

"*Diaphania*" *costata* (F.), a misidentified pest of Apocynaceae in the Southeastern United States

James E. Hayden*, FDACS Division of Plant Industry, 1911 SW 34th St. Gainesville, FL, USA
 E. Richard Hoebeke, UGA Collection of Arthropods, Georgia Mus. of Nat. Hist., Athens, GA, USA
 Matthew Bertone, NCSU Plant Disease and Insect Clinic, NC State University, Raleigh, NC, USA
 Vernon A. Brou Jr., 70420 Jack Loyd Road, Abita Springs, LA, USA
 *James.Hayden@FreshFromFlorida.com

INTRODUCTION: "*Diaphania*" *costata* (Fabricius, 1775) (Crambidae: Spilomelinae, Figs. 1–3) is a white moth distributed in the Caribbean, South, and Central America, where it folds leaves of Apocynaceae. It has been recorded from Texas, USA since at least 1980. In fact, it has become widespread in the southeastern USA, but it is commonly misidentified as *Palpita kimballi* Munroe.

In August–September 2013, ERH discovered massive damage to *Vinca major* L. in Athens, Georgia, USA (Figs 8, 9). Also in Sept. 2013, MB received for identification larval samples from *V. major* L. and *Amsonia tabernaemontana* Walter from sites in North Carolina. In all cases, larvae folded leaves and stripped epidermis. ERH collected moths at light and reared them from *Vinca*, and JEH identified them by dissection. JEH obtained specimens from Tallahassee, Florida from Peter Homann in 2013 and 2014. Plant damage has not been reported since 2013, but moths have appeared in autumn 2015 (P. Homann, pers. comm.).

At first, the existence of the Georgia population had two explanations: either local introduction through trade, or undetected natural spread from the West over many years. We sought specimens in collections to find support for the latter hypothesis.

Phalaena costata F. and its synonyms have been placed in five genera: *Diaphania* Hübner, *Glyphodes* Guenée, *Margarodes* Guenée, *Pachyarches* Lederer, and *Stemorrhages* Lederer. The confusion resembles that of *Cydalima perspectalis* (Walker), a pest of *Buxus* L. in Europe. Indeed, both species belong to the *Diaphania* group of Spilomelinae (Munroe 1995). To complicate things, the application of the name *D. costata* is unclear, pending examination of the type specimens.

MATERIALS & METHODS: We examined specimens in the FSCA & MGCL (Gainesville, FL, USA), UGA (Athens, GA, USA), MEM (Starkville, MS, USA), and Vernon A. Brou Collection. We expected the specimens of VAB and Bryant Mather (MEM), collected daily over many years, to yield dates of first arrival. We examined photographs on line at <http://bugguide.net> that clearly show diagnostic characters. We included records in the News of the Lepidopterists' Society Season Summaries. We georeferenced with <http://earthexplorer.usgs.gov> or www.google.com/maps and mapped with Diva-GIS 7.5.0.0 (www.diva-gis.org) (Fig. 4). We dissected genitalia in 10% KOH, stained with Chlorazol Black or Eosin Y, slide-mounted, and photographed with AutoMontage. Larval chaetotaxy was drawn from a larval cuticle slide with Adobe Illustrator CS6. Ef1-a and the mtDNA COI "barcode" region were sequenced from a specimen from northern Florida. JEH modified the dataset of Mally and Nuss (Table 1). We did not examine type specimens for this preliminary analysis. Coding of *Parotis psittacalis* Hübner is based on specimens from India identified by G.F. Hampson in the Carnegie MNH (Pittsburgh, USA). We dissected many other specimens of *Parotis* Hübner and "*Diaphania* misplaced" spp. in the FSCA/MGCL to understand character variation.

We edited data with Winclada 1.00.08 and analyzed with TNT 1.1 (Goloboff et al. 2000) with commands hold 1000; cc -; mult-hold 10 replic 10.

