

NORTH CAROLINA MOSQUITO RECORDS. I. UNCOMMON *Aedes* AND *Anopheles* (DIPTERA: CULICIDAE)

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ABSTRACT. New distribution records are provided for 10 mosquito species that are rare or uncommon in North Carolina: *Aedes aegypti*, *Ae. cinereus*, *Ae. dupreei*, *Ae. fulvus pallens*, *Ae. hendersoni*, *Ae. mitchellae*, *Ae. thibaulti*, *Ae. tormentor*, *Ae. trivittatus*, and *Anopheles atropos*. Biological notes are provided for habitats, behavior, and, in some cases, color patterns. Comments are also made about 6 additional species that are rare or uncommon in North Carolina.

KEY WORDS Rare, *Aedes*, *Anopheles*, uncommon, North Carolina

INTRODUCTION

Publications documenting the distributions of mosquito species in North Carolina are scarce. This state has some of the most variable ecosystems in the United States, ranging from subtropical in the southeastern corner to boreal on the highest western mountains. Despite this recognized diversity, virtually no efforts have been made to systematically examine the mosquito fauna of the state. The first comprehensive listing for North Carolina mosquitoes included 21 species (Dyar 1922). Brimley (1938) listed 32 species in his general insect survey for the state. Later editions of this work (Wray 1950, 1967) reported records published elsewhere. A large number of the initial records for species in the state and accompanying information on their distributions resulted from U.S. Army mosquito surveys conducted on and around military installations during World War II (King et al. 1942, 1943; Bradley et al. 1944; Middlekauff and Carpenter 1944; Carpenter et al. 1945; Carpenter and Chamberlain 1946; Miles and Rings 1946). Schoof and Ashton (1944), working as state entomologists, also contributed a number of precise distribution records. Since these early works nearly all published efforts involving mosquitoes have been narrowly focused biological studies or studies dealing with control issues. Also, nearly all of the mosquito publications since World War II have addressed coastal plain or piedmont mosquitoes. Although Slaff and Apperson (1989) provided a list of 57 species for the state, no distribution data were published for the species occurring in the western half of the state. Based on known and examined material, including the U.S. National Museum (USNM) (Smithsonian) collections, we have been able to document only 55 species, including *Anopheles*

smaragdinus Reinert [Robertson et al. 1993, as *Anopheles quadrimaculatus* B; Reinert et al. 1998 (1997)] in North Carolina.

A study of the mosquitoes of the western piedmont and mountainous regions of North Carolina was initiated in 1994 by the Public Health Pest Management Section, North Carolina Department of Environment and Natural Resources. The limited information about the mosquitoes of this area and a growing concern about mosquito-borne diseases were the primary reasons for starting the study. The western part of the state is developing rapidly with a large influx of permanent and temporary residents. Human disturbances of the environment in this area will increase mosquito populations, human-mosquito contacts, and the potential for exposure to mosquito-borne human pathogens. Arboviruses have been isolated in other states from several of the included species. Because some of those species can be locally common, it is important to determine their distributions in North Carolina. During the past 4 years numerous mosquito collections were made in the western half of the state. Records for these collections, plus some from more eastern areas, are presented below. Additional unpublished records from collections made before this study was initiated are also included.

MATERIALS AND METHODS

Mosquito collections were made in urban, suburban, and rural areas. Sites exhibiting a large species diversity were targeted for repeated collections. These included state, county, and local parks, and ecological and environmental preserves. The collection methods were: standard larval dipping, human landing-biting, back-pack and mouth aspirators, New Jersey light traps, and Centers for Disease Control (CDC) light traps supplemented with CO₂ (dry ice). After collection, immatures were transported in 6-oz. plastic bags to the laboratory and set up for rearing or were killed in tepid water and preserved for identification. Adults collected biting, by aspiration, or in the CDC light traps were frozen in an ice chest with dry ice and transported back to the laboratory for identification.

Immature and adult specimens were identified

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using Carpenter and LaCasse (1955), King et al. (1960), Darsie and Ward (1981), and Sloff and Apperson (1989). Once identified, immatures were preserved in 75% ethanol in labeled vials, and adults were glued with ambroid cement to paper points on insect pins and labeled.

Preserved immatures and adults are deposited in the Public Health Pest Management Collection, North Carolina Department of Environment and Natural Resources, Winston-Salem, or the Department of Entomology Insect Collection, North Carolina State University, Raleigh.

