FURTHER EXTENSION OF THE RANGE OF THE ROCK POOL MOSQUITO, *AEDES ATROPALPUS*, VIA TIRE BREEDING[1]

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ABSTRACT. In the past, *Aedes atropalpus* was limited to those areas of the eastern U.S. and Canada that had rivers or shorelines with large rocks containing rock pools. In the last 10 years, many new records of larval breeding in scrap tires have accumulated. We present records of larval breeding in non-rock pool containers for 54 counties; most are far from the original range. The species has not only found a new habitat but has greatly extended its range via commercial transport of scrap tires.

Aedes (Ochlerotatus) atropalpus (Coquillett), the eastern rock pool mosquito, historically has been restricted to eastern Canada and to areas east of the Mississippi River in the United States. A sibling species, *Ae. (Ochlerotatus) epactius* (Dyar and Knab), is mainly distributed in Mexico and some of the mountain and southwestern states, all west of the Mississippi. Both species are found in areas where the geology is conducive to the formation of rock pools. In the east, this includes the Appalachian Mountains and the Canadian Shield. In the west, typical areas are the Ouachita and Ozark mountains, the Edwards Plateau and the Rocky Mountains.

Rock pools are water-filled depressions found in old rock formations such as granite. They are usually located near water falls, rapids, dams or on rocky lake shores. Due to its specialized larval habitat, *Ae. atropalpus* was previously considered a relatively rare and innocuous species, only troublesome near its larval breeding sites. Now *Ae. atropalpus* is much more common and widespread due to colonization of non-rock pool habitats such as discarded or used tires.

The earliest known record of *Ae. atropalpus* found in a non-rock pool habitat was reported by Shields (1938). Sometime between 1934 and 1936, larvae were collected from an abandoned septic tank near Knoxville, Tennessee, presumably in Knox County. In 1966, North Carolina mosquito workers collected *Ae. atropalpus* from an unspecified canister (N. Newton, unpublished data). Near the beginning of the present decade, mosquito workers began to notice larvae of *Ae. atropalpus* appearing in collections from discarded tires in the eastern United States (Covell and Brownell 1979, Restifo and Lanzaro 1980, White and White 1980). These discoveries prompted others to look for this species in tires.

By the mid-1980s, tire-breeding *Ae. atropalpus* was found in four states (Indiana, Kentucky, New York and Ohio) and 10 counties, six of which were in Ohio (Berry and Craig 1984). More recently, Berry et al. (1988) listed 16 counties in Ohio that had this species breeding in tires. In Connecticut, five out of the eight counties were positive for tire-breeding *Ae. atropalpus* (Andreadis 1988).

The establishment of the Asian tiger mosquito, *Aedes (Stegomyia) albopictus* (Skuse), in North America via imported tires has spurred many local and several national tire surveys for this potential disease vector (Sprenger and Wuithiranyagool 1986). This effort has produced many new records of tire-breeding *Ae. atropalpus* in the United States. As of the end of 1987, *Ae. atropalpus* has been collected from or near tires and other non-rock pool habitats in up to 11 states and 54 counties (Table 1). An unofficial record, Jefferson County in Missouri, was reported by William A. Hawley during the *Ae. albopictus* survey of Kansas City. This record was later confirmed as *Ae. atropalpus* by the Centers for Disease Control (CDC), thus adding to the growing list of non-rock pool *Ae. atropalpus* sites.

The rapid spread of *Ae. atropalpus* in recent years has increased its importance as a possible pest mosquito and potential disease transmitter. *Aedes atropalpus* has become one of the dominant mosquito species in some tire yards (Beier et al. 1983, Andreadis 1988). This species has taken over from *Aedes triseriatus* (Say) as the dominant mosquito species in a large tire yard near Buffalo, NY (J. A. Berlin, personal communication). Also, *Ae. atropalpus* is known as a rapid colonizer of sun-exposed tire piles (Berry and Craig 1984). Unlike *Ae. triseriatus, Ae. atropalpus* females are autogenous in their first ovarian cycle (O'Meara and Krasnick 1970). Eggs of *Ae. atropalpus* are laid on the water surface during the summer, and thus do not need to wait to be flooded in order to hatch. Eggs laid during the shorter photoperiods of autumn are

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Table 1. Non-rock pool collections of *Aedes atropalpus* in the United States.*

