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CONTROL OF CULICID PESTS ALONG LOW-LAND RIVERS OF AUSTRIA: THE ATTACK-ATTRACT STRATEGY

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Abstract In Austria the research activity for developing alternatives to insecticides controlling mosquito pests is closely related to Usutu-virus (Flaviviridae) epidemics found in 2001. The decision making of those Austrian communities mentioned in this paper is orientated on prevention of the urban inhabitants from mosquito-borne diseases and from mosquito invasions emerging in neighbouring flood areas. The comprehensive use of pesticides is forbidden by several laws. Accordingly, we have been attacking the larval development of mosquitoes by use of *Bacillus sphaericus* and *Bacillus thuringiensis israelensis* substances before they become adults. Using certain synergies of the landscape topography we are able to keep the invasions away from urban districts of the city of Tulln in six from seven flood events since 2005. The attract strategy is going to be realized as a substitute for the larvicid application. This new approach is based on a two-component attractant, which pulls female mosquitoes -mostly of the genus *Aedes*- towards selected sites to deposit their egg clutches, where we can get rid on them by prepared traps and passively pushing. This method gave best results also with domestic mosquitoes (*Culex*) to diminish the population in gardens, at tourist areas and in urban parks. Experiments on the feasibility against blood-feeding pest of pastured cattle and around and inside stables are yet going to be done.
Key Words Mosquito, control, attack-attract strategy, attractant, trapping.

INTRODUCTION

Culicidae use short temporal and spatial niches for mass development in a wide span of ecosystems which run from temporary vernal waters to waste water ditches and rainwater filled vehicle tyres (Wiggins et al., 1980; Seidel, 2004). Unnatural aquatic sites in urban areas obviously establish a plenty of pattern for successful mosquito habituating (Kuhn, 1998). The variable culicid life history is an outcome of their ecological species diversity and the culicid pest management has to consider the specific development, distribution and abundance. Nevertheless, the destroying of relevant biotic regulating factors is the bad solution most frequently done as side effect by the attempt of poisoning the culicid population.

Austria has two capitals related to innovative applied mosquito pest control. Firstly, the city of Tulln and secondly, an area situated along river Fischa including the town Fischamend and several villages, which have founded a mosquito control association (Fig. 1). The use of toxic chemicals at those mosquito emerge places after river inundation events or after periods of huge rainfall is prevented by several nature protecting laws. From the ecological site of view a chemical insecticide application has a reducing impact on invertebrates and even if mosquitoes play a neglecting part in the food web of potential predators, the development of future mosquito generations tend to be increased. The main reasons to care about an effective control system are the frequent invasions of flood hatching mosquitoes that bother and harass the urban inhabitants. Hygenical and medical reasons have been of secondary matter when strategies and financing of the control program have been discussed (Tewari et al, 1990; Gratz, 1991). But they had been observed, of course. Tough, in 2003 samples of 100 over wintering *Culex pipiens* show a 10% infestation rate of Usutu-virus

(USUV, Flaviviridae) and therefore, a significant risk to human health (Nowotny et al., 2003; Chvala et al., 2007, Bakonyi et al., in this volume). The USUV epidemics was mainly caused by bird feeding *Culex pipiens*, whilst the flood hatching genus of *Aedes* played a neglecting part as vector but they recruit a huge mass of ugly biters. The pools sampled in Tulln and the *Cx. hortensis* probe from Persenbeug are of special interest because of their high infestation rate per specimen (Table 1).

