Invertebrates found in underground shelters of western Bohemia. I. Mosquitoes (Diptera: Culicidae)

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Abstract: Mosquitoes found hibernating in underground shelters were studied in western Bohemia, Czech Republic. Species collected included *Culiseta alaskaensis*, *Cs. annulata*, *Cs. glaphyroptera*, *Culex* spp., and *Anopheles maculipennis* s.l.. *Culex* spp. were the most common, followed by *Cs. glaphyroptera* and *Cs. annulata* with few records of *Cs. alaskaensis* and *An. maculipennis* s.l.. *Culex* spp. were found in a variety of shelters, *An. maculipennis* s.l. preferred cellars, and *Cs. alaskaensis* where they were found, exhibited little preference. *Culiseta annulata* and *Cs. glaphyroptera* were found in similar numbers of cellars, caves, and bunkers, but *Cs. glaphyroptera* were found more commonly in mines than *Cs. annulata*. ***Journal of the European Mosquito Control Association* 32: 27-32, 2014**

Keywords: Culicidae, *Culiseta*, *Culex*, *Anopheles*, hibernation, underground shelters, Czech Republic

Introduction

Mosquitoes found hibernating in underground shelters in the Czech Republic have only been studied in a few parts of the country. Although some previous data can be found in Pax & Maschke (1935) and Maschke (1936) from north-western Moravia, the first major study evaluating thousands of mosquitoes was published from south Moravia (Minář & Hájková, 1966). Other data has been published from northeast Bohemia (Kramář *et al.*, 1967) and the Třeboň region (Rettich *et al.*, 1978). A very detailed study on mosquitoes including hibernation habits was published by Minář (1975) from the Lipno reservoir area in southern Bohemia. Dvořák (2012) found *Cs. glaphyroptera* to be a common species found in underground shelters of western Bohemia.

In this paper, more data is presented on mosquitoes hibernating in underground shelters in western Bohemia, with a specific objective of further defining the hibernating requirements for *Culiseta* species.

Materials and Methods

Mosquitoes were searched for in 217 underground shelters by using a head lamp. In most cases, mosquitoes were counted in the presently studied localities, only in the case of unclear specimens or for the collection of voucher specimens were mosquitoes collected using a killing bottle with ethyl acetate. Mosquitoes were identified using Kramář (1958) and Maslov (1989). The voucher specimens are deposited in the collections of Municipal Museum Mariánské Lázně, Czech Republic.

Results

From a total of 217 localities visited, 4507 specimens (except *Culex* spp.) of five taxa were found. Altogether, 56 mapping quadrants (6'N, 10'E; ~ 130 km^2) were studied (Figure 1).

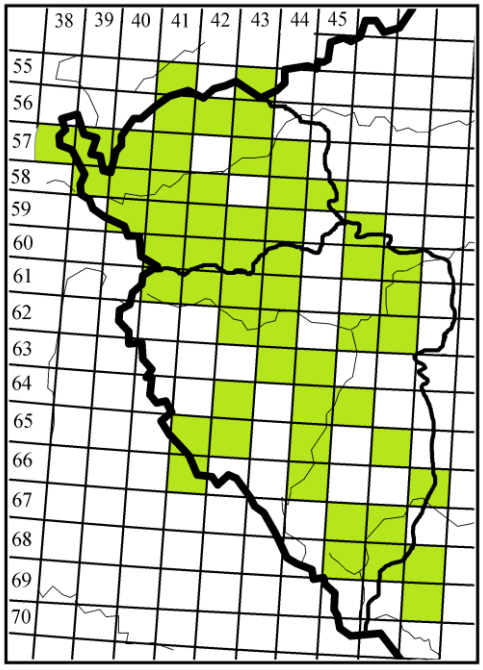

Figure 1. Studied map quadrants, W. Bohemia, Czech Republic

Except for the *Culex* spp., the most common species found was *Culiseta glaphyroptera*. *Culisetea annulata* was also commonly found, while *Cs. alaskaensis* and *Anopheles maculipennis* s.l. were rarely encountered.

Culex spp. was found in more than 90% of the recorded localities, *Cs. glaphyroptera* in more than 50% of these localities, *Cs. annulata* was found in almost 40% of these localities, and *Cs. alaskaensis* and *An. maculipennis* s.l. were found in ca. 5% of these localities (Figure 2).

