

Changes in the occurrence of mosquitos in the recent period

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Abstract: The mosquito fauna was observed in mountain and lowland regions of Bohemia for 50, respective 40 years. As has been proven by the long term research of this medically significant family of the dipteran and its occurrence on the territory of both the Czech and Slovak republic, changes in species composition of mosquito fauna and ecology in central Europe are indicators of contemporary ongoing climatic change and climate warming.

Key words: Diptera, mosquitoes, Culicidae, Šumava mountains, Polabí region, climatic change

Introduction

The research of the mosquito family Culicidae has been paid a great attention especially due to its significance as blood-eating pests of vertebrates, including man and serious disease agent carriers.

Mosquitos belong among evolutionarily older paraphyletic dipteran “suborder” Nematocera which evolved from a mecopteroid group of insect in late Permian or early Triassic (Obenberger 1955, Martynov 1959, Rodendorf 1964, etc.). The evolution of the mosquito family continued in the early Cenozoic, a period from which many representatives of current genera are known (Cockerell 1914, Edwards 1923, Staatz 1944, Štekelberg 1957). Present distribution of mosquitos, in particular on the northern hemisphere, has been establishing itself 12,000 years since the termination of the Ice Age and its changes are taking place even at present.

The number of current mosquito species exceeds 3,000 (Gillet 1971, Knight, Stone 1977 - 1978), with more than 200 species in the Palearctic area (Minář 1986, 1990, etc.). Systems and ecology of mosquitos was studied especially in the Holarctic region (Natvig 1948, Martini 1950, Mončadskij 1951, Gucevič et al. 1970, Tanaka et al. 1979, Carpenter, La Casse 1955, Wood, Dang, Ellis 1979, Darsie, Ward 1981, Minář 1986, 1990, 2000, etc.). Many works deal with fauna of individual states (Marshall 1951, Rioux 1958, Mihályi, Gulyás 1963, Mohrig 1966, Božkov 1966, Monchadsky, Garciia 1966, Rageau et al. 1970, Skierska 1971, 1977, Dubickij 1978, Minář 1976, 1978, Dahl 1977, Kucharčuk 1980, Samanidou – Voyadoglou, Darsie 1993, Šeremet 1998, Pakalniškis et al. 2000, etc.).

On the territory of Czechoslovakia, the research has been carried out for more than 100 years. Kowarz (1894) mentions 8 mosquito species in total, Wimmer (1913) 9 species, Kramář (1958) 48 species, Minář, Halgoš (1997) 50 species, Ország et al. (2009) 52 species. The development of this family research began in the second half of the twentieth century and was particularly aimed at the ecology of mosquitos in mass occurrence areas (Breindl, Komárek 1940, Kramář, Weiser 1951, Rosický, Weiser 1952, Trpiš 1962, Lauterer, Chmela 1977, Labuda 1977, Rettich et al. 1978, Vaňhara 1981, Vaňhara, Rettich 1998, Jalili et al. 1999, Rettich 2000, etc.).

Further research was related to the transfer of disease agents (Breindl, Komárek 1941, Málková et al. 1974, Minář, Rosický 1975, Rosický et al. 1980, Minář 1987, Hubálek et al. 1990, etc.).

In the recent years the mosquito research has been carried out in relation to extraordinary floods (Rettich 1998, Rettich, Ryba 1998, Chmela 1999, Gelbič, Chmela et al. 2000, Minář,

Gelbič, Olejníček 2001). Several works have also dealt with the changes in the occurrence and ecology of mosquitos related to climatic changes (Minář, Halgoš 1977b, Chmela 2000, Olejníček, Minář, Gelbič 2004, Minář, Gelbič, Olejníček 2004, Minář, Halgoš et al. 2007).

Changes in the occurrence and ecology of mosquito species and groups, initiated by climatic change, can be the indicators of the climatic change in question.