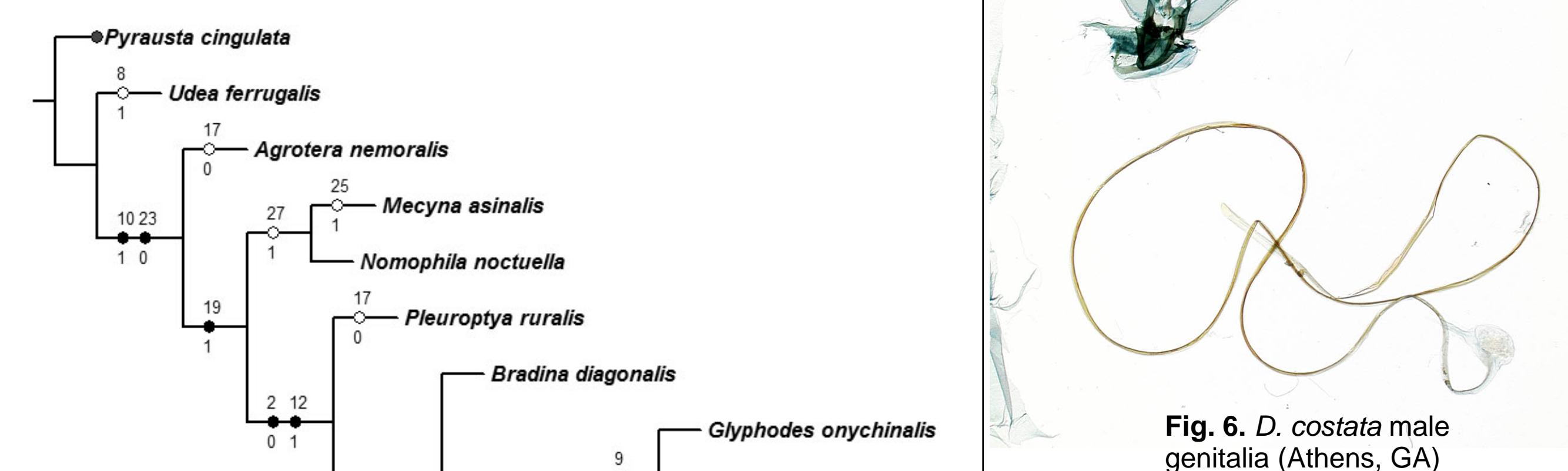


Fig. 5. Single cladogram. • = unique apomorphies; o = homoplasies.

Table 1. Characters.

0 Male pedicel: 0, unmodified; 1, modified.
1 Male subcostal androconial tuft: 0, absent; 1, present.
2 Violet iridescence: 0, present; 1, absent.
3 Wing ground color: 0, not white; 1, white.
4 Forewing antemedial line: 0, present; 1, absent.
5 Suffusion of forewing costa (dependent on character 3): 0, brown or orange, restricted between costal and subcostal veins; 1, suffused posterior of subcostal vein.
6 Discal Costa white spot: 0, absent; 1, present.
7 Brown margin on remen of wings: 0, absent; 1, present.
8 Apex of uncus: 0, curved; 1, bulbous.
9 Base of uncus: 0, broad; 1, narrow.
10 Costa (dorsal margin) of valva: 0, straight or concave; 1, shallowly oval; 2, subircular with dorsal elbow.
11 Position of fibula on valva: 0, near base of valva or near costa; 1, near ventral margin.
12 Coremata pads: 0, absent; 1, present without distinct margin; 2, with sclerotized margin, often with enlarged setal sockets.
13 Sacculus: 0, undifferentiated; 1, simple ridge; 2, ridge apically extended as process.
14 Cacum penis: 0, present; 1, absent.
15 Length of phallus: 0, short; 1, longer than abdomen.
16 Ventral sclerotized strip of phallus: 0, absent; 1, present.
17 Sternite VIII: 0, evenly sclerotized; 1, medially weak, appearing U-shaped.
18 Tergite VII: 0, evenly sclerotized; 1, Y-shaped.
19 Tergite VIII "groat": 0, absent; 1, present.
20 Sternite VII anterior projection: 0, absent; 1, present.
21 Signa: 0, absent; 1, present.
22 Shape of signa (dependent on character 20): 0, shield-shaped, not produced; 1, produced as thorn(s).
23 Junction ductus bursae–corpus bursae: 0, ductus bursae gradually widening into corpus bursae; 1, corpus bursae globular & distinct.
24 Wall of ductus bursae: 0, not scobinate; 1, scobinate.
25 Ostim bursae: 0, between SVII and SVIII; 1, invaginated in SVII.
26 Gynocorema: 0, absent; 1, present.
27 Colliculum: 0, dorsally open; 1, dorsally closed, entire.

