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Original scientific paper

Analysis of the Feeding Sites for some Horse Flies (*Diptera, Tabanidae*) on a Human in Croatia

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A B S T R A C T

The landing patterns of horse flies on the human body were observed in Croatia. A total of 386 horse flies belonging to 22 species were sampled. The five most commonly collected species were used in the analysis. The stochastic linear connection is tight among the landings of the species Tabanus bromius*,* Tabanus maculicornis*,* Tabanus tergestinus*, and* Philipomyia graeca *on the human body regions (matrix R). The preferred feeding area for these four species was the lower leg, whereas for the species* Haematopota pluvialis *it was the head and neck. Of the total number of horse flies that landed 44.81% were on the lower leg. Only 0.26% landed on the forearm. Chi-square analysis indicated non random landing patterns on human by these horse flies.*

Key words*:* Diptera*,* Tabanidae*, human, feeding sites, Croatia*

Introduction

Many different species of Diptera are implicated in mechanical transmission of diseases agents, but haematophagous species are the most important[1,2]. The Tabanidae are considered to be among the major Dipteran pests of human and animals worldwide[3]. Tabanids are known as important mechanical vectors of viruses, bacteria, protozoans and helminths, which cause diseases of wild and domestic animals, and also of humans[3,4–8]. These flies cause a painful bite owing to their blood feeding habit, and in many areas of the world they are very abundant during the summer season, when people visit outdoor recreation areas. To the host, a feeding fly results in annoyance and loss of blood at best, and significant disease risk and, ultimately, death at worst[9]. To minimize these risks people have developed many mechanisms to prevent or mitigate attack by horse flies. Many faunistic and ecologic studies of horse flies were performed in the world during the last 50 years. However, there is no information on the feeding sites on humans for this important group of nuisance insects. The present paper provides new data, which expand the knowledge about the feeding sites of horse flies on the human body in Croatia.

Material and Methods

Horse flies (*Tabanidae*) were collected between 1995 and 2005 at 29 localities in Croatia. No field trips were made particularly for the collecting of horse flies landing on humans. Specimens of horse flies were hand picked from volunteers during the various fieldworks. Collected horse flies were stored in the field in 70% alcohol, separately with respect to the landing places on the human, collection locality, and date. We have divided the surface of the human body into 8 areas (Figure 1). Absolute and relative frequencies of horse flies arriving on different parts of the human body, specified as: back (B=E_1 variable), chest (C=E_2 variable), forearm (F=E_3 variable), head (H=E_4 variable), lower leg (L=E_5 variable), neck (N=E_6 variable), upper leg (R=E_7 variable), upper arm (U=E_8 variable), were recorded. Species identification was made according to Chvála et al. (1972)[10]. In the analysis of the acquired data, the probability statistical method and Chi-square test was applied[11]. All the collected horse flies are deposited in the insect collections of the JJ Strossmayer University Department of Biology, Osijek.

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Results

During the investigation period, a total of 386 specimens of horse flies, belonging to 22 species, were collected on the humans (Table 1). Most of the species belong to the genus *Tabanus* (8), followed by *Haematopota* (5), *Chrysops* (4), *Atylotus* (2), *Silvius* (1), *Heptatoma* (1), *Philipomyia* (1). The most common species were *Haematopota pluvialis* (L., 1758) (37.30%), *Tabanus maculicornis* Zetterstedt, 1842 (17.09%), *Philipomyia graeca* (Fabricius, 1794) (9.84%), *Tabanus bromius* L., 1758 (9.06%), and *Tabanus tergestinus* Egger, 1859 (7.77%), (Table 1). These five species comprised 81.08% of horse flies sampled on human bodies. In Table 2 the degree in which arriving horse flies were choosing particular parts of the human body for taking their blood meals is shown. Of the total number of horse flies collected, 44.81% landed on the lower leg. On the other hand, only 0.26% of the total number of horse flies landed on the forearm (Table 2). Five species of horse flies comprised 81.08% of the horse flies collected on a human. Let us consider only the basic parameters about the locations of taking of blood meals for more numerous species of horse flies and let us try to establish the possible existence of quantitative agreements, i.e. of relations between adequate data. In that sense, we will mark the variable relating to the landing of horse flies *T. bromius* with T_1, *T. maculicornis* with T_2, *T. tergestinus* with T_3, *H. pluvialis* with T_4, and *P. graeca* with T_5. Observations results are presented in Table 3. If a specimen of one of numerous species of horse flies has landed on a human, then the probabilities of landing on areas $E_1, E_2, \ldots E_8$ are presented by the following stochastic matrix:

$$N = \begin{array}{c} \begin{array}{ccccc} T_1 & T_2 & T_3 & T_4 & T_5 \end{array} \\ \left[\begin{array}{ccccc} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.020 & 0 \\ 0 & 0 & 0 & 0.006 & 0 \\ 0 & 0 & 0 & 0.611 & 0 \\ 0.914 & 1.000 & 1.000 & 0 & 0.973 \\ 0 & 0 & 0 & 0.319 & 0 \\ 0.08 & 0 & 0 & 0.027 & 0.026 \\ 0 & 0 & 0 & 0.013 & 0 \end{array}\right] \end{array} \begin{array}{c} \\ E_1 \\ E_2 \\ E_3 \\ E_4 \\ E_5 \\ E_6 \\ E_7 \\ E_8 \end{array}$$

