

HYBRIDIZATION OF *CALLOSAMIA* (SATURNIIDAE)

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The genus *Callosamia* Packard contains three closely related species that generally do not hybridize in nature because of effective temporal isolation. These are *C. promethea* (Drury), *C. angulifera* (Walker), and *C. securifera* (Maassen). Although no wild hybrids have been found and I can see only scant evidence of introgression, the species can be easily crossed in captivity. The cross *angulifera* ♂ × *promethea* ♀ has been described and figured by Haskins & Haskins (1958) and Remington (1958), but I find nothing published on other crosses in this genus. Several lepidopterists in the northeastern states of the U.S.A. have made the above cross, and the two following crosses have been reared to adults at least once: *promethea* ♂ × *angulifera* ♀ and *securifera* ♂ × *angulifera* ♀. The rarity of hybrids with *C. securifera* is due to the unavailability of stock of that species.

For three years I have crossed the species of *Callosamia*, with varied success. The purpose of this paper is to describe and figure some of the stages of the hybrids and to discuss techniques that may aid the reader in making crosses with Lepidoptera.

To compare my hybrids described and pictured here with stages of the parent species, the reader is referred to Jones (1909), Packard (1914), Peigler (1976), and the excellent color plates and text in Ferguson (1972). The *C. securifera* larva figured in color by Dominick (1972) shows larger tubercles than almost all those in several broods that I have reared from Florida and South Carolina.

MATERIALS AND METHODS

Because *C. promethea* is rare or absent throughout the South, I obtained cocoons from northern states. Except where noted, all *C. angulifera* stock used was from Clemson, South Carolina and was mostly wild males taken at lights, although some were reared from ova. All *C. securifera* stock was from Berkeley Co., South Carolina, mostly from wild cocoons, although again some were reared from ova.

After adults emerged from cocoons and their wings were dry, they were transferred to a shoebox in the refrigerator. The box contained a wet paper towel to provide humidity. The lower temperature prevented fluttering and prolonged adult life. Females that had mated were kept

in envelopes with wings folded back to minimize wing damage during oviposition.

Adults were hand-paired by a method very different from that described in Collins & Weast (1961). I held moths by the thorax below the wings, but no squeezing of the abdomen was done, as it is not necessary for the female genitalia to protrude. A gentle rubbing together of the posterior ends of the moths usually caused the male to clasp on within a few minutes. Transferring to a foothold was necessary, and if the pair tried to pull apart, I found that blowing strongly on them gave the needed calming effect. Also, it sometimes helped to clip off metathoracic legs of a female that was trying to coax the male to release her.

