

NOTES ON THE *PALUSTRIS-CUBENSIS* COMPLEX OF THE
GENUS *NEONEMOBIUS* HEBARD
(ORTHOPTERA: GRYLLIDAE: NEMOBIINAE).

DIANE E. JOHNSTONE AND V. R. VICKERY
Lyman Entomological Museum
MacDonald Campus of McGill University
Ste. Anne de Bellevue, 800, Quebec, Canada.

ABSTRACT

Three small ground crickets of the genus *Neonemobius* Hebard, 1913, whose classification has been in a state of confusion, are shown to be valid species. *N. cubensis* (Saussure, 1874) and *N. palustris* (Blatchley, 1900) are valid names for the taxa to which they are applied. *Nemobius* [= *Neonemobius*] *palustris aurantius* Rehn and Hebard, 1911, is synonymized as a colour variety of *N. palustris*. A common *Neonemobius* of the South-eastern United States superficially resembles *aurantius* but is specifically distinct, and may be *N. mormonius* Scudder, 1896.

Key Words: Orthoptera, Gryllidae, Gryllinae, *Neonemobius*, systematics.

INTRODUCTION

Some of the species of Nemoibiinae which were formerly included in the genus *Nemobius* Audinet-Serville, 1839, have been assigned to the genus *Neonemobius* Hebard, 1913 (Vickery and Johnstone, 1970). The placement of the taxa called *palustris* Blatchley, 1900; *cubensis* Saussure, 1874; and *aurantius* Rehn and Hebard, 1911, all of which belong in *Neonemobius*, has been confused for some time. *N. palustris* has been placed as a subspecies of *cubensis* by some authors (Urquhart, 1941; Cantrall, 1968), and as a distinct species by others (Fulton, 1931; Vickery, 1961, 1969). In addition to this, *aurantius* was described as a subspecies of *palustris*, and it is obvious that *palustris* cannot be a subspecies of *cubensis* if *aurantius* is indeed a subspecies of *palustris*.

The types of *Nemobius cubensis* Saussure, 1874, were examined and found to be conspecific with specimens from Florida which were determined as *cubensis* by Dr. T. J. Walker, University of Florida, Gainesville, Florida, U.S.A. A lectotype has been designated in another paper (Vickery and Johnstone, 1970).

Paratypes of *Nemobius palustris aurantius* Rehn and Hebard, 1911, were borrowed from the Academy of Natural Sciences, Philadelphia. In addition, we have studied homeotypic topotypes of *Nemobius palustris* Blatchley, 1900, from Fulton County, Indiana, which were collected and determined by Blatchley.

T. J. Walker sent specimens of *N. cubensis* and of a species ("nr. *mormonius*") that he had tentatively but wrongly (see below) identified as *aurantius*. The *cubensis* were collected at Hollywood Beach, Broward County, Pahokee, Palm Beach County, and Indian River County, Florida, and in addition we have specimens from Pine-crest, Monroe County, and Thompson State Park, Dade County, Florida. The specimens of 'nr. *mormonius*' were from Maclay Gardens State Park, Leon County, and Jackson County, Florida, and we have a specimen from Natchitoches, Louisiana.

A large number of specimens of *palustris* was collected in a sphagnum bog at Lac Carré, Terrebonne County, Quebec, Canada, by R. Lalonde, W. Boyle, and V. R. Vickery. These were recorded by Vickery (1969) [as - *Pteronemobius palustris*]. Samples of many other isolated populations are at hand and a study of the variation between populations will be presented in a separate paper.

