A New Species of *Catocala* (Lepidoptera: Noctuidae) from the South Central United States

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Abstract

A new species of underwing moth, *Catocala bastropi* sp. nov., is described from Texas and Louisiana, USA. Wing pattern, genitalic and cytochrome oxidase subunit I 5′ mitochondrial DNA characters separate *C. bastropi* from phenotypically similar and closely related species. The new species occurs in xeric uplands from western Louisiana to the Bastrop Lost Pines ecoregion in Bastrop County, Texas, north to Ste. Genevieve County, Missouri, USA. Also evaluated here is a distinctive wing pattern phenotype with forewings resembling *C. andromedae* but with yellow-banded hind wings.

Keywords

Ericaceae, mitochondrial DNA, genitalia, new species, underwing moth, lost pines, Texas State Park

Introduction

The Nearctic *Catocala* fauna includes a morphologically well-defined species group, herein referred to as the *C. andromedae* species group, comprising four currently recognized species: *C. sordida* Grote, *C. gracilis* Edw., *C. andromedae* Guenee and *C. louiseae* Bauer. Within this group there is high structural homogeneity, and with the exception of *C. louiseae* these species cannot be separated by genitalia. Examples of synapomorphies unique to the Nearctic *Catocala* shared by this group include: vesica diverticulum 6 small (less than one-tenth the volume of diverticulum 7); vesica diverticulum 7 curved dorsally over the vesica and anteriorly beyond the base of the ventral aedeagus hood; receptacle duct of vesicle looped around for a full circle or nearly so. These four species also share many other potential synapomorphies of character states that exhibit homoplasy within the Nearctic fauna. These are also the only *Catocala* species recorded to utilize Ericaceae as larval hosts.

Catocala louiseae (Figure 1) is widely distributed across Florida, and has also been previously reported through the Gulf Coast states to eastern Texas and then north into Missouri (west of the Mississippi River), and into North Carolina along the Atlantic coastal plain. However, a gap appears to exist within the geographic range of *C. louiseae* between western Louisiana and Alabama, and specimens west of this gap usually differ subtly in wing pattern compared with Floridian material. We have examined *C. louiseae* from across its range using genitalic characters and mitochondrial DNA sequences from the 5′ region of cytochrome oxidase subunit I (COI), and find the following: *C. louiseae* specimens west of the aforementioned geographic gap are closer in COI sequence to *C. andromedae* than to Floridian *C. louiseae*; both male and female genitalia of the western *C. louiseae* specimens are indistinguishable from *C. andromedae*, but the male vesica differs slightly from Floridian *C. louiseae*. Consequently, this western *C. louiseae* represents a morphologically and genetically diagnosable taxon that has remained undescribed. Only the names *louiseae* and *protonympha* Boisduval might apply to it. The holotype of *C. louiseae* (Figure 2R) is a typical Floridian specimen. The holotype of *C. protonympha* (Figure 2Q) has been shown to be *C. louiseae* and not a European species, and most probably collected prior to 1840 in Georgia or Florida and not farther west (Gall 2001 and pers. comm.; the *protonympha* holotype cannot be unequivocally separated from western *C. louiseae* due to its age and corresponding fading and color shifts). The name *protonympha* has been designated a nomen oblitum (Gall 2001) per article 23.9.2 of the International Code of Zoological Nomenclature (ICZN 1999), and thus the western "*C. louiseae*" lacks a name, and we describe it here as a new species.

In addition, there is also a rarely collected phenotype in the *andromedae* species group that has forewings similar to *Catocala andromedae* but yellow-banded hind wings like *C. louiseae*. This phenotype is distributed sporadically near the coasts from Texas to Massachusetts and occurs in sympatry with *C. andromedae*, *C. louiseae* and/or the new species. We discuss it further below as "Phenotype AGU" (Andromedae Group Unplaced).

Materials and Methods

Specimens studied or examined are from the following private and institutional collections: HLK, Hugo Kons, Jr. (Appleton, Wisconsin, USA); Jeff Slotten (Gainesville, Florida, USA); LBC, Lepidoptera Biodiversity LLC collection (Mequon, Wisconsin, USA); MGC, McGuire Center for Lepidoptera Research, University of Florida, Gainesville, Florida, USA; RJB, Robert J. Borth (Mequon, Wisconsin, USA); Texas Lepidoptera Survey (Houston, Texas, USA); Vernon A. Brou collection (Abita Springs, Louisiana, USA); YPM ENT, Division of Entomology, Peabody Museum of Natural History, Yale University, New Haven, Connecticut, USA. Genitalia were dissected and imaged by HLK with GT Vision or Auto-Montage imaging systems as described in Kons and Borth (2015). Genitalic terminology follows Lepidoptera Biodiversity (2014). The 5′ region of COI was sequenced by Paul Hebert's lab at the University of Guelph as described in Hebert et al. (2003). Specimens were collected at MV (mercury vapor) sheets, UV (ultraviolet) traps, bait traps and bait trails.

Catocala bastropi Kons and Borth, sp. nov.

Figures 1A–K, 2A–B, 3–4, 5A–C, 6, 7A

Type material. Restricted to specimens with COI 5′ sequences and/or dissections.

Holotype. Male, DNA voucher no. 5056-150508-TX, dissection no. 2015HLK:2105, TEXAS, USA, Bastrop Co., Bastrop State Park, xeric loblolly pine forest overlook, 30.11120°N, 97.26942°W, MV Sheet, 15 May 2008, H.L. Kons Jr. and R.J. Borth (YPM ENT 872213).

Paratypes. TEXAS, USA: Bastrop Co., Bastrop State Park, 7 males, same data as holotype, DNA nos. 5044-150508-TX, 5046-150508-TX, 5049-150508-TX, 5052-150508-TX, 5054-150508-TX, 5055-150508-TX, 5051-150508-TX/dissection no. 2010HLK:636 (LBC); 6 females, DNA nos. 5043-150508-TX, 5045-150508-TX, 5047-150508-TX, 5048-150508-TX, 5050-150508-TX, 5053-150508-TX, same data as holotype (LBC); 1 male, DNA no. 5387-160508-TX, dissection no. 2010HLK:681, 30.10768°N, 97.27842°W, bait trap, xeric loblolly pine/oak forest, 16 May 2008 (RJB); 1 male, DNA no. 068-48-01060, 30.10797°N, 97.27845°W, MV sheet, xeric loblolly pine/oak forest, 1 June 2004 (RJB); 1 female, DNA No. 5377-140508-TX, 30.10780°N, 97.27926°W, bait trap, xeric loblolly pine/oak forest, 14 May 2008 (RJB); 1 female, DNA no. 5386-160508-TX, 30.10768°N, 97.27842°W, bait trap, xeric loblolly pine/oak forest, 16 May 2008 (RJB); 1 male, DNA no. 5383-170508-TX, 30.10768°N, 97.27842°W, bait trap, xeric loblolly pine/oak forest, 17 May 2008 (RJB); 1 female, DNA no. 340-48-27050-TX, dissection no. 2011HLK:1231, 30.10837°N, 97.27828°W, bait trap, xeric loblolly pine/oak forest, 27 May 2004 (RJB); 1 female, DNA no. 773-270504-TX, dissection no. 2014HLK:2015, vicinity of 30.10783°N, 97.27838°W, xeric loblolly pine-oak forest, bait trail, 27 May 2004 (HLK); 1 female, DNA no. 237-48-270504-TX, dissection no. 2014HLK:2002, 30.10797°N, 97.27845°W, xeric loblolly pine-oak forest, MV sheet, 27 May 2004 (HLK); 1 male, dissection no. 2014HLK:2041, 30.10790°N, 97.27905°W, xeric loblolly pine-oak forest, bait trap, 27 May 2004 (HLK); 1 male, dissection no. 2014HLK:2016, 30.10898°N, 97.28037°W, xeric loblolly pine-oak forest, bait trap, 27 May 2004 (HLK); 1 male, dissection no. 2014HLK:2024, 30.10793°N, 97.27912°W, xeric loblolly pine-oak forest, bait trap, 27 May 2004 (HLK); Angelina Co., Angelina National Forest, 1 male, DNA no. 5427-020508-TX, 31.07953°N, 97.27237°W, xeric longleaf pine/oak savanna/woodland, bait trap, 22 May 2008 (RJB); 1 female, DNA no. 5026-250508-TX, dissection no. 2010HLK:700, 31.08024°N, 94.26921°W, xeric longleaf pine/oak savanna/woodland, bait trap, 25 May 2008 (RJB); 1 male, dissection no. 2014HLK:2044, 31.07953°N, 94.27237°W, xeric longleaf pine/oak savanna/woodland, bait trap, 23 May 2008 (HLK); 1 male, DNA no. 5427-020508-TX, 31.07953°N, 94.27237°W, xeric longleaf pine/oak savanna/woodland, bait trap, 23 May 2008 (RJB). LOUISIANA, USA: Natchitoches Parish, Red Dirt Wildlife Management Area, 1 male, DNA no. 5817-280508-LA, 31.49658°N, 93.11208°W, xeric oak-pine woodland/savanna, bait trap, 28 May 2008 (RJB); 1 female, DNA no. 5816-280508-LA, Road 342, 31.49720°N, 93.11320°W, xeric oak-pine woodland/savanna, bait trap, 28 May 2008 (HLK); 1 male, DNA no. 5075-300508-LA, 30 May 2008 (RJB).

