

MOSQUITOES (DIPTERA: CULICIDAE) COLLECTED NEAR THE GREAT DISMAL SWAMP: NEW STATE RECORDS, NOTES ON CERTAIN SPECIES, AND A REVISED CHECKLIST FOR VIRGINIA

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Abstract.—This paper provides lists of the mosquitoes collected around the North Carolina and Virginia sides of the Great Dismal Swamp National Wildlife Refuge in 1998; the first collection records for *Ochlerotatus aurifer* and *Oc. j. japonicus* in Virginia; notes on *Aedes albopictus*, *Oc. grossbecki*, *Oc. infirmatus*, *Oc. thibaulti*, *Oc. trivittatus*, and *Wyeomyia smithii*; an up-dating of recent publications that affect the Virginia faunal list; and a revised checklist of the mosquitoes of Virginia. The record of *Oc. flavescens* is deleted from the Virginia checklist.

Key Words: new records, mosquitoes, Virginia, North Carolina, checklist

During 1998 mosquito-borne virus and mosquito faunal surveys were conducted in the vicinity of the Great Dismal Swamp (GDS) in southeastern Virginia and northeastern North Carolina. The Great Dismal Swamp National Wildlife Refuge (GDSNWR) currently consists of 107,000 acres of forested wetlands. Additional areas of the swamp occur outside the refuge. The entire swamp area in the refuge is in a re-growth phase, as all areas have been lumbered at least once. Most areas outside the GDSNWR are under agriculture or housing development. The refuge contains one of the most southern large stands of Atlantic white cedar, *Chamaecyparis thyoides* (L.)

BSP. The GDS also serves as a major refuge for many mammal, bird, reptile, amphibian, and plant species. The presence of large numbers of potential bird and mammal hosts for viruses and the recent rapid encroachment of humans around the periphery of the swamp was a primary reason for selecting the GDS as a study site.

Primary goals of the project included: (1) an assessment of mosquito-borne viruses in the area (which will not be addressed in this paper); (2) a survey of mosquito species that occur in the area; (3) up-dating a checklist of the mosquitoes of Virginia; and (4) training and capacity strengthening for all the collaborating participants.

MATERIALS AND METHODS

The basic design for this study was to collect adult female mosquitoes in mosquito light traps (Centers for Disease Control) set in diverse habitats around the periphery of the swamp, with eight trap sites in North Carolina and eight trap sites in Virginia. The trap line was 104 miles long and involved sites in Camden, Gates, and Pasquotank counties in North Carolina and Suffolk and Chesapeake cities in Virginia. Five, two-night collection periods were planned between late April and early October; however, the arrival of Hurricane Bonnie in late August canceled one collection period. Traps, supplemented with CO₂ (dry ice), were set out between 4:30–5:30 PM and picked up the following morning between 7:30–8:30 AM. Female mosquitoes retrieved from the traps were returned to the laboratory in Chesapeake, Virginia, anesthetized with triethylamine (Kramer et al. 1990), identified to species (Darsie and Ward 1981, Slaff and Apperson 1989), sorted into pools of up to 50 specimens, and frozen on dry ice for shipment to the Centers for Disease Control and Prevention (CDC, Fort Collins) for virus isolation. Specimens were processed the same day they were captured and removed from the traps. Uncommon species or unusual specimens were preserved as voucher specimens along with collection data. Species collected in each state during the study are noted in the checklist (Table 1).

Use of the genus *Ochlerotatus* Lynch Arribalzaga and the abbreviation, *Oc.*, follows Reinert (2000). Both *Oc. atlanticus* (Dyar and Knab) and *Oc. tormentor* (Dyar and Knab) are documented from Virginia and North Carolina based on larval characters. However, adult females of these two species cannot be separated morphologically with certainty in the mid-Atlantic Region (Harrison et al. 1998). Therefore we arbitrarily chose to report only the former during this study. Likewise, only *Culex pipiens* L. is reported even though adult females are in-

distinguishable from *Cx. quinquefasciatus* Say, and hybrids, all of which might have been encountered.

