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THE CITIZEN SCIENCE PROJECT 'MÜCKENATLAS' SUPPORTS MOSQUITO (DIPTERA, CULICIDAE) MONITORING IN GERMANY

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Abstract Owing to a neglect of mosquito research for several decades, basic data on the occurrence and distribution of mosquitoes are absent for Germany. However, without having available the status quo, it is particularly difficult to detect invasive species and monitor the spread of potential vector species, topics which have gained special attention recently. Alarmed by cases and outbreaks of mosquito-borne diseases in other parts of Europe during the last few years, a mosquito monitoring programme was initiated in Germany in 2011. In addition to mosquito traps operated all over the country, an instrument for passive monitoring by community participation was launched in 2012, the "Mückenatlas". Private people are requested to collect mosquitoes and send them to the monitoring scientists to assist in mosquito research. The Mückenatlas is a typical citizen science project which has substantially added to the analysis of the spatiotemporal mosquito distribution in Germany and, in particular, has led to the discovery of new populations of the invasive Asian bush mosquito *Aedes japonicus*.
Key words Citizen science, Culicidae, passive monitoring, climate change, mosquito distribution.

INTRODUCTION

Germany's ecosystems are undergoing biodiversity alterations as a consequence of increasing globalization and continuing environmental and climatic changes. Among others, alterations pertain to the culicid fauna as non-native mosquito species actively invading or passively introduced succeed to establish. Whether previously endemic species have disappeared recently is not known because respective investigations are missing. Except for the Upper Rhine Valley, where mosquito data have been collected for more than 30 years (Becker and Ludwig, 1983), there are only out-dated local or regional studies on the occurrence of these insects. During the past decades no longitudinal nation-wide monitoring programme was carried out to assess where and when which culicid species occurs.
Until a few years ago, 46 mosquito species were considered indigenous to Germany (Dahl et al., 1999) although this figure is nothing but an addition of all species ever demonstrated in Germany. After the discovery of some recently invaded and a newly recognized species (Kronefeld et al., 2012; Werner et al., 2012), the number of species supposed to occur in Germany increased to 50. Although with West Nile, Sindbis, Tahyna, Batai, Lednice and Inkoo viruses it became evident that at least six facultatively pathogenic mosquito-borne viruses circulate in Europe (Lundström 1999), there have been no studies yet on mosquito-borne pathogens possibly occurring in Germany. Respective cases of disease have not

been recognized but might have appeared and been mis-diagnosed as a flu due to lacking differential diagnostic examinations.

While comprehensive knowledge exists on the biological characteristics of tropical mosquitoes demonstrated to be vectors of disease in their native areas, little is known on the indigenous species. No data are available on whether indigenous mosquitoes are able to transmit imported tropical disease agents. Studies in the recent years demonstrated Sindbis virus, Batai virus and the animal pathogenic Usutu virus in mosquito pools collected in Germany (Jöst et al., 2010, 2011a, 2011b). In other European countries, cases of West Nile fever, chikungunya fever, dengue fever and malaria recently occurred (Rezza et al., 2009; Danis et al., 2011; Sousa et al., 2012; Papa, 2012). A spread of mosquito-borne dirofilariae (*Dirofilaria repens*, *D. immitis*) to North and Northeast Europe, including Germany, has been observed (Genchi et al., 2011; Kronefeld et al., 2014).

MATERIALS AND METHODS

The Leibniz Centre for Agricultural Landscape Research and the Friedrich-Loeffler-Institut (German Federal Research Institute for Animal Health) have been commissioned by the Robert-Koch-Institut (German National Public Health Institute) and the German Federal Ministry of Food and Agriculture to carry out a nation-wide study on the occurrence and spatiotemporal distribution of culicids in Germany. For this purpose, mosquito traps have been operated since spring 2011 at more than 120 locations over the country. To complement the trap collection of species poorly attracted to traps, rare species, and species occurring in ecologically particular and remote areas, and to obtain data from many more locations than can be covered by the trap grid, the citizen science project Mückenatlas was initiated in 2012. People are invited to participate in mosquito research by catching mosquitoes in their surroundings and to send them to the research institutions, with some details of the collection. Detailed instructions are provided on the project's homepage: www.mueckenatlas.de. Mosquitoes are to be collected by putting a closable container over them. These containers are to be put in the freezer to kill the mosquitoes. The dead mosquitoes are then transferred to the research institutions together with a questionnaire. In the laboratory, the mosquitoes will be identified morphologically or genetically, and added to the reference collections of pinned specimens or DNA samples. The identification plus information coming with the mosquito will be entered into the German mosquito database Culbase where data from research projects and corresponding collections are brought together. The submitter of the mosquito will receive the identification result together with biological details of the species and may request to appear as a spot on an interactive collection map of the Mückenatlas homepage.

