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METHODS OF MOSQUITO PLAGUE CONTROL IN ŚWINOUJŚCIE AREA BASED ON THE ANALYSIS OF SPECIES DISTRIBUTION

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ABSTRACT

OBJECTIVE. Studies conducted in 2013 in Świnoujście area aimed at determining mosquito species distribution and analyzing sites, productivity and dynamics of larva and adult breeding as well as developing guidelines for effective mosquito control in this area.
MATERIAL AND METHODS. Entomological studies were conducted from March to September 2013. Distribution of mosquito larvae and adults was investigated. Mosquito larvae were observed mainly in April in transient snow-melt pools.
RESULTS. *Ochlerotatus cantans, Oc. communis, Oc. annulipes, Oc. punctor* were the most predominant mosquito species. Since July, larvae of the following genera: *Culex spp., Culiseta spp., Anopheles spp*. were collected in standing water bodies. A total of 17 species adult mosquito were identified. Of them, *Oc. communis, Aedes vexans, Culex pipiens/torrentium, Oc. Cantans, Oc. caspius* predominated over other species.
CONCLUSIONS. Mosquito plague in Świnoujście area can be controlled if constant actions would be undertaken from April (use of microbial biocides for snow-melt mosquito larva control) to August (use of microbial biocides for polygeneration larva species control and use of chemical biocides for adult mosquito control). Furthermore, there is a need for actions that would make environment less friendly to mosquitoes and would help to identify breeding sites of aggressive mosquito species - *Aedes vexans.* There is also a necessity to educate the inhabitants of Świnoujście area on the danger resulting from uncontrolled use of insecticides in protected areas and those which are unique from a faunistic perspective.

Key words*: mosquito control, microbial biocides, chemical biocides*

INTRODUCTION

Świnoujście is located in the north-western part of Zachodniopomorskie province on three islands: Uznam, Wolin and Karsibór. In the central part of Świnoujście, on Uznam and Wolin islands in the region of Przytór, Łunowo and Karsibór villages (which belong to Świnoujście area), there are extensive forest areas, accounting for 21.56% of total Świnoujście area – 195 km^2. Meadows and pasturelands cover 4.67% of its area. Islands of archipelago in the inverted delta of the Świna river are mainly treeless, marshy, periodically flooded reed fields and grasslands. In the neighbourhood of the western border of Świnoujście city, there are the remainings of Zerninsee lake and small waterholes on the territories of the Świdny Forest and Międzyzdrojski Forest. They are located in the depressions between dunes. Appearance of marshy areas is mainly associated with the inverted delta of the Świna river and local holding depressions in which water collects for a long time following heavy precipitations. Forest areas: mixed oak–birch forest and swamp forest are present in the areas with shallow level of ground waters while alder forest in interdunal tunnels and firm surfaces of peaty soils. Meadows are situated in the south-eastern part of Świnoujście city. To a large extent, these are wet grasslands, short sedge acidic fens and anthropogenic damp and wet meadows. Shores of all islands (except

for the sea shore) are covered with land or water reed beds present in non-used meadows (1).

Such environment forms favourable conditions for the breeding of many mosquito species (*Diptera: Culicidae*). Until the 1960s, they were considered to be the areas of malaria, tularaemia and encephalitis distribution, in which mosquitoes were the vectors of these diseases (2,3). Actions undertaken in the 1950s and 1960s resulted in the elimination of endemic outbreaks of these diseases. Mosquito distribution, however, is still high there. It causes nuisance for both inhabitants and tourists visiting that area. Potentially, such situation may also lead to epidemic danger related to diseases whose etiological agents may be arboviruses (4,5,6,7).

Studies conducted from March to September 2013 in Świnoujście area aimed at developing the fundamentals of mosquito control strategy in this area by means of:

1. Determination of mosquito species as well as the sites and dynamics of breeding of mosquito larvae and adults.
2. Elaboration of guidelines for effective mosquito plague control with reference to local social and environmental determinants.

