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Melanoplus nossi Hill (Orthoptera: Acrididae): a grasshopper species endemic to the North American Coastal Plain ?

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ABSTRACT

Additional distribution records and habitat information is presented for *Melanoplus nossi*. Based on the information currently available, *M. nossi* appears to be endemic to the North American Coastal Plain where it inhabits a variety of open forest or woodland conditions.
Key words: North American Coastal Plain, field notes, Melanoplinae

INTRODUCTION

The North American Coastal Plain (NACP) has been an area of interest to botanists and zoologists for several centuries; however, the overall biotic significance of the region went largely unnoticed until recently when several studies congruently illustrated the biological richness of the region, which resulted in it subsequently being named the world's 36th biodiversity hotspot (Noss 2016). Even with the long history of biological exploration, undescribed species are still being found in the region. One such species is *Melanoplus nossi* Hill (Orthoptera: Acrididae: Melanoplinae) (Fig. 1), a brachypterous grasshopper species and a member of the *Tribulus* (*sensu lato*) species group that was described in 2014 based on a small series of specimens from two locales in adjacent counties on either side of the Florida-Georgia state line (Hill 2014). In recent years, new specimens of *M. nossi* were discovered among the undetermined specimens of the University of Michigan Museum of Zoology (UMMZ) and during further field studies of *Melanoplus* in the southeastern United States. Additionally, specimens of *M. nossi* from North Carolina, which were housed in the private collection of SH, were sent to JGH for identification. To further elucidate the natural history of this recently described species, we herein report these new records of *M. nossi*, which greatly expand its range into Georgia and include the first records from North Carolina, along with more detailed morphological and habitat information.

METHODS

Specimens examined in this study were borrowed from the UMMZ or were collected by the authors and deposited in the Mississippi Entomological Museum (MEM) or the Texas A&M University Insect Collection (TAMU). Woller and Hill (2015) demonstrated how detailed field notes that are linked to specimens can provide more detailed locality and habitat information than what is typically presented on a specimen label. Likewise in this study, habitat information from historical specimens was found by linking the code numbers on the locality labels of the specimens to field notebook entries by T.H. Hubbell (1953).

Photos of the live specimens in Figure 1 A&B) were taken by DAW in the Song Laboratory of Insect Systematics and Evolution in a simulated habitat using a Canon EOS 6D Digital SLR Camera equipped with a 100 mm lens and a Cannon MT-24EX Macro Twin Lite Flash paired with two multi-directional halogen lights for additional lighting. Figure 1C was taken in the field by SH using a Canon 7D DSLR and EF 100mm f/2.8L IS USM Macro Lens. The illustration in Figure 1D was created by JGH using a drawing

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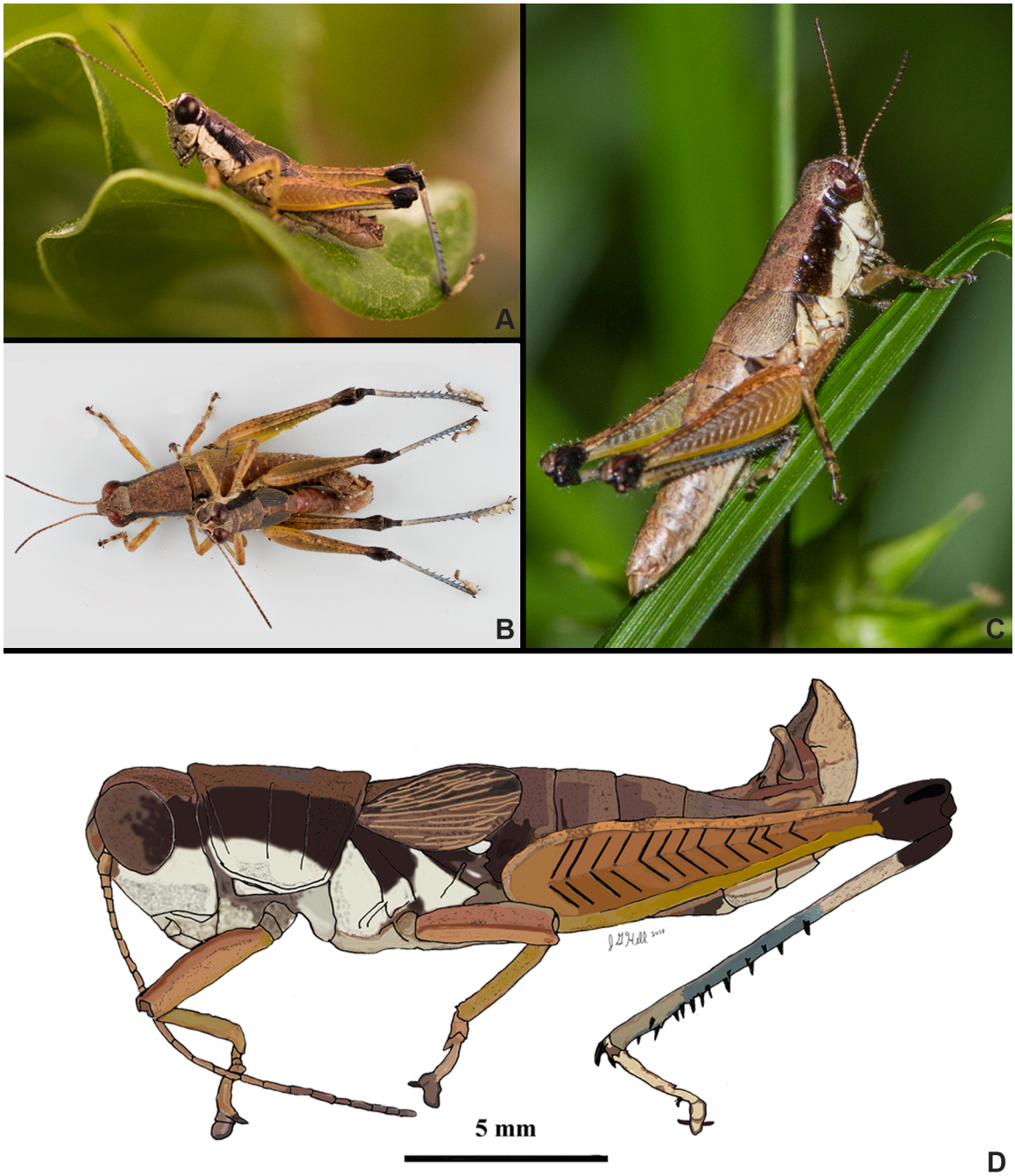

