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NEARCTIC PINE TIP MOTHS
OF THE GENUS *RHYACIONIA*:
BIOSYSTEMATIC REVIEW
(Lepidoptera: Tortricidae, Olethreutinae)

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**NEARCTIC PINE TIP MOTHS
OF THE GENUS *RHYACIONIA*:
BIOSYSTEMATIC REVIEW
(Lepidoptera: Tortricidae, Olethreutinae)**

by
Jerry A. Powell, Professor of Entomology
University of California, Berkeley, Calif. 94720
and
William E. Miller, Principal Insect Ecologist
North Central Forest Experiment Station, St. Paul, Minn. 55108

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Knowledge of 13 previously known species of pine tip moths in North America is reviewed, and 11 new species are described and named.

KEYWORDS: biogeography, taxonomy, *Pinus*.

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INTRODUCTION

The genus *Rhyacionia* is widespread in the Holarctic Region, ranging from Japan and Asia to the Caribbean Antilles and Mexico. It attains greatest diversity in the mountainous parts of the western and southwestern Nearctic. The genus is represented by about 35 described species worldwide; 24 are treated here, including 11 previously undescribed. Larvae of these moths inhabit growing tips of pines and sometimes reach densities of economic concern in nurseries, in ornamental plantings, and in natural and planted reforestation projects.

Except for several eastern species that are multivoltine, most American *Rhyacionia* fly only in early spring, so they have been infrequently sampled by general collectors. Most of our knowledge about their biologies originates from conspicuous larval damage in pure, planted stands. Geographic distributions of most species are poorly documented, being dependent on sporadic collections. No one has attempted to systematically survey these moths in the Rocky Mountains, the Sierra Madre Occidental of Mexico, and other ecologically diverse regions.

The taxonomy of North American *Rhyacionia* has rested largely on the treatment by Heinrich (1923), which has grown increasingly obsolete. Recent contributions by Miller (1961, 1967b) have updated knowledge in the *frustrana* complex, while studies by MacKay (1959), Lindquist (1962), Miller and Wilson (1964), Yates (1967), and Dickerson and Kearby (1972) have provided aids to identification of larvae, pupae, and adults of selected species.

The purpose of the present work is to revise comprehensively the classification of the Nearctic *Rhyacionia*. We were prompted to undertake the task by inquiries for identification and the resultant discovery of undescribed forms.

Although we cooperated on various phases of the work, responsibility for individual species was divided: in general Miller handled

species of the eastern half of the continent and Powell the western. Most of the specimens for given species were studied by only one of us. Photographs for all species were produced at the North Central Forest Experiment Station in St. Paul and drawings and maps at the University of California at Berkeley.

Material has been examined from the following collections; the abbreviations are used in the text to indicate specimen repositories:

American Museum of Natural History, New York, N.Y. (AMNH).

André Blanchard, Houston, Tex. (Blanchard).

British Museum (Natural History), London, England (BMNH).

California Academy of Sciences, San Francisco, Calif. (CAS).

California State Department of Agriculture, Sacramento, Calif. (CDA).

Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario (CFS-GL).

Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta (CFS-N).

Canadian Forestry Service, Pacific Forest Research Centre, Vancouver, British Columbia (CFS-P).

Canadian National Collection, Ottawa, Ontario (CNC).

Charles P. Kimball, Barnstable, Mass. (Kimball).

Florida Division of Plant Industry, Gainesville, Fla. (FDPI).

Los Angeles County Museum of Natural History, Los Angeles, Calif. (LACM).

Maine Forest Service, Augusta, Maine (MFS).

Bryant Mather, Jackson, Miss. (Mather).

Michigan State University, East Lansing, Mich. (MSU).

National Museum of Natural History, Washington, D.C. (NMNH).

Shirley Hills, Pensacola, Fla. (SH).

Gayle Strickland, Baton Rouge, La. (Strickland).
 USDA Forest Service, North Central Forest Experiment Station, St. Paul, Minn. (USFS-NC).
 USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif. (USFS-PS)
 USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: Albuquerque, New Mex. (USFS-RMA); Bottineau, N. Dak. (USFS-RMB); Ft. Collins, Colo. (USFS-RMFC).
 University of California, Berkeley, Calif. (UCB).

University of Michigan, Ann Arbor, Mich. (UM).
 University of Wisconsin, Madison, Wis. (UW).

Primary types are deposited in CAS on indefinite loan from UCB, in LACM, and in NMNH in part as gifts from Blanchard, Kimball, and USFS-RMA. The letter n in text indicates number of specimens examined.

Copies of specimen label data and original photographs are available at the California Insect Survey, University of California, Berkeley, Calif., and at the North Central Forest Experiment Station, St. Paul, Minn.

BIOLOGY

The biologies of *Rhyacionia* species are similar. Moths fly in spring, though some are multivoltine. In species where host plants are known, the larvae feed in developing pine shoots during late spring and summer.

Volitinism

Most of the North American species appear to be univoltine as seen in the following tabulation:

<i>Status of knowledge</i>	<i>No. of species</i>
Univoltine; life history investigated	6
Univoltine according to available records	7
Multivoltine; life history investigated	4
Multivoltine according to available records, at least in South	3
Available records too fragmentary to permit conclusion	4

Adults of *pasadenana* and *frustrana* emerge as early as late February or March in western and southern coastal areas, and often in April or May in other areas. Adults of several species, including *adana* (Martin 1960), *neomexicana*, *jenningsi* (personal communication with Daniel T. Jennings), and *monophylliana* are active while patches of snow are still on the ground. On the other hand, *versicolor*, a montane species, flies in late June and July, as does the introduced *buoliana*. Members of the *rigidana* and *frustrana* groups are bi- or multivoltine,

the number of generations varying with latitude. For example, *frustrana* annually develops three to six generations in the South and only two in Pennsylvania and Ohio (Yates 1960, Berisford 1974b).

A strong, obligate diapause has not been clearly demonstrated for any species. In several, like *pasadenana* and *frustrana*, little if any diapause seems to occur; pupae brought indoors in fall or winter complete development and emerge.

Life Stages

Moths of most species are usually crepuscular or nocturnal, sometimes diurnal. This information is often lacking on the collection record. *Rhyacionia buoliana* is the most extensively studied of the crepuscular species. Observations by Pointing (1961) in Ontario showed that adult emergence peaks at 6:00 to 7:00 a.m., with sporadic eclosion through the day. Flight and mating occurs between 6:00 and 10:00 p.m., with greatest activity between 7:00 and 8:00 p.m. Most oviposition (numbers of eggs per hour per individual and numbers of individuals participating) takes place between 4:00 and 8:00 p.m., peaking at 6:00 to 8:00 p.m. Based on numbers of males of *frustrana* and *rigidana* attracted to caged, virgin females, Berisford (1974b) found that female calling periods are short and overlap only slightly. Ac-

tivity of *frustrana* occurs mostly at 7:00 to 7:30 p.m., while that of *rigidana* was highest at 8:00 to 9:00 p.m. The major flight period of *neomexicana* occurs at night, between 8:00 and 12:00 p.m. (Jennings 1975).

By contrast, spring generation *bushnelli* are said to fly on warm days in May, although oviposition occurs at night (Swenk 1927). Males of *zozana*, a species for which there are no light attraction records, have been taken flying during afternoon, but Stevens (1966) states that mating and presumably oviposition take place at night. Adults of *adana* are mainly diurnal, with copulation occurring between 1:00 and 8:00 p.m. when the air temperature is at or above 16°C (Martin 1960).

Oviposition in all species recorded occurs irregularly, with eggs deposited singly or in loosely organized groups of from 2 to 11. They are placed on or between needles, on needle sheaths, on bud scales, or on twigs near terminals. Development is related to temperature, usually lasting from 14 to 21 days but from 8 to 14 days in *buoliana* (Pointing 1963), and as short as 6 days in the summer brood of *bushnelli* (Swenk 1927).

Newly hatched larvae of most species feed first between needles, often entering a needle and mining. Later instars feed inside needle sheaths (*subcervinana*) or buds and finally in the growing shoots, completing growth by mid-summer or fall. *Rhyacionia buoliana*, introduced from Europe, differs from native American species in overwintering as a partly grown larva in the buds. In spring, larvae of *buoliana* resume feeding, moving to new terminals to complete development.

Pupation occurs in the larval gallery, on or in the ground away from the tree bole, or in cocoons attached to the root collar just below soil level. Most univoltine species spend the pupal wintering period on the ground (*zozana*, *neomexicana*, *adana*, *busckana*), but *pasadenana*, which lives in a maritime climate, pupates in terminals. As noted, the introduced *buoliana* is exceptional; the larva overwinters, and the brief pupal stage takes place in the larval gallery. By contrast, facultatively multivoltine species usually spend the winter in terminals (*rigidana*, *subtropica*, *frustrana*). *R. bushnelli* apparently uses both strategies; some or all overwintering pupae occur in the ground, summer generation pupae in the larval galleries (Swenk 1927).

Host Plant Associations

All *Rhyacionia* larvae for which data are available feed on pine. Rearing records believed to represent native populations on natural hosts in America north of Mexico are summarized in table 1. Nomenclature of pines throughout this work follows Critchfield and Little (1966). Records involving introduced trees, such as *Pinus sylvestris*, or unnatural situations such as mixed native tree species in nurseries, are excluded. There are no host data for exclusively Mexican *Rhyacionia* species, and the diverse pine flora of Mexico is omitted from the table.

Table 1.—Known host plants for native North American *Rhyacionia*, based on rearing records within native ranges of the pine species

<i>Pinus</i> taxonomic group and host species	<i>Rhyacionia</i> species occurring on host
SUBGENUS <i>STROBUS</i>	
Sect. <i>Strobus</i>	none
Sect. <i>Parrya</i>	
Subsect. <i>Cembroides</i>	
<i>monophylla</i>	<i>monophylliana</i>
SUBGENUS <i>PINUS</i>	
Sect. <i>Ternatae</i>	none
Sect. <i>Pinus</i>	
Subsect. <i>Sylvestres</i>	
<i>resinosa</i>	<i>rigidana</i> , <i>adana</i> , <i>busckana</i> ,
<i>tropicalis</i>	<i>subtropica</i>
Subsect. <i>Australes</i>	
<i>palustris</i>	<i>subtropica</i>
<i>taeda</i>	<i>rigidana</i> , <i>subtropica</i> ,
	<i>frustrana</i> , <i>aktita</i>
<i>echinata</i>	<i>rigidana</i> , <i>frustrana</i>
<i>rigida</i>	<i>rigidana</i> , <i>frustrana</i> , <i>aktita</i>
<i>pungens</i>	<i>frustrana</i> ¹
<i>elliottii</i>	<i>subtropica</i> , <i>frustrana</i> , <i>aktita</i>
<i>caribaea</i>	<i>subtropica</i> , <i>frustrana</i>
<i>occidentalis</i>	<i>frustrana</i>
<i>cubensis</i>	<i>frustrana</i>
Subsect. <i>Ponderosae</i>	
<i>ponderosa</i>	<i>multilineata</i> , <i>zozana</i> , <i>neomexicana</i> ,
	<i>jenningsi</i> , <i>busckana</i> ,
	<i>fumosana</i> , <i>bushnelli</i> , <i>subcervinana</i>
<i>jeffreyi</i>	<i>zozana</i> , <i>subcervinana</i>
Subsect. <i>Contortae</i>	
<i>banksiana</i>	<i>adana</i> , <i>busckana</i> , <i>sonia</i>
<i>contorta</i>	<i>pasadenana</i> ¹ , <i>zozana</i> ¹
<i>virginiana</i>	<i>rigidana</i> , <i>frustrana</i>
Subsect. <i>Oocarpae</i>	
<i>radiata</i>	<i>pasadenana</i>
<i>muricata</i>	<i>pasadenana</i> ¹

¹ Unconfirmed records.

Conclusions concerning host specificity must be tentative because several species have been reared at only one or a few localities. Records from the better known species in the Eastern United States and Canada suggest that a diversity of pines within the subgenus *Pinus* are used by *Rhyacionia* whenever available. Similar host profiles are shown by the *rigidana* group, *adana*, and the *frustrana* group in Subsections *Australes* and *Contortae*. On the other hand, the most widespread western pine of Subsection *Contortae*, *Pinus contorta*, has been definitely linked with only one *Rhyacionia*. Most western *Rhyacionia* are known from only one or two closely related pines.

A perplexing evolutionary problem is emerging from known host relations. Rather than an even distribution of *Rhyacionia* species across taxonomic groupings of the pines, nearly all records involve the subgenus *Pinus*. Only *Rhyacionia monophylliana* definitely is associated with a member of the subgenus *Strobis*. The whole Section *Strobis*, the white pines, and Subsections *Balfourianae* and *Sabinianae* are not known to harbor any *Rhyacionia*. In sharp contrast, eight *Rhyacionia* species, 50 percent of those whose food plants are known, are harbored by *Pinus ponderosa*. Thus, there is an uneven distribution of moth species among the conceivable ecological niches.

Berisford (1974a, b) showed isolating mechanisms and partial division of resource utilization through differences in pheromone broadcast time and seasonal flight periods for *frustrana* and *rigidana* living together. For most *Rhyacionia*, however, too little is known to explain how coexisting species accomplish ecological or microgeographical subdivision of the niche resource or whether observed isolating mechanisms are primary or secondary.

The concentration of eight species of *Rhyacionia* on ponderosa pine is particularly difficult to interpret. Except for *busckana*, each has been reared only from members of the Subsection *Ponderosae*. If any of the records are incidental for these seven moths, the usual hosts are unknown. Their known distributions fall within that illustrated for *Pinus ponderosa*

by Critchfield and Little (1966). The host's geographic range is partially subdivided; *subcervinana* is limited to Pacific coastal areas and *bushnelli*, *neomexicana*, *fumosana*, and *jenningsi* to the eastern or Rocky Mountains (var. *scopulorum*). The remaining two, *zozana* and *multilineata*, are broadly sympatric in the west with *subcervinana*, and in the eastern part of the range with other members of the complex. Moreover, within the eastern group, *neomexicana* and *fumosana* exhibit broad sympatry, both narrowly overlapping the nearly allopatric *bushnelli* to the east. Data show local sympatry among several pairs or triads: *zozana* and *multilineata* in California; *bushnelli*, *neomexicana*, and *fumosana* in North Dakota; *zozana* and *fumosana* near Ft. Collins, Colo.; *multilineata*, *neomexicana*, and *fumosana* near Colorado Springs, Colo.; *neomexicana*, *fumosana*, and *jenningsi* in Arizona. At most of these places light attraction or pheromone trap records indicate that two or more species fly together on the same dates.

According to the equilibrium theory of island biogeography (MacArthur and Wilson 1967), diversity increases for many organisms with increasing geographic extent of habitat (Sullivan and Shaffer 1975) or food-plant range (Opler 1974, Strong 1974). A similar relation applies to native North American *Rhyacionia* and the genus *Pinus* when widespread subgenus *Strobis* pines are excluded. In the subgenus *Pinus* the number of *Rhyacionia* species harbored (S) is positively correlated with area of pine species distribution (A) ($r^2 = 0.74$, $P < 0.05$, fig. 1). For all pine species on which one or more *Rhyacionia* species were known to feed, A was estimated as an index of km² based on range width \times range length (right angle), using maps of Critchfield and Little (1966). The equation $S=a+b A$ gives a closer fit than $\log S$ and $\log A$. The subgenus *Pinus* can be envisioned as an evolutionary stage for speciation in *Rhyacionia*. Why the widespread species *Pinus strobus*, *albicaulis*, and other members of the subgenus *Strobis* as well as certain members of the subgenus *Pinus* are not utilized remains unexplained.

**NO. *RHYACIONIA*
SPECIES HARBORED (S)**

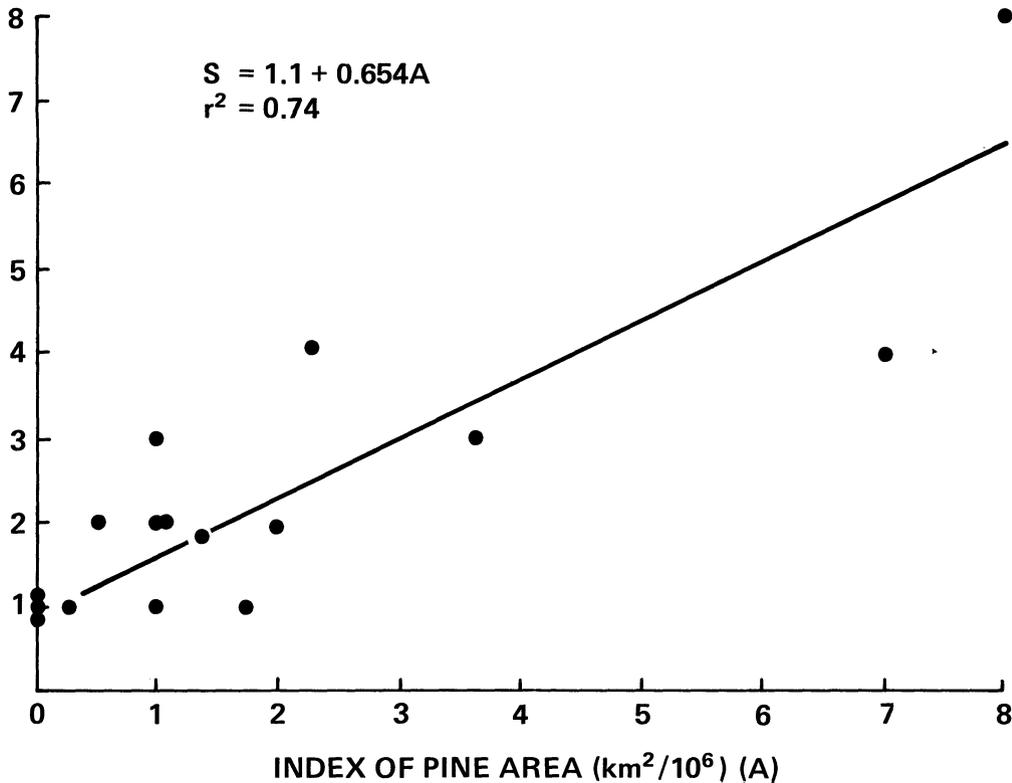


Figure 1.—Correlation between number of *Rhyacionia* species harbored per pine species (S) and index of the area of geographic range (A) of individual pine species. Each point represents one North American subgenus *Pinus* species.

GEOGRAPHIC DISTRIBUTION

The genus *Rhyacionia* is widely distributed in the northern hemisphere. Its range approximates the distribution of the genus *Pinus* (Critchfield and Little 1966), although *Rhyacionia* have not been discovered in the southernmost extensions of *Pinus* in southeast Asia, the Philippines, and Sumatra. There are 10 species assigned to *Rhyacionia* in the Palearctic (Obraztsov 1964), a much larger area of *Pinus* than that occupied by the 23 native Nearctic species treated here. The greatest concentration of *Rhyacionia* species occurs in the Western United States.

Rhyacionia buoliana, introduced from the Palearctic, is widely distributed in North America (Map 1), and has become established in South America, in Argentina, and in Uruguay (Obraztsov 1964). Most native American *Rhyacionia* are distributed in either the eastern or western half of the continent.

Although many species are widespread, only *busckana* is known to occur transcontinentally. Among native Nearctic species, 1 is widespread, 7 are restricted to the eastern half of the continent, 12 are restricted to the western half, and *bushnelli* occurs in the middle, sympatrically with members of the eastern and western cohorts. Two species are described from Mexico, and there are additional specimens insufficient for description that represent possibly two others, all from the Sierra Madre Occidental in Sinaloa and Durango. No endemic *Rhyacionia* have been described from Eastern or Southern Mexico and Central America, a region of diverse pine species. Two Eastern North American species range into the Greater Antilles, *subtropica* in Cuba and *frustrana* on all the major islands, and into southern Mexico and Central America.

The area of greatest concentration of species

is the southern Rocky Mountains; 10 species are represented in Colorado, New Mexico, and Arizona. Most of these are associated with *Pinus ponderosa*, and at several places as many as three have been taken. In addition, *versicolor*, for which no biological data are

available, occurs sympatrically with members of the ponderosa pine assemblage. Near Flagstaff, Ariz., and near Colorado Springs, Colo., they have been collected together. Four species have been collected at Rock Creek near Colorado Springs.

