New Report of Brevipalpus yothersi (Prostigmata: Tenuipalpidae) on Blueberry in Florida

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New report of *Brevipalpus yothersi* (Prostigmata: Tenuipalpidae) on blueberry in Florida

**Rana Akyazi**, Eddie A. Ueckermann, and Oscar E. Liburd

**Abstract**

*Brevipalpus yothersi* (Baker, 1949) (Prostigmata: Tenuipalpidae) is newly reported on southern highbush blueberry, *Vaccinium corymbosum* L. X *V. darrowi* Camp (Ericaceae), in Florida, USA. The specimens were collected from a commercial southern highbush blueberry planting of Abundance, Emerald, and Meadowlark blueberry varieties from Sep to Nov 2016. The species is described based on morphological (light microscopy, scanning electron microscopy) methods. Information on its economic importance, host plants, and geographical distribution also is provided.

**Key Words:** false spider mite; flat mite; new record; *Vaccinium* spp.

**Material and Method**

**COLLECTION OF SAMPLES**

Mites were collected from 3 different southern highbush blueberry varieties, Abundance, Emerald, and Meadowlark, from Sep to Nov 2016. Approximately 30 to 50 leaves per blueberry bush were collected every 2 weeks and samples were taken randomly from an organic commercial farm in Eustis, Florida, USA (28.8692°N, 81.63023°W; 38 masl). Samples were placed separately (according to variety) into 3.7 L zipper storage bags, labeled, and brought to the laboratory. There, the mites were collected from the leaves under a stereomicroscope. Specimens were preserved in vials containing 70% ethanol.

**LIGHT MICROSCOPY**

Mite specimens were cleared in Lacto-phenol, mounted in Hoyer’s solution on microscope slides, and dried in an oven at 50 °C. Light microscopy photographs were taken with a JVC KY-F70B digital camera, and automontage pro software (version 5.02, Syncroscopy, Frederick, Maryland, USA) mounted on a Leica DMLB compound microscope. For identification, the following keys were used: Baker et al. (1975); Ghai & Shenhmar (1984); Baker & Tuttle (1987); Welbourn et al. (2003); Mesa et al. (2009); Beard et al. (2015a); and Çobanoğlu et al. (2016).

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All specimens were deposited in the mite collection of Ordu University, Agricultural Faculty, Plant Protection Department, Ordu, Turkey.

Photos of living mites were taken with a digital camera mounted on a stereoscopic microscope LEICA M205 C (Leica Microsystems Inc., Buffalo Grove, Illinois, USA) connected to a computer.

SCANNING ELECTRON MICROSCOPY (SEM)

To prepare specimens for electron microscopy, the method of Çobanoğlu et al. (2011) was used. Briefly, the samples were fixed in 70% alcohol. After fixation, the samples were dehydrated in an alcohol series (70%, 80%, 90%, 100%, and 100%) for 30 m each. Dehydrated specimens were critical-point-dried, and mounted on SEM stubs. Mounted samples were coated with gold/palladium (20 nm). The specimens were examined with a scanning electron microscope (FEI Nova 430 w/EDS & CL, Nanoscale Research Facility, University of Florida, Gainesville, Florida, USA).

Results

Family Tenuipalpidae Berlese

Type genus—Tenuipalpus Donnadieu, 1875
Genus Brevipalpus Donnadieu 1875
Type species: Brevipalpus obovatus Donnadieu 1875

Brevipalpus yothersi Baker 1949

New synonymsies (Beard et al. 2015a):

Brevipalpus mcbridei Baker 1949
Brevipalpus deleoni Pritchard and Baker 1958
Brevipalpus phoenicoides Gonzalez 1975
Brevipalpus amicus Chaudhri 1972
Brevipalpus recula Chaudhri 1972

Fig. 1. Brevipalpus yothersi on blueberry (abundance) leaf - adult (a), egg (b), larva (c), protonymph (d).
Fig. 2. *Brevipalpus yothersi* female - dorsal propodosoma (a), opisthosoma (b).

Fig. 3. *Brevipalpus yothersi* female - dorsal view (a), ventral view (b).

