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## The type species of *Eucosma* Hübner (Lepidoptera: Tortricidae: Eucosmini)

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### Abstract

*Eucosma* Hübner is the largest genus in the Tortricidae with more than 290 named species. Historically, there has been confusion about the assignment of species to *Eucosma* and related genera, a problem which is perpetuated by the lack of a type specimen for the type species, *E. circulana* Hübner. Here we designate a neotype for *E. circulana* following analysis of eight North American species having similarities with that taxon. *Eucosma circulana* and *E. gemellana* Heinrich are redescribed, the latter being elevated from subspecies to species status. *Eucosma paragemellana*, new species, is described from specimens previously confused with *E. gemellana*, and *E. fraudabilis* Heinrich is reviewed.

**Key words:** *circulana*, *fraudabilis*, *gemellana*, Olethreutinae

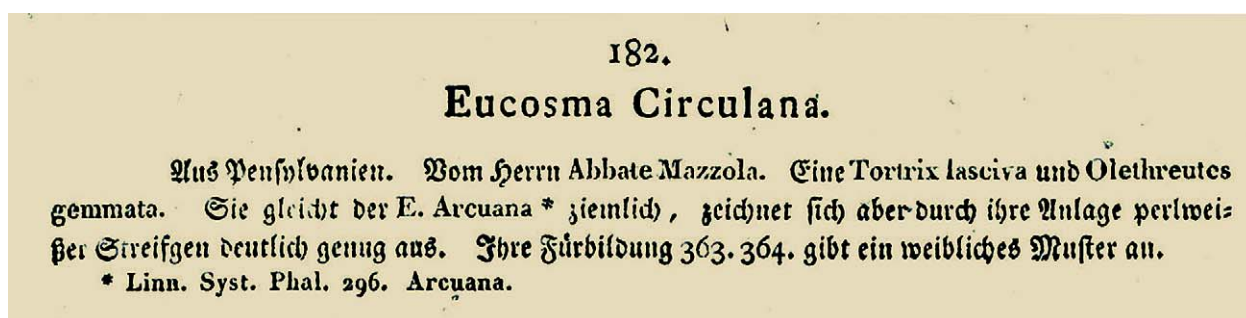
### Introduction

*Eucosma* Hübner is the largest genus in the Tortricidae, consisting of some 290 named species (Gilligan *et al.* 2012). It has a Holarctic distribution, with the highest species diversity occurring in western North America. Several authors have provided descriptive accounts of the genus (e.g. Heinrich 1923; Obraztsov 1968; Razowski 1989, 2003; Gilligan *et al.* 2008), but no synapomorphies have been discovered that consistently separate *Eucosma* from closely related genera such as *Pelochrista* Lederer. The resulting ambiguity, which has persisted for nearly two centuries and has resulted in different interpretations of these taxa in the Palearctic and Nearctic, is due in part to the lack of a type specimen of the type species of *Eucosma*.

*Eucosma* first appeared in the literature with the description of *E. circulana* in the second volume of Hübner's *Zuträge zur Sammlung exotischer Schmettlinge* [sic] (1823). The "Zuträge" was published in five parts (the last two authored by Carl Geyer) between 1818 and 1837 as a supplement to *Sammlung exotischer Schmetterlinge*, Hübner's (1806–[1832], [1819–1832]) prominent work on exotic (non-Palearctic) Lepidoptera (Hemming 1937a, b). The description of *E. circulana* consists of a short paragraph of text (Fig. 1) and hand painted illustrations numbered 363 and 364 of dorsal and ventral views, respectively, of a female from Pennsylvania (Fig. 2). The fate of the illustrated specimen is unknown, and consequently the identity of *E. circulana* has never been satisfactorily established. The Hübner types were acquired by Vincenz Abbate Edler von Mazzola in the early part of the 19<sup>th</sup> century, and the European material was deposited in the "Hof-Naturalien-Kabinet" at the Hofburg Imperial Library in 1823 (Calhoun 2003). There is no record of the deposition of the North American material. If it also went to Hofburg, then the type of *E. circulana* may have perished in a fire during the Vienna Rebellion of 1848 that destroyed many of the Hübner types (Calhoun 2003). The surviving Hübner specimens currently reside in the Naturhistorisches Museum Wien in Vienna (NMW). In response to an inquiry to NMW, we were informed that there are no specimens labeled "*Eucosma circulana*" in their collections (S. Gaal, pers. comm. 2012), so we conclude that the *E. circulana* type is lost or was destroyed.

There was no consensus among 19<sup>th</sup> century authors as to the application of *Eucosma* and related generic names (such as *Paedisca* Treitschke). Apart from the description of *E. circulana*, the earliest literature references to *Eucosma* are Hübner ([1816–1825]), who listed *E. circulana* in his *Verzeichniss bekannter Schmettlinge* [sic], and Geyer (1832), who described *Eucosma tuberculana* (determined by Fernald (1882) to be a pyralid) in the fourth

volume of the “Zuträge.” Mid-19<sup>th</sup> century authors (e.g. Wilkinson 1859, Heinemann 1863) utilized *Paedisca* for Palearctic species, although Walker (1863) listed two species of *Eucosma* (including *E. circulana*) as present in the British Museum. Fernald (1882) transferred *E. circulana* to *Paedisca* and treated *Callimosema* [= *Pelochrista*] *scintillana* Clemens (1865) and *Paedisca dodecana* [= *Pelochrista scintillana*] Zeller (1875) as synonyms of *P. circulana*, thus beginning a period of approximately 40 years during which North American authors considered the species now known as *Pelochrista scintillana* (Clemens) to be conspecific with *E. circulana*. Fernald (1891) repeated this arrangement in Smith’s *List of Lepidoptera of Boreal America*, but in Dyar’s list of North American Lepidoptera (Fernald 1903), he followed Walsingham (1897) and treated *Paedisca* as a junior synonym of *Eucosma*. In his last contribution on the subject, Fernald (1908) treated 25 generic names as synonyms of *Eucosma* and designated “*Eucosma circulana* Hübner” as the type species of the genus. Walsingham (1914) expanded on Fernald’s list and included other genera such as *Crociosema* Zeller, *Notocelia* Hübner, *Spilonota* Stephens, *Strepsicrates* Meyrick, and *Thiodia* Hübner as synonyms of *Eucosma*, effectively combining the early 20<sup>th</sup> century genera that today reside in Eucosmini. Pierce and Metcalfe (1922) were some of the first taxonomists to incorporate genitalic characters into the classification of Tortricidae. They report having referred to a male of *E. circulana* in deciding their placement of *Eucosma caecimaculana* (Hübner) [now *Pelochrista caecimaculana*]. The specimen they examined, however, was probably *P. scintillana*, since *scintillana* was synonymous with *circulana* at the time, and there are no specimens fitting the current concept of *E. circulana* in The Natural History Museum, London (K. Tuck, pers. comm. 2012).