ALLOPATRIC SPECIES PAIRS

A parallel pattern of variation and distribution is shown by six pairs of Nearctic *Rhyacionia* species: *rigidana-subtropica* (Map 2), *monophylliana-martinana* (Map 6), *adana-jenningsi* (Map 7), *frustrana-bushnelli* (Map 10), *sonia-aktita* (Map 11), and *subcervinana-pallifasciata* (Map 12). Each pair is allopatric with slight differentiation in size, color, minor features of genitalia, and biology. Present knowledge of *Rhyacionia* biology makes it arbitrary whether these are considered species, subspecies, or unnamed components of polytypic species. We elected to treat each segre-

gate as a species, partly because different species of pines are used by the allopatric sibs in each pair where such data are available.

Both members of some pairs are widespread (*rigidana-subtropica*, *frustrana-bushnelli*, *sonia-aktita*), while other pairs have one widespread member or both members are restricted in known range (*monophylliana-martinana*). Distribution patterns range from widely disjunct (*adana-jenningsi*) to nearly contiguous or parapatric (*rigidana-subtropica*, *frustrana-bushnelli*).

TAXONOMIC CHARACTERS AND DIAGNOSIS

Sixteen characters were used for determining species and defining species groups as seen below. These may be grouped as follows: two external features of both sexes, one external feature of male, one sexual dimorphic, six male genitalic (fig. 14), four female genitalic (figs. 59, 60) and two biological.

1. Labial palpus II segment length: 0.6 to 1.4x eye diameter.
2. Labial palpus III segment length: 0.2 to 0.4x II segment length.
3. Antennal pectination length (σ): 0.3 to 2.0x segment diameter.
4. Sexual dimorphism in size: σ larger or φ larger.
5. Pollex of valva (σ): absent, rudimentary, or present.
6. "Clasper" (sacculus extension) of valva (σ): absent, rudimentary, or present.
7. Aedeagus form (σ): short, thick (length 3 to 7x width), or elongate, slender (8 to 13x width).
8. Terminal spur of aedeagus (σ): present or absent.
9. Subapical serration of aedeagus (σ): present or absent.

10. Number of cornuti (σ): range 0 to 20+.
11. Sterigma form (φ): multistate.
12. Accessory lobe below sterigma (φ): present or absent.
13. Sclerotized areas of ductus bursae (φ): present or absent.
14. Signa (φ): absent, small, large.
15. Food plant: species of subgenus *Strobos* or subgenus *Pinus*.
16. Overwintering stage: larva or pupa.

We found the genital characters, especially valva and aedeagus in the male and sclerotization of sterigma and bursa copulatrix (including signa) in the female, to be the most reliable for species definition. These features should be employed in specimen determination. Valva shape should be used cautiously as a diagnostic character, as it is variable among individuals depending partly on orientation in slide mounting. Thus we illustrate more than one valval aspect for some species. The number, distribution, and relative size of the cornuti may prove equally valuable, but we were unable to develop a technique for properly inflating the vesica. Moreover, it is not known whether the

number varies within or between populations or if cornuti are normally deciduous during the life of the moth. We found cornuti occasionally in corpus bursae, indicating transfer with spermatophores. Cornutus size may be correlated with number; when 1 to 3 in number, they are usually elongate and slender; when numerous, they are short and stout.

Forewing color is often conveniently used in making species identifications; it varies little within species. However, pattern and color are extremely similar among several species (*multilineata*, *zozana*, *busckana*, *blanchardi*, *fumosana*, *adana*, *jenningsi*). Absolute size may also be useful in comparing species in some cases, as we found narrow ranges within species, using forewing length, base to apex, as an index. We have no evidence that size of specimens is affected by laboratory rearing (usually from field-collected, full-grown larvae or pupae) and for this reason do not report whether measured specimens were reared or field collected as adults.

We omit keys in the belief that the user can identify a particular specimen more quickly and more easily by comparing it with the wing photos (figs. 62-85) and with the drawings of male genitalia (figs. 3-40) and female genitalia (figs. 41-61). To aid such comparison, illustrations of each kind for all species are grouped together at the end of the text.

Where more than one species of *Rhyacionia* populate the same pine stand or tree, field symptoms may not be distinctive enough to in-

dicating the presence of several species. One frequent and well documented mixture is *frustrana-rigidana* (Miller and Wilson 1964, Baer and Berisford 1975). Multispecies adult collections or rearings (present data) also include *aktita-blanchardi*, *aktita-frustrana*, *busckanasonia*, *bushnelli-fumosana*, and *jenningsi-neomexicana*, which suggests *Rhyacionia* mixtures may exist on a larger scale than previously supposed.

Where mixtures are likely and population as well as individual diagnosis is desired, enough individuals must be diagnosed and findings interpreted statistically. Population composition can be estimated from the size and composition of a representative sample of individuals, adults or immatures, using binomial confidence intervals (Miller and Wilson 1964). Binomial confidence interval tables are found in Snedecor and Cochran (1967) and in many other statistical references. Their use is illustrated here by two examples. If a sample of 10 individuals consists entirely of *frustrana*, the population randomly represented by the sample is between 69 and 100 percent *frustrana* ($P \leq 0.05$). In a sample of 20 individuals, if 15 are *frustrana* and 5 are *rigidana*, the population randomly represented is between 51 and 91 percent *frustrana* and between 9 and 49 percent *rigidana* ($P \leq 0.05$). Sample size is paramount; binomial confidence intervals show at a glance the size of sample needed to give the degree of precision desired for population diagnosis.

GENUS *RHYACIONIA* HÜBNER [1825]

Type species: *Phalaena Tortrix buoliana* Denis and Schiffermüller (1776) (selected by Walsingham 1900:124).

Rhyacionia Hübner (1825:379); Obratsov (1964:6, synonymy).

Retinia Guenée (1845:180).

Type species: *Phalaena Tortrix buoliana* Denis and Schiffermüller 1776 (selected by Fernald 1908:32).

A redescription of *Rhyacionia* and related genera, together with thorough taxonomic synonymy has been given by Obratsov (1964).

Members of this genus differ from all other Eucosmini by the following combination of characters: forewing termen simple, not notched, apex not falcate; veins M_2 and M_3

usually connate, sometimes separate but closely adjacent at base (rarely short stalked), always nearer to one another at base than M_3 is to Cu_1 ; costal fold of male absent. In male genitalia the socii are rudimentary or absent, the cucullus separated by a weak or moderate constriction. The forewing features are shared by members of *Petrova* Heinrich (1923) and *Barbara* Heinrich (1923). These moths are differentiated by their possession of well developed, elongate socii and a deep constriction preceding the cucullus.

Biologically, *Rhyacionia* differ from all other conifer-feeding Eucosmini including *Petrova*, which feed beneath bark sometimes creating pitch nodules or blisters, and *Barbara*, which

are cone moths. An exception occurs in pine shoot borers of the *sonomana-gloriola* complex of *Eucosma*. These are easily distinguished by

the well developed costal fold as well as other adult and larval characters (Heinrich 1923, MacKay 1959, Obraztsov 1964).

SYSTEMATICS OF SPECIES GROUP 1: *BUOLIANA*

Female larger than male. Antennal pectination of ♂ minute, < 0.1 segment diameter. Labial palpus short, II = 0.9 eye diameter. Male genitalia: sacculus without extensions or pollex development; aedeagus elongate with terminal spur, 3 to 7 elongate cornuti. Female genitalia: sterigma simple; signa lacking.

Rhyacionia buoliana (Denis and Schiffermüller)

(Figures 3, 4, 41, 62; Map 1)

Tortrix buoliana Denis and Schiffermüller (1776:128).

Evetria buoliana; Banks (1909:3).

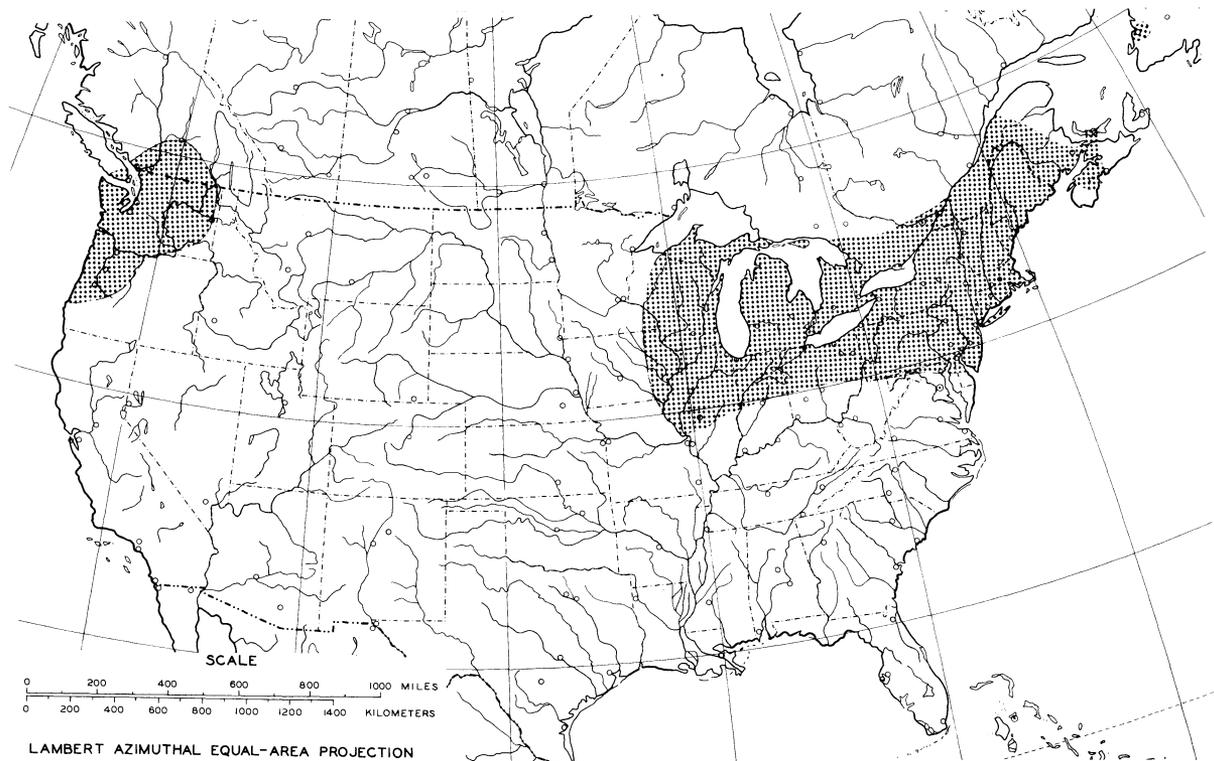
Rhyacionia buoliana; Heinrich (1923:15); Obraztsov (1964:141, synonymy).

The forewing is orange with silvery white crossbands. The moth is medium sized: forewing length in males 8.0 to 9.5 mm (25 n);

females, 8.0 to 11.0 mm (25 n). Male genitalia (figs. 3, 4): valva broad; aedeagus tapered distally, vesica with 3 to 7 elongate cornuti (25 n). Female genitalia (fig. 41): sterigma funnel-like, ductus bursae with a sclerotized spot, signa absent (21 n). Larvae and pupae have been differentiated from other *Rhyacionia* by MacKay (1959), Lindquist (1962), and Dickerson and Kearby (1972).

Type data.—Vicinity of Vienna, Austria; no syntypes are known (Obraztsov 1964).

Geographic distribution.—Introduced in North America (Map 1): Newfoundland south to Delaware and west to Upper Michigan and Missouri; also coastal British Columbia, Washington, and Oregon (Pointing and Miller 1967, Carolin and Daterman 1974). It also occurs through much of Europe and in a small area in South America (Obraztsov 1964, Miller 1967a).



Map 1.—Geographic distribution of the European pine shoot moth, *Rhyacionia buoliana*, in North America (after Pointing and Miller 1967, Carolin and Daterman 1974).

Flight period.—Mainly June. The insect is univoltine throughout its North American range (Pointing and Miller 1967).

Hosts.—Many species of subgenus *Pinus* (Miller 1967a).

Discussion.—This is the well known European pine shoot moth, accidentally introduced to North America in the early 1900's. Complete taxonomic synonymy treating the Old World literature is given by Obraztsov (1964).

The one-sentence original description is insufficient to distinguish between two similar *Rhyacionia* occurring at the type locality. The current identity of *buoliana* is due to Bankes (1909) who called attention to genitalic differences and, in effect, assigned the names *buoliana* and *pinicolana*. All subsequent authors in Europe and North America have followed Bankes' designations. *Rhyacionia pini-*

colana (Doubleday) does not occur in North America.

Obraztsov (1964) and others have given Schiffermüller as the sole author responsible for the name *buoliana* probably because only he is mentioned in the original work (copy examined at Niedersachsen State and University Library, Göttingen, West Germany). According to Hagen (1862, 1863), both Denis and Schiffermüller were responsible; other names originating in the original work are given dual authorship (as in Bradley and coworkers 1973). The year of publication is taken as 1776 after Dos Passos (1958).

This insect is the most studied member of the genus. Miller (1967a) gives the most recent comprehensive account of its biology and importance.

GROUP 2: *RIGIDANA*, *SUBTROPICA*

Female larger than male. Antennal pectination of ♂ short, 0.4 segment diameter. Labial palpus short, II = 0.6 to 0.8 eye diameter. Male genitalia: sacculus extension rudimentary, pollex not developed; aedeagus elongate, no spur, cornuti absent. Female genitalia: sterigma unmodified, ductus bursae with sclerotized basal sleeve; signa tiny.

Rhyacionia rigidana (Fernald)

(Figures 5, 6, 7, 42, 63; Map 2)

Retinia rigidana Fernald, in Comstock (1880:237).

Rhyacionia rigidana; Heinrich (1923:19).

The moths have reddish-brown forewing markings with a pale medial crossband as wide or wider than the basal patch. The pattern is similar to *subtropica*, but the pale areas are darker in *rigidana*. Moths are moderate sized: forewing length in males 5.5 to 8.0 mm (28 n); females, 6.0 to 9.0 mm (33 n). Male genitalia (figs. 5, 6, 7): valva broad, sacculus with a distal triangular flange; emargination preceding cucullus accentuated on the unflattened valva (compare figs. 5, 6, 7); aedeagus straight in dorsal-ventral aspect, sinuate and slightly bent downward distally in lateral aspect (fig. 7a) (27 n). Female genitalia (fig. 42): sterigma small, a nonsclerotized dorso-medial seam dividing lamella postvaginalis for 0.5 or more of its length; ductus bursae sclerotized basally, usually forming a partial ring, sometimes (8

percent of examples) a complete ring; two small, unequal sized thornlike signa (24 n). Larvae are indistinguishable from *subtropica* but both were differentiated from *frustrana* by Miller and Wilson (1964) and from *neomexicana* and *buoliana* by MacKay (1959). Pupae were differentiated from those of three other *Rhyacionia* by Yates (1967) and Dickerson and Kearby (1972); Yates (1969) also differentiated pupal sexes.

Type data.—Ithaca, N. Y.; lectotype female 70834 in NMNH designated by Miller (1970).

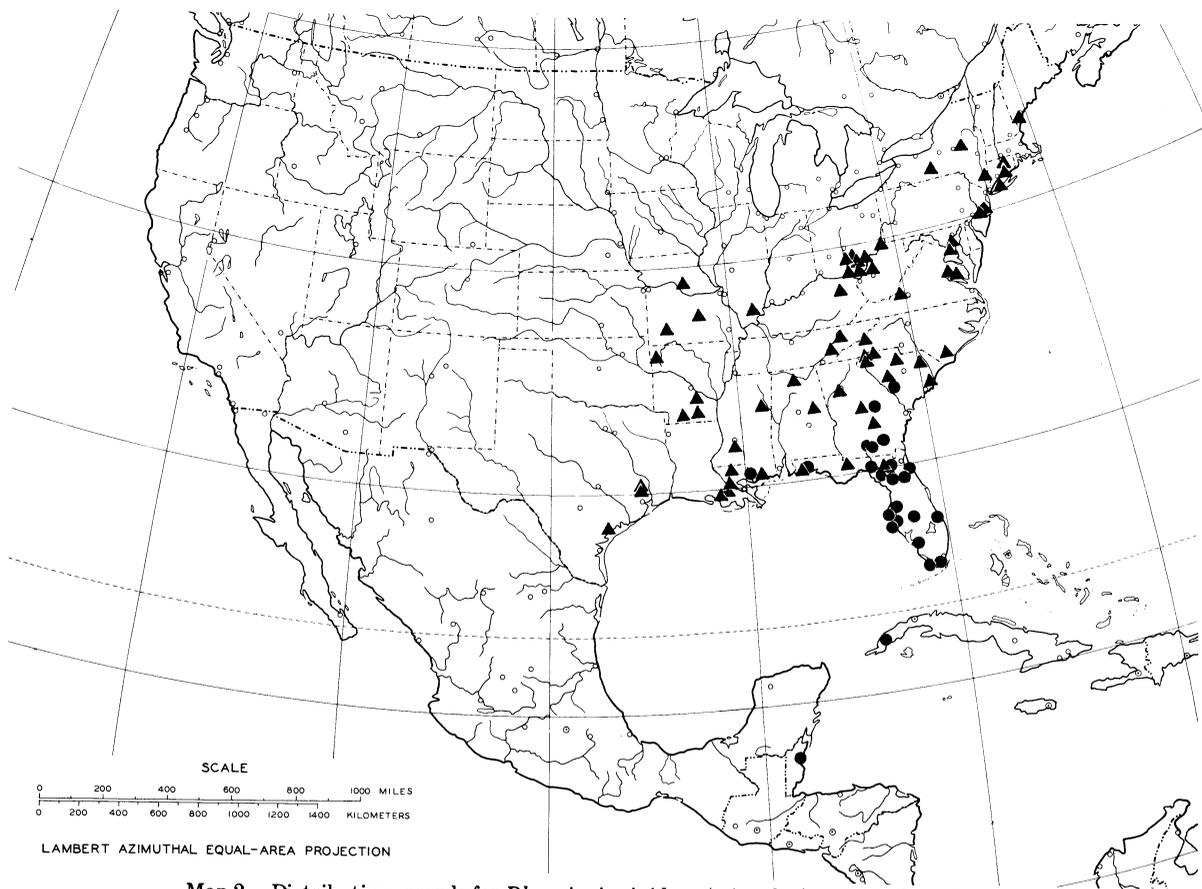
Geographic distribution.—(Map 2) Maine south to Florida and west to Missouri and Texas (Miller and Neiswander 1959).

Flight period.—Mid-March to May and during July (Miller and Neiswander 1959, Berisford 1974a).

Hosts.—Various species of subgenus *Pinus* (Miller and Neiswander 1959) (table 1).

Discussion.—Moths of either sex of *rigidana* are distinguishable from those of *subtropica* by the darker medial crossband and other pale forewing areas; females by presence of the dorso-medial seam of lamella postvaginalis, which is absent in *subtropica*, and by thin lateral margins of the sterigma, which are thick in *subtropica*. No structural differences between males are known.

Two small male examples taken in flight at Pensacola, Fla. (11-3-62, SH), are tentatively placed here. They are not distinguishable in



Map 2.—Distribution records for *Rhyacionia rigidana* (triangles) and *R. subtropica* (circles).

genitalia, but possess longer antennal pectination and the forewing ground color is deep red and hindwings are darker than typical specimens. The contrast in forewing hues is reminiscent of *subtropica*, but overall appearance is more similar to *rigidana*. No matching females are available.

Further study of male genitalia showed polymorphism reported in the ventro-distal area of the valva (Miller 1961) to be an artifact of nonuniform microslide mounting.

Rhyacionia subtropica Miller

(Figures 8, 43, 64; Map 2)

Rhyacionia subtropica Miller (1961:231).

The moth has forewing markings similar to *rigidana* but the contrast in hues is greater in *subtropica*. The moths are moderate sized: forewing length in males 5.0 to 8.0 mm (22 n); females, 5.5 to 9.5 mm (31 n). Male genitalia (fig. 8): similar to *rigidana* (10 n). Female genitalia (fig. 43): sterigma small, lateral margins forming a thick lip; ductus bursae sclerotized basally, often forming a complete ring, less often (33 percent of examples) a partial ring; two small, unequal sized thornlike

signa (21 n). Larvae are indistinguishable from *rigidana* but both were differentiated from *frustrana* by Miller and Wilson (1964). Pupae were differentiated from two other *Rhyacionia* by Yates (1967); Yates (1969) also differentiated pupal sexes.

Type data.—Valparaiso, Fla., May (Gemmer); holotype female 65012 in NMNH.

Geographic distribution.—(Map 2) South Carolina south to Florida and Cuba, west to Mississippi and British Honduras (Miller 1961, 1965; Hochmut 1972).

Flight period.—December to March, May to August, and September and October; in Florida the species is bivoltine with a partial third emergence (Miller 1961, McGraw 1975).