The terms rare, uncommon, and common were defined on a numerical basis in our study: rare = 1 or fewer collections per year, uncommon = 2–10 collections per year, and common = more than 10 collections per year. The records and specimens reported here are grouped by counties and dates and have been abbreviated and condensed to conserve space. The sequence for the records follows: county, with a regional indication for coastal plain (C), piedmont (P), or mountains (M); number of collections; month(s) and year(s) of collections; and specimens by sex and stage. Complete records for these specimens, including locality, exact dates, habitat, collection method, collectors, and associated species, are available upon request. Emergency mosquito collections after Hurricane Fran in 1996 targeted the most common species. The less common species were recorded, but numbers were not kept. The sexes and stages are coded as follow: female = ♀, male = ♂, whole pupa = P, whole larva = L, and larval skin = 1. Generic abbreviations used in the text follow Reinert (1975).

RESULTS AND DISCUSSION

Sixteen species are included in this paper. Ten species are discussed in detail, and 6 are discussed briefly at the end. Thirteen of these were reported as rare or uncommon in North Carolina (Sloff and Apperson 1989) and 10 of the 13 have distributions that extend into the piedmont region and some even into the mountains. Most have spotty distributions and are uncommon, but at certain times they can be very abundant locally. New records for 5 species match or extend their western distributions in the state (Darsie and Ward 1981).

Aedes aegypti (Linnaeus)

Alamance (P): (2 coll.), VIII, IX, 1991, 1993, 8♀, 3P, 44L. Brunswick (C): (8 coll.), V–XII, 1994, 153♀♂; (7 coll.), VI–XII, 1995, 206♀♂; (2 coll.), VII, VIII, 1996, 38♀♂; (2 coll.), IX, X, 1997, 3♀♂. Cabarrus (P): (1 coll.), 1992, 1♀. Carteret (C): (1 coll.), V, 1994, 1♀. Catawba (P): (1 coll.), IX, 1989, 7♀. Iredell (P): (1 coll.), IX, 1992, 3♀. Jackson (M): (1 coll.), IX, 1987, 1P, 17L. Randolph (P): (1 coll.), VIII, 1993, 10♀, 1♂, 9P, 121L. Row-

an (P): (1 coll.), IX, 1989, 9♀, 12♂, 9L. Wake (P): (1 coll.), IX, 1975, 7♀, 1♂.

The first published records of *Ae. aegypti* in North Carolina were from Mecklenburg and New Hanover counties (Brimley 1938). King et al. (1942) listed this species in North Carolina, but without locality data. Carpenter and Chamberlain (1946) listed specimens collected in Cumberland, New Hanover, and Scotland counties. Subsequently, and to the present, many counties in the state have been reported to have *Ae. aegypti*. This is particularly true in the coastal plain counties. In fact, this species is apparently able to survive the winters in Brunswick County, where it has been collected every month except January and March. In the piedmont and mountainous regions this species is transient, depending on the harshness of the winters.

Aedes aegypti was established in North Carolina long before mosquito distribution lists were made. Several yellow fever epidemics caused considerable mortality in eastern North Carolina up until the late 19th century.

Sloff and Apperson (1989) listed *Ae. aegypti* as abundant in North Carolina. That was 2 years after the discovery of *Aedes albopictus* (Skuse) in the state, when *Ae. aegypti* was still abundant. Since then *Ae. aegypti* has nearly disappeared from the state, with collections being made only from a tree hole in the southeastern corner of the state during 1997. Accordingly, we now consider *Ae. aegypti* to be rare in the state. There is conjecture regarding the demise of populations of this species in North Carolina and other southeastern states. Two factors bearing on this in North Carolina are more rigid tire regulations requiring tires to be stored under cover and a rapid and successful tire pile cleanup program.

Aedes cinereus Meigen

Anson (P): (1 coll.), VI, 1996, 1♀. Cabarrus (P): (1 coll.), V, 1996, 1♀. Davie (P): (2 coll.), IV, V, 1997, 13L. Forsyth (P): (16 coll.), V–XI, 1993–97, 113♀, 24L. Henderson (M): (2 coll.), VII, VIII, 1994, 15♀. Jackson (M): (1 coll.), VII, 1994, 2♀. Rutherford (P): (1 coll.), VII, 1995, 1♀. Stokes (P): (2 coll.), IV, VI, 1997, 1♂, 8L. Transylvania (M): (1 coll.), VII, 1994, 34♀.