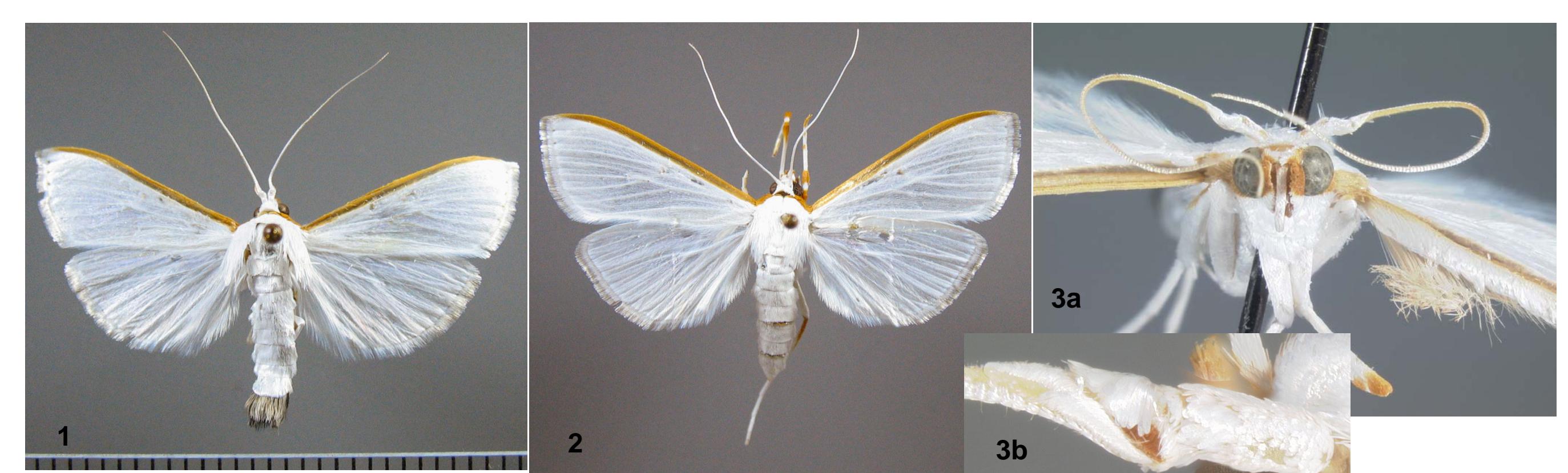


Fig. 1. Male *D. costata* (Athens, GA, 2013). Fig. 2. female, same. Scale mm. Fig. 3a. Male *D. costata* showing subcostal androconia. 3b. Base of antenna.