Figure 1. *Melanoplus nossi*: A) Live photo of a male (taken in a simulated indoor habitat), B). Live pair *in copula,* C) Live photo of a female (taken in a simulated indoor habitat), D) Illustration of a male.

tube mounted on a Leica MZ 100 microscope and colorized with Adobe Photoshop CS6.

Many of the UMMZ staff's field notebooks and maps have been digitized and are available upon request to the collection manager. The entries relevant to *M. nossi* were isolated using Adobe Acrobat's selection tool and then enhanced with Adobe Photoshop CS6 (Figs. 2 & 3). Habitat information for recently collected specimens from Georgia was collected by DAW and JGH and that from North Carolina was collected by SH.

The habitat photos (Fig. 4) were taken by DAW using a Ricoh WG-4 GPS Adventure Proof camera, which was also used to capture the coordinates for some of the Georgia locations.

The modern locality map (Fig. 5) was created using a CSV file created in Microsoft Excel, a KML file containing the boundary of the NACP floristic province, and Google's My Maps web-based software. The recently unearthed historical map (Fig. 5) came from Hubbell's 1953 and 1954 collecting trips to Decatur County, Georgia. Both maps were edited with Adobe Photoshop CS6 for cropping purposes and adding the map legends.

Given the rather limited geographic distribution and number of individuals of the type series, 41 specimens of *M. nossi* from across its updated distribution were measured to better document intraspecific morphological variation that may exist in the species. Measurements were made with a reticle mounted inside a Leica MZ12.5 stereomicroscope in the following ways:

Body Length — Dorsally from the fastigium vertices to the distal end of the genicular lobe of caudal femur in a parallel plane with the abdomen.

Pronotum Length — Dorsally, along the median carina.

Tegmen Length — Laterally, from the junction of the ventral margin of the left tegmen and the caudal margin of the pronotum to its apex.

Hind Femur Length — Laterally, from the base to apex of the left femur.

Cercus Length — Laterally, maximum possible measurement of the left cercus.

Cercus Basal Width — Laterally, along the point of attachment from the dorsal to ventral margin.

Cercus Mid Width — Laterally, at the mid-length of the left cercus

Cercus Apex Width — Laterally, along the distal end.

RESULTS

Specimen measurements — Male (mm) : (n = 18) Body length 17.5 – 22.5 (mean = 23.9); pronotum length 4.0 – 4.7 (mean = 4.4); tegmen length 3.3 – 4.2 (mean = 3.7); hind femur length 10.5 – 12.1 (mean = 11.2); cercus length 1.2 – 1.5 (mean = 1.4); basal width of cercus 0.4 – 0.7 (mean = 0.5); mid-cercal width 0.2 – 0.4 (mean = 0.3); cercus apex width 0.3 – 0.4 (mean = 0.3).