The first recorded specimen of *Ae. cinereus* from North Carolina was found in Union County (Middlekauff and Carpenter 1944). Subsequent county records include Buncombe (Schoof and Ashton 1944); Buncombe, Richmond, and Robeson (Carpenter et al. 1945); Union (Carpenter and Chamberlain 1946); and Duplin (Irby and Apperson 1992).

Aedes cinereus is a more northern species that can be a serious pest, and has been found positive for Cache Valley virus (Calisher et al. 1986). This species is infrequently encountered in the southern

states and little is known about the biology of the species in the south (Carpenter and LaCasse 1955). Combining the record of Irby and Apperson (1992) with our records, this species extends from the coastal plain to the mountains, but seems to be more locally common in the piedmont and mountains. In these areas adults were always collected near flooded pools in deciduous forests in creek or river bottoms. The adults were not hesitant to bite, but seemed to prefer the legs rather than the upper half of the body. Usually the larvae of this species are difficult to find in North Carolina, and one must collect large numbers of *Aedes vexans* (Meigen) and *Aedes canadensis* (Theobald) larvae to find a few specimens of *Ae. cinereus*. According to Carpenter and LaCasse (1955) and King et al. (1960), *Ae. cinereus* is an univoltine species. Wood et al. (1979), however, indicated that it is partly multivoltine in southern Canada. Our collections of adults from May to November suggest that *Ae. cinereus* is multivoltine in North Carolina.

Aedes dupreei (Coquillett)

Anson (P): (4 coll.), VII–XI, 1996, 18♀. Brunswick (C): (multiple coll.), IV–X, 1992–96, 17♀, 135♂. Catawba (P): (1 coll.), VIII, 1997, 1♀. Columbus (C): (multiple coll.), IX, X, 1996, 6♀. Duplin (C): (multiple coll.), V, VII–IX, 1984–88, 7♀, 82L. Forsyth (P): (2 coll.), VII, 1995, 2♀. Guilford (P): (1 coll.), VII, 1995, 1♀. Pender (C): (1 coll.), IX, 1993, 1♀. Robeson (C): (1 coll.), X, 1996, 1♀. Rowan (P): (4 coll.), VI, IX, 1994, 1995, 9♀, 1♂, 2L. Stanly (P): (2 coll.), VI, VII, 1994, 1995, 4L.

King et al. (1942) first recorded *Ae. dupreei* from North Carolina, without providing county records. Subsequent county records include Edgecombe, New Hanover, and Pasquotank (Schoof and Ashton 1944); Cumberland, Richmond, Robeson, Union, and Wayne (Carpenter and Chamberlain 1946); Durham (Miles and Rings 1946); and Duplin (Irby and Apperson 1988, 1992).

This species is widely distributed in the southeastern states. Darsie and Ward (1981) figured the distribution of this species throughout the state. However, we have found no confirmed specimens or published records of it in the mountains. Our records document its occurrence from the coast to at least 1,000 ft. (305 m) elevation in the western piedmont. The only places that large numbers of larvae were collected at a single time were in Brunswick and Duplin counties in the southeastern corner of the state. This species should be considered common in the southeastern coastal plain counties and uncommon in the piedmont.

Very little is known about the biology of this species. Suyemoto et al. (1973) found that 2 engorged specimens had fed on mammals, whereas Irby and Apperson (1988) found 6 specimens that had fed on passerine birds.

Based on the Brunswick County data, larvae

were collected from April to October over a 4-year period. All of the larval sites containing *Ae. dupreei* were heavily or partially shaded woodland pools with extensive leaf litter in the water. At least 2 of the larval sites in the piedmont region were transient, only holding water about 3 weeks.

Aedes fulvus pallens Ross

Anson (P): (6 coll.), VIII–XI, 1996, 896♀. Brunswick (C): (multiple coll.), VI–XI, 1992–96, 1,069♀♂. Carteret (C): (1 coll.), VII, 1996, 2L. Columbus (C): (multiple coll.), IX, 1996, 5♀. Forsyth (P): (4 coll.), VII, VIII, X, 1995, 5♀. Mecklenburg (P): (1 coll.), IX, 1995, 1♀. New Hanover (C): (1 coll.), IX, 1996, 1♀. Pender (C): (1 coll.), IX, 1996, 1♀. Robeson (C): (1 coll.), X, 1996, 1♀. Rowan (P): (1 coll.), VII, 1995, 2♀. Wake (P): (2 coll.), VI, VIII, 1975, 1995, 1♀, 1L.

