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INVESTIGATION OF MOSQUITO FAUNA ALONG THE REACH OF THE RIVER TISA BETWEEN TISZABECS AND KISKÖRE (NE-HUNGARY)

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ABSTRACT – This paper presents the results of qualitative and quantitative examinations of mosquitoes along the Upper Tisa. We used own and referenced data too. 7270 specimens of 29 species were found in the area. There are significant differences in the compound of mosquito assemblages along the five seperated reaches between Tiszabecs and Kisköre. The assemblage of the Lake Tisa was basically different from the flood-plain assemblages of the other upper reaches. In 2003 the mosquito density showed an explicit increasing tendency from the frontier to downwards. The significant differences come from the quite few bite numbers on the reach Tiszabecs-Vásárosnamény. Between 2002 and 2010 the surveys presented, that the bite numbers were increased in this period on the two upper reaches (Tiszabecs-Vásárosnamény and Vásárosnamény-Dombrád). The results indicate, that there may be significant differences among compound of mosquito assemblages and quantity of mosquitoes in time and space.

Key words: bite number, mosquito assemblages, Upper Tisa.

1. Introduction

Mosquitos (Diptera: Culicidae) are important component of wetlands (MITSCH et al. 1994). There can be spatial and temporal differences between mosquito assemblages as regards their compound and number of individuals. ZHONG et al. (2003) have shown that these differences due to variable habitat preference and host preference of species, and variable environmental conditions. This is likely connected with the experiences that there are significant differences between assemblages living in adjoining habitats considering their compound and phenology (BOGYÓ and SZABÓ 2006; SZABÓ 2007a).

The mosquito fauna of Hungary is well researched (TÓTH 2004). But the surveys concentrated in the first place on the large lakes of Hungary due to tourist reasons, mainly on the Lake Balaton (MIHÁLYI 1941; MIHÁLYI et al. 1953; TÓTH et al. 2009), the Lake Velence (TÓTH 2003) and Transdanubia (TÓTH 2006). There was just a few, mainly sporadic data till the last few years from the east part of the country (TÓTH 2004). In the last few years the faunistic investigation increased in this area too (SZABÓ 2007a, 2007b; SZABÓ et al. 2011).

There are just few surveys performed in flood-plains of large rivers in Hungary. TÓTH and KENYERES (2011) reported about the mosquito fauna along the Danube. Although there is knowledge about the mosquito fauna of the catchment area of the River Tisa (TÓTH 1977), but there are limited data from the upper reach of the river. This study remedies this deficiency using data from references and our own results.

2. Materials and methods

The surveys were performed from the entrance point of the River Tisa (Tiszabecs) to the southern part of the Lake Tisa (Tiszalök, Abádszalók). We used the data regarded this reach from the book of reference (TÓTH 2004). Although the surveys have covered the settlements, but in this study we used the data only from flood-plains and settlements which are on the riverside, and can be consider as flood-plain.

The data were analysed in 5 seperated reach of the river (DÉVAI et al. 2010; LAJTER et al. 2010):

- the reach between Tiszabecs and Vásárosnamény
- the reach between Vásárosnamény and Dombrád
- the reach between Dombrád and Tiszalök
- the reach between Tiszalök and Tiszabábolna
- the Lake Tisa

The mosquito assemblages were investigated from 2002 till 2010. The surveys on the reach Tiszabecs-Vásárosnamény and Vásárosnamény-Dombrád were performed many times between June and September in the period 2002-2004, in 2008 and in 2010.

The sampling methods were human trapping and collecting by aspirator. The human trapping was performed all the time by the same man. The mosquitos landing on the skin were collected in 10-15 minutes, and the data were referred to bite/hour values. The collected specimens were identified on the basis of the works from MIHÁLYI and GULYÁS (1963), MOHRIG (1969) and KENYERES and TÓTH (2008).

This study announces the full checklist, but we left out the specimens of *Culex pipiens pipiens* and *Cx. pipiens molestus* of the statistical analysis, because these two subspecies were collected in large amount (1602 specimens, 22.04%) almost only from settlements, cellars and stablings, and these specimens would have effected significant bias in the results.