Methods

The impact of environmental changes, including climatic change, on fauna and ecology of mosquitos can manifest itself on the changes of species composition in an area observed for a longer time-period while carrying out a long-term comparison of mosquitos occurrence at different localities at a certain period with different natural conditions and observing the changes in the seasonal occurrence of individual mosquito species during a vegetation period. In the long run, in the course of several decades since 1960 up to 2013, the occurrence of mosquitos has been observed in the area of the Vltava upper reaches in the southeast Šumava in the altitude 700 – 800m, beginning with the construction of Lipno valley water reservoir (Minář 1964, 1965, 1970, 1975) up to the present. Furthermore, the occurrence of mosquitos in this area has been compared to the results of a long-term mosquito research in the lowlands of central Polabí in the altitude 150 – 200 m, carried out by Kramář (1955, 1958) and to the observation of mainly spring species of the genus *Aedes* between 1971 (Kolman et al. 1972) and 2013. Differences in the seasonal occurrence of individual mosquito species during vegetation period were also observed. For details of collecting methods see references above.

Results

Results of 50 years studies are gathered in Tab. 1. Data in this table were partly published (see “Methods”) and partly they resulted from subsequent (unpublished) collections.

Prior to the construction of Lipno water reservoir in 1961 – 1962, 18 mosquito species were elicited in this area (Tab. 1), of which *Aedes pullatus* is a boreo-alpine species while *Culiseta alaskaensis*, *Cul. ochroptera* and *Aedes punctor* are boreo-mountainous species and *Cul. glaphyoptera* is a central European endemic mountainous species. *Aedes communis* is an abundant, early spring species of the subarctic mild zone of the Holarctic area. *Culex hortensis* species, elicited for the first time, and once only, here in Bohemia (Minář 1975) is a Mediterranean species of higher altitudes. *Aedes geniculatus* inhabits warm climate zone of deciduous forests and is spread more in the southern Europe. Other recorded species belong among widely spread Euro-Siberian and Holarctic species of a mild climate zone (Kramář 1958, Gucevič et al. 1970, Minář 1986, etc.).

In 1987, a female of *Anopheles plumbeus* was captured here, a species also spread especially in the southern Europe and, similarly to *Ae. geniculatus*, maturing in tree cavities (Minář, Hagoš 1997b).

Following the wide Vltava valley inundation by Lipno water reservoir, breeding grounds of mosquitos in coastal meadow marshes ceased to exist. This involved *Aedes cantans*, *Ae. vexans* and *Ae. cinereus* species. In the years that followed the species were no longer elicited in the locality. The finding of one adult of *Ae. vexans* species in a nearby locality Vyšší Brod on 18 August, 2001 was rather rare.

In the last 8 years (2006 – 2013), 13 mosquito species were recorded in the southeast area of the Šumava (Tab. 1). In 2008, 2009 and 2012, from May to June, the larvae of *Aedes cinereus* were found in temporary puddles on meadow and forest edges. The larvae of *Ae. cantans* were discovered in May 2008, which was after the period of 45 years for both species respectively.

During the 50 years of research, the larvae of *Ae. communis* and *Ae. pullatus* were collected from the beginning of April till the beginning of June in forest and peaty pools. The larvae of *Ae. punctor* were collected later – from May till June, exceptionally even in July.

In May 2008 the larva of the thermophilic species *Aedes geniculatus* was found in an atypical breeding ground – in a trough carved into a stone on the edge of a forest with a layer of rotting leaves and needles on the bottom.

In central Polabí area, 15 abundant mosquito species were elicited during the research (Tab. 1). In the last 8 years the larvae of spring species *Aedes leucomelas*, *Ae. cataphylla*, *Ae. cantans* and *Ae. annulipes* were discovered in temporary puddles in April at water temperature 6 – 13 °C. In the years prior to that there were abundant larvae of cold tolerant species *Aedes communis* which, during the last eight years, were found in one locality only in 2010.

The results of the research revealed that while in higher altitudes above 600 – 700 m above sea level species of warmer meadow biotopes have reappeared in recent years, in the lowlands to 200 m above the sea level a previously abundant species *Aedes communis* with its occurrence prevailing in the northern part of the Holarctic zone vanished. Together with a previously discovered shift in the time-period of occurrence of several mosquito species to earlier time period and with findings of southern European mosquito species and other invertebrates, the mentioned observations bring forth evidence of overall climate warming and consequent changes in the fauna composition and time occurrence of some species on our territory.