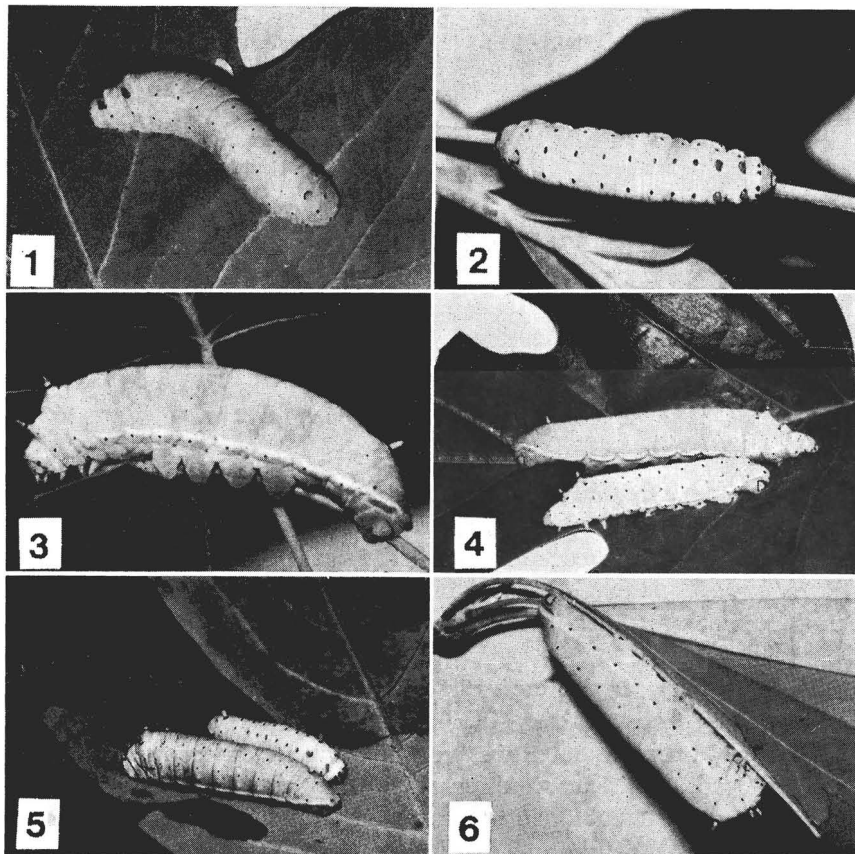
Ova were kept in petri dishes. Upon eclosion, the larvae were put into large cloth bags on limbs of growing foodplants, as ventilation is a must for larvae in this genus. This method of rearing gave larger adults but prevented close observation of the early instars. Therefore, I only describe mature larvae, since the data on early instars are fragmentary.¹ Only in large hybrid broods were any larvae killed for preservation, but those that died of disease or other causes were put into alcohol or the freezer. The late Dr. R. B. Dominick kindly freeze-dried larvae of crosses 2 and 3. All hybrid larvae were reared in Greenville or Clemson, South Carolina on tuliptree (*Liriodendron tulipifera* L.) or sweetbay (*Magnolia virginiana* L.). Cocoons were spun in the bags and, therefore, under natural conditions, although some were spun in folds of the bags rather than on branches among leaves.

DESCRIPTIONS OF HYBRIDS

1. *C. angulifera* ♂ × *promethea* ♀

The ova, supplied by Dale F. Schweitzer, were a mixture from two females reared from cocoons collected on wild black cherry (*Prunus serotina* Ehrh.) in Medford, New Jersey. Both females were induced to emit pheromone after dark by artificial light in Strafford, Pennsylvania and attracted wild *C. angulifera* males; the matings were natural, not hand-paired. The percent hatch was very high. Larvae were reared on tuliptree. A total of 33 cocoons was obtained, which produced 19 males and 14 females. Seven females emerged singly the first spring, but 26 cocoons overwintered again (probably because they were kept in the refrigerator the first winter). The emergence pattern the second spring

¹ My larval descriptions do not involve the various black markings on the head, prolegs, and anal plate because my impression is that they are unreliable because of much variation within the pure species, especially *C. angulifera*.



Figs. 1-6. Larvae of hybrid *Callosamia*. 1, *angulifera* ♂ × *promethea* ♀. 2, *promethea* ♂ × *securifera* ♀. 3, *angulifera* ♂ × *securifera* ♀. 4, *securifera* ♂ × *angulifera* ♀. 5, (*angulifera* ♂ × *securifera* ♀) ♂ × *securifera* ♀. 6, *securifera* ♂ × (*securifera* ♂ × *angulifera* ♀) ♀. (Figs. 1-5 on tuliptree, fig. 6 on sweetbay; all larvae in last instar except smaller one in Fig. 5.)

was spread over 43 days. Excepting two early males, all females emerged singly, then all males emerged singly or in two's.

Larva (Fig. 1): Very uniform in all characters. Red and yellow scoli cylindrical or slightly swollen. Black scoli intermediate in size. Yellow subspiracular abdominal stripe absent.²

Cocoon: All very dark brown, but a few golden before weathering. All but eight with good peduncles.

Male (Fig. 9): Size and outline same as *C. promethea*, yet quite variable. Apex

²This lateral yellow stripe, absent in *C. promethea* and *C. promethea* hybrids, occurs in *C. angulifera*, *C. securifera*, and hybrids between them. A larva hanging head-down on a tuliptree or sweetbay leaf midrib does not seriously disrupt the pattern of the leaf's underside because of this stripe, even if viewed at high angles from either side.

of forewing very pointed and falcate in most specimens. Color intermediate and uniform among individuals, but a few with more golden suffusion beyond postmedian line. Discal spots present but reduced, better developed in forewing. Underside almost exactly like *C. promethea* except for discal marks. A few with sparse scaling on thorax and abdomen.