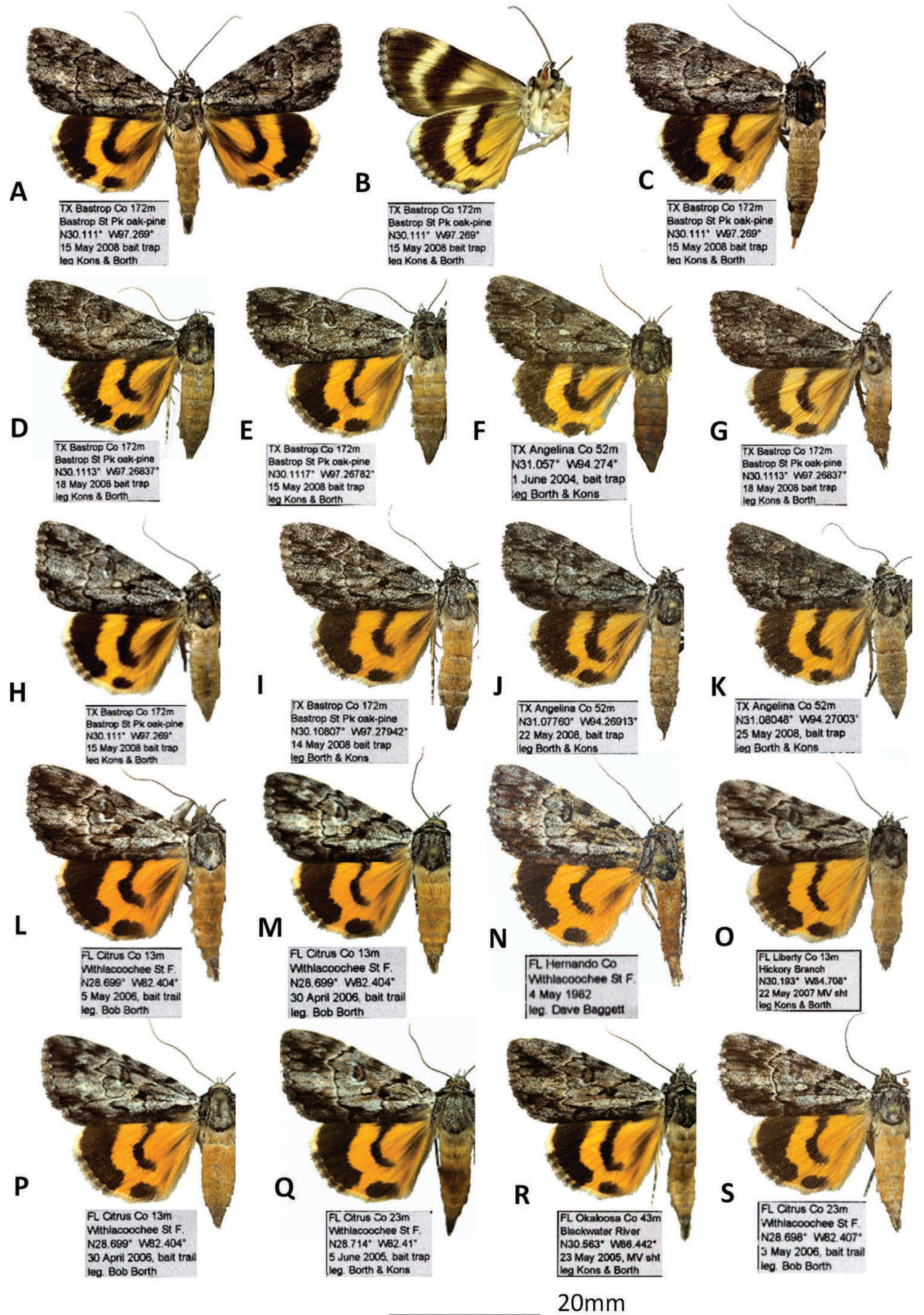

Figure 1. *Catocala* adults. **A,** *Catocala bastropi* holotype male (YPM ENT 872213; DNA no. 5056-150508-TX). **B,** *C. bastropi* (ventral) holotype male. **C,** *C. bastropi* female (DNA no. 5045-150508-TX). **D,** *C. bastropi* female. **E,** *C. bastropi* female. **F,** *C. bastropi* female (DNA no. 067-48-010604-TX). **G,** *C. bastropi* male. **H,** *C. bastropi* female (DNA no. 5377-140508-TX). **I,** *C. bastropi* male. **J,** *C. bastropi* female. **K,** *C. bastropi* female. **L,** *C. louiseae* male (DNA no. 241-48-030506-FL). **M,** *C. louiseae* female (DNA no. 240-48-300406-FL). **N,** *C. louiseae* male. **O,** *C. louiseae* female (DNA no. 2046-220507-FL). **P,** *C. louiseae* female (DNA no. 239-48-300406-FL). **Q,** *C. louiseae* male (DNA no. 339-48-050605-FL). **R,** *C. louiseae* male (DNA no. 5815-230505-FL). **S,** *C. louiseae* female.

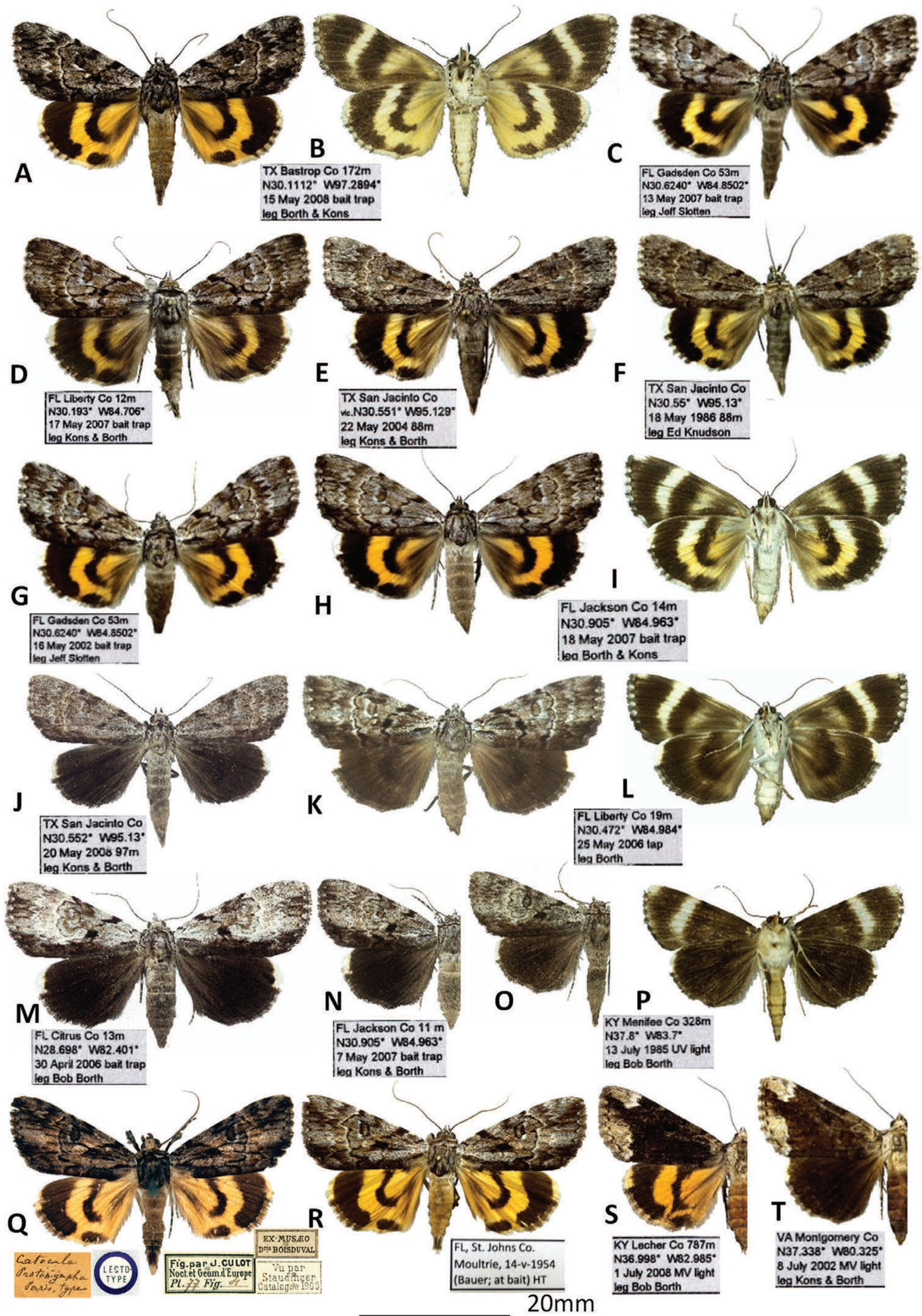

Figure 2. *Catocala* adults. **A,** *Catocala bastropi* female (DNA no. 5054-150508-TX). **B,** Same (ventral). **C,** Phenotype AGU male. **D,** Phenotype AGU male (DNA no. 2011-170507-FL). **E,** Phenotype AGU male. **F,** Phenotype AGU male. **G,** Phenotype AGU male. **H,** Phenotype AGU female (DNA no. 2012-180507-FL). **I,** Same (ventral). **J,** *C. andromedae* male. **K,** *C. andromedae* female. **L,** Same (ventral). **M,** *C. andromedae* female (DNA no. 241-48-030506-FL). **N,** *C. andromedae* female. **O,** *C. andromedae* male. **P,** Same (ventral). **Q,** *C. protonympha* male lectotype. **R,** *C. louiseae* male holotype. **S,** *C. micronympha* female (DNA no. 5215-010708-KY). **T,** *C. micronympha* male (DNA no. 090-76-080702-VA).