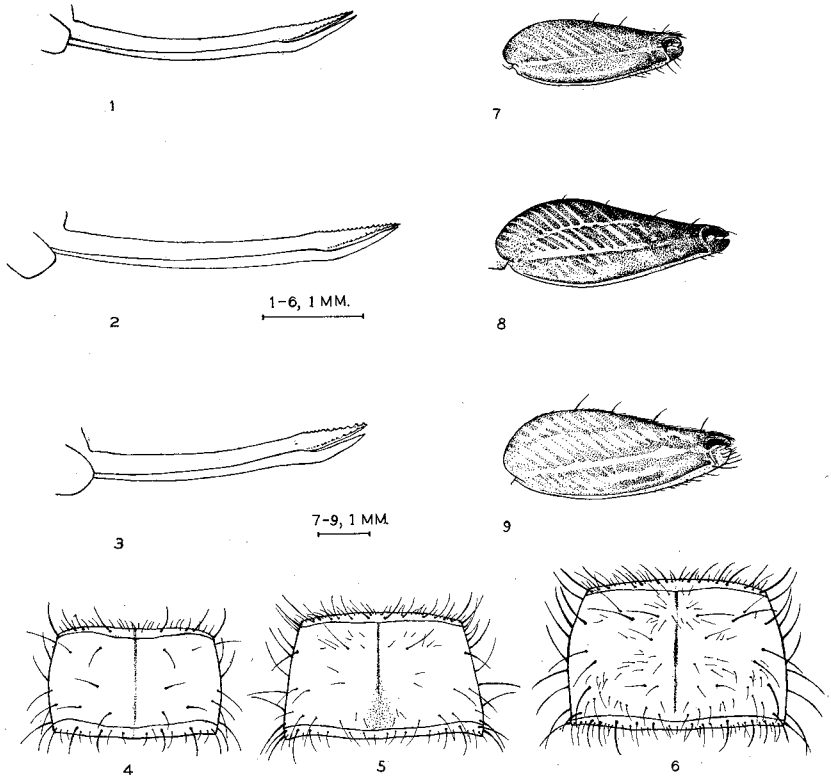
The many isolated populations of *N. palustris* are variable in colour, although this character appears to be rather constant within populations. The paratypes of *aurantius* Rehn and Hebard agree with their description of *aurantius* and also with specimens of *palustris* from a New Jersey population in colour, colouration being the only character which Rehn and Hebard (1911) considered as important in differentiating this "subspecies" from "true *palustris*". Since we have population samples of *palustris* at hand which range from golden-buff to pitchy-black in colour, we are placing the name *aurantius* Rehn and Hebard, 1911, in synonymy under *palustris* Blatchley, 1900. The "nr. *mormonius*" of the southeastern United States, is left nameless, as it is not the same species as that to which the name *aurantius* was originally applied. This species may possibly be undescribed but is, according to Walker [*in litt.*, 1969], at least close to *mormonius* Scudder, 1896.

COMPARISON OF EXTERNAL CHARACTERS

The ovipositor of the female "type" of *aurantius* was said to be 3.5 mm. in length (Rehn and Hebard, 1911) and the ovipositor of a paratype is of the same length. Measurements of the ovipositors of 20 specimens of *palustris* from Quebec, New Jersey, New York and Connecticut range from 3.1 to 3.8 mm. long, with the mean being 3.34 mm. Measurements of samples of five female *cubensis* range from 2.9 to 3.4 mm., with a mean of 3.25 mm, while a similar sample of 'near *mormonius*' ranged from 2.9 to 3.0 mm. The teeth of the dorsal ovipositor valves differ in the three species, apparently in correlation with oviposition habits: in *palustris*, which deposits its eggs in sphagnum (Vickery, 1969), the teeth are extremely fine (Fig. 1); in *cubensis*, which oviposits in soft, moist soil, the teeth, although small and regular (Fig. 2), are coarser than those of *palustris*; 'near *mormonius*' has coarse ovipositor teeth (Fig. 3), since it inhabits dry, well drained areas (Walker, *in litt.*, 1969), and would require stronger teeth for penetration of the ovipositor into this kind of soil.

The shape of the pronotum, in dorsal aspect, differs in the three species: that of *palustris* is slightly rounded laterally with anterior and posterior margins of nearly equal breadth (Fig. 4) (although the hind margin is slightly broader in the topotype); 'near *mormonius*' is distinctly convex laterally and only slightly broader at the hind margin (Fig. 6); in all of the macropterous *cubensis* which were examined, the sides of the pronotum are linearly divergent posteriorly (Fig. 5), while in two micropterous specimens, one male and one female, the pronotum appears more like that of *palustris*. The linear divergence may be an adaptation accompanying macropterism.