Male genitalia (Fig. 19): *Callosamia promethea* characters dominant. Costal lobe of valve almost as narrow as in *C. angulifera*, median lobe intermediate, saccular lobe wider than in *C. promethea* but heavily sclerotized and toothed slightly. Posterior opening of anellus V-shaped. In two examples seen, aedeagi identical and intermediate. Cornuti on vesica almost as large as in *C. promethea*.

Female: Color reddish but lighter than *C. promethea* and none orange in color. Highly variable in blackish suffusion in all areas of wings. Discal marks all well developed in all wings of all specimens. Underside with less contrast than *C. promethea*, but marginal lines thicker than in *C. angulifera*. A few with less than normal number of ova.

2. *C. promethea* ♂ × *securifera* ♀

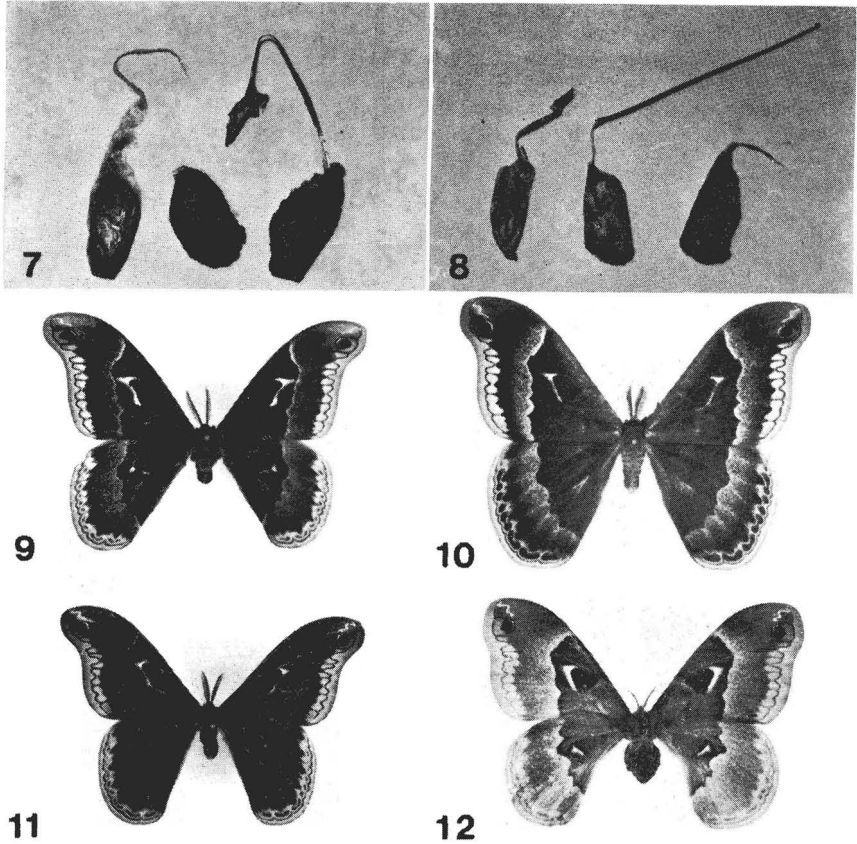
Two broods of this cross were reared. The male used for the first brood was one I reared from Auburn, Pennsylvania. Hatch was 89%. Although newly hatched larvae were offered wild black cherry, they chose tuliptree. Of 55 cocoons obtained, over 40 contained dead larvae that failed to pupate. Only three males were obtained, the other adults being too weak to pull themselves out of cocoons. Emergences were at the end of July.

The following year this cross was made again with a male from Pine Grove, Pennsylvania (reared by Wm. H. Houtz, Jr. on *Lindera benzoin* (L.) Blume). Percent hatch was very high again and about 35 cocoons were obtained; the larvae were reared on tuliptree. Two did not pupate successfully, and I cut open anterior ends of all cocoons to facilitate emergences. In late July and early August, 23 males and eight females emerged in a highly clustered pattern. Many adults had poorly formed wings, some hindwings being scaleless and transparent. Scaling on the body was sparse in all adults of both broods.