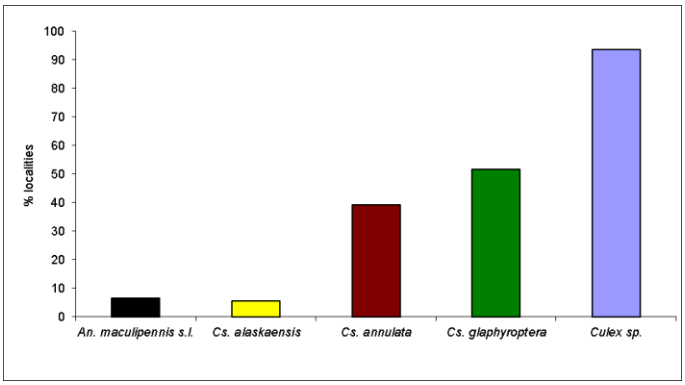

Figure 2. Number of localities inhabited by each mosquito species is expressed by percentage (%)

Figure 3 depicts the altitude of underground sites surveyed and the associated species found. *Cs. annulata* is quite common up to ca. 600 m a.s.l. but is rarer in higher altitudes. *Cs. glaphyroptera* was commonly found from altitudinal ranges of 450–600 m and higher, while this species is rare in lower altitudes. The presence of all mosquito taxa in the individual localities is shown in Appendix 1.

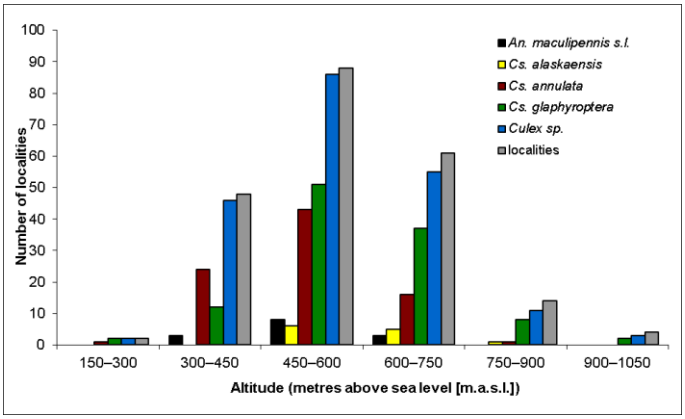

Figure 3. Number of studied localities and localities occupied by each mosquito species is divided into altitudinal ranges higher than 150 m a.s.l.

Culiseta alaskaensis (Ludlow, 1906)

A boreo-montane forest species (Minář, 1975, Minář & Halgoš, 1997), which is very rarely found at low altitudes. In the Czech Republic, it is present mainly in hilly and mountainous regions, especially in south Bohemia (Minář, 1975). For example, *Cs. alaskaensis* was a very rare species in southeast Moravia in the 1990s (Gelbič *et al.*, 2003), but it has not been recorded since 2000 (I. Gelbič, pers. comm.). Similarly this species is rare in lowlands in other central European countries, for example near Balaton Lake in Hungary more than 16,000 adults from the genus *Culiseta* were caught, of which only 12 adults (0.075%) were of *Cs. alaskaensis* (Márkus *et al.*, 2009). It is considered a very rare species in Slovakia (Országh *et al.*, 2001; Országh, 2004).

Hibernation of *Cs. alaskaensis* is known from various countries in Europe and from various underground shelters. Minář (1975) found only individual females in three cellars by Lipno Reservoir in Bohemia. A very interesting finding is the hibernation of one female in a cellar in Valtice, south Moravia, Czech Republic, where this species is very rare (Minář & Hájková, 1966). In Slovakia, the species has been found hibernating in caves: one female in the Medvedí Jaskyňa cave in the Slovenský Raj Mts. (Košel, 1976) and 79 females in two caves in the Belianske Tatry Mts. (Košel, 2004). Common occurrences are recorded at the caves of the Polish Tatra mountains. (Kowalski, 1955) and in the mines of south Norway (Kjaerandsen, 1993). Cellars have also been recorded as a hibernation location, e.g., from Uppsala in Sweden (Jaenson, 1987).

In the studied region, only 14 females of *Cs. alaskaensis* have been found in 12 localities in nine mapping quadrants (Figure 4). The altitudinal ranges recorded were from 530 m a.s.l. (Zelená Hora, quadrant 6547 in the cellars of a castle) to 900 m a.s.l. (Ždánov, quadrant 6847, military bunker No. 22). In Mariánské Lázně, quadrant 6042, two females were recorded in the cellars of the hotel Jitřenka, 30.X.2012, while a single female was recorded on all other localities.