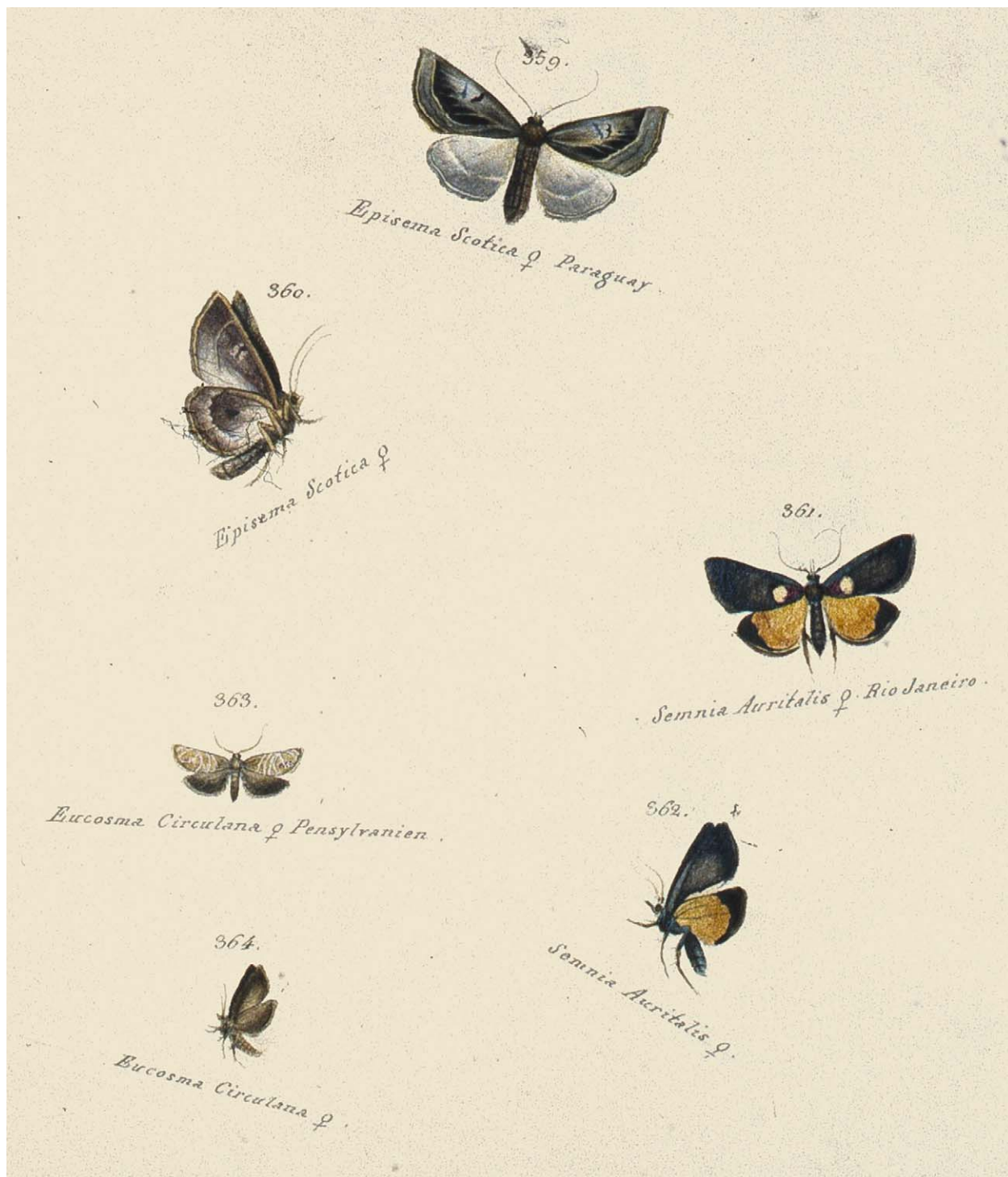


**FIGURE 1.** Description of *E. circulana* by Hübner (1823).

The genus-level confusion addressed by these early authors was to a large extent resolved with the 1923 publication of Heinrich’s *Revision of the North American moths of the subfamily Eucosminae of the family Olethreutidae*. Heinrich was first to utilize the male genitalia in characterizing the Nearctic genera, and he resurrected many of the generic names synonymized by Fernald and Walsingham. His concept of *E. circulana* was based on specimens from Florida and Louisiana with male genitalia that differ substantially from those of *P. scintillana*. He resurrected *P. scintillana* and described the “variety” *E. circulana gemellana*, which resembles *E. circulana* in forewing appearance but differs from it sufficiently in genitalia to justify the use of a different name.

*Eucosma circulana* (*sensu* Heinrich) is poorly represented in collections, and literature records from the late 19<sup>th</sup> and early 20<sup>th</sup> centuries (e.g., Walsingham 1884, Kearfott 1905) are unreliable because they most likely refer to *P. scintillana*. Consequently, we know very little about the range of *E. circulana* and even less about its historical distribution. We found no specimens of it from Pennsylvania, the type locality mentioned by Hübner. Engel (1908) reported *E. circulana* from the vicinity of Pittsburg, but we examined those specimens, currently in the Carnegie Museum of Natural History, and determined them to be *P. scintillana*.

Heinrich’s interpretation of *E. circulana* has been accepted by several authors (e.g., Obraztsov 1968, Powell 1983, Brown 2005), but there are a number of North American species besides *P. scintillana* that are similar in forewing appearance to Hübner’s illustration of *E. circulana*, and in recent years there has been some informal discussion as to which of them might be best suited to bear the *circulana* name (R. Brown, M. Sabourin, pers. comm. 2012). Here we evaluate the candidates, ranking them according to morphological features discernible in Hübner’s illustration, and designate a neotype for *E. circulana*. We elevate *E. gemellana* to species status, describe *E. paragemellana*, new species, and provide redescrptions of *E. circulana* and *E. gemellana*. We also review *E. fraudabilis* Heinrich, a candidate with some unique similarities to Hübner’s illustration. This work is a preliminary step toward a forthcoming revision of *Eucosma*, *Pelochrista*, and *Phaneta* based on molecular and morphological data.



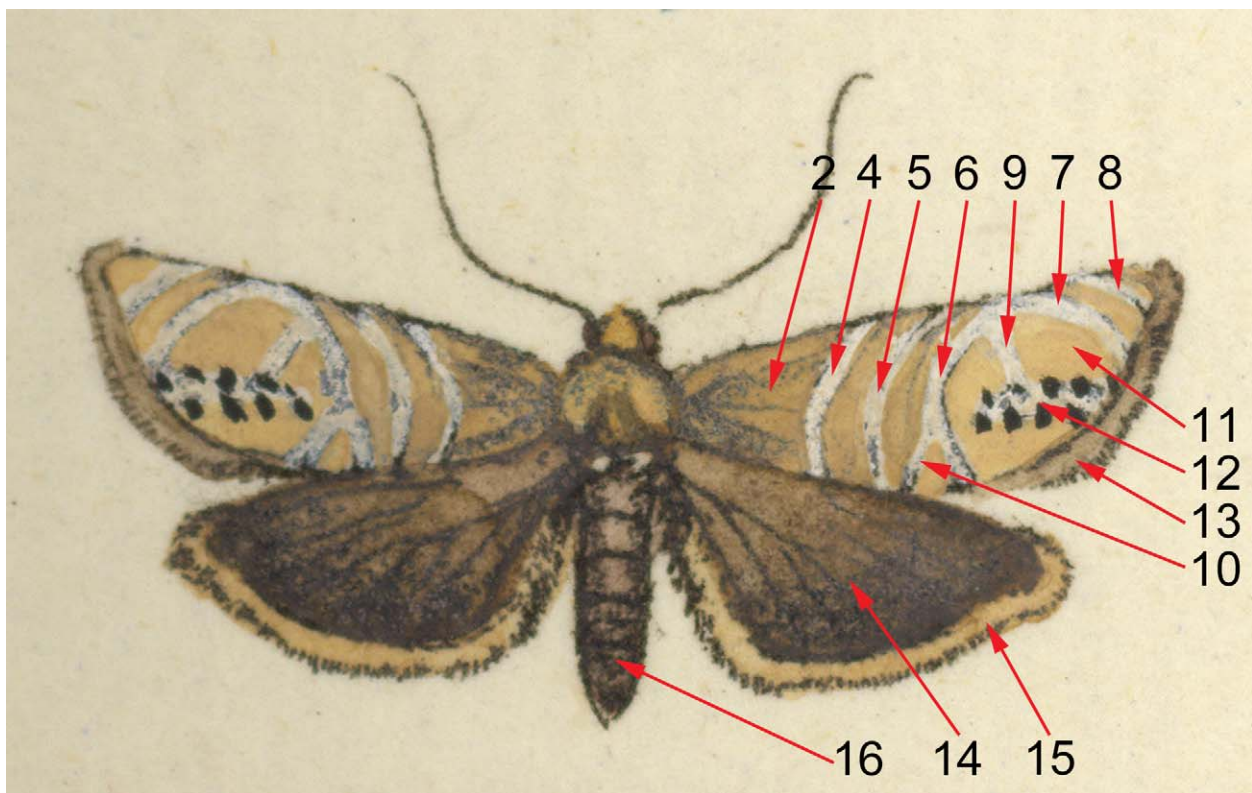
**FIGURE 2.** Illustrations of *E. circulana* by Hübner (1823; Figs. 363, 364; Plate [63]).

### Material and methods

Two hundred and thirty-two adult specimens (196 ♂, 36 ♀) were examined in this study, together with 45 associated genitalia preparations. Genitalia dissection methodology follows Brown and Powell (1991) except that some preparations used Euparal (Bioquip Products, Rancho Dominguez, Calif.) as the mounting medium. Adult photographs were taken with a Canon EOS digital SLR (Canon U.S.A., Lake Success, N.Y.) and edited using Adobe Photoshop CS5 Extended (Adobe Systems Inc., San Jose, Calif.). The distribution map (Fig. 35) was created using SimpleMappr (Shorthouse 2010).