The sense and the strength of connections between variables T_i and T_j ($i, j = 1,2,\ldots5$, $i \neq j$) will be shown by the adequate coefficient of correlation, i.e. by non diagonal member of the correlation matrix:

$$R = \begin{array}{c} \begin{array}{ccccc} T_1 & T_2 & T_3 & T_4 & T_5 \end{array} \\ \left[\begin{array}{ccccc} 1.0000 & 0.9956 & 0.9956 & -0.2439 & 0.9978 \\ & 1.0000 & 1.0000 & -0.2453 & 0.9996 \\ & & 1.0000 & -0.2453 & 0.9996 \\ & & & 1.0000 & -0.2308 \\ & & & & 1.0000 \end{array}\right] \end{array} \begin{array}{c} \\ T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \end{array}$$

TABLE 1
LIST OF THE SPECIES OF HORSE FLIES (TABANIDAE) COLLECTED ON A HUMAN

Genus	Species	Specimens
Silvius Meigen, 1830	*Silvius alpinus* (Scopoly, 1763)	2
Chrysops Meigen, 1803	*Chrysops caecutiens* (L., 1758)	3
	Chrysops parallelogrammus Zeller, 1842	12
	Chrysops relictus Meigen, 1820	7
	Chrysops viduatus (Fabricius, 1794)	6
Atylotus Osten-Sacken, 1876	*Atylotus flavoguttatus* (Szilády, 1915)	1
	Atylotus loewianus (Villeneuve, 1920)	1
Tabanus L., 1758	*Tabanus autumnalis* L., 1761	1
	Tabanus bifarius Loew, 1858	1
	Tabanus bovinus L., 1758	1
	Tabanus bromius L., 1758	35
	Tabanus maculicornis Zetterstedt, 1842	66
	Tabanus quatuornotatus Meigen, 1820	1
	Tabanus sudeticus Zeller, 1842	18
	Tabanus tergestinus Egger, 1859	30
Heptatoma Meigen, 1803	*Heptatoma pellucens* (Fabricius, 1776)	1
Haematopota Meigen, 1803	*Haematopota grandis* Meigen, 1820	4
	Haematopota italica Meigen, 1804	1
	Haematopota pandazisi Kröber, 1936	12
	Haematopota pluvialis L., 1758	144
	Haematopota subcylindrica Pandellé, 1883	1
Philipomyia Olsufjev, 1964	*Philipomyia graeca* (Fabricius, 1794)	38
Σ7	22	386

TABLE 2
FREQUENCIES OF HORSE FLIES (TABANIDAE) THE HUMAN BODY

Ordinal number	Body part (E_i)	Absolute frequencies f_I	Cumulative frequency below	Cumulative frequency above	Relative frequency p_i
1	E_1	17	17	386	0.0440
2	E_2	4	21	369	0.0103
3	E_3	1	22	365	0.0026
4	E_4	100	122	364	0.2590
5	E_5	173	295	264	0.4481
6	E_6	63	358	91	0.1632
7	E_7	22	380	28	0.0569
8	E_8	6	386	6	0.0155
		386			0.9996

E_1 – back, E_2 – chest, E_3 – forearm, E_4 – head, E_5 – lower leg, E_6 – neck, E_7 – upper leg, E_8 – upper arm

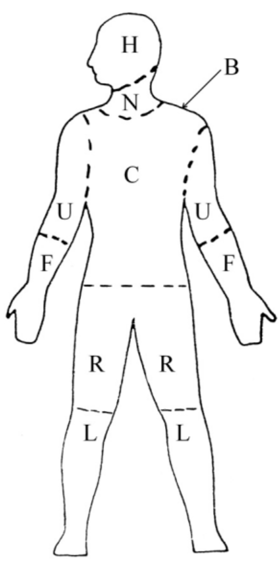

Fig. 1. Parts of the human body on which horse flies take their blood meal. B – back, C – chest, F – forearm, H – head, L – lower leg, N – neck, R – upper leg, U – upper arm.