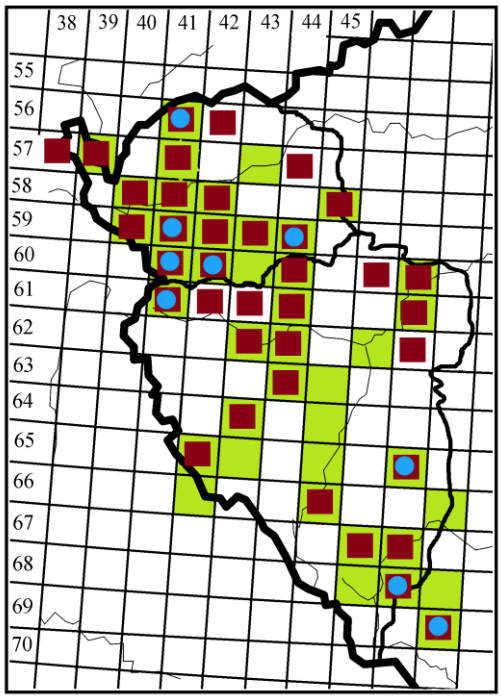

Figure 4. Distribution of *Culiseta* species in the studied region. Light green background: *Cs. annulata*, brown quadrants: *Cs. glaphyroptera*, blue circles: *Cs. alaskaensis*

Culiseta annulata (Schrank, 1776)

Culiseta annulata is a common Western Palaearctic species, in the Czech Republic and is widely distributed up to ca. 1000 m a.s.l. (Kramář, 1958).

The hibernation of *Cs. annulata* in the Czech Republic has been recorded by previous authors of Czech speleobiology. Pax & Maschke (1935) and Maschke (1936) published this species from two caves in the Kralický Sněžník mountains (=Glatzer Schneeberges Mts.). Cellars have previously been reported as the most common hibernation site in northeast Bohemia (Kramář *et al.*, 1967) and in the Třeboň region (Rettich *et al.*, 1978). In a major study conducted in south Moravia 30,000 hibernating mosquitoes were counted, but *Cs. annulata* was recorded only in individual females in cellars and bunkers (Minář & Hájková, 1966). The authors also noted the hibernation of this species in the caves of the Český Kras karst (Minář & Hájková, 1966). Small numbers of females (9–11 females per 1 m^2) have also been recorded in cellars by Lipno Reservoir (Minář, 1962, 1977).

In Slovakia, *Cs. annulata* has been recorded in a cave in Liptov (Moravčík, 1976) or in Zbojnícka cave (Košel & Horváth, 1996). It is a very common and widely distributed species, so many records of hibernation in underground shelters have been published from various European countries: in cellars in Croatia (Merdić, 1989, 1990, Merdić & Vujičić-Karlo, 2005), in mines in south Norway (Kjaerandsen, 1993), in a cellar near Uppsala in Sweden (Jaenson, 1987), in caves in Montii Banatului in Romania (Boitan & Negrea, 2001), in caves in Oltenia in Romania (Motas *et al.*, 1967) and in caves by Montpellier in south France (Gazave *et al.*, 2001, only four female *Cs. annulata* from more than 1,500 mosquitoes).

In the studied region, 1,113 female *Cs. annulata* were found in 85 localities from 41 mapping quadrants (Figure 4). It is the third most common mosquito found hibernating in underground shelters. It is widely distributed in the entire studied region and with the exception of the highest altitudes, it has been found from 300 m a.s.l. (Krašov, quadrant 6047, in cellars by a castle) up to 780 a.s.l. (Amálino Údolí valley, quadrant 6847, in Bedřich mine). This fact corresponds with the results of Kramář (1958), who has documented *Cs. annulata* from a maximum altitude of 1000 m. *Culiseta annulata* hibernates as either single specimens or in smaller numbers up to several dozens of females. The highest numbers were found in the following localities: Chotěšov, quadrant 6345, in the cellar of a monastery, 3.II.2014 (177 females), Čepice, quadrant 6747, in a mine, 25.XII.2011 (69 females), 17.XI.2012 (39 females); Bečov nad Teplou, quadrant 5943, in a mine under a railroad, 30.X.2013 (57 females); Karlovy Vary, 5743, in a mine behind Thermal, 30.X.2013 (56 females); and Cheb, 5940, and in a cellar in a castle court, 24.I.2013 (50 females). These findings are in contrast to the study of Minář (1975), who did not found such large numbers of *Cs. annulata*. Also one male was found in one shelter: Čepice, quadrant 6747, mine, 25.XII.2011.