Morphological terms and wing pattern descriptions follow Horak (2006) and Gilligan *et al.* (2008). The strigulae associated with the labeled striae in Fig. 3 are numbered in accordance with the generalized olethreutine wing pattern proposed by Brown and Powell (1991), refined by Baixeras (2002), and illustrated by Gilligan *et al.* (2008). The following abbreviations and symbols are utilized: FW = forewing; FWL = forewing length, measured from base to apex including fringe; AR = forewing aspect ratio = FWL divided by medial forewing width; NR = neck ratio = minimal neck width divided by valval width near saccular corner; CFR = costal fold ratio = costal fold length divided by FWL; SA = saccular angle = angle formed at juncture of ventral margins of sacculus and neck; HW = hindwing; ca. = circa (approximately); n = number of specimens examined. Institutional and private collections providing study material are abbreviated as follows: AMNH, American Museum of Natural History, New York, N. Y.; BMNH, The Natural History Museum, London; CMNH, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania; CNC, Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada; DJW, Donald J. Wright collection, Cincinnati, Ohio; FSCA, Florida State Collection of Arthropods, Gainesville, Florida; LDG, Loran D. Gibson collection, Florence, Kentucky; MEM, Mississippi Entomological Museum, Mississippi State, Mississippi; TMG, Todd M. Gilligan collection, Loveland, Colorado; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.



**FIGURE 3.** Pattern elements in Hübner's Fig. 363 (1823).

Riley (1886) noted that Hübner's figures are not necessarily uniform from one copy to another of the "Zuträge," the colors sometimes varying with the colorist and/or the effects of aging. We examined the plate ([63]) containing *E. circulana* (Fig. 2) in copies of the "Zuträge" located at the USNM, the CNC, and the Cyril F. dos Passos literature collection at Wittenberg University Library, Springfield, Ohio and found them to be reasonably consistent, with the pattern elements unchanged from copy to copy.

## Results and discussion

Roughly translated from the German, Hübner's description of *E. circulana* (Fig. 1) reads: "From Pensilvania [Pennsylvania]. Discovered by [From] Mr. Abbate Mazzola. A *Tortrix* [= *Phalanx* = Superfamily] *lasciva* [= *Tribus*

= Family] and *Olethreutes* [= *Stirps* = Subfamily] *gemmata* [= *Familia* = Tribe]. It resembles *E. Arcuana*\* [= *Olethreutes arcuella* (Clerck)] but can be differentiated by its pearly white stripes/the pearly white stripes are outstanding. [Figures] 363.364. illustrate a female. \*Lina. Syst. Phal. 296. *Arcuana*.” The description provides little in the way of morphological information except for the resemblance to *O. arcuella* and emphasis on the “white stripes,” which we interpret as metallic-gray striae emanating from various paired costal strigulae.

Hübner’s illustration shows a yellowish-brown forewing upperside with darker suffusion at the base, a circular ocelloid region with a prominent ocellus, and a rather extensive system of metallic-gray striae. We identified 17 morphological elements that could be used to compare the illustration with *Eucosma* neotype candidates (Fig. 3, Table 1): 1. FW ground color yellowish-brown (not labeled); 2. basal portion of FW suffused with dark brown; 3. FW termen slightly concave (not labeled); 4. stria from pair of strigulae 4 to dorsum; 5. stria from pair of strigulae 5 to dorsum; 6. stria from pair of strigulae 6 to dorsum; 7. stria from pair of strigulae 7 to termen (which, in combination with element 5, partially “encircles” ocelloid region); 8. stria from pair of strigulae 8 or 9 to termen; 9. stria from pair of strigulae 6 or 7 to center of ocelloid region; 10. “branch” from element 6 to dorsum; 11. ocelloid region unicolorous golden yellow apart from ocellus and element 9; 12. ocellus consisting of two rows of 4–5 black dots; 13. FW fringe pale brown; 14. HW dark brown, lighter towards base; 15. HW fringe contrastingly paler than HW ground color; 16. abdomen dark brown; 17. AR ca. 2.83 (not labeled).

**TABLE 1.** Pattern elements present in Hübner’s *E. circulana* illustration scored for candidate species (*Pe.* = *Pelochrista*; *Ph.* = *Phaneta*).

	1 (FW ground yellowish-brown)	2 (basal portion of FW dark brown)	3 (FW termen weakly concave)	4 (stria from strigula 4)	5 (stria from strigula 5)	6 (stria from strigula 6)	7 (stria from strigula 7)	8 (stria from strigula 8 or 9)	9 (stria to center of ocelloid region)	10 (branch from element 6)	11 (ocelloid region unicolorous golden yellow)	12 (ocellus with two rows of 4-5 marks)	13 (FW fringe pale brown)	14 (HW dark brown)	15 (HW fringe paler than ground color)	16 (abdomen dark brown)	Total	17 (FW aspect ratio)
Hübner Fig. 363	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	2.83
<i>E. circulana</i>	1	1	1	0	1*	1	1	1	0	1*	1	1	1	1	1	1	14	2.78
<i>E. gemellana</i>	1	1*	1	0	1	1	1	1	0	0	0	1	1	1	1	1	12	2.90
<i>E. paragemellana</i>	1	1*	1	0	1	1	1	1	0	0	0	1	1	1	1	1	12	2.66
<i>E. fraudabilis</i>	1	0	0	1	1	1*	1	1	0	0	0	0	1	1	1	1*	10	2.69
<i>Pe. scintillana</i>	1	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	10	3.06
<i>Pe. fratruelis</i>	1	1	0	0	1	1	1	1	0	0	0	0	1	1	0	1	9	2.53
<i>Ph. autumnana</i>	1	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	12	3.11
<i>Ph. verna</i>	1	1	1	0	1	1	1	1	0	0	0	1	1	0	1	0	10	3.15

0 = element absent; 1 = element present; 1\* = element remnant in some specimens

North American species most closely resembling Hübner’s illustration are: *E. circulana* (*sensu* Heinrich) (Figs. 5–7), *E. gemellana* Heinrich (Figs. 8–11), *E. paragemellana* Gilligan and Wright (Figs. 12–13), *E. fraudabilis* Heinrich (Figs. 14–15), *Pelochrista scintillana* (Clemens) (Figs. 16–18), *P. fratruelis* (Heinrich) (Fig. 19), *Phaneta verna* Miller (Figs. 20–21), and *P. autumnana* (McDunnough) (Figs. 22–24). Table 1 summarizes the extent to which each agrees with Hübner’s illustration based on the 17 elements cited above. By those criteria, the best match is *E. circulana* (*sensu* Heinrich). It has the disadvantage that element 4 is not present and element 5 is only partially expressed. *Eucosma fraudabilis* is the only species in which elements 4 and 5 are fully expressed, *P.*

*scintillana* exhibits one or both with varying degrees of expression, and *E. fratruelis* has only element 4. These three species differ from Hübner's illustration in that the ocellus has three or four rows of black dots instead of two, and the rest of the ocelloid region is not golden yellow but is largely filled with blackish-brown scales with white apices. In *P. verna* and *P. autumnana* the ocellus conforms to Hübner's illustration, but the background of the ocelloid region is not uniformly golden yellow, and the small striate markings associated with the costal strigulae seem unlikely to have inspired the bold "white stripes" in Hübner's painting. Curiously, element 9 (the stria projecting into the ocelloid region) does not occur in any of the candidate species. All things considered, we conclude that Heinrich's concept of *E. circulana* is the best of the available options. The site closest to the type locality (Pennsylvania) from which valid specimens of this species have been collected is in western Kentucky. Per Article 75 of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature 1999), we determine the name-bearing type of *E. circulana* to be lost or destroyed and select a Kentucky specimen (see *E. circulana* redescription below) as the neotype.

## Descriptions and redescriptions

### *Eucosma circulana* Hübner

(Figs. 5–7, 25, 29, 32)

*Eucosma circulana* Hübner 1823:28, Figs. 363–364.

*Eucosma circulana*; Hübner [1816–1825]:374; Fernald 1903:455; Fernald 1908:4; Walsingham 1914:226; Barnes & McDunnough 1917:169; Heinrich 1923:95; McDunnough 1939:46; Obraztsov 1968:1; Powell 1983:34; Razowski 1989:175; Razowski 2003:84; Brown 2005:317.

*Paedisca circulana*: Fernald 1882:36; Walsingham 1884:136; Fernald 1891:91.

**Diagnosis.** *Eucosma circulana* (Figs. 5–7) is similar in forewing appearance to *E. gemellana* (Figs. 8–11) and *E. paragemellana* (Figs. 12–13) but lacks the whitish subcostal band and basal streaking in the latter two taxa. Males differ in valval shape (Figs. 25–27, Table 2). In *E. circulana* the neck is wider (NR = 0.42 vs. 0.28 and 0.19), the saccular angle is slightly obtuse instead of acute (SA = 102 vs. 89 and 78), and the dorsal/ventral developments of the cucullus are larger/smaller, respectively, than those of *E. gemellana* and *E. paragemellana*. Females are separated by subtle differences in sternum 7 (Figs. 32–34). In *E. circulana* the posterior extremities of sternum 7 (flanking the sterigma) usually extend to the posterior margin of the lamella postvaginalis; in the other two species they extend noticeably beyond that point. In all three species the posterolateral margins of sternum 7 are concavely inflected, but there are interspecific differences in the locations of the deepest points of inflection relative to the sterigma. In *E. circulana* the deepest points align with the lamella antevaginalis; in *E. gemellana* and *E. paragemellana* they align with the midpoint and posterior margin, respectively, of the lamella postvaginalis.