The hind femora also differ in shape, those of 'near *mormonius*' being robust (Fig. 9) and broader in proportion to length than either *cubensis* (Fig. 8) or *palustris* (Fig. 7); those of *cubensis* are distinctly more tapered distally than those of the other two species.



Figs. 1-3. Female ovipositors, lateral: Fig. 1 - *N. palustris*, Lac Carré, Quebec; Fig. 2 - *N. cubensis*, Indian River County, Florida; Fig. 3 - *N.* 'near *mormonius*', Jackson County, Florida.

Figs. 4-6. Pronotum, dorsal: Fig. 4 - *N. palustris*, Lac Carré, Quebec; Fig. 5 - *N. cubensis*, Pahokey, Palm Beach County, Florida; Fig. 6 - *N.* 'near *mormonius*', Jackson County, Florida.

Figs. 7-9. Hind femora, lateral: Fig. 7 - *N. palustris*, Lac Carré, Quebec; Fig. 8 - *N. cubensis*, Indian River County, Florida; Fig. 9 - *N.* 'near *mormonius*', Jackson County, Florida.

As previously mentioned, the colour of *palustris* is so variable, that comparison of colour of this species with the other two would be useless. It is, however, worthy of note that in *palustris* the colour is not usually broken into quite well defined blotches or stripes, regardless of basic colour, as is the case in 'near *mormonius*' and, to a lesser extent, in *cubensis*. In *palustris* the tegmina do not usually have a well defined stripe on the lateral fold as in 'near *mormonius*' and also in *cubensis*. *N. cubensis* and 'near *mormonius*' can be separated on the basis of colour.

N. cubensis is generally ebony-brown to nearly black, with pale greyish-buff markings; tegmina with rather poorly defined blackish patches in the basal area, spreading somewhat apically, with the tip a translucent

greyish-cream color; tegmina medially with a broad stripe of greyish-cream extending from base to tip and sharply divided by the nearly black lateral fold which is also bordered by paler colour (in a few dark specimens, this pattern is nearly totally obscured, having only a narrowed pale stripe at the median fold); face and vertex dark, without stripes; pronotum dark, sometimes with buff or greyish spots which are more numerous at the hind edge; underside of body paler than dorsally; legs light brownish, with varying degrees of black infuscation; hind tibial spurs paler at bases and tips.

Neonemobius 'near *mormonius*' is generally golden brown in colour, or buff overlaid with brownish grey mottlings; head with a transverse dark line crossing the occiput and continuing to the eyes, giving a "collared" appearance; anterior border of pronotum ringed with a conspicuous profusion of black setae; legs rich buff to grey with black setae on the femora; tibial spurs brownish-buff; a few brown striations cross the hind femur, especially along the central half and on the upper edge; body pale beneath; male tegmen buff, smudged with dark brown at the base and between the veins near the base, a distinct brown patch occurs along the outer edge in front of the cordal area, some main veins suffused with brown, apical area silvery-buff, a broad stripe of cream or cream-buff extends the length of the tegmen, and, adjacent to this is an intense dark patch over the greater part of the lateral fold, which however, is bordered by cream; tegminal colour in the female is similar except that the darker areas near the centre and the tip are broken by buff cross-veins, giving a "checkered" appearance.