Discussion

In recent decades the occurrence of several southern European thermophile mosquito species has newly been found in Bohemia, Moravia and in Slovakia (Minář, Halgoš 1997b). In Bohemia, *Aedes pulchritarsis* was found (Ryba 1979), familiar to eastern Slovakia (Danielová based on Kramář 1958). *Uranotaenia unguiculata* (Ryba et al. 1974) and *Culex martinii* (Vaňhara 1981) were found in Moravia and recently also *Anopheles hyrcanus* (Šebesta et al. 2009). In Slovakia *Culex theileri* (Halgoš, Petrus 1996) and *An. hyrcanus* (Halgoš, Benková 2004) were recorded.

In the last decade, the mosquito research in the Morava and Danube river basin revealed a shift in the occurrence of late spring mosquito species to an earlier month and the occurrence of summer species as soon as to the spring period. The occurrence of *Aedes cataphylla*, *Ae. vexans* and *Ae. cinereus* larvae were recorded in the first half of May between 2001 and 2003 together with the vanishing of originally abundant early spring species *Ae. communis*. The spring species were represented by *Ae. leucomelas* and *Ae. cataphylla* only (Chmela 2000, Olejníček, Minář, Gelbič 2004, Minář, Gelbič, Olejníček 2004, Minář, Halgoš et al. 2007). In Polabí the shift in the occurrence of summer mosquito species to spring period was recorded by Rettich (2000), the vanishing of cold tolerant species *Ae. communis* was proven by the observations mentioned in the results of this work.

In the last two decades, the occurrence and spread of other southern European invertebrates has been found on our territory. A prominent Mediterranean *Agriope bruennichi* was recorded in central Bohemia in 1993 (Kůrka 1994) and was further observed by the author in southeast Šumava in Vyšší brod in 2004. Similarly, southern European *Dictima civica* and *Arion lusitanicus* spread to the whole territory of Bohemia and Moravia during this period. *Mantis religiosa*, inhabiting up to now the southern Moravia and Slovakia only, spread continuously as far as the northern Moravia and in 2000 – 2004 was observed in Polabí (Janšta et al. 2008).

Tab 1: The occurrence of mosquito species in Šumava mountains and Polabí region

Region	Šumava mountains		Polabí region
Period	1960 - 1962	2000 - 2013	1971 - 2013
<i>Anopheles maculipennis</i>	+	+	+
<i>Anopheles messeae</i>	+	+	+
<i>Anopheles claviger</i>	+	+	+
<i>Anopheles plumbeus</i>	-	+	-
<i>Culex pipiens</i>	+	+	+
<i>Culex territans</i>	+	-	-
<i>Culex hortensis</i>	+	-	-
<i>Culiseta annulata</i>	+	+	+
<i>Culiseta alaskaensis</i>	+	+	-
<i>Culiseta glaphyoptera</i>	+	+	-
<i>Culiseta ochroptera</i>	+	-	-
<i>Aedes cinereus</i>	+	+	+
<i>Aedes vexans</i>	+	+	+
<i>Aedes cantans</i>	+	+	+
<i>Aedes annulipes</i>	-	-	+
<i>Aedes excrucians</i>	+	-	+
<i>Aedes flavescens</i>	-	-	+
<i>Aedes communis</i>	+	+	+
<i>Aedes punctor</i>	+	+	-
<i>Aedes pullatus</i>	+	+	-
<i>Aedes leucomelas</i>	-	-	+
<i>Aedes cataphylla</i>	-	-	+
<i>Aedes sticticus</i>	-	-	+
<i>Aedes geniculatus</i>	+	+	-
Number of species	18	15	15