Female (mm): (n = 23) Body length 22 – 26.5 (mean = 23.9); pronotum length 4.8 – 6.0 (mean = 5.4); tegmen length 3.3 – 5.8 (mean = 4.6) hind femur length 11.9 – 14.7 (mean = 13.4).

Specimens examined — Note that each UMMZ specimen is given a unique identifier in the form of "UMMZI-#" and "UMMZI-000" will only be used for first entry; GPS coordinates are based on the WGS84 system: – 121 specimens: 47♂, 69♀, 5 nymphs. **Florida**: Liberty Co., Torreya State Park, ravine forest, 31 May 1953, T.H. Hubbell, Field # 7a (3♂ = UMMZI-00056746 – 56770, 1♀ = 56760); 4 June 1953, Field # 29 (24♂ 56666-56673, 56677, 56703-56716; 5 nymphs 56719-56722, 56708; 29♀ = 56674-56702, 56731); 16 June 1953, Field # 81 (5♂ = 56771 – 56775, 9♀ = 56761 - 56769). Torreya State Park, 10 mi N Bristol, ravine, 23 June 23 June 1956, T.J. Cohn & P.B. Kannowski, Field # 29 (4♂ = 56723 – 56728; 9♀ = 56729-56730, 56732 – 56739). **Georgia**: Decatur Co., 7 mi WSW Faceville, District 21, Lot 368, Mosquito Cr[eek] Hammock. 20 June 1956, T.J. Cohn & P.B. Kannowski, Field # 19 (5♂ = 57049- 57050, 256974 – 56975, 1 unnumbered; 8♀ = 56976-56983); 27 June 1956, Field # 41 (1♀ = 57048). Mosquito Cr[eek] on GA Hwy 97, 14 June 1953, T.H. Hubbell, Low hammock (1♀ = 57042); 15 June 1953, Field # 78 (3♂ = 56932-569343**);** 16 June 1953 Field # 80 (3♂ = 56958-56960, 3♀ = 59653-59655**)**. Jefferson Co. 2 mi. N Wadley, 32.895854, -82.394444, 18 May 2014, D.A. Woller & E. Kosnicki, (1♂, 1♀)(TAMUIC); 32.890923, -82.400249, 18 May 2014, D.A. Woller & E. Kosnicki, (2♂) (TAMUIC); Wadley, 32º53'27"N 82º24'01"W, 13 May 2015, J.G. Hill, D.A. Woller,

in understory of pine plantation (1♂)(MEM); NE edge of Wadley, 32.870836, -82.392727, 13 May 2015, D.A. Woller & J.G. Hill (1♂, 2♀ MEM). **North Carolina:** Martin Co., Devil's Gut Preserve, 35.83406 -76.951874, 25 June 1996, S. Hall, ridge hardwood forest, 6 ft (1♂, 1♀ MEM); 19 July 1996, (1♂, 1♀ MEM). Northampton Co., Roanoke River Wetlands Game Land, 36.325459 -77.462956, 14, June 2012, S. Hall, floodplain, 30ft (Specimens) (MEM); Pender Co., Rocky Point Marl Forest, 34.445936º, -77.862544º, 18 May 1998, S. Hall, marl forest, 22ft 1♂, 1♀.MEM).

Habitat Descriptions

North Florida /Southwest Georgia — Hill (2014) described the habitat of *M. nossi* "as understory of hardwood forest ravines in Torreya State Park that were also inhabited by small individuals of the Florida torreya (*Torreya taxifolia*)" and an "abandoned home site that was converting back to forest in a somewhat open area, which was likely the former lawn of the house, as evident by scattered patches of St. Augustine Grass (*Stenotaphium secundatum*) and cultivated azaleas (*Rhododendron* sp.) growing around the bases of the large pine trees (*Pinus* sp.)". At the second locale, *M. nossi* was collected among wild grape (*Vitis* sp.) and Carolina jasmine (*Gelsemi sempervirens*) growing along the ground".

In his field notes, Hubbell (1953) describes collecting *M. nossi* along slopes and ravines in Liberty County, Florida much like Hill (2014) did 61 years later. In the same field notes, Hubbell described the site in Decatur County, Georgia as the edge of a road ditch and a low hammock along Mosquito Creek (see Hubbell's original map of the site in Fig. 2) with pignut hickory (*Carya glabra*), sourwood (*Oxydendron arboretum*), cane (*Arundinaria* sp.), and a variety of shrubs and vines. Detailed descriptions of the vegetation are given in the field notes, which are presented in Figure 3 and in typed form in Table 1.