RESULTS AND DISCUSSION

A total of 72,638 mosquito specimens were collected in 110 trap-nights during four two-night collection periods in April, June, July, and October. Of that total, 96.2% of the specimens (69,880) were collected during the first two periods and *Ochlerotatus c. canadensis* (Theobald) made up 97.9% of those specimens. After June, rainfall was extremely sparse and specimen numbers declined dramatically to only 1,634 in July and 1,124 in October. The paucity of rainfall affected temporary pool species, which probably explains the limited number of *Aedes* Meigen, *Ochlerotatus*, and *Psorophora* Robineau-Desvoidy that were collected. The lack of rainfall also affected the pH of the water in the swamp in October (as low as 3.2 to 3.6 in some areas), which may have influenced the presence of certain species. A total of 24 species were collected in both states, of which 21 species came from North Carolina and 23 species came from Virginia (Table 1). *Ochlerotatus aurifer* (Coquillett), *Oc. grossbecki* (Dyar and Knab) and *Oc. trivittatus* (Coquillett) were not collected by us in North Carolina. Neither *Oc. aurifer* nor *Oc. grossbecki* have ever been collected in North Carolina even though they were found in Virginia 3.9 and 17.7 km, respectively, from the state line. *Psorophora columbiae* (Dyar and Knab) was not collected on the Virginia side of the GDS during this study, but is commonly collected by local mosquito control personnel in Chesapeake City. Notes for the new state records and other species are below.

NEW STATE RECORDS

Ochlerotatus aurifer (Coquillett)

Ochlerotatus aurifer females were collected in two sites in Suffolk, Virginia. Twenty specimens were collected beside

Jericho Lane at GDS site VA-5, on the edge of the Great Dismal Swamp National Wildlife Refuge (GDSNWR) on: 28 April (4 ♀); 29 April (12 ♀); and 19 May (4 ♀). This trap site was in a mature deciduous forest with a pasture on one side and a road with a ditch filled with clear water on the other, and is approximately 17.7 km from North Carolina. An additional two females were collected in wet deciduous forest next to Desert Road site VA-8 on 29 April (1 ♀) and 3 June (1 ♀), and only 3.9 km from North Carolina. Seven specimens collected at VA-5 on 28 and 29 April 1998 are deposited in the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC, and the remaining specimens are deposited in the Public Health Pest Management (PHPM) collection in Winston-Salem, NC.

Certain characters on these specimens differ from the description of this species provided by Carpenter and LaCasse (1955). Those authors described: (1) the sides of the scutum and most of the prescutellar space with pale golden scales; (2) the posterior pronotum with curved brown scales dorsally, becoming pale golden ventrally; (3) the first abdominal tergum dark with a few intermixed pale scales; and (4) the femora with dark and pale scales intermixed, darker toward the apices, pale on the posterior surface. Our specimens have: (1) the sides of the scutum with bronzy-brown scales anteriorly, becoming slightly lighter posteriorly over the wing root, and the scales around the prescutellar bare spot bronzy-brown anteriorly, slightly paler posteriorly; (2) the posterior pronotum covered in curved bronzy-brown scales; (3) the first abdominal tergum with a distinct median posterior patch of creamy scales; and (4) the femora (particularly the forefemur) almost entirely cream colored, except a few very sparse scattered dark scales that become more common and form a dark area near the apices. Other than these differences, the specimens fit the keys listed above and that of Carpenter and LaCasse (1955). Dr. R. C.

Wilkerson, Walter Reed Biosystematics Unit, Walter Reed Army Institute of Research, kindly examined specimens of *Oc. aurifer* in the NMNH mosquito collection and found many had bronzy-brown scales on the sides of the scutum like our specimens, instead of pale golden scales as listed by Carpenter and LaCasse (1955). The senior author (BAH) collected specimens of *Oc. aurifer* in 1967 in the Walter Reed Army Institute of Research field study site in the Pocomoke Cypress Swamp in Worchester County, Maryland, only 2.4 km from Virginia. Those specimens had the sides of the scutum pale golden, as described by Carpenter and LaCasse (1955). The differences noted on the GDS specimens should be considered variations.

Map number 14 (p. 239) in Darsie and Ward (1981) depicts the distribution of *Oc. aurifer* across the northern part of Virginia. However, there are no previous published collection records of this species in Virginia. Apparently these authors based that map distribution on a 1945 record of *Oc. aurifer* collected in Charles County, MD, across the Potomac River from the northern part of Virginia, and a 1937 record collected in the Pocomoke Cypress Swamp in Worchester County, MD, adjacent to Virginia on the eastern shore (Bickley 1957). Accordingly, the above 22 specimens collected during this study represent the first documented evidence of this species in Virginia. These collections of *Oc. aurifer* just north of the state boundary suggest that it probably occurs in northeastern North Carolina.