RESULTS AND DISCUSSION

Since its launch in 2012, the Mückenatlas has experienced popularity and has generated several interesting and surprising results. In 2012, 2,020 postal items were submitted to the Mückenatlas of which 1,564 (77.4%) contained culicids. The remainder consisted of spiders, beetles, grasshoppers, bugs, and various flies. The number of submitted culicids amounted to 6,127. In 2013, the number of postal items received increased to 2,409 of which 1,838 (76.3%) contained mosquitoes. A portion similar to 2012 comprised other arthropods, this consisted of significantly more mosquito-like insects such as chironomids, trichocerids and anisopodids and less non-mosquito-like insects as compared to 2012. The number of mosquitoes submitted in 2013 was 11,273. Figures 1 and 2 show the locations where submitted mosquitoes were collected in 2012 and 2013. Submitted mosquitoes belonged to 36 species in 2012 and 38 species in 2013, with *Cx. pipiens* accounting for the major part of the

submissions. In total, 4 *Aedes*, 6 *Anopheles*, 1 *Coquillettidia*, 5 *Culex*, 5 *Culiseta* and 17 *Ochlerotatus* species were registered (Table 1). Widely distributed species, such as *Cx. pipiens*, *Cx. torrentium*, *Cs. annulata*, *Ae. vexans* and *Oc. sticticus* were regularly sent in substantial numbers. Less frequent and rare species such as *Cs. glaphyroptera* and *Cs. ochroptera* were collected (Kampen et al., 2013).

Figure 1. Mosquito collection sites in 2012

Figure 2. Mosquito collection sites in 2013 (as of January 2014)

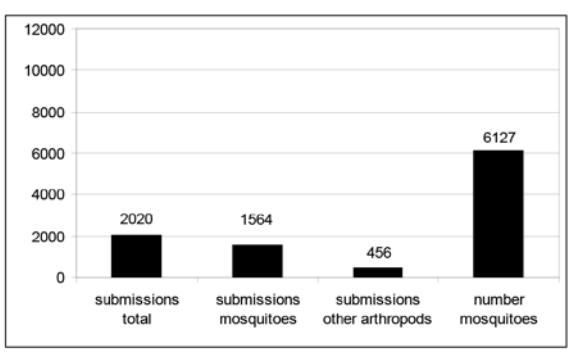

Figure 3. Mosquito submissions: 2012.

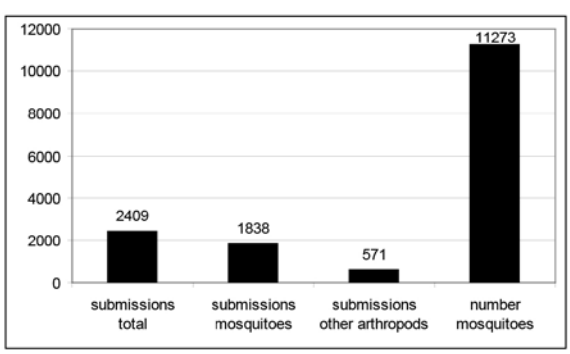

Figure 4. Mosquito submissions: 2013.

The Mückenatlas has gained relevance as an instrument to recognize hitherto unknown distribution areas. This became obvious when submissions of mosquitoes led to the detection of two established populations of the Asian bush mosquito *Ae. japonicus* in western and northern Germany (Kampen et al., 2012; Werner and Kampen, 2013).

In conclusion, the Mückenatlas has turned out an excellent tool for large-scale passive mosquito monitoring. It is successful with regard to both sides a citizen science project is meant to serve, i.e. the scientific one and the public one. The natural sciences are supported by data input from interested and cooperative citizens whilst the scientists make their expertise available to the community and contribute to their education.