The all of the data about mosquito assemblages were compared by cluster analysis (WARD-method). The experienced differences were tested by SIMPER analysis (CLARKE 1993). The reaches were merged on the basis of the clusters in stages.

The assemblages of bordering reaches were compared on the basis of frequent species (dominant) by Chi^2-test.

The differences in the bite numbers were investigated in 2003, and the date from the reach Tiszabecs-Vásárosnamény and Vásárosnamény-Dombrád were compared by KRUSKAL&WALLIS and MANN&WHITNEY tests.

Analyses were performed by Microsoft Excel 2003 and Past 2.09 (HAMMER et al. 2001).

3. Results and discussion

3.1. Comparing characterisation of assemblages

There were found 29 species and 7270 specimens on the investigated reaches of the River Tisa, and 28 species 5668 specimens without the *Culex pipiens* samples.

The dominant species were the *Culex modestus*, *Aedes vexans* and *Ochlerotatus sticticus* on the whole area (28.67%, 23.03% and 10.34% respectively). The species, which have over 5% frequency, are the *Aedes rossicus* (7.99%), the *Aedes cinereus* (5.64%) and the *Anopheles atroparvus* (5.13%). The *Ochlerotatus cantans* (3.20%) and the *Anopheles messeae* (2.73%) also have major share. The rest 10 species altogether have only 13.27% frequency (Fig. 1, Table 1).

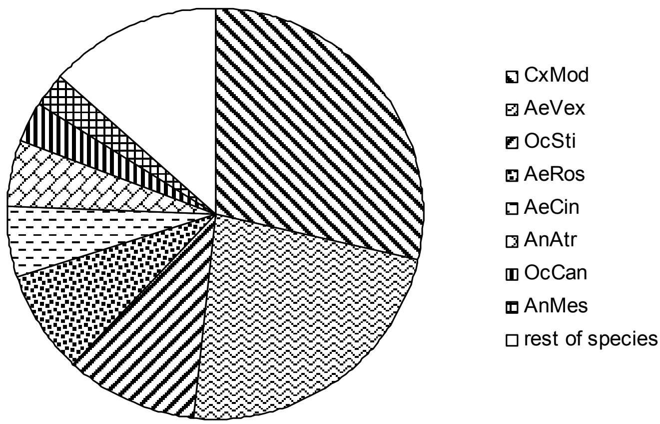

Figure 1
The compound of the mosquito assemblages of the investigated Tisa-reach (list of abbreviations: Table 1).

The presences of *Anopheles algeriensis, Culiseta longiareolata, Culex theileri* and *Culex territans* are remarkable in faunistic respect.

The cluster analysis presents that the assemblages of investigated reaches are well separated. Apparently, the assemblage of the Lake Tisa keeps apart from the assemblages of flood-plains (Fig. 2). The reason is clear: the Lake Tisa is a litoral shallow lake (DÉVAI et al. 2001), but the other sites on the flood-plain of the

River Tisa. This analysis also shows that the two swelled reaches (Dombrád-Tiszalök and Tiszalök-Tiszabábolna) resemble each other. The upper river reaches are more and more different.

Table 1
Number of individuals on the investigated reaches of the River Tisa (abbreviations: Tbecs = Tiszabecs, Vnam = Vásárosnamény, Domb = Dombrád, Tlök = Tiszalök, Tbáb = Tiszabábolna).