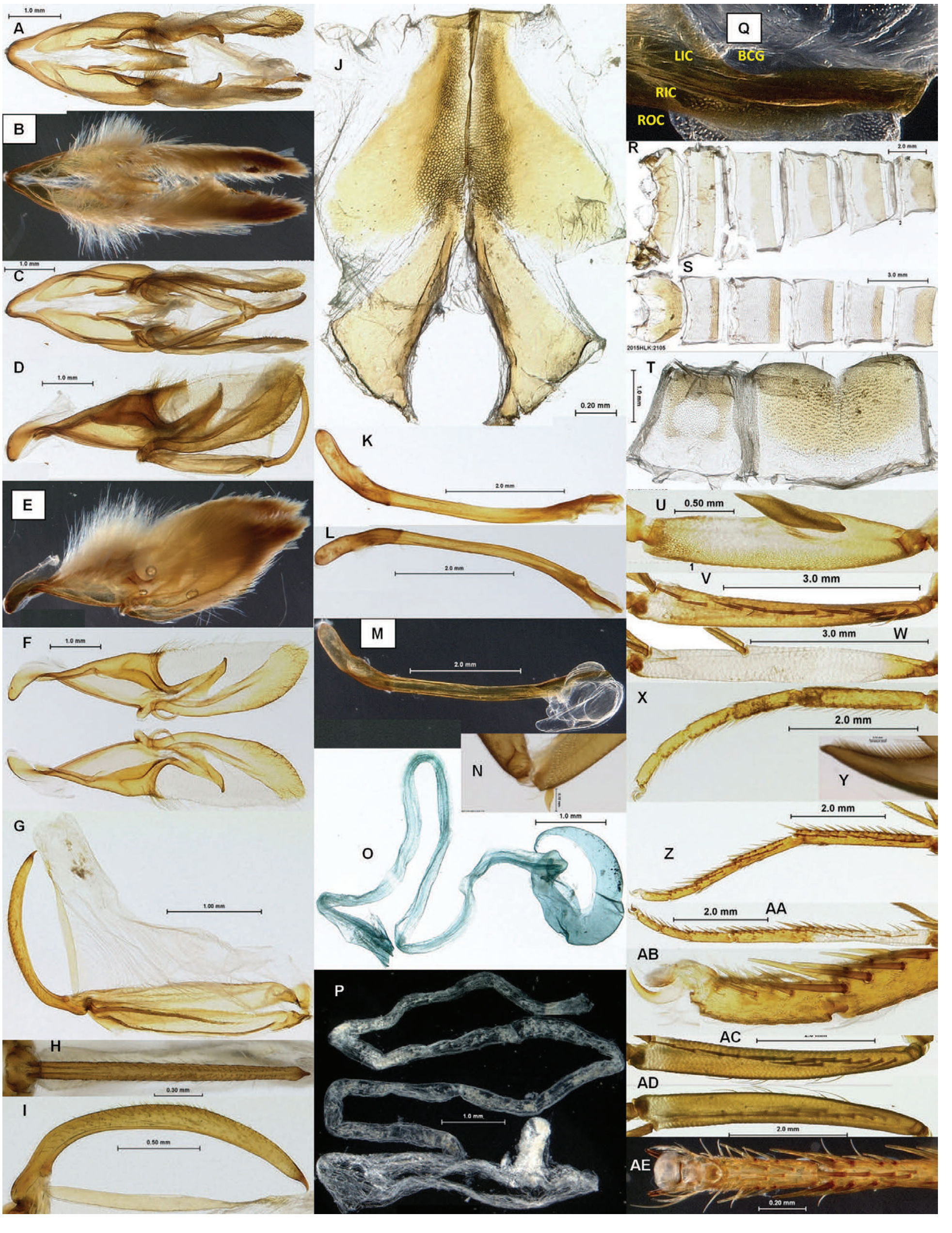

Figure 3. *Catocala bastropi* male genitalic and leg structures (dissection numbers are in parentheses). Holotype: A–M, O–T (2015HLK:2105); male: N, AE (2014HLK:2016); male: Y (2014HLK:2024); female: U–X, Z–AB (2011HLK:1231); male: AC, AD (2014HLK:2041). **A,** Capsule (ventral). **B,** Capsule (ventral, before hairs and scales removed). **C,** Capsule (dorsal). **D,** Capsule (lateral). **E,** Capsule (lateral, before hairs and scales removed). **F,** Valvae (inner). **G,** Uncus and tegumen (lateral). **H,** Uncus (posterior). **I,** Uncus (lateral). **J,** Anellus/juxta (ventral flattened). **K,** Aedeagus (coecum hole oriented up). **L,** Aedeagus (coecum hole oriented down). **M,** Aedeagus with vesica everted. **N,** Profemoral flattened apical spine. **O,** Ductus ejaculatorius. **P,** Rectum and intestine. **Q,** Ventral aedeagus hood over everted vesica. **R,** Tergites 1 to 7. **S,** Sternites 2 to 7. **T,** Abdominal segment 8 (tergite on left). **U,** Protibia (inner). **V,** Mesotibia (outer). **W,** Metatibia (outer). **X,** Protarsi (outer lateral). **Y,** Protibial flange (apex). **Z,** Mesotarsi (outer lateral). **AA,** Metatarsi (outer lateral). **AB,** Mesotarsomeres 4 and 5. **AC,** Mesotibia (outer). **AD,** Mesotibia (inner). **AE,** Protarsomeres 4 and 5 (ventral). *Abbreviations*: BCG, basal concave gouge; LIC, left inner chord; RIC, right inner chord; ROC, right outer chord.

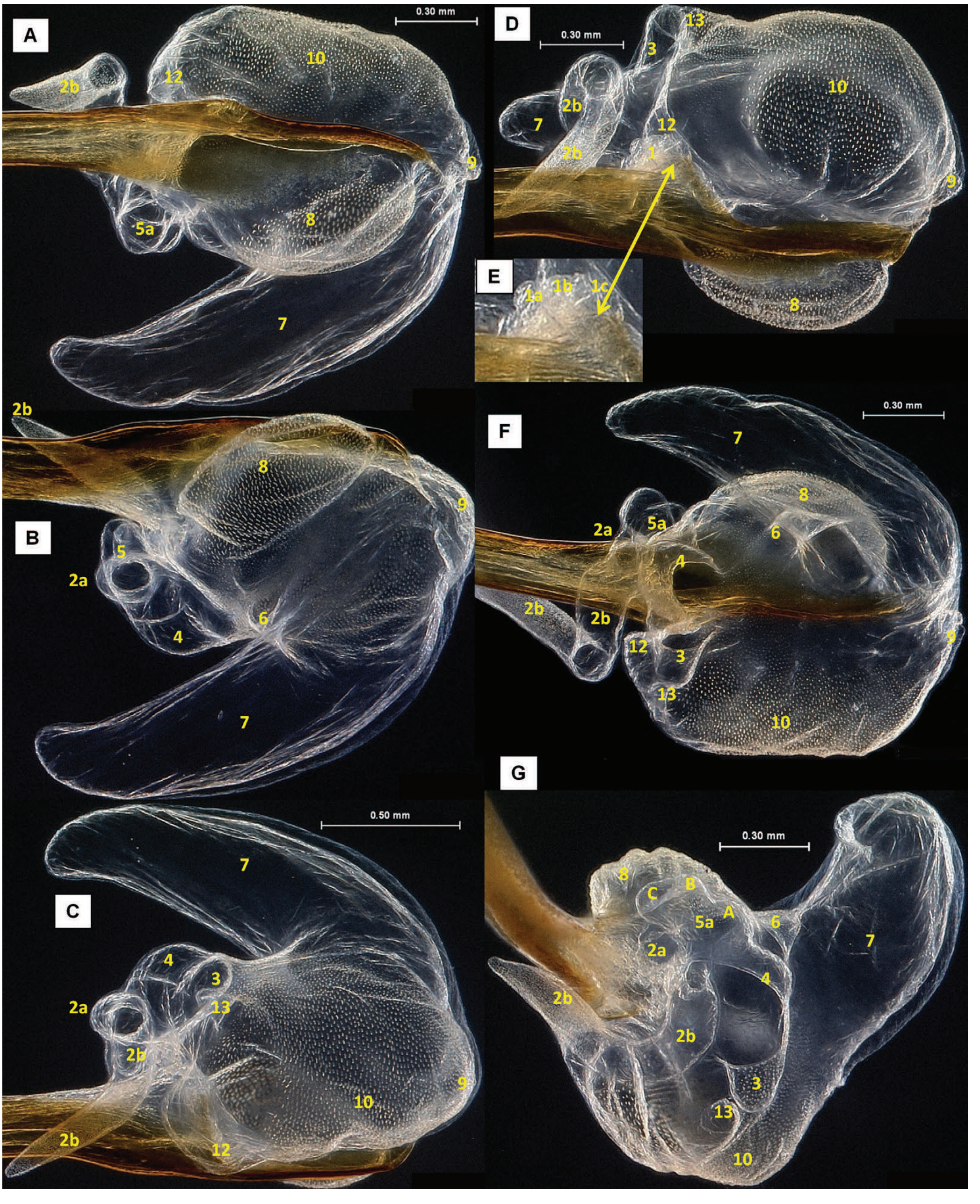

Figure 4. *Catocala bastropi* everted vesica (dissection no. 2015HLK:2105). Vesica diverticula numbering system follows Kons and Borth (2015). **A,** Ventral. **B,** Lateral (ventral hood above). **C,** Lateral (ventral hood below). **D,** Ventral, tilted right. **E,** Same, zoomed in on diverticulum 1. **F,** Dorsal. **G,** Anterior.