**Description.** *Head.* Frons white; vertex creamy white medially, brownish laterally; labial palpus with medial surface creamy white, lateral surface brownish; antenna tan; ventral surface of scape creamy white. *Thorax.* Dorsal surface brown; fore- and mid-legs with anterior surfaces pale brown, posterior surfaces creamy white; hind-legs creamy white; tarsi with weakly contrasting white annulations. Forewing (Figs. 5–7): ♂ FWL 6.6–9.6 mm (mean = 8.1, n = 27), AR = 2.79, CFR = 0.33; ♀ FWL 7.8–10.7 mm (mean = 9.1, n = 8), AR = 2.75; costal margin nearly straight; apex acute; termen weakly concave; dorsal surface with proximal one-half brown to brownish yellow, distal one-half golden yellow, the latter section edged with brown along costa, dorsum, and termen and containing a circular ocelloid region that extends from tornus nearly to costa; ocelloid region with golden-yellow central field and metallic-gray circular boundary, the anterior semicircle largely intact but with up to three short interruptions, the posterior semi-circle fragmentary, consisting of two or three dots and a short arc; ocellus (ca. between M<sub>2</sub> and CuA<sub>1</sub>) consisting of two rows (and sometimes a partial third) of three to five black dots separated by metallic-gray scaling, the primary rows often at least partially confluent; costal strigulae not expressed; subcostal portion of golden-yellow region crossed by several lustrous gray striae and/or fragments of striae, the most clearly defined being those arising at the positions of strigulae 6 and 9, with stria 6 often extending to inner margin after an interruption in the cell; fringe brown. Hindwing: brownish gray. *Abdomen.* Male genitalia (Fig. 25) (n = 5): Uncus moderately developed, divided medially by shallow indentation, well differentiated from dorsolateral shoulders of tegumen; socii fingerlike; phallus stout, moderately long, tapering distally; anellus approximate to phallobase;

vesica with 22–40 (mean = 29, n = 4) deciduous cornuti; valva with costal margin concave, ventral emargination moderate, NR 0.35–0.46 (mean = 0.42, n = 5), ventrolateral margin of neck scooped out (indicated by dashed line in Fig. 25), saccular corner angular, SA 96–108 (mean = 102, n = 5); cucullus with apex semicircular, distal margin nearly straight, anal angle moderately produced, setation of medial surface coarse toward distal margin and anal angle grading to fine toward costal margin and apex; vertex of anal angle with one ventrally projecting spiniform seta that is slightly stouter than adjacent setae on medial surface of cucullus. Female genitalia (Fig. 29, 32) (n = 4): papillae anales laterally facing and moderately setose; lamella postvaginalis rectangular (length  $\approx$  width) and microspinulate; lamella antevaginalis ringlike; posterior margin of sternum 7 emarginated to length of sterigma and approximate to anterior and lateral margins of sterigma; posterolateral margins of sternum 7 concavely inflected, the deepest points of indentation aligned with lamella antevaginalis; scaling of sternum 7 dense on posterior projections and anterolateral margins, sparse in broad band joining inflections of posterolateral margins; ductus bursae with sclerotized ring posterior to juncture with ductus seminalis, the latter midway between ostium and corpus bursae; corpus bursae with two large signa of approximately equal size.

**TABLE 2.** Comparison of selected morphological character states for *E. circulana* and closely related species.

	FWL (mm)			AR	CFR		
	Range	Mean	n		Range	Mean	n
<i>E. circulana</i>	6.6-10.7	8.3	35	2.78	0.29-0.38	0.33	18
<i>E. gemellana</i>	7.2-12.3	9.3	61	2.90	0.33-0.43	0.38	15
<i>E. paragemellana</i>	5.0-7.6	6.4	64	2.66	0.16-0.28	0.23	40
<i>E. fraudabilis</i>	5.1-7.8	7.1	29	2.69	0.33-0.36	0.34	3

continued.

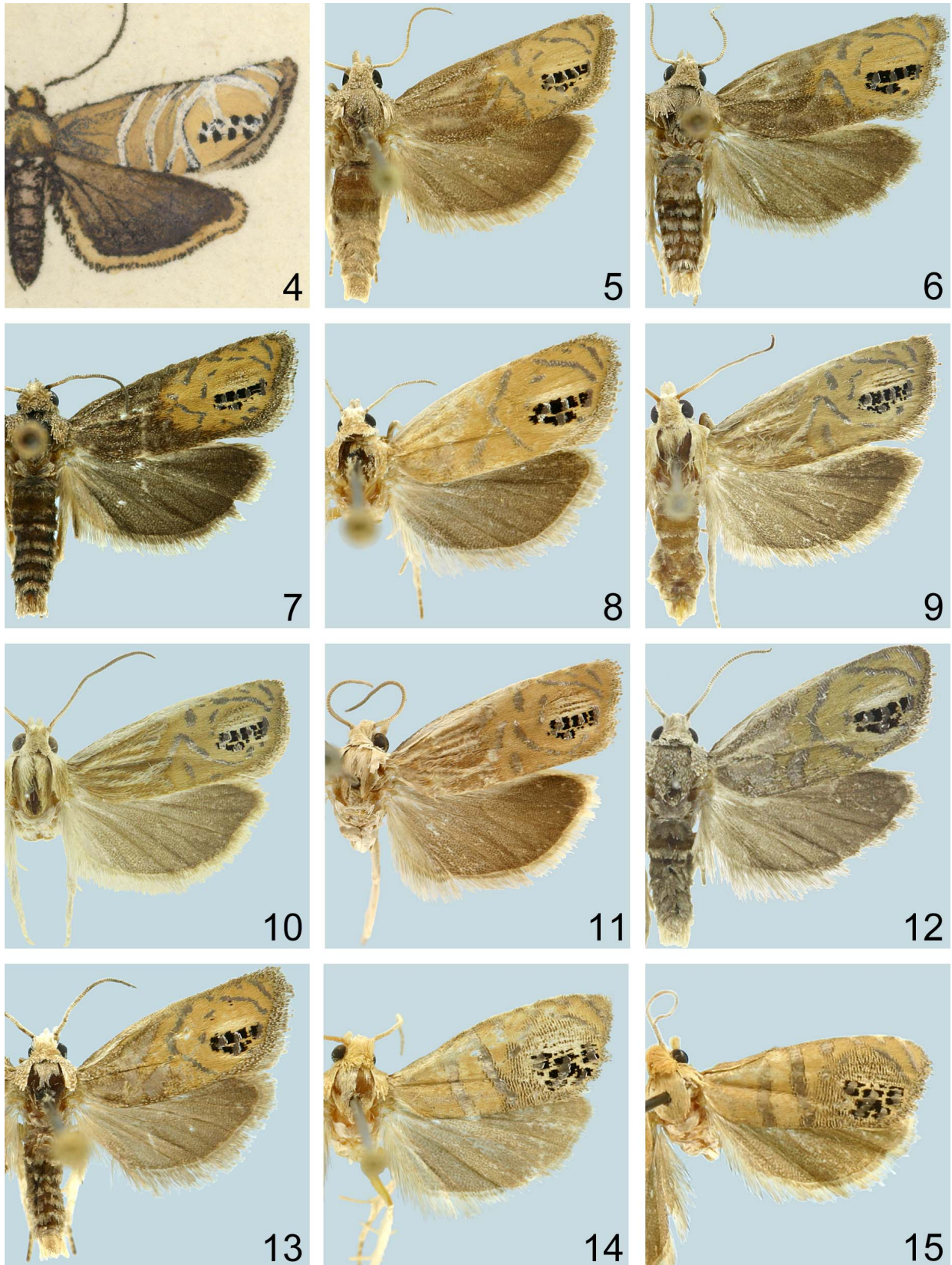
	SA			NR		
	Range	Mean	n	Range	Mean	n
<i>E. circulana</i>	96–108	102	5	0.35–0.48	0.42	5
<i>E. gemellana</i>	85–92	89	9	0.23–0.36	0.28	9
<i>E. paragemellana</i>	65–86	78	9	0.17–0.25	0.19	9
<i>E. fraudabilis</i>	127–150	139	6	0.42–0.59	0.50	6

**Neotype here designated (Fig. 5).** ♂, USA, Kentucky, McCracken County, 1/4 mi WNW Route 60 and Broad Street, D. J. Wright, 12 August 2008, 37 03' 43" N, 88 35' 56" W, USNM.