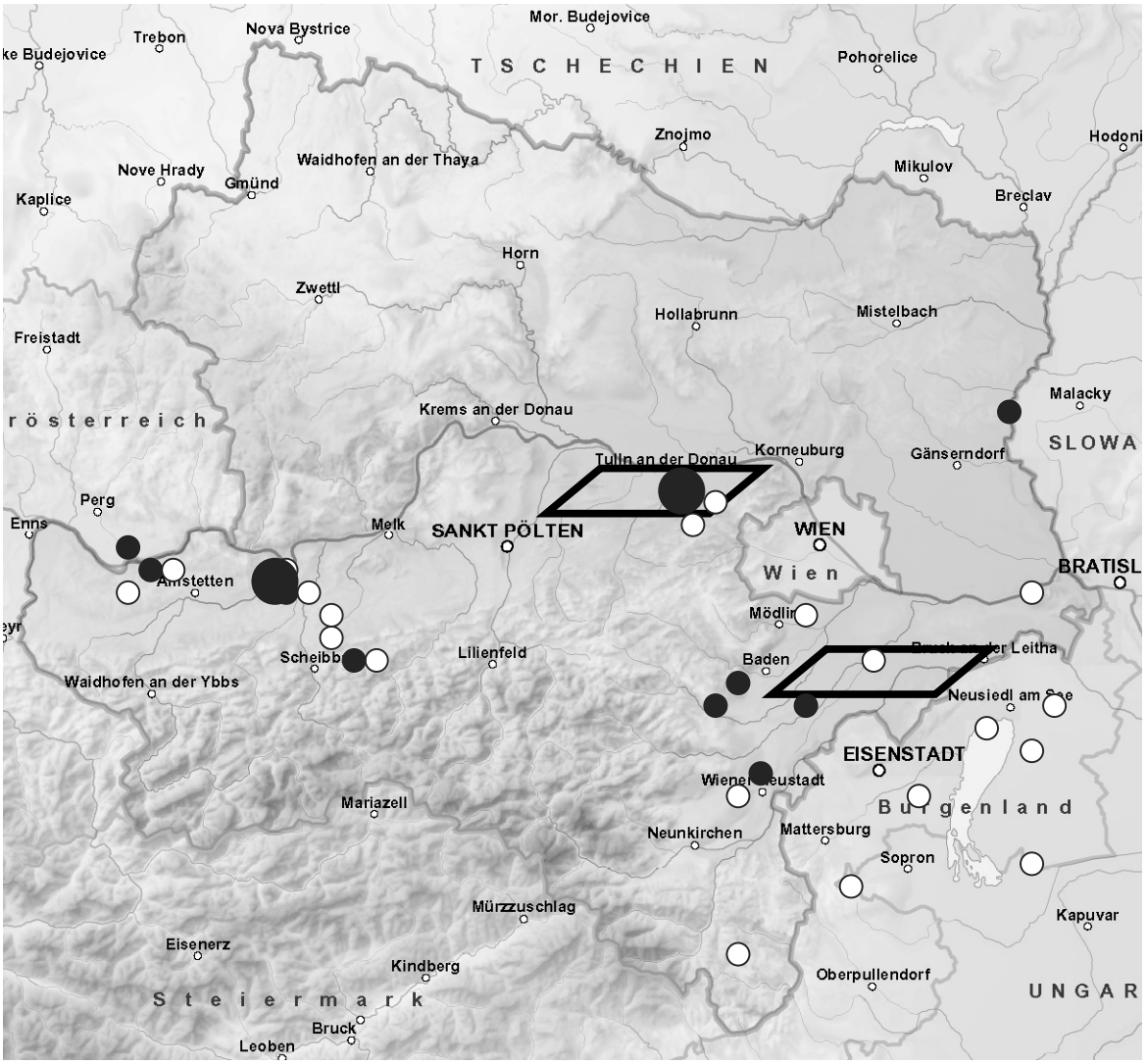

Figure 1. Map of Lower Austria and Burgenland shows the collection sites of the Usutu-virus positive (solid circles) and Usutu-virus negative (open circles) mosquitoes of 2003-2004; mosquito control area indicated by block.

Table 1. Usutu virus positive mosquito pools in 2002-2003.

Date of collection	Place	Mosquito species	Number of mosquitoes in the pool	Developmental stage
26. 08. 02	Wr. Neustadt	*Cx. pipiens*	6	larval
27. 08. 02	Tribuswinkel	*Cx. pipiens*	92	larval
28. 08. 02	Stopfenreuth	*Ae. cinereus*	6	adult
03. 09. 02	Orth	*Cx. territans*	9	larval
05. 09. 02	Stockerau	*Cx. sp.*	26	egg
06. 09. 02	Marchegg	*Ae. vexans*	36	adult
18. 09. 02	Stockerau	*Cs. annulata*	19	larval
19. 09. 02	Persenbeug	*Cx. hortensis*	3	larval
21. 12. 02	Stockerau	*Cx. pipiens*	50	adult
08. 03. 03	Jedenspeigen	*Cx. pipiens*	100	adult
26. 08. 03	Persenbeug	*Cx. sp.*	10	egg
26. 08. 03	Persenbeug	*Cx. sp.*	10	egg
26. 08. 03	Persenbeug	*Cx. sp.*	10	egg
05. 12. 03	Tulln	*Cx. pipiens*	10	adult
05. 12. 03	Tulln	*Cx. pipiens*	10	adult
05. 12. 03	Tulln	*Cx. pipiens*	10	adult
05. 12. 03	Tulln	*Cx. pipiens*	10	adult
05. 12. 03	Tulln	*Cx. pipiens*	10	adult
05. 12. 03	Tulln	*Cx. pipiens*	10	adult

Therefore, the major concerns of the control activity have focused on the flood emerging pests. According the mentioned natural constraints of the mosquito emission areas the control has been pointed towards two applied solutions: Firstly, attacking target organism only, in Culicidae possibly to achieve by sterilized protein larvicids and, secondly, finding a method not pushing them away to let them continue their life cycles elsewhere but collect and concentrate them by attractant items and trap them at the first opportunity. However, whilst push stimuli with botanical repellents are commonly used (Barnard and Xue, 2004), attractant pull stimuli are unknown and had to be invented (Cook et al., 2007).