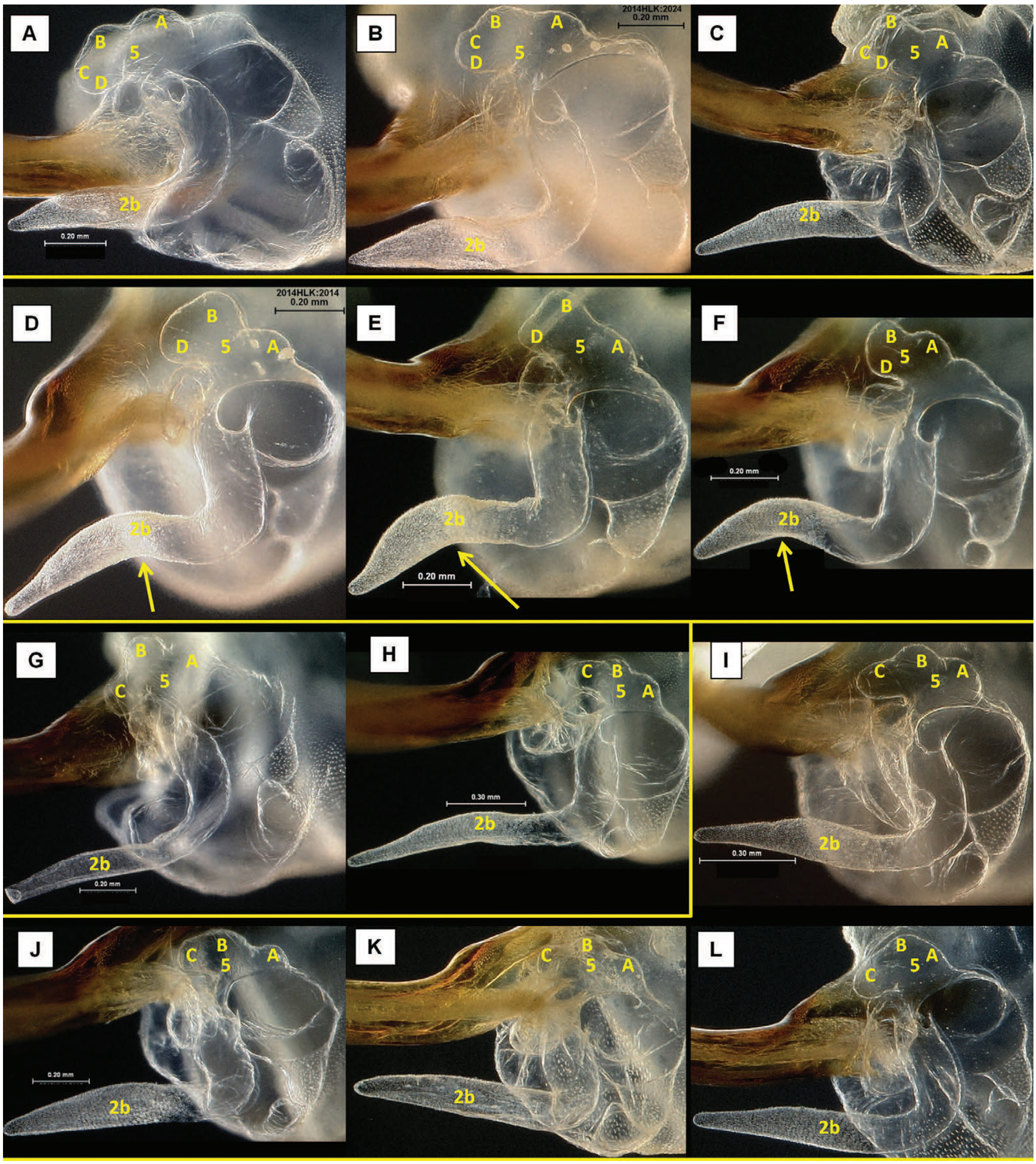

Figure 5. Comparison of diverticula 2b and 5 between *Catocala bastropi* and related species (vesica in anterior aspect, zoomed in on anterior rosette of diverticula). Vesica diverticula numbering system follows Kons and Borth (2015); dissection numbers are in parentheses. **A,** *C. bastropi* (2015HLK:2106). **B,** *C. bastropi* (2014HLK:2024). **C,** *C. bastropi* (2014HLK:2045). **D,** *C. louiseae* (2014HLK:2014). **E,** *C. louiseae* (2014HLK:2042). **F,** *C. louiseae* (2014HLK:2044). **G,** *C. andromedae* (2015HLK:2110). **H,** *C. andromedae* (2014HLK:2043). **I,** Phenotype AGU (2016HLK:2212). **J,** Phenotype AGU (2015HLK:2116). **K,** Phenotype AGU (2010HLK:619). **L,** Phenotype AGU (2015HLK:2130).

Figure 6. *Catocala bastropi* female genitalic structures and labial palpi. Female: A–E, G, H, J (dissection no. 2011HLK:1231); female: F (dissection no. 2014HLK:2004); female: I (Texas, USA, Bastrop Co., 27 May 2004, Kons and Borth). **A,** Female genitalia, ventral habitus. **B,** Female genitalia, lateral habitus. **C,** Colleterial gland complex. **D,** Anal papillae (lateral, dorsal side on left). **E,** Ductus seminalis. **F,** Sinus vaginalis (with ventral membrane between A8 and A7 flattened out). **G,** Tergite 8 and antrum. **H,** Anal papillae (dorsal). **I,** Head (lateral). **J,** Tergite 7 (flattened).

Additional material examined. ARKANSAS, USA: 1, Lincoln Co., 20 June 1936, L.H. Bridwell (YPM ENT). MISSOURI, USA: 1, Ste. Genevieve Co., Lakes Genevieve, 22 July 1978, black light, E.G. Riley (MGC). OKLAHOMA, USA: 1, Pittsburg, 17 June 1989, RJW (YPM ENT).

Diagnosis.

External morphology. We found no single universally reliable wing pattern character for separating *Catocala bastropi* from *C. louiseae,* although specimens can usually be separated by overall forewing pattern, and some of the individual pattern characters show little overlap. *Catocala bastropi* (Figures 1A–K and 2A and B) usually has more even gray forewings with less white mottling relative to *C. louiseae* (Figure 1L–S), giving a darker and coarser overall appearance to the forewing; occasional darker forms of *C. louiseae* (primarily from the Florida Panhandle) (Figure 1R) are more challenging to separate from *C. bastropi*. *Catocala louiseae* often has a prominent black shade along the inner margin, which is usually more diffuse or nearly absent in *C. bastropi.* Fresh specimens of *C. louiseae* males have a faint purplish sheen (best seen in natural light) lacking in *C. bastropi.* The black patch between the subreniform spot and antemedial line is usually conspicuous in *C. louiseae*, but usually smaller or absent entirely in *C. bastropi.* Many specimens of *C. louiseae* have a strongly contrasting whitish area on the forewing distal to the postmedial line between veins CuA1 and M2, whereas this area is always grayish in *C. bastropi.* We found no useful hind wing or forewing underside characters for separating *C. louiseae* and *C. bastropi.* Typical specimens of *C. andromedae* (Figure 2J–P) are easily separated from *C. bastropi* by the black hind wing lacking yellow-orange bands. Phenotype AGU (Figure 2C–I) differs from *C. bastropi* and *C. louiseae* by the paler dorsal hind wing yellow and paler underside of both the forewing and hind wing. *Catocala bastropi* usually has a distinct pointed tooth on the dorsal forewing postmedial line between veins M3 and M2 (Figure 1C and E–K), whereas the postmedial line is smoothly curved in *C. andromedae* and Phenotype AGU; however, occasional individuals of *C. bastropi* have the postmedial line smooth and similar to *C. andromedae* (Figures 1D and 2A).

