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Abstract

This paper reports on the remarkable results we achieved with a novel, inexpensive collecting method, *i.e.* band-shelter trapping, during a survey conducted in 25 urban parks and greenbelts in the Beijing metropolitan area from April to October during 2007–2009. The trap was made of 3-cm wide, opaque, plastic fiber, wrapped around willow tree trunks (*Salix* spp.) at a height of 1.5 m height. Traps were checked every two weeks. We collected a total of 45,074 weevils, of which

817 belong to five species unrecorded from China, *i.e.*, *Melanapion mandli* (Schubert), *Asperogronops inaequalis* (Boheman), *Dorytomus occallescens* (Gyllenhal), *Ellescus schoenherri* (Faust), and *Tachyerges pseudostigma* (Tempère). Moreover, we collected 43,952 individuals of *Melanapion naga* (Nakane), *Dorytomus alternans* Faust, *Dorytomus roelofsi* Faust, and *Dorytomus setosus* Zumpt, which are new records for Beijing. The genera *Asperogronops* Solari and *Ellescus* Dejean are newly recorded for China. During their seasonal peak, we frequently and abundantly collected *D. setosus* and *D. roelofsi* with band-shelter traps, but never by sweeping, beating, or light trapping methods. A review of the biology of these species shows that all have a short active season and prefer shaded tree trunks. Band-shelter traps appear to effectively capture species with these characteristics and underline the importance of collecting methods that take into account the specific life strategy of target species.

Key Words: band-shelter trap, weevils, Curculionoidea, new country records, urban green space

Curculionoidea is the largest superfamily of Animalia, with more than 5,800 genera and 62,000 species described and the likely total number of 220,000 species in existence (Oberprieler *et al*. 2007). In China, about 1,000 weevil species have been described, but their total number is estimated to be one-tenth of the in the world's weevil fauna (Ren and Zhang 2001). Weevils are everywhere (Oberprieler *et al*. 2007). They occur in all biotically suitable latitudes and altitudes above, on, and under the ground. They live on mosses, horsetails, ferns, gymnosperms, and angiosperms, in all ecological niches, including those of deserts, seashores and wetlands. From our perspective, there is no lack of species, but rather a lack of discovery.

Most weevil species are strictly phytophagous and usually have a narrow range of suitable host plants. A great many of them are highly host specific (Kuschel 1995; Anderson 2002). At the same time, many weevils are cryptic, nocturnal, may have a short active period followed by a long diapause, or feign death when disturbed. Therefore, collecting them can prove difficult. Collecting methods for weevils are diverse. Beating, sweeping, and visual examination are commonly used for collecting weevils in forest ecosystems. Pyramidal traps were developed for monitoring pecan weevils in orchard gardens (Tedders and Wood 1994). However, suitable collecting methods are rarely reported for populated areas such as urban parks.

In the Beijing urban area, willows (*Salix* L. spp., Salicaceae) are commonly and abundantly planted in parks and greenbelts, with nearly 1.6 million trees recorded (Beijing Gardening and Greening Bureau 2000). Since they are planted for amenity in metropolitan areas with more than 18 million residents including many entomologists, people can always observe insects living on those trees. Despite spatial proximity and ample opportunities for encounters and interactions, we still know surprisingly little about the insects' presence and lives.

In this article, we report on interesting weevil species collected from willow tree trunks in the Beijing metropolitan area by means of a very simple and quite inexpensive survey method dubbed band-shelter trapping. We discuss why the presence of these weevils has been ignored (or remained undetected) for a long time and highlight the need for a wide spectrum of appropriate collecting methods in the discovery and description of insect diversity.

Material and Methods

The study was conducted in Beijing, which is located in the northern part of the North China Plain (39°54′N, 116°23′E). Twenty-five parks and greenbelts in the plain area (<100 m elevation) were chosen as our study sites (described in Su *et al*. 2011). All park areas were established less than 60 years ago, with the exception of Summer Palace and Old Summer Palace which are older than 250 years. Willows occur throughout, and we surveyed *Salix babylonica* L., *Salix matsudana* Koidz, and *Salix matsudana* var. *umbraculifera* Rehd.

Band-shelter traps first described by Huang *et al*. (2010) were used to collect weevils specimens inhabiting or visiting willow tree trunks. The trap was made of a strip of 3 cm wide, opaque, synthetic fiber (plastic) band without any attractants, wrapped around the tree trunk at approximately 1.5 m above the ground. We selected 10–35 willow trees with a 10–20-cm diameter at breast height at each site, and installed one trap per trunk. The traps were inspected every two weeks. All weevils underneath the traps were counted and individuals were taken to the laboratory for identification. The traps were then retied to a new position, about 5 cm above or below the former position. The investigation was conducted from April to October in 2007–2009.