Hosts.—Several pines of subgenus *Pinus*, but mainly *P. elliottii* var. *elliottii* and *P. elliottii* var. *densa* (Bethune 1963, Hochmut 1972, McGraw 1975) (table 1).

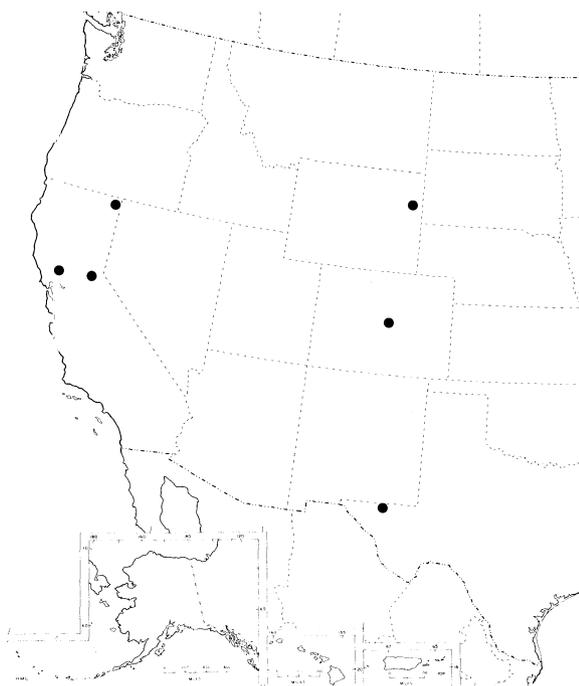
Discussion.—Separation of adults of *subtropica* and *rigidana* is discussed under *rigidana*. Further study of male genitalia showed polymorphism reported in the ventro-distal area of the valva by Miller (1961) to be an artifact of nonuniform microslide mounting.

GROUP 3: *MULTILINEATA*

Female slightly larger than male. Antennal ciliation of ♂ short, 0.3 segment diameter. Labial palpus short, II = 0.9 eye diameter. Male genitalia: sacculus extension not defined, pollex weak; aedeagus short without armature; > 10 cornuti. Female genitalia: sterigma an open bowl, ductus bursae unmodified, signa large.

Rhyacionia multilineata Powell, New Species

(Figures 9, 10, 44, 65; Map 3)



Map 3.—Distribution records for *Rhyacionia multilineata*.

A small moth with forewing pattern *zozana*-like, bluish with reddish termen, largely obscured by many whitish transverse lines.

Male.—Length of forewing 6.5 to 7.0 mm (7 n). **Head:** Labial palpus moderately short, II segment length 0.9 eye diameter, III 0.4 as long as II; scaling broadly spreading, III segment nearly obscured, pale gray tinged darker exteriorly toward base. Scaling of front and crown whitish gray, slightly to extensively tinged with dark gray, the scales white-tipped. **Thorax:** Dorsal scaling darker than head, the scales dark gray, white-tipped. Venter shining

whitish, legs sprinkled with dark gray exteriorly. **Forewing:** Moderately broad, length 2.9 to 3.0 times width; apex acute, termen strongly angled back, tornal angle distinct. Upper side dark gray to end of cell, orange-brown beyond, crossed by about 12 ill-defined transverse lines, whitish on basal half of wing, metallic bluish in distal part of gray, silvery and shining orange in terminal area, the basal half bluish to the unaided eye; the lines in mid-dorsal area enlarged, somewhat coalesced, sometimes appearing as a pale blotch. Tornal “ocellus” represented by a few to many black scales roughly arranged along two transverse rows. Fringe dark gray with a distinct black line at base. Underside dark gray mottled with whitish in dorsal and terminal areas. **Hindwing:** Slightly broader than forewing; apex round, termen slightly convex, broadly curved to dorsum, tornal angle not discernible. Ground color whitish basally, becoming dark gray at distal margins, to dark gray brown. Fringe pale gray. Underside whitish, the veins dark gray. **Abdomen:** Dorsal scaling shining dark gray, venter pale, genital scaling whitish. Genitalia (figs. 9, 10, drawn from paratypes JAP preps. 3452, Colorado, and 3462, California; 7 n): valva broad without marked constriction before cucullus, pollex short, aedeagus abruptly attenuate distally; cornuti 11 to 12.

Female.—Length of forewing 6.4 to 7.1 mm (9 n). Essentially as described for the male, but darker and more vividly colored. Forewing slightly broader than in male, length 2.8 to 2.9 times width; terminal area banded pale and dark orange between the transverse shining lines. Hindwing darker than in male. Genitalia (fig. 44, drawn from paratype, Blodgett Forest, JAP prep. 3472; 4 n): ductus bursae with a sclerotized band at junction of ductus seminalis; signa broad, curving.

Holotype male and allotype female: California, Buck Creek Ranger Station, 1,660 m elevation, Modoc County, June 5 to 7, 1970, at light (P. A. Opler and J. Powell) (CAS). Fourteen paratypes, as follows. California: same data as holotype, 1♂; Blodgett Forest, 21 km E. Georgetown, El Dorado Co., 1♀ VI-24-67, at light (J. Powell); Middletown, Lake Co., 1♀ III-23-64, emerged from *Pinus ponderosa* log (D. Kinn). Wyoming: 10 km NW Newcastle,

Weston Co., 4♂, 5♀ VI-23-25-65 (R. W. Hodges). Colorado: Rock Creek Canyon, Colorado Springs, El Paso Co., 1♂ V-15-59, 1♀ VI-3-59 (M. May) (Kimball, NMNH, and UCB).

Additional specimens subsequently examined: Texas, Guadeloupe Mts., Smith Canyon, Culberson Co., 1,753 m, 2♂, 3♀ V-22-73 (R. W. Hodges); Blodgett Forest, Calif., 6♂, 1♀ VI-4, 5-75, at light (P. A. Rude and J. Powell).

The Wyoming, Colorado, and Texas specimens differ from California examples in having

the hindwing slightly darker (a distinction more evident in the male) and in the more uniformly colored forewing, the basal half less bluish and terminal area less reddish.

The single rearing record from *Pinus ponderosa* probably represents pupation in bark; the moth emerged from logs caged for bark beetle studies. The March emergence date is abnormal, presumably the result of laboratory conditions.

GROUP 4: *PASADENANA* TO *MARTINANA*

Male larger than female. Antennal ciliation of ♂ short to moderate, 0.3 to 0.7 segment diameter. Labial palpus normal, II = 0.9 to 1.0 eye diameter. Male genitalia: sacculus and pollex weakly to well developed, aedeagus short to moderately elongate with terminal spur; 1 to < 20 cornuti. Female genitalia: sterigma a broad ring, ductus bursae unmodified; signa tiny to large.

Rhyacionia pasadenana (Kearfott)

(Figures 13, 45, 66; Map 4)

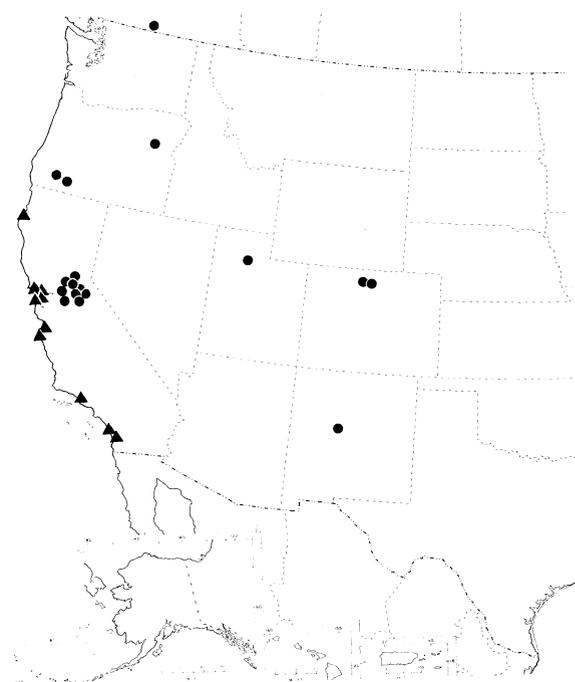
Evetria pasadenana Kearfott (1907:3).

Rhyacionia pasadenana; Heinrich (1923:16).

A pale moth with extensive reddish orange over the distal half of the forewing, gradually blending with the grayish basal area. Forewing length of males 7.0 to 9.1 mm (15 n); females 6.5 to 8.0 mm (10 n). Male genitalia (fig. 13): pollex and distal projection of sacculus weakly developed; aedeagus short, blunt, vesica with about six slender cornuti (3 n). Female genitalia (fig. 45): sterigma a simple, broad ring, ductus bursae sclerotized basally; signa tiny (3 n).

Type data.—Three specimens, Pasadena, Calif., W. G. Dietz; Alameda Co., Calif., March; Carmel-by-the-Sea, Monterey Co., Calif., A. H. Vachell. Lectotype male, Alameda County, in AMNH designated by Klots (1942) based on the selection of Heinrich (1923). Type locality restricted here to the city of Alameda for reasons discussed below.

Geographic distribution.—(Map 4) Immediate coastal areas of California. The native range is unknown, but it may have been lim-



Map 4.—Distribution records for *Rhyacionia pasadenana* (triangles) and *R. zozana* (circles).

ited to the Monterey peninsula, the endemic distribution of *Pinus radiata*. Now *pasadenana* occurs from Humboldt County (Koehler and Tauber 1964) south to Los Angeles County on ornamental and feral pines.

Flight period.—End of March to beginning of July according to combined year collections at light in the east San Francisco Bay area (25 n), and as late as August at Eureka, the northernmost locality. These records represent a single generation per year (Koehler and Tauber 1964).

Hosts.—*Pinus radiata* in naturalized stands and *P. contorta* and *P. muricata* (Lange 1937), the last two possibly only in ornamental situations. A specimen labelled "reared from cypress twigs," (UCB) probably is mislabelled or involves a misidentified host.

Discussion.—This species closely follows the "fog belt" distribution pattern, which limits many insects to areas near the coast in California (Keifer 1935). *R. pasadenana* was not taken during a 5-year light trap survey at Walnut Creek in an area with many *Pinus radiata* of all ages. This station is only 17 airline km east of the Berkeley Hills, which harbor populations of the moth yet serve as a barrier to inland influence of the fog belt. Thus it is assumed that the species was originally limited to a coastal pine, either *Pinus radiata* or *P. muricata*. There are no records from native stands, but adults were collected before 1907 at Carmel, within the natural range of these pines as well as at Alameda and Pasadena where no native pine occurs.

The selection of "Alameda County" as the type locality is inadequate because it raises the possibility of *Pinus sabiniana* serving as the native host at higher, inland locations. The present coastal distribution of the moth, together with negative evidence from sampling *P. sabiniana* fauna of inland Alameda County (Burdick and Powell 1960), suggests that ornamental pine on the San Francisco Bay coast was the source of the type specimen. Moreover, the label on the type is from the Koebele collection, and Koebele made his headquarters at Alameda during 1885 to 1888 (Essig 1931:674). He must have reared a pine-feeding olethreutid there because the tachinid *Urophylloopsis retiniae* (Coquillett 1897) was described from "Alameda, Calif., bred April 17, 1888, from chrysalids of *Retinia* sp. by Mr. Albert Koebele." This fly has been reared from *R. pasadenana* in San Francisco (JAP lot 61B2, det. C. W. Sabrosky). Thus the type locality probably is the city of Alameda with *Pinus radiata* the probable host.

***Rhyacionia zozana* (Kearfott)**

(Figures 14, 15, 46, 67; Map 4)

Evetria zozana Kearfott (1907:2).

Petrova zozana; Heinrich (1923:26).

Rhyacionia zozana; Lange (1937:25, 31).

Evetria matutina Meyrick (1912:35) (unnecessary substitute name).

Evetria montana Busck (1914:147). New synonymy.

Rhyacionia montana; Heinrich (1923:18).

The moths have a dark bluish-gray thorax and basal two-thirds of the forewing, marked with whitish transverse striae. The head, palpi, thorax anteriorly, and distal one-third of the forewing are reddish orange, the forewing becoming dark red at the margin. The species thus resembles *jenningsi*, described further on. However, in that species the adults are smaller, with gray palpi and thorax, and the orange of the forewing is less extensive. *R. zozana* also is superficially similar to certain *Petrova*, especially *P. edemoidana* (Dyar), and was thought to be a *Petrova* until the male was discovered and the biology studied (Lange 1937).

Forewing length in males 8.7 to 11.0 mm (usually 10 to 11 mm) (27 n); females, 7.8 to 9.0 mm (14 n). Male genitalia (figs. 14, 15): pollex moderately elongate, less defined when valva flattened (compare figs. 14 and 15); vesica with a dense bunch of 12 to 15 cornuti (13 n). Female genitalia (fig. 46): sterigma a heavy ring with posterior protruding enlargement, base of ductus bursae with a broad sclerotized sleeve; corpus bursae with a sclerotized band on proximal half; signa small with broadly sclerotized bases (8 n).

Type data.—Placer Co., Calif., April 20 (A. H. Vachell); female type in AMNH (Klots 1942) (*zozana*). Elliston, Mont., on *Pinus contorta*, issued December 10, 1913 (J. Brunner); male type in NMNH (*montana*).

Geographic distribution.—(Map 4) Widespread in the Western United States, from Tuolumne County, Calif., northward on the west slope of the Sierra Nevada to Oregon, southern British Columbia, western Montana, and northern Colorado.

The species was also recorded in eastern Washington by Stevens (1966), but Stevens (personal communication) states that this was based on a record from Grant County sent him from NMNH. We examined the NMNH specimen from Grant County, and it proved to be *R. busckana* Heinrich.

Flight period.—Mid-March to Mid-May in California and Oregon, based on field collected adults (10 n) and Stevens (1966).

Hosts.—*Pinus ponderosa* and *P. jeffreyi* in California (Lange 1937, Stevens 1966) and *P. contorta* in Montana (Busck 1914). Pines of both subgenera serve as hosts under conditions of mixed planting (Stevens 1966).

Discussion.—The synonymy of *montana* Busck under *zozana* was suggested by Lange (1937) but not followed by subsequent workers. We did not locate further material from Montana or adjacent States, but comparison of the type male with specimens from northern California and Oregon reveals no appreciable differences. The *montana* type is slightly darker than typical *zozana*, duller golden reddish in the terminal area, while some specimens from northern California and Oregon are intermediate. The male genitalia of the *montana* type show no differences when compared to El Dorado County, Calif., material.

Further information is needed to clarify the status of the following populations from Colorado, Utah, and New Mexico, which are tentatively referred to *zozana*.

Two samples from near Ft. Collins, Colo. (USFS-RMFC), differ from typical *zozana* and from one another: 1♂, 1♀, 16 km NW of Ft. Collins, collected at light in May 1973, have the whitish striae of the forewing obscured by dark ground color and the terminal orange duller than typical. The female appears to lack the sclerotization of the corpus bursae (although the preparation is heavily red-stained, which may obscure a light sclerotization). Nine♂♂, Ft. Collins, taken at pheromone traps between May 27 and June 20, 1975, have an excessive number of cornuti (20 to 24) and a slightly narrower pollex (4 n). The moths are larger than ♂♂ from California (forewing length 11.1 to 12.1 mm) and have a more restricted, less defined, and paler apical orange blotch on the forewing. This results in a larger dark portion, which has distinctive, whitish cross striae.

Four ♂♂ reared at Albuquerque, N. Mex., from ornamental ponderosa pine in 1974 (USFS-RMA) are indistinguishable from the typical California phenotype, unlike the darker Colorado examples discussed above. Whether they represent an introduction from nearby or distant populations is unknown. If native New Mexico components of the species exist in this phenotype, a polytopic interpretation of the variation will be necessary. One ♀ reared from

Pinus mugo (a Palearctic species) at Bountiful, Davis Co., Utah, in 1971 (NMNH) is atypical. The reddish terminal of the forewing is reduced in extent and brightness, with corresponding expansion of the dark ground and pale transverse striae, so the forewing somewhat resembles *multilineata*. The sterigma form is less defined, especially the posterior median protrusion.

Rhyacionia neomexicana (Dyar)

(Figures 11, 12, 47, 68; Map 5)

Evetria neomexicana Dyar (1903:286).

Rhyacionia neomexicana; Heinrich (1923:16).

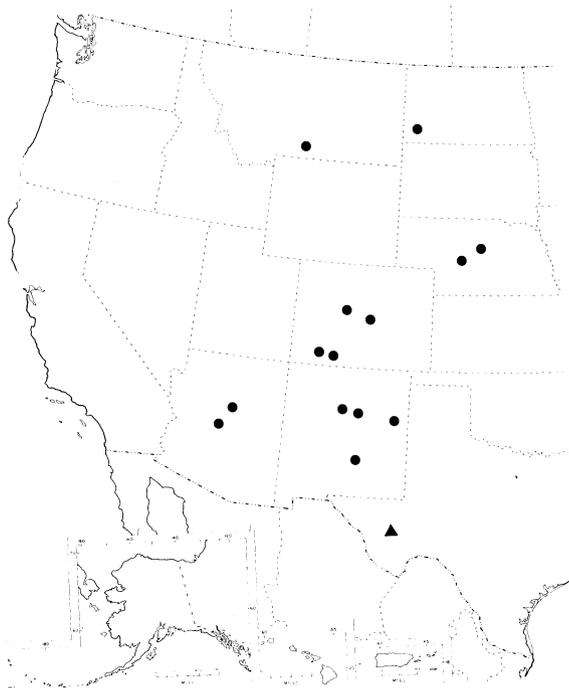
The pinkish buff covering the distal area of the forewing, above the tornus and beyond the cell, distinguishes adults of *neomexicana*. This area has no transverse striae and is marked only by two thin black lines from the end of the cell through the terminal area. There is marked sexual dimorphism, the females smaller and brighter colored, with more distinct markings. Forewing length in males 12.5 to 13.5 mm (10 n); females, 8.7 to 10.0 mm (10 n). The males are the largest moths in *Rhyacionia*. Male genitalia (figs. 11, 12): pollex and distal flange of sacculus moderately well defined; cornuti, three slender spines (3 n). Female genitalia (fig. 47): sterigma a broad ring with subtending sclerotized enlargement, ductus bursae unmodified; signa large, moderately broad cones with broadly sclerotized bases (3 n). Larvae were distinguished from other *Rhyacionia* by MacKay (1959).

Type data.—Las Vegas, San Miguel Co., N.M., "bred from pine" (T. D. A. Cockerell); holotype male in NMNH.

Geographic distribution.—(Map 5) North central Arizona, New Mexico, Colorado, Nebraska, southern Montana, and southwestern North Dakota.

Flight period.—From late March to late May in the south (Jennings 1975) to June in the north (Keen 1952). There are specimen records (NMNH) for mid-March (1 n) and late June (6 n) in northern Arizona and July in Colorado (18 n).

Hosts.—*Pinus ponderosa* (Arizona, southwestern Colorado, and Nebraska) (NMNH, Jennings 1975) and *P. ponderosa* var. *scopulorum* (Colorado Springs) (NMNH).



Map 5.—Distribution records for *Rhyacionia neomexicana* (circles) and *R. salmonicolor* (triangle).

Discussion.—The original specimens were reared from “imported pine trees” in a plantation, but Cockerell (1901) stated that the same caterpillars were found in *Pinus ponderosa* var. *scopulorum* at nearby Las Vegas Hot Springs, N.M.

The species was also reared at Halsey, Nebr., from 1928 to 1933 from ponderosa pine plantings, in a manmade forest planted near the turn of the century (Pool 1953). This colony may have resulted from short-distance spreading—less than 100 km—rather than as an introduction from a distant population because ponderosa pine was present in the western half of Nebraska before 1900.

***Rhyacionia salmonicolor* Powell, New Species**

(Figures 16, 69; Map 5)

A small moth with salmon-colored forewings with a thin longitudinal dark line through the cell.

Male.—Length of forewing 7.2 to 7.7 mm (4 n). **Head:** Labial palpus short, II segment 0.8 eye diameter, III less than 0.3 length of II. Scaling of palpus grayish, becoming reddish distally. Scaling of front and crown pale orange, becoming whitish posteriorly. **Thorax:**

Dorsal scaling orange brown anteriorly, becoming whitish gray posteriorly. Underside white, legs dark gray, metathoracic leg paler. **Forewing:** Length 3.4 times width, costa nearly straight, termen strongly angled back. Uperside pale salmon colored; base blackish, bordered at immediate base and outwardly with whitish (bluish to unaided eye); a thin, dark reddish brown line in cell from just beyond basal patch to end of cell; termen narrowly dark red, bordered outwardly at base of fringe with whitish; fringe distally bright rose pink. Underside dark gray, dorsal area whitish, fringe as above. **Hindwing:** Pale gray, fringe whitish. Underside white. **Abdomen:** Shining sordid whitish. Genitalia (fig. 16, drawn from JAP prep. 3587; 2 n) similar to *neomexicana* except distal projection of sacculus less prominent; pollex narrower and slightly curved; apical spur of aedeagus relatively smaller; cornuti three long spines.