Ochlerotatus japonicus japonicus
(Theobald)

Ochlerotatus j. japonicus was first recognized in the United States in 1998 and reported from New Jersey and New York (Peyton et al. 1999). Since then it has spread into other states and districts as far south as Virginia. It was first detected in Virginia when three males and one female were collected as larvae in Occoquan, Prince William County, Virginia, on July

21, 2000. The reared adults were shipped to the senior author for identification and confirmed as this species. The larvae were collected in stone flower pots and birdbaths by Jim Herendeen and Karrie Trumble under the supervision of Benjamin F. McLaurin, Jr., Gypsy Moth and Mosquito Control Program, Prince William, Prince William County, VA. These specimens represent the first collection of *Oc. j. japonicus* in Virginia. Two males and one female are deposited in PHPM.

COMMENTS ON CERTAIN SPECIES

Aedes albopictus (Skuse)

Aedes albopictus was first detected in Virginia in 1991 in Virginia Beach and reported by Dreda McCreary in the non-refereed Virginia Mosquito Control Association Newsletter, (Skeeter, Vol. 52, 1992). Since then it has become a major cause for mosquito complaints in many areas of the state. In North Carolina this species is distributed throughout every county and is the primary cause of mosquito complaints, sometimes even in areas with salt marsh. During this study 16 specimens of *Ae. albopictus* were collected in CDC light traps in five of the eight Virginia trap sites around the GDS in Chesapeake and Suffolk cities between 2 June and 7 October. In North Carolina, seven specimens were collected in four of the eight traps in Camden, Gates and Pasquotank counties between 2 June and 7 October. Positive sites were those that were closest to human habitation or near discarded tires and containers.

Ochlerotatus flavescens (Mueller)

Darsie and Ward (1981) recorded *Oc. flavescens* in Virginia based on one sentence in the non-refereed newsletter distributed by the Virginia Mosquito Control Association (Skeeter, Vol. 23, 1978). This sentence, "Chuck Burr caught a rare mosquito this year, *Aedes flavescens*." is the only indication for this species in Virginia, as the identification was not confirmed and the

specimen was not preserved. *Ochlerotatus flavescens* is considered a Holarctic species that prefers deep temporary pools in meadows and marshes on the open plains, and is most abundant in the early spring (Carpenter and LaCasse 1955). The nearest published records of this species to Virginia are in New Jersey (Crans 1970), while Means (1979) lists only three collections from New York. Considering the circumstances surrounding this record and the total absence of specimens collected in Virginia (or even near Virginia) before and since that time, we feel the specimen was probably misidentified. Accordingly, *Oc. flavescens* is deleted from the checklist of Virginia mosquitoes.

Ochlerotatus grossbecki (Dyar and Knab)

Gladney and Turner (1969) reported records of this species in Grassymead and Pittsylvania County, Virginia. We have been unable to locate "Grassymead", which apparently came from Dyar (1922). The senior author (BAH) collected specimens of this species in a large freshwater (clear) pool on Assateague Island, Accomack County, Virginia, in March, 1967. Seven females of this species were collected at two sites in Suffolk City and one site in Chesapeake City during the summer of 1998. Three specimens were collected beside Jericho Lane at GDS site VA-5, on the edge of the Great Dismal Swamp National Wildlife Refuge on 28 April (1 ♀) and 29 April (2 ♀). The description of this site is given under *Oc. aurifer* (above). Two additional females were collected at the same site on 19 May in a focused attempt to collect this species. Two larvae were collected in Emerald Greens, Chesapeake City on 21 May and reared to adults. These last two specimens were collected in a ditch with clear water. In the mid-Atlantic and southern states *Oc. grossbecki* is a late winter-early spring mosquito that is rarely collected, primarily because adults hatch and die before most mosquito collection efforts start. The Jericho Lane site on the edge of

the GDSNWR in Suffolk is only 17.7 km from North Carolina. Collections of *Oc. grossbecki* from that site suggest that it almost certainly occurs in North Carolina, where it previously has not been documented (Harrison et al. 1998). A specimen of *Oc. grossbecki* from trap site VA-5 collected on 29 April, has been deposited in NMNH, the remaining six specimens are deposited in PHPM.

