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APPLICABILITY OF COLOURED TRAPS FOR THE MONITORING OF THE INVASIVE ZIGZAG ELM SAWFLY, *APROCEROS LEUCOPODA* (HYMENOPTERA: ARGIDAE)

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Aproceros leucopoda (Hymenoptera: Argidae), native to East Asia, is an invasive pest of elms (*Ulmus* spp.) recently reported from several European countries. The identification of effective and practical tools suitable for detecting and monitoring the species has become necessary. As no trapping methods have been developed for *A. leucopoda* yet, in this study we compared white, yellow and fluorescent yellow sticky "cloak" traps for their applicability for catching adults. The experiment was carried out in a mixed forest plantation of black locust (*Robinia pseudoacacia*) and Siberian elm (*Ulmus pumila*), the latter infested heavily with *A. leucopoda*, in Hungary, 2012. Both the yellow and fluorescent yellow sticky "cloak" traps proved suitable for capturing high numbers of individuals of *A. leucopoda*, while the white traps caught significantly less adults. Trapping with the former coloured traps, completed with the inspection of host plants, may be recommended for the detection and monitoring of the pest.

Key words: Symphyta, alien species, *Ulmus*, trapping, signalisation.

INTRODUCTION

The zigzag elm sawfly, *Aproceros leucopoda* Takeuchi, 1939 (Hymenoptera: Argidae), native to East Asia, was identified as a new pest of elms (*Ulmus* spp.) in Europe in 2003 (Blank *et al*. 2010). Following the first discoveries of the pest in Poland, Hungary, Romania, Ukraine, Slovakia and Austria (Blank *et al*. 2010, Vétek *et al.* 2010), it has been found in Serbia (Hirka 2010, Glavendekić *et al.* 2013), Italy (Zandigiacomo *et al.* 2011), Germany (Kraus *et al*. 2011), Croatia (Matošević 2012), Slovenia (de Groot *et al.* 2012) and Bulgaria (Doychev 2015). It was also reported from Moldova as early as 2008 (Timuş *et al.* 2008), but misidentified as *Arge* sp. (Blank *et al.* 2014). *Aproceros leucopoda* occurs also in the European part of Russia (Artokhin *et al*. 2012, Lengesova 2012, Shchurov *et al*. 2012, Lengesova & Mishchenko 2013); e.g. in the Rostov Region, the pest was recorded in an area as large as almost

30 000 km^2 in 2011 (Artokhin *et al.* 2012). A range extension of the sawfly towards western Europe has been documented by recent reports from Belgium (Boevé 2013, Ravoet 2014), the Netherlands (Mol & Vonk 2014, 2015), the Czech Republic (Jurášková *et al.* 2014) and northeastern Germany (Blank *et al.* 2014). Severe damage up to defoliation of most of the canopy caused by the larvae of *A. leucopoda* may occur in various elm taxa (Blank *et al*. 2010, 2014).

Aproceros leucopoda is supposed to spread both actively and passively. Since the adult sawflies are strong fliers (Wu 2006), their natural expansion may result in new infestations (Blank *et al.* 2014). However, the human-mediated dispersal of various developmental stages of the pest as stowaways in road, rail etc. traffic and along corridors, or as contaminants of plants for planting via trade might also contribute to its range expansion (Blank *et al.* 2010, Zandigiacomo *et al.* 2011, Artokhin *et al.* 2012, Shchurov *et al*. 2012, Glavendekić *et al.* 2013, Blank *et al.* 2014, Mol & Vonk 2014, 2015).

Considering the severe damage the invasive alien *A. leucopoda* is able to cause to its host plants (Blank *et al.* 2010, Zandigiacomo *et al.* 2011, Artokhin *et al.* 2012, Shchurov *et al*. 2012, Vétek *et al.* 2012, Blank *et al.* 2014) and the lack of effective methods of trapping adults of the pest, there is an evident need for tools that could be applied for early detection and population monitoring purposes.