Specimens were preserved in 99% ethanol and identified by MAAZ and RZ. The identified specimens were deposited in the Institute of Zoology, Chinese Academy of Sciences, Beijing, China. The taxonomic arrangement of Alonso-Zarazaga and Lyal (1999) is followed in this paper. New records, either for China or for Beijing, were

established based on the Zoological Record (1864–2009) electronic database, WTaxa (wtaxa.csic.es), Fauna Europaea (www.faunaeur.org), *Coleopterorum Catalogus* (Wagner 1910; Schenkling and Marshall 1929; Klima 1934, 1935; Alonso-Zarazaga and Lyal 1999), the list of Chinese Insects (Hua 2002), and volume 7 of the Catalogue of Palaearctic Coleoptera (Löbl and Smetana 2011).

In order to compare the efficiency of band-shelter trapping with traditional methods, we also used sweeping, beating, and light trapping at Cuihu (40°5′55.75″N, 116°10′41.98″E) from early May to late July 2007. Cuihu is an urban wetland park located in the suburb of Beijing, in which 35 band-shelter traps were set. Also, five willow trees (up to 2 m tall) were inspected visually on 6 and 11 September 2007 at Cuihu to capture weevils under bark.

To understand the importance of timing in insect specimen collection, we plotted the temporal occurrence of the two most dominant weevil species using data sampled in Cuihu from early May to late October in 2007–2009. The mean number of individuals per trap in each survey was calculated and used as an indicator for the activity level of the weevils.

Results and Discussion

We collected a total of 45,074 weevils with band-shelter traps and identified 11 of the 19 recognized morphospecies (see Table 3 in Su *et al*. 2011 for complete list). Five of the identified species are **new country records** for China: the apionid *Melanapion mandli* (Schubert, 1959) and the curculionids *Asperogronops inaequalis* (Boheman, 1842), *Dorytomus occallescens* (Gyllenhal, 1835), *Ellescus schoenherri* (Faust, 1887) and *Tachyerges pseudostigma* (Tempère, 1982). The genera *Asperogronops* Solari and *Ellescus* Dejean are recorded here for the first time from China. Moreover, *Melanapion naga* (Nakane, 1963), *Dorytomus alternans* Faust, 1882, *Dorytomus roelofsi* Faust, 1882, and *Dorytomus setosus* Zumpt, 1933 are new records for Beijing. The numbers of individuals of newly recorded species for China and Beijing were 817 and 43,952, respectively (Table 1). None of these species was captured by sweeping, beating, or light trapping. A total of 705 individuals of *D. setosus* was collected during the two survey days at Cuihu by visual examination.

In general, almost all captured species, except *A. inaequalis*, are known to be associated with Salicaceae trees (Table 1). The larva of at least one species of *Melanapion* Wagner is known to develop inside galls made by species of *Pontania* Costa (Hymenoptera: Tenthredinidae) and *Iteomya capraeae* (Winnertz) (Diptera: Cecidomyidae) (Dieckmann 1977). Species of *Dorytomus* Germa and *Ellescus* Dejean lay eggs in buds and catkins where the larvae develop before they pupate in soil. After eclosion, adults are commonly sedentary and aestivate under tree bark. Larvae of the genus *Tachyerges* Schönherr are leaf miners on *Salix* and *Populus* L. (Salicaceae) (O'Brien and Wibmer 1978; Anderson 1989, 2002; Downie and Arnett 1996). Species of Cyclominae, the subfamily of *A. inaequalis*, have been reported to often emerge in spring and to remain quiescent in summer (Marvaldi 1998).

As stated above, more than one-half of the captured species feed as larvae on catkins or buds of Salicaceae (Table 1). After that, adults are commonly sedentary and aestivate. For example, flying *Dorytomus* weevils were observed neither outdoors nor indoors, except during their mating flight period in February and March. The seasonal activity dynamics of *D. setosus* and *D. roelofsi* (Fig. 1) showed a clear unimodal pattern, with a single peak in late May followed by a sharp decline. However, no *Dorytomus* weevils were captured

Table 1. New records of weevils collected with band-shelter traps on willows in the Beijing metropolitan area, China during 2007–2009.

