

AN PRELIMINARY LIST OF THE MOSQUITOES (DIPTERA: CULICIDAE) OF SHANDONG PROVINCE, CHINA

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ABSTRACT: This survey, resulting in the collection of over 40,000 adults specimens, was conducted by the authors from 2011 to 2013. The collection records and literature show 33 species and 1 subspecies as occurring or having occurred in Shandong province. A key to all known genera of mosquito in Shandong province is provided.

KEY WORDS: Shandong, mosquitoes, distribution, surveys.

Mosquitoes, comprise a monophyletic taxon (Wood & Borkent, 1989; Miller et al., 1997; Harbach & Kitching, 1998; Harbach, 2007) belonging to family Culicidae, order Diptera. This family is divided into three subfamilies: Toxorhynchitinae, Anophelinae (anophelines) and Culicinae (culicines). Culicidae, includes 3523 extant species classified in 111 genera (including the 80 genera of tribe Aedini recognized in the phylogenetic classification of Reinert et al., 2009), is a large and abundant group that occurs throughout temperate and tropical regions of the world, and well beyond the Arctic Circle. Mosquitoes are most diverse and least known in tropical forest environments. Mosquitoes have a worldwide distribution.

Shandong province is located on the eastern edge of the North China Plain. Shandong borders the Bohai Sea to the north, Hebei province to the northwest, Henan province to the southwest, Jiangsu province and Anhui province to the south, and the Yellow Sea to the east and southeast. The Yellow River passes through Shandong's western areas, entering the sea along Shandong's northern coast; in its traversal of Shandong it flows on a levee, higher than the surrounding land, and dividing western Shandong into the Hai He watershed in the north and the Huai He watershed in the south. The Grand Canal of China enters Shandong from the northwest and leaves on the southwest. Weishan Lake is the largest lake of the province.

Shandong province was one of the areas in China with the highest prevalence of malaria, but its incidence rate has declined yearly since the 1990s. However, with increased trade and travel, incidences of imported cases of malaria also have increased. Cases of malaria were reported between 1989 and 2008 from several areas in Shandong province, such as Heze and Jining in the western area of the province and Rizhao on the coast of Yellow Sea (Gui et al., 2008; Wang & Zhao, 2009).

Although various authors (Zheng et al., 1990; Jing et al., 2007; Yang et al., 2007; Dai et al., 2011) have reported mosquito collection records as a result of surveys of public health malaria inspections and localized surveys, there has been no previous systematic statewide study of mosquitoes in Shandong. The distribution records in this paper are based on the published records of authors cited in the references and our surveys in 17 cities in Shandong province (see fig. 1) from 2011-2013. The surveys were conducted during June to October each year, when mosquitoes are most abundant and diverse in Shandong.

Adults specimens were collected using CDC (Centers for Disease Control) miniature light traps, with carbon dioxide from dry ice as an attractant. The traps were placed in trees approx or near pools, 1.5 m above the ground surface. The traps were operated from 5:00 pm until to 7:00 am. Collected specimens were anaesthetized with carbon dioxide, dispensed into plastic ampoules, and killed by freezing on dry ice. Date were grouped and organized according to locality.