Culiseta glaphyroptera (Schiner, 1864)

This species is considered as an endemic species which has been recorded in mountainous areas of Central Europe (Kramář, 1958, Minář, 1975, Minář & Halgoš, 1997), particularly at lower altitudes in shaded rivers and stream valleys (Kramář *et al.*, 1967). In Slovakia, where the mosquito fauna has been well studied, *Cs. glaphyroptera* was only recorded in six localities (Minář & Halgoš, 1997). Országh *et al.* (2001) and Országh (2004) listed *Cs. glaphyroptera* from seven mapping quadrants in the following mountain ranges: Malá Fatra, High Tatra, Belianské Tatry, Slovenský Ráj, and Vihorlat.

Studies similar to those in Slovakia are lacking from the Czech Republic. *Culiseta glaphyroptera* were recorded in several mountainous and sub-mountain regions: Jizerské Hory, Krušné Hory (Ore mountains), Hrubý Jeseník (Altvater mountains), Českomoravská Vrchovina highlands (all Kramář, 1958), the Lipno Reservoir surroundings (Minář, 1962, 1977), northwestern Bohemia (Kramář *et al.*, 1967), Třeboň region (Rettich *et al.*, 1978), and the planned Hněvkovice Reservoir surroundings (Olejníček & Kohn, 1987). For the list of these localities see Dvořák (2012).

In the most recent Red List of invertebrates of the Czech Republic *Cs. glaphyroptera* is listed as a vulnerable species (VU) and is one of the seven of the rarest species in the Czech Republic (Minář, 2005). The situation in Slovakia is similar: *Cs. glaphyroptera* is listed as one of four vulnerable species (Jedlička & Stloukalová, 2001). As Dvořák (2012) recorded, *Cs. glaphyroptera* should be removed from the Red List of both countries and listed as a common species.

Figure 5. Distribution of *Culiseta glaphyroptera* in the Western Palaearctic

The southernmost European localities are from Bulgaria (Bozhkov, 1959, Dvořák, 2012). The records from Iran are doubtful (Azari-Hamidian, 2007). A Greek checklist (Samanidou-Voyadjoglou & Darsie, 1993) includes *Cs. glaphyroptera* as a member of Greek fauna based on distribution only, and Snow & Ramsdale (1999) did not include *Cs. glaphyroptera* in the list of Greek fauna. Unexpected new records of *Cs. glaphyroptera* were published from northeast Algeria (Boudemagh, 2013). The newest European records of *Cs. glaphyroptera* were published from Germany, where this species is rare (Kampen *et al.*, 2013). The distribution of *Cs. glaphyroptera* in Europe and North Africa is shown on Figure 5.

The published records of hibernating specimens are very scarce. There are records in a cave cellar in Mutzig in France (Eckstein, 1918), in a cave in Lower Austria (Martini, 1925), and in Slovakia where five females were found in Vlčie Diery cave in the Slovenský Ráj mountains. (Košel, 1999) and seven females in two caves of the Belianské Tatry mountains. (Košel, 2004). Minář (1975) found individual females in cellars by Lipno Reservoir in the Czech Republic.

In the studied region, 3,290 females *Cs. glaphyroptera* have been found at 112 localities in 37 mapping quadrants (Figure 4). It is the second most common mosquito hibernating in underground shelters and a widely distributed species. The altitudinal level of localities varies from 340 m a.s.l. (Holýšov, quadrant 6344, mine in the Hradecká Skála rock) up to 940 m a.s.l. (Ždánov, quadrant 6847, military bunker No. 4). *Culiseta glaphyroptera* hibernates either as individual females, or in dozens, but scarcely in mass numbers. The highest numbers have been counted at the following localities: Broumov, quadrant 6142, in the cellars of Jánský castle, 26.XI.2013 (326 females), 16.I.2013 (236 females), 29.XII.2011 (201 females); Výškov, quadrant 6042, in a mine Starostova, 12.XI.2013 (202 females); Vysoká-Háj, quadrant 6041, Dyleňská cave, 29.X.2013 (183 females), 31.XII.2011 (105 females); Vítkov, quadrant 5841, in an ammunition depot of a former quarry, 13.II.2014 (148 females); Vysoká-Háj, quadrant 6041, in a cellar of a former gamekeeper's lodge, 29.X.2013 (138 females), 12.I.2012 (136 females), Výškov, quadrant 6042, mine Trampský Převis, 12.XI.2013 (113 females), and Výškovice, quadrant 6042, in a mine Parukářka, 10.XI.2012 (111 females).