Female.—Unknown.

Holotype male.—Texas, Mt. Locke, 2,161 m, Davis Mtns., May 19, 1971 (A. & M. E. Blanchard) (NMNH). Three paratype males, same data (Blanchard and UCB).

This moth strikingly resembles the widespread mistletoe feeding pyralid, *Dasypygia alternosquammella* Ragonot. *Rhyacionia salmonicolor* seems closely related to *neomexicana*, judging from wing color and morphology. Thus the female may be expected to be smaller with less extensive salmon color on the forewing. The host plant of *salmonicolor* is unknown, but a likely suspect is the isolated segregate of ponderosa pine in the Davis Mountains.

***Rhyacionia monophylliana* (Kearfott), New Combination**

(Figures 17, 70; Map 6)

Evetria monophylliana Kearfott (1907:1).

Petrova monophylliana; Heinrich (1923: 26).

The moths are paler than any other *Rhyacionia*, having bluish gray basal, reddish terminal areas, on the forewing. The whole basal one-fourth and the basal half of costal areas are pale blue gray with whitish transverse striae. The remainder of the wing is pale ochreous except that the terminal margin and fringe are dark reddish. Forewing length in males 7.9 to

8.4 mm (5 n). Male genitalia (fig. 17): pollex moderately elongate, slender, sacculus with a weak distal ridge; vesica with two or three slender spines (2 n).

Type data.—Coso Valley, Calif., May 1891 (Koebele); lectotype male in AMNH, designated by Klots (1942), who followed Kearfott in stating that this locality is in Kern County. Recent maps do not show a Coso Valley. Presumably the name refers to the area west of the Coso Range near Coso Junction, or to the east between the Coso Range and Argus Mountains. Part of the type series came from the Argus Mountains. All of these places are in Inyo County.

Geographic distribution.—(Map 6) Known only from the margins of the Mojave Desert in California, in southern Inyo and northwestern Ventura counties.

Flight period.—May; a series from the west base of Frazier Mountain at 1,670 m elevation was collected May 7 to 9, a few days after the last snowfall in the area.

Hosts.—*Pinus monophylla* (Kearfott 1907).

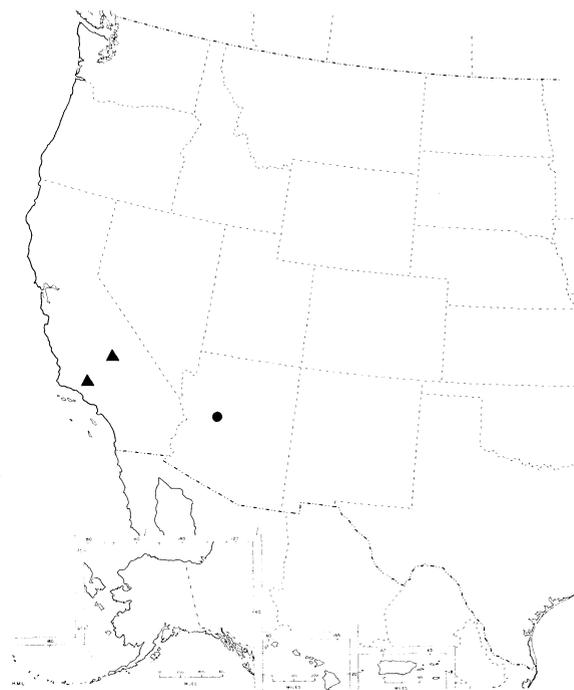
Discussion.—The species was originally described from four specimens, but by 1923 all four had lost their abdomens. The only later collection we have seen is a series of males taken in 1959 (UCB); we have not been able to study female genital characters.

Rhyacionia martinana Powell, New Species

(Figures 48, 71; Map 6)

The forewing of this small moth has the basal area and costal half to the end of the cell bluish gray, sharply contrasted with the salmon-ochreous dorsal-terminal area.

Male.—Length of forewing 7.2 to 8.8 mm (14 n). *Head:* Labial palpus short, II segment length 0.7 to 0.8 eye diameter, III 0.3 to 0.4 as long as II; scaling spreading, nearly obscuring III segment, brick red exteriorly, white interiorly, III blackish. Scaling of crown pale rust brown. *Thorax:* Dorsal scaling ochreous and dark rust red on collar, becoming pale ochreous to whitish posteriorly; venter shining whitish, legs banded with dark brown, metathoracic leg paler. *Forewing:* Narrow, length 3.6 to 3.8 times width; termen steeply angled back, evenly curved to dorsal margin. Color pattern sharply divided, basal one-fourth and costal half to end of cell white with scattered



Map 6.—Distribution records for *Rhyacionia monophyllana* (triangles) and *R. martinana* (circle).

gray scales, bluish to the unaided eye; basal area with indistinct darker, transverse strigulae; dorsal half beyond one-fourth immaculate ochreous salmon becoming salmon pink in terminal area; termen narrowly deep rust-red and a tinge of rust red in costal area beyond cell; outer costa and base of fringe narrowly white, fringe distally dark rust red. Underside dark gray in costal half through cell, blending to whitish distally; whitish and red spotting of costa and terminal fringe repeated. *Hindwing:* About 1.1 wider than forewing; costa moderately concave distally, apex narrowly acute. White, lightly tinged with brownish gray on veins distally and at margins. Fringe white. Underside white, lightly tinged with brownish along veins on costal half. *Abdomen:* Dorsal scaling pale brownish gray, venter whitish. Genitalia similar to *monophyllana* (fig. 17), pollex slightly broader, not recurved; aedeagus with one to two cornuti (3 n).

Female.—Length of forewing 6.3 to 8.3 mm (7 n). Essentially as described for male except eye slightly smaller, labial palpus II segment 0.8 to 0.9 eye diameter. Forewing broader, length 3.3 to 3.6 times width. Genitalia (fig. 48, drawn from paratype, JAP prep. 3944; 2 n): sterigma a slightly raised ring, produced posteriorly; ductus bursae broad, unsclerotized; signa large.

Holotype male and allotype female: Arizona, 8 km north of Prescott, elev. 1,660 m, Yavapai Co., May 7, 1973, and May 1, 1974 (L. M. Martin) (LACM). Paratypes (19): 1♂, same data except V-7-73; 12♂, 6♀, same data except IV-28 to V-11-74 (LACM, NMNH, and UCB).

This species is closely related to *R. monophylliana*. It differs from *monophylliana* by having the bluish-gray area of the forewing sharply delimited and restricted to the basal area and costal half of the cell. The salmonochreous area is darker and is extended over the dorsal half more broadly and distinctly than in *monophylliana*. In male genitalia the pollex of *monophylliana* is more slender and

slightly recurved, and there are two to three cornuti compared with one to two in *martinana*. In female genitalia the new species is similar to *zozana*, with the sterigma less produced, the signa larger, and ductus bursae without a sclerotized band. Females of *monophylliana* and *salmonicolor*, when found, probably will be similar to *martinana*.

The close relation to *monophylliana* and to distributions of pinyon pines (Critchfield and Little 1966) suggest that *Pinus edulis* is the host plant of *R. martinana*.

This moth is named for Lloyd M. Martin, dean of Arizona Lepidoptera collectors.

GROUP 5: ADANA, JENNINGSI

Male larger than female. Antennal ciliation of ♂ short. Labial palpus normal, II = 1.0 eye diameter. Male genitalia: sacculus extension not developed, pollex moderately broad; aedeagus elongate, slender; two to four cornuti, elongate. Female genitalia: sterigma a broad ring, ductus bursae unmodified; signa small.

Rhyacionia adana Heinrich

(Figures 18, 72; Map 7)

Rhyacionia adana Heinrich (1923:18).

Like several other *Rhyacionia*, the basal three-fourths of the forewing has alternating light and dark gray crossbands. The adult cannot be reliably separated from *busckana*, *blanchardi*, and *jenningsi* except by genitalic characters and the long antennal pectination of males of the first two. The moths are small to medium sized: forewing length in males 6.5 to 9.0 mm (47 n); females, 5.5 to 8.5 mm (42 n). Male genitalia (fig. 18): valva moderately constricted preceding cucullus; aedeagus gradually attenuated, vesica with two to four spines (10 n). Female genitalia (6 n) similar to *jenningsi* (fig. 49), distinguished under that species. The larvae have been differentiated from three other *Rhyacionia* by Lindquist (1962).

Type data.—Forest Hills, Mass., IV-5-1910 (Raff); holotype male 24786 in NMNH.

Geographic distribution.—(Map 7) Massachusetts south to Virginia and west to Ontario and Mississippi.

Flight period.—March through May in the North where the insect is known to be univoltine (Martin 1960). A Mississippi specimen was captured flying in January.

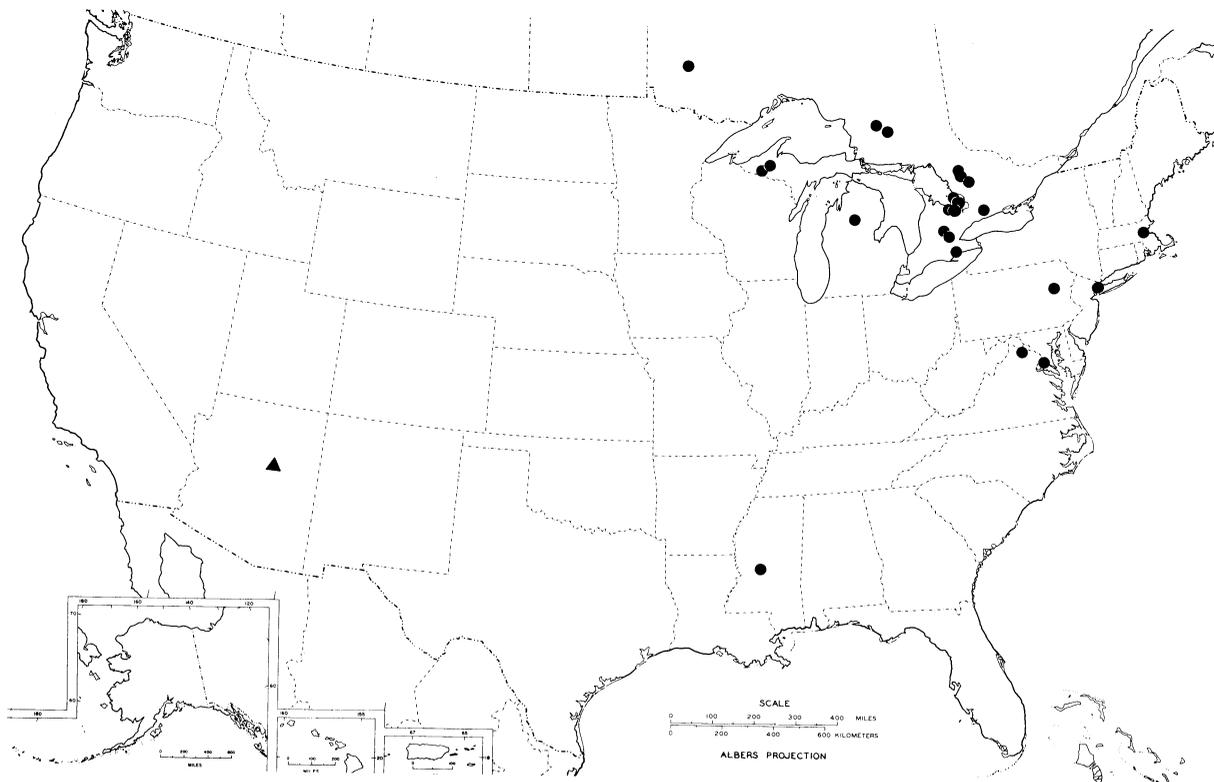
Hosts.—*Pinus resinosa*, *P. banksiana*, and *P. sylvestris* in the North (Martin 1960).

Rhyacionia jenningsi Powell, New Species

(Figures 19, 20, 49, 73; Map 7)

A western species resembling *adana* and *zozana*, with the base of the forewing bluish, distal one-third orange and reddish.

Male.—Length of forewing 7.5 to 8.5 mm (18 n). *Head*: Labial palpus moderately long, II segment length 1.0 eye diameter; III segment 0.4 as long as II; scaling broadly spreading, hoary gray, the scales dark, tipped with white. Antennal ciliation slightly more than 0.5 segment width. Scaling of front and crown hoary gray, slightly to broadly tinged with reddish posteriorly. *Thorax*: Dorsal scaling entirely hoary gray to slightly tinged with reddish orange anteriorly. Venter and legs paler gray, the scales white-tipped. *Forewing*: Length 3.2 to 3.3 times width; costa evenly curved, termen strongly angled back. Ground color dark gray on basal half, in cell and beyond in costal area, crossed by whitish transverse striae; apex, terminal area beyond cell and tornal area from well before end of cell pale orange, becoming dark red at margins. Fringe dark gray, sometimes with basal scale row dark reddish. Underside dark gray, some



Map 7.—Distribution records for *Rhyacionia adana* (circles) and *R. jenningsi* (triangle).

whitish marks along costa. *Hindwing*: Slightly broader than forewing; apex bluntly rounded, termen slightly concave, tornal angle distinct. Ground color dark gray, slightly darker toward margins. Fringe slightly paler. Under-side pale gray, the veins darker. *Abdomen*: Scaling dark gray, genital scaling paler. Genitalia (figs. 19, 20, drawn from paratypes, JAP prep. 2671, 3640; 4 n) similar to *adana* (fig. 18), the pollex usually slightly broader, aedeagus stouter, abruptly narrowed at the slender, curved tip in *jenningsi*; cornuti three, elongate.

Female.—Length of forewing 6.4 to 7.8 mm (20 n). Essentially as described for male, but eye slightly smaller, labial palpus length 1.0 to 1.2 eye diameter. Genitalia (fig. 49, drawn from paratype, JAP prep. 3745; 4 n) similar to *adana*, the sterigma plate, especially bordering the ostium, distinctly defined, shape variable but relatively shorter (length 0.45 to 0.55 width in *jenningsi*, 0.55 to 0.65 in *adana*); with anterior margin excavated laterally, less triangular than in *adana*; base of ductus bursae more heavily, broadly sclerotized in *jenningsi*; signa variable, one small, one large, slender.

Holotype male and allotype female: Arizona, Chelvon Ranger District, Sitgreaves National Forest, Coconino Co., reared from *Pinus ponderosa*, April 2 and 8, 1969, Hopkins U.S. 37276 (D. T. Jennings) (NMNH). Paratypes (36), all with the same data except as follows: 8♂, 3♀, Hopk. U.S. 37257, 37274, III-28-31-69; 2♂, 14♀, Hopk. U.S. 37276, III-31 to IV-17-69; 6♂, 2♀, Hopk. U.S. 37322, III-26 to IV-7-70; 1♂ Hopk. U.S. 37323 IV-22-70 (NMNH, UCB, USFS-NC, USFS-PS, and USFS-RMA). The emergence dates may not reflect the true flight period.

This species is closely related to *adana*. In addition to distinguishing features in the genitalia, the new species has longer ciliation on the antennae in the male (setae length slightly more than 0.5 the segment diameter, 0.3 in *adana*). The above diagnosis of females is based on specimens of *adana* from Ontario and Michigan. It should be reassessed when specimens become available from areas near the type locality of *adana* (Massachusetts). *Pinus ponderosa* is the only known host for *jenningsi*, while *adana* has been recorded on pines of other subsections, *P. resinosa* and *P. banksiana*.

We saw worn specimens from one locality in the geographical gap between *adana* and *jenningsi*, the man made forest near Halsey, Nebr. (Pool 1953). These were collected in 1927 and 1928, and some were reared and bear two host labels each, *P. ponderosa* and *P. banksiana*. The condition of these specimens prevents definite identification, but they have *jenningsi* antennal and aedeagus characteristics. Whether a long-distance introduction occurred is unknown. It may have been a temporary establishment because we have no evi-

dence of collection records there in the subsequent half century.

The Arizona specimens originated from an area that burned in 1956 west of Chevelon Canyon, 72 km SW of Winslow. In places that did not regenerate naturally, plantings of ponderosa pine were colonized by *Rhyacionia* (Jennings 1975).

The species is named for Daniel T. Jennings who conducted biological studies on *Rhyacionia* in the Southwest and supplied material for our study.

GROUP 6: *BUSCKANA*, *BLANCHARDI*

Male larger than female. Antennal ciliation of ♂ long, two times segment diameter. Labial palpus normal, II = 1.0 eye diameter. Male genitalia: sacculus extension and pollex well developed, aedeagus stout with terminal spur and apical dentation, two to eight cornuti, short. Female genitalia: sterigma a convex ring with convoluted folds, ductus bursae with basal sleeve; signa tiny.

Rhyacionia busckana Heinrich

(Figures 21, 22, 23, 50, 74; Map 8)

Rhyacionia busckana Heinrich (1923:17).

Like several other *Rhyacionia*, the basal three-fourths of the forewing has light and dark alternating grayish crossbands. One conspicuous distinguishing feature is the elongate antennal ciliation of the male. Individual setae are about twice segment width, proportionately much greater than in all other Nearctic *Rhyacionia* except *blanchardi*. Otherwise the moth is similar in appearance to *adana*, *jenningsi*, and *zozana*, though there are marked genitalic differences. Adults of *busckana* are medium sized: forewing length in males 5.5 to 9.5 mm (25 n); females, 4.5 to 9.0 mm (28 n). Male genitalia (figs. 21, 22, 23): valva shape variable depending on orientation, pollex broad; vesica with two to eight cornuti (13 n). Female genitalia (fig. 50): sterigma ringlike with posterior convolutions, ductus bursae enlarged distally (26 n). Larvae have been differentiated from three other *Rhyacionia* (Lindquist 1962).

Type data.—Bellmore, Long Island, N. Y., IV. 1913. Holotype male 24785 in NMNH.

Geographic distribution.—(Map 8) The most widely distributed North American *Rhyacionia*. It occurs from Maine south to Florida and west to British Columbia, Oregon, Colorado, and Texas. Records west of a line between Manitoba and Texas are based on seven specimens. *R. busckana* ranges to 55° N. lat. at Walker Lake, Manitoba (not mapped).

Flight period.—March to June; also taken in flight in November in Levy Co., Fla. (Heppner 1975).

Hosts.—*Pinus banksiana* in Ontario (Lindquist 1961). Specimens from Ontario were reared from *P. resinosa* and *P. sylvestris* (CFS-GL). Specimens from British Columbia were reared from *P. ponderosa* (CFS-P).

Discussion.—The seven western specimens mentioned above are larger than eastern ones. With more specimens and biological information additional taxa might have to be recognized. One of the western specimens is the basis of an early erroneous record of the European *Rhyacionia* (*Retinia*) *duplana* (Hbn.) in North America (Walsingham 1879:77). The specimen is Walsingham 91964 (NMNH) collected in Grant Co., Oreg., during the 1871 to 1872 expedition (Essig 1941) and labeled by Walsingham as a voucher for the published record.

Rhyacionia blanchardi Miller, New Species

(Figures 24, 51, 75; Map 8)

A small moth with forewing pattern similar to *busckana* and several others.

Male.—Length of forewing 5.5 mm (1 n).