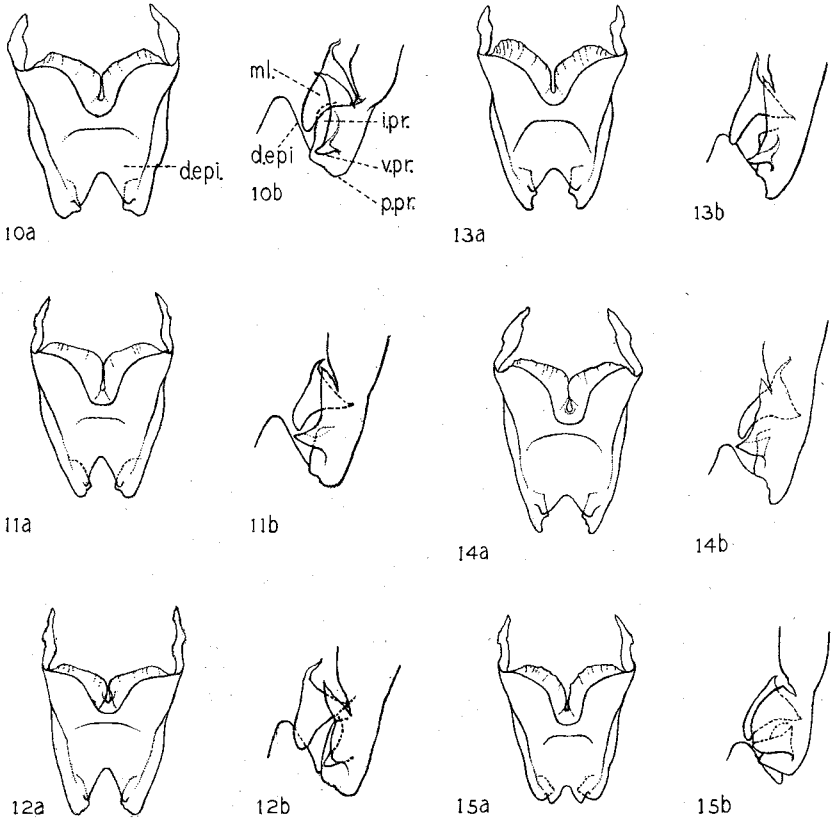
N. palustris appears to be entirely micropterous; no specimen has been found in which the wings extend beyond the tip of the abdomen. Walker (*in litt.*, 1969) states that "*N.* 'near *mormonius*' is close to 100% micropterous", although one lab-reared specimen provided by Walker is macropterous. Walker (*l.c.*) also states that *N. cubensis* is frequently macropterous in Florida and "often flies to light in numbers".

Walker (*l.c.*) stated that *cubensis* and 'near *mormonius*' can be distinguished easily as nymphs in the first instar, since in first instar *cubensis* most of the antennal flagellum is white. This is also the case in early instar nymphs of *palustris*, from Lac Carré, Quebec, and from South Ohio, Yarmouth County, Nova Scotia.

Stridulation

Walker (*in litt.*, 1969) has kindly analyzed and commented on tape recordings made of *N. palustris* males in Quebec. In addition, he has provided information on stridulation and on the stridulatory files of males of *N. cubensis* and of the species 'near *mormonius*'.

N. cubensis has a slightly slower pulse rate than 'near *mormonius*' (55 vs. 58 p/sec. at 25°C.), and that of *palustris* is even slower (42 p/sec.), although the phrasing of *cubensis* and *palustris* is similar. In comparison of tapes of *cubensis* from Florida and *palustris* from Quebec, this difference is consistent and does not overlap. It is significant to note that the songs of *Allonemobius fasciatus* (De Geer) from Florida and from Quebec are identical, as are the songs of *Eunemobius c. carolinus* (Scudder) from these areas (Walker, *l.c.*).



Figs. 10-15. Male external genitalia: (a) - dorsal aspect; (b) - ventral aspect of terminal processes (enlarged) (*ml* - mesal lobes; *d.epi.* - distal part of dorsal epiphallallic plate; *p.pr.* - posterior process; *v.pr.* - ventral process; *i.pr.* internal process. Note - Ventral processes 'open' in 10b, 12b and 13b; 'closed' in 11b, 14b and 15b.) Fig. 10 - *N. palustris*, topotype, Fulton County, Indiana; Fig. 11 - *N. palustris aurantius*, paratype, Thomasville, Georgia; Fig. 12 - *N. palustris*, Lac Carré, Quebec; Fig. 13 - *N. cubensis*, Hollywood Beach, Florida; Fig. 14 - *N. cubensis*, lectallotype, Cuba; Fig. 15 - *N. 'near mormonius'*, Maclay Gardens State Park, Leon County, Florida.