References

- Božkov D.K. (1966): Krovososušcie komary (Diptera, Culicidae) Bolgarii. – Ent. Obozrenie, XLI : 570-571.
- Breindl V. & Komárek J. (1940): Anofelismus Čech a Moravy. – Věstník čs. Zool. společnosti v Praze 8: 177-193.
- (1941) : Rozšíření malarických komárů a otázka malárie u nás. – Praktický lékař 21: 45.
- Carpenter S. J. & La Casse W. J. (1955): Mosquitoes of North America. Univ. of California Press, Berkeley & Los Angeles, 353 pp.
- Cockerell T. D. A. (1914): The oldest mosquitoes. – Letters to the Editor, Nature, London 103: 43-46.
- Dahl Ch. (1970): Taxonomy and geographic distribution of Swedish Culicidae (Diptera, Nematocera). – Ent. Scand. 8: 59-69.
- Darsie R. F. Jr. & Ward R. A. (1981) : Identification and geographical distribution of the mosquitoes of North America, North of Mexico. Supplements to Mosquito systematics, 1, Amer. Mosq. Control Assoc., Fresno, Kalifornia, 313 pp.
- Dubickij A. M. (1970): Krovososušcie komary (Diptera, Culicidae) Kazachstana. Izd. „Nauka“, Kazach. SSR, Alma-Ata, 220 pp.

- Edwards F. W. (1923): Oligocene mosquitoes in the British Museum, with a summary of our present knowledge concerning fossil Culicidae. – J. Geol. Soc. London (1923): 139-155.
- Gelbič I., Chmela J., Minář J. & Olejníček J. (2000): Změny v populacích komárů v zaplavovaných oblastech střední a jižní Moravy. IV. Konference DDT, Přívorovy dny, Poděbrady, 23.-25.5.2000. Sborník referátů, pp. 245 – 263.
- Gillet J. D. (1970): Mosquitoes. Weidenfeld and Nicolson, London, 274 pp.
- Gucevič A. V., Mončadskij A. S. & Štavelberg A. A. (1970): Komary. Semejstvo Culicidae. Fauna SSSR, Nasekomye dvukrylye, Tom III., vyp. 4, Izd. „Nauka“, Leningrad, 384 pp.
- Halgoš J. & Benková J. (2004): First record of *Anopheles hyrcanus* (Diptera, Culicidae) from Slovakia. – Biologia, (Bratislava) 59: 15-68.
- Halgoš J. & Petrus O. (1996): First record of *Culex theileri* in Slovakia. – Biologia (Bratislava) 51: 190.
- Hubálek Z., Halouzka J., Juřicová J., Příkazský Z., Žáková J. & Šebesta O. (1999): Surveillance virů přenášených komáry na Břeclavsku v povodňovém roce 1997. – Epidemiol., Mikrobiol., Imunol. 48 : 91-96.
- Chmela J. (1999): Výskyt jarních kalamitních komárů v záplavové zóně řeky Moravy po povodni v r. 1997. – Desinfekce, Desinsekce, Deratisace 7: 94-101.
- (2000): Výskyt jarních kalamitních komárů na Olomoucku v r. 2000. – Desinfekce, Desinsekce, Deratisace 9: 82-83.
- Jalili N., Halgoš J., Ondriska F. & Brestovský J. (1999): Mosquito communities of the Morava flood plain area during floods in 1997. Dipterologica bohemoslovaca.
- Jansta P., Vrabec V., Stránský J. & Mikát B. (2008): Výskyt kudlanky nábožné (*Mantis religiosa*) (Mantodea, Mantidae) ve středních Čechách a její rozšíření v České republice. – Klapalekiana 44: 21-25.