Jefferson Co., Georgia —The sites located two miles north of Wadley, Jefferson County, (32.895854, -82.394444: Fig. 4A and 32.890923, -82.400249: Fig. 4B) where *M. nossi* was collected more recently were relatively young upland pine-hardwood forests. Predominant trees included loblolly pine (*Pinus taeda* L.), sweetgum (*Liquidambar styraciflua* L.), and various oaks (*Quercus* ssp.). At these sites, oak seedlings and a dense layer of pine needles and hardwood leaf litter covered the ground. Additionally, like the Georgia locality described by Hill (2014), a portion of these areas seems to have been the site of a home (or other manmade structure) at some point in the past due to the various bricks around and other human-related debris. The site located at the edge of Wadley (32.870836, -82.392727: Fig. 4C) was a pine plantation with an understory consisting of Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch), Carolina jasmine, scattered ferns, and a fairly dense canopy.

Martin County, North Carolina — The Devil's Gut Preserve is located within the floodplain of the Roanoke River and includes both swamp forests as well as bottomland and upland forest located on old terraces and narrow ridges. The site where the population of *M. nossi* was discovered in 1996 is located along a narrow ridge and accessed by way of an old logging road. The central portion of this ridge rarely floods and supports a fairly mature, though second-growth, stand of Dy-Mesic Oak-Hickory Forest (Coastal Plain Subtype). Relatively large America beech (*Fagus grandifolia*) were present, as were white oaks (*Quercus alba*), southern red oak (*Q. falcata*), black oak (*Q. velutina*), mockernut hickory (*Carya tomentosa*), and other characteristic upland species. Most of the trees were under 2.5m diameter at breast height. Understory species included red maple (*Acer rubrum*), ironwood (*Carpinus betulae*), flowering dogwood (*Cornus florida*), and American holly (*Ilex opacum*). The herb layer was sparsely developed at this site, although a few grass species, including longleaf spikegrass (*Chasmanthium sessilifolium* var. *sessilifolium*), were common, particularly along the logging road where the *Melanoplus* specimens were collected. Thickets of blueberries (*Vaccinium* spp.) were also present, although patchy in occurrence.

The lower portions of the ridge support Brownwater Bottomland Hardwood Forest (High Subtype). Red maple, willow oak (*Q. phellos*), laurel oak (*Q. laurifolia*), cherrybark oak (*Q. pagoda*), water oak (*Q. nigra*), sweetgum (*Liquidambar styraciflua*), and loblolly pine (*Pinus taeda*) were present in the canopy. Ironwood was common in the shrub layer,