	Abbreviations	Tbecs-Vnam	Vnam-Domb	Domb-Tiszalök	Tlök-Tbáb	Lake Tisa	Total
Aedes cinereus MEIGEN, 1818	AeCin	19	173	46	10	66	314
Aedes rossicus DOLB.,GORITZ., MITROF., 1930	AeRos	204	17	97	86	41	445
Aedes vexans (MEIGEN, 1830)	AeVex	387	374	142	93	287	1283
Anopheles algeriensis THEOBALD, 1903	AnAlg	4	1	0	0	0	5
Anopheles atroparvus VAN THIEL, 1927	AnAtr	15	3	146	0	122	286
Anopheles claviger (MEIGEN, 1804)	AnCla	0	7	0	11	0	18
Anopheles hyrcanus (PALLAS, 1771)	AnHyr	0	5	1	0	14	20
Anopheles maculipennis MEIGEN, 1818	AnMac	19	94	16	1	14	144
Anopheles messeae FALLERONI, 1926	AnMes	5	3	118	12	14	152
Coquillettidia richiardii (FICALBI, 1889)	CoRic	31	0	23	30	27	111
Culex hortensis FICALBI, 1890	CxHor	2	5	0	1	7	15
Culex modestus FICALBI, 1890	CxMod	194	155	318	136	794	1597
Culex pipiens LINNAEUS, 1758	CxPip	139	793	492	37	212	1673
Culex territans WALKER, 1856	CxTer	0	0	0	4	13	17
Culex theileri THEOBALD, 1903	CxThe	0	0	1	0	1	2
Culiseta annulata (SCHRANK, 1776)	CsAnn	12	12	4	52	5	85
Culiseta longiareolata (MACQUART, 1838)	CsLon	1	0	0	0	0	1
Culiseta morsitans (THEOBALD, 1901)	CsMor	0	0	0	8	0	8
Ochlerotatus annulipes (MEIGEN, 1830)	OcAnn	53	20	11	24	0	108
Ochlerotatus cantans (MEIGEN, 1818)	OcCan	114	35	5	8	16	178
Ochlerotatus caspius (PALLAS, 1771)	OcCas	0	3	34	11	41	89
Ochlerotatus cataphylla DYAR, 1916	OcCat	42	4	17	1	1	65
Ochlerotatus dorsalis (MEIGEN, 1830)	OcDor	0	3	0	0	2	5
Ochlerotatus excrucians (WALKER, 1856)	OcExr	6	0	1	0	0	7
Ochlerotatus flavescens (MÜLLER, 1764)	OcFla	2	22	7	0	1	32
Ochlerotatus geniculatus (OLIVIER, 1791)	OcGen	1	0	0	0	0	1
Ochlerotatus leucomelas (MEIGEN, 1804)	OcLeu	2	2	22	0	0	26
Ochlerotatus rusticus (ROSSI, 1790)	OcRus	0	0	7	0	0	7
Ochlerotatus sticticus (MEIGEN, 1838)	OcSti	394	76	23	65	18	576
Total		1646	1807	1531	590	1696	7270

The results of the SIMPER test present that the frequent, dominant species cause primary the difference among the assemblages. These species are the next (the ratios causing the differences are in brackets): *Culex modestus* (24.51%)>*Aedes vexans* (15.17%)>*Ochlerotatus sticticus* (12.79%)>*Anopheles atroparvus* (7.32%)>*Ae. rossicus* (7.16%)>*Ae. cinereus* (6.9%).

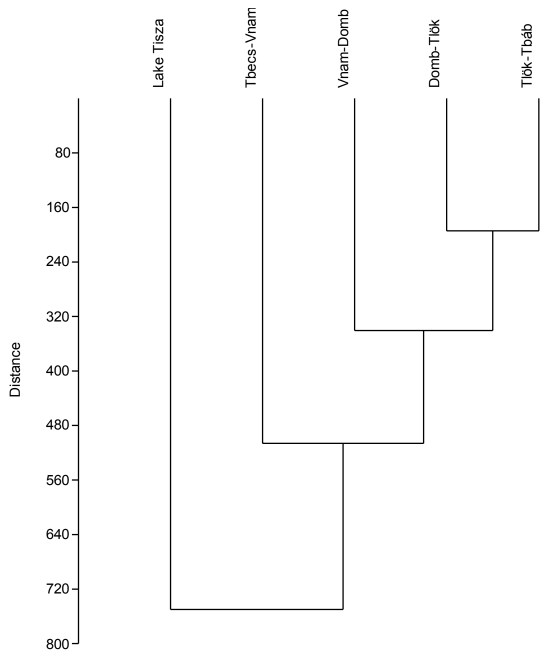

Figure 2
The result of the cluster analysis (WARD-method) for the mosquito assemblages (list of abbreviations: Table 1).