A few larvae in the second brood showed a distorted pattern, having segments and scoli out of line. One of these made a cocoon and a male emerged that differed strikingly from the other males by closely resembling pure *C. securifera* with golden suffusion in the postmedian area, larger discal marks, and lighter underside. One cannot ignore the possibility that a genetic correlation existed between the anomalous larva and unique imago.

Females emitted pheromone at "*C. promethea* time" on the first day and during the flight times of both parent species on the second day. A hybrid male in a cage was attracted to, and mated with, a calling sister 3 hr before dark. The ova produced no larvae.

Larva (Fig. 2): Intermediate but homogeneous in appearance. Colored scoli very



Figs. 7-12. Cocoons and adults of hybrid *Callosamia*. 7, *angulifera* ♂ × *securifera* ♀, cocoons. 8, *promethea* ♂ × *securifera* ♀, cocoons. 9, *angulifera* ♂ × *promethea* ♀, male. 10, *securifera* ♂ × (*securifera* ♂ × *angulifera* ♀) ♀, male. 11-12, *promethea* ♂ × *securifera* ♀, male, female.

short and tapered in first brood, cylindrical in other brood. Color bluish as in *C. promethea*; black scoli intermediate. Lateral yellow abdominal stripes lacking.

Cocoon (Fig. 8): Intermediate in size and compactness. Light brown with gray or red cast, never silvery. About 61% had strong peduncles, 25% made weak attachments, and 14% made none.

Male (Fig. 11): Outline like *C. promethea*. Color very dark but not as black as *C. promethea*. Discal marks weakly developed in forewing, usually absent in hindwing. Very minimal golden suffusion in postmedian area. Apices of forewings more pointed than either parent species. Underside intermediate with weak red suffusion past postmedian line.

Male genitalia (Fig. 20): *Callosamia promethea* characters very dominant. Median lobe of valve as large and long as in *C. promethea*, costal lobe intermediate. Anellus opening variable. In one specimen, cornuti on vesica large; in another specimen, cornuti half that size. Aedeagi almost as large as in *C. promethea*.

Female (Fig. 12): Undersized but full of ova. Color dull orange, being between females of parents. Discal marks developed in all wings. Postmedian line less undulating (as in some *C. promethea*) and more proximal than in both parental species. Underside very similar to *C. angulifera*.

Ova: Chorion thin, causing collapse. White color changing to translucent yellow when dry. Size same as *C. promethea*, smaller than *C. securifera*.

3. *C. angulifera* ♂ × *securifera* ♀

About five-sixths of the ova hatched. Most of the brood were reared on tuliptree, but some were reared on sweetbay. The latter grew slower but attained equal proportions as adults. Of 52 cocoons, only a few died. Adults totalled 24 males and 23 females. The emergence pattern ran from 15 July to 25 August with heaviest emergences early in this range. The first 12 to emerge were females, the last ten all males, and between was a mixture. Six cocoons overwintered and adults emerged in early May; five were females.

Larva (Fig. 3): Homogeneous in all aspects. Epidermal color and minute black scoli very close to *C. angulifera*, but colored scoli like *C. securifera*. Lateral stripe prominent.

Cocoon (Fig. 7): Most golden brown, a few dark brown like father species. Intermediate in size but closer to *C. securifera*. About 33% made strong stem attachments, 45% made weak ones, and 22% made no attempt to attach.

Male (Fig. 13): All intermediate but the series quite variable. *Callosamia securifera* characters dominant but larger than in that species. Color dark brown and present, but reduced, discal marks (because they are summer form). Underside of forewing like *C. securifera*; hindwing more intermediate with less contrast than *C. angulifera* but with dark brown median area as in *C. angulifera*. Abdominal terga and anal margin of hindwing maroon as in *C. securifera*.

Male genitalia (Fig. 21): Median lobe of valve short like in *C. angulifera*. Smaller, shorter, more rounded sacculus lobe than in reciprocal cross. Anellus opening rounded. Vesica with pair of large cornuti.

Female (Fig. 14): Extremely variable, some assignable to spring form, others summer form, others intermediate. All with traits of both parent species, with *C. angulifera* characters predominating. Color orange with varying degrees of black suffusion. Underside much more like *C. securifera*, but more contrast between median and postmedian areas.