Key to the genera of mosquitoes of Shandong province: adults

1. Scutellum evenly rounded with setae evenly distributed along border; maxillary palpus of females with 5 palpomeres and about as long as proboscis (in males, somewhat clubbed, at apex); abdominal sterna (and usually also terga) wholly or largely devoid of scales (subfamily Anophelinae)-----*Anopheles*
- Scutellum trilobed with setae in 3 distinct groups; maxillary palpus of females with fewer than 5 palpomeres and distinctly shorter than proboscis (usually male palpus longer than proboscis and generally not clubbed at apex); abdominal sterna and terga covered with scales; vein Rs without basal spur (subfamily Culicinae)-----2
2. Prespiracular setae present; wing with setae present ventrally at base of subcosta (Sc) [paratergite with scales]-----*Culiseta*
- Prespiracular setae absent; wing without setae ventrally at base of Sc-----3
3. Fore- and midtarsomere I longer than tarsomeres 2-5 combined, and tarsomere 4 shorter than 5; scutum with delicate white lines-----*Orthopodomyia*
- Fore- and midtarsomere I shorter than tarsomeres 2-5 combined, and tarsomere 4 longer than 5; scutum with another scale pattern-----4
4. Postspiracular setae present-----5
- Postspiracular setae absent-----7
5. Dorsal surface of wing with broad, asymmetrical dark and pale scales intermixed -----*Mansonia*
- Dorsal surface of wing with narrow scales, if broad, then not asymmetrical----- 6
6. Proboscis rather stout, laterally compressed and curved downwards; occiput with broad decumbent scales-----*Armigeres*
- Proboscis more slender, not laterally compressed or notably curved; occiput with at least some decumbent scales narrow (except in subgenus *Stegomyia*)----- (in part) *Aedes*
7. Postspiracular area covered with broad pale scales; female palpus less than 0.4 length of proboscis----- (in part) *Aedes*
- Postspiracular area without scales-----8
8. Pulvilli conspicuous; ungues (claws) of hindleg small and inconspicuous; hindtarsomere 1 as long as or longer than hindtibia; scales of wing usually narrow-----*Culex*
- Pulvilli inconspicuous; ungues of hindleg large and conspicuous; hindtarsomere 1 distinctly shorter than hindtibia; scales of wing usually broad [upper and lower mesepimeral setae present; upper proepisternal setae present; femora, tibia, and abdominal terga covered by broad scales; proboscis largely pale-scaled]-----*Coquillettia*

The species list of mosquitoes of Shandong province as follows:

Subfamily Anophelinae

Genus *Anopheles* Meigen, 1818

Anopheles (Anopheles) lindesayi Giles, 1900

Distribution. Shandong (Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Yantai, Weihai, Qingdao).

***Anopheles (Anopheles) sinensis* Wiedemann, 1828**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Anopheles (Cellia) pattoni* Christophers, 1926**

Distribution. Shandong (Jinan, Linyi, Rizhao, Tai'an, Laiwu, Qingdao).

Subfamily Culicinae**Tribe Aedini****Genus *Aedes* Meigen, 1818*****Aedes (Aedimorphus) vexans* (Meigen, 1830)**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Aedes (Finlaya) koreicus* (Edwards, 1917)**

Distribution. Shandong (Linyi, Rizhao, Tai'an, Laiwu, Yantai, Weihai, Qingdao).

***Aedes (Finlaya) seoulensis* Yamada, 1921**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Tai'an, Laiwu, Zibo, Weifang, Yantai, Weihai, Qingdao).

***Aedes (Finlaya) togoi* (Theobald, 1907)**

Distribution. Shandong (Rizhao, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Aedes (Stegomyia) albopictus* (Skuse, 1894)**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Aedes (Stegomyia) chemulpoensis* Yamada, 1921**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Dongying, Yantai, Weihai, Qingdao).

***Aedes (Ochlerotatus) dorsalis* (Meigen, 1830)**

Distribution. Shandong (Jinan, Jining, Tai'an, Laiwu, Zibo).

Genus *Armigeres* Theobald, 1901***Armigeres (Armigeres) subalbatus* (Coquillett, 1898)**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

Tribe Culicini**Genus *Culex* Linnaeus, 1758*****Culex (Culex) bitaeniorhynchus* Giles, 1901**

Distribution. Shandong (Jinan, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) sitiens* Wiedemann, 1828**

Distribution. Shandong (Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) fuscocephala* Theobald, 1907**

Distribution. Shandong (Zaozhuang, Jining, Linyi, Rizhao, Yantai, Weihai, Qingdao).

***Culex (Culex) tritaeniorhynchus* Giles, 1901**

Distribution. Shandong (Jinan, Dezhou, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) jacksoni* Edwards, 1934**

Distribution. Shandong (Jinan, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) mimeticus* Noe, 1899**

Distribution. Shandong (Rizhao, Tai'an, Laiwu, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) mimulus* Edwards, 1915**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Linyi, Tai'an, Laiwu).

***Culex (Culex) pipiens pallens* Coquillett, 1898**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) pseudovishnui* Colless, 1957**

Distribution. Shandong (Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Weifang, Binzhou, Weihai, Qingdao).