Considering the more frequent species, the ratio of *Culex modestus* is increasing from Tiszabecs to the Lake Tisa. The ratio of *Aedes sticticus* is the largest between Tiszabecs and Vásárosnamény, and there is much less on the other reaches. The *Aedes vexans* had a significant presence on every site, but between Vásárosnamény and Dombrád it was especially significant. The *Aedes cinereus* had a large ratio on the reach Vásárosnamény-Dombrád, and the *Anopheles atroparvus* was meaningful on the reach Dombrád-Tiszalök and on the Lake Tisa (Fig. 3).

There are significant differences between the assemblages of consecutive reaches according to dominant species as the Chi^2-test presents as well (df = 8; Chi^2 = 34.56 – 57.72; p = 3.22E-05 – 1.27E-09).

3.2. Density of female mosquitoes

3.2.1. Changes of bite number among reaches

The surveys performed in 2003 show different results on different reaches (Fig. 4). Apparently, the average bite numbers were increasing from the frontier to the Lake Tisa (Tiszabecs-Vásárosnamény: 33.17 bites/hour; Vásárosnamény-

Dombrád: 59.05 bites/hour; Dombrád-Tiszalök: 73.60 bites/hour; Tiszalök-Tiszabábolna: 106.80 bites/hour; Lake Tisa: 172.36 bites/hour). The KRUSKAL&WALLIS test presented significant differences among river reaches ($Chi^2 = 21.96$; $p = 0.0002$). The MANN&WHITNEY post hoc tests indicate that in the first place the low bite numbers on the reach Tiszabecs-Vásárosnamény cause the differences. These are significant lower than the values on Vásárosnamény-Dombrád ($p = 0.0043$), on Dombrád-Tiszalök ($p = 0.0083$), on Tiszalök-Tiszabábolna ($p = 0.0061$) and on the Lake Tisa ($p = 6.85E-05$). In addition to there was significant difference only between the reach Vásárosnamény-Dombrád and the Lake Tisa. Among the other reaches there were not significant differences, although the bite numbers were variable. It can be explain with the meaningful standard deviation.

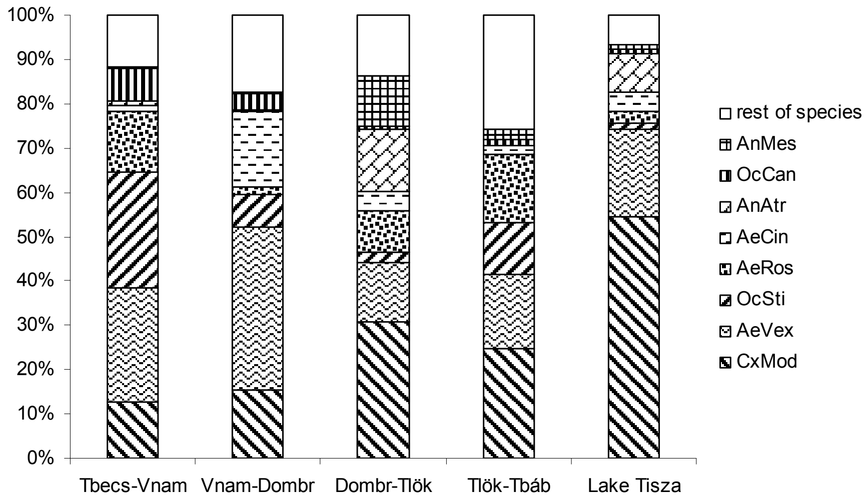

Figure 3
Compound of reaches on basis of dominant species (list of abbreviations: Table 1).