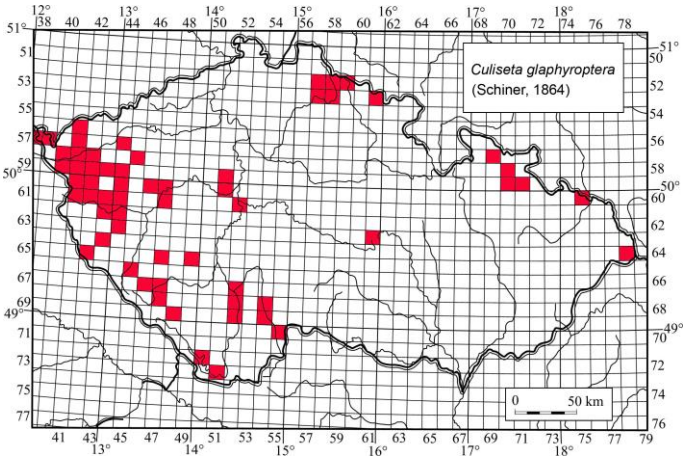

Figure 6. The present known distribution of *Culiseta glaphyroptera* in the Czech Republic

Also material of several hibernating females from east Bohemia (Krušné Hory mountains), central Bohemia (Český Kras karst and Prague), south Bohemian plateaux (Blatná environs), and east Moravia (Moravskoslezské Beskydy mountains) have been studied by the author. The present known distribution in the Czech Republic is based on published data and records of hibernating mosquitos is shown in Figure 6.

Culex spp.

Only small numbers of *Culex* spp. females were collected and identified. Only *Cx. torrentium* and *Cx. pipiens* s.l. were found. Identification of females of *Cx. torrentium* and *Cx. pipiens* is very difficult and identification can accurately be made in only a few specimens (Onyeka, 1982; Jaenson, 1987). No *Cx. territans* Walker, 1856 or *Cx. hortensis* Ficalbi, 1889 were found. With this in mind all records are listed as *Culex* spp.

A common species, *Cx. pipiens* s.l. is collected practically in all of Europe. Thousands of specimens are often collected. So, the hibernation habits are well known, e.g., in a cellar by Uppsala in Sweden (Jaenson, 1987; together with *Cx. torrentium* and *Cx. territans*), in a cave in Olteina in Romania (Motas *et al.*, 1967), in a cave by Montpellier in southern France (Gazave *et al.*, 2001; together with *Cx. hortensis*), in mines in southern Norway (Kjaerandsen, 1993; together with *Cx. territans*), in the Zbojnícka cave in Little Carpathians in Slovakia (Košel & Horváth, 1996), in caves in the Belianske Tatry mountains in Slovakia (Košel, 2004), in caves in the Liptov region in Slovakia (Moravčík, 1976; together with *Cx. torrentium*) or in caves in Croatia (Merdić, 1989, 1990; Merdić & Vujičić-Karlo, 2005). Minář (1975) regarded *Cx. pipiens* as the most common mosquito found in cellars by Lipno Reservoir with large numbers collected up to 6,280 females per 1 m^2.

In the present research, it is the most common species that occurred in 203 localities (93%) in 55 mapping quadrants (Figure 7), quite often it is found in huge numbers (these however were not counted). Also one male of *Cx. pipiens* s.l. was found in one shelter: Broumov, quadrant 6142, in the cellars of Jánský castle, 26.XI.2013.

Anopheles maculipennis s.l.

This complex includes several species, from which only two could be found hibernating in west Bohemia: *An. maculipennis* s.s. Meigen, 1818 and *An. messeae* Falleroni, 1926. Females could be identified with some difficulties by using scale index of the wings (e.g. Dirlbek, 1954). The studied specimens were identified as *An. messeae*, but owing to morphological complexities, these are listed here as *An. maculipennis* s.l. Both species are widely distributed throughout most of Europe, with *An. maculipennis* s.s. having a wider overall distribution (Snow & Ramsdale, 1999).