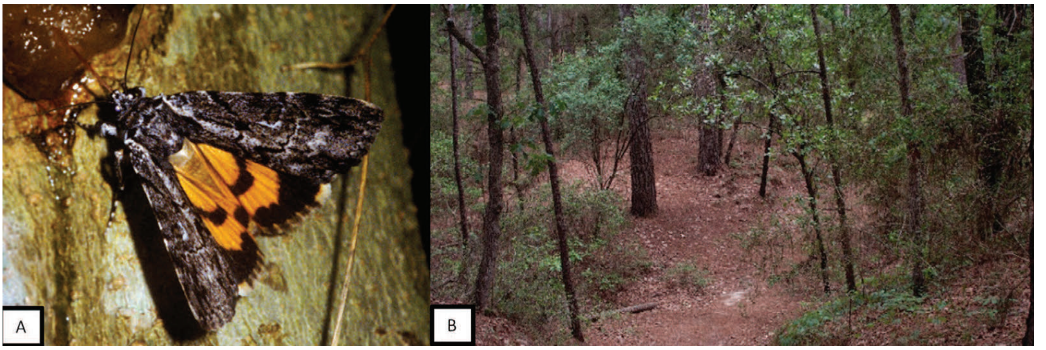

FIGURE 7. Type locality for *Catocala bastropi*: Texas, USA, Bastrop County, Bastrop State Park, 15 May 2008. **A,** *Catocala bastropi* adult feeding at bait. **B,** Xeric oak–pine woodland with *Vaccinium arboreum*.

Male genitalia. Two minor but consistent differences were found in the three-dimensional structure of the vesica between *Catocala bastropi* and *C. louiseae* (*n* 7), when the vesica is viewed from the anterior side such that the anterior rosette of diverticula 2 to 5 is viewed head on (Figure 5). The terminal area of diverticulum 2b that is covered with minute inverted teeth is more strongly curved in *C. louiseae* (Figure 5D–F, see yellow arrows) than in *C. bastropi* (Figure 5A–C). The outer margin of diverticulum 5 has three distinct lobes (A–C) in *C. bastropi* (Figure 5A–C) but only two (A–B) in *C. louiseae* (Figure 5D–F) (the inner margin has a single lobe (D) in both species). These same two characters of diverticula 2b and 5 separate *C. louiseae* from both *C. andromedae* (Figure 5G and H) and Phenotype AGU (Figure 5I–L), but *C. bastropi*, *C. andromedae* and Phenotype AGU lack any consistent differences for either character. Other features of the male genitalia were not found to be diagnostic among any of these species.

Female genitalia (*n* 6). No diagnostic characters are known.

COI 5′ (*n* 27). Two consistent character state differences were found between *Catocala bastropi* and *C. louiseae*: *C. bastropi* has 487(C) and 556(A), whereas *C. louiseae* has 487(T) and 556(T). One character state differed between all 27 *C. bastropi* and 34 of 35 *C. andromedae* sequenced: *C. bastropi* has 22(A), whereas all but one *C. andromedae* have 22(G). There was no overlap in haplotypes recorded between *C. bastropi* and *C. andromedae*, as the one *C. andromedae* with 22(A) also has 616(C). Character 616 is polymorphic for C or T in *C. andromedae* but was always state T in *C. bastropi*. All of the haplotypes recorded among these three species are shown (Table 1).

Description.

Head (Figures 1A–K and 6I). Vertex and frons with predominately black scales except for white bands along the eyes, with some gray and white scales peppered into the black area. Labial palp segment 1 with predominately pale whitish elongate scales, but with a patch of black scales often present on the dorsal side bordering the eye; segment 2 with predominately black scales with sparse white scales mixed in, except for narrow patches of white at base and apex; segment 3 with predominately black scales but peppered with some white scales (Figure 6I).

Thorax (Figure 1A–K). Dorsally a mosaic of black, gray and whitish scales, some scales banded and multicolored, gray scales dominate; tegulae comparably peppered without a triangular black border. Ventrally with dense pale tan hairs.

Wings. FOREWING UPPER SIDE (Figure 1A–K): Forewing length (base to apex) of holotype male 24 mm, males 20 to 24 mm, females 22 to 27 mm. Background color predominately dark gray with a speckling of whitish and lighter gray scales. Dense gray scaling inside reniform spot bordered by a variably broken ring of black scales, and often with a broken inverted white J on the distal and posterior sides of the black border. Basal dash short, black and conspicuous, less than one-half the distance from the wing base to the antemedial line. Two additional black dashes occur in the basal area: one occurs basal to the antemedial line and follows the veinlet between veins Cu2 and 2A; the other is simple basal to the antemedial line and forked distal to it, following the posterior margin of the discal cell and the M3+Cu1/Cu2 fork. Basal line distinct anterior to discal cell but diffuse and usually not discernible posterior to the anterior side of the discal cell. Antemedial line black, of variable thickness but usually thickest at the costa and at the vein M3+Cu1/Cu2 fork; weakly undulated with up to six convex to triangular loops, with the deepest basally projecting division between the posteriormost loop (posterior to vein 2A) and the remainder of the antemedial line, posterior loop smoothly curved between vein 2A and inner margin, remaining shallow loops convex, triangular or indistinct. Median line indiscernible posterior of reniform, black with diffuse margins from the costal margin basal of the reniform to the anterior edge of the reniform. Postmedial line sharp and black, undulations protrude distally mostly as smooth convex loops: posterior to vein 2A smoothly curved and extending basally at vein 2A; between Cu2 and 2A a single concave loop; between veins Cu1 and Cu2 and Cu2 and M3 simple concave loops well disjunct from the subreniform; a shallow convex undulation between veins M2 and M3; either a smooth convex undulation or distinct triangular tooth between veins M1 and M2, extending the farthest distally of any point on the postmedial line; slanting or curving distal to basal between veins R5 and M1; with a small tooth and then sharply turned basally between veins R5 and R4; a black patch between vein R4 and costa. Subterminal line variably diffuse to conspicuous, comprised of a mix of white and gray scales, the latter paler than

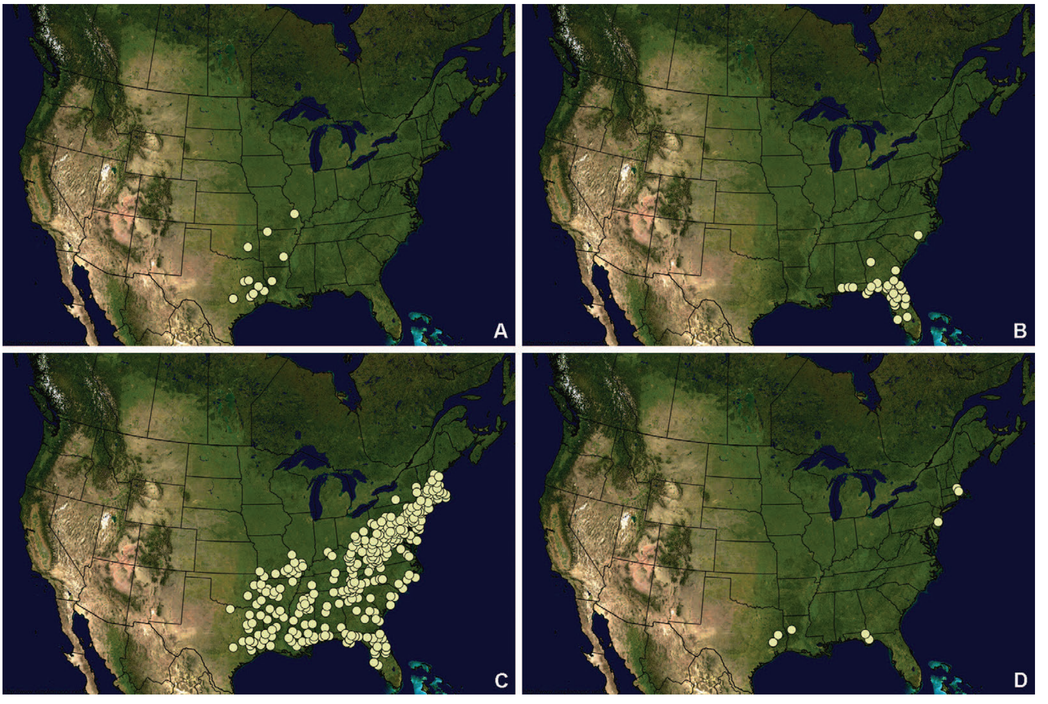

FIGURE 8. Geographic distribution maps for *Catocala*. **A,** *Catocala bastropi*. **B,** *Catocala louiseae*. **C,** *Catocala andromedae*. **D,** Phenotype AGU. County-level or equivalent records derived from databases on *Catocala* for a forthcoming *Moths of America North of Mexico* volume (courtesy L.F. Gall).

background color, convex undulations between the veins. Marginal band black, thin, black, conspicuous and contrasting, a series of distally protruding undulations or teeth between the veins, sometimes with short breaks. Distal edge of marginal line sometimes with contrasting white patches between the undulations. Fringe a mosaic of black, darker and lighter gray scales, usually with at least small black patches along the veins. A diffuse blackish band sometimes present along the inner margin posterior to vein 2A. Two black patches with diffuse edges usually present distal to the postmedial line: one posterior to vein Cu1, the other between veins M2 or M3 and the costa, roughly arch shaped, and extending from the apex to the basal side of the subterminal line.