- Knight J. & Stone A. (1977–1978): A catalog of the mosquitoes of the World (Diptera : Culicidae). The Thomas Say Foundation, vi, Baltimore, Maryland, 611 pp.
- Kramář J. (1955): Komáři rodu *Aedes* v ČSR. – Rozpravy ČSAV 9: 67.
- (1958): Komáři bodaví – Culicinae. (Řád: dvoukřídlí – Diptera). Fauna ČSR, sv. 13, Nakl. ČSAV, Praha, 285 pp.
- Kramář J. & Weiser J. (1951): Komáři calamity v jižní Moravě. – Zool. a Ent. Listy XIV(2): 180-183.
- Kolman J.M., Kopecký K., Minář J. & Hausenblasová M. (1972): Výskyt protilátek proti viru Ťahyňa, Čalovo a klíštěcí encefalitidy u obyvatelstva na území Čech. I. Polabí. – Čs. EMI 21(2): 79-85.
- Kowarz F. (1894): Seznam hmyzu českého – hmyz dvojkřídlý. Spol. Pro fysiochr., Praha.
- Kucharčuk Z.P. (1980): Krovososuščie komary (Diptera, Culicidae) Sibiri. Sistematika. Izd. “Nauka”, Novosibirsk, 221 pp.
- Kůrka A. (1991): První nález křížáka pruhovaného *Agriope bruennichi* v Čechách (Araneida: Araneidae). – Čas. Nár. Mus., ř. Přír. 163: 25-27.
- Labuda M. (1997): Komáři Diptera, Culicidae na Záhorskej nížine (západné Slovensko). – Entomol. Problem, 14: 123-173.
- Lauterer P. & Chmela J. (1977): Komáři kalamitních oblastí horní Moravy a dolní Bečvy (Diptera, Culicidae). – Čas. Mor. Musea, Brno, 62: 99-118.
- Málková D., Danielová V., Minář J. & Ryba J. (1974): Virological investigations in some biotopes of Southern Moravia in summer season 1972. – Folia parasitol. (Praha) 21: 363-372.
- Martini E. (1929-1931): Culicidae. In Lindner: Die Fliegen der Palearkt. Region 3. Stuttgart: 398 pp.
- Martynov A. (1959): Filogenetičeskie vzajmootnošenia nasekomych mekopterojdnogo kompleksa. – Tr. Inst. Morf. Životn. 27: 221-320.
- Marshall J.F. (1938): The British Mosquitoes. British Museum, London, 341 pp.
- Mihályi F. & Guyiás M. (1963): Magyarorszag czunyogjai. Akademiai Kiadó, Budapest, 229 pp.
- Minář J. (1964): Změny vodního a pobřežního rozstlnstva na Lipenské nádrži. Sborník veg. problem. při bud. vod. děl. Nakl. ČSAV, Praha, pp. 233-246.
- (1965) : Tabanidae, Ceratopogonidae, Simuliidae oblasti Lipenské vodní nádrže. – Čs. parasitol. 12: 192-206.
- (1970): Přírodní poměry oblasti Lipenské vodní nádrže. – Ochrana přírody 25(6): 122-127.
- (1975): Vliv hydrotechnických změn při výstavbě Lipenské vodní nádrže na výskyt komárů. – Sb. Jihočes. mus. v Č. Budějovicích, Přírodní vědy, XV, Suppl. 1: 74.
- (1976): Culiciden aus der Mongolei (Diptera). Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolai Nr. 380. – Acta Zool. Acad. Sci. Hung. 22(3-4): 335-350.
- (1978): Zoogeography of mosquito fauna in Mongolia. Dipterologica bohemoslovaca (Bratislava) 1: 175-180.
- (1986): Zoogeografie čeledi Culicidae v palearktické oblasti. – Dipterologica bohemoslovaca, IV., Jihočeské museum v Čes. Budějovicích, Přírodní vědy (1986): 21-26.
- (1987): Světové rozšíření komárů podčeledi Anophelinae a jeho vztah k přenosu malaria. – Čs. epid., mikrobiol., imunol. 36(4): 244-251.

