The mosquito fauna (Diptera: Culicidae) of the „forest city" Eberswalde

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Zusammenfassung: Um einen Überblick über die Stechmückenfauna (Diptera: Culicidae) der Waldstadt Eberswalde in Brandenburg, Deutschland, zu gewinnen, wurden zwischen Ende Mai und Ende September 2016 Mückenlarven, -puppen und -imagines in ihren verschiedenen Habitaten auf Friedhöfen, urbanen und landwirtschaftlichen Flächen, in Wäldern, Kleingärten und Parks gesammelt. Aquatische Stadien wurden mit einem Dipper oder einem Sieb, Adulte mit einem Aspirator, einem Kescher oder per Hand gefangen. Insgesamt konnten so 670 Mückenexemplare erhalten werden, die 14 Arten bzw. Artkomplexe aus den fünf Gattungen *Aedes*, *Anopheles*, *Coquillettidia*, *Culex* und *Culiseta* repräsentierten. 550 Individuen, die als Larven und Puppen gesammelt worden waren, gehörten vier Taxa an: *Aedes annulipes*-Gruppe, *Ae. geniculatus*, *An. plumbeus* und *Culex pipiens*-Komplex. Die 120 gefangenen Imagines wiesen eine wesentlich höhere Artenvielfalt auf und setzten sich aus 14 Taxa in fünf Gattungen zusammen. Die meisten Exemplare gehörten zum *Cx. pipiens*-Komplex, wovon 116 Männchen morphologisch in *Cx. pipiens* und *Cx. torrentium* separiert werden konnten. Die Gattung *Aedes* war mit der höchsten Artenvielfalt vertreten (acht Taxa); die Gattungen *Coquillettidia* und *Culiseta* waren am seltensten (13 bzw. 5 Exemplare) und wurden nicht im aquatischen Stadium nachgewiesen. Friedhöfe zeigten die höchste Anzahl und Dichte von potenziellen Brutplätzen im urbanen Raum, wurden allerdings fast ausschließlich von Mücken des *Cx. pipiens*-Komplexes genutzt. Im Gegensatz dazu besaßen Wälder und Parks die höchste Artenvielfalt (acht bzw. neun Arten). Keine Stechmücken wurden auf landwirtschaftlichen Flächen gefunden. Ab Ende August sank die Anzahl der gesammelten aquatischen Exemplare deutlich ab. Während keine Neozoen, die als Überträger von Krankheitserregern gelten, in den Proben festzustellen waren, zeigt die Studie ein Artenspektrum an einheimischen Arten, das mögliche Vektoren enthält.

Key words: Brandenburg, Culicidae, Eberswalde, habitat, mosquito monitoring, species spectrum

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Introduction

Due to the growing awareness in Germany of mosquitoes not only being a nuisance, but representing potential vectors of disease agents, the public interest in the native mosquito fauna has considerably increased again in recent years. The emergence of invasive vector species and of unexpected outbreaks of mosquito-borne diseases in southern Europe has prompted pertinent research activities also in Germany, including mosquito monitoring, vector competence studies and risk assessments. When it comes to mosquito management, fundamental biological and ecological data on the various culicid species are required since not all species are a nuisance and not all species are vectors. The present study aims to contribute to the nationwide mosquito monitoring with special reference to breeding habitat preferences and landscape use in the "forest city" Eberswalde.

Material and Methods

Eberswalde is a town of 40,000 inhabitants in the northeast of the German federal state of Brandenburg, located at an altitude of about 25 m a.s.l. The climate is somewhere between atlantic and continental (Müller & Luthardt 2009), with a mean annual temperature of 8.4 °C and a mean annual precipitation of 572 mm (HNE Eberswalde 2019).

By using a raster map, the Eberswalde municipality was virtually divided into five landscape categories to be sampled for mosquitoes in 2016: cemeteries, forested areas, parks, residential areas and agricultural areas. In addition, allotment gardens were included. An area of 13 km * 17 km with cells of 1 km * 1 km was considered to select sampling plots. Due to the limited size of Eberswalde, which prohibited the random selection of plots, squares with the highest portion of the respective category were finally selected. The smallest plot was a cemetery of approximately 0.4 ha, whereas agricultural and forested areas were available in full square size of 1 km². Collections were performed five times for one week each per month, beginning in late May and stopping in late September (Fig. 1). The first of five sampling periods represented a test run, not including all plots subsequently sampled.