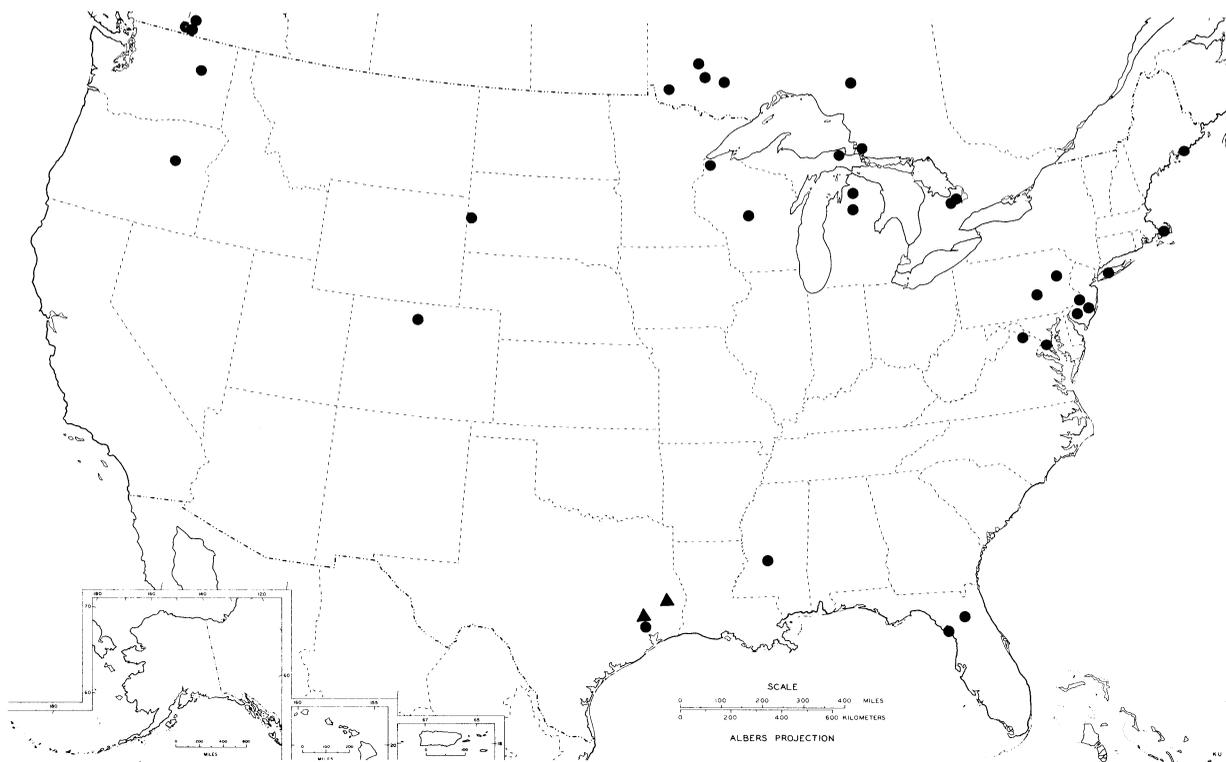
Head: Antennal setae twice as long as the width of antennal segments. Labial palpus short, length of II segment 0.9 eye diameter, III 0.4 as long as II and nearly obscured by scaling of II; white interiorly, pale grayish brown exteriorly. Scaling of front and crown pale grayish brown, the scales white-tipped. **Thorax:** Dorsal scaling similar to head. Venter shining whitish, metathoracic legs whitish, pro- and mesothoracic legs pale grayish brown exteriorly, tarsi white banded. **Forewing:** Narrow, length 2.8 times width; apex acute, termen strongly angled back. Ground color of basal third grayish brown crossed by irregular whitish striae; apical two-thirds reddish orange crossed by several irregular, pale shining blotchlike fasciae. Middle third between cell and costa dark bluish. Fringe gray with basal scale row dark red. Underside dark gray, several white marks along costa. **Hindwing:** Slightly wider than forewing; apex round, termen slightly convex, broadly curved to dorsum, tornal angle not discernible. Ground color brownish gray. Fringe pale gray. Underside brownish gray. **Abdomen:** Dorsal scaling shining dark gray, venter pale, genital scaling whitish. Genitalia (fig. 24, drawn from JAP

prep. 3627; 2 n): Pollex curved interiorly, neck of valva deeply excavated interiorly, aedeagus with about 12 short or rudimentary spurs; vesica with 2 to 3 cornuti; posterior margin of uncus oval in outline.

Female.—Length of forewing 5.5 to 6.5 mm (7 n). Essentially as described for male but more vividly colored. Forewing slightly broader, length 2.9 to 3.0 times width. Genitalia (fig. 51, drawn from JAP prep. 3628; 5 n): sterigma a broad plate encircling ostium and with a central posterior lobe, tiny dual signa.

Holotype male and allotype female: Texas, Conroe, Montgomery Co., March 10, 1968, genitalia slide WEM 1219733; and March 9, 1971, genitalia slide WEM 1219732, respectively (A. and M. E. Blanchard) (NMNH). Eight paratypes as follows: 1♂, 1♀ same data as holotype, genitalia slides JAP 3627, 3628; 1♀, same data as holotype except March 13, 1969, genitalia slide WEM 125743; 4♀♀, same data as allotype, genitalia slide WEM 125744; 1♀, Town Bluff (Dam B), Jasper Co., Tex., March 11, 1966, genitalia slide JAP 3631 (Blanchard, NMNH, and UCB).

This species most resembles *busckana* in wing shape, color pattern, and genitalia of both



Map 8.—Distribution records for *Rhyacionia busckana* (circles) and *R. blanchardi* (triangles). The northernmost record for *busckana*, at Walker Lake, 55° N., is near the geographic center of Manitoba, beyond the limits of this map.

sexes. In genitalia males differ by their oval posterior margin of uncus; females differ by their broader sterigma.

This species is named in honor of the lepidopterist André Blanchard who collected the types as well as many other *Rhyacionia*.

GROUP 7: *FUMOSANA*

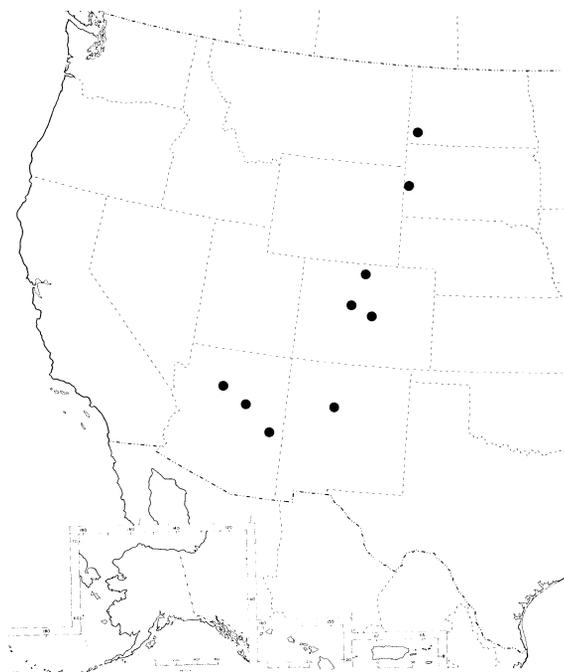
Male larger than female. Antennal ciliation of ♂ short. Labial palpus normal, II=1.1 eye diameter. Male genitalia: sacculus extension weakly developed, pollex distinct; aedeagus moderately elongate with terminal spur and extensive dorsal dentation; six to eight cornuti, short. Female genitalia: sterigma complex with posterior lobe, ductus bursae weakly sclerotized at base; signa tiny to a trace.

Rhyacionia fumosana Powell, New Species

(Figures 25, 26, 27, 52, 76; Map 9)

A large, narrow-winged species like *neomexicana*, the forewing pattern obscured by smoky infuscation, usually with dull orange in the terminal area.

Male.—Length of forewing 9.4 to 11.0 mm (12 n). *Head*: Labial palpus II segment length 1.1 eye diameter, III 0.3 as long as II; scaling moderately spreading, hoary gray, the scales white-tipped. Scaling of head and crown dark to light hoary gray. *Thorax*: Dorsal scaling hoary gray, the scales more broadly white distally on tegulae and on scutellar area. Underside grayish white; legs dark gray exteriorly. *Forewing*: Moderately narrow, length 3.3 to 3.5 times width; costa nearly straight, termen strongly angled back, tornal angle not distinct. Ground color dark gray from base to beyond cell, becoming dull orange brown in terminal area, the pattern completely obscured by smoky infuscation to moderately distinct with numerous transverse whitish striae in middle third of wing, giving a bluish-gray appearance to basal two-thirds. Fringe gray with a whitish basal scale row. Underside gray, paler distally. *Hindwing*: 1.2 wider than forewing; apex broadly rounded; termen slightly concave. Ground color smoky gray, margins and fringe darker. Underside pale gray, the veins slightly darker. *Abdomen*: Scaling entirely gray. Genitalia (figs. 25, 26, 27, drawn from paratypes, JAP prep. 3564 Arizona, 3621 Colorado and WEM prep. IV-21-71 North Dakota; 16 n) simi-



Map 9.—Distribution records for *Rhyacionia fumosana*.

lar to *neomexicana*, the pollex outwardly recurved distally, inner margin of sacculus with 3 or 4 flaplike projections forming an irregular ridge; dorsal surface of aedeagus particularly at sides with many fine spurlike teeth; vesica with six to eight cornuti.

Female.—Length of forewing 7.9 to 9.8 mm (9 n). Essentially as described for male but labial palpus more elongate, II segment length 1.4 eye diameter; and forewing broader, length 3.1 to 3.2 times width. Genitalia (fig. 52, drawn from paratype, JAP prep. 3599; 9 n): sterigma a broad convex plate, produced posteriorly into an irregular or notched lobe; one signum very small, the other absent or a speck.

Holotype male and allotype female, Colorado, Rock Creek Canyon [Colorado Springs], El Paso Co., May 2, 1959, and April 20, 1960 (Margot May) (NMNH). Paratypes (19) as follows. South Dakota: Hardy W. C. (T3N, R1E S30) [29 airline km SW Lead, Lawrence

Co.], 3♂ VI-18-65 (R. W. Hodges). Colorado: same data as holotype, 1♀ V-20/VI-7-57; 1♂, 2♀ V-13/15-59; 3♂, 4♀ IV-19/26-60; 1♀ V-12-62. Arizona: Apache Co., Greer, 1♂ VI-11-36 (G. H. and J. L. Sperry). Coconino Co., Chevelon Ranger Distr., Sitgreaves Natl. Forest, 2♂ IV-12-71 (netted at night) (D. T. Jennings); Fort Valley, elev. 2,240 m, 12 km NW Flagstaff, 1♂ VI-19-61 (R. W. Hodges) (AMNH, Kimball, NMNH, USFS-RMA, and UCB).

Additional specimens subsequently examined: North Dakota, Sec. 11, T. 136 R. 102, Slope Co., 1♂, 2♀ VII-9-70 "collected from *Pinus ponderosa*" (Hopk. U.S. 54060-G, with pupal shells) (A. D. Tagestad); same locality, 1♂ VII-20-72 (Hopk. U.S. 56507-L) (M. E. McKnight); same locality, 18♂, 7♀ V-15-73 "collected from *Pinus ponderosa*" (McKnight and Tagestad); same data, 1♂ VI-7-73 (Hopk. U.S. 54176). Colorado, Blue Mtn. Cyn., Pike Natl. For., Park Co., 2,438 m, 2♂ VI-9-73 light trap (R. E. Stanford); Rist Cyn., Bellvue, Larimer Co., 1♂, IV-21-71 "ponderosa pine stand" (J. Bodenham); 16 km NW Ft. Collins, Larimer Co., 7♂ V-1973 "light" (J. Bodenham). New Mexico, Fenton Lake, Jemez Mts., Sandoval Co., 1♀ V-2-74 at U.V. light (M. E. Toliver) (NMNH and USFS-RMFC).

The variation is in part geographical, there being a decrease in melanistic coloration from

north to southwest. About half the individuals from North Dakota and those from South Dakota have smoky blackish forewings, while the rest of the North Dakota series, most of the Colorado specimens, and eastern Arizona examples are intermediate, with a dull orange-brown termen and variable development of the whitish transverse striae. The moths from Coconino County, Ariz., exhibit the most distinct color pattern, with little smoky infuscation.

Rhyacionia fumosana resembles *neomexicana* in size, wing shape, and sexual dimorphism in size, though the last is more pronounced in *neomexicana*. The male genitalia are closest to *neomexicana*, differing by the recurved pollex, ridged sacculus, and dentate dorsal surface of the aedeagus. The female genitalia of *fumosana* are markedly different from *neomexicana*, with a larger, more convex, posteriorly produced sterigma, less sclerotization in the ductus and a small single signum. The signa in *neomexicana* are double and large.

The two species have been collected sympatrically in Slope County, N. Dak., at Chevelon Ranger District, Ariz., and at Rock Creek Canyon, Colo., and adults of the two were taken on the same nights in April and May.

GROUP 8: *FRUSTRANA* TO *AKTITA*

Female larger than male. Antennal ciliation of ♂ minute to short. Labial palpus normal, II = 0.8 to 1.0 eye diameter. Male genitalia: sacculus projection well developed, pollex elongate; aedeagus stout with terminal spur; cornuti absent. Female genitalia: sterigma a simple ring, sometimes broadened laterally; ductus bursae without sclerotized structures; signa tiny.

Rhyacionia frustrana (Comstock)

(Figures 28, 29, 53, 77; Map 10)

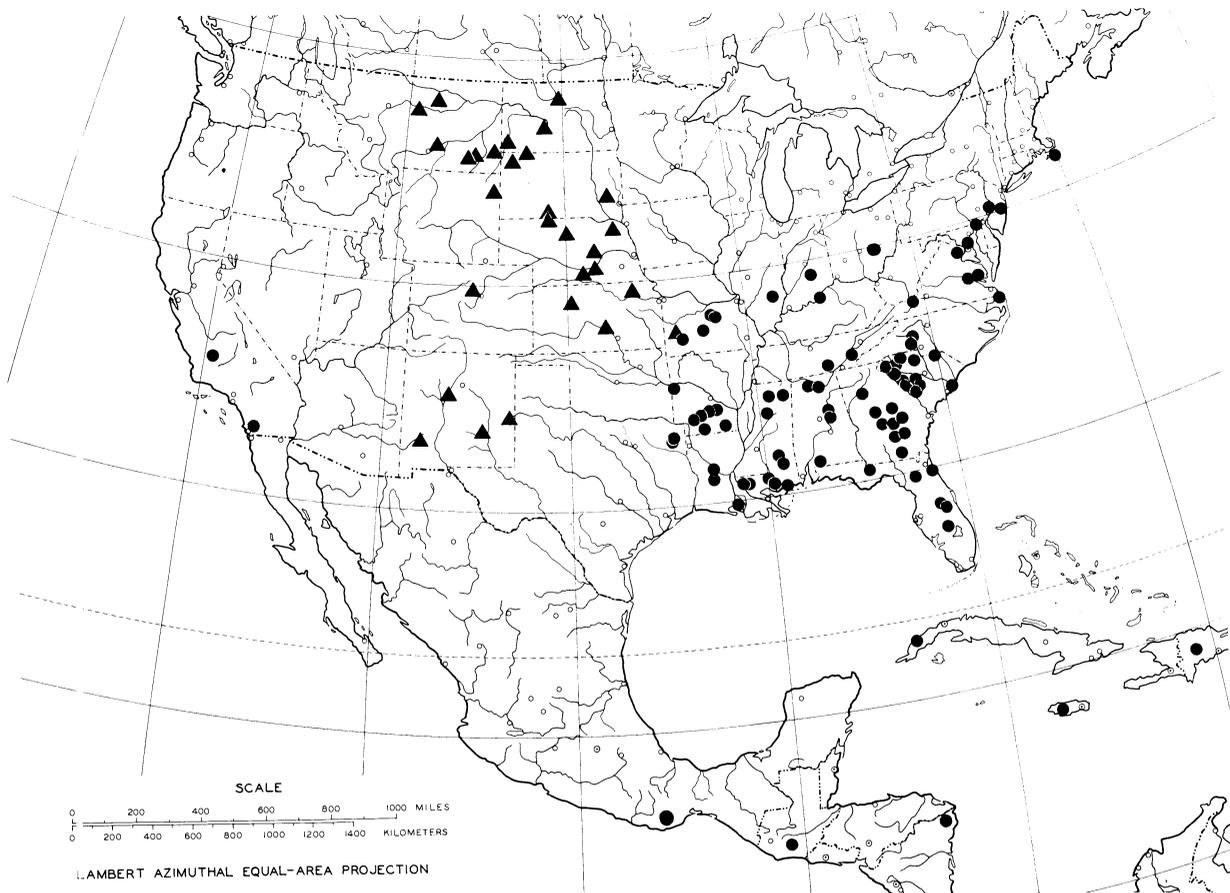
Retinia frustrana Comstock (1880:236).

Rhyacionia frustrana; Heinrich (1923:20);
Miller (1965:58; 1967b:591)

Rhyacionia pseudostrobana Amsel (1962:396)

Rhyacionia schwerdtfegeri Miller (1967b:594),
nomen nudum.

Like several other *Rhyacionia*, the moth has mottled rusty red forewing markings and a dark basal patch bordered by a lighter crossband that is narrower than the basal patch. Adults can be reliably distinguished from *sonia* and *aktita* by genital characters and from *bushnelli* only by nonstructural means as discussed below. The moth is the smallest North American member of the genus: forewing length in males 4.0 to 7.0 mm (103 n); females, 4.0 to 7.5 mm (108 n). Male genitalia (figs. 28, 29, drawn from CDW prep. 410, 411; 17 n): valva with a moderately pronounced emargination preceding cucullus, deaccentuating the sacculus projection; pollex slender, variable in



Map 10.—Distribution records for *Rhyacionia frustrana* (circles) and *R. bushnelli* (triangles).

shape; aedeagus stout with a rectangulate, preapical thickened area. Female genitalia (fig. 53, drawn from JAP prep. 3716; 25 n): sterigma ringlike, poorly defined posteriorly; signa tiny or reduced to a speck. Larvae have been differentiated from other *Rhyacionia* by MacKay (1959) and Miller and Wilson (1964) and pupae by Yates (1967) and Dickerson and Kearby (1972).

Type data.—Virginia (near Washington, D.C.). Lectotype female in NMNH designated and illustrated by Miller (1967b).

Geographic distribution.—(Map 10) The second most widely distributed native North American member of the genus, *R. frustrana* occurs from Massachusetts south to Florida, Dominican Republic (Etheridge 1971), Cuba (Hochmut 1972) and Jamaica, west to Missouri, Oklahoma, Texas, Oaxaca State, Mexico, Guatemala (Schwerdtfeger 1962), Honduras, and Nicaragua (Becker 1973). The species was discovered in San Diego and Kern Counties,

Calif., where it appears to be recently introduced from Eastern U.S. (Brown and Eads 1975).

Flight period.—From two to six generations per year are known in the U.S. (Yates 1960, Berisford 1974b). Voltinism is probably greater in parts of the Caribbean area; Hochmut (1972) found larvae and pupae every month of the year in Cuba. Schwerdtfeger (1962) postulated four generations per year in Guatemala at an elevation of 1,500 m.

Hosts.—Many species of subgenus *Pinus* (Yates and Beal 1971, and others) (table 1).

Discussion.—This is the well known Nan-tucket pine tip moth. Daviault's (1932) reference to *R. frustrana* in Quebec was in error and actually pertained to *Eucosma gloriola* Heinrich (Daviault 1942).

Differentiation of *frustrana* from *bushnelli* rests on size (fig. 2), geographic distribution, and place of hibernation. Overwintering *frustrana* have been found on the host tree rather

than on the ground (Miller 1967b, Brown and Eads 1975). Further discussion of differentiation appears under *bushnelli*.

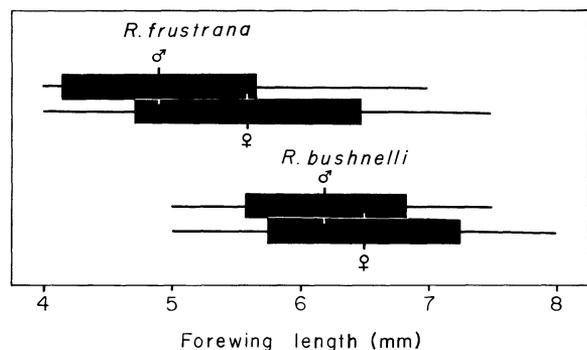


Figure 2.—Forewing lengths of male and female *Rhyacionia frustrana* and *R. bushnelli*. Short vertical lines indicate means, horizontal bars one standard deviation, and horizontal lines total range. Based on 102 to 118 measurements per sex per species, made to nearest 0.5 mm.

Rhyacionia bushnelli (Busck)

(Figure 78, Map 10)

Evetria bushnelli Busck (1914:144).

Rhyacionia frustrana bushnelli; Heinrich (1923:20).

Rhyacionia bushnelli; Miller (1967b:593).

Like several other *Rhyacionia*, this moth has mottled rusty red forewings and a dark basal patch bordered by a lighter crossband that is narrower than the basal patch. Adults can be reliably distinguished from *sonia* and *aktita* by genital characters but from *frustrana* only by nonstructural means. The moths are moderate sized: forewing length in males 5.0 to 7.5 mm (118 n); females, 5.0 to 8.0 mm (102 n). Male and female genitalia as in *frustrana* (40 n and 41 n, respectively).

Type data.—Fort Bayard, N. M. Holotype female 18439 in NMNH.

Geographic distribution.—(Map 10) Montana and North Dakota south to New Mexico, Kansas, and Missouri (Miller 1967b, McKnight 1973).