Fig. 4. *Brevipalpus yothersi* female - ventral view of propodosoma (a), the region between coxal fields of legs III and IV, and the bases of setae 3a and 4a, and the area between setae 3a and 4a, and the area posterior to the 4a setae (b).
MATERIAL EXAMINED

One larva, 23.IX.2016; 1 deutonymph, 20.X.2016 on Meadowlark blueberry variety. 1 larva, 1 deutonymph, 23.IX.2016; 1 ♀, 10.X.2016 on Emerald blueberry variety. 2 larvae, 3 protonymphs, 3 deutonymph, 4 ♀, 1 ♂, 23.IX.2016 on Abundance blueberry variety.

STEREOMICROSCOPE ANALYSIS OF DIFFERENT STAGES OF BREVIPALPUS YOTHERSI

Adult females are red-orange in color. They are flat, and oval in shape (Fig. 1a). Eggs are elliptical and bright reddish-orange color (Fig. 1b). Larvae are orange-red and have 3 pairs of legs (Fig. 1c) The protonymph stage (Fig. 1d) is similar in appearance and color pattern to the deutonymph stage, but smaller.

LIGHT MICROSCOPY AND SEM ANALYSIS OF DIFFERENT STAGES OF BREVIPALPUS YOTHERSI

FEMALE (N = 5) (FIGS. 2–6)

Dorsum: Central portions of prodorsum with strong areolae, usually longitudinally elongate, while the posterior cuticle of the sublateral prodorsum is reticulate with large cells and anterior to setae v2 with weak reticulation, becoming broadly wrinkled to smooth posterior to v2 (Fig. 2a). Opisthosoma with 6 pairs of lateral setae with setae f2 absent (Fig. 2b, 3a). Ornamentation between setae c1–c1 to d1–d1 smooth to weakly reticulate. Area between the setae d1–d1 and e1–e1 with weak reticulations and wrinkles. The strong V-shaped folds from setae e1–e1 to h1–h1 is one of the characteristics of B. yothersi, but much weaker towards h1 (Fig. 2b).

Fig. 5. Brevipalpus yothersi female - ventral view of anal and genital regions (a), spermatheca (b), dorsal seta on palp femorogenu (c), distal part of palpus (d).
Measurements of setae as follows: length between setae v2–h1 217 to 222; width between setae sc2–sc2 138 to 144, c3–c3 149 to 179. Dorsal setae lanceolate, barbed: v2 9 to 12, sc1 8 to 11, sc2 10 to 11, c1 6 to 8, c3 6 to 9, d1 6 to 7, d3 8 to 9, e1 7 to 9, e3 8 to 10, f3 9 to 11, h1 9 to 11, h2 8 to 10.

Ventral: Base of coxal fields of legs I and II are finely verrucose (Fig. 4a). The region between coxal fields of legs III and IV and the bases of setae 3a and 4a is verrucose. Area posterior to the 4a setae is uniformly verrucose but between setae 3a and 4a is smooth to finely verrucose (Fig. 3b, 4b).

The ventral plates are uniformly verrucose, whereas the genital plate is verrucose-reticulate with large cells (Fig. 5a).

Spermathecal apparatus (Fig. 5b): The spermathecal duct is long, narrow and ending in vesicle. The spermathecal vesicle is oval-shaped with a thick distal stipe.

Palpus: Dorsal seta on palp femorogenu is barbed, narrow, setiform (Fig. 5c) and palp tibia with 2 setae and 1 omega (Fig. 5d).

Legs: *B. yothersi* has 2 solenidia (ω) on tarsus II (Fig. 6). Length of legs (base of coxae to tip of claws) as follows: leg I 149 to 179; leg II 156 to 173; leg III 140 to 150; leg IV 150 to 160.

**MALE (N = 1) (FIG. 7A)**

The adult males are more wedge-shaped than females. They have same ventral pattern as female.