MATERIAL AND METHODS

The use of *Bacillus thuringiensis israelensis* (*B t i*.) and *Bacillus sphaericus* (*B. s*.) was restricted to lentic aquatic sites which mostly are rest waters from a decreasing flood (Arshad et al., 1986). These sites have been dried up before the phase of inundation. Therefore, the list of non target organisms (NTOs) contains odonata larvae, adults of Heteroptera, Coleoptera and Amphibia which have to colonize the temporary water from outside and are absolutely resistant (Garcia et al., 1980; Mathavan and Velpandi, 1984). The impact of the *B. t. i*. and *B. s*. substances to the NTOs is minimal (Lacey and Mulla, 1990). The concerns on the food web are none, because even mass developing culicids are quantitatively and qualitatively a neglecting prey for birds, bats, amphibians, fish, and invertebrates.

The attract strategy. We started simple experiments such as cleaning of littoral patterns by ploughing of the substrate or covering the substrate by plastic sheets and putting earth from elsewhere on it, which both immediately made the sites inappropriate for oviposition. We reached a lower number of larvae.

In July 2005 close to the town of Tulln, a transect of a spring growing geophyt was flooded by Danube inundation and in April 2006 the rebuild transect was flooded again. At both aspects we could hardly found flood hatching mosquito larva in the nearer locality within the retrieving water. This experience rapidly influenced our running work. After several years of field experiments several components have recently become an Austrian patent status, which is partly going to be extended for Europe. However, the attract manipulation of the life history on population scale is focused on female mosquitoes to lay their egg clutches along treated sites. The material we developed works like a language that is understood not only in flood hatching mosquitoes but also in domestic ones as our experiments show.

RESULTS

In all cases the emission areas after floods are greater than application can be achieved in the short term of larval development. Therefore, within the attack strategy an approach has been worked out and be proper enough to give shelter against mosquito invasion towards the urban places. The presented example deals around the flood area across the river Danube of the city of Tulln with more than five km length and one km width. Corridors were defined to be kept mosquito free from metamorphosing larva/pupae in the flood forest, which should stop the invasive avalanche rolling towards the city like a big sponge of bushes and trees. The performance was proved in seven inundation cases of the Danube between spring of 2005 and September 2007. The comparative testing of this strategy was done by counting and if not possible by assessing the attacks of mosquitoes along the different corridors within five minute intervals. The important result was that the city areas have ranked always around zero except in two weeks of 2006.

The attract strategy. The municipal customers are going to introduce the attract strategy as mosquito control method to be able to reduce the application of substances. The attractant material developed is proper to pull mosquito females towards selected sites for depositing their egg-clutches. The production of that attractant has to consider two components which have to be arranged later in the field in tandem: firstly, a coarse structure based on specific plant material and secondly an odour, which is biotechnologically produced. Both components applied lead the mosquito females towards an egg deposit site like among natural conditions: just stronger, faster and in higher numbers depending on the quantity of material used. The material consists of proper natural items from the field, which meet all applied ecological requirements.

Several experimental series with water filled baskets show the overlapping effect of the produced material even on different dipteran's genus which shows different life history behaviour (flood hatchers versus water breeding domestic mosquitoes, using the baskets for oviposition). Therefore, the material, in different packages of quantity, can be used for garden rain barrels as well as for technical water construction plants in river landscape engineering. However, ways of pulling mosquitoes need consequently methods to trap them or getting rid on them. A trap for rain water barrels was developed and tested together with the attractants; it will be presented at the 6thICUP conference as well as one of the projects for technical water construction, which are still ready for successful mosquito control after the next flood of river Danube.

DISCUSSION

"Push" and "pull" of pest insects is a proper strategy in agriculture for plant protection (Pyke et al. 1987). Pushing mosquitoes away has a long tradition and even a longer list of brands of repellents helping the individual against the harassing blood-suckers (Fradin and Day, 2002; Barnard and Xue, 2004). Pulling of mosquitoes in particular on the large scale of the population level in field among environmental relevant constraints seems to be obviously a new strategy. The presented pulling method works also on domestic mosquito genus at a smaller scale of area for example in rain barrels of urban garden areas, where species like *Culex pipiens* lay egg rafts into (Mohrig, 1969). We have no experience how the attract method may help in context with horse and cattle farming when attractiveness of the host animals is occurring and may become a disturbing effect. Although the numbers of projects still is low the attract method opens a new control opportunity in planning of technical water construction a flood water management.

Recently, the experiences have only been done among temperate climate conditions, where we cannot use the method during the dormancy phase of overwintering just because the mosquitoes are not able to appear. In climate regions, where the hot and dry season cause the dormancy phase of pregnant mosquito

females and these mosquitoes are potentially be active, the strategy could be improved to bring quantitatively even better results than among temperate climate.

Domestic (urban) pests that infest homes, workplaces, public buildings and places treated with chemical insecticides is often impractical and does not reach a public consent (Kennedy and Hamilton, 1995; Pauluhn, 1996). The total effect of insecticide application is restricted to very narrow areas which reach a relative low percentage of the actual "fly about population" and it is not safety to humans at all. The attract strategy in combination with an effective trapping method, e. g. for aquatic breeding site, cuts the life cycles at every generation of the domestic mosquitoes. That can be several times within a season which eminently reduces the total number of biters or even leads to a collapse of the population respectively.

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