

SCIENTIFIC NOTE

A CHECKLIST OF THE 67 MOSQUITO SPECIES OF ONTARIO, CANADA

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ABSTRACT. We provide an updated checklist of 67 endemic mosquito species known from Ontario, Canada. Nine endemic species are added to the checklist found in Darsie and Ward (2005): *Aedes cantator*, *Ae. churchillensis*, *Ae. nigripes*, *Ae. pullatus*, *Anopheles perplexens*, *An. crucians*, *An. smaragdinus*, *Culex erraticus*, and *Cx. salinarius*. Only 4 specimens of *Ae. albopictus* have been recorded in Ontario since 2001 despite concerted efforts to find this species; therefore, it is considered an “accidental” species and is excluded from the checklist.

KEY WORDS Ontario, mosquito surveillance, new record, distribution

Over the past 15 years, the province of Ontario has seen an increase in the amount of mosquito surveillance that has been conducted by health units, First Nations, municipal governments, university researchers, pest control companies, and environmental consulting companies. Much of the work has been related to mosquito surveillance for West Nile virus and eastern equine encephalitis virus using CO₂-baited Centers for Disease Control and Prevention (CDC) miniature light traps, although mosquito surveillance purely for systematics and ecological research has also been done. Common keys being used for identification in Ontario are Wood et al. (1979), Darsie and Ward (2005), and Thielman and Hunter (2007). However, none of these keys contains an up-to-date species checklist for Ontario.

Historically, information on the mosquito fauna of Ontario was found in Hearle (1920), Dyar (1921), Carpenter and LaCasse (1955), Steward and McWade (1961), Carpenter (1968), and Wood et al. (1979). Wood et al. (1979) documented 57 species in Ontario. Twenty-six years later, Darsie and Ward (2005) revised the species count to 58 with the addition of the invasive species *Aedes japonicus japonicus* (Theobald). *Aedes j. japonicus* was first discovered in 2001 in the Niagara Region of Ontario (Thielman and Hunter 2006), but it is now abundant throughout much of the province (Entomogen 2014, PHO 2014). Thielman and Hunter (2007) presented a pictorial key to the mosquitoes of

Canada, but it might not be clear to users which species, in addition to those listed in Darsie and Ward (2005), are found in Ontario. We aim to rectify this with this publication. In addition, we have found records for other species in the published literature and in the collection databases from Entomogen Inc. and Brock University. Here we provide an updated checklist of the mosquito species found in Ontario (Table 1), bringing the tally to 67 endemic species.

Aedes cantator (Coquillett) is collected regularly throughout Ontario, generally in low numbers (Entomogen 2014); species identity has been verified using DNA bar coding (Cywinska et al. 2006). *Aedes churchillensis* Ellis and Brust is known to inhabit northeastern and southeastern Manitoba (Wood et al. 1979). As such, it is no surprise that this species has also been detected in the Northwestern Health Unit in Ontario (9 specimens in 2003–04).

Beresford (2011) collected insects from Polar Bear Provincial Park in northern Ontario and established a new record for *Ae. nigripes* (Zetterstedt). Ringrose et al. (2013) collected mosquitoes in 2 different northern Ontario ecozones as part of a larger biodiversity study. Mosquitoes were collected in either an ad hoc manner (as mosquitoes alighted on the researchers) or by sweep-netting at dusk and dawn. They also collected *Ae. nigripes* from the northwestern Ontario Shield ecozone. Taken together, these records extend the known range of *Ae. nigripes* southward from the Arctic into northern Ontario.

Aedes pullatus (Coquillett) has long been known from 2 distinct populations—Labrador and northern Quebec in the east and Yukon, British Columbia, and Alberta in the west (Wood et al. 1979). Although Ringrose et al. (2013) only collected a single specimen of this species, they argue convincingly that this is not an unexpected member of the northern Ontario mosquito fauna. Thus, we add it to the checklist of species for Ontario.

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Table 1. Checklist of 67 mosquito species endemic to Ontario, Canada. Species added to the checklist found in Darsie and Ward (2005) are marked with an asterisk (*). *Aedes albopictus* is excluded from the checklist, as it is considered an "accidental" species.

