



Taxonomy of Korean *Bactrocera* (Diptera: Tephritidae: Dacinae) with review of their biology



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ABSTRACT

The genus *Bactrocera* Macquart, currently comprising over 650 described species, is the most economically significant fruit fly genus with at least about 50 species considered to be pests of agricultural and quarantine importance. As a part of effort to investigate both agricultural and quarantine *Bactrocera* pests in Korea, the present study aims at reviewing the naturally occurring *Bactrocera* species in this country. Two *Bactrocera* species, pumpkin fruit fly (*B. depressa* (Shiraki)) and striped fruit fly (*B. scutellata* (Hendel)), are currently recognized in South Korea. *Bactrocera depressa* is an important agricultural pest infesting pulp of host fruits including pumpkins, and *B. scutellata* is known to infest flower buds of pumpkins as well as other cucurbit hosts. We recently found the third *Bactrocera* species, *B. hyalina* (Shiraki), for the first time in Korea. We here provide a taxonomic key to the Korean *Bactrocera* species, brief review of their biology, summary of their taxonomic status, diagnoses, descriptions, and detailed photographs of adults including postabdominal structures for their accurate identification. In addition, we here synonymize *Zeugodacus bezzianus* Hering with *B. depressa*.

Introduction

The family Tephritidae is a large group of schizophoran flies of over 4700 recognized species worldwide (Norrbon et al., 1999; Catalogue of Life as of August 13th 2017 – www.Catalogueoflife.org). Tephritid larvae are mostly phytophagous including some of the most significant pests of agricultural and quarantine importance (White and Elson-Harris, 1992). Recent molecular analyses (Han and Ro, 2016) indicated that this family is relative young and might have explosively diversified since the late Eocene (~36 million years ago). In Korean fauna, the most up-to-date official species count for the family Tephritidae is 100 species under 55 genera (Han and Kwon, 2000; Han et al., 2014; Han, 2016).

The genus *Bactrocera* Macquart, currently comprising 651 described species (largest of about 500 known tephritid genera), is the most economically significant fruit fly genus with at least 50 species considered to be important pests (Vargas et al., 2015). *Bactrocera* flies are widely distributed in Oriental, Australasian and Oceanian regions, but much smaller number of species naturally occur in Afrotropical (11 native and 8 endemic species) and Palaearctic (10 native and 2 endemic species) regions (Norrbon et al., 1999; De Meyer et al., 2014). Many *Bactrocera* species are highly polyphagous, and some of them have repeatedly invaded and even been established in non-native ranges (Vargas et al., 2015).

In South Korea, six exotic *Bactrocera* species have been intercepted by quarantine inspection processes (National Plant Quarantine Service, 2008; Animal and Plant Quarantine Agency, 2014), but none of them has been established in Korea yet. Nevertheless, through the increased commerce with *Bactrocera* ridden tropical and subtropical countries as well as the continual process of global warming, risk of accidental introduction of fruit fly pests to the southern part of the Korean Peninsula is getting higher.

Two *Bactrocera* species, pumpkin fruit fly (*B. depressa* (Shiraki); Fig. 1A) and striped fruit fly (*B. scutellata* (Hendel); Fig. 1D) are currently known to naturally occur throughout South Korea. *Bactrocera depressa* is an important agricultural pest infesting pulp of host fruits, especially pumpkins (Fig. 1B, C). On the other hand, *B. scutellata* flies are widely known to infest male flower buds of pumpkins, but recent studies indicated that they could actually infest significant proportion of female pumpkin flowers (Kim YP et al., 2010 – 54% of male and 31% of female flowers damaged in their survey). We recently found the third *Bactrocera* species, *B. hyalina* (Shiraki), for the first time in Korea. Twelve male and eight female flies were discovered from the yellow sticky traps installed near methyl eugenol traps for *Bactrocera* fruit fly detection by Animal and Plant Quarantine Agency (Korea) in 2015. In the present study, we provide a taxonomic key to the above three Korean *Bactrocera* species, summary of their taxonomic status, brief

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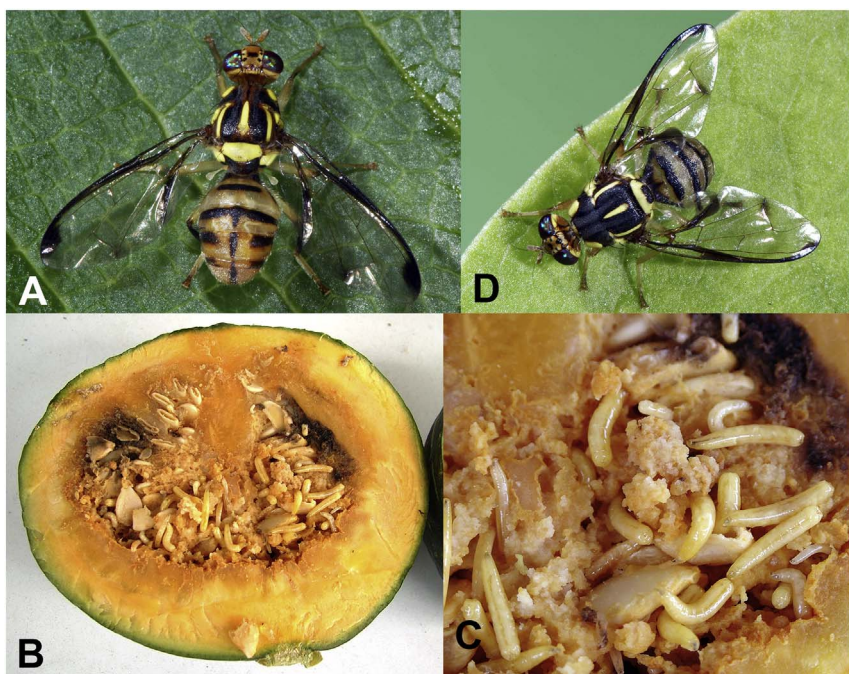


Fig. 1. (A) *Bactrocera depressa*, male. (B) *ditto*, developing larvae in pumpkin. (C) *ditto*, magnified view. (D) *Bactrocera scutellata*, male.

review of their biology, diagnoses, descriptions accompanied with detailed photographs of adults including postabdominal structures. We are hoping that this article will provide essential information for tephritid researchers as well as quarantine officers to study or inspect Korean *Bactrocera* flies.