**Material Examined.** (60 ♂; 11 ♀). FLORIDA: Archer (1 ♀) MEM; Hastings, 8 June (1 ♂, slide 70325, illustrated in Heinrich 1923, Fig. 148) USNM. KENTUCKY: same location as neotype, D. J. Wright, 12 August 2008 (13 ♂; 4 ♀, slides DJW 3104, 3169) DJW, TMG; L. D. Gibson, 16 June 2007 (10 ♂) LDG, TMG, 27 June 2008 (7 ♂), 7 September 2007 (15 ♂; 4 ♀) LDG, TMG; 9 September 2006 (6 ♂, slides DJW 1700, 2004) LDG, DJW. LOUISIANA: Vernon [Parish], G. Coverdale (1 ♂) AMNH. MISSISSIPPI: Hinds Co., Jackson, 31 March 1931 (1 ♀) MEM; Clinton, B. Mather, 27 February 1962 (1 ♂) MEM; Oktibbeha Co., 6 mi. SW Starkville, R. L. Brown, 18 April 1987 (1 ♂) MEM; nr. Hattiesburg, C. D. Michener, 1–15 August 1944, (1 ♂, slide DJW 1178; 1 ♀, slide DJW 1345) AMNH. TEXAS: Harris Co., Houston, A. & M. E. Blanchard, 5 June 1967 (1 ♂), 6 June 1968 (1 ♂, slide 134150), 8 June 1968 (1 ♀, slide 134151), 7 September 1965 (1 ♂) USNM.

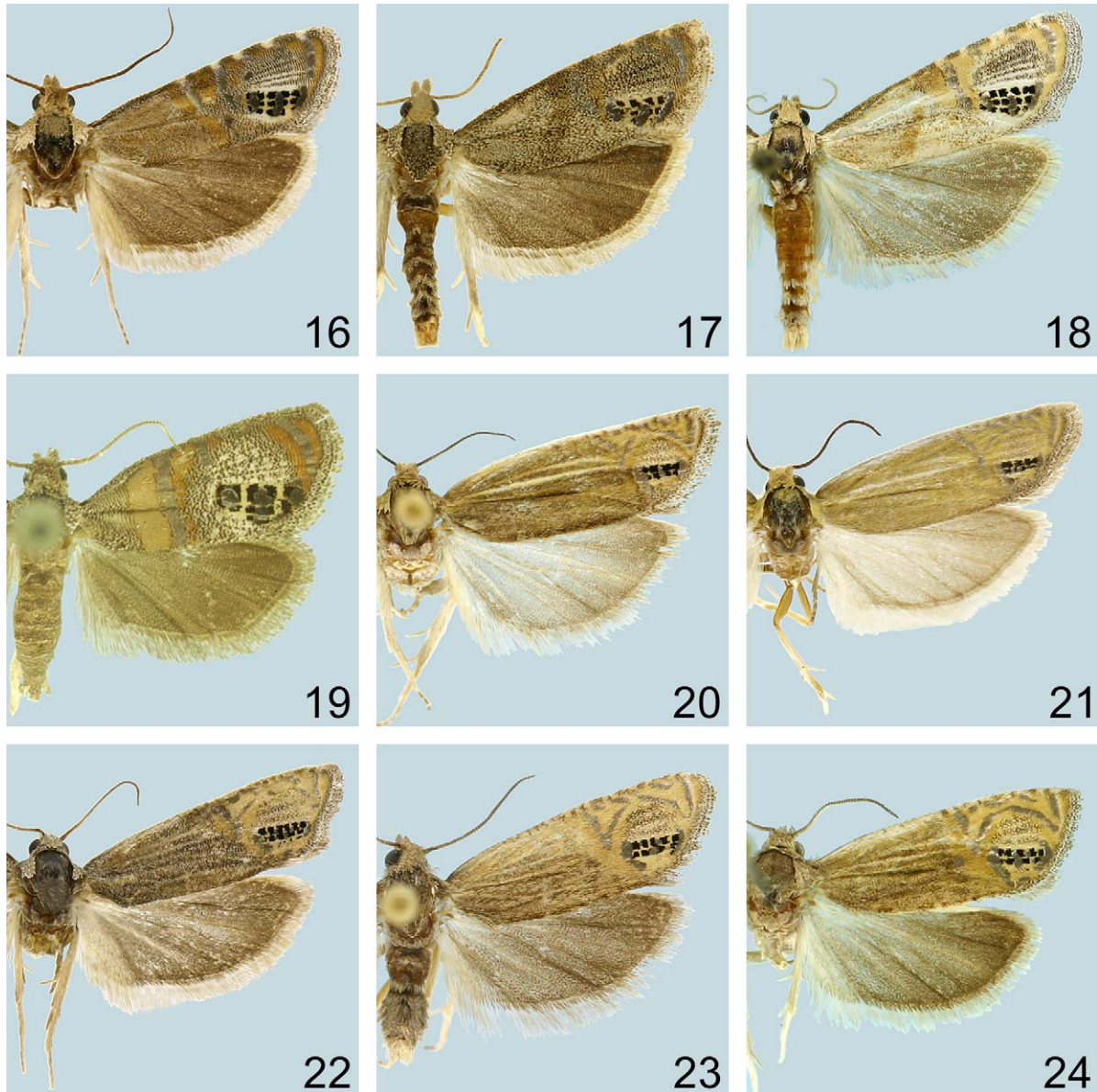
**Distribution (Fig. 35) and Flight Period.** Northern Florida, western Kentucky, western Louisiana, Mississippi, east Texas; late February – early September.





**FIGURES 4–15.** *Eucosma circulana* and closely related species. 4, Hübner's illustration. 5–7, *E. circulana* (5, Neotype). 8–11, *E. gemellana*. 12–13, *E. paragemellana* (13, Holotype). 14–15, *E. fraudabilis* (15, Holotype).





**FIGURES 16–24.** Species easily confused with *E. circulana*. 16–18, *Pelochrista scintillana*. 19, *P. fratruelis*. 20–21, *Phaneta verna*. 22–24, *P. autumnana*.

***Eucosma gemellana* Heinrich, new status**

(Figs. 8–11, 26, 33)

*Eucosma circulana gemellana* Heinrich 1923:96, Fig. 150.

*Eucosma circulana gemellana*; McDunnough 1939:46; Powell 1983:34; Brown 2005:317.

**Diagnosis.** *Eucosma gemellana* (Figs. 8–11) is similar in appearance to *E. circulana* (Figs. 5–7) and *E. paragemellana* (Figs. 12–13); maculation and genitalic differences are discussed in the diagnoses under the latter two species.

**Description.** *Head.* Frons and vertex creamy white; labial palpus creamy white with some pale brown tinting on lateral surface; antenna creamy white. *Thorax.* Dorsal surface creamy white to pale brown; fore- and mid-legs with anterior surfaces pale brown, posterior surfaces creamy white; hind-legs creamy white; tarsi with weakly contrasting white annulations. Forewing (Figs. 8–11): ♂ FWL 7.2–11.0 mm (mean = 9.3, n = 48), AR = 2.91, CFR = 0.42; ♀ FWL 8.1–12.3 mm (mean = 10.2, n = 13), AR = 2.88; costal margin weakly arched; apex acute; termen

weakly concave; dorsal surface as in *E. circulana* except: most specimens have a creamy white subcostal streak from base to mid-wing and creamy-white streaking on cell, CuP, and A<sub>1+2</sub>, the anterior one-half of the ocelloid region has variably expressed dark streaks along the medial veins, the ocellus has white edging along its anterior margin and lacks metallic-gray scaling separating the distal two columns of black dots, and males have a thin gray-brown streak on the costa from base to distal end of fold. Hindwing: brownish gray. *Abdomen*. Male genitalia (Fig. 26) (n = 9): Uncus weakly produced but distinguishable from dorsolateral shoulders of tegumen; socii fingerlike, phallus stout, moderately long, tapering distally; anellus approximate to phallobase; vesica with 20–40 (mean = 28, n = 4) deciduous cornuti; valva with costal margin weakly concave, ventral emargination deep and U-shaped, proximal extremity of neck narrow, NR 0.23–0.36 (mean = 0.28, n = 9), ventrolateral margin of neck scooped out (indicated by dashed line in Fig. 26), saccular corner angular, SA 85–92 (mean = 89, n = 9); cucullus with apex rounded and moderately produced, distal margin weakly convex of nearly uniform curvature, ventral development long and narrow, setation of medial surface coarse toward distal margin and anal angle grading to fine toward costal margin and apex; anal angle with one spiniform seta at vertex that is isolated from nearby setae on medial surface of cucullus. Female genitalia (Fig. 33) (n = 3): As in *E. circulana* except the posterior projections of sternum 7 extend beyond posterior margin of the sterigma, and the indentations in the posterolateral margins of sternum 7 are aligned with the midpoint of the lamella postvaginalis.

Holotype. ♂, Florida, [Pinellas Co.], St. Petersburg, May, slide 72903, USNM.