***Culex (Culex) sinensis* Theobald, 1903**

Distribution. Shandong (Jinan, Dezhou, Liaocheng, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) theileri* Theobald, 1903**

Distribution. Shandong (Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) tritaeniorhynchus* Giles, 1901**

Distribution. Shandong (Jinan, Liaocheng, Jining, Linyi, Rizhao, Tai'an, Laiwu, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) vagans* Wiedemann, 1828**

Distribution. Shandong (Jining, Linyi, Rizhao, Tai'an, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

***Culex (Culex) whitmorei* (Giles, 1904)**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Rizhao, Tai'an, Weifang, Binzhou, Dongying, Weihai, Qingdao).

***Culex (Culicomyia) pallidothorax* Theobald, 1905**

Distribution. Shandong (Zaozhuang, Jining, Linyi, Rizhao, Qingdao).

***Culex (Eumelanomyia) hayashii* Yamada, 1917**

Distribution. Shandong (Jinan, Jining, Linyi, Rizhao, Tai'an, Laiwu).

***Culex (Eumelanomyia) malayi* (Leicester, 1908)**

Distribution. Shandong (Zaozhuang, Jining, Linyi, Rizhao, Qingdao).

***Culex (Lutzia) fuscans* Wiedemann, 1820**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Weifang, Qingdao).

***Culex (Lutzia) halifaxia* Theobald, 1903**

Distribution. Shandong (Jinan, Heze, Zaozhuang, Jining, Linyi, Rizhao, Tai'an, Laiwu, Zibo, Weifang, Binzhou, Dongying, Yantai, Weihai, Qingdao).

Tribe Culisetini**Genus *Culiseta* Felt, 1904*****Culiseta (Culiseta) niveitaeniata* (Theobald, 1907)**

Distribution. Shandong (Jinan, Jining, Tai'an).

Tribe Mansoniini**Genus *Coquillettidia* Dyar, 1905*****Coquillettidia (Coquillettidia) ochracea* (Theobald, 1903)**

Distribution. Shandong (Jinan, Zaozhuang, Jining, Tai'an, Laiwu).

Genus *Mansonia* Blanchard, 1901***Mansonia (Mansonioides) uniformis* (Theobald, 1901)**

Distribution. Shandong (Jinan, Jining, Tai'an).

Tribe Orthopodomyiini**Genus *Orthopodomyia* Theobald*****Orthopodomyia (Orthopodomyia) anopheloides* (Giles, 1903)**

Distribution. Shandong (Heze, Zaozhuang, Jining, Linyi, Tai'an, Laiwu, Zibo).

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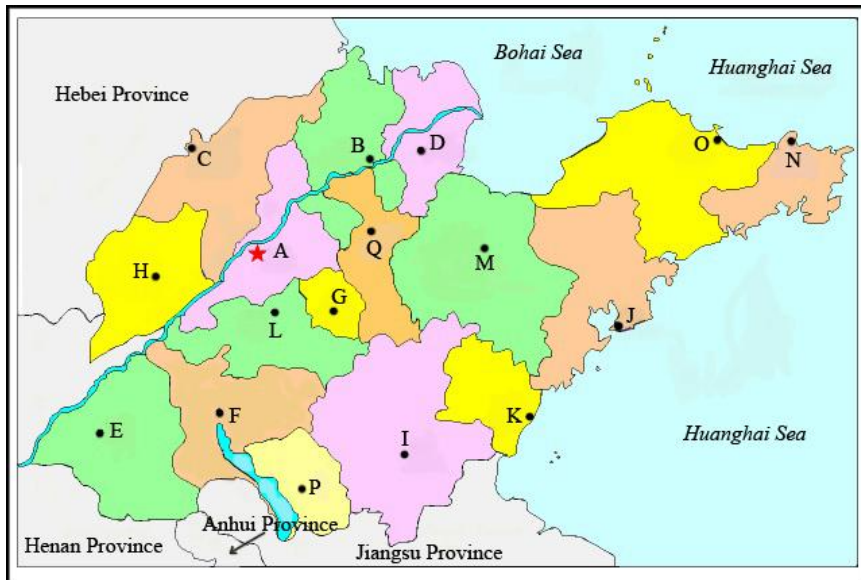


Figure 1. Cities of Shandong province. A. Jinan, B. Binzhou, C. Dezhou, D. Dongying, E. Heze, F. Jining, G. Laiwu, H. Liaocheng, I. Linyi, J. Qingdao, K. Rizhao, L. Taian, M. Weifang, N. Weihai, O. Yantai, P. Zaozhuang, Q. Zibo.