Barret (1919) first recorded this species (as *Aedes bimaculatus* Coquillett) in North Carolina from Mecklenburg County. Records thereafter include Mecklenburg County (Dyar 1922, as *Ae. bimaculatus*); Brunswick and Mecklenburg counties (Brimley 1938, as *Ae. bimaculatus*); North Carolina (King et al. 1942); Cumberland, Edgecombe, and Wayne counties (Schoof and Ashton 1944); Cumberland, Richmond, and Robeson counties (Carpenter and Chamberlain 1946); New Hanover and Robeson counties (Miles and Rings 1946); and Duplin County (Irby and Apperson 1988, 1992). Our collections in Forsyth, Mecklenburg, and Rowan counties confirm the most western distribution of the species in North Carolina (Darsie and Ward 1981).

This large golden-orange and black mosquito is one of the most obvious and easily identified species in North America. Although Roberts and Scanlon (1975) reported that in Texas the species did not bite until after sunset, we commonly collected females biting in shaded woodlands in the morning and afternoon. They are very persistent in their attacks. Barret (1919) reported that the larvae of this species are brown and rest horizontally in the water like anopheline larvae. Larvae collected in Brunswick County were brown with a cream-colored thorax, but they hung from the surface with a slight angle, not horizontally. *Aedes fulvus pallens* requires heavy rains to hatch in large numbers. Such hatches usually occur following summer–fall tropical depressions and hurricanes. Thus, large hatches in North Carolina occurred in June 1992, but in September–October 1996. In 1992, one of the authors (E.Y.H.) reared 1,059 males and females from larvae collected in 3 woodland pools between June 12 and November 14. Of these, 507 were collected in June. Larval development is apparently slower than in many of the other *Aedes* and *Psorophora* species and requires 14 or more days. Although typically considered a coastal plain–woodland pool

species, it readily survives in the piedmont at elevations up to 1,000 ft. (305 m).

Aedes hendersoni Cockerell

Burke (P/M): (3 coll.), VIII, 1996, 4♀, 6♂. Halifax (C/P): (1 coll.), VII, 1987, 1L. New Hanover (C): (10 coll.), VII, IX, 1994, 1996, 8P, 487L. Stanly (P): (1 coll.), VI, 1995, 1♀. Wake (P): (1 coll.), IX, 1974, 1♀. Yadkin (P): (1 coll.), VI, 1996, 2♀.

The first published records for *Ae. hendersoni* in North Carolina are those of Zavortink (1972), who examined specimens from Henderson, McDowell, Mecklenburg, and Robeson counties. Irby and Apperson (1988, 1992) reported specimens from Duplin County. Szumlas et al. (1996a) reported collecting *Ae. hendersoni* eggs in ovitraps set in Jackson and Swain counties in the western part of the state. In 1966, one of the authors (B.A.H.) examined a single larva of this species from Cumberland County (Ft. Bragg) collected by R. E. Parsons.

Aedes hendersoni was considered a variety or a synonym of *Aedes triseriatus* (Say) for many years until elevated to species status by Breland (1960). Even then it was considered a western species, until Zavortink (1972) demonstrated that it was widely distributed in the eastern United States. We think that *Ae. hendersoni* is widespread in North Carolina and common in some areas. However, because it oviposits in tree holes at heights that are impractical to sample, immatures are collected infrequently (Scholl and DeFoliart 1977, Sinsko and Grimstad 1977). Also, adult females will come to ground level to bite and probably are often incorrectly identified as *Ae. triseriatus*, a much more common species. These behavioral traits and morphologic similarities probably account for the infrequent collections and identification of *Ae. hendersoni*. Persons wishing to collect this species should target mature deciduous trees including elm, oak, maple, beech, and hackberry.

Aedes mitchellae (Dyar)

Brunswick (C): (37 coll.), I–IV, VI–XII, 1992–96, 116♀, 79♂. Cabarrus (P): (2 coll.), IX, 1994, 1995, 1♀, 1♂. Carteret (C): (1 coll.), II, 1995, 1L. Pender (C): (1 coll.), IX, 1996, 1♀.