Paratypes. FLORIDA: [Pinellas Co.], St. Petersburg, R. Ludwig, 11 April 1914 (1 ♂); Morrison, 1884 (1 ♂) [determined as *Paedisca circulana* by Walsingham], USNM.

**Additional material examined.** FLORIDA: Charlotte Co., Punta Gorda, H. Ramstadt, 1–10 May 1903 (1 ♂) USNM; Citrus Co., Sandhill Crane NWR, H. D. Baggett, 2 June 1984 (1 ♂) MEM; Hwy 480 W Floral City, H. D. Baggett, 2 June 1984 (1 ♂) FSCA; Lecanto, J. Glaser, 1 October 1996 (1 ♂, slide TMG 601) USNM; Hernando Co., Croom Wildlife Preserve, W. L. Adair, 8 February 1989 (1 ♂) FSCA; Highlands Co., Highlands Hammock St. Park, G. J. Balogh, 5 November 1987 (1 ♂, slide DJW 330) DJW; Hillsborough Co., USF Ecology Area, W. L. Adair, 23 May 1992 (1 ♀) FSCA; Tampa, H. D. Baggett, 27 April 1984 (1 ♂) FSCA, (1 ♂, slide RLB 1781), 27 April 1989 (1 ♂) MEM, 9 October 1933, (1 ♂) USNM; Stemper, G. Krautwurm, 14 February 1911 (1 ♂), 7 October 1911 (1 ♂) CMNH, 1–7 July (1 ♂) USNM; Lee Co., Ft. Myers, 22 April 1912 (1 ♀, slide DJW 3168) AMNH; Levy Co., Goethe State Forest, J. E. Hayden & G. E. Lee, 15 June 2012 (1 ♂) FSCA; Liberty Co., Wilma, J. Glaser, 30 September 1996 (2 ♂, slide 141872) USNM; Marion Co., Ocala NF, Lake Delancy, J. S. Kutis, 10 April 1991 (1 ♂), 23 June 1991 (1 ♀), 28 June 1991 (1 ♂, slide TMG 606), 11 September 1991 (3 ♂), 21 September 1991 (1 ♂), 9 October 1991 (1 ♂, slide RLB 1783), 18 October 1990 (1 ♂) MEM; H. D. Baggett, 10 April 1991 (1 ♂), 16 April 1990 (1 ♂), 22 June 1991 (2 ♂), 28 July 1991 (1 ♀), 11 August 1990 (1 ♂), 17 September 1991 (1 ♀, slide RLB 1782), 16 October 1990 (3 ♂), 18 October 1990 (1 ♂, slide TMG 611), 19 October 1991 (2 ♂) MEM; W. L. Adair, 31 October 1992, (1 ♂, 1 ♀) FSCA; Orange Co., Winter Park, A. B. Klots, May 1946 (1 ♂; 1 ♀, slide DJW 1179), September 1946 (1 ♀, slide DJW 1347) AMNH; Pinellas Co., St. Petersburg, 16–23 February (2 ♂, slide TMG 597), 1–7 March (1 ♂, slide TMG 598), 16–23 October (2 ♂) USNM; Putnam Co., Lake Delancy, H. D. Baggett, 2 March 1985 (1 ♂) MEM; U. of Florida Preserve, Welaka, H. D. Baggett, 19 September 1987 (1 ♀) MEM; Welaka, D. C. Ferguson, 17 April 1973 (1 ♂, slide 124081) USNM; Santa Rosa Co., FAMU Biological Station near Holt, J. B. Heppner, 25–28 August 1986 (1 ♀) FSCA; Volusia Co., Cassadaga, S. V. Fuller, 3 May 1965 (1 ♂), 1 July 1964 (1 ♂), 3 September 1996 (1 ♀), 9 October 1962 (1 ♀), 15 December 1965 (1 ♂) FSCA.

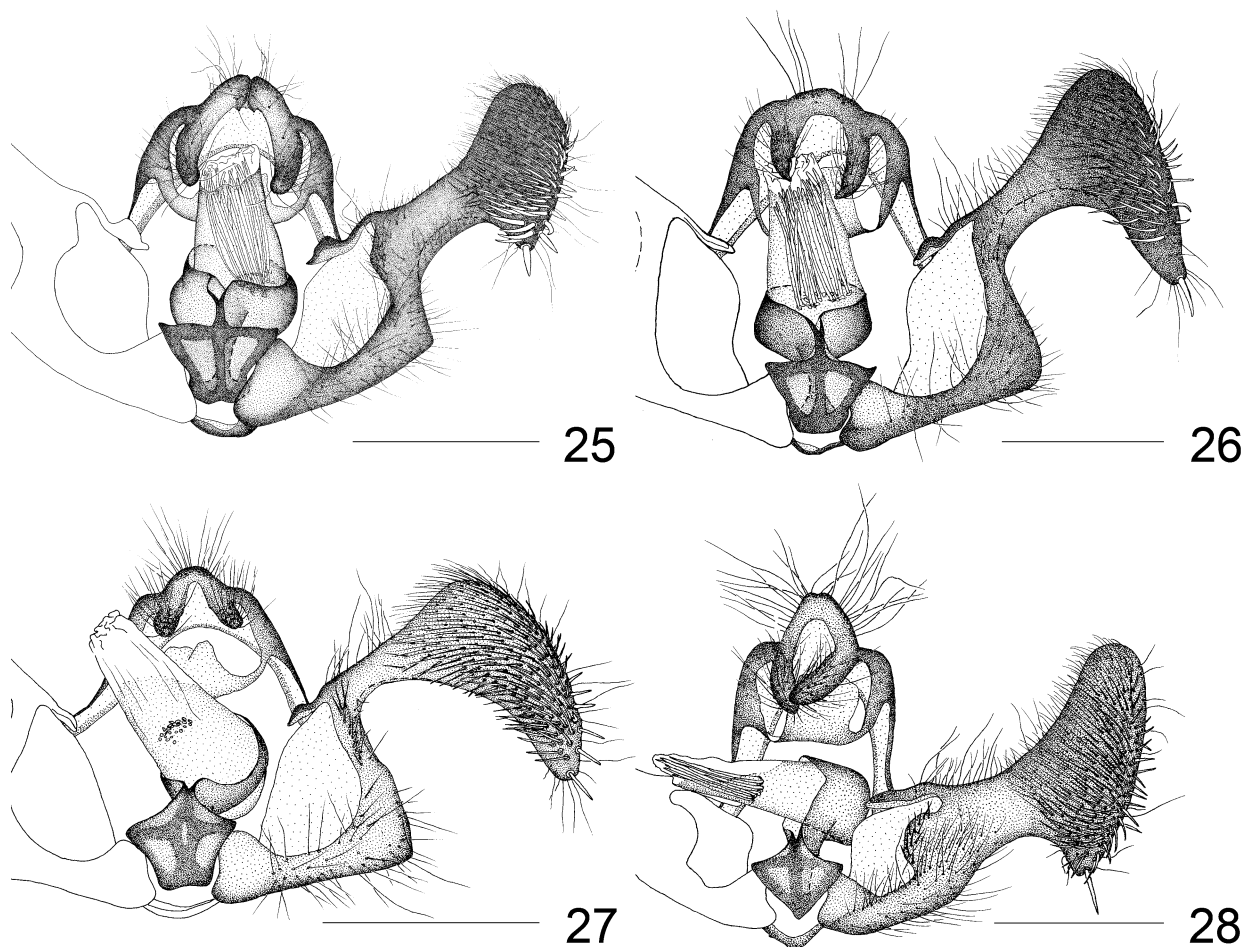
**Distribution (Fig. 35) and Flight Period.** Florida, February – December.

### *Eucosma paragemellana* Gilligan & Wright, new species

(Figs. 12–13, 27, 30, 34)

**Diagnosis.** *Eucosma paragemellana* (Figs. 12–13) is indistinguishable from *E. gemellana* (Figs. 8–11) in forewing color and maculation, but *E. paragemellana* is smaller (mean FWL = 6.4 vs. 9.3 mm) and has a shorter costal fold (CFR = 0.25 vs. 0.42). Males differ in the shape and setation of the valva (Figs. 26, 27): the neck in *E. paragemellana* is somewhat narrower (NR = 0.19 vs. 0.28), the saccular angle is slightly more acute (SA = 78 vs. 89), the anal angle is more elongate, and the setae on the medial surface of the cucullus extend to the vertex of the

anal angle. Females differ in the locations of the indentations in the posterolateral margins of sternum 7 in relation to the lamella postvaginalis (Figs. 33, 34): aligned with the posterior margin in *E. paragemellana*, aligned with the midpoint in *E. gemellana*. Differences between *E. paragemellana* and *E. circulana* are discussed above in the diagnosis of the later taxon.