With regard to the value of elements r_{ij} ($i \neq j$) of the correlation matrix, we can observe: that gradual landings of pairs (T_1, T_2), (T_1, T_3), (T_1, T_5), (T_2, T_3), (T_2, T_5) and (T_3, T_5) species of horse flies are manifested unidirectionally, whereas other pairs do not manifest themselves unidirectionally. The stochastic linear connection between landings of horse flies in pairs (T_1, T_4), (T_2, T_4), (T_3, T_4), (T_4, T_5) is entirely insignificant. Just the opposite, between landing pairs (T_1,T_2), (T_1, T_3), (T_1,T_5), (T_2, T_5), (T_3, T_5) is very tight and between landings (T_2, T_3) it is identical, because the species *T. bromius*, *T. maculicornis*, *T. tergestinus* and *P. graeca* mostly landed on the lower leg whereas the species *H. pluvialis* mostly landed on the head and neck body regions. The χ^2 analysis of landings by these horse flies on respective parts of the human bodies showed that horse flies landing patterns significantly differ among parts of the human body: *T. bromius* (χ^2=199.91 $p<0.05$), *T. maculicornis* (χ^2= 464.79 $p<0.05$), *T. tergestinus* (χ^2=212.80 $p<0.05$), *P. graeca* (χ^2=253.11 $p<0.05$), *H. pluvialis* (χ^2=405.30 $p<0.05$). Horse flies were distributed unequally among the 8 body regions. In general, lower leg was preferred compared with the others body regions.

TABLE 3
THE MORE NUMEROUS SPECIES OF HORSE FLIES TAKING BLOOD MEAL

Ordinal Number	Body part (E_i)	T_1	T_2	T_3	T_4	T_5
1	E_1	–	–	–	–	–
2	E_2	–	–	–	3	–
3	E_3	–	–	–	1	–
4	E_4	–	–	–	88	–
5	E_5	32	66	30	–	37
6	E_6	–	–	–	46	–
7	E_7	3	–	–	4	1
8	E_8	–	–	–	2	–
	Σ	35	66	30	144	38

E_1 – back, E_2 – chest, E_3 – forearm, E_4 – head, E_5 – lower leg, E_6 – neck, E_7 – upper leg, E_8 – upper arm, T_1 – *T. bromius*, T_2 – *T. maculicornis*, T_3 – *T. tergestinus*, T_4 – *H. pluvialis*, T_5 – *P. graeca*

Discussion

The presence of 22 species of horse flies on the human body has been documented. Five species comprised 81.08% of horse flies sampled on human bodies. It has been determined by testing, although it is immediately visible, that the differences in landing of the same species according to parts of the bodies of human are very significant. Proportions of landings of horse flies according to species on different body parts are not equal. This character is not accidental; horse flies significantly distinguish between parts of the bodies of human. During the research period, the largest number of horse flies landed on the lower leg. Unfortunately, we cannot comparing our results obtained from human bodies with others, because there are no data from similar studies. However, some authors have reported that horse flies also significantly distinguish between particular parts of the bodies of domestic animals[12,13–16]. Comparative studies on the landing site preferences of mosquito species showed that olfactory cues emanating from particular areas of the human body enhance landing on those areas for the specialised species, whereas generalists feeders land at random[17]. De Jong and Knols[17] also learned that out of the eight species of mosquitoes they studied, five of them prefer receiving blood meals at the head and upper torso[17]. Of these five, three preferred biting the face directly, as did *H. pluvialis* in our research. Their study suggests that carbon dioxide is very powerful attractant and it tends to attract mosquitoes to the area of the body that emits the largest amount of compound. Removal of the carbon dioxide from human breath decreases attraction to the host, but the catch of tabanids increased 100 fold when traps were baited with carbon dioxide[18–20]. Furthermore, studies on mosquitoes showed that lactic acid and sweat enhanced the number of landings in the presence of carbon dioxide on the human hand and legs[21]. Our study showed that horse flies are highly selective for landing sites on humans. Data on landing sites of tabanids on the human bodies are very scarce. Because of this direct comparisons between our data and data of other investigators are not possible. Despite the fact that studies of vector ecology are essential to understand predict and control insect-borne diseases, relatively few studies have been conducted about blood feeding by tabanids on humans. This points out the necessity of further research.

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ANALIZA MJESTA ISHRANE NEKIH VRSTA OBADA (*DIPTERA*, *TABANIDAE*) NA LJUDIMA U HRVATSKOJ

S A Ž E T A K

Obavljena su istraživanja mjesta ishrane obada (*Tabanidae*) na ljudima u Hrvatskoj. Uzorkovano je ukupno 386 obada svrstanih u 22 vrste. Analizirano je pet najbrojnijih vrsta obada. Stohastička linearna veza između nadolazaka vrsta *Tabanus bromius* L., 1758, *Tabanus maculicornis* Zetterstedt, 1842, *Tabanus tergestinus* Egger, 1859 and *Philipomyia graeca* (Fabricius, 1794) vrlo je tijesna jer slijeću na iste djelove tijela čovjeka (matrica R). Izbor mjesta hranjenja odnosno uzimanja krvnog obroka ovih četiriju vrsta je potkoljenica, dok je za vrstu *Haematopota pluvialis* (L., 1758) glava i vrat. Od ukupnog broja pristiglih obada 44.81% skupljeno je na potkoljenici. Jedino 0.26% od ukupnog broja obada slijeće na podlakticu. *Hi*-kvadrat test pokazuje da ove vrste obada ne slijeću nasumce na tijelo čovjeka, već signifikantno razlikuju pojedine dijelove tijela čovjeka.