HIND WING UPPER SIDE (Figure 1A–K): Background color yellowish orange. Apical patch narrow and inconspicuous, with thin band of scales of yellow-orange background color. Marginal band black, thickening posterior to anterior, broken most of the distance between veins Cu2 and 2A, basal side concave and fairly straight to weakly undulated. Medial band sharp, black, of variable thickness, abruptly changing direction on distal side along vein M2, bulging between veins M2 and CuA1, section in cell Cu2 weakly curved basally or not distinctly curved, not extending basal to vein 2A. Basal area predominately yellow-orange, but with variably sharp to diffuse band of black scales and hairs in anal cell, sometimes extending between apex of medial band and wing base, other times not reaching the medial band. Fringe pale whitish cream with black patches at the ends of veins 2A and Cu2-M1, sometimes with diffuse black scaling at end of vein Rs.

FOREWING UNDERSIDE (Figure 1B): Background color pale cream, sometimes with faint orange tinge posterior to vein Cu2 and basal to the medial band, cream background between marginal and medial black bands heavily diffused with gray scaling posterior of veinlet between veins Cu2 and Cu1. Marginal band black, sharp basal border, distal border less distinct because bordering with gray, basal side slightly undulated. Median band sharp and black, except sometimes more diffuse posterior to vein Cu2. Basal band diffuse grayish black. Inner marginal band black, variably sharp to somewhat diffuse, posterior of veinlet between veins 2A and Cu2. Dark gray scaling between marginal band and outer margin, except apex with a contrasting cream patch. Fringe similar to upper side but black patches along veins usually narrower.

HIND WING UNDERSIDE (Figure 1B): Background pale cream, some pale orange tint posterior of vein M2, orange tint more conspicuous basal to the medial band. Discal spot indiscernible. Marginal and median bands sharp and black, of similar shape to upper side but with margins more jagged or undulated. Fringe similar to upper side but with black patches thinner.

Legs. TARSI (Figure 3X, Z–AB and AE): All tarsi with similar spination: tarsomeres 1 to 4 with three ventral rows of large triangular spines, and two rows of minute hairlike curved spines

Table 1. Cytochrome oxidase subunit I 5′ characters that vary within the *Catocala andromedae* species group. Character states in bold do not occur in *C. gracilis* + *C. sordida*, which is the sister group to *C. louiseae* + *C. andromedae* + *C. bastropi*. Character state status values: 1, consistent difference between *C. louiseae* and *C. bastropi*/*C. andromedae*; 2, consistent difference between *C. bastropi* and *C. louiseae*/*C. andromedae* (one exception); 3, polymorphic in *C. louiseae*, invariant in *C. bastropi*/*C. andromedae*; 4, polymorphic in *C. andromedae*, invariant in *C. bastropi*/*C. louiseae*; 5, polymorphic in *C. andromedae*/*C. louiseae*, invariant in *C. bastropi.*

			Character state: sequence position (status)								
Taxon and haplotype	**No. specimens**	**Locality**	**206 (3)**	**499 (3)**	**487 (1)**	**556 (1)**	**22 (2)**	**20 (4)**	**412 (4)**	**589 (4)**	**616 (5)**
C. louiseae 2045	9	FL	T	T	T	T	**G**	G	T	T	T
C. louiseae 892	1	FL	T	**C**	T	T	**G**	G	T	T	T
C. louiseae 2046	2	FL	**C**	T	T	T	**G**	G	T	T	T
C. louiseae 20351	3	FL	T	T	T	T	**G**	G	T	T	C
C. bastropi 5026	27	TX, LA	T	T	**C**	A	**A**	G	T	T	T
C. andromedae 2022	12	FL, TX, LA, KY	T	T	**C**	A	**G**	G	T	T	C
Phenotype AGU 2011	3	FL	T	T	**C**	A	**G**	G	T	T	C
C. andromedae 2023	18	FL, TX, LA	T	T	**C**	A	**G**	G	T	T	T
Phenotype AGU 5033	3	FL, TX, MA	T	T	**C**	A	**G**	G	T	T	T
C. andromedae 5263	1	KY	T	T	**C**	A	**G**	**T**	T	T	C
C. andromedae 5450	1	TX	T	T	**C**	A	**G**	G	**C**	T	T
C. andromedae 5459	2	TX, LA	T	T	**C**	A	**G**	G	T	**C**	T
C. andromedae 5465	1	LA	T	T	**C**	A	**A**	G	T	T	C
C. gracilis			T	T	T	T	T	G	T	T	T
C. sordida			T	T	T	A	T	G	T	T	C

between them (Figure 3AE [tarsomere 4]). Tarsomere 5 with four ventral rows of large triangular spines, with a row of minute hairlike spines in-between each inner and outer row (Figure 3AE). Scattered minute hairlike spines present along dorsal midline of tarsomeres and along sides. Tarsal claws simple (Figure 3AB).

foreleg (Figure 3N, U and Y): Profemur unspined in females, one flattened, curved subapical spine on dorsal side in males (Figure 3U). Protibia unspined, with a small convex sulcus with radiating spines near basal extremity on the inner side, setae on fringe of protibial flange long and conspicuous (Figure 3Y).

midleg (Figure 3V, AC and AD): Mesofemur unspined. Mesotibia sexually dimorphic, wider in males (Figure 3AC and AD) than in females (Figure 3V) except at distal and basal edges where width comparable between genders. Each gender with 11 to 15 spines on outer side, most spines in a single row but with one to three spines outside of the main row (Figure 3V and AC). Inner side unspined in both genders and with a hair pencil groove in males (Figure 3AD).

hind leg (Figure 3W): Metafemur unspined. Metatibia with one to two apical spines on outer side.

Abdomen. Tergites covered with gray scales and yellow-orange hind wing background colored hairs (Figure 1A, B and D–K), sternites covered with lighter tan scales (Figure 1C). Male abdominal cuticle tergites 1 to 7 as shown (Figure 3R), sternites 2 to 7 as shown (Figure 3S), terminal tergite (left) and sternite (right) as shown (Figure 3T). Female sternite 7 with posterior side weakly concave medially and weakly convex on each side, lateral sides strongly concave, anterior side convex medially and concave on sides (Figure 6J).

Male genitalia (*n* 8). capsule (Figure 3A–E): Juxta and vinculum strongly fused with valvae, vinculum weakly fused with tegumen, vinculum arms laterally expanded and weakly fused midventrally, diaphragma membranous except for juxta/anellus.

valvae (Figure 3F): Outer surfaces densely covered with elongate light tan to darker brown colored hairs and scales except for anterior portion of sacculus (Figure 3B and E); inner surface of "cucullus" with shorter scales and hairs along ventral margin. Sacculus with short triangular posterior extension at fusion with cucullus, about as long as wide. Elongate setae scattered along posterior margin of sacculus on inner side, densest over saccular extension (Figure 3F). Ventral inner sides of sacculus with concave indentation along margin of clasper base (Figure 3A). Right and left cucullus clear and membranous. Cucullus with scattered elongate setae on inner surface along ventral margin, with decreasing density posteriorly (Figure 3F). Both costa heavily sclerotized and largely symmetrical, progressively widening posteriorly, not extending distally beyond cucullus and terminating with a broad curve; thickened area extending over three-fourths of the total length with indistinct posterior boundary, ventral boundary sharp and more heavily sclerotized from base to just beyond clasper apex, then grading to indistinct (Figure 3F). Claspers similar, bases dorsoventrally flattened, projecting posteriorly with apices sharply curved ventrally/inward. Clasper apices covered with scattered minute short setae, apices not expanded relative to subapical area. Ventral and dorsal margins of clasper base with elongate setae but not dense patches, scattered shorter setae extending distally along margins. Ventral margins of claspers fairly straight to slightly convex, dorsal margins distinctly concave. Viewed from ventral side, both claspers with outer margins (bordering the valvae) concave medially, convex distally; inner margins (opposite the valvae) convex basally, strongly concave distally (Figure 3A).

JUXTA (Figure 3J): Two elongate nearly symmetrical lobes, but with right slope slightly more elongate. Lobes narrowest posteriorly, progressively widening anteriorly. Lobes fused to anellus at posterior apex, narrowly touching each other at posterior end.

ANELLUS (Figure 3J): Lobes fused together throughout and appearing as a single sclerotized plate, slightly asymmetrical with broad concave indentations on the outer margin of each lobe, except convex toward anterior edge. Each plate with a distinct lobe at posterior apex, margin fairly straight to either slightly convex or slightly concave. Anterior sides convex. Wide band of variably sclerotized, dense, shallow depressions (pits) along midline; sclerotization of some or all of this pitted area darker than remainder of plates. The pitted area sometimes extends variably outside the midline region along the posterior and anterior edges of each lobe.

UNCUS (Figure 3H and I): Tubular, widest medially (lateral aspect), posterior margin strongly convex, anterior margin strongly concave. Terminating in a heavily sclerotized curved spine, appearing pointed apically in lateral view (Figure 3I), but actually narrowly rounded, as visible in dorsoventral view (Figure 3H). Conspicuous setae throughout the length of the uncus projecting from the sides (Figure 3H), most shorter than the width of the uncus, with the longest only slightly wider than the uncus at its widest point (Figure 3H and I), some setae slightly longer basally and subapically, setae oriented dorso-posteriorly (Figure 3H and I).

