N O T E

Comparative Efficiency of Three Trap Types for Collecting Host-seeking Female Tabanid Flies (Diptera: Tabanidae)[1]

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Host-seeking females of the family Tabanidae (Diptera) may serve as mechanical vectors of disease agents for livestock (Foil 1989, Parasitol. Today 5: 88–96) and negatively impact livestock production, causing losses in weight gain and milk production (Perich et al. 1986, J. Econ. Entomol. 79: 128–131). Traps for sampling and monitoring tabanid populations using visual stimuli were developed in North America in the second half of the 20th Century (Baldacchino et al. 2014, Infection Gen. Evol. 28: 596–615). Trapping efficiency was improved with the addition of chemical attractants (i.e., carbon dioxide, 1-octen-3-ol, ammonia, phenols, aged urine of different mammals, etc.) (Mihok and Mulye 2010, Med. Vet. Entomol. 24: 266–272). Nzi traps were developed for sampling tsetse flies (*Glossina morsitans* Westwood), stable flies (*Stomoxys calcitrans* [L.]), and various tabanids in Africa (Mihok 2002, Bull. Entomol. Res. 92: 385–403.). Nzi traps either baited or not baited with chemical attractants effectively trapped tabanids in studies conducted in Ontario and Alberta (Canada) and in Iowa, Florida, and Louisiana (USA), Africa, and Queensland (Australia) (Mihok and Carlson 2007, J. Econ. Entomol. 100: 613–618; Van Hennekeler et al. 2008, Med. Vet. Entomol. 22: 26–31). Recently developed polarization traps, commonly known as liquid traps (Egri et al. 2013, Bull. Entomol. Res. 103: 665–674), and horizontal sticky traps (Egri et al. 2013, Int. J. Parasitol. 43: 555–563) effectively trapped tabanids in Europe (Herczeg et al. 2014, Parasitol. Res. 113: 4251–4260). Horizontally polarized light only attracts water-seeking males and females (Horváth et al. 2008, Naturwissenschaften 95: 1093–1100) while linearly polarized light attracts host-seeking females (Egri et al. 2012, Naturwissenschaften 99: 407–416).

Because tabanid response to traps differs among species and locations, it is necessary to continue to develop and assess trapping methods for tabanid flies in

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different geographic regions or areas. The study reported herein, therefore, compared the efficiency of Nzi traps, Malaise traps, and bottle traps in collecting tabanids along the Danube River in Eastern Croatia. The study site was in a meadow in the Monjoroš Forest complex (N45°45′, E18°52′; UTM CR37) on the western bank of the Danube. Trees in the forested area adjacent to the study site were primarily white willow (*Salix alba* L.), black poplar (*Populus nigra* L.), and common oak (*Querqus robur* L.). The traps were placed in the meadow on 11 July 2015 and were operated from 7:00 a.m. to 7:00 p.m. each day until completion of the study on 25 July 2015. On each day, flies were collected from each trap and stored in 70% ethanol until taxonomically identified using the taxonomic keys of Krčmar et al. (2011, Period. Biol. 113: 1–61). A chi-square test (χ^2) was used for analysis of the numbers of tabanids captured by different traps ($P = 0.05$). Standard deviations were determined for the mean number of tabanids collected per trap types. Both analyses were conducted using the software program Statistica 7.0 (originally SoftStat, currently Dell).

Traps were placed in the middle of the meadow, approximately 50 m from the edge of the forest, and arranged in 3 rows separated by 10 m. Traps within rows were 10 m apart and were placed within the rows as follows: first row: Nzi trap, bottle trap, Malaise trap; second row: Malaise trap, Nzi trap, bottle trap; third row: bottle trap, Malaise trap, Nzi trap.

During the study period, a total 1,318 tabanids, representing 15 species, were collected at the study site. All 15 species were collected in the Nzi traps while 9 species were collected in the Malaise traps and 2 species in the bottle traps (Table 1). *Tabanus* was the most-frequently represented genus with 6 species followed by the genera *Chrysops* and *Haematopota* with 3 species each, *Hybomitra* with 2 species, and *Atylotus* with 1 species. The most-frequently collected species in all 3 types of traps was *Tabanus bromius* (L.) (41.6% of the total tabanids collected), *Tabanus tergestinus* (Egger) (25.6% of total), and *Tabanus sudeticus* (Zeller) (21.7%); the remaining 12 species combined comprised only 11.2% of the total (Table 1).