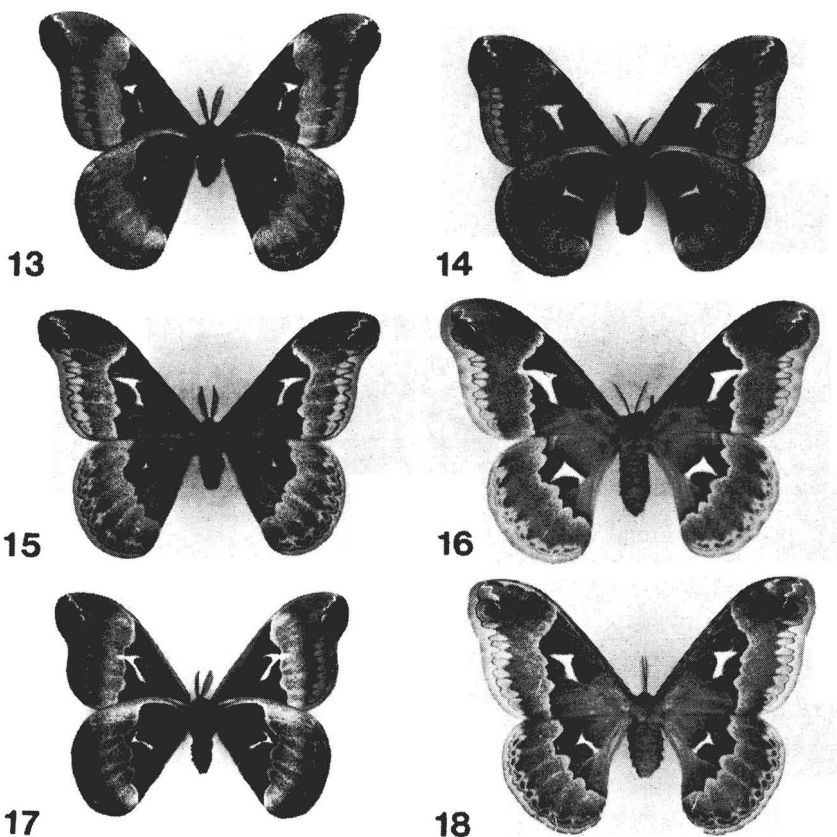
Ova: Size of *C. securifera*, but larger than *C. angulifera*. A few with weak chorion.

4. *C. (angulifera* ♂ × *securifera* ♀) F₂

A male and female from cross 3 were hand-paired, and six or seven of the 125 ova hatched. Tuliptree was used for food, and two cocoons were obtained that yielded females the following May. One was undersized and weak with thin scaling on the wings; the description below is based on the other specimen.

Larva: Surprisingly like *C. promethea*. Thick red thoracic and yellow scoli cylindrical. Black scoli larger than in most *C. securifera*, approaching *C. promethea*, dorsal ones largest. Abdominal yellow stripes present.

Cocoon: No peduncles. Color of silk and size intermediate.



Figs. 13–18. Adults of hybrid *Callosamia*. 13–14, *angulifera* ♂ × *securifera* ♀, male, female (ventral views). 15–16, *securifera* ♂ × *angulifera* ♀, male, female. 17–18, *angulifera* ♂ × (*angulifera* ♂ × *securifera* ♀) ♀, male (ventral view), female.

Female: One specimen. Would easily pass for pure *C. angulifera* if examined closely dorsally or ventrally. One minor *C. securifera* trait noted—a double distal edge of discal mark on underside of forewing.

Ova: Size like *C. securifera*. Chorion thin, collapsing and color becoming translucent yellow as ova dry, a few remaining white.

5. *C. securifera* ♂ × *angulifera* ♀

Only 21 ova hatched of 128 laid. Larvae were reared on tuliptree, a few being started on sweetbay and transferred to tuliptree in third instar because of higher mortality on sweetbay. Twelve cocoons were obtained and six males and five females emerged in May. One female was observed to emit pheromone during *C. promethea* flight time, ceased

at dark, and resumed for another hour under a 15-watt lamp with reflector.