The hibernation of *An. maculipennis* s.l. at various sites were published, e.g. Eckstein (1918). In the Czech Republic, the hibernation habits were observed in cold cellars in the Třeboň region (Rettich *et al.*, 1978) or in south Moravia (Minář & Hájková, 1966). Minář (1975) found both species in cellars by Lipno Reservoir. Although specimens of *Anopheles maculipennis* s.l. prefer other shelters, they could be found hibernating in cold cellars (Minář, 1975). For example, other records were published from cellars in Osijek in Croatia (Merdić, 1990; Merdić & Vujičić-Karlo, 2005), from a cave near Montpellier in southern France (Gazave *et al.*, 2001) or from a cellar by Uppsala in Sweden (Jaenson, 1987).

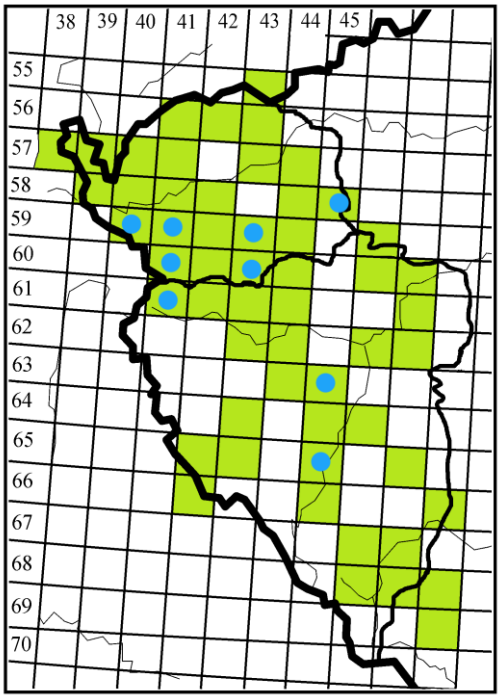

Figure 7 Distribution of *Culex* spp. (light green backround) and *Anopheles maculipennis* s.l. (blue circles) in the studied region

Some authors separate both species and published records of *An. maculipennis* s.s. hibernating in the Třeboň region (Rettich *et al.*, 1978) and by Montpellier (Gazave *et al.*, 2001), *An. messeae* in Osijek (Merdić, 1990; Merdić & Vujičić-Karlo, 2005), while both species were found in south Moravia (Minář & Hájková, 1966) and by Lipno Reservoir (Minář, 1975).

In the studied region, 90 females *An. maculipennis* s.l. have been found on 14 localities in nine mapping quadrants (Figure 7). The highest situated locality is Tři Sekery, 6041, cellar by the house No. 21 (665 m. a.s.l.). Minář (1975) stated that records of *An. messeae* higher than 700 m a.s.l. was very surprising. Only two "mass hibernacula" have been discovered: Tři Sekery, quadrant 6041, in a cellar by a house No. 21, 18.XII.2011 (23 females) and Dolní Žandov, quadrant 5941, cellar of a house by a former military training area, 7.I.2012 (21 females).

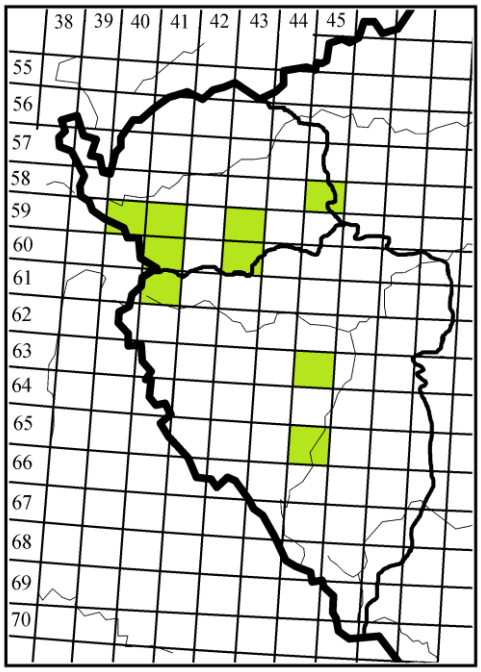

Figure 4. Distribution of *Anopheles maculipennis* s.l. in the studied region.

Discussion and conclusion

Five taxa of mosquitoes were found in western Bohemia during research of underground hibernacula. *Culex* spp. are common everywhere and they occur in various underground shelters throughout the whole studied region. *Culiseata glaphyroptera* is the second most common mosquito species, found mainly at medium and higher altitudes. The third most common species is *Cs. annulata* which is widely distributed and is quite common except in higher altitudes. *Culiseta alaskaensis* is probably a very rare species, not only in underground shelters, but probably throughout the Czech Republic. *Anopheles maculipennis* s.l. is rarely found hibernating in underground shelters.

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