Brimley (1938) was the first to record this species in North Carolina, from New Hanover County. Subsequent county records include Onslow (King et al. 1942); New Hanover, Onslow, Pasquotank, and Robeson (Schoof and Ashton 1944); New Hanover, Richmond, Robeson, and Union (Carpenter and Chamberlain 1946); and Pamlico (Parker 1986). Our collections in Cabarrus County extend the distribution of this species further west in North Carolina than figured in Darsie and Ward (1981).

Aedes mitchellae is most abundant in the Atlantic and Gulf coastal plains, where adults and larvae occur throughout the year (Carpenter and LaCasse

1955). This species has been found naturally infected with eastern equine encephalomyelitis virus (Morris 1992). The immature stages are usually found in shallow grassy pools in open sunlight. Our collections were made in every month except May and all of the larval collection sites, except one, were in open sunlight and in grassy pools. The single exception was a woodland pool in Brunswick County. Although larvae and adults were found throughout the year, data from Brunswick County (coastal) show a distinct fall abundance peak in October–November. The collection of 2 specimens in a light trap in Cabarrus County matches the previous westernmost collection in Union County reported by Carpenter and Chamberlain (1946). *Aedes mitchellae* should be considered rare in the piedmont region of North Carolina.

Aedes thibaulti Dyar and Knab

Anson (P): (2 coll.), V, VI, 1996, 1997, 2♀. Brunswick (C): (multiple coll.), XI–V, 1991–96, 387♀, 345♂. Duplin (C): (1 coll.), V, 1987, 2♂. Lenoir (C): (1 coll.), V, 1995, 2♀.

The first record of *Ae. thibaulti* in North Carolina was that of King et al. (1942) based on a specimen from Edgecombe County. Other published county records include Edgecombe, Johnston, Stanly, Pasquotank, and Robeson (Schoof and Ashton 1944); Durham and Robeson (Carpenter and Chamberlain 1946); Robeson (Miles and Rings 1946); and Duplin (Irby and Apperson 1992).

Aedes thibaulti is almost always associated with heavily shaded woodland pools, swamps, or river bottoms that contain standing hollow trees and stumps in water. The larvae are usually found inside hollow trees or stumps (King et al. 1960). According to Wood et al. (1979) eggs are oviposited on the inside of the hollow trees and stumps, and although the species overwinters in the egg stage in northern states, in southern states it overwinters in the larval stage.

In North Carolina, Schoof and Ashton (1944) reported collecting larvae from a rock pool below Lake Tillery (Stanly County). Otherwise, all of our collections have been from hollow trees or stumps. Also, all but one of the hollow trees and stumps were alive. Records of larvae from a green ash and a swamp chestnut oak appear to be among the first records for trees other than a gum or cypress. Larvae overwinter in North Carolina, and their numbers increase from December until they peak in April.

According to one of the authors (E.Y.H.), *Ae. thibaulti* is a very aggressive and hard-biting mosquito similar to *Aedes sollicitans* (Walker). Our collections of *Ae. thibaulti* from the Pee Dee National Wildlife Refuge in Anson County occurred only about 10 mi. from Lake Tillery where Schoof and Ashton (1944) reported this species. These represent the current westernmost records for this spe-

cies in North Carolina. Several local unpublished records were seen that would extend the distribution of the species into the foothills of the mountains. However, because no specimens were retained for those records, they cannot be confirmed. Because this species is usually associated with gum and cypress swamps, it should be considered locally common in the coastal plain and rare in the piedmont region of North Carolina.

Aedes tormentor Dyar and Knab

Duplin (C): (multiple coll.), V–IX, 1984, 1987, 1988, 384L. Forsyth (P): (1 coll.), VI, 1996, 18L. Mecklenburg (P): (2 coll.), V, IX, 1995, 1997, 2L. Rowan (P): (1 coll.), VI, 1994, 1L. Stanly (P): (2 coll.), V, VI, 1994, 1995, 5L. Wake (P): (1 coll.), VI, 1995, 1L.

Middlekauff and Carpenter (1944) first reported *Ae. tormentor* in North Carolina from New Hanover County. However, Bradley et al. (1944) and Schoof and Ashton (1944) reported an even earlier collection in Craven County. Other county records include Richmond (Carpenter and Chamberlain 1946), and Robeson (Miles and Rings 1946). Our collection in Forsyth County extends the distribution of this species in North Carolina further west than reported in Darsie and Ward (1981).