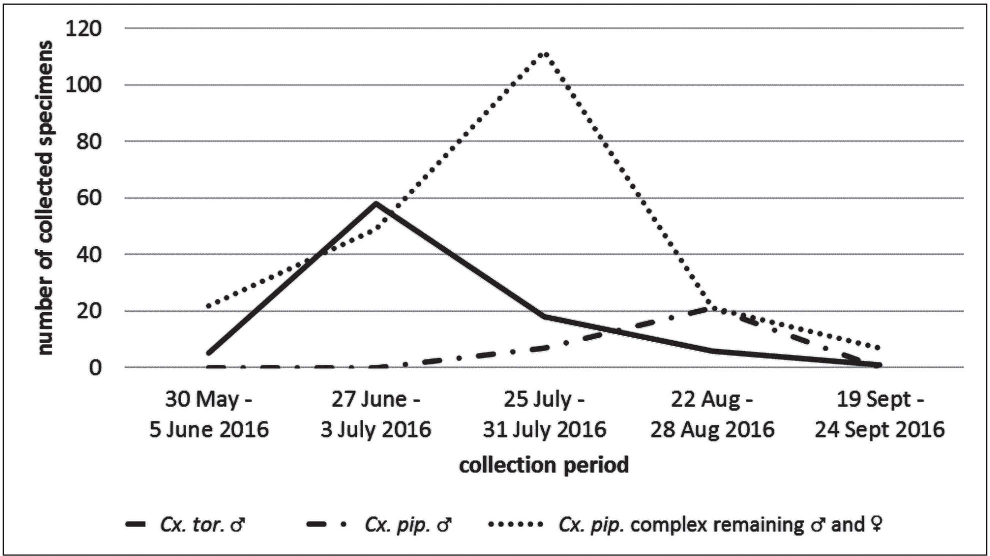

Fig. 1: Timeline of collection numbers of *Cx. pipiens* complex taxa.

Mosquitoes were sampled as aquatic and terrestrial life stages. Collection of larvae and pupae was carried out with a dipper, in some cases by emptying containers (e.g. flower vases), or a sieve (tree holes). To keep the impact on sampled plots low regarding subsequent samplings, each checked site was refilled with fresh water. Collected larvae and pupae were taken to the laboratory to be reared until adult emergence. Adults were killed by overnight freezing and identified morphologically using the determination key by Becker & al. (2010). Larvae, which did not pupate until November, were morphologically identified in the fourth stage, using the same determination key.

Because of the large size and non-uniform structure of forested, residential and agricultural areas, the sampling of larvae was reduced to a 1 km transect within each grid square. All water pools and containers detected while walking along the transects were sampled. Limited accessibility to private property reduced sampling opportunities in residential areas and largely prevented sampling in allotment gardens. Cemeteries turned out to contain such a high number of potential breeding sites, that checking was ceased after 100 of them (predominately flower vases) per plot. Larvae in parks could be sampled without limitations. In total, 16 plots were sampled, consisting of three plots per landscape category, plus one for allotment gardens.

Adults were collected in a less systematic manner. In late June, some of the plots were sampled with an aspirator, approaching females were hand-caught, and in residential areas, additional catches were performed with a net. No adult traps were used in this study.

Results

In total, 121 samples contained 670 mosquito specimens. Of those, 550 were collected in an aquatic stage, with 99 in too poor a condition to be identified morphologically. Ninety-two samples contained one species only. Hundred and twenty-two specimens were caught in the first, 159 in the second, 230 in the third, 72 in the fourth and 87 in the fifth sampling period. On six plots, specimens were caught in an aquatic stage and could be assigned to four taxa: *Aedes annulipes* group, *Ae. geniculatus*, *Anopheles plumbeus* and *Culex pipiens* complex, the latter of which was most abundant. All 82 specimens which were identified in a larval stage turned out to be *An. plumbeus*. When taking the adults into account as well, two additional genera showed up: *Coquillettidia* and *Culiseta*, increasing the number of collected taxa to 14. The genus with the highest species diversity was *Aedes* (n = 8). All taxa demonstrated as imagoes were also present in an aquatic stage (Table 1).