State/County	Container	Year	Reference/Source
Connecticut			
Fairfield Co.	Tire	1987	Andreadis 1988
Middlesex Co.	Tire	1987	Andreadis 1988
New Haven Co.	Tire	1987	Andreadis 1988
New London Co.	Tire	1987	Andreadis 1988
Tolland Co.	Tire	1987	Andreadis 1988
Illinois			
Cook Co.	Tire	1987	B. R. Farmer, pers. comm.
Saint Clair Co.	Tire	1987	L. Haramis, pers. comm.
Indiana			
Dubois Co.	Tire	1987	Dunn 1987
Harrison Co.	Tire	1987	Dunn 1987
Knox Co.	Tire	1986	V. E. Dunn, pers. comm.
Knox Co.	Tire	1987	Dunn 1987
Kosciusko Co.	Tire	1987	E. M. McDonald, pers. comm.
Lake Co.	Tire	1987	Dunn 1987
Marion Co.	Tire	1983	M. Sinsko, pers. comm.
Marion Co.	Tire	1987	B. E. Foster, pers. comm.
Morgan Co.	Tire	1987	B. E. Foster, pers. comm.
Saint Joseph Co.	Tire	1979	Restifo and Lanzaro 1980
Saint Joseph Co.	Tire	1982	Beier et al. 1983
Saint Joseph Co.	Tire	1985–87	S. J. Nawrocki
Vanderburgh Co.	Tire	1987	S. J. Nawrocki
Warrick Co.	Tire	1986	V. E. Dunn, pers. comm.
Warrick Co.	Tire	1987	Dunn 1987
Kentucky			
Jefferson Co.	Tire	1979	Covell and Brownell 1979
Michigan			
Allegan Co.	Tire	1988	N.E. Pennington, pers. comm.
Clare Co.	Tire	1988	N.E. Pennington, pers. comm.
Livingston Co.	Tire	1988	N.E. Pennington, pers. comm.
Kalamazoo Co.	Tire	1987	N. E. Pennington, pers. comm.
Kent Co.	Tire	1987	N. E. Pennington, pers. comm.
Muskegon Co.	Tire	1987	N. E. Pennington, pers. comm.
Muskegon Co.	Tire	1988	N.E. Pennington, pers. comm.
Saint Joseph Co.	Tire	1987	S. J. Nawrocki
Saint Joseph Co.	Tire	1988	N.E. Pennington, pers. comm.
Wayne Co.	Tire	1987	N. E. Pennington, pers. comm.
Wayne Co.	Tire	1988	N.E. Pennington, pers. comm.
Missouri			
Jefferson Co.	Tire	1987	Centers for Disease Control, unpubl. data
New Jersey			
Warren Co.	Tire	1987	Crans 1987
New York			
Chautauqua Co.	Tire	1983	J. A. Berlin, pers. comm.
Suffolk Co.	Tire	1980	White and White 1980

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State/County	Container	Year	Reference/Source
North Carolina			
Guilford Co.	Tire	1987	C. S. Apperson, unpubl. data
Jackson Co.	Tire	1987	C. S. Apperson, unpubl. data
Rockingham Co.	Tire	1987	C. S. Apperson, unpubl. data
Stokes Co.	Tire	1987	C. S. Apperson, unpubl. data
Surry Co.	Tire	1987	C. S. Apperson, unpubl. data
Swain Co.	Canister	1966	N. Newton, unpubl. data
Ohio			
Crawford Co.	Tire	1987	Berry et al. 1988
Cuyahoga Co.	Tire, plastic pan, broken light fixture, auto wheel well.	1987	Berry et al. 1988
Darke Co.	Tire	1979	Restifo and Lanzaro 1980
Darke Co.	Tire	1985/86	S. J. Nawrocki
Darke Co.	Tire, bird bath, cups and jars	1987	Berry et al. 1988
Hancock Co.	Tire	1982	R. A. Restifo, pers. comm.
Hancock Co.	Tire	1987	Berry et al. 1988
Huron Co.	Tire	1977	Restifo and Lanzaro 1980
Jackson Co.	Tire, metal bucket, farm implement.	1986/87	Berry et al. 1988
Lawrence Co.	Tire	1987	Berry et al. 1988
Lorain Co.	Tire	1987	Berry et al. 1988
Mahoning Co.	Tire	1987	Berry et al. 1988
Marion Co.	Tire	1987	Berry et al. 1988
Sandusky Co.	Tire	1979	R. A. Restifo, pers. comm.
Stark Co.	Tire	1981	R. A. Restifo, pers. comm.
Stark Co.	Tire	1986	Berry et al. 1988
Summit Co.	Tire	1972/75-77/79	Restifo and Lanzaro 1980
Summit Co.	Tire	1986	Berry et al. 1988
Trumbull Co.	Tire	1987	Berry et al. 1988
Tuscarawas Co.	Tire	1987	Berry et al. 1988
Wyandot Co.	Tire	1987	Berry et al. 1988
Tennessee			
Knox Co.	Abandoned septic tank.	1934-36	Shields 1938

* Collections consisted of one or more of the following: adults, pupae, larvae and/or eggs from ovitraps placed near tires.

placed above the water line (G. B. Craig, Jr., unpublished data). The characteristics of autogeny and oviposition on water allow for rapid exploitation of available habitats by this species. *Aedes atropalpus* is a good vector of La Crosse virus in the laboratory (Freier and Beier 1984). Although all strains of *Ae. atropalpus* are autogenous, there is increasing evidence that females from tire yards will feed more readily than rock pool strain females (Restifo and Lanzaro 1980, Andreadis 1988; S. J. Nawrocki, unpublished data).