Materials and methods

The terminology and morphological interpretations used in this paper follow the glossary of White et al. (1999). For the reference information in the synonymy of each Korean *Bactrocera* species, we tried to include as many Korean references as possible but included only non-Korean references of taxonomic and agricultural significance. When making a citation of a last name “Kim”, the initials of first names were also included in order to avoid confusion due to the multiple authors with same surname in our References section.

Photographs were taken with a Panasonic (Osaka, Japan) Lumix GMC G5 camera with a Lumix G X Vario 45–175 mm lens and a Raynox (Yoshida Inc., Tokyo, Japan) MSN-202 macro conversion lens. The consecutive digital images in different focal planes (usually 50–100 shots per a single figure) were Z-stacked using Helicon Focus software® (Helicon Soft, Ltd., Ukraine). Photographs of postabdominal structures were taken with a Nikon (Tokyo, Japan) D90 camera mounted on an Olympus (Tokyo, Japan) CX41 compound microscope.

Acronyms of the Korean provincial names used in the Material examined sections are as follows: CB – Chungcheongbuk-do; CN – Chungcheongnam-do; GG – Gyeonggi-do; GB – Gyeongsangbuk-do; GN – Gyeongsangnam-do; GW – Gangwon-do; JB – Jeollabuk-do; JN – Jeollanam-do; JJ – Jeju-do.

Acronyms of depositories cited in this study are as follows: APQA – Animal and Plant Quarantine Agency, Hyeoksins 8-ro, Gimcheon-si, Gyeongsangbuk-do 39660, Korea; BCIQT – Animal and Plant Quarantine Laboratory, Taichung Branch Office, Bureau of Commodity Inspection and Quarantine, Ministry of Economic Affairs, Taiwan; BMNH – The Natural History Museum, Department of Entomology, Cromwell Road, London SW7 5BD, England, UK; DEI – Deutsches Entomologisches Institut, Deutschen Akademie der Landwirtschaftswissenschaften zu Berlin, Schicklerstrasse 5, 13 Eberswalde, D-1300, Germany (formerly Institut für Pflanzenschutzforschung); KUSK – Korean Entomological Institute, Korea University, 145 Anam-

ro, Seongbuk-gu, Seoul 02841, Korea; KUTK – Systematic Entomology Laboratory, Division of Applied Biology, College of Agriculture and Life Sciences, Kyungpook National University, Daegu 41566, Korea; NIAES – Laboratory of Insect Systematics, National Institute of Agro-Environmental Sciences, Kannondai, Tsukuba, Ibaraki Pref. 305, Japan; NTU – National Taiwan University, Department of Plant Pathology and Entomology, Taipei, Taiwan; SSUK – School of Biological Sciences and Chemistry, Sungsin Woman's University, Bomun-ro, Seongbuk-gu, Seoul 02844, Korea; USNM – United States National Museum of Natural History, United States National Entomological Collection, Washington, DC 20560, USA; and YSUW – Division of Biological Science and Technology, Yonsei University, 1 Yonsei-dae-gil, Wonju-si, Gangwon-do 26493, Korea.

Systematic accounts

Genus *Bactrocera* Macquart

Bactrocera Macquart, 1835: 452. Type species: *Bactrocera longicornis* Macquart, 1835, by monotypy.

Diagnosis. The genus *Bactrocera* can only be satisfactorily recognized by comparing with other genera of the tribe Dacini (subfamily Dacinae). This large tribe of about 900 species consists mostly of wasp mimics (as Figs. 1, 2, 5, 7) with significant reduction in chaetotaxy of the head and thorax (Drew and Hancock, 1999). The subtribe Dacini (sensu Drew and Romig, 2013) currently includes four superficially similar genera: *Bactrocera* Macquart, *Dacus* Fabricius, *Ichneumonopsis* Hardy, and *Monacrostichus* Bezzi. Among these genera, *Ichneumonopsis* has been sometimes placed in the tribe Gastrozonini but its affinity is still not resolved (Norrbon et al., 1999; Kovac et al., 2013). Drew and Romig (2013) provided diagnoses for these four genera, and we slightly modified and summarized them as follows.

The genus *Ichneumonopsis*, with only a single known species, can be readily separated by: 1) pecten on abdominal tergite 3 of male absent; 2) wing vein R_{4+5} setose; 3) orbital setae on head reduced; and 4) antennae with plumose arista. The genus *Monacrostichus*, with two known species, can also be easily separated by a number of distinct morphological characteristics including: 1) pecten on abdominal tergite 3 of male absent; 2) wing veins R_{2+3} and M with pronounced curvature; 3) scutum and face with transverse furrows; and 4) frontal setae on head absent. The genera *Dacus* (235 known species; Norrbom et al.,

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