Larva (Fig. 4): All but one very close to reciprocal cross but colored scoli slightly thinner. Aberrant one (Fig. 4, foreground) very unusual. Color grayer overall. Colored scoli shorter, tapered, and much thicker. Thoracic ones dull brick orange similar to faded ones in freeze-dried specimens. Black scoli large like in *C. promethea*. (Aberrant larva produced female imago closely matching sisters; mother of cross 7).

Cocoon: Of 12 cocoons, half with strong, long peduncle, four with partial, two with none. Color duller gray brown than those of cross 3 and smoother silk. Color and size intermediate, with father species dominant.

Male (Fig. 15): One male (figured) quite unlike brothers, having much golden suffusion. Other males alike, closely resembling males of reciprocal cross, but smaller overall and a bit redder in median area of underside of hindwings. Discal marks not prominent. Abdominal terga and anal margins of hindwings maroon.

Male genitalia: Costal lobe of valve very much like *C. angulifera*, median lobe long, saccular lobe wide. *Callosamia angulifera* traits dominant. Teeth of uncus shorter. Anellus with V-shaped opening. Aedeagus exact length and thickness as in cross 8, but two cornuti much smaller.

Female (Fig. 16): Very close to *C. angulifera* and cross 4. Extremely large discal marks. Underside mostly like *C. angulifera*, but postmedian line much like *C. securifera* (unlike *C. angulifera*). Lateral ornamentation of abdomen more like *C. securifera*. Antennae intermediate. Wing outline rather variable in view of all other similarities.

Ova: Intermediate size. Some with weak chorion, others normal appearing.

6. *C. angulifera* ♂ × (*angulifera* ♂ × *securifera* ♀) ♀

This backcross was done three times using females from cross 3, but fertility of ova and viability of larvae and pupae were low. Hatching ranged from about 10–60%. A total of six cocoons and three adults were obtained; one pair was the spring form and another male a summer form.

Larva: Most intermediate or closer to *C. angulifera*. One with black scoli split into pairs, metathoracic scoli with thick double (disjunct) black base. Black circled area on anal prolegs with black line running through middle.

Cocoon: Dark brown and small like *C. angulifera*, but five of six with silken attachment to branch.

Male (Fig. 17): Spring form (figured) indistinguishable from *C. angulifera*, but size and wing shape more like *C. securifera*. Summer form closely resembling males of crosses 3, 5, and 8. Wing scaling slightly sparser.

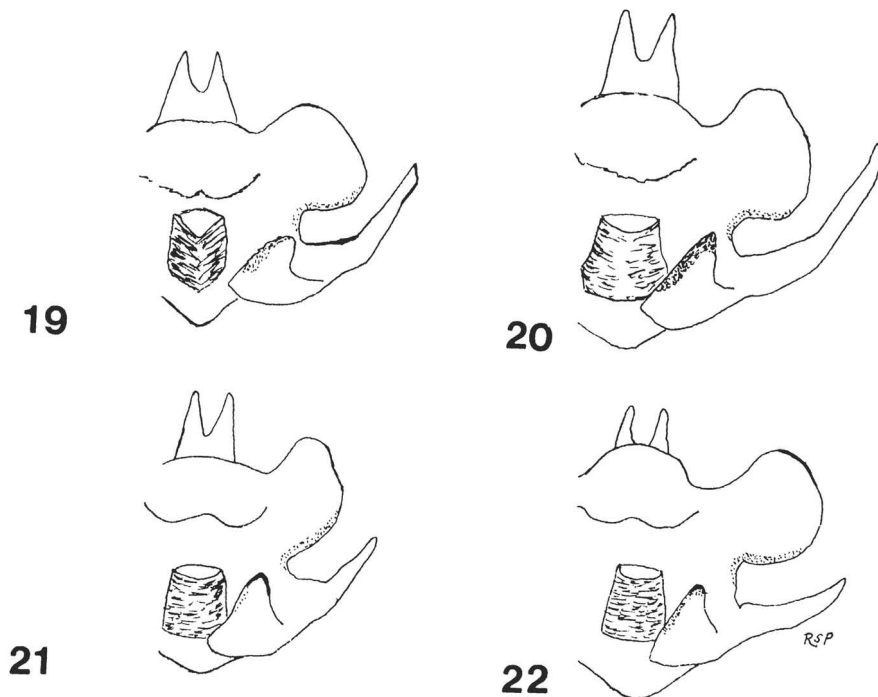
Male genitalia: Like pure *C. angulifera* except for a few minor trends: rounded anellus, slightly longer median lobe of valve, and vesica with larger cornuti. Aedeagus as wide as in *C. securifera*.