The calling song of 'near *mormonius*' consists of fast-pulsed, high-frequency trills lasting 10-20 seconds or longer, with each trill immediately preceded by a series of single, irregularly spaced pulses. The trill increases in frequency during the first three seconds and remains steady for the duration of the trill.

Stridulatory apparatus

The three species vary slightly in numbers of teeth on the stridulatory file: *cubensis* (Florida), 120-132, mean 128 in a sample of 5; *palustris*

(Lac Carré, Quebec), 101-123, mean 115 in a sample of 15; 'near *mormonius*' (Florida), 110-123, mean 119 in a sample of 5; in the length of the file in mm. (same samples): *cubensis*, 0.98-1.06, mean 1.02; *palustris*, 0.75-0.90, mean 0.85; 'near *mormonius*', 0.89-0.96, mean 0.93; and in the number of teeth per millimeter: *cubensis*, 122.4-129.0, mean 125.5; *palustris*, 118.8-154.1, mean 136.6; 'near *mormonius*', 123.6-129.7, mean 127.9. Although the samples of *cubensis* and 'near *mormonius*' included here are small, the data correspond very closely with those obtained by Walker (*in litt.*, 1969). The data obtained from one of Saussure's Types of *cubensis* from Cuba are as follows: number of teeth, 132; length of file, 1.05 mm.; number of teeth per millimeter, 125.7, all of which are within the range of the data from specimens of *cubensis* from Florida.

All of the above counts and measurements were made on the right tegmen, since this is the tegmen that operates during stridulation in all cases observed, and in all specimens which were examined the right tegmen was found to lie above the left one. Counts of teeth were also made on the left tegmen of all three species, and in each case, the left tegmen was found to have fewer teeth on the stridulatory file.

Counts of the stridulatory teeth of *N. palustris* from different populations were found to vary rather widely: for example, the topotype from Fulton County, Indiana has 141 teeth; a specimen from Sea Island Junction, New Jersey has 155 teeth; one from Ragged Lake, Ontario has 115 teeth; several from South Ohio, Yarmouth County, Nova Scotia, range from 125 to 135 teeth; and a series from Mer Bleue bog, near Ottawa, Ontario, ranges from 124 to 143 teeth. This is not surprising, since *palustris* occurs in isolated colonies (*cubensis* and 'near *mormonius*' apparently do not) and these disjunct populations of *palustris* have altered in several aspects due to their limited gene pools.

Male Genitalia

Fulton (1931) was the first to show that the male genitalia of nemobiine crickets in North America have taxonomic significance. He showed distinct differences in "attached lateral pieces" which he called "claspers", and had lobes which he labelled as "distal", "ventral", "inner", and "movable".

Johnstone (in preparation) has homologized the external male genitalia of nemobiines morphologically with those of the grylline crickets. She also considers the terminal processes of the lateral epiphallic plates ("claspers" of Fulton) to be of taxonomic value in the nemobiines, as well as the posterior edge of the epiphallus in some cases, the shape of the mould-capsule for the tip of the spermatophore tube, while in other cases the relative size and shape of the entire phallic complex is diagnostic.

The terminal process (they are not true lobes, Johnstone, *loc. cit.*) are processes of the lateral epiphallic plates as follows (Fig. 10b): posterior process, *p.pr.* ("distal lobe" of Fulton); ventral process, *v.pr.* ("ventral lobe" of Fulton); and an internal, darkly pigmented, often thickly clavate process, the internal process, *i.pr.* ("inner lobe" of Fulton). The structure which Fulton (*op. cit.*) called the "movable lobe" is actually the mesal lobe, (*ml*, Fig. 10b) and is homologous with the mesal lobe of the Gryllinae. The structure which Fulton called the "dorsal flap" is actually the terminal part of the dorsal epiphallic plate, (*d.epi.*, Fig. 10a).