MATERIAL AND METHODS

Monitoring of mosquito breeding sites. Entomological studies were conducted from March to September 2013. The map shows area of the study (Fig.1).

In April 2013, the areas on the right and level side of Świna were subject to entomological monitoring. A total of 19 sites were selected for mosquito larva collection, located on Uznam island – in the city, interdunal depressions of grey dunes, urban green spaces (Zdrojowy Park), forest complex in Świdny Forest, on Karsibór island – meadows, forest and built-up areas in Karsibór village, on Wolin island – shrublands and reed fields in Przytór and Warszów quarters.

Furthermore, in August and September, larvae were collected in irrigation canals in Karsibór in meadows/reed fields, bird sanctuary and water bodies situated on island in the delta of Świna river. Samples were collected, using dipper of standard volume, i.e. 0.35 l. Hot water was used to killed larvae. Then, they were placed in 96% alcohol for preservation. Such samples were stored until they could be identified.

During monitoring, basic water parameters were analyzed, including temperature, pH and conductivity, using pocket tester by Hanna Instruments.

Fig.1. The area of Świnoujście, where monitoring of larvae and adult mosquitoes in 2013 was carried out.

Table I. Distribution of mosquito larvae in Świnoujście area from April to September 2013.

No.	Mosquito species	Timing of mosquito collection					
		April	May	June	July	August	September
1.	*Ochlerotatus cantans*	+++	-	-	-	-	-
2.	*Ochlerotatus annulipes*	++	-	-	-	-	-
3.	*Ochlerotatus communis*	+++	-	-	-	-	-
4.	*Ochlerotatus punctor*	++	-	-	-	-	-
5.	*Aedes cinereus*	+	-	-	-	-	-
6.	*Anopheles maculipennis* s.l.	-	-	-	+	+	+
7.	*Culex pipiens/torrentium.*	-	-	-	+	+	++
8.	*Culiseta annulata*	-	-	-	+	+	+
9.	*Conquiletidia richardii*	-	-	-	+	+	+

A cross (+) ranks the abundance of mosquito larvae from "+ – sporadic" to "+++ - massive" appearance.

Monitoring of adult mosquitoes. Adult mosquitoes were observed from May 2013 in 12 - 13 areas, of which a part was situated near larva breeding sites and others in areas of high mosquito apperance.

Mosquitoes were caught, using standard traps, i.e. EVS Traps by Bioquip. Traps were filled with dry ice and then they were placed in selected areas in the evening. In the morning hours, trapped mosquitoes were collected, then killed by freezing and processed for analysis.

RESULTS

Distribution of mosquito larvae. Table I presents the distribution of mosquito larvae in observed territory in Świnoujście area.

Mosquito larvae were observed mainly in April. *Ochlerotatus cantans, Oc. communis, Oc. annulipes, Oc.punctor* were most commonly identified. The highest number of larvae was collected in the forest, situated in the city in the neighbourhood of Rycerska community (67 per dipper) and transient interdunal pools in forest behind Posejdon community (80 per dipper). In these two sites, the distribution from monocyclic larvae species was determined, i.e.: *Oc. cantans* and *Oc. annulipes.* Damp meadows in Karsibór village were also the places with the high number of breeding sites. On average, 35 and 12 larvae per dipper were collected in pools situated in meadows in Karsibór and in the village, respectively. Both, larvae of the monogeneration (*Oc. cantans, Oc. annulipes*) and polygeneration (*Oc. punctor*) species were identified there.