Species	New record for	Number collected	Plant part
Apionidae			
Melanapion naga (Nakane)	Beijing	12	Galls on twigs, petioles. and leaf midribs
Melanapion mandli (Schubert) (= *winteri* Korotyaev and Egorov)	China	301	Galls on twigs, petioles, and leaf midribs
Curculionidae			
Asperogronops inaequalis (Boheman)	China	136	——
Dorytomus alternans Faust	Beijing	5	Catkins, buds
Dorytomus occallescens (Gyllenhal)	China	314	Catkins, buds
Dorytomus roelofsi Faust	Beijing	5,077	Catkins, buds
Dorytomus setosus Zumpt	Beijing	38,858	Catkins, buds
Ellescus schoenherri (Faust)	China	63	Catkins, buds
Tachyerges pseudostigma (Tempère)	China	3	Leaves

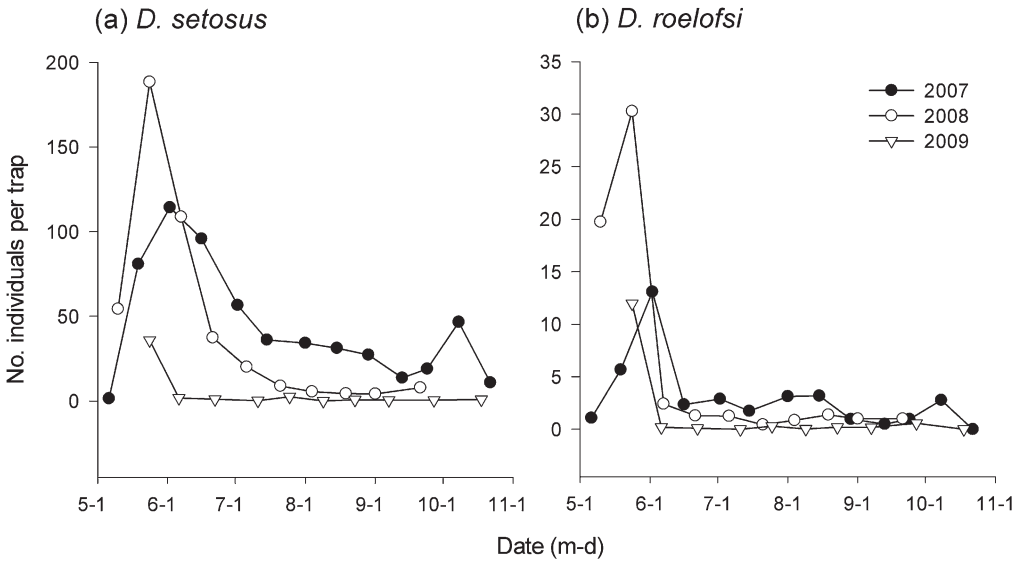

Fig. 1. Seasonal activity dynamics of adult *Dorytomus setosus* (a) and *Dorytomus roelofsi* (b) collected in band-shelter trap on willows in Cuihu Wetland Park, Beijing, China.

using sweeping, beating, or light trapping methods in the peak season. These observations suggest that a large number of individuals are actively looking for shelter on trunks (*e.g.*, bark crevices as well as our band traps) in May, and few are likely to relocate once they have found a suitable place. In other words, they have a very short activity period and therefore are difficult to find if sampled at the wrong time by inappropriate methods. Consequently, these taxa are easily ignored or overlooked, which causes bias in species inventories.

In our study, band-shelter traps set to simulate refuge habitats attracted a large number of weevils, especially in the genus *Dorytomus*. By comparison, only a few *Dorytomus* weevils were collected in previous studies by beating branches (Keys 1916; Morris 1998). This shows that it is important to apply collecting methods tailored to the biological characteristic of the target group and that these methods do not necessarily need to be elaborate or expensive. If more studies are conducted on a large scale and by different means of collecting, they may produce more representative inventories including new records, thereby adding to the existing knowledge on insect diversity. There are 100,000 tree species estimated worldwide, of which about 540 belong to Salicaceae. The number of tree species in China is estimated to be 8,000, of which 226 belong to Salicaceae. It is expected that band-shelter traps can help to detect more new species and to better understand the current status of insect species diversity in natural landscapes.

Another important question is whether or not modifications to the trap design would increase its efficiency. One property to be tested in the future is the width of the band, since it is plausible that a wider band may allow the capture of larger weevils, whose requirements may not be met under a small refuge. Another aspect is the way the band is fastened to the trunk. Up to now, it has been secured with a knot so we do not know whether tight bands are preferred over loose ones or vice versa. A third uncertainty is the irregular fit of the trap to the trunk that may affect collecting efficiency. Assuming that most weevils descend from the tree crown, they may find it more difficult to slip under the band if the upper margin is more tightly attached to the trunk than the lower margin. This and the second problem, posed by the collecting methodology, could be addressed by fastening a broader band to the trunk by means of a staple gun and by making sure that the lower staple is fastened when the band is very tight, with the upper staple being applied when it is less tight. The collecting procedure preferably would start by carefully extracting the upper staple and making a collecting round along the band, then removing the next staple below and making a new round, and so on, thus avoiding the loss of specimens.

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