Female (Fig. 18): All characters like *C. angulifera* but smaller and browner. Double edge of discal marks on underside barely discernable. Underside areas with much less contrast along post median line than *C. angulifera*.

Ova: Like *C. angulifera*, perhaps a bit larger.

7. *C. securifera* ♂ × (*securifera* ♂ × *angulifera* ♀) ♀

The mother of this hybrid brood was the aberrant larva with larger tubercles mentioned in cross 5. The ova gave 8% hatch, and the larvae



Figs. 19–22. Male genitalia of hybrid *Callosamia*. 19, *angulifera* ♂ × *promethea* ♀. 20, *promethea* ♂ × *securifera* ♀. 21, *angulifera* ♂ × *securifera* ♀. 22, (*securifera* ♂ × *angulifera* ♀) ♂ × (*angulifera* ♂ × *securifera* ♀) ♀.

were reared on sweetbay. Only four cocoons were obtained and one adult.

Larva (Fig. 6): Brood included largest larvae I have ever seen of genus. Black scoli not as large as in mother but larger than in most *C. securifera*. Colored thoracic scoli somewhat light, short, and thick.

Cocoon: A bit smaller and darker than *C. securifera* and peduncle wanting. Very much like *C. securifera* nonetheless.

Male (Fig. 10): Pattern and colors exactly like summer form of *C. securifera*. Hindwings less rounded, more like *C. promethea*. Larger than in *C. securifera*.

Male genitalia: Pure *C. securifera* in all respects. Median lobe of valve slender and longer than costal lobe. Costal lobe squared off. Aedeagus longer than in *C. angulifera*. Two large cornuti on vesica.

8. (*securifera* ♂ × *angulifera* ♀) ♂ × (*angulifera* ♂ × *securifera* ♀) ♀

Only eight larvae were obtained from 190 ova laid by one female. Two larvae reached maturity, all others dying in the earliest instars. All were on tuliptree. Two males emerged in mid-July.

Larva: No characters seen to distinguish from pure *C. angulifera*, but possibly less yellowish epidermal color.

Cocoon: No peduncles. Intermediate in color. Almost as large as in *C. securifera*.

Male: Closely resembling males in cross 3 and the summer male of cross 6. Especially red on undersides in postmedian area. Discal marks on forewing average, on hindwing feeble. One male with maroon abdomen.

Male genitalia (Fig. 22): Costal and median lobes of valve more like *C. angulifera*, saccular lobe more like *C. securifera*, less pointed, more rounded. Anellus rounded. Uncus comparatively small. Noticeable bend in aedeagus, which is thicker than in *C. angulifera*. Large cornuti on vesica.

9. *C. (angulifera* ♂ × *securifera* ♀) ♂ × *securifera* ♀

Twenty-three of 118 ova hatched, and the larvae were reared on sweetbay until the last two instars, when they were transferred to tulip-tree. All larvae died of a disease except one, which made a cocoon and died at pupation. About a third of the brood was "super-tuberculate" in that there was a dorsal pair of reduced colored tubercles on the first abdominal segment. This peculiar character apparently occurs occasionally in the pure species. It has been reported in X-radiated *C. promethea* stock by Haskins (1934) and is incorrectly given as a constant character of *C. securifera* by Ferguson (1972), although I find only four *C. securifera* larvae of about 30 in the Wedge Plantation Collection show it. That collection also has a few *C. angulifera* larvae (from SE Pennsylvania) with this trait.

Larva (Fig. 5): See discussion above for most unusual characteristic. Black scoli the size of those in *C. securifera* or slightly larger. Scarlet scoli slightly swollen or cylindrical, thicker than in *C. securifera* and *C. angulifera*.