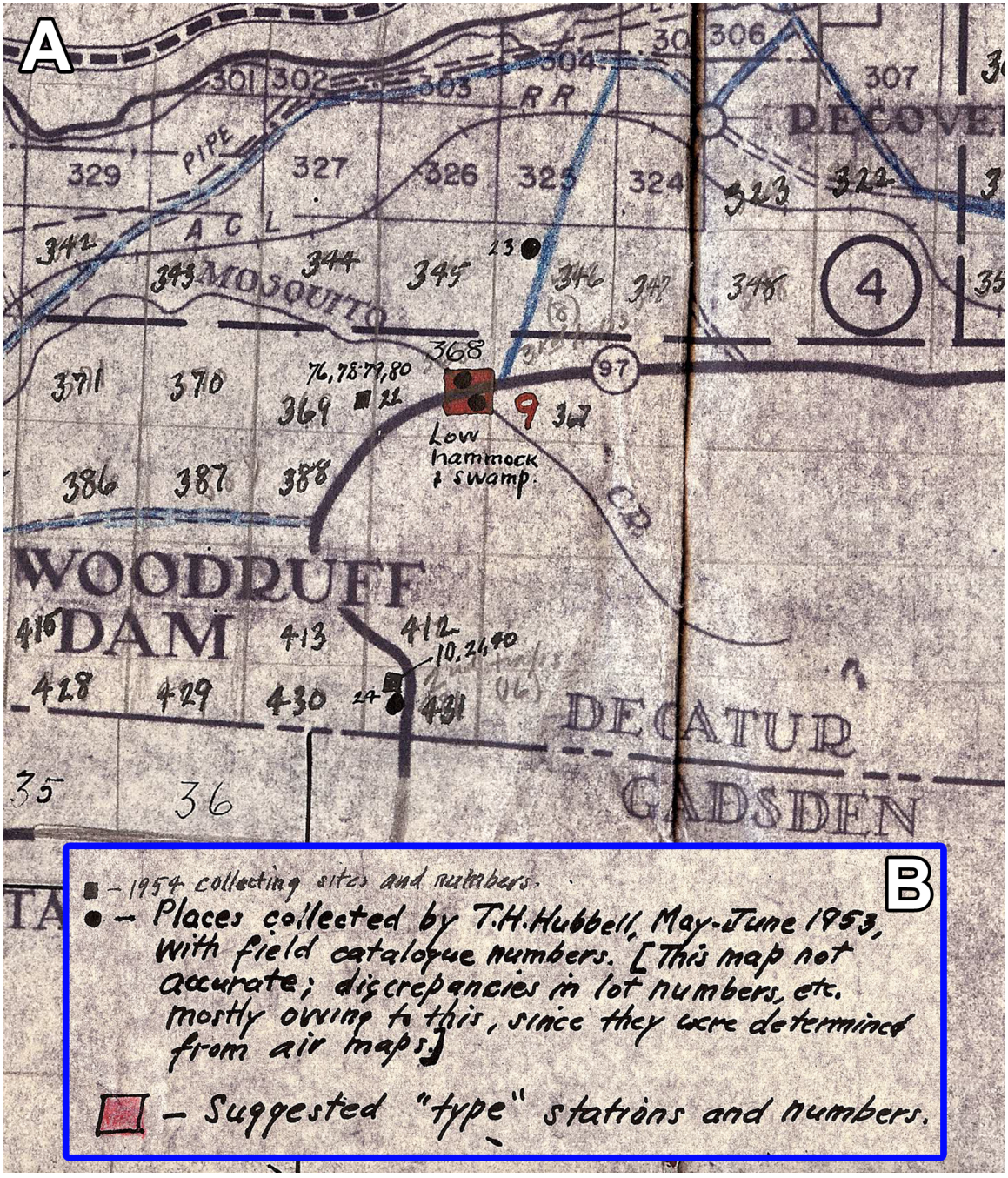

Figure 2. A) T.H. Hubbell's historical map of collecting trips (1953 and 1954) to Decatur County, Georgia where *Melanoplus nossi* was initially discovered in 1953, B) Original map legend.

