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EFFICACY OF H-TRAPS IS AFFECTED BY EXPOSURE TO SUNSHINE

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In recent years, H-trap-type insect traps have been used to reduce horsefly densities. We investigated the impact of the factors affecting the efficacy of H-traps. Catching data of 15 H-traps were analyzed. The traps were deployed at an outdoor equestrian paddock (Sántos, Somogy county) from May to July 2018. In twelve weeks, the traps collected 10,556 horsefly specimens, dominated by *Tabanus autumnalis* and *Haematopota italica*. In the first experiment we found that the distribution of caught individuals was inhomogeneous among the samples. According to the amount of caught individuals, trap efficacy showed spatial and temporal inhomogeneity. In the second experiment, after the rearrangement of traps, we found that traps placed in open, sunny places in the centerline area caught significantly more horseflies than those in shady border regions. It can be concluded that the positioning of H-traps in sunny areas significantly enhances their tabanid-catching efficacy.

Keywords: Tabanidae, horseflies, collection efficacy, insect trap, livestock

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Posljednjih godina za smanjivanje gustoće obada koriste se klopke H-tipa. Istraživali smo utjecaj različitih čimbenika na efikasnost H-klopki. U radu se analiziraju podaci o ulovu 15 H-klopki. Klopke su bile aktivirane unutar ograde za konje (Sántos, županija Somogy) od svibnja do srpnja 2018. u 12 tjedana klopke su prikupile 10.556 primjeraka obada, među kojima su dominirale vrste *Tabanus autumnalis* i *Haematopota italica*. U prvom pokusu utvrdili smo da je zastupljenost uhvaćenih vrsta među uzorcima nehomogena. Klopke su pokazivale prostornu i vremensku nehomogenost u odnosu na prikupljene primjerke. U drugom pokusu, nakon preraspodjele klopki, utvrdili smo da su klopke postavljene na otvorene sunčana mjesta na središnjoj liniji plohe uhvatile značajno više obada nego one u sjenovitim graničnim područjima. Može se zaključiti da smještanje H-klopki na sunčana mjesta znatno povećava njihovu efikasnost prikupljanja obada.

Ključne riječi: Tabanidae, obadi, efikasnost prikupljanja, lovke za kukce, stoka

INTRODUCTION

The females of most horsefly (Tabanidae) species suck the blood of large mammals and of humans (Majer, 1987a, 1987c), which they need to ripen their eggs. During punctuation, their powerful mouth organs inflict a painful wound upon the skin of the animal. Tabanids can drain up to 300 ml of blood daily (Tashiro & Schwardt, 1949). Due to blood loss, pain and persistent harassment, the nervous, weakened target animals become more susceptible to diseases. In

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addition, certain horsefly species can be vectors of some serious illnesses, like tularemia, anthrax, epidemic anemia, pork cholera, foot and mouth disease (Krinsky, 1976), different types of encephalitis, rinderpest, influenza, Potomac horse-fever and bovine babesiosis, as well as species of several other pathogen bacteria genera like *Clostridium, Pasteurella, Brucella* and *Listera* (Foil, 1989).

Since continuous harassment is presumed to cause permanent stress and reduced comfort in pasture animals, defense against tabanids is desirable. Mock (1994) suggested that farmers should keep livestock away from wet habitats in which the larvae of biting insects develop. However, this is not always possible, especially for smaller horse farms. Chemical control is not a lasting solution, as horseflies often come from distant areas (Beesley & Crewe, 1963; Bennett & Smith, 1968; Thornhill & Hayes, 1972; Sheppard & Wilson, 1976), so they can reappear in big quantities around the grazing animals a few days after spraying. For the same reason, the elimination of their reproduction sites by the drainage of wetlands cannot be taken into account, and what is more this method may be damaging to the environment. There are experimental results using repellent substances (Krčmar & Gvozdić, 2016) but they cannot be applied on a daily basis on many animals at the same time. Dark horses and cattle can be protected from tabanid flies with the use of white or striped or spotted horse/cattle-coats, because white, striped or spotted targets have been shown to be unattractive to host-seeking tabanids (Horváth *et al.* 2010, 2019; Blahó *et al.* 2012a, 2013; Egri *et al.* 2012a).