Flight period.—One or more generations develop per year depending on latitude (McKnight 1973). Where two annual generations occur, moths fly during May and from June to late July (Swenk 1927).

Hosts.—*Pinus ponderosa* var. *scopulorum* and other members of the subgenus *Pinus* (Graham and Baumhofer 1930) (table 1).

Discussion.—Separation of *bushnelli* and *frustrana* rests on size (fig. 2), geographic distribution, and place of overwintering (Miller 1967b). *R. bushnelli* occurs in a region where the large-budded *Pinus ponderosa* var. *scopulorum* predominates. Heinrich (1923) believed the larger size of *bushnelli* to be host induced. Size integrity of the two forms remains to be examined in a manner that rules out host as an accountable variable. Information that *bushnelli* overwinters on the ground is due to Swenk (1927) whose studies should be repeated elsewhere to clarify whether place of overwintering is fixed or variable relative to latitude and other factors.

Rhyacionia sonia Miller

(Figures 30, 31, 54, 79; Map 11)

Rhyacionia sonia Miller (1967b:592).

The moth is similar in forewing color and pattern to *aktita*, *frustrana*, and *bushnelli*. It can be separated reliably only on genital characters. The moth is small: forewing length in males 4.5 to 6.5 mm (17 n); females, 4.5 to 6.0 mm (20 n). Male genitalia (figs. 30, 31, drawn from prep. CDW 271 and WEM 307732; 11 n): valva with a deep emargination preceding cucullus, sacculus with a broad flange and small terminal extension, pollex irregular in shape; aedeagus stout with a long apical spur. Female genitalia (fig. 54, drawn from prep. CDW 273; 15 n): sterigma a broad ring, widened laterally; signa as in *aktita* (fig. 55). The larvae have been differentiated from three other *Rhyacionia* (Lindquist 1962).

Type data.—Burwash, Ontario, Canada, reared from *Pinus banksiana*, 1959; holotype female in CNC.

Geographic distribution.—(Map 11) Ontario, Manitoba (Miller 1967b), and Upper Michigan.

Flight period.—April and May.

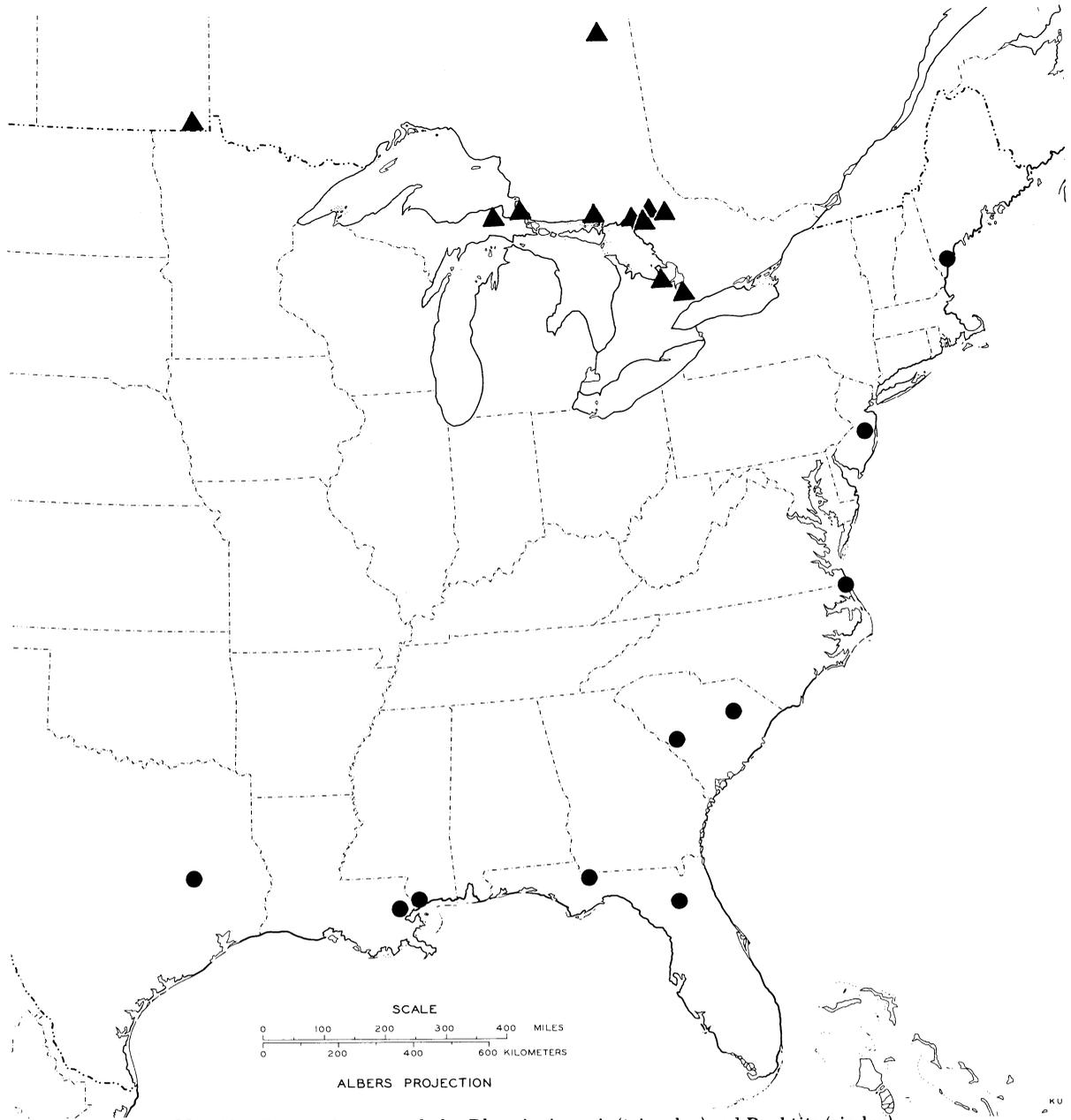
Hosts.—*Pinus banksiana* (Sippell and Lindquist 1961, McDowell and Wong 1962).

Discussion.—Re-examination of specimens identified as *sonia* from Maine (Miller 1967b) and South Carolina (Fox and Harris 1969) shows they are *aktita*.

Rhyacionia aktita Miller, New Species

(Figures 32, 33, 55, 80; Map 11)

Rhyacionia sonia Miller (1967b:592) (part); Fox and Harris (1969).



Map 11.—Distribution records for *Rhyacionia sonia* (triangles) and *R. aktita* (circles).

A small moth with *sonia*-like forewing pattern, color, and genitalia.

Male.—Length of forewing 4.0 to 7.0 mm (18 n). *Head*: Labial palpus short, II segment length 0.9 eye diameter, III 0.3 as long as II; scaling spreading, partly obscuring III segment; scaling of palpus, front and crown gray with white tips. *Thorax*: Dorsal scaling darker than head, white tipped. Venter shining white; legs gray with white bands exteriorly sometimes sprinkled with rust; metathoracic legs much paler. *Forewing*: Narrow, length 3.0 to 3.3 times width; apex acute, termen strongly

angled back, tornal angle distinct. Basal quarter gray, forming a faint basal patch. Four or five blotchlike irregular orange to rust bands from a few to many scales wide partly or entirely crossing wing. Basal patch and cross-band just beyond middle sometimes appearing bluish to the unaided eye. Costa with 8 to 10 white marks, usually arranged in pairs. Apex, including fringe, heavily dusted with brick-red scales. Fringe, except near apex, dark gray with a black line extending around termen. Underside gray except for a sprinkling of brick-red scales near costa. *Hindwing*: Slightly

broader than forewing; apex round, termen slightly concave, ternal angle discernible. Ground color pale grayish brown. Fringe paler, nearly white. Underside light gray. *Abdomen*: Dorsal scaling shining light gray, venter paler. Genitalia (figs. 32, 33, drawn from paratypes New Jersey, WEM prep. 118731, 287733; 11 n): valva constricted before cucullus; caudal margin of cucullus sculptured interiorly to form a broadly pointed process; pollex longer than cucullus, spatulate; aedeagus terminating in a fingerlike spur.

Female.—Length of forewing 5.0 to 6.0 mm (17 n). Essentially as described for male. Genitalia (fig. 55, drawn from paratypes North Carolina, WEM prep. 29673c, d; 9 n): ostium at center of sterigma, sterigma depressed caudally around ostium, flattened laterally; small dual thornlike signa.

Holotype male: New Jersey, Lakehurst, 5 May 1962 (R. W. Hodges) genitalia slide WEM 277734; allotype female: North Carolina, Currituck Co., Knotts Is., July 8, 1962 (D. R. Davis) genitalia slide WEM 118732 (NMNH).

Thirteen paratypes as follows: same data as holotype, 2♂, slides WEM 118731 and 287733 (UCB, NMNH); 4♂ same data except May 4 to 6, 1962, slides WEM 88732, 88733, 72742, and 72743; North Carolina, 1♂ and 2♀, same

data as allotype, slides WEM 29673a, c, and 125742 (UCB, NMNH); Maine, 1♂, 2♀, Pine Point, March 1963 (C. A. Millet) genitalia slides JTE 49, 50, and WEM 28743; Texas, 1♂, Montgomery Co., Conroe, 9.III.71 (A. and M. E. Blanchard) slide JAP 3630 (Blanchard).

This species is similar to *sonia* from which it differs in genital characters such as narrower valva with less extensive basal opening, interior process on cucullus, more curved apical spur on aedeagus, and small details of sterigma. It overwinters in shoots (Fox and Harris 1969) whereas *sonia* overwinters on the ground (Sippell and Lindquist 1961).

Previously published records for *sonia* in Maine (Miller 1967b) and South Carolina (Fox and Harris 1969) apply to *aktita*. The confusion of the two species arose from their close similarity coupled with previously limited localities and numbers of *aktita* specimens.

Rhyacionia aktita is coastal in distribution; it is allopatric to *sonia* which occurs inland in the North. Label data suggest two generations of *aktita* per year, at least in the South. Adults have been reared from pupae overwintering in terminals of *Pinus rigida* (Miller 1967b), *P. taeda* and *P. elliotii* var. *elliotii* (Fox and Harris 1969). Adults were found in the same capture series with *frustrana* and *blanchardi*.

GROUP 9: *SUBCERVINANA*, *PALLIFASCIATA*

Female larger than male. Antennal ciliation of ♂ moderately long. Labial palpus normal, II = 0.8 to 1.0 eye diameter. Male genitalia: without sacculus projections, pollex variable; aedeagus moderately elongate with terminal spur; one to two cornuti, elongate. Female genitalia: sterigma funnel-like with enclosed narrow fold; ductus bursae with small sclerotized spot or unmodified; signa small.

Rhyacionia subcervinana (Walsingham)

(Figures 34, 56, 81; Map 12)

Retinia subcervinana Walsingham (1879:25).

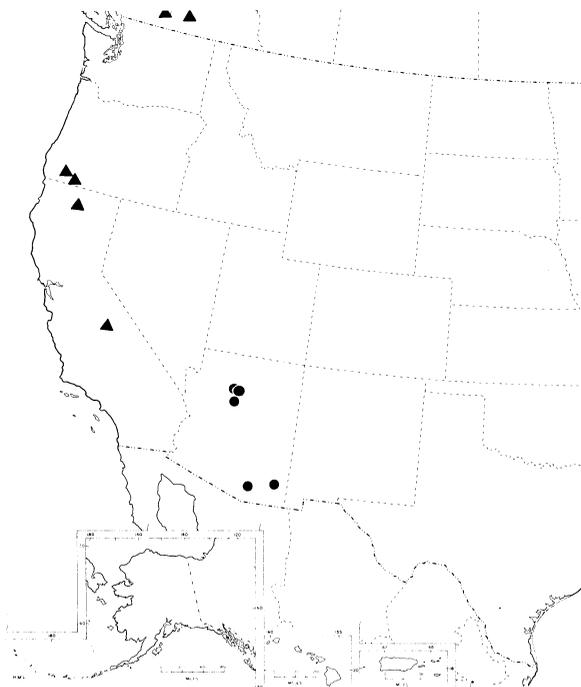
Evetria subcervinana; Fernald (1903:449).

Rhyacionia subcervinana; Heinrich (1923:21).

This is a small Pacific Coast species with pale forewings and dark hindwings. The forewing has transverse bands of lead-colored scales that are lost on some specimens, leaving

whitish bands alternating with pale rust-tan ones. As the species has been known only from the original description based on worn females, it is redescribed as follows:

Male.—Length of forewing 5.4 to 7.0 mm (9 n). *Head*: Labial palpus short, II segment length 0.8 to 0.9 eye diameter, III 0.4 as long as II; scaling moderately spreading, pale ochreous to whitish with a few brown scales on outer side. Scaling of front pale ochreous to whitish, crown posteriorly darker, dark ochreous to brown. *Thorax*: Dorsal scaling concolorous with posterior of crown. Venter shining whitish, legs brownish exteriorly. *Forewing*: Moderately narrow, length 3.5 to 3.6 times width; costa nearly straight, apex acute, termen strongly angled back, ternal angle not distinguished. Ground color pale rust brownish, or ochreous tan, crossed by about five evenly spaced broad, transverse bands of



Map 12.—Distribution records for *Rhyacionia subceruinana* (triangles) and *R. pallifasciata* (circles).

metallic lead-colored scales, darker, brownish at costa; distal two bands irregular, less defined and broken. Fringe shining gray. Underside uniform brownish gray, base of fringe with a pale line. *Hindwing*: Narrow, apex acute, termen strongly angled back and slightly convex. Ground color dark brownish gray; fringe paler gray. Underside as on forewing. *Abdomen*: Dorsal scaling brownish gray, ventral and genital scaling paler. Genitalia (fig. 34, drawn from plesiotype, Sequoia Natl. For., Calif., JAP prep. 3612; 3 n): valva broad with moderately deep emargination preceding cucullus, pollex moderately elongate with a spurlike expansion on inner side; aedeagus with fine dentation near apex; vesica with one elongate cornutus.

Female.—Length of forewing 5.7 to 6.4 mm (3 n). Essentially as described for male, but with metallic scaling of transverse bands on forewing less developed, reduced to shining whitish bands, with or without scattered lead-colored scales, brownish at costa. Genitalia (fig. 56, drawn from plesiotype, Rogue River Natl. For., Oreg., JAP prep. 3604; 4 n): sterigma with enclosed sclerotized fold, subtended by slight enlargement and sclerotization of ductus bursae basally; signa tiny.

Type data.—Oregon, “Rogue River, June 1872.” The lectotype female (BMNH) by present designation bears the data “Rogue R., Josephine Co., Oreg., 7.V.1872 Wlsm. 91965,” a label probably written after 1900 by Durrant, based on the Carrier diary of Walsingham’s expedition (Essig 1941) (BM slide 11787).

Geographic distribution.—(Map 12) Southern British Columbia to southern Sierra Nevada in California. In addition to the type, the following specimens were examined: Canada, British Columbia, Vernon, 6♂, 1♀ VI-5-12-61 r.f. *P. ponderosa* (61-5101-01 FIS); Lytton, 1♀ VI-6-72 “*P. ponderosa*” (72-289-07 FIS). Oregon, Rogue River Natl. For., 3 km. N Bull Gap, Jackson Co., 1♀ VII-3-70 (R. E. Dietz and P. A. Rude). California, Ash Cr. Rgr. Sta., 15 km. E. McCloud, Siskiyou Co., 1♂ VI-11-74 at light (Chemsak and Powell); Grant Grove, Sequoia Natl. Park, 4♂, 1♀ IV-28-59 (pupae) r.f. *P. jeffreyi* (Hopk. U.S. 37575 A) (R. C. Hall) (CNC, UCB, USFS-PS).

Flight period.—Early June to early July based on field-collected adults (2 n).

Hosts.—*Pinus jeffreyi* in California, *P. ponderosa* northward. Specimens reared from *jeffreyi* were recorded as having been collected as pupae in “needle sheath mines,” and British Columbia specimens are pinned with bases of needle bundles where larvae pupated.

Discussion.—The type specimen is worn. Our identification with recent material is based on examination of the type by Miller, a Kodochrome photo in the Obratzsov file at AMNH, and the type genitalia slide (BMNH 11787). The slide preparation is distorted and overly cleared, but diagnostic features appear to match recent slides from British Columbia, Oregon, and California. The type lacks all metallic scaling on the forewing (as does our single Oregon example) and has more rust-tan ground color bands than our specimens, which are ochreous tan in Oregon, brownish tan in California. The reduction of metallic scaling may be due to age.

The precise type locality and date of collection are unknown. The only known account of the Oregon part of the expedition (Essig 1941) is a copy at the British Museum made by Durrant in 1902, and this corroborates the May 7, 1872, label data on the type but the “Rogue” spelling is repeated. Presuming “Rogue” to be a misspelling of Rogue by Carrier, Walsing-

ham, and Durrant (there is no Rouge River in southern Oregon or Northern California), it may be assumed that the type locality was near Grants Pass, Josephine County, according to the itinerary. If the original June date is correct, then the locality may have been further south, in the area of the present Rogue River National Forest in Jackson County where the Walsingham party spent the first 2 weeks of June 1872.

***Rhyacionia pallifasciata* Powell, New Species**

(Figures 35, 57, 82; Map 12)

Small moths with narrow forewings transversely banded with pale rust tan and whitish.

Male.—Length of forewing 5.9 to 8.3 mm (24 n). *Head*: Labial palpus short, II segment 0.8 to 1.0 eye diameter, III 0.3 as long as II; scaling loosely spreading, whitish, tinged with pale brownish exteriorly. Scaling of upper front and crown spreading, roughened, pale brownish tipped with white. *Thorax*: Dorsal scaling as on head, ventral shining whitish, legs brownish. *Forewing*: Narrow, length 4.0 to 4.4 times width; costa nearly straight, termen strongly angled back, tornal angle not evident. Ground color shining pale whitish with about six pale rust-tan transverse bands, more or less evenly spaced, the two nearest base narrower, the two beyond middle somewhat broken and irregular; each brown at costa, giving a more distinctly banded appearance to costal area; the pale intervening bands of ground color overlaid with brownish, which is mostly lost in older specimens. Fringe whitish, the scales tipped with brownish. Underside pale brownish, darker on veins; fringe as above. *Hindwing*: Narrow, only slightly broader than forewing; apex acute, almost lanceolate, termen strongly angled back, slightly concave. Dorsal scaling pale brown, darker at distal margin. Fringe whitish. *Abdomen*: Dorsal scaling pale brown, ventral whitish. Genitalia (fig 35, drawn from paratype, Rustler Park, JAP prep. 3571; 4 n): valva with slight emargination before cucullus, pollex broad, short with a secondary extension on inner side; aedeagus with fine dentation near apex, vesica with two elongate cornuti.

Female.—Length of forewing 5.7 to 7.4 mm (7 n). Essentially as described for male except labial palpus more variable in size, II segment length 0.7 to 1.1 eye diameter; forewing broader, length 3.7 to 4.0 times width. Genitalia (fig. 57, drawn from paratype, Fort Valley, JAP prep. 3570; 2 n): sterigma with subtending sclerotized folds, ductus bursae sclerotized at base with weak enlargement; signa small, spinelike.

Holotype male and allotype female, Arizona, Fort Valley, 2,240 m elev., 12 km northwest of Flagstaff, Coconino Co., July 10 and 20, 1961 (R. W. Hodges) (NMNH). Paratypes (29) all Arizona, as follows: same data as holotype, 20♂ VII-10-19-61, 2♀ VII-23-61; Hart Prairie, elev. 2,590 m, 16 km NNW of Flagstaff, Coconino Co., 1♀ VII-12-61 (R. W. Hodges); West Fork, elev. 1,980 m, 26 km SW of Flagstaff, Coconino Co., 1♂, 1♀ VII-15-61 (R. W. Hodges); Madera Canyon, Santa Rita Mts., Santa Cruz Co., 1♂ VII-27/30-47 (L. M. Martin); Rustler Park, elev. 2,590 m, Chiricahua Mts., Cochise Co., 1♂, 2♀ VII-12/14-72, at light (J. Powell) (LACM, NMNH, and UCB).

This species appears closely related to *subcervinana*, from which it differs by having narrower wings, paler colors (especially the hindwing), and by the more distinctly banded forewing pattern. In *subcervinana* the pattern consists of narrower, more irregular and less defined lead colored and tan to orange bands. There are differences in the sterigma as well. Labial palpus size in *pallifasciata* appears to increase allometrically with increase in eye diameter and forewing length; this may be more exaggerated in females, but the small sample size limits conclusions.