**FIGURES 25–28.** Male genitalia. 25, *E. circulana*. 26, *E. gemellana*. 27, *E. paragemellana*. 28, *E. fraudabilis*. Scale bar = 0.5 mm.

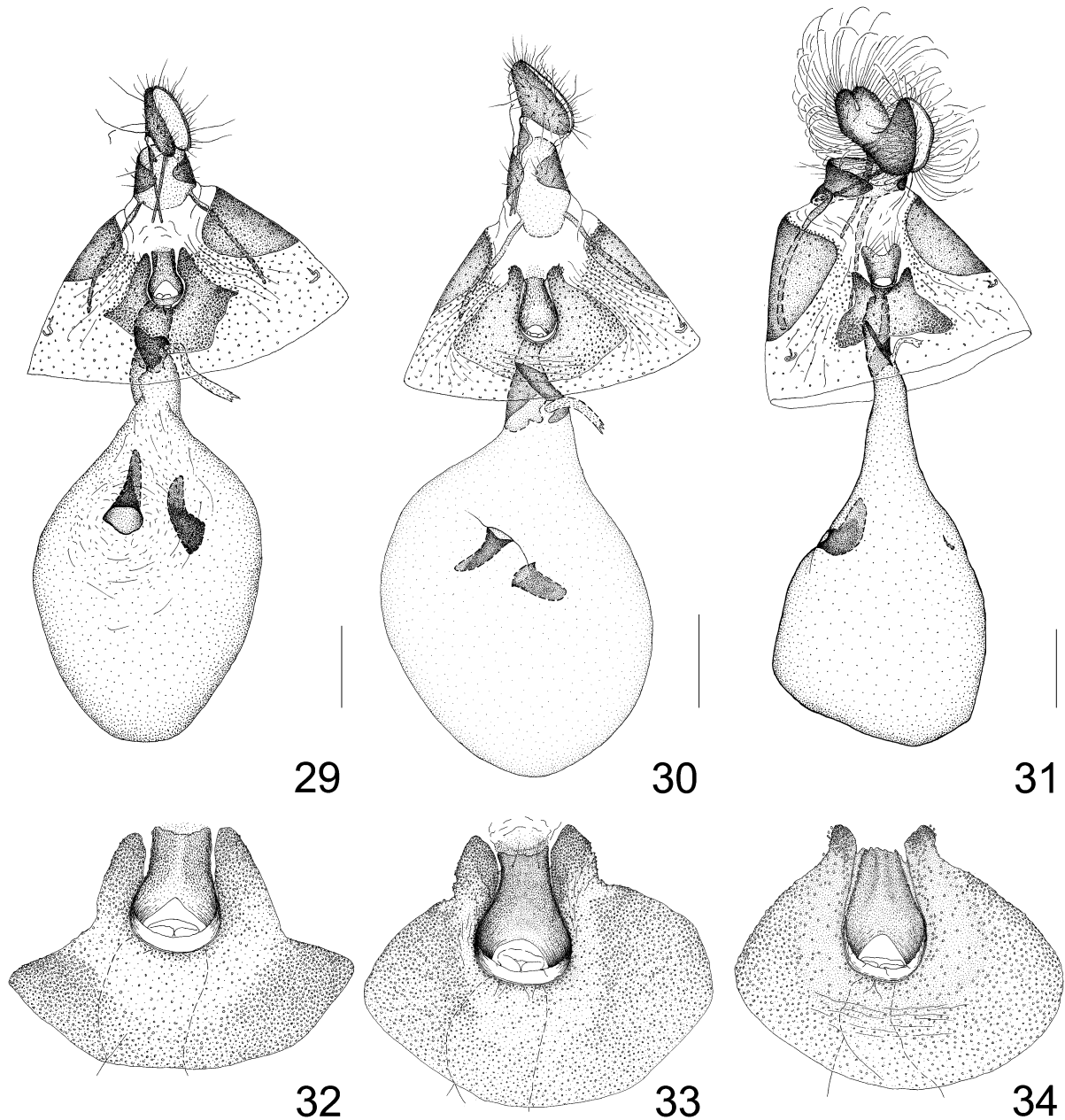
**Description.** *Head and Thorax* as in *E. gemellana* except: ♂ FWL 5.0–7.6 mm (mean = 6.3, n = 56), AR = 2.66, CFR = 0.25; ♀ FWL 6.6–7.3 mm (mean = 6.7, n = 8), AR = 2.70. *Abdomen.* Male genitalia (Fig. 27) (n = 9): Uncus moderately produced and clearly differentiated from dorsolateral shoulders of tegumen; socii fingerlike, phallus stout, moderately long, and tapering distally; anellus approximate to phallobase; vesica with 25–28 deciduous cornuti; valva with costal margin straight to weakly concave, ventral emargination deep, proximal extremity of neck narrow, NR 0.17–0.25 (mean = 0.19, n = 9), ventrolateral margin of neck weakly scooped out, saccular corner angular, SA 65–86 (mean = 78, n = 9); cucullus with apex weakly developed, distal margin weakly convex, ventral projection long and narrow; setation of medial surface of cucullus extending to spiniform seta at vertex of anal angle, coarse toward distal margin and anal angle grading to fine toward costal margin and apex. Female genitalia (Fig. 30, 34) (n = 4): As in *E. gemellana* except that the indentations of the posterolateral margins of sternum 7 align with the posterior margin of the lamella postvaginalis.

*Holotype* (Fig. 13). ♂, Alabama, Baldwin Co., Weeks Bay Estuarine Reserve, D. J. Wright, 22 June 2008, USNM.

*Paratypes.* ALABAMA: Baldwin Co., Weeks Bay Estuarine Reserve, R. L. Brown, 20 June 2001 (2 ♂) MEM; D. J. Wright, 21 June 2008 (5 ♂, slides DJW 2050, 3123, 3124), 22 June 2008 (6 ♂; 1 ♀, slide DJW 2773) DJW; T. M. Gilligan, 21 June 2008 (5 ♂), 22 June 2008 (2 ♂; 1 ♀) TMG; L. D. Gibson, 21 June 2008 (4 ♂) LDG. FLORIDA: Pensacola, 11–14 October 1914 (1 ♀, slide DJW 1346) AMNH. MISSISSIPPI: Harrison Co., Pass Christian, R. Kergosien, 6 August 1994 (1 ♂, slide TMG 612) MEM; Jackson Co., 1 mi. W Hwy 90 & 57, R. L.

Brown, 5 April 1991 (1 ♂), 12 April 1991 (1 ♂), D. M. Pollock, 5 April 1991 (1 ♂) MEM; I-10 at Escatawpa River, R. L. Brown, 13 April 1991 (1 ♂, slide TMG 607) MEM; I-10 1 mi. W Ala., T. L. Schiefer, 22 July 1989 (1 ♂, slide DJW 2006; 3 ♀) MEM, DJW; Sandhill Crane NWR, J. A. MacGown, 29 August 1995 (3 ♂), 7 September 1994 (3 ♂, TMG 605; 1 ♀, slide TMG 610) MEM; Grand Bay Savannah, R. L. Brown and E. L. Martinez, 30 April 2004 (4 ♂), J. A. MacGown, 6 September 1994 (1 ♂) MEM. NORTH CAROLINA: Pender Co., Holly Shelter Game Land, J. B. Sullivan, 1 July 1998 (2 ♂, slide TMG 595), 7 August 1997 (4 ♂), 26 August 1997 (9 ♂, slide TMG 603; 1 ♀, slide TMG 596), 26 September 1995 (1 ♂) USNM.

**Distribution (Fig. 35) and Flight Period.** Gulf Coast of Alabama, Mississippi, and the panhandle of Florida; coast of North Carolina; April – September.



**FIGURES 29–31.** Female genitalia. 29, *E. circulana*. 30, *E. paragemellana*. 31, *E. fraudabilis*. **FIGURES 32–34.** Sterigma and sternum 7. 32, *E. circulana*. 33, *E. gemellana*. 34, *E. paragemellana*. Scale bar = 0.5 mm.