Restifo and Lanzaro (1980) discussed the possibility that specimens collected from the tires were not *Ae. atropalpus* but *Ae. epactius*. Separation of these sibling species is based on relatively minor morphological differences. Both larvae and adults show useful characters (Darsie and Ward 1981). In the larvae of *Ae. atropalpus*, seta 1-M is longer and there are more comb scales (>35) relative to *Ae. epactius*. In *Ae. atropalpus* females, the posterior setae on the scutal fossa are lacking, the interocular space is wider and there are many more pale scales (0.3–0.5 of length) on the hindfemur than in *Ae. epactius*. The biological differences between these species are: 1) in nature, *Ae. atropalpus* dwells only in rock pools, but *Ae. epactius* may occasionally be found in other natural breeding sites such as ground pools and tree holes; 2) in rock pools, *Ae. atropalpus* is rarely found with other mosquito species, whereas *Ae. epactius* may be associated with species such as *Culex tarsalis, Cx. restuans* and *Psorophora confinnis* (Hedeen 1953); 3) *Ae. epactius* is more commonly found in artificial containers than is *Ae. atropalpus;* and 4) *Ae. atropalpus* is autogenous, whereas *Ae. epactius* is anautogenous (O'Meara and Kras-

nick 1970). The specimens collected from the non-rock pool habitats so far have been identified as *Ae. atropalpus.*

Figure 1 shows the distribution of counties positive for non-rock pool records of *Ae. atropalpus.* Most of these counties lie outside the distribution of the rock pool-breeding *Ae. atropalpus.* These extralimital counties represent a large western extension in the range of *Ae. atropalpus*, approaching the northeastern limits of *Ae. epactius.* The close proximity of the Jefferson County (Kansas City, MO) and the Saint Clair County (East St. Louis, IL) sites to the northeastern range of *Ae. epactius* brings up the possibility of overlap in the near future of these allopatric sibling species.

The only California record of *Ae. epactius* is a single adult female collected in the Sierran foothills of eastern Sacramento County in 1969 (Bohart and Washino 1978). Although it may be tempting to attribute this record to mosquitoes brought to this area by tire traffic, a rock pool source is quite possible. Bohart and Washino (1978) state that rock pools next to streams may be found in many areas of the lower Sierra.

Berry et al. (1988) attribute all the Ohio records of *Ae. atropalpus* to tire business sites and to the movement of tires between these sites. Since *Ae. albopictus* is also distributed by the tire trade, these workers used the presence of *Ae. atropalpus* as an indicator for the likely occurrence of *Ae. albopictus* at any given tire site. If one is selecting a list of sites to survey for *Ae. albopictus*, then priority should be given to sites where nonindigenous populations of *Ae. atropalpus* have been found. Indeed, *Ae. atropalpus* may be both an indicator of tire movement and a harbinger of *Ae. albopictus.*

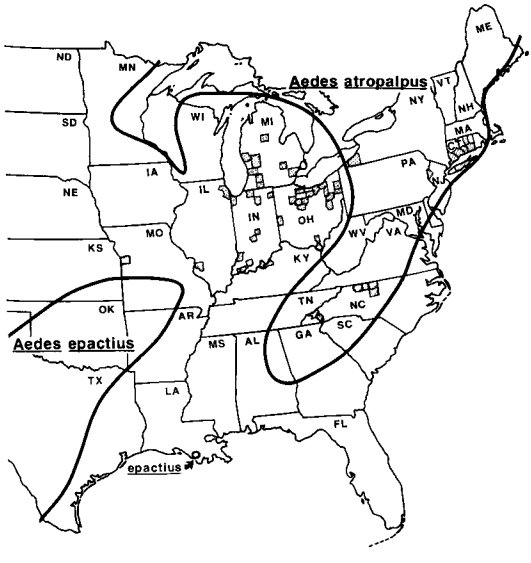

Fig. 1. Map of the eastern United States showing the distribution of counties positive for non-rock pool records of *Aedes atropalpus* (shaded areas). Included are the distributional limits of rock pool *Ae. atropalpus* and *Ae. epactius* (adapted from: Anonymous 1951, Darsie and Ward 1981 and Zavortink 1972).

Almost all the non-rock pool records of *Ae. atropalpus* have come from tires. Only 5 of the 54 counties in Table 1 indicate collections made from containers other than tires. These non-tire containers range from plastic cups, jars and pans to a bird bath, a metal bucket and an unidentified farm implement. Most of these containers are known to be in close proximity to tires holding *Ae. atropalpus* larvae. The non-tire containers in Cuyahoga, Darke and Jackson Counties were estimated to be no more than 25–35 meters from the nearest tire pile (Ellen D. Peterson, personal communication). Such information was not available for Swain County, NC, or Knox County, TN.

The expansion of *Ae. atropalpus* into non-tire containers may be due to large numbers of this species in the tire habitat. In tire sites where populations are high, some *Ae. atropalpus* females may oviposit in anything that holds water, not just tires. This brings up the possibility of even greater dispersal and a wider distribution of *Ae. atropalpus* than that due to tires alone. Whether this expansion into non-tire containers will continue in the future should be investigated.

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