Genus	Species
<i>Aedes</i>	<i>abserratus</i>
	<i>atropalpus</i>
	<i>aurifer</i>
	<i>campestris</i>
	<i>canadensis</i>
	<i>cantator*</i>
	<i>churchillensis*</i>
	<i>cinereus</i>
	<i>communis</i>
	<i>decticus</i>
	<i>diantaeus</i>
	<i>dorsalis</i>
	<i>euedes</i>
	<i>excrucians</i>
	<i>fitchii</i>
	<i>flavescens</i>
	<i>grossbecki</i>
	<i>hendersoni</i>
	<i>hexodontus</i>
	<i>impiger</i>
	<i>implicatus</i>
	<i>intrudens</i>
	<i>japonicus</i>
	<i>mercurator</i>
	<i>nigripes*</i>
	<i>pionips</i>
	<i>provocans</i>
	<i>pullatus*</i>
	<i>punctor</i>
	<i>rempeli</i>
	<i>riparius</i>
	<i>sollicitans</i>
	<i>spencerii</i>
	<i>sticticus</i>
	<i>stimulans</i>
	<i>thibaulti</i>
	<i>triseriatus</i>
	<i>trivittatus</i>
	<i>vexans</i> ¹
<i>Anopheles</i>	<i>barberi</i>
	<i>crucians*</i>
	<i>earlei</i>
	<i>perplexens*</i>
	<i>punctipennis</i>
	<i>quadrifasciatus</i> ² s.s.
<i>Coquillettidia</i>	<i>smaragdinus*</i>
	<i>walkeri</i>
	<i>perturbans</i>
<i>Culex</i>	<i>erraticus*</i>
	<i>pipiens</i> ³
	<i>restuans</i>
<i>Culiseta</i>	<i>salinarius*</i>
	<i>tarsalis</i>
	<i>territans</i>
	<i>impatiens</i>
	<i>inornata</i>
	<i>melanura</i>
<i>Orthopodomyia</i>	<i>minnesotae</i>
	<i>morsitans</i>
	<i>alba</i>

Table 1. Continued.

Genus	Species
<i>Psorophora</i>	<i>signifera</i>
	<i>ciliata</i>
	<i>columbiae</i>
	<i>ferox</i>
<i>Toxorhynchites</i>	<i>rutilus septentrionalis</i>
<i>Uranotaenia</i>	<i>sapphirina</i>
<i>Wyeomyia</i>	<i>smithii</i>

¹ Likely includes *Ae. vexans nipponi* (Thielman and Hunter 2007).

² A few specimens consistent morphologically with *An. diluvialis* and *An. inundatus* were collected by Thielman (2011); however, after due consideration of the known distributions of these species, they were assumed to be morphological variants of *An. quadrifasciatus* s.s.

³ No evidence for *Cx. pipiens molestus* despite efforts to find this species in hibernacula.

On the basis of only a few specimens, *Anopheles perplexens* Ludlow and *An. crucians* Wiedemann were included in Thielman and Hunter (2007) as species that were potentially endemic to Ontario. Thielman (2011) then completed an ecological and taxonomic revision of the *Anopheles* species of Canada and supported the endemic designation for *An. perplexens* by documenting a total of 42 specimens from multiple sites within southern Ontario.

Previously, *An. crucians* was only known from 1 adult specimen collected in 2002 from Point Pelee Provincial Park and another in 2003 from the Toronto Zoo (Thielman and Hunter 2007). However, we have now identified this species from light-trap collections from Windsor-Essex County in 2004 ($n = 7$), Simcoe County in 2005 ($n = 1$), Elgin County in 2007 ($n = 1$), and Chatham-Kent in 2013 ($n = 6$). Due to these multiyear and multisite collections, we now consider *An. crucians* to be an established, albeit rare, endemic species in Ontario.

Thielman (2011) also examined members of the *An. quadrifasciatus* (Say) species complex using the morphological traits described by Reinert et al. (1997) and the keys of Darsie and Ward (2005); she identified 70 specimens of *An. smaragdinus* Reinert. *Anopheles smaragdinus* has a known distribution extending almost as far north as *An. quadrifasciatus* s.s. (Levine et al. 2004); its inclusion in the checklist of Ontario's endemic mosquitoes merely extends its known range.

Culex salinarius Coquillett has been collected repeatedly in CDC light traps since 2001 (Entomogen 2014, Thielman and Hunter 2007). Each year, dozens of *Cx. salinarius* specimens are collected in the southern part of the province. *Culex erraticus* (Dyar and Knab), first detected in 2002 from Windsor-Essex County and Durham Region, is now found extensively across much of southern Ontario. During routine province-wide mosquito surveillance using light traps, 34 specimens were collected from 2002 to 2011. The low

numbers raised the possibility that these were "accidental" collections, with specimens originating from Michigan and/or New York State; however, in 2012 and 2013, 379 specimens were collected (F. F. Hunter, unpublished data). These specimens were found outside the species' estimated flight ranges from the Michigan and New York borders.