Trapping is a convenient access to obtain large, general samples of Hymenoptera from most habitats. Malaise traps or yellow pan traps are often used, which work continuously contrary to a person collecting with a handnet. Yellow pan traps (as well as yellow sticky traps) work on the principle that many insect species are attracted to the yellow colour (Gauld & Bolton 1988, Viitasaari 2002). Yellow sticky traps represent an approach to monitor flight activity, abundance and distribution of sawfly species, which occur as pests (e.g. Digweed *et al.* 1997, Kessel 2000, Holusa & Drápela 2003, 2006, Rodeghiero 2006, Holuša & Lubojacký 2007, Looney *et al.* 2012), but also of other Hymenoptera species like parasitoids (e.g. Langor *et al.* 2000). However, for example, adults of the azalea sawfly, *Nematus lipovskyi* Smith (Tenthredinidae), a recently reported species alien to Europe, were not attracted to either yellow pitfall traps or yellow sticky plates (Macek & Šípek 2015).

Most literature data about collections of sawflies with the help of yellow sticky traps refer to pest species associated with Tenthredinidae and Pamphiliidae (e.g. Battisti & Rodeghiero 1998, and the previous references). There is limited information available from faunistic literature about trapping of Argidae with yellow-coloured sticky traps or pan traps (e.g. Perović *et al.* 2006). Cardaş *et al.* (2011) applied white and yellow sticky panels to check the flight period of the adults of *A. leucopoda*, a member of Argidae being the subject of this paper, but the quantities have not been mentioned in their paper, which basically focused on Carabidae species occurring in a Romanian hardwood forest infested with *A. leucopoda*. Glavendekić *et al.* (2013) used yellow sticky traps to catch adults of *A. leucopoda* in a survey, which targeted to obtain data on the occurrence of the pest in Serbia. However, no further data have been presented on either the design or the effectiveness of the traps applied.

The aim of our study has been to test the applicability and to compare the effectiveness of traps of three different colours for catching *A. leucopoda*.

MATERIAL AND METHODS

The study was carried out in a mixed forest plantation comprising black locust (*Robinia pseudoacacia* L.) and Siberian elm (*Ulmus pumila* L.) located at Kecskemét, Hungary, in 2012. The 15 ha large plantation was established in 1999. Regular and severe defoliation of elms caused by *A. leucopoda* has been observed since 2011. To carry out the trapping trial, a ca. 0.8 ha large plot close to the southern edge of the forest [46.9899°N 19.6706°E] was chosen.

Three different colours of the same "cloak" trap type with a sticky surface of 23 × 36 cm (Csalomon®, Plant Protection Institute, Centre for Agricultural Research, Hungarian Academy of Sciences, Budapest, Hungary) were tested, hereafter symbolised as PALf (white), PALs (yellow) and PALz (fluorescent yellow) by following the abbreviation of the commercially available trap types. The latter colour was included in the study because it proved more effective than yellow sticky "cloak" traps in the case of *Rhagoletis cerasi* (L.) (Diptera: Tephritidae), a major pest of cherries (Tóth *et al.* 2004). The efficiency of fluorescent yellow traps [colour 154 B defined by the Colour chart of the Royal Horticultural Society (1966 cit. van Epenhuijsen & de Silva 1991)] was confirmed by van Epenhuijsen and de Silva (1991) in a study on trapping *Caliroa cerasi* (L.) (Tenthredinidae), a pest of stone and pome fruits. On the other hand, Looney *et al.* (2012) found lime green Asian citrus psyllid sticky traps ineffective compared to yellow sticky traps for detecting the alder-feeding *Monsoma pulveratum* (Retzius) (Tenthredinidae). Therefore, trials with PALz traps seemed practical. The reflectance spectrum of each of the traps has been recorded previously: white PALf trap (Schmera *et al.* 2004), yellow PALs and fluorescent yellow PALz traps (Tóth *et al.* 2004).