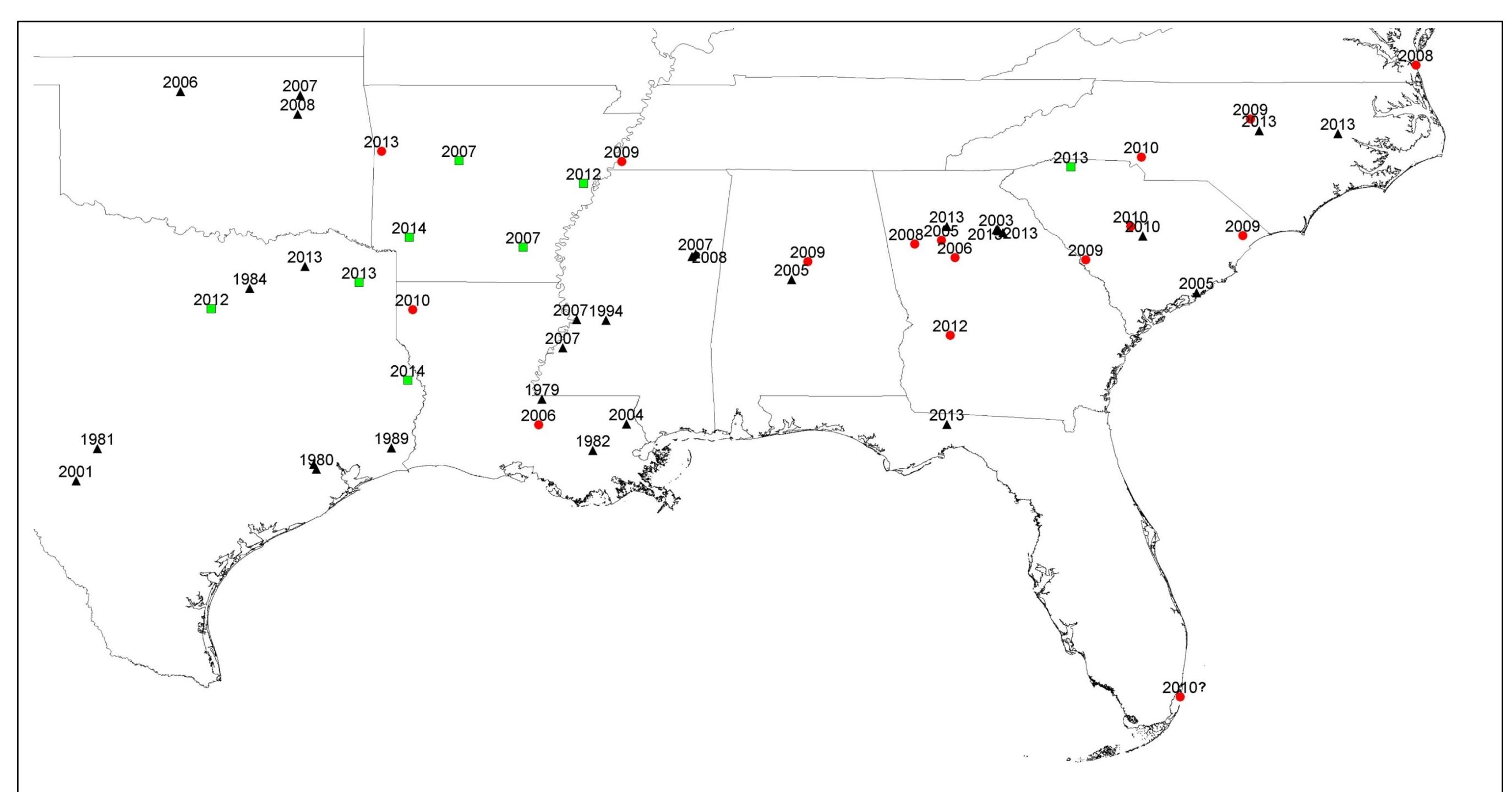


Fig. 4. Distribution of *D. costata* with first known year of collection. Black triangles: records based on specimens examined by the authors or E. Knudson (Texas); red circles: photographs on line (Bugguide.net); green squares: from Lepidopterists' Society Season Summaries.

Diagnosis from other Nearctic Spilomelinae: Both sexes: wingspan ca. 3 cm, wings white with one faint gray discal spot on forewing; distal forewing more truncate than species of *Palpita* Hübner (Figs 1, 2). Males: forewing with large hair pencil underneath costa (Fig. 3a); black anal androconia; antennal pedicel and flagellum base expanded and diagonally furrowed (Fig. 3b); valvae with one fibula on margin; phallus very elongate (Fig. 6). Females: very elongate ductus bursae; corpus bursae spherical, without signa (Fig. 7). Larva: with extra pair of pinacula on T2 and T3 posterior of D and SD (Fig. 10). Pupa: clypeal area strongly projected (Fig. 11).



Fig. 6. *D. costata* male genitalia (Athens, GA).

Fig. 7. *D. costata* female genitalia (Hinds Co., MS).

Fig. 8. Damage on *Vinca major* in Athens, Georgia, 2012 (ERH).

Fig. 9. Larva on *Vinca major* (ERH).

Fig. 10. Larval chaetotaxy. A, body; B, head, anterior aspect; C, mandible.

Fig. 11. Pupa of *D. costata* (Athens, GA).

Fig. 12. Male *Parotis psittacalis* Hbn. Northern India (CMNH).

Fig. 13. Larval *Parotis marginata* (Hampson) in folded leaf of *Alstonia scholaris* (L.) in Taiwan (after Lin 1997).

RESULTS. Distribution: VAB first collected *Diaphania costata* in Louisiana in 1979 (Fig. 4). It appeared in western Mississippi in 1994, and in Clark County, Georgia, in 2003. The most northeastern is a 2008 photograph from Virginia Beach, VA. In Florida, the only verified specimens are from the north (Tallahassee). Its absence from South Florida is curious, because it is present in the Greater Antilles; one photograph from a Miami park is plausible. Most photographs posted online of "*Palpita kimballi*" from the southeastern U.S. are identifiable as *D. costata*. We found specimens of *Palpita kimballi* only from peninsular Florida and coastal Georgia.

Hosts: *Vinca major* and *Amsonia tabernaemontana* in the Nearctic. In addition to the NC records, it was reared on *A. tabernaemontana* in Starkville, MS, Sept. 2008. Adults have been observed near *Trachelospermum jasminoides* (Lindl.) in Texas, but not reared (E. Knudson, pers. comm.). In Guanacaste, Costa Rica, *D. costata* has been reared on *Stemmadenia* Benth. and *Rauvolfia* L. spp., and *Dapkey02* and *Dapkey07* on *Stemmadenia* and *Tabernaemontana alba* Mill. (Janzen 2009). There are records on *Rauvolfia* also from Puerto Rico (Wolcott 1950) and Cuba (Alayo 1982).