One of the obvious methods of controlling blood-sucking insects is their mass collection by traps. Several types of equipment have been developed against blood-sucking insects (horseflies, deer flies, stable flies, mosquitoes, etc.). Earlier, mainly Malaise traps were used for automated collecting of tabanids for sampling and monitoring (Malaise, 1937; Townes, 1962). However, due to their size, structure, handling and price, these traps cannot be used on a large scale in the everyday practice of livestock raising. The first canopy traps, designed by Thorsteinson (1958), were further developed by Catts (1970), Adkins *et al*. (1972) and Hribar *et al*. (1991). The Nzi traps were designed for controlling different biting flies in Africa and were validated in North America (Mihok, 2002; Mihok *et al*., 2006). Several attempts have been made to increase the efficacy of traps (Krčmar, 2005, 2007; Krčmar *et al*., 2005a; 2010). Recently, numerous experiments to compare different types of traps have been carried out (Hennekeler *et al*., 2008; Krčmar & Poklukar, 2011; Krčmar *et al*., 2014; Krčmar, 2017). To date, however, there is no generally accepted and widespread type of trap for horseflies suitable for mass collection. In consequence, the action against tabanids is still an unresolved problem in the outdoor breeding of livestock, especially horses and cattle.

Recently, numerous scientific papers have been published on the attractive effect of polarized light on horseflies (Horváth *et al*., 2008, 2017; Kriska *et al*., 2006, 2009; Blahó *et al*., 2012b; Egri *et al*., 2012a,b). Based on this, modified canopy traps, so-called H-traps were developed (Fig. 1). The lower part of the H-trap is made of a shiny (smooth) black sphere, which reflects strongly and linearly polarized light that attracts host-seeking female tabanid flies (Egri *et al*., 2012b, 2013a, 2013b). The insects leave the area upwards, so they fly into a funnel that drives them into a plastic container where they will be killed and collected. These traps are already commercially available, but there are unsettled issues in connection with their effective use. For example, it is not known how the traps can be used efficiently, what the relationship is between the size of the area and the number of devices needed to be placed, how selective the traps are, how dangerous they are for nature conservation, etc.

Fig. 1. Self-made H-trap (Author: M. Z. Otártics)

One of the most obvious questions that immediately arises when such traps are used is how they should be positioned in a given area. No experimental results are available on the effect of the positioning of H-traps on their efficacy. The only advice that the H-trap manual suggests in the event of inefficient functioning is the repositioning of the traps (https://horseflies.insective.com/). During our study, we sought to find out how the positioning of the traps affects their efficacy, especially, if direct sunshine is necessary for H-traps to be able to catch horseflies.

MATERIALS AND METHODS

The study was carried out near the village of Sántos (Somogy county; 46°21′17.44″ N - 17°52′42.70″ E), on a 4 ha equestrian farm. The territory is located on the border of a wood patch in the Zselic hill-country, 300m from the Kapos River, where the hills meet the floodplain areas. On the farm, nine horses were kept until 10th June 2018, but later there were 11 of them. From dusk until 9 am the horses were in closed boxes, but they could move freely in the yard during daytime.

In the first experiment (from 3 May to 3 July 2018), we randomly placed ten H-traps in the farm (Fig. 2). The H-traps used in our experiments were made of a hanging, white muslin pourer (d = 1m) and a shiny black beach ball (d = 0.6m). On the top of the trap, there was a transparent plastic box, in which the insects were killed by the high temperature due to the greenhouse effect.

Emptying of the traps happened 21 times during seven weeks, with an average interval of 2.5 days. Each sampling event occurred at the same time of the day. The number of horseflies collected by each trap was considered a sample for that period.

Observing a large variation in tabanids caught during the first experiment, we rearranged the traps in the second experiment (between 16 and 31 July) to attempt to test if exposure to different amounts of direct sunshine was responsible for the variability in the catch. A total of 15 traps were placed with the following arrangement: 5 traps in the open, sunny centerline of the farm ("sunny, S"), a further 5 traps near to the western ("west, W") and eastern ("east, E") bordering woody areas (Fig. 3). The latter two groups of traps obtained the same, reduced amount of sunshine, but in different parts of the day. Samples were collected three times in the second experiment.

The collected material was pinned, registered and stored in insect boxes. For identification of the species, we used the keys of Aradi (1958), Majer (1987b) and Chvála *et al*. (1972). Statistical analyses of data were done performing χ^2-test, t-test (MS Excel 2013) and analysis of variance with Tukey post-hoc test (SPSS Statistics 17.0).