Cocoon: One specimen. Smaller and darker than *C. securifera* but with firm attachment to stem. Silk golden.

10. *C. (securifera* ♂ × *angulifera* ♀) ♂ × [*angulifera* ♂ × (*angulifera* ♂ × *securifera* ♀) ♀] ♀

I killed the female (Fig. 18) after 72 ova were laid. One egg hatched and the larva was reared to maturity on tuliptree. Unfortunately, it was killed accidentally in the last instar.

Larva: Colored scoli with very thick black bases, especially metathoracic pair. Black scoli size of those in *C. securifera*. Color like *C. angulifera*, and yellow lateral stripe present.

DISCUSSION

One inherent problem in the hybridization project was the large genitalia of *C. promethea* when compared with the other two species. Best results can be obtained with reared *C. promethea* intentionally made undersized by crowding or poor food during larval life. Females of

C. angulifera, *C. securifera*, and their hybrids can be ruptured and killed by mating with a male *C. promethea*. Conversely, it is difficult for *C. angulifera*, *C. securifera*, or hybrid males to clasp onto *C. promethea* females.

A large number of crosses were made that produced no larvae from the ova. In most cases, matings seemed successful, lasting over $\frac{1}{2}$ hr to several hours, and females oviposited freely. These crosses included duplicates and reciprocals of some of the above crosses and seven that involved all three species. An example of the latter is *C. (securifera* $\delta \times$ *angulifera* ♀) $\delta \times$ *promethea* ♀ , in which the female (from Cedar Rapids, Iowa) laid 157 ova.

If a hybrid that combines all three species is reared, probably one parent will be pure *C. promethea* since all my tests suggest hybrids which involve *C. promethea* are sterile. Ova of crosses between *C. angulifera* and *C. securifera* often give a high percentage of eclosion, and resultant adults of both sexes are partially fertile, as shown by six of my crosses. Hybrid females of the allied genus *Hyalophora* rarely contain ova (Collins & Weast, 1961 and pers. obs.), but all *Callosamia* hybrid females do. Most mortality in hybrid broods occurs in ova and earliest instar larvae.

Some observations were made on certain behavioral traits that are probably polygenic. The attachment of the cocoon (almost always in *C. promethea* and *C. securifera*, rarely in *C. angulifera*) seems to be a dominant trait. Unlike the other two species, females of *C. angulifera* do not oviposit freely. However, all hybrid females that I mated oviposited freely. If the males used in cross 2 came from univoltine populations, it would appear that this trait was not expressed in the offspring. Larvae of *C. promethea* and *C. securifera* regurgitate a green fluid when handled, but I have not observed *C. angulifera* larvae to do so. This trait of *C. angulifera* occurred in hybrid larvae of crosses 3-6 and 8.

Examples of my hybrids can be found in the following private and museum collections: Dale E. Pforr, Canada; Michael M. Collins, California; Dr. Claude Lemaire, France; Wedge Plantation Collection; Los Angeles County Museum of Natural History; United States National Museum. A future paper will describe and figure my hybrids of the cross *C. angulifera* $\delta \times$ *Samia cynthia* (Drury) ♀ .

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Lemaire, a saturniid authority and personal friend, very kindly made the genitalic preparations. Dr. T. R. Adkins of Clemson University allowed me to bag tuliptrees in his yard for two summers.

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COCYTIUS DUPONCHEL (SPHINGIDAE): SECOND UNITED STATES CAPTURE

On 30 September 1975 while operating a UV light along Route 29 near Immokalee, Collier Co., Florida, the author took a large male sphingid that under the light appeared to be the resident species, *Cocytius antaeus* (Drury). Upon mounting the specimen, it tentatively was indentified as *Cocytius duponchel* (Poey). The specimen was sent to William Sieker of Madison, Wisconsin who confirmed the identification as *C. duponchel*.

This constitutes only the second U.S.A. record for this neotropical species. The other capture of *C. duponchel* within the U.S.A. is from Edwards Co., Texas in May 1902 (Hodges 1971, *Moths of North America*, Fascicle 21, Sphingoidea, 25). The specimen has been deposited in the Florida State Collection of Arthropods in Gainesville, Florida.

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