Ochlerotatus infirmatus (Dyar and Knab)

The only previous record of *Oc. infirmatus* from Virginia is that of three females from Assateague Island reported by Arnell (1976). Nine females of this species were collected at five sites in Virginia during this study. One specimen was collected at GDS site VA-1 on 15 July. This site was in wet deciduous forest beside U.S. highway 17 in Chesapeake City, about 1 km from North Carolina. Four specimens were collected at GDS trap site VA-2 on 14 July (2 ♀) and 6 October (2 ♀). This site was also in wet deciduous forest beside U.S. highway 17 in Chesapeake City, about 4.8 km from North Carolina. One specimen was collected at GDS site VA-6 on 6 October. This site was in mature deciduous forest beside Washington Ditch lane in the GDSNWR in Suffolk. One specimen was collected at GDS site VA-7 on 7 October in a mature pine forest beside Railroad Ditch lane and behind the GDSNWR headquarters. Two specimens were collected at GDS site VA-8 (see site description above under *Oc. aurifer*) on: 6 October (1 ♀) and 7 October (1 ♀). One voucher specimen from Virginia (Chesapeake, highway U.S. 17, VA-1, 15 July 1998) is deposited in PHPM. The remaining specimens were pooled for virus isolation attempts. *Ochlerotatus infirmatus* can be very common in the coastal regions of North Carolina and specimens were collected during the project in Camden and Gates counties.

Ochlerotatus thibaulti (Dyar and Knab)

Gladney and Turner (1969) reported only two previous collections of *Oc. thibaulti* in

Virginia (Giles County and Virginia Beach). During this study one female of *Oc. thibaulti* was collected in Suffolk, Virginia at GDS site VA-8 (see the site description under *Oc. aurifer*) on 14 July. Three additional specimens were identified during the study period from collections in Virginia Beach (courtesy, Dreda McCreary). Specimens of this species were also collected at two sites in North Carolina. One female was collected in Camden County at GDS site NC-2 on 2 June at the North Carolina Welcome Center next to the Dismal Swamp Canal on U.S. highway 17 about 4.8 km from Virginia. The trap site was in mature deciduous forest next to a cultivated field. The second collection (5 ♀, 4 ♂), on 30 April, was in Merchant's Mill Pond State Park, Gates County, just southwest of the GDSNWR. One specimen was captured while biting, while the others were aspirated from resting sites in hollow trees and stumps. The nine specimens from Gates County are deposited in PHPM. These two additional records, plus those of Harrison et al. (1998), suggest that this species is probably scattered throughout the coastal plain of North Carolina, wherever there is suitable old swamp habitat.

Ochlerotatus trivittatus (Coquillett)

Only three previous Virginia collections of *Oc. trivittatus*, in Franklin, Pittsylvania and Roanoke counties in the western piedmont and mountains, have been published (Gladney and Turner 1969). One female of this species was collected in Virginia at GDS site VA-3 on 15 July. This site is located off George Washington highway in Chesapeake in deciduous forest near a housing development. This record represents the most eastern collection of this species in Virginia. In North Carolina, *Oc. trivittatus* is considered a locally common piedmont and mountain species (Harrison et al. 1998), and has only been collected in one coastal plain county (Robeson).