In addition we examined two female specimens from Mexico representing a population that is closely similar to *pallifasciata* and *subcervinana*. The specimens were collected 16 km west of El Salto, Durango, elevation 2,680 m, July 18, 22, 1964 (J. A. Chemsak and J. Powell). They resemble *pallifasciata* in size, wing shape, and color pattern but are much darker, with dark gray hindwings as in *subcervinana* and bronze-brown forewings crossed by rust-colored bands. The genitalia (1 n) are nearly indistinguishable from *pallifasciata*.

GROUP 10: *AUREOLA*

Male larger than female. Antennal ciliation of ♂ short. Labial palpus elongate, II = 1.2 to 1.3 eye diameter. Male genitalia: sacculus without projections, pollex broad, stout; aedeagus elongate with apical spur and distal dentation; 8 to 10 short cornuti. Female genitalia: sterigma funnel-like, with enclosed narrow fold, ductus bursae with slight accessory lobe; signa small, one tiny, one larger.

Rhyacionia aureola Powell, New Species

(Figures 36, 37, 59, 83)

A Mexican species with rust-orange forewings crossed by many fine silvery striae, burnished golden to the unaided eye.

Male.—Length of forewing 7.0 to 8.4 mm (10 n). *Head*: Labial palpus moderately elongate, II segment 1.2 to 1.3 as long as eye diameter, III 0.3 to 0.4 as long as II; scaling broadly spreading, whitish tan blotched with orange brown exteriorly; scaling of upper front and crown spreading into upraised tufts, whitish tan tinged with brown. *Thorax*: Dorsal scaling bright rust orange anteriorly becoming whitish posteriorly. Underside shining white, anterior and middle legs rust orange exteriorly. *Forewing*: Moderately narrow; length 3.5 to 3.8 times width; costa gently curved, termen strongly angled back, tornal angle scarcely discernible. Ground color rust orange with about 15 evenly spaced, somewhat broken and irregular, transverse striae of shining metallic silver, reflecting rosaceous, whitish at costa, crossing full width of wing. Fringe whitish, the scales tipped with tan. Underside pale brownish gray, becoming whitish distally. *Hindwing*: Slightly broader than forewing; apex acute, termen slightly concave. Ground color pale gray, slightly darker toward margins. Fringe whitish. Underside white; fringe scales pale ochreous at their base. *Abdomen*: Scaling entirely shining whitish. Genitalia (figs. 36, 37, drawn from paratypes, JAP prep. 3568, 3636; 3 n): valva broad with a deep emargination preceding cucullus not apparent on the unflattened valva (figs. 36, 37); cornuti a cluster of 8 to 10 stout spines.

Female.—Length of forewing 6.6 to 8.2 mm (6 n). Essentially as described for male but labial palpus slightly larger, II segment length

1.3 to 1.5 eye diameter; and forewing slightly broader, length 3.3 to 3.6 times width. Genitalia (fig. 59, drawn from paratype, JAP prep. 3567; 3 n): ductus bursae sclerotized and enlarged basally; signa small, one twice the size of the other, proportionately broader.

Holotype male and allotype female, Mexico, 13 road km west of El Palmito, 1,950 m elevation, Sinaloa, August 8 through 12, 1972 (J. Powell, D. Veirs, and C. D. MacNeill) (CAS). Paratypes (14) same locality: 1♂ VII-29-64 (J. A. Chemsak and J. Powell), 9♂, 5♀ same data as holotype (NMNH and UCB). All specimens were taken at lights.

The host is unknown; the type series was taken in a mixed madrone-pine woods. Three species of pines were present in the immediate vicinity, *Pinus lumholtzii*, *P. montezumae*, and *P. oocarpa*, the last most abundant.

Four additional specimens (UCB) were examined but not designated as paratypes:

Five road km east of Revolcaderos, Durango, 1♂ 1♀ VIII-11-72 (J. Powell). These specimens are in good condition and are indistinguishable on external features from typical *aureola*. However, there are appreciable differences in both male and female genitalia (figs. 38, 58) especially the long, slender aedeagus, which lacks the terminal spur, bearing instead a row of small teeth on its venter. The female has a more elongate sclerotized area at the base of the ductus. Both individuals are slightly larger than the largest *aureola* of the corresponding sex (forewing length in each 8.7 mm). Based on knowledge of other *Rhyacionia* these would seem to be species-distinguishing structural differences, but it seems best to defer nomenclatural designation until more information is available. This locality is only 30 road km (probably half that distance airline) from the type locality of *aureola*, and probably less than 300 m higher in elevation. There are nonetheless appreciable differences in the habitat and moth fauna sampled at lights, so that a different pine host may be involved.

Forty-eight km west of Durango, Dgo., 2♀ VII-31-64 (J. A. Chemsak and J. Powell). These females are very worn, but the genitalia appear to be essentially the same as the

Revolcaderos female (fig. 58). This locality is 125 km east of the Revolcaderos site, and although higher (2,560 m) is well into the dry,

east or rainshadow side of the Sierra Madre Occidental. The habitat is considerably different, an oak-juniper-scrub pine association.

GROUP 11: *VERSICOLOR*, *FLAMMICOLOR*

Female larger than male. Antennal ciliation of ♂ moderately long. Labial palpus elongate, II = 1.3 to 1.7 eye diameter. Male genitalia: sacculus projection weakly developed, pollex narrow and truncate or broad; aedeagus elongate without armature, cornuti none to eight. Female genitalia: sterigma a broad ring with transverse fold, ductus bursae with sclerotized accessory lobe at base; signa tiny.

Rhyacionia versicolor Powell, New Species

(Figures 39, 60, 84; Map 13)

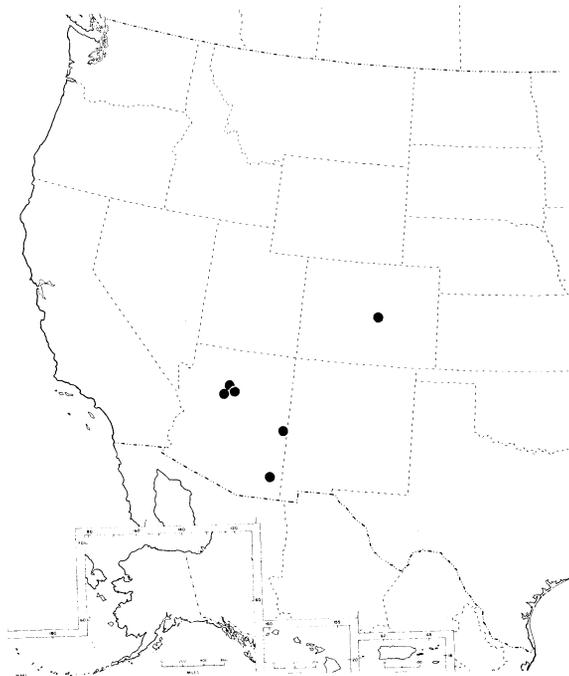
A large moth with shining pale forewings irregularly blotched with rust orange and tinged with iridescent rose purplish in the distal third.

Male.—Length of forewing 8.4 to 10.0 mm (13 n). *Head*: Labial palpus elongate, II segment 1.3 eye diameter, III 0.4 as long as II; scaling of palpus, upper front and crown roughened, spreading, white tinged with gray exteriorly. *Thorax*: Dorsal scaling shining white; ventral whitish, prothoracic legs tinged with gray. *Forewing*: Length 3.3 times width; costa nearly straight, termen strongly angled back, gradually curved to dorsum. Ground color whitish, irregularly overlaid with golden in transverse striae and rust orange in broad blotches, concentrated near base and beyond middle, leaving an ill-defined, broad transverse band of parallel, whitish striae before middle; an iridescent blotch of rose purplish or pink on outer area of cell and surrounding area below costa (paler and less discernible on older specimens), blended with orange in its basal half; costa white with brownish at origin of the golden striae in outer half. Fringe and underside whitish, lightly tinged with brownish. *Hindwing*: Pale gray, veins slightly darker, fringe whitish. *Abdomen*: Scaling probably shining whitish (greasy). Genitalia (fig. 39, drawn from paratypes, Arizona, NMNH slide 183, JAP prep. 3600; 3 n): valva with broad, shallow emargination preceding cucullus, sacculus with elongate, protruding flange, pollex broad, round; aedeagus elon-

gate, slender, tapered to a point on dorsal edge; cornuti, eight stout spines.

Female.—Length of forewing 10.2 to 11.6 mm (5 n). Essentially as described for male except larger and forewing slightly broader, length 3.0 to 3.1 times width. Some patches of salmon-colored scales along Cu fold and beyond in fresh examples; the golden banding generally broader and more contrasting than in male. Genitalia (fig. 60, drawn from paratype, Arizona, JAP prep. 3561; 2 n): sterigma a broad rim around ostium, with a transverse flap and subtending pouchlike base of ductus heavily sclerotized; signa small spurs with broad sclerotized bases.

Holotype male, Arizona, Fort Valley, elev. 2,240 m, 12 km NW Flagstaff, Coconino Co., June 29, 1961 (R. W. Hodges) and allotype female, Arizona, Vail Lake Rd., 1,980 m, 15 km SE Flagstaff, VII-11-61 (R. W. Hodges) (NMNH). Sixteen paratypes: Arizona, same data as holotype, 3♂ VII-10/12-61; 1♂ West



Map 13.—Distribution records for *Rhyacionia versicolor*.

Fork, elev. 1,980 m, 26 km SW Flagstaff, Coconino Co., VII-19-61 (R. W. Hodges); 2♂ Alpine Divide Camp, 6 km N Alpine, elev. 2,590 m, Apache Co., VII-15-65 (F., P. & M. Rindge); 4♀ Rustler Park, elev. 2,590 m, Chiricahua Mts., Cochise Co., VII-3/20-72 at light (J. Powell). Colorado, 6♂ Rock Creek Cyn., Colorado Springs, El Paso County, VI-23-59, VI-27-60 (M. May) (AMNH, Kimball, NMNH, and UCB).

This species resembles *flammicolor* in external features (size, form of labial palpus, antennal pectination, wing shape) and in female genitalia, but the male genitalia in *versicolor* is distinct from all known *Rhyacionia*.

Rhyacionia flammicolor Powell, New Species

(Figures 40, 61, 85)

A large Mexican moth with shining dark red forewings.

Female.—Length of forewing 8.2 to 9.6 mm (7 n). *Head*: Labial palpus elongate, II segment length 1.5 to 1.7 eye diameter, III 0.3 as long as II; scaling of palpus, front and crown broadly spreading, grayish, the scales pale basally, darker apically. *Thorax*: Dorsal scaling gray, tinged with red brown anteriorly. Underside shining whitish, anterior and middle legs gray brown exteriorly. *Forewing*: Broad, length 3.1 to 3.2 times width; apex acute, termen strongly angled back, tornal angle evident. Ground color shining metallic red, basal half with ill-defined transverse grayish striae; discal area beyond middle to beyond cell with a rose-purplish shade, terminal area deep red, becoming ochreous orange below costa and above tornus. Fringe gray. Underside gray, a pale line

around terminal margin. *Hindwing*: Apex acute, termen strongly angled back, slightly concave. Ground color dark gray; fringe pale gray. Underside whitish gray, the veins darker. *Abdomen*: Dorsal scaling dark gray, ventral whitish gray. Genitalia (fig. 61, drawn from paratype, JAP prep. 3644; 2 n): sterigma a complex broad ring with transverse fold anteriorly.

Male.—Length of forewing 9.2 mm (1 n). A single, worn specimen essentially as described for female except labial palpus relatively shorter (eye larger), II segment length about 1.4 eye diameter. Genitalia (fig. 40, drawn from allotype, JAP prep. 3432; 1 n): valva weakly emarginate preceding cucullus, pollex well defined, short, subtending an emargination in the distal edge of the cucullus; aedeagus elongate, slender, strongly curved, cornuti absent.

Holotype female and allotype male, Mexico, 16 km west of El Salto, 2,680 m elevation, Durango, August 18, 1964 (J. A. Chemsak and J. Powell) (CAS). Six paratype females, same data VII-18-30-64 (NMNH and UCB).

The host is unknown. The locality is a mixed conifer and oak forest with 12 pine species, of which *Pinus durangensis* and *P. cooperi* are the most abundant (Thomas 1966).

The external features, particularly the elongate labial palpus, broad wings, purplish blotch in the discal area of the forewing, and female genitalia suggest this species is close to *versicolor*, but the male genitalia characters differ. These two species show phenetic similarity in 12 characters (86 percent), dissimilarity in 2 (with no comparison in the 2 biological features) among the 16 characters used in this study.

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as a byproduct to other field work, was funded by the National Science Foundation grant, "Carpenter Bees of the World" (P. D. Hurd, Jr., principal investigator).

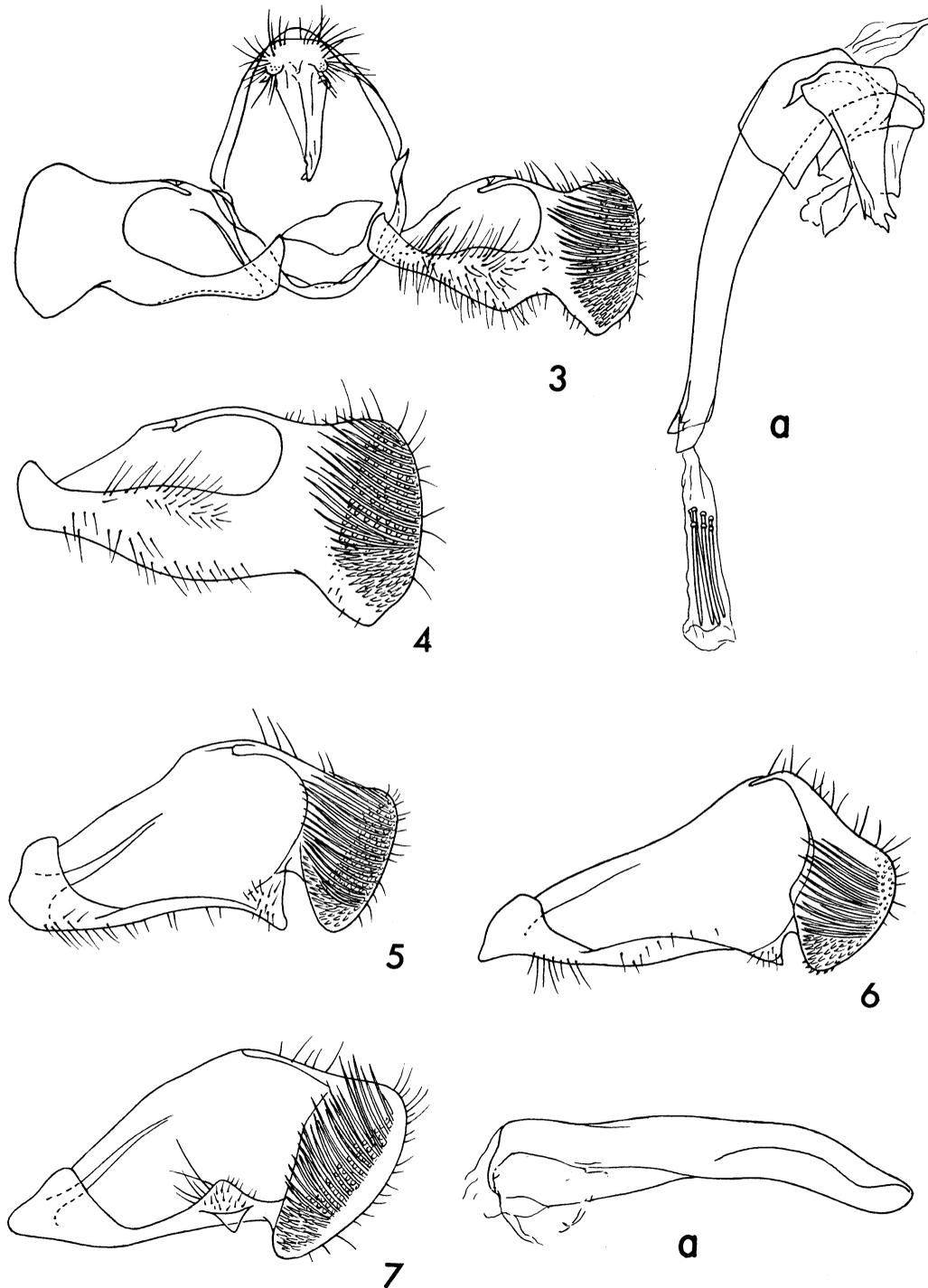
The maps were prepared by R. E. Dietz and the drawings by Celeste Green, University of California, Berkeley; their help is gratefully acknowledged.

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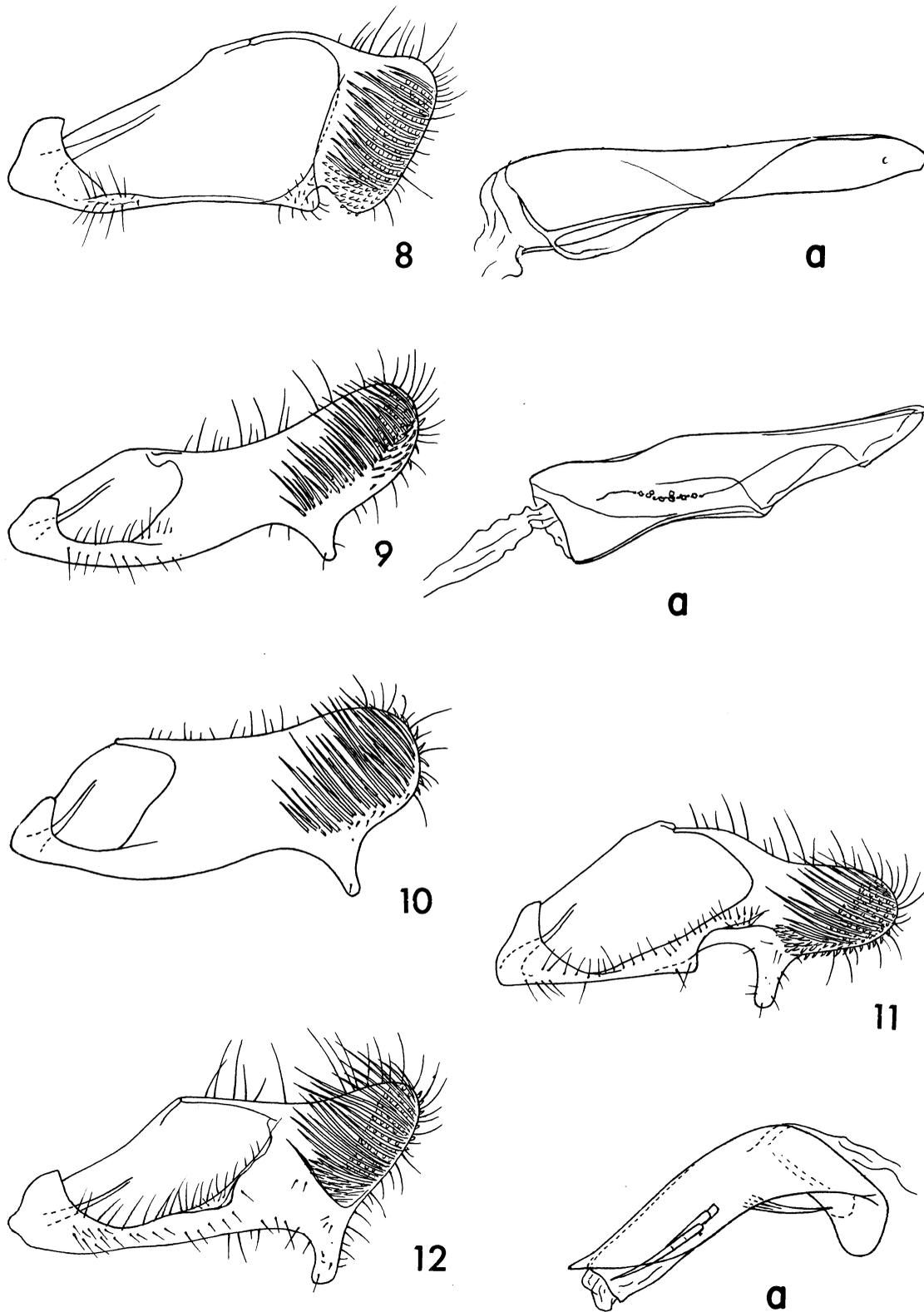
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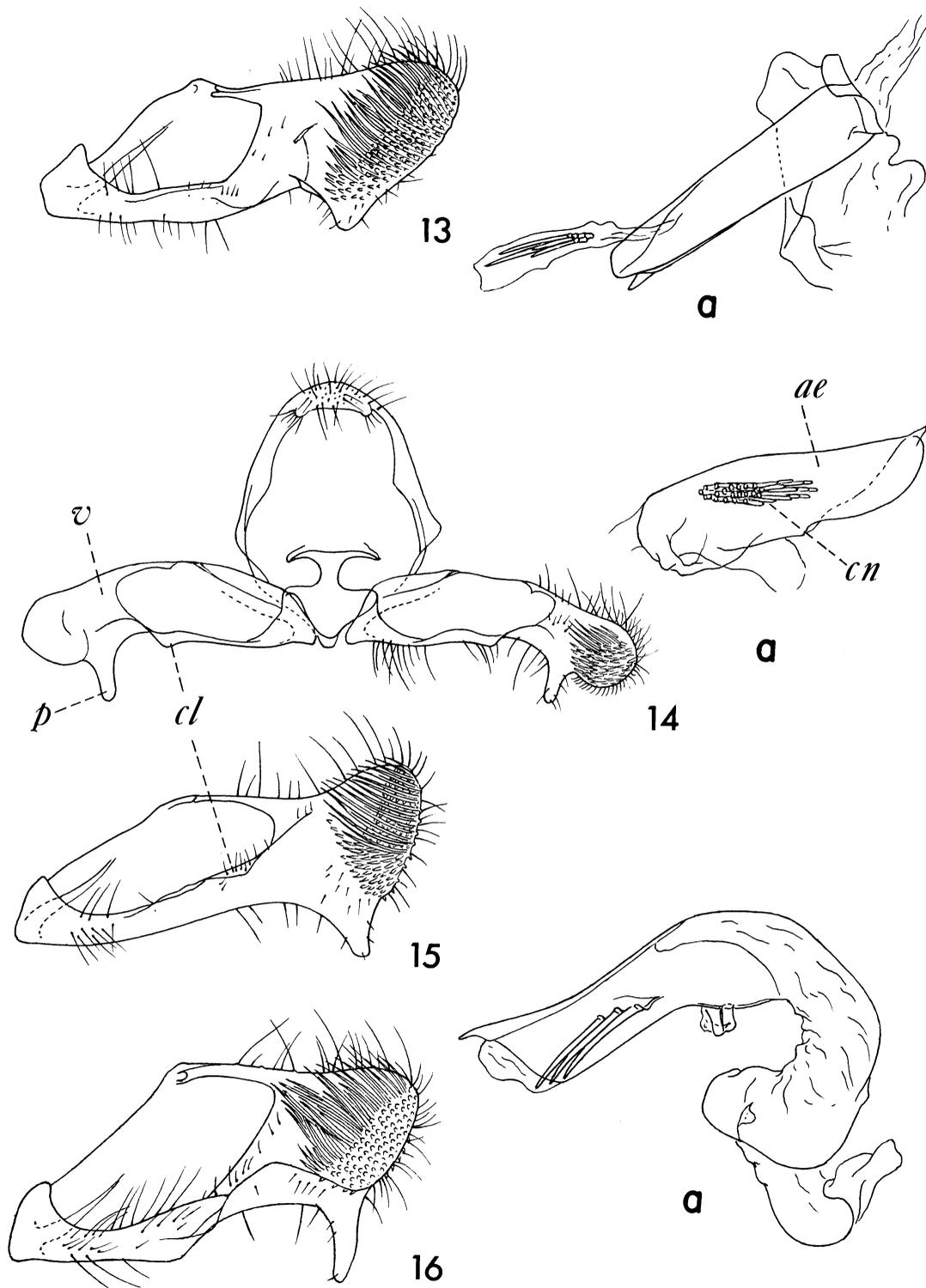
MALE GENITAL CHARACTERS, FIGURES 3-40



