of painted bugs in the field was difficult. On the plains at Toba Tek Singh in the Punjab, it was observed in February–May that painted bug adults were aggregating on heaps of dry debris of Indian mustard, *Brassica juncea* (L.) Czerniak, and canola, *Brassica napus*. To determine if the material contained eggs, the plant debris was shaken onto a plastic sheet, and the material (leaves, soil particles, etc.) was brought to the laboratory and examined under a microscope. Eggs were subsequently discovered and placed in glass vials for possible emergence of parasitoids. To supplement these collections, eggs from field-collected *B. hilaris* adults, reared in the laboratory on cabbage, were glued to paper cards and stapled to the undersides of leaves of both *Brassica juncea* and *Brassica napus* at two unsprayed field sites where *B. hilaris* were detected in very low numbers. These sentinel eggs were recovered after 4 d of exposure in the field and brought to the laboratory and kept in glass vials for emergence of parasitoids. From these eggs, parasitoids began emerging in 15–18 d. In all, three hymenopterous parasitoid species were recovered: *Trissolcus* sp. and *Gryon* sp. (Platygastridae) and a uniparental *Ooencyrtus* sp. (Encyrtidae). Tables 1 and 2 show the results from the field-collected plant debris and from sentinel eggs from two sites on two dates. The number of each species was not recorded. Each parasitoid species was colonized and shipped to the U.S. Department of Agriculture–Agricultural Research Service Stoneville Research Quarantine Facility, National Biological Control Laboratory, Stoneville, MS, where they are being evaluated for possible release for establishment. The parasitoids are also being reared at Commonwealth Agricultural Bureaux International Central West Asia, Rawalpindi. The identity of each species is pending.

This study reports the first occurrence of egg parasitoids attacking *B. hilaris* in Pakistan. Populations of *B. hilaris* were found to be extremely low at both sample sites, and the insect seemed well under natural control at each date sampled.

Table 1. Parasitism of *Bagrada hilaris* eggs collected from plant debris in different months at different localities in Toba Tek Singh District on the Punjab plains, 2014.

Date	Locality	Crop	No. of Eggs Collected	No. of Eggs Parasitized (% Parasitism)	Parasitoids Recovered
3 April	Chatiana	<i>Brassica juncea</i>	258	92 (35.6)	<i>Trissolcus</i> sp.
2 May	Dabanwala	<i>Brassica napus</i>	145	51 (35.1)	<i>Trissolcus</i> sp. <i>Ooencyrtus</i> sp. <i>Gryon</i> sp.

Although sample sizes were low, three different genera of parasitoids were recovered. Interestingly, all three parasitoids were recovered from eggs deposited in plant debris, whereas only *Trissolcus* sp. was recovered from sentinel eggs placed on aboveground leaves of growing plants.

Although no egg parasitoids of *B. hilaris* have previously been recorded from Pakistan, several species have been reported from neighboring India. Genera include the platygastriids *Gryon*, *Telenomus*, and *Trissolcus* (Chacko and Katiyar 1961, Proc. Royal Entomol. Soc. London (B) 30:161–163; Mani 1942, Indian J. Entomol. 4: 153–162; Rao and Chacko 1961, Beitrage Entomol. 11: 812–824). This is the first report of an *Ooencyrtus* sp. attacking *B. hilaris* eggs.

Further research may determine which species is most efficient in different crop and noncrop habitats, and whether interspecific competition creates interference that may affect parasitism rates. Research is also needed to reveal their host-finding cues, seasonal phenology and relative importance in Pakistan, and their potential host range in the United States.

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Table 2. Parasitism in *Bagrada hilaris* eggs glued on paper cards (sentinel eggs) and exposed in the field for 4 d in different crops at two localities in Toba Tek Singh District on the Punjab plains, 2014.

Date	Locality	Crop	No. of Eggs Exposed in Field	Parasitism (%)	Parasitoid Recovered
1 April	Chatiana	<i>Brassica juncea</i>	100	32	<i>Trissolcus</i> sp.
2 May	Dabanwala	<i>Brassica napus</i>	100	38	<i>Trissolcus</i> sp.