TUBA ANILIS (Figure 3G): Membranous except for scaphium. Scaphium an elongate, weakly concave, rectangular plate, terminating distinctly dorsal of uncus apex (Figure 3G).

AEDEAGUS (Figure 3K–M): Translucent throughout. Coecum doubly bent about 45° just anterior and posterior of anterior opening. Aedeagus not bent at posterior margin of coecum, bent about 30° to 45° at roughly five-eighths of the distance from the posterior margin of the coecum to the posterior apex, fairly straight in-between (Figure 3K and L). Vesica projects from posterior opening about 90° to the right of coecum opening (Figure 3M).

AEDEAGUS VENTRAL HOOD (Figure 3Q): Left flank of posterior ventral extension ("hood" over everted vesica) with a broad basal concave gouge, slightly convex apically, no left sclerotized plate (for an example of a left sclerotized plate see Borth and Kons [2016]). Right flank concave anteriorly, concave posteriorly. Right outer chord conspicuous anterior of hood, but not discernible along the right side of the hood, no discernible left outer chord. Right inner chord and left inner chord thick and heavily sclerotized throughout length of the hood, roughly parallel and narrowly separated until fusing together subapically. Apex of hood narrowly convex.

DUCTUS EJACULATORIUS (Figure 3O): Slender region with one sharp bend just before scoop-shaped region. Scoop-shaped region outer side strongly convex, inner side strongly concave. Apex of scoop curves back around distinctly basal of the sharp bend at the terminus of the slender region.

VESICA (Figure 4A–G): Diverticulum 1 weakly trilobal, 1a to 1c shallow convex bulges of similar size and length (Figure 4E). Diverticulum 2 bilobal, 2a short, irregular convex bulge (Figure 4G); 2b elongate, of similar width throughout most of length but tapering apically to a narrowly convex terminus, the apical portion covered with minute inverted teeth fairly straight to slightly bent, the basal portion without inverted teeth with a strong U-shaped curve (Figures 4G and 5A–C). Diverticulum 3 a simple convex bulge, apex touching apex of diverticulum 13 (Figure 4C, F and G). Diverticulum 4 a broad and simple convex bulge (Figure 4G). Diverticulum 5 with three distinct convex lobes on outer margin (labeled A–C), inner margin convex distally and concave basally (Figure 5A–C). Diverticulum 6 a small, simple convex lobe, much shorter and smaller than diverticulum 7 (Figure 4B, F and G). Diverticulum 7 large and elongate, curving dorsally over the remainder of the vesica and extending anterior beyond the base of the base of the aedeagus hood, widest at base and gradually tapering throughout to a broadly convex apex (Figure 4A–C and F). Diverticulum 8 large, broad and smoothly curved, covered with minute inverted teeth, not extending around in front of the apex of aedeagus hood (Figure 4A, B and D). Diverticulum 9 a short, broad, simple convex bulge (Figure 4A–D). Diverticulum 10 large and broad, covered with minute inverted teeth (Figure 4A, C, D and F). Diverticulum 11 absent. Diverticulum 12 a prominent, smoothly curved, simple convex bulge, extending to about even with the left flank of the aedeagus hood (Figure 4A). Diverticulum 13 a small, simple convex bulge (Figure 4C and G).

Female genitalia (*n* 6). PAPILLAE ANALES (Figure 6A and D): Translucent, dorsal side with sclerotized band from base to just below apex, curving inward and tapering to a point posteriorly (Figure 6G); ventral and lateral sides unsclerotized (Figure 6D). Setae project posteriorly or posteriorly-outward, longest setae concentrated at base on ventral side but some long setae throughout, dense short setae on sides and apex (Figure 6A, B, D and G). Shape narrow and elongate, dorsal side convex, ventral side convex basally, concave medially and convex distally; apex narrowly rounded (Figure 6D).

INTERSEGMENTAL MEMBRANE BETWEEN PAPILLAE AND SEGMENT 8 (Figure 6A): Widest medially with sides convex, ratio of length/width at anterior end approximately 1.1 to 1.3 (Figure 6A).

SEGMENT A8 (Figure 6A and F): Scattered elongate posteriorly projecting setae encircling posterior margin, except in area of ventral midline; shape (dorsal aspect) as shown (Figure 6F).

INTERSEGMENTAL MEMBRANE BETWEEN LAMELLA AND SEGMENT 8 ON VENTRAL SIDE (Figure 6B, F and G): Strongly curved and largely concealed under lamella vaginalis plates (Figure 6A), unless flattened out and held in place (Figure 6B and G). Ventral sclerotization an elongate band with dense spiculations between A8 and the antrum (Figure 6F).

LAMELLA ANTEVAGINALIS (Figure 6A): Posterior margin of lobes convex, anterior margin deeply concave inward and convex outward, outer anterior corners of lobes not extending as far anteriorly as inner corners. Slit in lamella antevaginalis along ventral midline narrow with concave sides, sides more heavily sclerotized and thickened anteriorly.

ANTRUM (Figure 6A and G): Sclerotized throughout except a small area around juncture with ductus bursae. Sides weakly convex, widest near anterior end of slit in lamella antevaginalis.

DUCTUS BURSAE (Figure 6A and B): Rectangular and strongly dorsoventrally flattened with a sclerotized plate on each side, twisted anteriorly at juncture with corpus bursae (Figure 6A), strongly bent posteriorly (Figure 6B).

CORPUS BURSAE (Figure 6A and B): Posterior section with longitudinal wrinkles elongate, in ventral aspect about 9.2 to 9.6 times as long as width at anterior base, about 5.2 to 5.6 times as long as maximum width at posterior end, posterior side more than twice the width of anterior side when fully inflated (Figure 6A). Anterior section densely covered with minute inverted teeth, globular, but often distorted by spermatheca (Figure 6A and B).

DUCTUS SEMINALIS (Figure 6E): Total length approximately 5 mm. Coiled basal section with three to five inflection points but lacking distinct coils.

COLLETERIAL GLAND COMPLEX (Figure 6C): Terminology follows Mitter (1987). Receptacle duct with about four to five coils basal to the vesicle; abrupt transition from differentiated to undifferentiated canals within the vesicle; vesicle unsclerotized, slightly expanded relative to preceding coils, looped around in a full circle or nearly so. Utriculus and lagena as shown (Figure 6C), utriculus with many narrow longitudinal grooves throughout. Colleterial gland elongate and tubular, gradually widening distally, then contracting before terminating in a globular expanded sack from which paired glands arise. Oviductus communalis as shown (Figure 6C). Vagina slightly asymmetrical, shape as shown (Figure 6C).

COI 5′ mitochondrial DNA. One haplotype has been recorded with a sample size of 27 specimens (see Tables 1 and 2). This haplotype has the following sequence for COI 5′ positions 1–658:

AACTTTATATTTTATTTTTTGGAATTTGAGCTG
GAATAGTAGGAACTTCATTAAGATTATTAATTC
GAGCTGAATTAGGTAATCCAGGCTCTTTAATTGGA
GATGATCAAATTTATAATACTATTGTTACAGCTCAT
GCTTTTATTATAATTTTTTTTATAGTTATGCCAAT
TATAATTGGAGGATTTGGTAATTGATTAGTACCTT
TAATATTAGGAGCTCCTGATATAGCTTTTCCTCG
TATAAATAATATAAGTTTTTGACTTCTCCCCCCCTCAT
TAACTTTATTAATTTCAAGAAGAATCGTAGAAAATG
GAGCAGGAACTGGATGAACGGTTTACCCCCCC
CTTTCATCAAATATTGCTCATAGAGGTAGTTCTGTA
GATTTAGCTATTTTTTTCATTACATTTAGCTG
GAATTTCTTCAATTTTAGGAGCTATTAATTTTATTAC
TACAATTATTAATATACGATTAAATAATTTAATATTC
GATCAAATACCTTTATTTATTTGAGCTGTAGGAAT
TACAGCATTTCTTCTTTTACTTTCAT
TACCAGTATTAGCTGGAGCTATTACTATACTTTTAACT
GATCGAAATTTAAATACTTCTTTTTTTGATCCTGCTG
GAGGAGGAGATCCAATTTTATATCAACACTTATTT

Etymology. The new species is named for the type locality, Bastrop State Park (Bastrop County, Texas, USA).

Discussion

Catocala bastropi appears to be restricted to xeric upland habitats. We have found the species in ecologically divergent upland types, including loblolly pine (*Pinus taeda* L.)–post oak (*Quercus stellata* Wangenh.) forest (e.g., Bastrop State Park, Bastrop County, Texas) and longleaf pine (*Pinus palustris* Mill.) savanna (e.g., Angelina National Forest, Angelina County, Texas; Red Dirt Wildlife Management Area, Natchitoches Parish, Louisiana). We have not recorded *C. bastropi* from sites lacking xeric uplands in the immediate vicinity, in contrast to *C. louiseae* and *C. andromedae*, which also occur in mesic and hydric habitats (Kons and Borth 2006). The type locality of *C. bastropi* in Bastrop State Park (Figure 7B) is within the distinctive Bastrop Lost Pines ecoregion. This area is an "outlier of [glacial] relict loblolly pine-post oak upland forest occurring on some dissected hills," and constitutes the westernmost tract of southern

TABLE 2. GenBank (Clark et al. 2016) and sample identification numbers for *Catocala* spp.