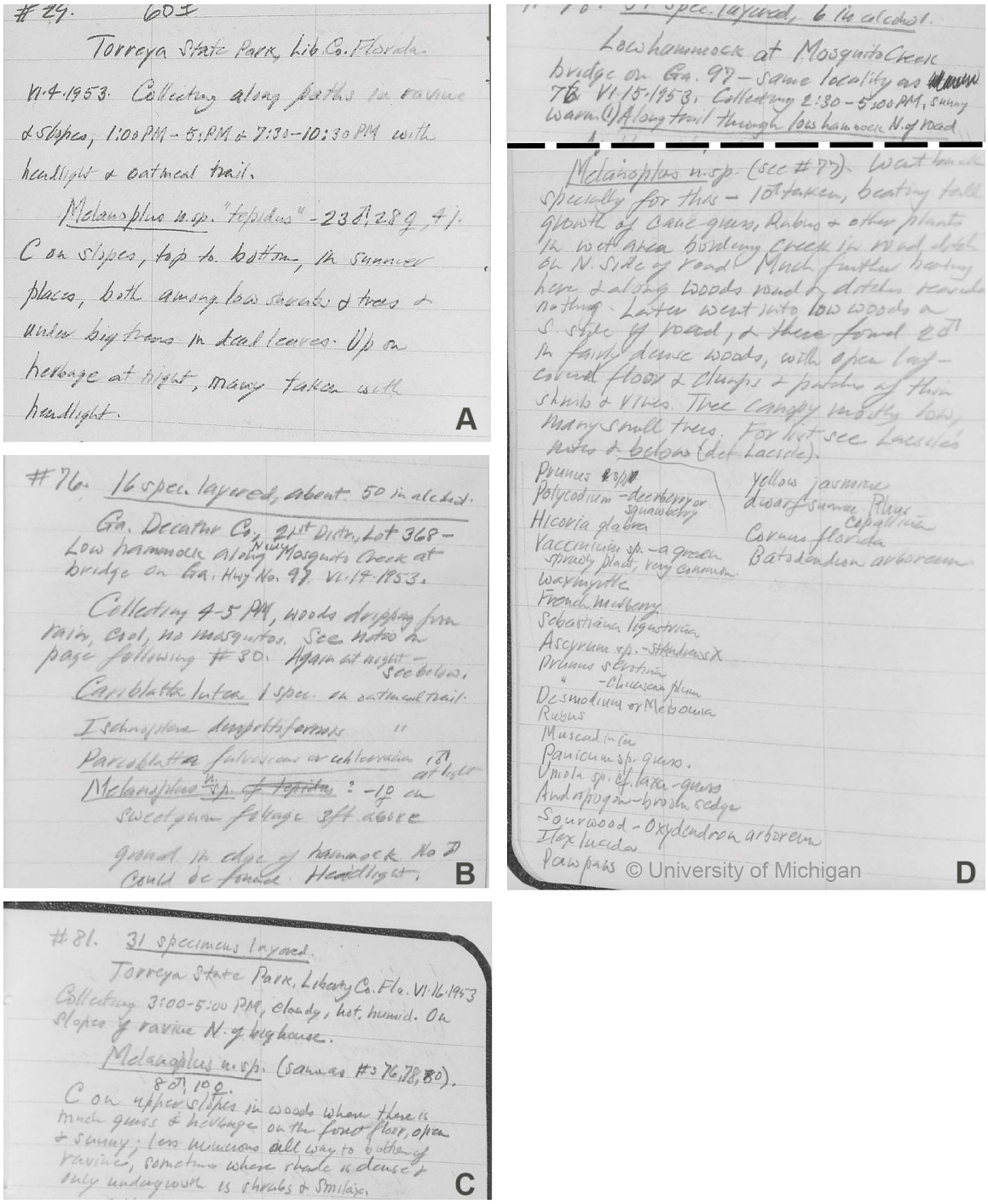

Figure 3. Field notebook entries from Hubbell (1953): A) #29, B) #76, C) # 81, D) #78. [Digitized field notebooks: M.J. O'Brien; enhanced selections: JGH].

Table 1. Field Notes Transcripts From Hubbell (1953)

#29. Torreya State Park, Lib[erty] Co. Florida.

VI.4-1953. Collecting along paths in ravine and slopes, 1:00 PM -5PM and 7:30-10:30 PM with headlight and oatmeal trail.

Melanoplus n. sp. "tepidus" 23♂, 28♀, 4 j[uvenile].

C[ollected] on slopes, top to bottom, in sunnier places, both among low shrubs and trees and under big trees in dead leaves. Up on herbage at night, many taken with headlight.

#76. 16 spec[imens]. Layered, about 50 in alcohol

Ga. Decatur Co., 21st Distr[ict], Lot 368 –

Low hammock along New Mosquito Creek at bridge on Ga. Hwy No. 97. VI-14-1953.

Collecting 4-5PM, woods dripping from rain, cool, no mosquitos. See notes on page following #30. Again at night – See below.

Cariblatta lutea 1 spec[imen]. On oatmeal trail.

Isch.....d

Parcoblatta fulv 1♂ at light

Melanoplus n. sp. cf tepidus? 1♀ on sweetgum foliage 3 ft above ground in edge of hammock. No ♂.

#81. 31 specimens layered

Torreya State Park. Liberty Co., FlA. VI-16-1953

Collecting 3:00-5:00 PM, cloudy, but humid. On slopes of ravine. N. of big house.

Melanoplus n. sp. (same as #76,78,80). 8♂, 10♀.

C[ollected] on upper slopes in woods where there is much grass and herbage on the forest floor, open and sunny; less numerous all way to bottom of ravine, sometimes where shade is dense and only undergrowth is shrubs and *Smilax*.

#78. 54 Spec[imens] layered, 6 in alcohol.

Low hammock at Mosquito Creek. Bridge on GA. 97 – same locality as 76 VI-15-1953. Collecting 2:30 -5:00 PM Sunny warm (1) Along trail through low hammock N of road.

Melanoplus n.sp (see **#77**). Went back specifically for this - 10♂ taken, beating tall growth of cane grass, Rubus and other plants in wet area bordering creek in road ditch on N. side of road. Much further beating here and along woods ???? and ditches revealed nothing. Later went into low woods on S. side of road, and there found 2♂ in fairly dense woods, with open leaf covered floor and clumps and patches of thin shrubs and vines. The canopy was mostly low, many small trees. For the list see Lacsile's notes and below. (det Lacsile).

Prunus sp.
Polycodium
Hicoria glabra [*Carya glabra*-pignut hickory]
Vaccinium sp. – a green sprout plant, very common
Wax myrtle [*Myrica cerifera*]
French Mulberrry [*Callicarpa americana*]
Sebatiaua liguastrium [*Ditrysinia fruticosa* – candleberry]
Ascyrium sp. [*Hypericum*]
Prunus serotina
Desmodium
Rubus
Muscadine
Panicum sp. grass
Uniola sp. cf *laxa*
Andropogon –broom sedge
Sourwood - *Oxydendron arboretum*
Paw paw
Yellow jasmine
Dwarf sumac – *Rhus copallina*
Cornus florida
Batodendion arboretum [=*Vaccinium arboretum*]