**DEUTONYMPH (N = 4)**

Dorsum: Length between setae v2–h1 171 to 222; width between setae sc2–sc2 110 to 129, c3–c3 117 to 145. Dorsal setae: v2 5 to 6, sc1 5 to 12, sc2 9 to 14, c1 4 to 5, c3 4 to 8, d1 3 to 4, d3 4 to 6, e1 3 to 4, e3 3 to 6, f3 13 to 17, h1 10 to 16, h2 10 to 16.

Legs: Length of legs (base of coxae to tip of claws) as follows: leg I 104 to 127; leg II 96 to 108; leg III 85 to 88; leg IV 82 to 94.

**PROTONYMPH (N = 2)**

Dorsum: Length between setae v2–h1 146 to 173; width between setae sc2–sc2 104 to 110, c3–c3 107 to 122. Dorsal setae: v2 4, sc1 6 to 7, sc2 9 to 11, c1 3, c3 3 to 7, d1 2, d3 3, e1 3, e3 3, f3 11 to 13, h1 11 to 12, h2 10 to 12.

**HOST PLANTS AND DISTRIBUTION**

*Brevipalpus yothersi* seems to have a cosmopolitan distribution and a very broad host range, with a strong association with *Citrus* spp.
Hosts of Brevipalpus yothersi (Beard et al. 2015a). Because B. yothersi was considered to be B. phoenicis (Gejskes) since 1952, when it was synonymized with the latter (Pritchard & Baker 1952), its hosts and geographic distribution are given here based on material examined by Beard et al. (2015a) in Table 1.

**Table 1.** Geographical distribution and host records of Brevipalpus yothersi (based on examined material by Beard et al. (2015a).