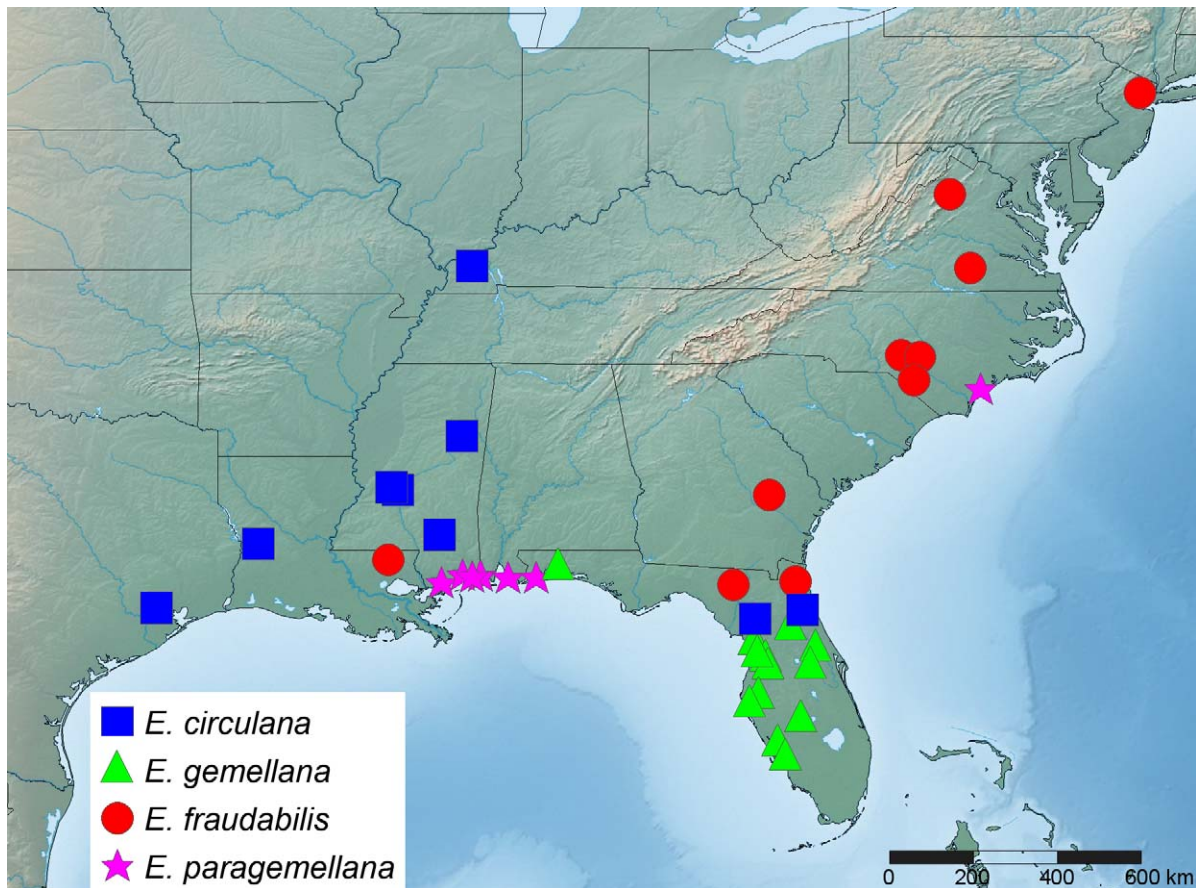


FIGURE 35. Distribution map for *E. circulana*, *E. gemellana*, *E. paragemellana*, and *E. fraudabilis*.

### *Eucosma fraudabilis* Heinrich

(Figs. 14–15, 28, 31)

*Eucosma fraudabilis* Heinrich 1923:98, Fig. 161.

*Eucosma fraudabilis*; McDunnough 1939:46; Powell 1983:34; Brown 2005:320.

**Diagnosis.** *Eucosma fraudabilis* (Figs. 14–15) differs from the other species considered here in having two conspicuous metallic-gray bands extending from costa to dorsum (elements 4 and 5) in the median area of the forewing. It is readily separated from *E. circulana*, *E. gemellana*, and *E. paragemellana* by male valval shape (Figs. 25–28). Moreover, it is the only species considered here in which the anterior lobes of the papillae anales are developed into ventral extensions flanking the anal opening.

**Description.** *Head.* Frons creamy white; vertex straw yellow; labial palpus creamy white with pale brown tints on lateral surface of second segment; antenna concolorous with vertex. *Thorax.* Dorsal surface straw yellow; fore- and mid-legs with anterior surfaces pale brown, posterior surfaces creamy white; hind-legs creamy white; tarsi with weakly contrasting white annulations. Forewing (Figs. 14–15): ♂ FWL 5.1–7.8 mm (mean = 7.0, n = 26), AR = 2.70, CFR = 0.34; ♀ FWL 7.6–7.7 mm (mean = 7.7, n = 3), AR = 2.65; costal margin weakly arched; apex acute; termen straight to weakly convex; dorsal surface straw yellow, with metallic-gray subbasal and median bands from costa to dorsum and a large circular ocelloid region extending from tornus nearly to costa; ocelloid region with apical quadrant edged by metallic-gray arc and with anterior portion of field filled with gray-brown scales with whitish apices; ocellus consisting of four obscurely defined rows of black dots on a creamy white field, with transverse metallic-gray bars at the proximal, medial, and distal positions; subcostal area anterior to ocelloid region crossed by metallic-gray striae and/or fragments thereof; distal one-half of costa with obscure whitish strigulae; fringe brown. Hindwing: brownish gray. *Abdomen.* Male genitalia (Fig. 28) (n = 6): Uncus strongly produced,

tapering distally, and clearly differentiated from dorsolateral shoulders of tegumen; socii fingerlike; phallus stout, moderately long, tapering distally; anellus approximate to phallobase; vesica with 9–20 (mean = 14, n = 3) deciduous cornuti; valva with costal margin concave, ventral emargination moderate, NR 0.42–0.59 (mean = 0.50, n = 6), saccular corner broadly rounded, SA 127–150 (mean = 139, n = 6), distal margin of basal excavation with broad tablike pulvinus; cucullus with apex semicircular, distal margin weakly convex of nearly uniform curvature, anal angle acute and moderately produced, setation of medial surface coarse toward distal margin and anal angle grading to fine toward costal margin and apex; vertex of anal angle with one spiniform seta of ca. twice the size of adjacent setae on medial surface of cucullus. Female genitalia (Fig. 31) (n = 2): Papillae anales with posterior lobes facing ventrally, anterior lobes produced into laterally facing ventral extensions; margins of posterior lobes with long ventrally curving setae; margins of anal opening with moderately long hook-tipped setae; lamella postvaginalis gradually widening posteriorly, with posterior margin concavely indented; lamella antevaginalis ringlike; sternum 7 with lateral margins concavely inflected, posterior margin invaginated to one-half length of sterigma and diverging from lateral margins of sterigma; scaling of sternum 7 dense on posterior projections and anterolateral corners, sparse elsewhere; ductus bursae with sclerotized patch at juncture with ductus seminalis and with microspinules on inner surface in the vicinity of that juncture; corpus bursae with two signa, one much larger than the other.

Holotype (Fig. 15). ♂, North Carolina, [Moore Co.], Southern Pines, slide 74784, USNM.

Paratypes. North Carolina, [Moore Co.], Southern Pines, 1–7 June (1 ♂), 8–15 June (1 ♂, slide TMG 600), 1–7 July (2 ♂), 8–15 July (3 ♂; 1 ♀, slide 124084; 1 misidentified ♀ of *P. scintillana*, slide TMG 599); 16–23 July (1 ♂), USNM; 8–15 June (2 ♂), 1–7 July (1 ♀, slide DJW 3164), 16–23 July (1 ♂; 1 ♀), AMNH. This accounts for fifteen of the seventeen paratypes mentioned by Heinrich (1923).

**Additional material examined.** FLORIDA: Suwannee Co., Suwannee River State Park, H. D. Baggett, 27 June 1981 (1 ♂) MEM; Duval Co., Jax. Police Academy, H. D. Baggett, 20 August 1980 (1 ♂) MEM. GEORGIA: Emanuel Co., Ochopee N. A., R. L. Brown, 16 June 2002 (3 ♂) MEM. LOUISIANA: Tangipahoa Parish, Sandy Hollow WLMA, D. P. Pashley, 26 May 1993 (1 ♂) MEM; 31 May 1994 (1 ♂, slide DJW 2017) DJW. NEW JERSEY: Essex Co. Park, 15 August (1 ♂, slide DJW 1180) AMNH. NORTH CAROLINA: Hoke Co., Ft. Bragg, 0.5 mi. NE Jct. Blues Rd & Manchester Rd., J. B. Sullivan & S. P. Hall, 20 June 2001 (1 ♂) USNM; Moore Co., Southern Pines, 8–15 July (1 ♂, slide DJW 1329) AMNH; Robeson Co., Maxton, A. B. Klots, 20 June 1944 (1 ♂), 10 July 1944 (2 ♂), 10 August 1944 (1 ♂) AMNH. VIRGINIA: Nottoway Co., Ft. Pickett Mil. Res. Grassland, 0.8 km E. jct. Wilcox & Range Rd., A. C. Chazal, 6 July 2000 (1 ♂, slide 118545) USNM; Page Co., Skyland, H. G. Dyar, 15 July 1911 (1 ♂, slide 70355) USNM.

**Distribution (Fig. 35) and Flight Period.** Florida, Georgia, Louisiana, New Jersey, North Carolina, Virginia; late May – mid-August.

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