Examining the bite numbers broken down by month it is obvious, that the trend in June and July is similar to the annual average values, i. e. the bite numbers are increasing uniformly from the frontier to the Lake Tisa. In August and September the Lake Tisa, the reaches Vásárosnamény-Dombrád and Dombrád-Tiszalök have larger bite number than the others, while in this period the bite numbers are lower (Fig. 4). Nevertheless the KRUSKAL&WALLIS tests show only in July differences ($Chi^2 = 13.08$; $p = 0.0109$). In July the bite numbers were lower on Tiszabecs-Vásárosnamény and Vásárosnamény-Dombrád than on the Lake Tisa (MANN&WHITNEY tests are respectively $p = 0.0158$ and 0.0143). Along other reaches the bite numbers were not significantly different ($Chi^2 = 2.185 – 8.189$; $p = 0.0872 – 0.7010$). In spite of that the MANN&WHITNEY tests present that in July the bite numbers were significantly lower on the reaches Tiszabecs-Vásárosnamény, Vásárosnamény-Dombrád and Dombrád-Tiszalök than on the Lake Tisa ($p = 0.0341 – 0.0408$).

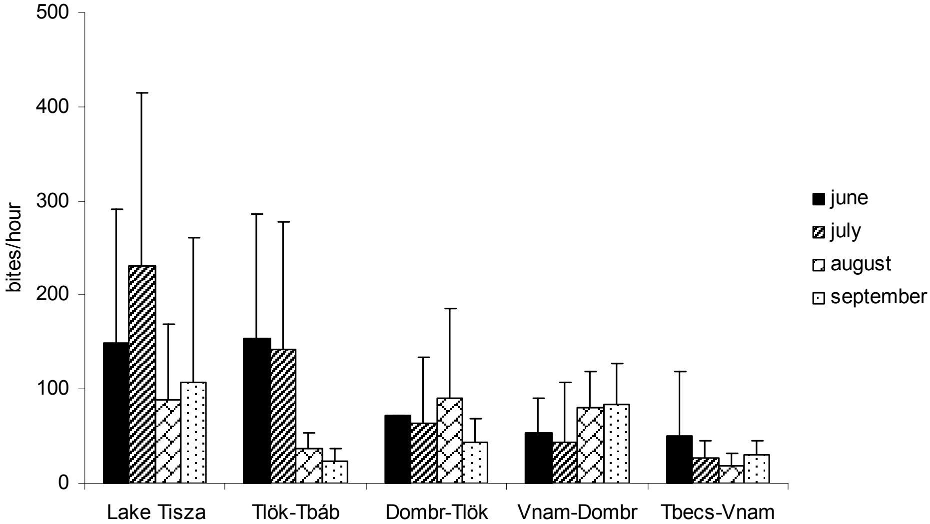

Figure 4
The monthly average values of bite numbers (bites/hour) on the investigated river reaches (list of abbreviations: Table 1).

The relative frequencies of bite number categories show, that the low bite numbers (0-100 bites/hour) were frequently almost in every time and every site (Table 2). The exceptions are the Lake Tisa and the reach Tiszalök-Tiszabábolna on which the low bite numbers were rare. On both reaches the high (100-300 bites/hour) and the extra high (>300 bites/hour) were frequently in early summer. In July over 500 bites per hour were observed on the Lake Tisa.

The reach Tiszabecs-Vásárosnamény is different from the others in the relative frequencies bite number categories to. Only in July were over 100 bites/hour observed on this reach.

3.2.2. Annual changes of bite numbers

This study presents the annual changes of bite numbers on the basis of the surveys performed on the two upper reaches (Tiszabecs-Vásárosnamény and Vásárosnamény-Dombrád).

In 2000 and in 2001 huge floods run along the Upper-Tisa. Since the chance of infection was enhanced, the mosquito control was very intensive in these years. In 2002 the amount of mosquitoes was especially few due to the exterminations (Fig. 5). After that bite numbers were increasing slowly, and for 2010 there grew for a large amount.