In April, extensive, shallow water pools appear in meadows and forests in Karsibór. Collection of larvae by dipping, by necessity performed locally, which is apparently of not high abundance should be considered with regard to large area of wetlands, being an effective 'mosquito breeder'. Similar situation was observed in April in Świdny Forest. Its lower parts were to a large extent flooded, forming extensive, shallow water pools of acid pH, in which the following mosquito species were bred: *Oc. cantans, Oc. communis, Oc. annulipes.* Apparently small collections (2-9 larvae per dipper), collected locally, should be referred to extensive area of breeding sites. Pools, abundant in mosquito larvae in April, situated in Świdny Forest, forests behind Zamkowa street and Posejdon community, forest on Karsibór island and Karsibór meadows, were gradually overgrown with greenery and then dried. Since May, no mosquito larvae were identified there.

Since July, the following mosquito larva species were determined: *Culex spp*., *Culiseta annulata, Anopheles maculipennis s.l.* and *Coquiletidia richardii* in standing water pools: in ditches near allotment gardens on the outskirts of the city, meliorative ditches in meadows/reed fields on Karsibór island and wetlands on islands in delta of Świna. Mosquito larvae of the genus *Culex spp.* were also identified in waterhole in allotment garden in Karsibór (it may be assumed that they were present in a number of allotment garden waterholes on private premises).

Mosquito species distribution and adult growth dynamics. In Świnoujście area in 2013 season, a total of 17 mosquito biting species were determined. Of them, 13 were of high abundance while for 4 species only sporadic appearance was observed. Table 2 presents mosquito species of high distribution.

Adult mosquitoes were not observed in April. From May to September, a total of 6,004 adult mosquitoes were collected and classified. In spring-summer season of 2013, an observed number of mosquitoes was not stable. Figure 2 shows the dynamics of mosquito abundance in particular months in studied areas.

In May, adult mosquitoes of the early, monogeneration species were mainly observed *(Oc. cantans, Oc. communis*), whose larvae were highly present in forest near Zamkowa street, behind Posejdon community, in Świdny Forest, on Karsibór island. A total of 1,871 mosquito females were collected, including only several dozens of those of the genus other than *Oc. cantans* and

Table 2. Recorded adult biting mosquitoes in Świnoujście area in spring – autumn season of 2013.

Mosquito species	Percentage of biting mosquitoes in fauna (%)	Biology
*Ochlerotatus cantans**	12.4	Monogeneration, late spring
*Oc. communis**	25.5	Monogeneration, early spring
*Oc. sticticus**	2.0	Monogeneration
*Oc. annulipes**	0.9	Monogeneration, late spring
Cocquiletidia richardii	4.8	Monogeneration, summer
Aedes vexans	25.5	Polygeneration
Ae. cinereus	4.8	Polygeneration
Oc. caspius	10.0	Polygeneration
Oc. punctor	1.4	Polygeneration
Culex pipiens/torrentium	15.3	Polygeneration
Cx. modestus	1.2	Polygeneration
Anopheles maculipennis	0.5	Polygeneration
Culiseta annulata	0.9	Polygeneration

*- larva species collected in April in water bodies situated in the city, Karsibór village and extensive wetlands in Świdny Forest, Międzyzdrojski Forest and meadow areas around Karsibór village.

Oc. communis. These were: *Oc. punctor* (54) and *Ae. cinereus* (26).

In June, late spring mosquitoes predominated in monogeneration species *(Oc. cantans, Oc. sticticus*), whose larvae breed in snow-melt pools. Furthermore, aggressive females of polygeneration species were identified, i.e. *Ae. vexans, Ae. cinereus, Oc. caspius, Cx. pipiens/torrentium.* In June, a total of 806 mosquitoes were collected, including 327 females of 5 monogeneration species and 479 of 8 polygeneration species (Fig.2).

In studied area of Świnoujście, no breeding sites of the species *Ae. vexans* were identified despite these highly anthropophilic and aggressive females were reported in this areas since June.

In July, spring and late spring species were observed rarely. Of biting mosquitoes, the dominance of polygeneration migrant species was reported, i.e. *Aedes vexans* and *Ochlerotatus caspius* and females of the genus *Culex pipiens/torrentium*. A total of 2,434 female mosquitoes were collected. Of them, 591 belonged to 5 monogeneration species and 1,843 females to 8 polygeneration species (Fig.2).