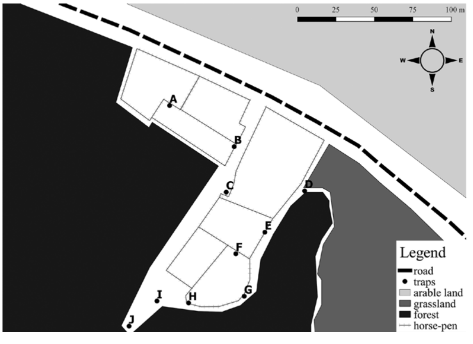

Fig. 2. The situation of randomly positioned traps in the first experiment

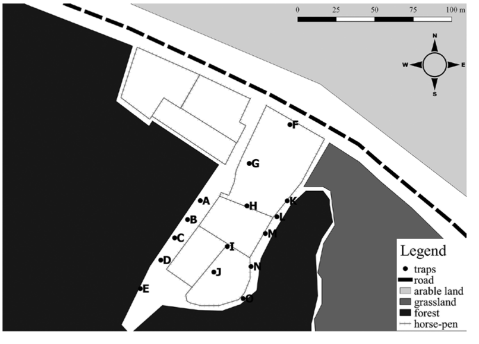

Fig. 3. The position of traps in the second experiment

RESULTS

In the first experiment, the ten traps collected 8,195 horseflies belonging to 18 species. The abundances of *Tabanus autumnalis* and *Haematopota italica* were salient. The percentages of catches from the given traps are shown in Fig. 4. The between-trap distribution of horseflies by total catch from all the traps was not homogenous (χ^2-test, P<0,001; Tab. 1). Traps of the same construction placed differently operated with different levels of efficacy. This difference was revealed when we separately analyzed the consecutive samples, and it was found that the distribution of caught individuals was inhomogeneous in each period. Some

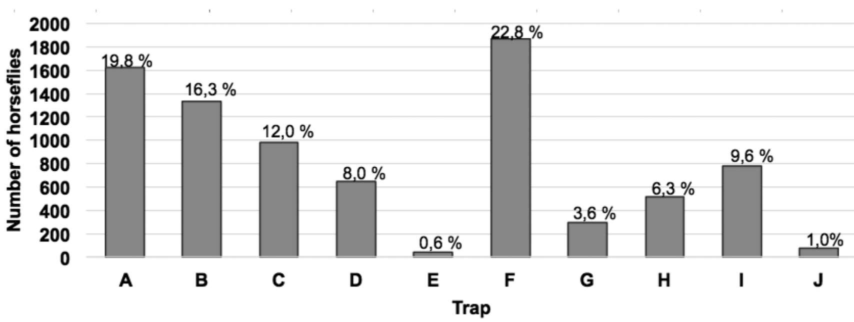

Fig. 4. Number and percentage distribution of tabanid individuals per trap in the first experiment

Tab. 1. Distribution of number of horse flies per sampling and trap in the first experiment

		Sampling events																				
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***17***	***17***	***18***	***19***	***20***	***21***
Trap	***A***	46	17	13	8	26	8	29	40	8	83	50	232	187	315	118	2	69	224	55	69	26
	B	17	2	7	0	8	0	10	14	3	18	42	133	117	410	126	3	99	159	52	64	48
	C	40	7	6	7	38	11	21	29	6	64	75	70	100	181	79	3	19	121	29	44	33
	D	18	8	10	3	22	11	17	20	9	30	47	63	60	95	46	0	39	94	18	25	17
	E	2	0	1	1	1	0	0	0	0	0	6	17	8	7	7	0	0	1	0	0	0
	F	39	9	11	9	45	9	12	26	7	76	115	200	228	319	243	2	137	121	114	62	88
	G	14	0	2	2	5	2	0	5	2	16	24	31	25	35	12	0	8	75	12	11	17
	H	13	3	2	2	14	0	4	6	3	31	18	19	66	87	23	0	46	93	33	27	26
	I	21	9	2	6	29	2	15	11	4	33	24	48	114	207	43	0	52	114	21	17	13
	J	14	1	0	4	4	1	1	4	1	3	4	12	10	13	0	0	1	0	3	3	2
		χ^2 test; P < 0,001 (for each sampling)																				

traps always caught a large number of horseflies whereas others consistently underperformed. The difference between the catches of the most (F) and least effective (E) traps was 33-fold, albeit they were placed only 19.4 m from each other. After the 15th sampling event, we exchanged the best and the weakest, but both the direction and the magnitude of the trapping difference remained the same. This indicates that there was no – possibly unnoticed – technical difference between the traps and that it was the placement of the traps that was responsible for their dissimilar efficacy.