The epiphallic processes differ in the three species under consideration, as is shown in Figs. 10b-15b. The posterior process is broad, shallowly notched, and blunt on the distal border in the topotype *palustris* (*p.pr.*, Fig. 10b), the same in the paratype *aurantius* (Fig. 11b) and in *palustris* from Quebec (Fig. 12b); narrower with a posterolateral projection in *cubensis* from Florida (Fig. 13b) and in the lectallotype from Cuba (Fig. 14b); short and broad without distal notches or minute teeth in 'near *mormonius*' Fig. 15b). The ventral process (*v.pr.*, Fig. 10b) is small and triangulate in *palustris* (Figs. 10b, 11b and 12b) and in *cubensis* (Figs. 13b and 14b); that of 'near *mormonius*' (Fig. 15b) is larger, broad and subspatulate.

The internal process (*i.pr.*, Fig. 10b) is developed almost horizontally anterior to the posterior process and lies partially beneath the ventral process in *palustris* (Fig. 10b, 11b and 12b) and in *cubensis* (Figs. 13b and 14b); in 'near *mormonius*' it is practically hidden by the medial swelling of the broad ventral process (Fig. 15b); the internal process, in the first two species, is obscured when the semi-mobile lateral epiphallic plates are closed ventro-mesad.

The mesal lobes (*ml.*, Fig. 10b) of the three species are all somewhat triangulate and are directed nearly posteriorly. Those of *palustris* (Figs. 10b, 11b and 12b) and of 'near *mormonius*' (Fig. 15b) are broad and subspatulate distally, that of the latter species being comparatively broader at the bases and shorter than in *palustris*; those of *cubensis* are more slender and narrowed distally (Figs. 13b and 14b). The mesal lobes of 'near *mormonius*' appear to be partially fused beneath the swollen anterior extensions of the ventral processes, while those of *palustris* and *cubensis* are freely mobile, attached by membranes to the lateral epiphallic plates and to the apodemes of the united dorsal lobes.

Another point of difference is found in the posterior edge of the dorsal epiphallic plate (*d.epi.*, Fig. 10a) as seen in dorsal aspect: in *palustris* (Figs. 10 to 12) and in *cubensis* (Figs. 13 and 14) the paired distolateral extremities of the V-emarginate plate are always shorter than the posterior processes of the lateral epiphallic plates but in 'near *mormonius*' (Fig. 15) always protrude beyond the posterior processes of the lateral epiphallic plates.

HABITAT

N. 'near mormonius' occurs in dry, well drained, open or partly shaded areas, such as roadsides, lawns and pastures.

N. cubensis is found in damp locations such as ditches and areas adjacent to streams and ponds.

N. palustris is confined to sphagnum bogs and its distribution is therefore discontinuous. The variation which has occurred due to the limited gene pool in each isolated population will be dealt with in a future paper.

Fulton (1931) stated that he had never found *cubensis* and *palustris* together in company, but had observed them in close proximity in North Carolina, each in its own type of habitat.

DISTRIBUTION

N. cubensis is recorded by T. J. Walker (*in litt.*, 1969) throughout Florida and in southern and coastal Georgia. Hebard (1913) reported it "from Staten Island, New York, south along the Atlantic coast to the extreme southern portion of the mainland of Florida, and also from Cuba," [the type locality] "Vera Cruz in Mexico, Nicaragua and Costa Rica to Brazil".