Although *Ae. tormentor* has a fairly wide distribution in the eastern states, it is considered a more southern species (Carpenter and LaCasse 1955). It is rarely common outside of the southern part of its range (King et al. 1960). In North Carolina it should be considered locally common in the southeastern coastal plain counties and rare elsewhere.

Adult females of *Ae. tormentor* currently cannot be separated from those of *Aedes atlanticus* Dyar and Knab and only the male genitalia and the larval stage can be used to separate these 2 species. Although Scanlon and Yates (1970) and Roberts and Scanlon (1979) reported 2 characters for separating the females of these species in Texas, we have not been able to rear an adequate number of specimens with associated immature exuviae to confirm these characters in North Carolina. For field identification purposes, a black and cream banded appearance can be useful in identifying the larvae of both *Ae. tormentor* and *Ae. atlanticus*.

Aedes trivittatus (Coquillett)

Alamance (P): (1 coll.), VII, 1995, 1♀. Anson (P): (6 coll.), V, VII–X, 1996, 1997, 18♀. Davidson (P): (3 coll.), V–VII, 1996, 1997, 73♀. Davie (P): (4 coll.), V, VII, 1996, 1997, 509♀, 21L. Forsyth (P): (11 coll.), VI–X, 1993, 1995–97, 14♀. Guilford (P): (5 coll.), VII–IX, 1994–1996, 7♀. Henderson (M): (2 coll.), VII, VIII, 1994, 15♀. Rockingham (P): (1 coll.), VIII, 1995, 1♀. Rowan (P): (4 coll.), VI, VIII, IX, 1994–96, 6♀, 2L. Rutherford (P): (1 coll.), IX, 1994, 1♀. Stanly (P): (2 coll.),

VI, VII, 1994, 1995, 1♀, 1L. Stokes (P): (1 coll.), VI, 1997, 143♀. Transylvania (M): (1 coll.), VII, 1994, 25♀. Yadkin (P): (4 coll.), VI, VIII, 1995, 1996, 20♀.

The first record of *Ae. trivittatus* in North Carolina was from Durham County (King et al. 1943). The only other published records are from Robeson County (Carpenter et al. 1945) and Jackson and Swain counties (Szumlas et al. 1996a, 1996b).

Aedes trivittatus is relatively rare in the southern states and is more common in the northern Atlantic states, the Ohio Valley, and the midwestern states, where it has been found naturally infected with Cache Valley virus (Calisher et al. 1986) and Trivittatus virus (Sudia et al. 1971). Our collections reveal a more western distribution in North Carolina, with all specimens either from the piedmont or mountainous counties. Furthermore, there are no confirmed published records of this species from the coastal plain of North Carolina. Probably, *Aedes trivittatus* is spread widely throughout the river bottoms of western North Carolina. Although the species is usually collected in small numbers, on 3 occasions (one each, in the Davidson, Davie, and Stokes county records) specimens were so abundant that the collectors were bitten severely and quickly left the areas. Adults were collected between June and October and were most abundant in July and August. The elevations for our collections ranged from 650 ft. (198 m) in the piedmont to above 2,200 ft. (670 m) in the mountains.

Anopheles atropos Dyar and Knab

Brunswick (C): (13 coll.), I, V, VII, VIII, XII, 1990–93, 1995, 40♀, 3♂. Carteret (C): (3 coll.), IX, 1993, 519♀. New Hanover (C): (1 coll.), V, 1997, 53♀.

The first record of *An. atropos* in North Carolina was based on specimen(s) from New Hanover County (King et al. 1942). Other county records include Carteret, Dare, and Onslow counties (Schoof and Ashton 1944) and New Hanover County (Carpenter and Chamberlain 1946). This species should be upgraded from uncommon to locally common along the southern half of the coast of North Carolina.

Anopheles atropos is a brackish water species that occurs along the Atlantic and Gulf coasts from New Jersey to Texas (King et al. 1960). To the inexperienced worker it is easily confused with either *Anopheles quadrimaculatus* Say or *Anopheles barberi* Coquillett, although the head scales and thoracic setae are diagnostic for *An. atropos*. Females of this species normally have dark palpi and unicolorous dark wings, but some specimens may have faint pale bands on the palpi and faint dark spots on the wings. Females are aggressive biters and will attack in bright sunlight (Carpenter and LaCasse 1955). Adults may be very common in salt marshes, but the larvae are usually very difficult to find.