Since the most effective traps were always installed in open, sunny areas, we hypothesized that trapping efficacy was strongly affected by the light condition of the trapping sites. We tested this hypothesis during the second experiment in which the traps were rearranged to three sets of five, differing in their light regime. The 15 traps caught a total of 2,361 horseflies (Tab. 2). The distribution of collected tabanids between the three trap groups was not homogeneous either (placement: $F(2,12) = 18.52$, $p = 0.0001$; repetition $F(2,24) = 3.47$, $p = 0.047$; interaction: $F(4,24) = 2.39$, $p=0.079$; Fig. 5). The traps of the centerline sunlit area caught significantly more tabanids than those at the borders in every sampling period. According to the post hoc Tukey-test, the two border trap sets caught similar but fewer horseflies

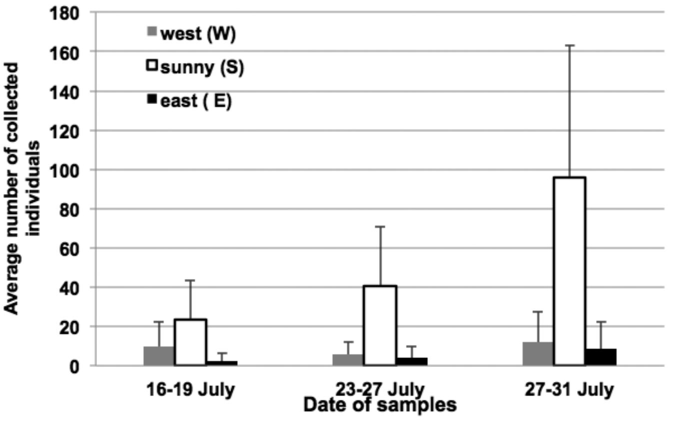

Fig. 5. The average amount of horse flies caught by trap groups in the second experiment

Tab. 2. Distribution of number of horse flies per sampling and trap in the second experiment

Sampling period	Trap groups														
	western (W)					centerline (sunny "S")					eastern (E)				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2018.07.16-2018.07.19.	3	1	1	3	5	92	93	206	236	118	10	1	0	13	6
2018.07.23-2018.07.27.	2	2	1	6	27	61	71	213	170	106	5	1	0	11	9
2018.07.27-2018.07.31.	0	0	0	19	33	49	131	261	221	128	9	0	1	27	9

than the centerline traps. These results further strengthened our hypothesis that H-traps operate best in sunny, open areas, where they can catch 30-40 times more horseflies than the shaded traps. We concluded that the placement of H-traps greatly influences their efficacy. The difference between the three days may indicate that weather factors can also have an effect.

DISCUSSION

We studied the factors affecting the catching efficacy of H-traps and found both spatial and temporal inhomogeneity in the number of caught tabanids. The positioning of traps greatly affected their success, as both the traps' exposure to sunshine and their proximity to the habitat suitable to horsefly larvae had a positive impact on horsefly abundance. We also experienced a day by day fluctuation in the capture rate suggesting a weather impact.

We found that traps positioned in sunny places caught 30-40 times more tabanids than the traps put in the shade. The essence of the H-traps is the black globe whose attraction has been explained in several ways (Blahó, 2009; Thorsteinson *et al.* 1965, 1966; Lehane, 2005; Baldacchino *et al.*, 2014; Horváth *et al.*, 2017). Probably, the polarized light reflected from the black, shiny ball attracts the animals to the trap. It can also be assumed that traps put in shady places reflect less polarized light and this reduces their efficacy. In a further explanation the ball absorbs heat and emits it and attracts insects by its elevated temperature (Symonds, 2014) but no publications were found to prove this statement. However, the increased tabanid-catch could be explained not only by the increased insolation of the centerline traps, but also by their being in the middle of the horse-pens (Figure 3) and thus much closer to the horses, which functioned as lures and increased the trapping efficiency of the H-traps. Consequently, the site effect of the tabanid-trapping efficiency can only be reduced, rather than completely eliminated with the used trap-positioning method.