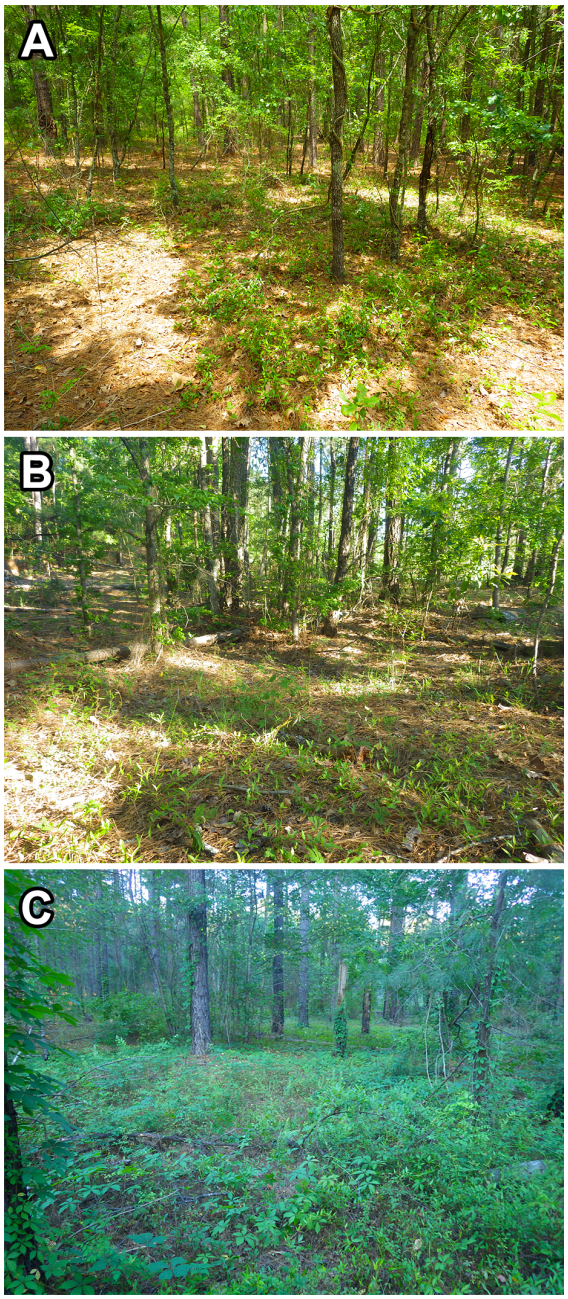

Figure 4. Habitat photos from Jefferson County, Georgia: A) 2 mi. N Wadley, 32.895854,-82.394444; B) 2 mi. N Wadley, 32.890923, -82.400249; C) NE edge of Wadley, 32.870836, -82.392727.

as were large patches of cane (*Arundinaria* sp.). Highbush blueberry were present too, but more scattered. Immediately adjoining the ridge, and completely surrounding it, is a backswamp composed of bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), and swamp cottonwood (*Populus heterophylla*), with scattered alluvial hawthorns (several different *Crataegus* species) and patches of *Carex* around the edges. Before the creation of the large flood-control and hydropower dams upstream, most of this area was swept almost annually by floods that covered nearly all of the vast floodplain of the lower Roanoke. The presence of beech and other flood-intolerant species along the higher ridges and terraces, however, indicate that at least a few places were able to escape at least prolonged flooding. Those are the sites where *M. nossi* also likely survived.

Northampton County, North Carolina — The site where a population of *M. nossi* was found is within the Roanoke River Wetlands Game Land located along the Roanoke River approximately 70.8 km (straight line) upstream from the Devils Gut Preserve site. The floodplain there is much narrower and contains fewer deep swamps. Instead, both the floodplain and adjoining slopes are characterized by deep deposits of sediment, with high levees created along the river and rich bottomland forests behind them covering most of the intervening space up to the steep bluffs forming the valley wall.

The first specimens of *M. nossi* at this site were found in June, well out in the bottomland, within a mature stand of Brownwater Levee forest (High Levee Subtype). The canopy was composed of green ash (*Fraxinus pennsylvanica*), sweetgum, sugarberry (*Celtis laevigata*), red maple, and box elder (*Acer negundo*). The *Melanoplus* themselves were found in a particularly extensive sedge meadow composed mainly of Asa Gray's sedge (*Carex grayi*), along with a few other species of sedges and wetland grasses. Similar sedge meadows were observed at other sites along the upper part of the Roanoke floodplain, covering many square miles of habitat. Although flooding is less prolonged than in the past, this portion of the floodplain is probably still inundated on an annual basis.