<table>
<thead>
<tr>
<th>Country</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td><em>Citrus sinensis</em> (Rutaceae), <em>Poncus trifolata</em> (Rutaceae), <em>Citrus x sinensis</em> (Rutaceae)</td>
</tr>
<tr>
<td>Australia</td>
<td><em>Cupaniopsis anacardioides</em> (Sapindaceae), <em>Caryota</em> sp. (Arecaceae), <em>Dendrobiium conothum</em> (Orchidaceae), <em>Macropilium atropurpureum</em> (Fabaceae), <em>Citrus</em> sp. (Rutaceae), lime <em>Citrus x aurantifolia</em>, <em>Citrus lemon</em> fruit and leaves (Rutaceae), <em>Lenwebbia</em> sp. (Myrtaceae), <em>Tecomaria capensis</em> (Bignoniaceae), <em>Tabebuia</em> sp. (Bignoniaceae), <em>Alstonia actinophylla</em> (Apocynaceae), <em>Hymenocallis littoralis</em> (Amaryllidaceae), leaves of <em>Hibiscus</em> sp. (Malvaceae), <em>Passiflora</em> sp. leaves (Passifloraceae), <em>Gardenia</em> sp. leaves (Rubiaceae), <em>Citrus</em> sp., <em>Passiflora edulis</em> Sims (Passifloraceae), <em>Punica granatum</em> (Lythraceae), <em>P. edulis</em>, native shrub, various ornamental shrubs</td>
</tr>
<tr>
<td>Bangladesh</td>
<td><em>Psidium guajava</em> fruit (Myrtaceae) ( Intercepted in Chicago, USA)</td>
</tr>
<tr>
<td>Belgian Congo</td>
<td><em>Carica papaya</em> (Caricaceae), <em>C. sinensis</em> (Rutaceae)</td>
</tr>
<tr>
<td>Brazil</td>
<td>Coffee leaves (Rubiaceae), <em>Citrus aurantifolia</em> (Rutaceae) ( Intercepted in New York)</td>
</tr>
<tr>
<td>Burma</td>
<td><em>Citrus</em> sp.</td>
</tr>
<tr>
<td>China</td>
<td><em>Citrus</em> sp., luggage ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>Colombia</td>
<td><em>C. aurantifolia</em> ( Intercepted in New York, USA), <em>Citrus tangerina</em> (Rutaceae) ( Intercepted in Charleston, South Carolina, USA)</td>
</tr>
<tr>
<td>Costa Rica</td>
<td><em>Hibiscus</em> sp. flower ( Intercepted in Texas, USA), <em>C. sinensis</em> (Rutaceae)</td>
</tr>
<tr>
<td>Cuba</td>
<td><em>C. sinensis</em> ( Intercepted in Houston, Texas, USA)</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td><em>C. sinensis</em> (Rutaceae), mixed plants ( Intercepted in New York, USA), <em>P. guajava</em> fruit ( Intercepted in New York, USA), <em>Citrus</em> sp. ( Intercepted in USA)</td>
</tr>
<tr>
<td>Ecuador</td>
<td><em>Citrus latifolia</em> (Rutaceae) ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>El Salvador</td>
<td><em>Simarouba glauca</em> (Simaroubaceae), <em>Fernaldia</em> sp. (Apocynaceae) ( Intercepted in Texas, USA)</td>
</tr>
<tr>
<td>Ethiopia</td>
<td><em>Citrus reticulata</em> (Rutaceae)</td>
</tr>
<tr>
<td>France</td>
<td><em>Locasia cucullata</em> leaf (Araceae) ( Intercepted in Washington DC, USA)</td>
</tr>
<tr>
<td>Guatemala</td>
<td><em>Fernaldia</em> sp. ( Intercepted in Texas, USA)</td>
</tr>
<tr>
<td>Honduras</td>
<td><em>Acalypha hispida</em> (Euphorbiaceae), <em>Acalypa wilkesiana</em> (Euphorbiaceae), <em>Musa</em> sp. (Musaceae)</td>
</tr>
<tr>
<td>India</td>
<td><em>Citrus</em> sp., <em>C. sinensis</em>, <em>C. medica</em> (Rutaceae), <em>C. reticulata</em> ( Intercepted in Texas, USA), <em>Rutaceae</em> ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>Indonesia</td>
<td><em>Camellia sinensis</em> (Theaceae)</td>
</tr>
<tr>
<td>Israel</td>
<td><em>Psidium guajava</em> (Myrtaceae) ( Intercepted in Washington DC, USA), <em>P. guajava</em> fruit ( Intercepted in Chicago, USA)</td>
</tr>
<tr>
<td>Malaysia</td>
<td><em>Hevea</em> sp. seedlings (Euphorbiaceae)</td>
</tr>
<tr>
<td>Mexico</td>
<td><em>Persea americana</em> Mill. (Lauraceae) ( Intercepted in California, USA), <em>Hibiscus</em> sp. leaf ( Intercepted in Texas, USA), <em>Fraxinus</em> sp. leaf (Oleaceae) ( Intercepted in Texas, USA), <em>Cocos nucifera</em> (Arecaceae), <em>C. nucifera</em> ( Intercepted in Brownsville, Texas, USA)</td>
</tr>
<tr>
<td>Nigeria</td>
<td><em>Musa</em> sp. (Musaceae), <em>C. sinensis</em> ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>Pakistan</td>
<td><em>Eriobotrya japonica</em> (Rosaceae), <em>Peganum harmala</em> (Nitrariaceae), <em>Helianthus annuus</em> (Asteraceae), <em>Citrus</em> sp., <em>P. guajava</em> fruit ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>Philippines</td>
<td><em>P. guajava</em> ( Intercepted in California, USA), <em>Orchid</em> leaf (Orchidaceae) ( Intercepted in Chicago, USA)</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td><em>Ficus</em> sp. leaf (Moraceae)</td>
</tr>
<tr>
<td>Spain</td>
<td><em>C. sinensis</em> ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td><em>Camellia sinensis</em> (Theaceae)</td>
</tr>
<tr>
<td>Thailand</td>
<td><em>Pandanus</em> sp. (Pandanaeaceae), <em>Hibiscus esculentus</em> (Malvaceae), <em>Cannabis sativa</em> (Cannabaceae), <em>P. guajava</em> ( Intercepted in New York, USA), <em>Cucurbitaceae</em> ( Intercepted in New York, USA)</td>
</tr>
<tr>
<td>USA</td>
<td><em>Grape</em>, <em>Vitis</em> sp. plants (Vitaceae) (USA), <em>Citrus</em> sp. (Orlando, Florida), <em>Juglans regia</em> (Juglandaceae) (Orlando, Florida), <em>C. nucifera</em> leaf (Arecaceae) (Fort Lauderdale, Florida), <em>P. guajava</em> fruit (Maryland), <em>Maranta</em> sp. (Marantaceae) (Bradenton, Florida), <em>Petrea</em> sp. (Verbenaceae) (Miami, Florida), <em>A. alexandrae</em> (Arecaceae) (Gainesville, Florida), <em>Citrus</em> sp. (with Leprosis) (Rutaceae) (Lake Alfred, Florida), <em>Haya</em> sp. (Caryophyllaceae) (Guadalcanal)</td>
</tr>
<tr>
<td>Venezuela</td>
<td><em>P. guajava</em> ( Intercepted in New York, USA), <em>Citrus lemon</em> fruit</td>
</tr>
</tbody>
</table>