In our study, the Nzi trap was superior to the Malaise and bottle traps in collecting tabanids in the Monjoroš Forest in Croatia. The Nzi traps captured 70.2% of the total tabanids captured by all 3 traps while the Malaise traps captured 28.9% and the bottle traps captured only 0.8% (Table 1). Furthermore, the Nzi traps captured a mean of 62 tabanids per collection period (61.8000 ± 24.54791) whereas the Malaise traps captured 25 (25.2222 ± 24.77230) and the bottle traps captured only 0.70 (0.7333 ± 1.33452) tabanids per trapping period (Table 1). The highest standard deviation from the mean in Malaise traps indicates that the data points are spread out over a wider range of values. The χ^2 analyses of the trapping data showed that the Nzi traps collected significantly more tabanids in comparison to the number of tabanids collected in Malaise traps and bottle traps ($\chi^2 = 964.52$; df $= 2$; $P = 0.05$). Also, Nzi traps collected significantly more *T. bromius*, *T. tergestinus*, *T. sudeticus*, and *Haematopota pluvialis* (L.) females than did Malaise traps (Table 1). A total of 94.91% of tabanids collected belonged to these four species.

The Nzi trap was recently developed in Africa as an efficient trap for tsetse flies and other biting flies (Mihok 2002). Subsequent studies found that the efficiency of standard Nzi cloth traps matched or exceeded that of conventional tabanid traps in trapping tabanids (Mihok et al. 2006, Bull. Entomol. Res. 96: 387–397; Mihok and

Table 1. Number of tabanid flies collected using three different trap types in the floodplain areas along the Danube River in Croatia.

Species	Nzi Traps	Malaise Traps	Bottle Traps	Total	χ^2
Tabanus bromius Linnaeus 1758	406	132	10	548	139.54*
Tabanus tergestinus Egger 1859	194	143	0	337	7.7*
Tabanus sudeticus Zeller 1842	217	69	0	286	76.58*
Haematopota pluvialis (Linnaeus 1758)	58	21	1	80	17.32*
Chrysops relictus Meigen 1820	11	8	0	19	NA†
Tabanus autumnalis von Linné 1761	14	1	0	15	NA
Hybomitra ciureai (Séguy 1937)	10	2	0	12	NA
Tabanus maculicornis Zetterstedt 1842	4	2	0	6	NA
Chrysops viduatus (Fabricius 1794)	1	2	0	3	NA
Tabanus bovinus Linnaeus 1758	3	0	0	3	NA

Table 1. Continued.

Species	Nzi Traps	Malaise Traps	Bottle Traps	Total	χ^2
Haematopota subcylindrica Pandellé 1883	3	0	0	3	NA
Chrysops parallelogrammus Zeller 1842	2	0	0	2	NA
Atylotus loewianus (Villeneuve 1920)	2	0	0	2	NA
Hybomitra muehlfeldi (Brauer *in* Brauer and Bergenstamm 1880)	1	0	0	1	NA
Haematopota italica Meigen 1804	1	0	0	1	NA
$\sum$ 15	926	381	11	1,318	
(Mean number ± SD)**	(61.8000 ± 24.54791)	(25.2222 ± 24.77230)	(0.7333 ± 1.33452)		

* Significant differences ($P = 0.05$).
† NA, not analyzed.
** Mean number of tabanids (± SD) per trap in the study area.

Carlson 2007, J. Econ. Entomol. 100: 613–618). Indeed, we found that Nzi traps trapped 2.43 times more tabanids than Malaise traps. Similar results were obtained in studies conducted in Louisiana (USA) and north Queensland (Australia), where Nzi traps collected 4.5 and 5 times more tabanids than did canopy traps (Mihok et al. 2006; Van Hennekeler et al. 2008), and in Sudan (Africa) where Nzi traps collected 3.0 and 12.0 times more tabanids than did the NGU2B and the biconical traps, respectively (Mohamed-Ahmed et al. 2007, J. Sci. Tech. 8: 46–64). In Canada, the standard cloth Nzi traps were equally as efficient as the Manitoba horse fly trap and the Greenhead trap in sampling tabanids (Mihok and Carlson 2007). Nzi traps used in the French Pyrenees were very effective in collecting a diversity of tabanids (Baldacchino et al. 2014, Bull. Entomol. Res. 104: 471–479).

We also collected *Chrysops parallelogrammus* Zeller in the Nzi traps in our study. This represents the first collection of this species in the Danube floodplain region in Croatia. To date, *Ch. parallelogrammus* had been collected only in localities along the Drava River between the Croatian and Hungarian border (Krčmar et al. 2006, Entomol. Gener. 28: 275–282).

In summary, the Nzi trap appears to be an effective means of monitoring and collecting tabanid species in lowland areas of Croatia. We recommend their use in future surveys, monitoring, and management programs for tabanid fly pests in that region.