Table 1. Revised checklist of mosquito species in Virginia.¹

1. <i>Aedes aegypti</i> (L.)	29. <i>Ochlerotatus fulvus pallens</i> (Ross)
2. <i>Aedes albopictus</i> (Skuse)—NV	30. <i>Ochlerotatus grossbecki</i> (Dyar and Knab)—V
3. <i>Aedes cinereus</i> Meigen	31. <i>Ochlerotatus hendersoni</i> (Cockerell)
4. <i>Aedes vexans</i> (Meigen)—NV	32. <i>Ochlerotatus infirmatus</i> (Dyar and Knab)—NV
5. <i>Anopheles atropos</i> Dyar and Knab	33. <i>Ochlerotatus j. japonicus</i> (Theobald)
6. <i>Anopheles barberi</i> Coquillett	34. <i>Ochlerotatus mitchellae</i> (Dyar)
7. <i>Anopheles bradleyi</i> King	35. <i>Ochlerotatus sollicitans</i> (Walker)
8. <i>Anopheles crucians</i> Wiedemann—NV	36. <i>Ochlerotatus sticticus</i> (Meigen)
9. <i>Anopheles punctipennis</i> (Say)—NV	37. <i>Ochlerotatus stimulans</i> (Walker)
10. <i>Anopheles quadrimaculatus</i> Say	38. <i>Ochlerotatus taeniorhynchus</i> (Wiedemann)
11. <i>Anopheles smaragdinus</i> Reinert	39. <i>Ochlerotatus thibaulti</i> (Dyar and Knab)—NV
12. <i>Anopheles walkeri</i> Theobald	40. <i>Ochlerotatus tormentor</i> (Dyar and Knab)
13. <i>Coquillettia perturbans</i> (Walker)—NV	41. <i>Ochlerotatus triseriatus</i> (Say)—NV
14. <i>Culex erraticus</i> (Dyar and Knab)—NV	42. <i>Ochlerotatus trivittatus</i> (Coquillett)—V
15. <i>Culex peccator</i> Dyar and Knab	43. <i>Orthopodomyia alba</i> Baker
16. <i>Culex pipiens</i> L.—NV	44. <i>Orthopodomyia signifera</i> (Coquillett)—NV
17. <i>Culex quinquefasciatus</i> Say	45. <i>Psorophora ciliata</i> (Fabricius)
18. <i>Culex restuans</i> Theobald—NV	46. <i>Psorophora columbiae</i> (Dyar and Knab)—N
19. <i>Culex salinarius</i> Coquillett—NV	47. <i>Psorophora cyanescens</i> (Coquillett)
20. <i>Culex territans</i> Walker—NV	48. <i>Psorophora discolor</i> (Coquillett)
21. <i>Culiseta inornata</i> (Williston)	49. <i>Psorophora ferox</i> (von Humboldt)—NV
22. <i>Culiseta melanura</i> (Coquillett)—NV	50. <i>Psorophora horrida</i> (Dyar and Knab)
23. <i>Ochlerotatus atlanticus</i> (Dyar and Knab)—NV	51. <i>Psorophora howardii</i> (Coquillett)
24. <i>Ochlerotatus atropalpus</i> (Coquillett)	52. <i>Psorophora mathesoni</i> Belkin and Heinemann
25. <i>Ochlerotatus aurifer</i> (Coquillett)—V	53. <i>Toxorhynchites rutilus septentrionalis</i> (Dyar and Knab)
26. <i>Ochlerotatus a. canadensis</i> (Theobald)—NV	54. <i>Uranotaenia sapphirina</i> (Osten Sacken)—NV
27. <i>Ochlerotatus cantator</i> (Coquillett)	55. <i>Wyeomyia smithii</i> (Coquillett)
28. <i>Ochlerotatus dupreei</i> (Coquillett)	

¹ Species with a "N" (= North Carolina) or a "V" (= Virginia) following the author(s) name(s) are species that were collected around the periphery of the Great Dismal Swamp in 1998.

Wyeomyia smithii (Coquillett)

Coyne and Hagmann (1970) determined that the species in Virginia was *Wyeomyia haynei* Dodge, rather than the more northern *Wy. smithii*, and this was reported in Darsie and Ward (1981). Bradshaw and Lounibos (1977), however, found that these names represent variations of a single species. Based on the work of Bradshaw and Lounibos (1977), Darsie and Morris (1998) sunk *Wy. haynei* as a junior synonym of *Wy. smithii*.

REVISED CHECKLIST OF MOSQUITO SPECIES IN VIRGINIA

The last publications to specifically address the mosquito fauna of Virginia were Bickley (1957) and Gladney and Turner (1969), who, using the data provided by

Dorer et al. (1944) and later collection records, documented 47 species occurring in the state. In subsequent studies an additional four species were recognized in Virginia and added to a list of the mosquitoes of Virginia published in Darsie and Ward (1981): *Wyeomyia haynei* Dodge (Coyne and Hagmann 1970); *Ochlerotatus hendersoni* (Cockerell) (Zavortink 1972); *Ochlerotatus infirmatus* (Arnell 1976); and *Ochlerotatus flavescens* (Skeeter 1978, non-refereed newsletter of the Virginia Mosquito Control Association). Since 1981 additional species have been documented in Virginia. *Aedes albopictus* was recognized in the state by McCreary (Skeeter 1992, non-refereed newsletter of VMCA). Following the recognition of five sibling species in the Quadrimaculatus Complex (Reinert et al.

1997), Strickman et al. (2000) confirmed the presence of *Anopheles quadrimaculatus* Say, *sensu stricto*, and *Anopheles smaragdinus* Reinert, in Virginia. Also, Powell and Harrison (2001) provided the first documentation of *Oc. tormentor* in Virginia. In this study we have documented the occurrence of *Oc. aurifer* and *Oc. j. japonicus* in Virginia.

Considering the above additions, our deletion of *Oc. flavescens* from the Virginia Checklist, and the recognition of *Wy. haynei* as a junior synonym of *Wy. smithii* (Darsie and Morris 1998), these actions result in 55 species and subspecies recognized in the checklist of the mosquito species in Virginia (Table 1).

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