(Brutaceae) (Beard et al. 2015b). Because B. yothersi was considered to be B. phoenicis (Gejskes) since 1952, when it was synonymized with the latter (Pritchard & Baker 1952), its hosts and geographic distribution are given here based on material examined by Beard et al. (2015a) in Table 1.

**DAMAGE**

*Brevipalpus* spp. are economically important plant-feeding mite species. These species damage plants directly by feeding on the epidermal cells of the stems, leaves, and fruits (Peña et al. 2015; Salinas-Vargas et al. 2016). They feed by inserting their chelicerae into the host plant tissue. During feeding, toxic saliva is injected into the cells. The sap is then mixed with saliva and sucked up by the mite. *Brevipalpus* spp. usually feed on twigs, leaves, and fruit (Childers et al. 2011). The symptoms associated with injury caused by these mites vary from necrotic brown spots on leaves, resinous leaf patches with opposing leaf, stem browning, gall formation, brownish patches on the fruit surface, corky ring-like bands around the fruit to defoliation and die back depending on the host plant species (Childers et al. 2003).

*Brevipalpus* mites also can act as vectors of viruses. Their role as vectors of citrus leprosis virus (CiLV) has greatly increased their worldwide importance as quarantine pests (Peña et al. 2015).
In this study, necrotic brown spots were observed together with the symptoms of *Xylella* sp. (*Bacteria: Xanthomonadales*) on blueberry leaves infested with *B. yothersi* (Fig. 8).

Recently, it has been shown that *B. yothersi* has a strong association with the citrus leprosis virus complex and it has been suggested to be a vector of the cytoplasmic leprosis viruses (Roy et al. 2015). These viruses induce localized necrotic or chlorotic lesions around the mite-feeding sites (Ramos-Gonzalez et al. 2016).

**Remarks**

*Brevipalpus yothersi* was originally described as a separate species in 1949 (Baker, 1949). It was later considered as a synonym of *B. phoenicis* together with *B. papayensis* in 1952 (Pritchard & Baker, 1952). However, *B. yothersi* differs from *B. phoenicis* in having a narrowly lanceolate dorsal seta on palp femorogenu (Fig. 5c) instead of broad as in *B. phoenicis*. The spermatheca vesicle is round without stipe or not developed in *B. phoenicis*, whereas the spermatheca vesicle is oval with a strong distal stipe in *B. yothersi*. Furthermore, the cuticle on the dorsal opisthosoma between setae e1–e1 to h1–h1 is usually with strong chevrons (V-shaped folds), becoming much weaker towards h1–h1 (Beard et al. 2015a). *Brevipalpus yothersi* differs from *B. papayensis* as shown in Table 2.

*Brevipalpus yothersi* is listed as *B. phoenicis* group species B (Beard et al. 2015b). However, it was raised to species level again. It was also confirmed that *Brevipalpus amicus* Chaudhri, *B. recula* Chaudhri, *B. mcbridei* Baker, and *B. deleoni* Pritchard and Baker are junior synonyms of *B. yothersi* (Beard et al. 2015a).

**Discussion**

The family Tenuipalpidae Berlese includes more than 1,100 species in 36 genera (Beard et al. 2015; Çobanoğlu et al. 2016). *Brevipalpus* Donnadieu, 1875 is the largest genus in the Tenuipalpidae (Welbourn et al. 2003) and includes more than 300 species worldwide.