The observed variation of catching efficacy among the traps of similar placement can be related to the ecological and ethological characteristics of horseflies. Several studies focused on the effect of certain meteorological factors on tabanids (Alverson & Noblet, 1977; Herczeg *et al*., 2015). Effects of temperature (Bowden, 1976; Burnett, 1974), air humidity (Trojan, 1958) and wind speed (Chvála *et al*., 1972; Wiesenhütter, 1975; Krčmar *et al*., 2005b) were investigated most often. In our experiments, temperature and air humidity could not have caused the traps' different efficacies because both were measured near the traps and the values did not differ.

Catch differences in the present study might also originate from directional gradients. The first six traps close to the paddock's entrance collected 79.5% of all horseflies. It can be assumed that a large part of the larvae of horseflies collected at the farm developed on the wet meadows of the nearby Kapos River floodplain and came from that direction, i.e. from the north. Traps at the paddock entrance might have gathered most tabanids so only some flies could reach the back areas of the paddock, but this assumption is still to be tested.

The found fluctuation in the trapping efficacy might be related to the activity pattern of the different tabanid species. Coincidence or anomaly of the activity peak and sunshine exposure of a trap could also influence the efficacy. The activity of different horsefly species alters during the day and every species has its characteristic active period (Trojan, 1958; Hollander & Wright, 1980; Kozanek, 1980; Ferreira *et al*., 2002; Ferreira & Rafael, 2004; Herczeg *et al*., 2014).

Summarizing our results, the differing efficacies of H-traps can be explained by at least three reasons: the reflection of polarized light was the most intense at traps situated in sunny places; traps at the entrance of the paddock were situated in the flight paths from moist areas; and the combination of this latter factor with the weather and the active periods of horseflies. Testing all these assumptions can only be done with new experiments.

Our study may contribute to an improved trapping methodology reducing horseflies. Unlike other insect-trapping methods, the H-trap catches tabanids in great numbers (Kline *et al.,* 2018) and is very selective, as there are only small quantities of other flying insects in the traps. It can be recommended to improve livestock welfare while not harming biodiversity. However, with further investigations, H-trap use efficacy can be improved.

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SUMMARY

Efficacy of H-traps is affected by exposure to sunshine

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Harassment by horse flies is presumed to cause stress and reduced comfort in pasture animals and therefore the defense against these insects is desirable. One of the obvious methods of controlling blood-sucking insects is their mass collection by traps. Although several types of equipment have been developed against biting insects to date, there is no generally accepted and widespread trap for horse fly control. In recent years, farmers have started to use H-traps to reduce the number of tabanids around horses. The operation of H-traps is partly based on the attractive effect elicited by the high degree of linear polarization of light reflected from the shiny (smooth) black sphere luring host-seeking female tabanids, but a number of unknown factors may affect the function of these traps. During our research, we investigated the impact of the positioning of H-traps on their efficacy. The study was carried out near the village of Sántos (Somogy county, South-West Hungary) on a 4 ha equestrian farm paddock, at the edge of a woodland, some 300m from the Kapos River. In the first experiment, the ten randomly placed traps collected 8,195 horse flies belonging to 18 species. The percentages of *Tabanus autumnalis* and *Haematopota italica* were salient. We found that the individual traps were operating with different efficacies as the distribution of caught individuals was inhomogeneous in the consecutive samples. Some traps always caught a large number of specimens whereas others consistently underperformed. The difference remained the same after the best and weakest trap were replaced, showing that the placement of the traps itself could have caused the anomaly. In the second experiment, the 15 H-traps were placed in 3 rows; two on the eastern and western, shady bordering sides, and one in the sunny locations in the centerline of the paddock. We found that the traps in the border regions caught significantly fewer horse flies in all the samples than those in the open, sunny places in the centerline area, the same trap being thus able to catch 30-40 times more horse flies if placed appropriately. We concluded that the positioning of H-traps significantly influences their catching efficacy. The H-trap is especially recommended as it catches tabanids in large numbersand is very selective, thus it may provide a useful tool to improve livestock welfare while not harming biodiversity.