In August, spring, monogeneration mosquitoes accounted for a small proportion of biting mosquitoes present in Świnoujście. Of 711 collected mosquitoes (Fig.2), 15 females of 5 monogeneration species were identified. Number of polygeneration migrant species (*Aedes vexans, Ochlerotatus caspius*) also decreased. Predominance of *Culex pipiens/torrentium* was reported. A total of 696 females of 8 polygeneration species were collected.

In September, mosquitoes of spring species were practically not observed (only one mosquito was collected). Compared to summer months, the number of mosquitoes of polygeneration species was also limited. There were a few representatives of aggressive migrant species: *Aedes vexans* and *Ochlerotatus caspius* (5 and 10 females, respectively). To the largest extent, synanthropic mosquitoes of the genus *Cx. pipiens/torrentium* were collected (159 females), whose typical breeding sites are anthropogenic pools (e.g. waterholes, artificial water pools on private premises). A total of 182 mosquito females were collected in that month.

DISCUSSION

From the European and national experience transpires that the most effective method of mosquito plague control consists in the intensification of technical and financial efforts on larval stadium control in breeding sites, using microbial *Bacillus thuringiensis israelensis* – based insecticides (8, 9, 10).

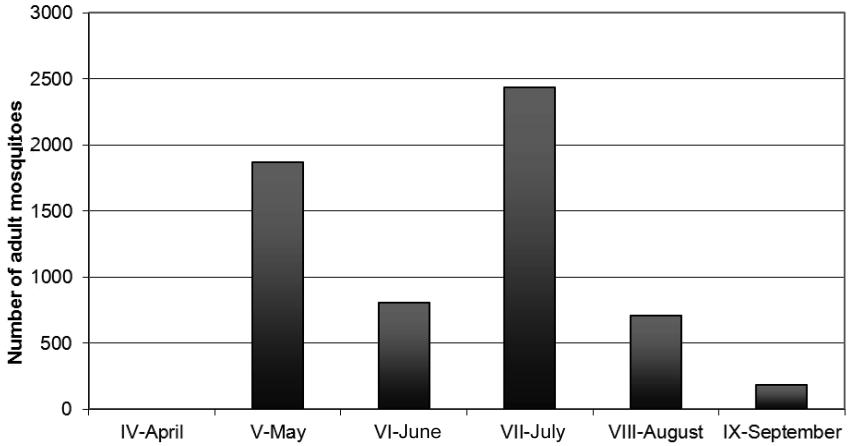

Fig. 2. Number of mosquito females collected, using EVS Traps, in Świnoujście area in spring-summer season of 2013 by month.

Methods of mosquito control in Świnoujście area seem to be relatively unambiguous if they refer to the control of early spring larvae which breed from the end of March to the end of April. In studies conducted in 2013, these were *Ochlerotatus cantans, Oc. communis* whose larva distribution was reported high in small water pools in April in the city and large wetlands in Świdny Forest, Międzyzdrojski Forest, meadows around Karsibór village. Having confirmed the presence of larvae in water pools (permanent and transient), biological agent should be applied evenly to larvae nutrition area. Due to the presence of mosquito larvae in small, easily accessible water bodies as well as extensive wetlands in forests, if feasible, mosquito larvae specific microbial products should be applied, using manual sprayers for small water bodies, while in case of large, extensive forest wetlands, aerial application is required, using agricultural aircrafts. Data obtained suggest a considerable share of monogeneration species in biting mosquitoes in Świnoujście, whose larvae bred in snow-melt pools in spring – ca 40% (Tab.2). Effective mosquito larva control at their breeding sites should result in a considerable limitation of activity of adult, aggressive females of such species in May and June when they dominate in the fauna of adult mosquitoes there. Since July, larvae of aggressive mosquito species *Culex pipiens/torrentium* (Tab.1) were observed in water bodies, including those made by humans. Their control should be accompanied by the use of larvicide with selective action. Decorative waterholes and other small water bodies on private premises should be frequently maintained or populated with fish to stop mosquito breeding. Inhabitants of Świnoujście area should be educated on aforesaid mosquito control methods. During studies conducted in 2013, the presence of polygeneration species females was reported, i.e. *Aedes vexans* and *Ochlerotatus caspius*. These mosquitoes appeared in June while their distribution was the highest in July. In studied area, no breeding sites of these mosquitoes were identified. It may be presumed that breeding sites of these aggressive species were situated beyond the studied area. To optimize mosquito control effectiveness and reduce the nuisance of biting adult mosquitoes in months of intense tourism movements, it is required to identify their breeding sites as to apply human- and environment-friendly microbial larvicides.