Within the genus *Brevipalpus*, *B. yothersi* was not detected during previous surveys carried out in Florida, USA, on blueberry. In this study, during surveys carried out in 2016 in Florida, it was reported on southern highbush blueberry (*Vaccinium corymbosum* L. × *V. darrowi* Camp (Ericaceae)). *Brevipalpus yothersi* was initially described from specimens collected on privet (*Ligustrum* sp.: Oleaceae) in Orlando, Florida, USA (Baker 1949). It was subsequently synonymized with *B. phoenicis*.
by Pritchard & Baker (1952). The mite was recently resurrected and re-described (Beard et al. 2015a; Novelli et al. 2016). According to Beard et al. (2015a), it was collected from Citrus sp. (Orlando), Juglans regia (Juglandaceae) (Orlando), Cocos nucifera (Arecaceae) (Fort Lauderdale), Maranto sp. (Marantaceae) (Bradenton), Petrea sp. (Verbenaceae) (Miami), Archontophoenix alexandrae (Arecaceae) (Gainesville), Citrus sp. (with leprosis) (Rutaceae) (Lake Alfred) in Florida.

Within the group of Brevipalpus species that transmit plant viruses, B. yonthersi is the principal vector of viruses causing the cytoplasmic type of leprosis (Rodrigues & Childers 2013; Roy et al. 2015; Arena et al. 2016; Ramos-Gonzalez et al. 2016). Previously, it was thought that all leprosis viruses could be transmitted only by B. phoenicis, but recently, the species status of B. phoenicis has been revised, and 4 species previously considered as synonyms of B. phoenicis have been confirmed as separate species.

Blueberry necrotic ring blotch virus (BNRBV) was reported from Florida by Quito-Avila et al. (2013). It is closely related to the viral plant diseases citrus leprosis virus and Hibiscus green spot virus (HGSV), which are transmitted by Brevipalpus species (Robinson 2013). In the future, it also will be necessary to elucidate the potential role of B. yonthersi as a vector of blueberry necrotic ring blotch virus.

Like viruses, other plant pathogens including bacteria also are transmitted or spread by mites from different families such as Tenuipalpidae, Acaridae, Eriophyidae, Sitaroptidae, Tarsonemidae and Tetranychidae which are transmitted by Brevipalpus species (Robinson 2013). In the development and spread of B. yonthersi in Vaccinium spp. we thank Dr. Phillip Harmon and the University of Florida/IFAS Plant Disease Diagnostic Center for the identification of Xylella sp. We also thank the Interdisciplinary Center for Biotechnology Research (ICBR) at the University of Florida for providing technical assistance with the use of the electron microscope. Finally, we thank an organic grower in central Florida for allowing collection of samples from his farm. The research was supported by private funding from a Florida blueberry grower group.

Acknowledgments

We thank Dr. Phillip Harmon and the University of Florida/IFAS Plant Disease Diagnostic Center for the identification of Xylella sp. We also thank the Interdisciplinary Center for Biotechnology Research (ICBR) at the University of Florida for providing technical assistance with the use of the electron microscope. Finally, we thank an organic grower in central Florida for allowing collection of samples from his farm. The research was supported by private funding from a Florida blueberry grower group.

References Cited


Dorsal palp femur seta

Sublateral region of propodosoma

Opisthosoma

Ventral region posterior to setae 4a

Spermatheca

Setiform and barbed (Fig. 5c)

Posterior region forming large cells, anterior region smooth (Fig. 2a)

Reticulation between setae e1 and h1 with “V” shaped folds (Fig. 2b)

Rounded reticulations (Fig. 4b; Fig. 3b)

With a long narrow duct, which merges to an oval vesicle with small distal stipe (Fig. 5b)

Broadly setiform and barbed

Reticulations and large cells only posteriorly

Reticulation between setae e1 and h1 starting with transverse folds abruptly becoming longitudinal folds towards h1

Elongate reticulations forming transverse bands With a long moderately thick duct, which ends in a spherical vesicle with a crown of small projections

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