Table 1: Culicid species and specimens collected

Species	No. of total specimens (of aquatic stages)	% of total
Ae. annulipes group	2 (1)	0.3
Ae. cataphylla	1 (0)	0.1
Ae. cinereus/geminus	2 (0)	0.3
Ae. geniculatus	20 (15)	3
Ae. punctor	2 (0)	0.3
Ae. rusticus	1 (0)	0.1
Ae. sticticus	1 (0)	0.1
Ae. vexans	2 (0)	0.3
An. maculipennis complex	4 (0)	0.6
An. plumbeus	108 (108)	16.1
Cq. richiardii	13 (0)	1.9
Cs. annulata	74 (0)	11
Cs. morsitans	3 (0)	0.4
Cx. pipiens complex	338 (327)	50.4
not identifiable	99 (99)	14.8
total	670 (550)	100

Species were not evenly distributed among the sampled landscape categories: forested areas and parks showed the highest species richness (n = 9 and 8, respectively). Furthermore, mosquitoes were found on 9 out of the 16 plots: 3 cemeteries, 2 parks, 2 forested areas, and 1 residential area plus the only accessible allotment garden. Agricultural sites turned out to be the only landscape category without mosquitoes. Five culicid species were only collected in one landscape category each, four of which belonged to the genus *Aedes* (Table 2).

By closer examination of 140 male mosquitoes of the *Cx. pipiens* complex which had been caught in an aquatic stage, 116 specimens could be morphologically assigned to the two complex species occurring in Central Europe: 28 belonged to *Cx. pipiens* and 88 to *Cx. torrentium*. Figure 1 shows the different collection proportions within the *Cx. pipiens* complex, with *Cx. torrentium* predominating early and *Cx. pipiens* predominating late in the season, although this phenology would have experienced some shift in one direction or the other, could the relatively high number of unidentified specimens in late July be assigned to species.

Table 2: Species according to landscape category

Species	Cemetery	Park	Forested area	Agricultural area	Residential area	Allotment garden
Ae. annulipes group		+*	+		+	
Ae. cataphylla					+	
Ae. cinereus/geminus			+			
Ae. geniculatus	+*	+*	+*			
Ae. punctor		+	+		+	
Ae. rusticus			+			
Ae. sticticus		+				
Ae. vexans	+				+	
An. maculipennis complex		+				
An. plumbeus	+*	+*	+*			
Cq. richiardii			+		+	
Cs. annulata	+		+			
Cs. morsitans	+	+				
Cx. pipiens complex	+*	+*	+*		+	+*
total	6	8	9	0	6	1

* = collected as both adults and aquatic stages

Discussion

The late start of the sampling period probably caused exclusion or underrepresentation of some of the typical snow melt mosquitoes while the lack of accessibility led to reduced sampling opportunities and probably attributed to low numbers of species in residential areas and allotment gardens. On the other hand, the absence of mosquitoes from the arid monocultural agricultural areas probably mirrors a realistic scenario.

It is unlikely that the damaged, and thus unidentifiable, larval specimens included a lot of species not found elsewhere. This assumption is based on the fact that out of the samples taken from a single water body, only 21 in 88 contained more than one species (namely 5) or unidentifiable specimens (namely 16). Seventy out of the 99 unidentifiable specimens were from a sample in which other mosquitoes could be identified.

The demonstrated species were compared with inventories provided by Czajka (2014) and Walther (2016) for nearby places (25 km east of Eberswalde close to the Oder river and 35 km northeast of Eberswalde in the Sernitz lowlands). Thirteen species were present in Eberswalde and at least one of the other studies, 10 species found in the other studies were not found in Eberswalde, and 1 species (*Ae. sticticus*) was encountered only in this study.

The methodology does not allow estimations about population sizes (Silver 2008), yet it is fair to assume that the *Cx. pipiens* complex is the most abundant mosquito taxon in Eberswalde, which is supported by other studies carried out in eastern Germany (e.g., Tippelt & al. 2018).

The data suggest seasonally separated peaks of abundance, and thus phenologies, of the two demonstrated *Cx. pipiens* complex species (Fig. 1), despite a relatively high number of specimens that could not be identified to species level. The ratio of specimens of the two *Cx. pipiens* complex species collected in the present study is contrary to that of Rudolf & al. (2013), who registered a large majority of *Cx.*

pipiens as compared to *Cx. torrentium* in trap collections carried out during a similar seasonal period in 2011 and 2012 approx. 30 km eastwards of Eberswalde. Unfortunately, the authors do not correlate their data to collection months or weeks.

Given the low mean temperatures of Eberswalde as compared to the German hotspots of invasive mosquito emergence, such as the Upper Rhine Valley (DWD 2019), and its geographical location far from known introduction routes, it is not surprising that non-native species recently detected in Germany (Kampen & al. 2017) could not be demonstrated. However, some of the native taxa identified are considered potential vectors of disease agents or may develop vector potential with rising temperatures (Kampen & Werner 2015), which necessitates continuous monitoring and research.

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