Reduction of aggressive biting mosquito population is also feasible (to a relatively low extent) by the use of chemical adulticides.

Such actions, however, are considerably less effective (mosquitoes come from non treated areas), more difficult (actions should cover larger territories), and, above all, they are not selective, consequently leading to the occurrence of resistance in insects. Chemical insecticides are also not neutral for human health and environment (11).

Adult mosquito control products which are available in Poland are biocidal products to combat flying insects. It should be taken into account, however, that mainly these are products used to eliminate insects in indoor settings or external walls of buildings. Such products, with a few exceptions, are not intended for spatial application in extensive areas as they were not tested with regard to risk for environment and non-target organisms. Act on biocidal products (12) does not specify such requirements for national registration within transition period to the day of 31st December 2024. All 22 biocidal products designed for the use by professionals to eliminate flying insects have labels, containing information on danger to the environment while their summary of product characteristics should have information on the avoidance of use in the vicinity of waters and any danger to bees. Therefore, the use of such products in large areas to control adult mosquitoes should be preceded by "for and against" in-depth analysis of local environmental settings and social factors (13, 14).

In Świnoujście, being a health resort subject to special protection, it should be considered to restrict adult mosquito control methods to those which are most required, e.g. protection of mass gatherings. It may be also deliberated to postpone the dates of some mass gatherings from June and July to the beginning of August or organize them at earlier hours during a day as to avoid the peak of mosquito activity which for the majority of species is twilight period.

Local media may play an important role in promoting pro-ecologic methods of mosquito control and protection against mosquitoes. Świnoujście population needs to be educated on danger resulting from uncontrolled use of insecticides in protected areas and creating favourable sites for mosquito breeding on private premises and garden allotments. Actions aiming at making environment less friendly to mosquitoes should be also promoted (e.g. damp meadow reclamation by amelioration, cleaning and populating waterholes and ponds with fish on private premises), protection of human meeting places by e.g. the use of, personal and spatial insect repellents, light traps and other modern systems intended for protection against mosquitoes.

CONCLUSIONS

1. Mosquito plague control in Świnoujście is feasible provided constant actions would be undertaken from April (snow-melt larvae control) to August (polygeneration species larvae control and reduction of adult mosquito population).
2. There is a necessity of identifying breeding sites of aggressive mosquitoes of the species *Aedes vexans* whose adults were collected in Świnoujście, how-

ever, their larvae breeding sites were not found in studied area. Due to the appearance of these mosquitoes and their aggressive behaviour during touristic season (June, July and August), it is required to monitor their breeding sites in areas not subject to studies in 2013.

3. Apart from larvae and adult mosquito control in studied area, it is required to undertake actions that would make environment less friendly to mosquitoes, use luight traps, personal and spacial insect repellents, and other modern systems intended for protection against mosquitoes.
4. There is also a need to educate inhabitants of Świnoujście on danger resulting from uncontrolled use of insecticides in environment, in protected areas which are unique from a faunistic perspective.

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