Although larvae of *An. atropos* and *Anopheles bradleyi* King can be found together, those of *An. atropos* are usually found in saltier water (King et al. 1960). The egg of *An. atropos* was described in detail by Linley (1992).

Brief comments about six additional species.

Aedes grossbecki Dyar and Knab

This species was listed as rare in North Carolina (Slaff and Apperson 1989). Darsie and Ward (1981) map the distribution of *Ae. grossbecki* throughout the state, but did not list published records to support that distribution. Slaff and Apperson (1989) included it in North Carolina (Slaff, personal communication) because it had been confirmed from South Carolina and Virginia (Carpenter and La-Casse 1955). Despite numerous collections, no specimens of this species have been found in North Carolina. Also, no specimens from North Carolina were found by B.A.H. in collections preserved in the state or in the USNM (Smithsonian) mosquito collections. Accordingly, we cannot accept the record of *Ae. grossbecki* in North Carolina until specimens collected there have been confirmed as this species.

Anopheles barberi Coquillett

Slaff and Apperson (1989) listed this tree hole species as uncommon in North Carolina but to date we have not collected it. However, published records for *An. barberi* in North Carolina include Dyar (1922) in Polk County; Schoof and Ashton (1944) in Buncombe, Craven, Cumberland, Mecklenburg, Robeson, and Scotland counties; Carpenter and Chamberlain (1946) in Buncombe, Cumberland, and Richmond counties; Parker (1993) in Pamlico County; and Szumlas et al. (1996b) in the Cherokee Indian Reservation (Jackson and Swain counties). Because of the cryptic larval habitat of this species and the infrequent published records it should be considered to be rare in North Carolina.

Anopheles crucians Wiedemann

This species was listed as uncommon in North Carolina by Slaff and Apperson (1989). During our collections we found the species to be common in many counties from the coastal plain to the mountains. Recently, Cockburn et al. (1993) provided evidence for a Crucians sibling species complex; thus more than one species may be masquerading under this name in North Carolina.

Anopheles georgianus King

This species was listed as rare in North Carolina by Slaff and Apperson (1989). Published records for this species in the state include King et al.

(1943) in Cumberland and Union counties; Schoof and Ashton (1944) in Cumberland, Richmond, and Wayne counties; Carpenter and Chamberlain (1946) in Cumberland, Richmond, Scotland, and Wayne counties; and Floore et al. (1976) in Cumberland and Richmond counties. These records all apply to collections made during the 1940s. Since that time, no specimens of *An. georgianus* have been collected and confirmed from North Carolina. Furthermore, based on an examination by B.A.H. of preserved and confirmed specimens of this species in the USNM (Smithsonian) mosquito collections, no confirmed collections of this species have been made in the United States after 1951. Apparently, this species has a very specific larval habitat (shallow natural seepage) and it may now be endangered due to the loss of that habitat.

Anopheles perplexens Ludlow

Slaff and Apperson (1989) listed this species as uncommon in North Carolina. Prior to Bellamy (1956), *An. perplexens* was considered a junior synonym of *Anopheles punctipennis* (Say). When Bellamy elevated *An. perplexens* to species status he listed specimens previously noted by Roth (1945) from Swannanoa, Buncombe County, North Carolina. The only subsequent published record of *An. perplexens* in North Carolina is from Duplin County (Irby and Apperson 1992). Identifying *An. perplexens* is compounded by variation in wing spot sizes in *An. punctipennis*, as described by Fritz et al. (1991). Progeny reared from eggs oviposited by individual feral females of *An. punctipennis* collected in North Carolina often exhibit wing patterns (Darsie and Ward 1981) representing both *An. perplexens* and *An. punctipennis*. Thus, we follow Bellamy (1956) and Fritz et al. (1991) in recommending the use of egg characters to separate these 2 species. These egg character differences are easily seen in micrographs in Linley and Kaiser (1994).

Anopheles walkeri Theobald

Slaff and Apperson (1989) listed this species as uncommon in North Carolina. Published records for this species in the state include Schoof and Ashton (1944) in Person County, and Carpenter and Chamberlain (1946) in Union County. No specimens of *An. walkeri* have been confirmed or reported from North Carolina since the 1940s. We consider this species to be rare.

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