Phenology: Bivoltine, with a small generation in May and greater abundance in August and September. Adults recorded as late as mid-November in Mississippi.

Taxonomy: The exact identity of *D. costata* is questionable because Fabricius's type(s) have not been examined and may be lost. *Margarodes aurocostalis* Guenée and *M. imitalis* Guenée currently stand in synonymy. These in fact may be two separate species (M. Alma Solis, pers. comm.); the former is from the Lesser Antilles, and the latter was described from the Greater Antilles. The Nearctic population might be referable to *P. imitalis*. BLAST results of the COI barcode region (<http://blast.ncbi.nlm.nih.gov/Blast.cgi>) show 99–100% similarity to "*Dapkey02*" and "*Dapkey07*" from Guanacaste, Costa Rica.

Relationships: Analysis yielded one tree of 53 steps. *Diaphania costata* is closest to *Parotis psittacalis* (currently a synonym of *P. marinata* (F.)). They share loss of signa and a spherical corpus bursae that is distinct from the narrow, elongate ductus bursae. They share subcostal forewing androconia with *Stemorrhages sericea* (Drury). The larval chaetotaxy of *D. costata* keys to *Parotis athysanota* (Hampson) or *Botyodes* Guenée in Lin (1995). Species of *Parotis* in Taiwan fold leaves and strip epidermis of Apocynaceae and Rubiaceae, making purselike nests (Fig. 13). The pupae have a similarly enlarged frontal crest (Lin 1997).

The *Diaphania* Hübner group *sensu* Munroe (1995) is characterized as follows. The male valvae are ovate, the fibula is single and curved, the uncus is capitate with bifid chaetae, the tegumen is dorsoventrally high (better dissected from the vinculum and mounted laterally), and the anal androconia usually are black. Females have an unmodified ostium bursae, and 0, 1, or 2 signa as round, granular patches or thorns. In some genera, the pedicel and basal flagellum of the male antenna are enlarged and contorted. The *Diaphania* group generally feed on leaves or fruits of laticiferous plants, especially Apocynaceae and Moraceae. Many clades have radiated onto other plant families, such as *Palpita* on Oleaceae and *Cadarena* Moore on Passifloraceae.

The synapomorphies of *P. psittacalis*+*D. costata*+*S. sericea* require testing with more taxa. Most of the species classified as *Diaphania* "misplaced" (Munroe 1995) may belong in *Parotis*, *Stemorrhages*, or *Cydalima* Lederer. *Parotis* and *Stemorrhages* Lederer may be synonymous. Hübner's description of *P. psittacalis*, type species of *Parotis* (Fig. 12), mentions a modified pedicel with yellow scales. However, until type material can be examined, the exact coding must remain preliminary. The development of signa and the length of the ductus bursae vary among otherwise externally identical species.

DISCUSSION: An explanation for the population's spread is the increased popularity of certain ornamental Apocynaceae in the Southeastern U.S. *Vinca* L. is not native to North America. *Vinca major* and *V. minor* L. are popular ground-cover plants, but they are also invasive weeds in forests, where they smother native plants and few herbivores attack them. *Diaphania costata* might be oligophagous on the tribe *Vinceae*, to which *Vinca*, *Rauvolfia*, and (in some classifications) *Amsonia* Walter belong (Simões et al. 2007). The other hosts are less closely related but also belong to Rauvolfioideae. No damage has been reported on other apocynaceous plants.

FUTURE WORK

- Examine type specimens and designate neotype for *Phalaena costata* if necessary.
- Compare Neotropical, Afrotropical, Asian, and Indo-Australian species.
- Survey genitalic character state variation among taxa.
- Dissect and sequence more species and populations outside of Costa Rica. Many species are nearly identical externally.
- Test larval feeding on more ornamental Apocynaceae, especially *Catharanthus* G. Don. and *Trachelospermum jasminoides* (Lindl.).
- Discover the overwintering stages.



Fig. 12. Male *Parotis psittacalis* Hbn. Northern India (CMNH).



Fig. 13. Larval *Parotis marginata* (Hampson) in folded leaf of *Alstonia scholaris* (L.) in Taiwan (after Lin 1997).

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