- (1990): Family Culicidae. In: Soos A. & Papp L. (eds) : Catalogue of Palearctic Diptera. Volume 2. Akadémiai Kiadó, Budapest, pp. 74-113.
- (2000): Family Culicidae. In : Papp L. & Darvas B. (eds): Contribution to the Manual of Palearctic Diptera. Appendix. Science Herald, Budapest: pp. 83-111.
- Minář J., Gelbič I. & Olejníček J. (2001): The effect of floods on the development of mosquito populations in the middle and lower river Morava Regions. – Acta Univ. Carol., Biol. 45: 139-146.
- (2004): Influence of climatic changes on biodiversity of mosquitoes. – Folia Fac. Sci. Nat. Univ. Masaryk. Brun., Biol. 109: 215-223.
- Minář J. & Halgoš J. (1997a): Culicidae (Komároci). In: Chvála M. (ed.): Check List of Diptera (Insecta) of the Czech and Slovak Republics., Karolinum, Charles University Press, Pratur, p. 34.
- (1997b): Zoogeographically significant mosquitoes in the territory of Bohemia and Slovakia. – Dipterologica bohemoslovaca, 95: 129-132.
- Minář J., Halgoš J., Bartalová A. & Jalili N. (2007): Current climatic change and its impact on mosquito fauna in conditions of Slovakia and Czech Republic. – Acta Zool. Univ. Comenianae 47(2): 177-182.
- Minář J. & Kramář J. (1987): Culicidae. Check list. Enumeratio insectorum Bohemoslovakiae. – Acta Faun. Ent. Mus. Nat. Pragae 18: 39-40.
- Minář J. & Rosický B. (1975): Vývoj anofelismu na jižní Moravě. – Čs. Epid., mikrobiol., imunol. 24(1): 40-46.
- Mohrig W. (1969): Die Culiciden Deutschlands. Parasitologische Schriftenreihe. Heft 18. VEB Gustav Fischer Verlag, Jena, 260 pp.
- Mončadskij A. S. (1951): Ličinki krovosusušich komarov SSSR i sopredelnyh stran (podsem. Culicinae). Izd. AN SSSR, Moskva – Leningrad, 288 pp.
- Montchadsky A. S. & Garcia Avila J. (1993): Las lasvas de los mosquitos (Diptera, Culicidae) de Cuba. Su biologia y determination. Poeyana. Instituto de biologia, Seria A. La Habana, Cuba, No 28 : 92 pp.
- Natvig L. R. (1948): Culicini. Contribution to the knowledge of the Danish and Fennoscandian mosquitoes. Norsk Entomologisk Tidsskrift, Suppl. 1, Oslo, 567 pp.
- Obenberger J. (1955): Entomologie II. Nakl. ČSAV, Praha, 725 pp.
- Olejníček J., Minář J. & Gelbič I. (2004): Changes in biodiversity of mosquitoes in the years 2002-2003 caused by climatic changes in tžhe Morava river basin. – Acta Fac. Ecologiae 12 (Suppl. 1): 115-121.
- Ország I., Minář J. & Halgoš J. (2009): Culicidae, Meigen 1818. In: Jedlička L., Kúdela M., Stloukalová V. (eds) : Check list of Diptera of Czech Republic and Slovakia. Electronic version: <http://zoology.fas.mba.sk>.
- Pakalnikis S., Rumšaitė J., Sprangauskaitė-Bernotienė R., Butautaitė R. & Podėnas S. (2000): Check – list of Lithuanian Diptera. – Acta Zool. Lithuanica 10(1): 3-96.
- Rageau J., Mouchet J. & Abonnenc F. (1970): Répartition géographique des moustiques (Diptera: Culicidae) en France. Cah. O. R. S. T. O. M., sér. Ent. Med. Parasitol. VIII. 3: 289-316.
- Rettich F. (1998): Kalamitní výskyt komárů v jihomoravském kraji po katastrofálních záplavách v roce 1997 a způsoby jejich hubení. 3. Conference DDD 1998, Poděbrady. Sborník referátů, pp. 219 – 234.
- (2000): Revize fauny komárů Poděbradska. IV. Conference DDD, Poděbrady. Sborník referátů, pp. 219 – 234.
- Rettich F., Albert J. & Kadlčík K. (1978): A study on the mosquitoes (Diptera, Culicidae) of the Třeboň basin. – Dipterologia bohemoslovaca Bratislava 1: 229-241.
- Rettich F. & Ryba J. (1998): Kalamitní výskyt komárů v Jihomoravském kaji po katastrofálních záplavách v roce 1997 a způsoby jejich hubení. In: Davidová P. & Rupeš V. (eds): Nové poznatky v dezinfekci, dezinsekcí a deratizaci při ostraňování následků záplav 1997. Sborník referátů III. Conference DDD, Poděbrady, pp. 179-192.
- Rioux J.A. (1958): Les Culicidae du “Midi”Mediterranéen. – Encycl. Ent. (A) 35: 303.
- Rodendorf B.B. (1964): Istorickéoe razvitie dvukrylych nasekomyh. Izd. Nauka, Moskva, Tr. paleontolog. inst., T 1000, AN SSSR, 310 pp.
- Rosický B., Málková D., Danielová V., Hájková Z., Holubová J., Kolman J., Marhoul Z., Minář J. & Šimková A. (1980): Ťahyňa virus. Natural focus in Southern Moravia. – Rozpravy ČSAV 90(7): 107.
- Rosický B. & Weiser J. (1952): Škůdci lidského zdraví.(Boj s hmyzem II). Přír. Nakl., Praha, 836 pp.
- Ryba J. (1979): Faunistic record from Czechoslovakia. Diptera, Culicidae. –Acta ent. Bohemoslov6: 143.
- Ryba J., Hájková Z. & Kaftan M. (1974): Occurrence of *Uranotaenia unquiculata* Edwards, 1913 (Diptera, Culicidae) in Czechoslovakia. – Folia parasitol. Praha 21 : 142.
- Samanidou-Voyadjoglou A. & Darsie R. F. (1993): An annotated checklist and bibliography of the mosquitoes of Greece (Diptera, Culicidae). – Mosquito systematics 25(3) : 176-180.
- Service M. W. (1993): Mosquito ecology. Chapman and Hall, London, 954 pp.
- Skierska B. (1971): Komary – Culicidae. Larwy i poczwarki (z uwzględnieniem jaj niektórych gatunków). Klucze do oznaczania owadów Polski, Warszawa, 138 pp.
- (1977): Culicidae. Part 28: Diptera, 9b. Klucze do oznaczania owadów Polski, Warszawa, 120 pp.