The traps were hanged by wires and fixed to lower branches of trees at a height of 1.5–2.5 m. There were n = 12 replicates of each colour (note: one PALz was found dropped to the ground, so in this case finally we had n = 11 replicates). The distance among traps within one block that contained the three different colours was min. 2 m, and the distance among the 12 blocks was min. 9 m. The traps were placed in the field on 19 May 2012, and the numbers of captured *A. leucopoda* adults were counted on 31 May. This trapping period was set to coincide with the peak of the second emergence of adults at the study site so as to catch as many specimens as possible with the different traps.

To compare the captures of the three coloured traps, random block design one-way ANOVA model was run with fixed factor 'colour' (white, yellow and fluorescent yellow). A single extreme value was winsorized at the 99% (Wilcox 2005). Normality of residuals was proved by Kolmogorov-Smirnov's test ($D(35) = 0.064$; $p = 0.2$). Since homogeneity of variances failed, notwithstanding small means occurred with small variances and sample sizes were almost the same, therefore post hoc test was run by Games-Howell's method. We also calculated the eta squared to detect the effect size which gives the explained variance rate as well as the observed power which provides the probability of correct detection of significant differences.

RESULTS

Most *A. leucopoda* adults (N = 4645) were captured with the yellow sticky "cloak" (PALs) traps followed by the fluorescent yellow (PALz) traps (N = 3441). The white (PALf) traps were the least attractive (N = 332) to the sawfly species. Mean number (±SD) of *A. leucopoda* adults captured with different sticky "cloak" (PAL) traps is shown in Figure 1. There was no significant difference between the catches of the PALs and PALz traps (Games-Howell's p = 0.534), and both of them proved significantly more effective compared to the PALf traps (Games-Howell's p < 0.001). Significant effect of the colour was proved ($F_{2,21}$ = 27.26, p < 0.001). Observed power was as high as 0.999 with eta squared $\acute{\eta}^2$ = 0.60.

DISCUSSION

Based on our results, both the yellow and fluorescent yellow sticky "cloak" traps are similarly suitable for catching *A. leucopoda* adults. Also yellow-coloured traps proved more effective for collecting sawflies compared to different further colours applied in other studies: RÜHL (1978) collected ca

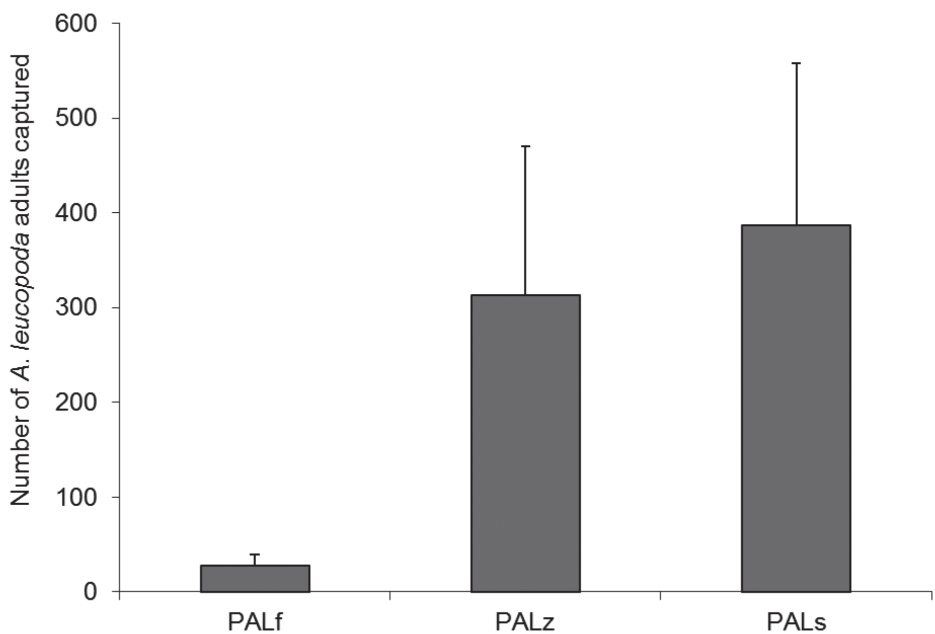

Fig. 1. Mean number (±SD) of *Aproceros leucopoda* adults captured with different Csalomon® sticky "cloak" (PAL) traps in a mixed forest plantation of black locust (*Robinia pseudoacacia*) and Siberian elm (*Ulmus pumila*) located at Kecskemét, Hungary, between 19 and 31 May 2012. (PALf – white; PALz – fluorescent yellow; PALs – yellow).