The KRUSKAL&WALLIS tests show, that there were significant differences between the years on the reaches according to the bite numbers (Tiszabecs-Vásárosnamény: Chi^2 = 63.23, p = 6.08E-13; Vásárosnamény-Dombrád: Chi^2 = 40.70, p = 3.10E-08). The post hoc MANN&WHITNEY tests performed in pairs report, that in 2002 the values were significantly lower than in others (Tiszabecs-

Vásárosnamény: p = 0.0008 – 2.02E-08; Vásárosnamény-Dombrád: p = 0.0016 – 5.54E-05). On the other hand the values were higher in 2010 than in others (Tiszabecs-Vásárosnamény: 0.0287 – 1.72E-06; Vásárosnamény-Dombrád: p = 0.0080 – 5.54E-05).

Table 2
The relative frequency (%) of bite numbers on the investigated river reaches (list of abbreviations: Table 1).

month	bites/hour	Lake Tisa	Tlök-Tbáb	Dombr-Tlök	Vnam-Dombr	Tbecs-Vnam
June	0-100	50.00	50.00	100	83.33	83.33
	100-300	28.57	33.33	0	16.67	16.67
	>300	21.43	16.67	0	0	0
July	0-100	34.62	42.86	66.67	80.00	100
	100-300	30.77	42.86	33.33	20.00	0
	>300	34.62	14.29	0	0	0
August	0-100	63.64	100	71.43	66.67	100
	100-300	36.36	0	28.57	33.33	0
	>300	0	0	0	0	0
September	0-100	75.00	100	100	66.67	100
	100-300	25.00	0	0	33.33	0
	>300	0	0	0	0	0

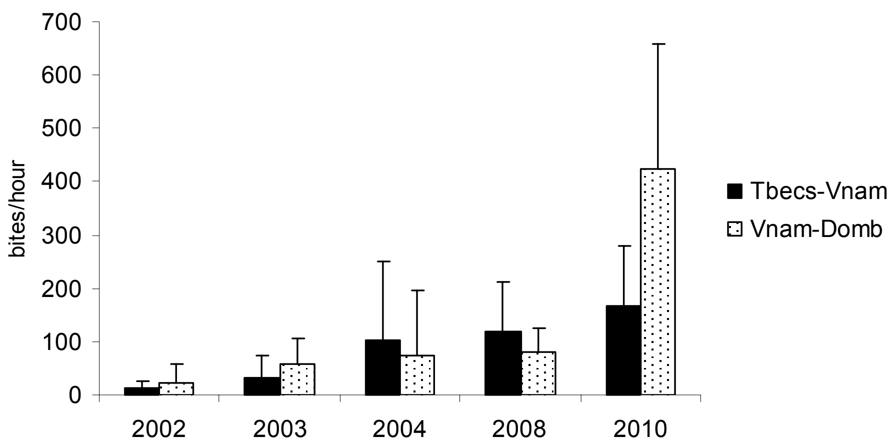

Figure 5
Annual average bite numbers (bites/hour) and their standard deviation on the two upper river reaches (list of abbreviations: Table 1).

The increase of annual average bite numbers imply the increase of relative frequencies of high (100-300 bites/hour) and extra high (>300 bites/hour) bite numbers on both reaches (Table 3). In 2010 we could detect 384 bites per hour on Tiszabecs-Vásárosnamény, while 680 and 800 bites per hour on Vásárosnamény-Dombrád.

Apparently, the amount of mosquitoes and the frequency of high bite numbers also have increased in the investigated period.

Table 3
The relative frequency of bite number categories on the investigated river reaches (list of abbreviations: Table 1).

	bites/hour	2002	2003	2004	2008	2010
Tbecs-Vnam	0-100	100	94.44	79.17	60.00	50.00
	100-300	0	5.56	12.50	40.00	37.50
	>300	0	0	8.33	0	12.50
Vnam-Domb	0-100	96.55	73.68	81.48	80.00	0
	100-300	3.45	26.32	11.11	20.00	50.00
	>300	0	0	7.41	0	50.00

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