Table 1. Species list of submissions to the Mückenatlas in 2012 and 2013

Genus *Anopheles*	**Genus *Aedes***	**Genus *Coquillettidia***	**Genus *Culex***	**Genus *Culiseta***	**Genus *Ochlerotatus***
An. claviger	*Ae. cinereus*	*Cq. richiardii*	*Cx. hortensis*	*Cs. annulata*	*Oc. annulipes*
An. atroparvus	*Ae. geminus*		*Cx. modestus*	*Cs. subochrea*	*Oc. cantans*
An. daciae	*Ae. rossicus*		*Cx. pipiens* (*pipiens/molestus*)	*Cs. glaphyroptera*	*Oc. caspius*
An. maculipennis	*Ae. vexans*		*Cx. territans*	*Cs. morsitans*	*Oc. cataphylla*
An. messeae			*Cx. torrentium*	*Cs. ochroptera*	*Oc. detritus*
An. plumbeus					*Oc. dorsalis*
					Oc. excrucians
					Oc. flavescens
					Oc. geniculatus
					Oc. intrudens
					Oc. japonicus
					Oc. leucomelas
					Oc. pullatus
					Oc. punctor
					Oc. riparius
					Oc. rusticus
					Oc. sticticus

Citizens obtain individual feedback about their data and additional information, which can increase their knowledge of wildlife and nature and bring about a change in attitudes. The material processing procedure still guarantees the highest possible quality of data since mosquito identification and data analysis and interpretation is performed by the scientists. As all citizen science projects, the Mückenatlas demands high quality communication between all participants. Scientists, citizens, communicators and the media are all involved. On a meta-level, the four main drivers for successful citizen science communication are realized within the Mückenatlas: dialogue at eye level, transparency, commitment and relevance.

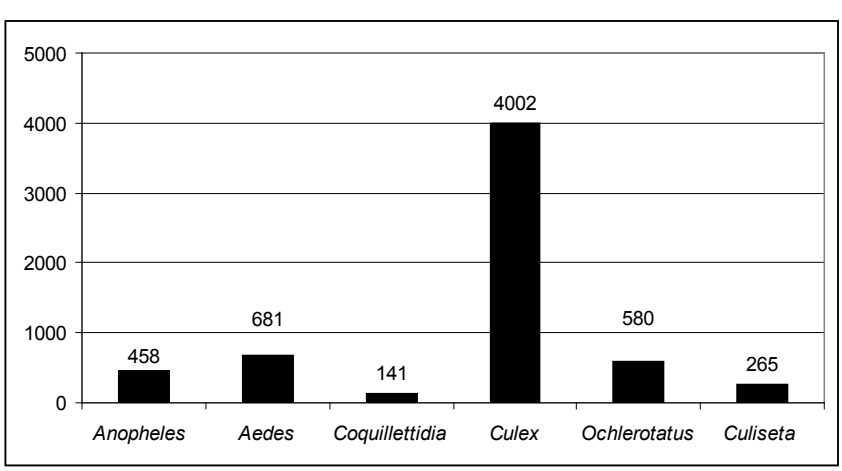

Figure 5. Mosquito submissions in 2012 according to genera

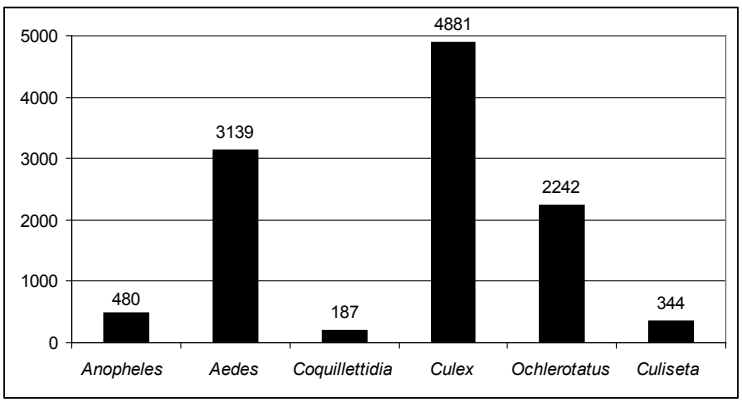

Figure 6. Mosquito submissions in 2013 according to genera

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