Species	Sample identification no.	GenBank no.
C. bastropi	067-48-010604-TX	KU564898
C. andromedae	901-COI-06	KU564899
	897-COI-06	KU564900
	899-COI-06	KU564901
	900-COI-06	KU564902
	898-COI-06	KU564903
C. louiseae	894-COI-06	KU564904
	069-48-080506-FL	KU564905
	893-COI-06	KU564906
	892-COI-06	KU564907
	896-COI-06	KU564908
	895-COI-06	KU564909
	5845-210507-FL	KU564910
	3979-COI-08.1	HM381722

pine in the United States about 160 km west of the east Texas pine belt (Omernik and Griffith 2013). Both the Angelina County and Natchitoches Parish localities are predominately upland longleaf pine savanna with oaks (*Quercus* sp.) and other scattered hardwoods. At all three localities adults were most common at rotten banana bait (Figure 7A) and MV lights, but seldom came to UV light traps.

Catocala bastropi and *C. louiseae* appear to be allopatric taxa, separated by the Mississippi Alluvial Basin, a 114,700 km^2 lowland ecoregion including parts of Louisiana, Mississippi, Arkansas, Tennessee and Missouri (McNab and Avers 1996; Figure 8). To date, neither *C. louiseae* nor *C. bastropi* have been recorded between coastal Alabama (Baldwin County) and western Louisiana. Notably, despite more than 33 yr of intensive collecting at lights and bait throughout the flight season, no specimens of *C. louiseae* or *C. bastropi* have been collected at Abita Springs, Saint Tammany Parish (Louisiana) (V. Brou, pers. comm.). *Catocala andromedae* is widespread in the Upper and Lower Austral Life Zones in the Nearctic, and the range of *C. bastropi* is a small subset within the overall range of *C. andromedae*; we have always found *C. andromedae* wherever *C. bastropi* occurs (Figure 8).

No larval host data are available for *Catocala bastropi*, but *Vaccinium arboreum* Marshall (sparkleberry, farkleberry) was present at all the localities where we collected *C. bastropi*, and this plant is abundant in both Bastrop State Park and Angelina National Forest. *Vaccinium arboreum* also has a disjunct distribution separated by the Mississippi Alluvial Basin, and the western and eastern distributions of this plant (USDA NRCS 2015) are more extensive than the known distributions of *C. bastropi* and *C. louiseae*, respectively. In Florida, wild larvae of *C. louiseae* have been found on *V. arboreum* as well as *V. stamineum* L., and wild larvae of *C. andromedae* have been found on *V. stamineum* (J. Peacock, J. Slotten, L. Gall, pers. comm.).

Phenotype AGU

On the basis of wing pattern, the rarely collected Phenotype AGU (Andromedae Group Unplaced) has been variously considered a possible form of *Catocala andromedae* or of *C. louiseae*, or a separate species. There are discrete differences in dorsal hind wing color between Phenotype AGU and *C. andromedae* (yellow-banded versus black), and Phenotype AGU has a lighter ventral wing pattern color than *C. andromedae.* We have found the male genitalia of Phenotype AGU (*n* 3) are not clearly distinguishable from *C. andromedae* (*n* 8), although there is some tendency for diverticulum 2b to be shorter and wider in Phenotype AGU (but no unequivocal discrete difference is clear, and precise measurements are impossible because this diverticulum is curved in three dimensions). Additionally, *C. bastropi* shows greater variation in the width of diverticulum 2b on an intrapopulation basis than that observed between *C. andromedae* and Phenotype AGU. However, the terminus of diverticulum 2 with dense, minute, inverted teeth is fairly straight in both Phenotype AGU and *C. andromedae*, and not strongly curved as in *C. louiseae.* Six specimens of Phenotype AGU were sequenced, including four from the Florida Panhandle (Liberty and Gadsden Counties), one from Texas (Angelina County) and one from Massachusetts (Middlesex County). Two haplotypes were recorded that are identical to *C. andromedae*, but differ from *C. louiseae* (*n* 15) and *C. bastropi* (*n* 27) (Tables 1, 2). Although Phenotype AGU has the same COI 5′ haplotypes as *C. andromedae*, overlapping haplotypes are widespread among closely related and established Nearctic *Catocala* species, and *C. andromedae* differs from sympatric *C. bastropi* by as little as one base pair. Because there are differences in three character systems (wing pattern, genitalia, COI 5′), it seems clear that Phenotype AGU is not *C. louiseae*. However, since there is only one character system (wing pattern) known that separates Phenotype AGU from *C. andromedae*, it is as yet unclear how to classify the relationship between these two. Additional evidence is needed at this juncture, such as rearing the progeny of a Phenotype AGU female, or sampling of additional portions of the genome.

Localities where we have collected Phenotype AGU include Liberty County (Florida) (*n* 3, Figure 2D), Jackson County (Florida) (*n* 1, Figure 2H and I), San Jacinto County (Texas) (*n* 1, Figure 2E and F) and Angelina County (Texas) (*n* 2). These specimens were all collected since 2003. Between 1981 and 2007, Phenotype AGU was taken by other lepidopterists in Gadsden County (Florida) (*n* 2, J. Slotten), San Jacinto County (Texas) (*n* 1, E. Knudson), Natchitoches Parish

(Louisiana) (*n* 1, V. Brou), Burlington County (New Jersey) (*n* 1, D. Schweitzer), Norfolk County (Massachusetts) (*n* 1, W. Winter, Jr.) and Middlesex County (Massachusetts) ($n > 10$, D. Willis). In Florida, Phenotype AGU flies with *Catocala louiseae* and *C. andromedae*; in Texas and Louisiana, it flies with *C. bastropi* and *C. andromedae*; and in Massachusetts and New Jersey, it flies with *C. andromedae*. The most productive locality for Phenotype AGU appears to be at Patoma Park in Middlesex County (Massachusetts), but no specimens have been recorded there in the past 15 yr, despite considerable sampling effort by D. Willis and L. Gall. Within the plausible geographic range of Phenotype AGU (see Figure 8) it has not been found at many repeatedly monitored localities where *C. andromedae* occurs (e.g., Abita Springs, Louisiana, where thousands of specimens of *C. andromedae* have been collected and where Phenotype AGU has never been seen; Brou 2010, and pers. comm.). However, we note that it would not be difficult to overlook or mistake live Phenotype AGU adults in the field for *C. andromedae* if the hind wings are not visible, especially since *C. andromedae* is often common to abundant.

If Phenotype AGU does represent *Catocala andromedae*, this appears to be unique within the genus *Catocala* in the Nearctic, as *C. andromedae* would be the only black-hind-winged species demonstrated to exhibit a chromatically banded hind wing form. The reverse situation—a chromatically banded species that exhibits a totally black-hind-winged form—has been noted for *C. micronympha* Guenee (form "sargenti" Covell 1978; Figure 2S and T) and *C. habilis* Grote (form "depressans" Sargent 1976: 113), and at least three specimens of each are recorded (L. Gall, pers. comm.). In addition, there are a number of chromatically banded Nearctic species known to infrequently but regularly express partial blackening of the chromatic hind wing bands, including but not limited to *C. micronympha*, *C. ilia* (Cramer), *C. connubialis* Guenee and *C. neogama* J.E. Smith.

Acknowledgments

E. Knudson and C. Bordelon assisted during visits to the Texas Lepidoptera Survey collection and recommended a number of Texas localities. C. Covell, Jr., J. Hayden, A. Sourakov and A. Warren assisted during visits to the McGuire Center collection. J. Slotten, D. Willis and L. Gall provided material for sequencing and/or dissection. Collecting and/or life-history information was provided by V. Brou, D. Willis, J. Peacock, J. Slotten and L. Gall. D. Wahl and the American Entomolgical Institute (Gainesville, Florida) provided use of a GT Vision imaging system, and D. Young and K. Johnson arranged use of an Auto-Montage imaging system (University of Wisconsin-Madison). L. Gall produced the distribution maps using SimpleMappr from databases on *Catocala* for the *Moths of America North of Mexico* series, and offered constructive comments on this manuscript. P. Herbert's BOLD (Barcode of Life Data Systems) lab at the University of Guelph sequenced COI 5′ for our *Catocala* samples. E. Zakharov along with BOLD personnel assisted with management and data collection for our BOLD DNA projects. Genome Canada, the Ontario Genomics Institute, the Ministry for Research and Innovation and the Canadian Foundation of Innovation provided support for the International Barcode of Life project. D. Riskind provided authorization to conduct research in Texas State Parks, and the staff of Bastrop State Park was helpful with our activities. M. Borth, L. Gall, H. Kons Sr. and S. Kons have been supportive of our *Catocala* work in numerous ways.

Received 27 December 2016; revised and accepted 11 January 2017.

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