In total, 4 specimens of *Aedes albopictus* (Skuse) have been collected since 2001. Two specimens were collected in Niagara in 2001 (Thielman and Hunter 2007), one in 2005, and another in 2012 (PHO 2014). *Aedes albopictus*' northernmost boundary in the northeastern USA is New Jersey and southern New York (Farajollahi and Crans 2012, Rochlin et al. 2013); coupled with the lack of multiyear and multisite collection data, *Ae. albopictus* is considered to be "accidental" species in Ontario.

REFERENCES CITED

- Beresford D. 2011. Insect collections from Polar Bear Provincial Park, Ontario, with new records. *J Entomol Soc Ont* 142:19–27.
- Carpenter SJ. 1968. Review of recent literature on mosquitoes of North America. *Calif Vector Views* 15:71–98.
- Carpenter SJ, LaCasse WJ. 1955. *Mosquitoes of North America (north of Mexico)*. Berkeley and Los Angeles, CA: Univ. Calif. Press.
- Cywinska A, Hunter FF, Herbert PDN. 2006. Identifying Canadian mosquito species through DNA barcodes. *Med Vet Entomol* 20:413–424.
- Darsie RF, Ward RA. 2005. *Identification and geographical distribution of the mosquitoes of North America, north of Mexico*. Gainesville, FL: Univ. Press of Florida.
- Dyar HG. 1921. The mosquitoes of Canada. *Trans R Can Inst* 13:71–120.
- Entomogen. 2014. Gasparotto A, Hunter FF (Entomogen Inc.). 2014. WNV-Mosquito Surveillance Unit Database [Internet]. Available from Entomogen Inc., Ontario, Canada [accessed Sept 7, 2014]. <https://secure.entomogen.ca/wnv/>.
- Farajollahi A, Crans SC. 2012. A checklist of the mosquitoes of New Jersey with notes on established invasive species. *J Am Mosq Control Assoc* 28:237–239.
- Hearle E. 1920. Notes on some mosquitoes new to Canada. *Can Entomol* 52:114–116.
- Levine RS, Peterson AT, Benedict MQ. 2004. Distribution of members of *Anopheles quadrimaculatus* Say s.l. (Diptera: Culicidae) and implications for their roles in malaria transmission in the United States. *J Med Entomol* 41:607–613.
- PHO [Public Health Ontario]. 2014. *Vector-borne diseases 2013 summary report*. Toronto, Canada: Queen's Printer for Ontario.
- Reinert JF, Kaiser PE, Seawright JA. 1997. Analysis of the *Anopheles (Anopheles) quadrimaculatus* complex of sibling species (Diptera: Culicidae) using morphological, cytological, molecular, genetic, biochemical, and ecological techniques in an integrated approach. *J Am Mosq Control Assoc* 13(Suppl):1–102.
- Ringrose JL, Abraham KF, Beresford DV. 2013. New range records of mosquitoes (Diptera: Culicidae) from northern Ontario. *J Entomol Soc Ont* 144:3–14.
- Rochlin I, Ninivaggi DV, Hutchinson ML, Farajollahi A. 2013. Climate change and range expansion of the Asian Tiger Mosquito (*Aedes albopictus*) in northeastern USA: implications for public health practitioners. *PLoS ONE* 8:e60874.
- Steward CC, McWade JW. 1961. The mosquitoes of Ontario (Diptera: Culicidae) with keys to the species and notes on distribution. *Proc Entomol Soc Ont* 91:121–188.
- Thielman A. 2011. *Cryptic species status of Anopheles (Diptera: Culicidae) mosquitoes in Canada using a multidisciplinary approach* [Ph.D. dissertation]. Brock University: St. Catharines, Canada.
- Thielman A, Hunter F. 2006. Establishment of *Ochlerotatus japonicus* (Diptera: Culicidae) in Ontario, Canada. *J Med Entomol* 43:138–142.
- Thielman A, Hunter F. 2007. A photographic key to adult female mosquito species of Canada (Diptera: Culicidae). *Can J Arthropod Identif* 4:1–117.
- Wood DM, Dang PT, Ellis RA. 1979. *The mosquitoes of Canada (Diptera: Culicidae): the insects and arachnids of Canada, part VI*. Ottawa, Canada: Agriculture Canada.