- Staatz G. (1944): Neue Diptera (Nematocera) aus dem Oberoligocene von Rott. V. Familie Culicidae (Stechmücken). – *Paleontographica* 95: 106-121.
- Šebesta O., Rettich F., Minář J., Halouzka J., Hubálek Z., Juřicová Z., Rudolf J., Šikutová S., Gelbič I. & Reiter P. (2009): Presence of the mosquito *Anopheles hyrcanus* in South Moravia, Czech Republic. – *Medical and Veterinary Entomology* 23 : 284-286.
- Šeremet V.P. (1998): Krovosisni komari Ukraini. Redakcijno vydavničij centr, Kiiv. Universitet, Kiiv, pp. 11-33.
- Štachelberg A. A. (1937): Semejstvo Culicidae. Fauna SSSR, Nasekomye dvukrylye, Tom III.,vyp. 4., Izd. AN SSSR, Moskva – Leningrad, 257 pp.
- Tanaka K., Mizusava K. & Saugstad E. S. (1979): A revision of the adult and larvae mosquitoes of Japan (including the Ryzkyu archipelago and the Ogasawara islands) and Korea (Diptera, Culicidae). Contribution of the American Entomological Institute, 987 pp.
- Trpiš M. (1962): Ökologische Analyse der Stechmücken-populationen in der Donautiefebene in der Tschechoslowakei. – *Biol. Práce* 8(3): 132.
- Vaňhara J. (1981): Diptera, Culicidae. Faunistic records from Czechoslovakia. – *Acta Ent. Bohemoslov.* 79: 317.
- Vaňhara J. & Rettich F. (1998): Culicidae. In: Rozkošný R., Vaňhara J. (eds): Diptera of the Pálava Biosphere Reserve of UNESCO, 1. – *Folia Fac. Sci. Nat. Univ. Masaryk. Brun., Biol.* 99: 97-105.
- Vimmer A. (1913): Seznam českého hmyzu dvojkřídlého. Entomol. příručky. Čes. Spol. entom., Praha, 98 pp.
- Wood D.M., Dang P.T. & Ellis R.A. (1979): The mosquitoes of Canada. Diptera : Culicidae. The insects and arachnids of Canada, Part 6. Biosystematics Research Institute, Ottawa, Ontario, 390 pp.

Změny ve výskytu komárů v současném období

Fauna komárů byla sledována v horské a nížinné oblasti Čech 50, resp. 40 let. Změny druhového složení fauny komárů a jejich ekologie ve střední Evropě jsou ukazatelem v současnosti probíhajících změn podnebí a jeho oteplování, jak bylo prokázáno dlouhodobým výzkumem této zdravotně významné čeledi dvoukřídlých na území Československa (současné České a Slovenské republiky).

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