81% of sawflies in yellow, 17% in white, and 3% in blue pan traps. In the case of raised bogs studied by Schuster (1985), yellow pan traps were the most attractive collecting 93% of all the sawflies, while only 5% and 2% of the specimens were captured in white and blue traps, respectively. In a study by Ritzau (1988) carried out on the sawfly fauna of two islands of northwestern Germany, 66% and 34% were trapped in yellow dishes and in white ones, respectively. Although the preference was dominated by *Athalia rosae* (L.) (Tenthredinidae) (540 of 863 specimens associated with 32 species), also the exclusion of this species resulted in similar rates for the remaining 323 specimens: 71% in yellow, and 29% in white traps.

Even though the white sticky "cloak" traps also captured many specimens in our experiment, they might be less practical for early detection and monitoring of *A. leucopoda*. Holuša and Drápela (2006) found that white sticky boards were not attractive to *Pristiphora abietina* (Christ) (Tenthredinidae), and although these traps captured some adults, the authors suggested that this might be a coincidence with the period of peak emergence of the species. Although in the case of *Hoplocampa testudinea* (Klug) (Tenthredinidae), a pest of apples, Owens and Prokopy (1978) experienced that white sticky rectangular traps which do not reflect the UV light captured more *H. testudinea* adults than yellow, red, orange, black, green, and blue enamels, various daylight fluorescent hues, and further surfaces tested, according to the authors, the species might respond to some visual cue supplied by apple blossoms.

The application of Malaise traps might be an alternative method of trapping *A. leucopoda* as they are suitable for collecting Argidae (Braud *et al.* 2003, Roller 2006, Smith 2006, Blank unpubl.). Holuša and Drápela (2006) found that there was a highly significant relationship between samples of Malaise traps and yellow sticky boards in the case of *P. abietina* (in both sexes in 1998, in males in 1999). Malaise traps, nevertheless, would not be recommended for the detection of *A. leucopoda* for many reasons: they collect a very large amount of insect material, which causes significant effort for sorting; the vast proportion of the collection comprises non-target species, which is unreasonable in view of nature conservation aspects; and due to their showy appearance they are not practical to use in some environments where elms regularly occur: public areas, along roads, in nurseries or private gardens. Furthermore, based on a study of *Cephalcia lariciphila* (Wachtl) (Pamphiliidae) by Holuša and Kuras (2010), the authors deemed Malaise traps more expensive and difficult to use in forestry, compared to yellow sticky boards.

Representing non-selective traps, yellow-coloured traps may capture several non-target insect species, including members of Symphyta other than *A. leucopoda* (see references in the Introduction). However, adults of *A. leucopoda* can readily be distinguished from other West Palaearctic Hymenoptera by using the keys and descriptions given by Blank *et al.* (2010) and Mol and Vonk (2015). Although searching for the easily recognizable zigzag feeding pattern on leaves caused by the young larval stages (Blank *et al.* 2010, Vétek *et al.* 2010) may be recommended for e.g. citizen scientists supporting monitoring programs (Blank *et al.* 2014), new invasions by the adults to uninfested regions might be signalised with either yellow or fluorescent yellow sticky "cloak" traps (PALs or PALz). Practically, trapping should complement the inspection of the host plants since the two approaches record different development stages of *A. leucopoda*, adults and larvae. These comparatively inconspicuous traps are suitable for application also in environments frequented by people. Besides early detection of the invasive species, phenological data may be recorded as well with both traps, and this may help understand the population dynamics of *A. leucopoda*.

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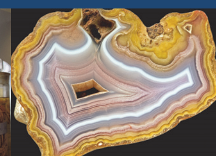


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