N. palustris was described from Fulton County, Indiana (Blatchley, 1900). Hebard (1913, 1934) reported it from Massachusetts, Connecticut, New Jersey, Pennsylvania, Washington, D.C., North Carolina, Illinois, Indiana, South Dakota and Ontario. Fulton (1931) reported it from North Carolina, Cantrall (1968) found it in Michigan, and Urquhart (1941) reported it in Ontario. Vickery (1961) recorded this species from Nova Scotia and from Quebec (Vickery, 1969). At hand are previously unrecorded specimens from a tamarack bog at Telford, Manitoba. The distribution of *palustris* is spotty, due to the sphagnum bog habitat to which it is confined. To the above distribution, Thomasville, Georgia, the type locality of *Nemobius palustris aurantius* Rehn and Hebard, 1911, must be added, since this taxon is synonymous with *Neonemobius palustris* (Blatchley).

Neonemobius 'near *mormonius*' has been recorded by T. J. Walker (*l.c.*) from Georgia, northern Florida, southern Alabama, Mississippi, Louisiana and southeastern Texas. The records of *cubensis mormonius* from Mexico by Hebard (1913) may well apply to this species.

DISCUSSION

The evidence presented here shows clearly that the three taxa are indeed distinct species. Both *palustris* Blatchley, 1900, and *cubensis* Saussure, 1874, are valid names for the taxa to which they are applied. The name *aurantius* Rehn and Hebard, 1911, is synonymized with *palustris*. The species from the southeastern United States is probably nameless although it is 'near *mormonius*' Scudder, 1896. Future study on the true identity of this species will be carried out by T. J. Walker.

ACKNOWLEDGEMENTS

The invaluable assistance of Dr. T. J. Walker, Department of Entomology and Nematology, University of Florida, Gainesville, Florida, is gratefully acknowledged. He provided many specimens, as well as notes and data on *N. cubensis* and on 'near *mormonius*'. Thanks are also extended to Dr. R. D. Alexander, Museum of Zoology, University of Michigan, Ann Arbor, Michigan, who read the manuscript.

LITERATURE CITED

- Blatchley, W. S., 1900. On the Species of *Nemobius* Known to Occur in Indiana. *Psyche* 9: 51-4.
- Cantrall, I. J., 1968. An Annotated List of the Dermaptera, Dictyoptera, Phasmatoptera, and Orthoptera of Michigan. *Michigan Ent. J.*: 299-346.

- Fulton, B. B., 1931. A study of the Genus *Nemobius* (Orthoptera: Gryllidae). Ann. Ent. Soc. Amer. 24: 205-37.
- Hebard, M., 1913. A Revision of the Species of the Genus *Nemobius* (Orthoptera: Gryllidae) found in North America north of the Isthmus of Panama. Proc. Acad. Nat. Sci. Phila. 65: 394-492.
- Hebard, M., 1934. The Dermaptera and Orthoptera of Illinois. Ill. nat. Hist. Surv. Bull. 20: 124-279.
- Johnstone, D.E., 1970. The Structure and Homologies of the Male Genitalia of the Nemobiinae (Orthoptera: Gryllidae) [in preparation].
- Rehn, J. A. G., and Hebard, M., 1911. Records of Georgia and Florida Orthoptera with the descriptions of one new species and one new subspecies. Proc. Acad. Nat. Sci. Phila. (1910): 585-98.
- Saussure, H. de., 1874. Etudes sur les Insectes Orthoptères — Famille des Gryllides. Miss. Sci. Mex. Amer. Centr., Pt. 6: 296-516 pl. 7 & 8.
- Urquhart, F. A., 1941. The species of *Nemobius* (Orthoptera, Ensifera) in Ontario. Can. Field-Nat. 40: 80-2.
- Vickery, V. R., 1961. The Orthoptera of Nova Scotia. Proc. N. S. Acad. Sci. 25: 1-70.
- Vickery, V. R., 1969. Two species of *Pteronemobius* previously unreported in Quebec (Orthoptera:Ensifera:Grylloidea:Nemobiinae). Ann. Soc. Ent. Quebec 14: 22-4.
- Vickery, V. R., and Johnstone, Diane E., 1970. The Generic status of some Nemobiinae (Orthoptera: Gryllidae) in northern North America. Ann. Ent. Soc. Amer. 63 (in press).
- J. Georgia Entomol. Soc. 5(4) October, 1970 pp. 233-241.