Specimens found at this site in July were also located in sedge meadow habitat, but much closer to the foot of the bluffs that form the outer wall of the

Roanoke floodplain; some individuals were seen up on the toe of the slope itself. As in the downstream site, *M. nossi* may gain some protection from flooding by occupying higher ground in addition to the floodplain itself. Although rich in herbaceous species, the slope does not contain the same abundance of graminoids as the floodplain.

Pender County, North Carolina — The site in Pender County where specimens of *M. nossi* were collected at Rocky Point Marl Forest, an example of a non-riverine, wet flat. Although it is located on an old terrace of the Northeast Cape Fear, a blackwater tributary of the Cape Fear River, it now rarely, if ever, receives any flooding from the river itself. Nonetheless, the flat terrain and poor drainage cause it to be fairly wet throughout the year, and the area supports a flora more typical of bottomlands than the uplands of the Coastal Plain.

This site, however, is far from typical. A layer of marl (a form of limestone) is located close to the surface here, and is actually exposed in some places. Due to the rich soils that weather from marl, the forest supports a flora that is far more similar to the bottomland hardwoods found along brownwater rivers, such as are present along the Roanoke, than along the sandy, acidic, nutrient-poor soils characteristic of blackwater systems. The canopy and subcanopy, for instance, contain water hickory (*Carya aquatica*), bitternut hickory (*Carya cordiformis*), green ash, Shumard's oak (*Q. shumardii*), Florida maple (*Acer floridanum*), boxelder and redbud (*Cercis canadensis*). Shrubs include pawpaw (*Asimina triloba*), painted buckeye (*Aesculus sylvatica*), red buckeye (*Aesculus pavia*), hop hornbeam (*Ostrya virginica*) and dwarf palmetto (*Sabal minor*). Even more significant is the presence of nearly obligate calciphiles, most notably nutmeg hickory (*Carya myristiciformis*), which is one of the dominant trees at this site but is found almost nowhere else in the state. Other calciphiles include basswood (*Tilia americana var. caroliniana*) and eastern rough-leaf dogwood (*Cornus asperifolia*).

DISCUSSION

Based on the data available at this time, *M. nossi* appears to be endemic to the southeastern region of the NACP (Fig. 5). Populations of *M. nossi* appear to be strongly localized. This was especially evident along the Roanoke River, where extensive field-work was conducted in the floodplain during 2012, including visits to nine sites from May to July, all with habitats similar to those the one where *M. nossi* was originally collected. Following the discovery of *M. nossi*, the species was a particular target of survey efforts along the Roanoke River and the following year during the same time span and in similar habitats along the Tar River (a brownwater river), but without any success. The highly localized nature of *M. nossi* is interesting, given the species' ability to inhabit a variety of forest types (upland and bottomland) and groundcovers (Fig. 5), which is similar to the more widespread members of the *Tribulus* (*sensu lato*) species group, such as *Melanoplus tepidus* Morse, with which *M. nossi* was once confused (Hill 2014).

Only the populations in Torreya State Park, Florida and Northampton County, North Carolina appear to be secure. These populations occur within state-owned properties that are likely to be maintained in their current condition. All of the currently known populations in Georgia occur on private property with significant coverage by *Pinus* spp., making the sites likely targets for logging activities. The population in Martin County, North Carolina in the lower portion of the Roanoke floodplain is also currently protected within preserve managed by The Nature Conservancy. However, this portion of the floodplain lies only about 6 feet above sea level and is likely to be permanently inundated or subject to salinization due to sea level rise. Since the population at that site is confined to a narrow ridge of higher ground, completely surrounded by swamps, there is little chance the population will be able to retreat as the water levels rise. The population of *M. nossi* in Pender County, North Carolina appears to be restricted to a remnant of what was previously a much larger expanse of the marl forest, all of which is privately owned and much of which has been clear-cut over the past couple of decades. The southern part of the marl forest, moreover, is now being mined for marl and a large swath in the central portion was obliterated by construction of Interstate 40 While the remnants of this unique forest have been high priorities for conservation since it was first documented back in the 1980s no progress has been made in protecting any portion of it.

Figure 5. Distribution of *Melanoplus nossi*. Dots represent collection localities and the line indicates the northern border of the North American Coastal Plain.

The additional collections presented here extend the known geographical range of *M. nossi* from north Florida and the southwestern corner of Georgia to northern North Carolina along the NACP. The discovery of *M. nossi* in North Carolina, raises the total grasshopper species documented from that state to 77 (Hill and Dakin 2011). Given the current known distribution of *M. nossi*, it seems likely that the species also occurs in South Carolina. As is the case with many brachypterous grasshopper species, further survey work is clearly needed to determine the actual range of *M. nossi*, as well as further details concerning its habitat associations.

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