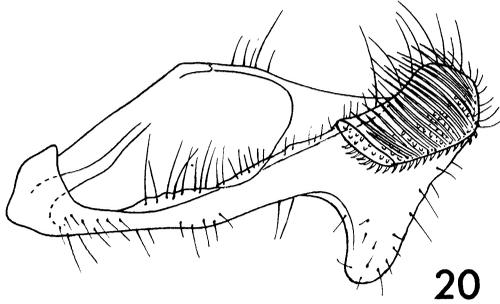
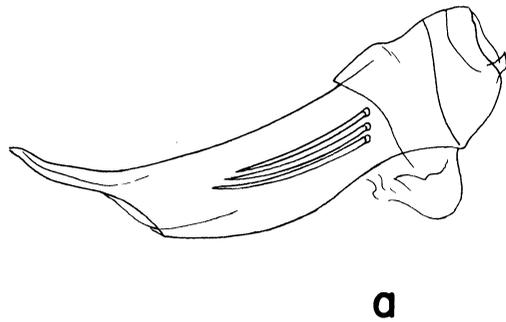
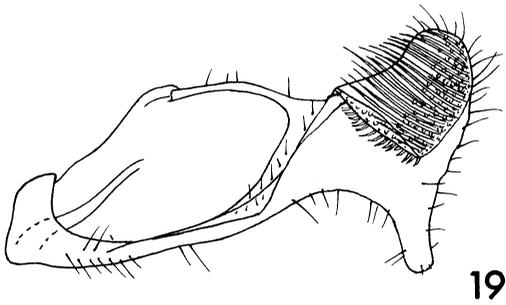
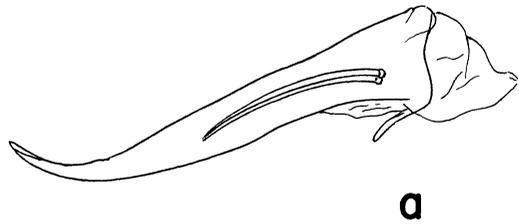
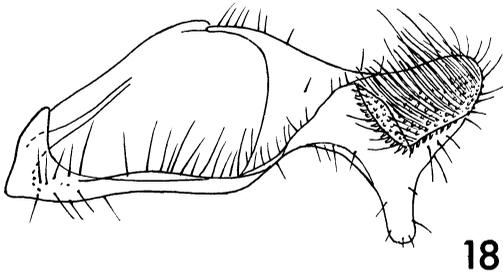
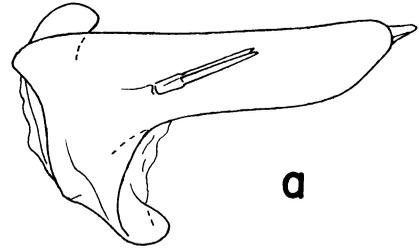
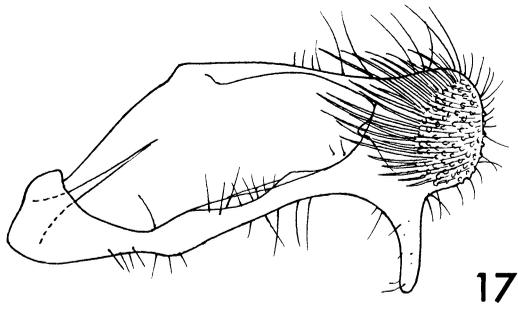
Figures 3 through 7.—Male genital characters of *Rhyacionia*: (3) *buoliana*, ventral aspect, valvae spread and (3a) aedeagus, lateral; (4) *buoliana*, valva inner aspect, flattened; (5-7) *rigidana*, valvae inner aspect, flattened in (7), and (7a) aedeagus venterolateral.



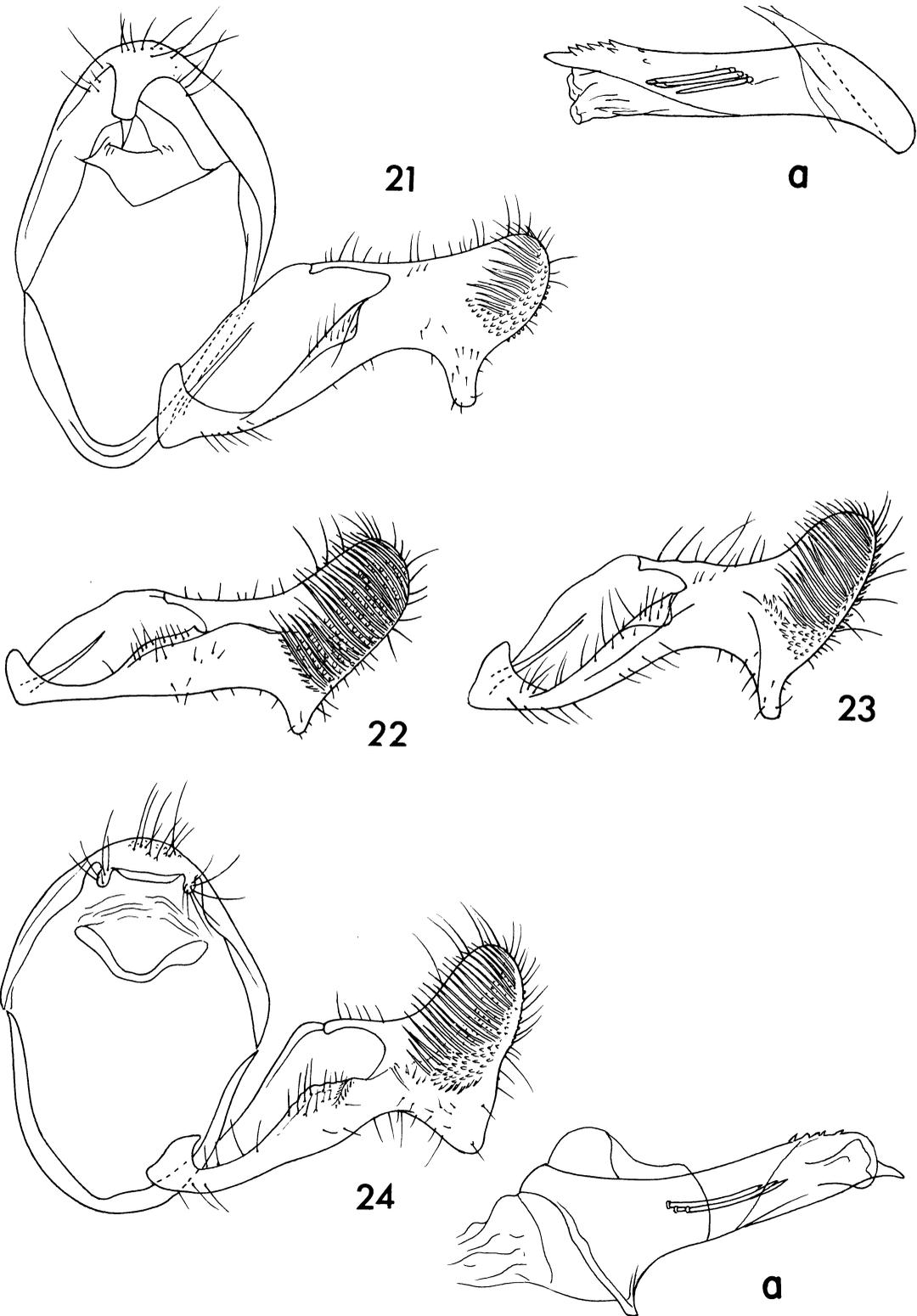
Figures 8 through 12.—Male genital characters of *Rhyacionia*: (8) *subtropica*, valva inner aspect and (8a) aedeagus ventero-lateral; (9, 10) *multilineata*, valvae inner aspect and (9a) aedeagus lateral with cornuti dehiscent; (11, 12) *neomexicana*, valvae inner aspect and (12a) aedeagus lateral.



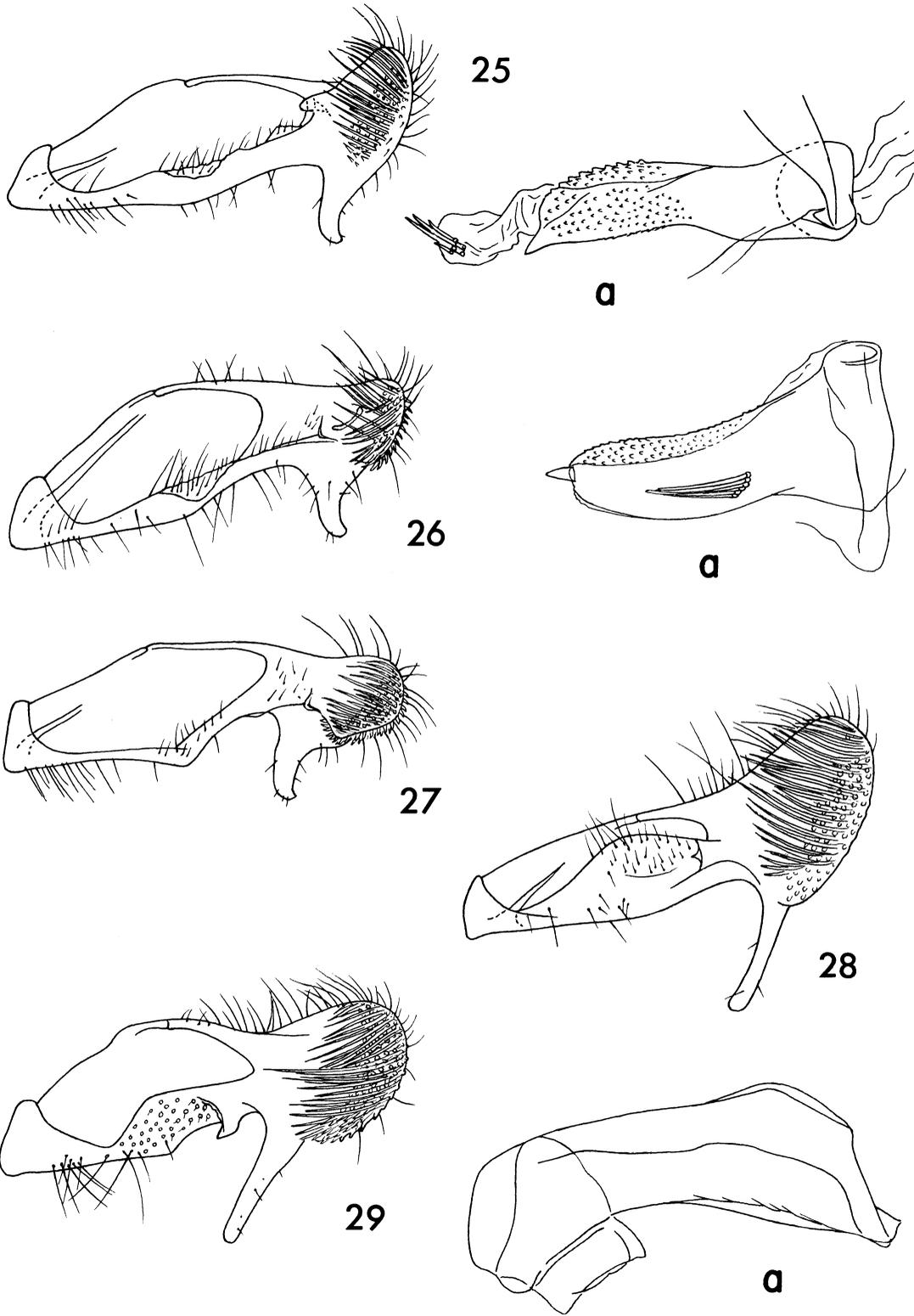
Figures 13 through 16.—Male genital characters of *Rhyacionia*: (13) *pasadenana*, valva inner aspect and (13a) aedeagus ventral; (14) *zozana*, ventral aspect, valvae spread and (14a) aedeagus, lateral; (15) *zozana*, valva inner aspect, flattened; (16) *salmonicolor*, valva inner aspect and (16a) aedeagus, lateral. *ae* = aedeagus, *cl* = "clasper," *cn* = cornuti, *p* = pollex, *v* = valva.



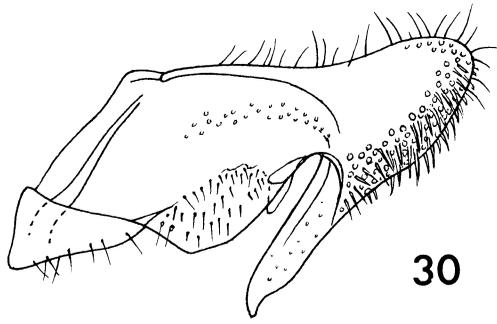
Figures 17 through 20.—Male genital characters in *Rhyacionia*: (17) *monophylliana*, valva inner aspect and (17a) aedeagus, dorsolateral; (18) *adana*, valva inner aspect and (18a) aedeagus lateral; (19, 20) *jenningsi*, valvae inner aspect and (19a) aedeagus lateral.



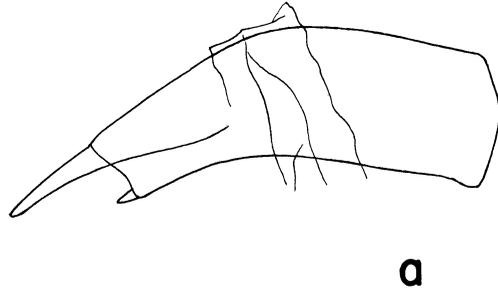
Figures 21 through 24.—Male genital characters in *Rhyacionia*: (21) *busckana*, ventral aspect, valva spread and (21a) aedeagus lateral; (22,23) *busckana*, valvae inner aspect; (24) *blanchardi*, ventral aspect, valva spread and (24a) aedeagus, lateroventral.



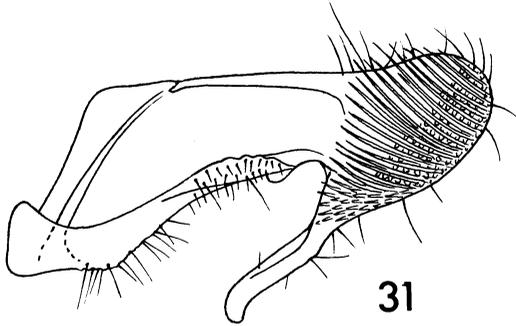
Figures 25 through 29.—Male genital characters in *Rhyacionia*: (25) *fumosana*, valva inner aspect and (25a) aedeagus, lateroventral; (26,27) *fumosana*, valva inner aspect and (26a) aedeagus, dorsolateral; (28,29) *frustrana*, valva inner aspect and (29a) aedeagus lateral.



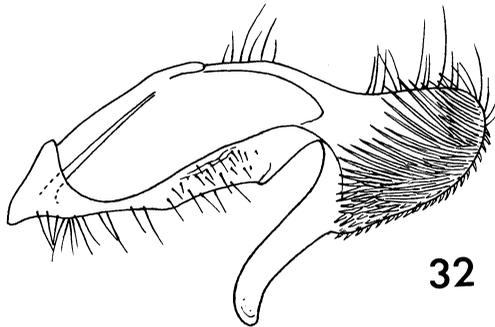
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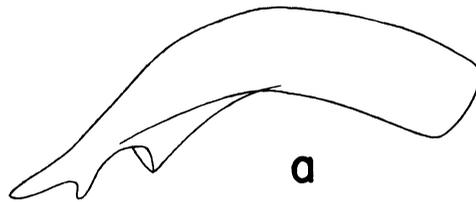
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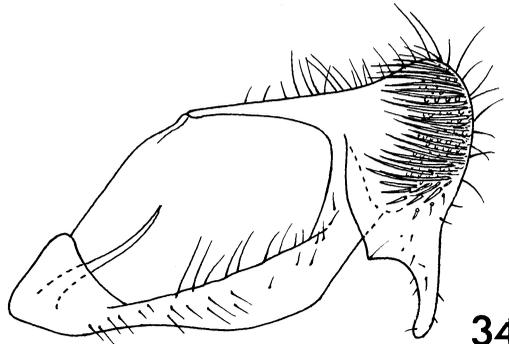
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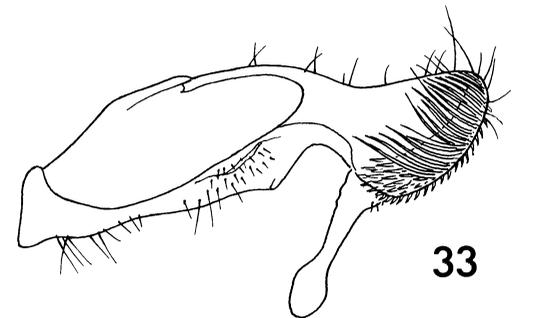
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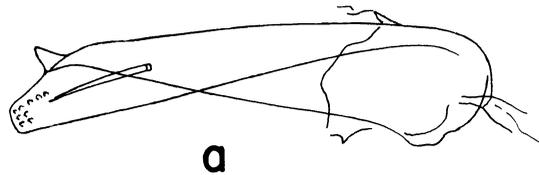
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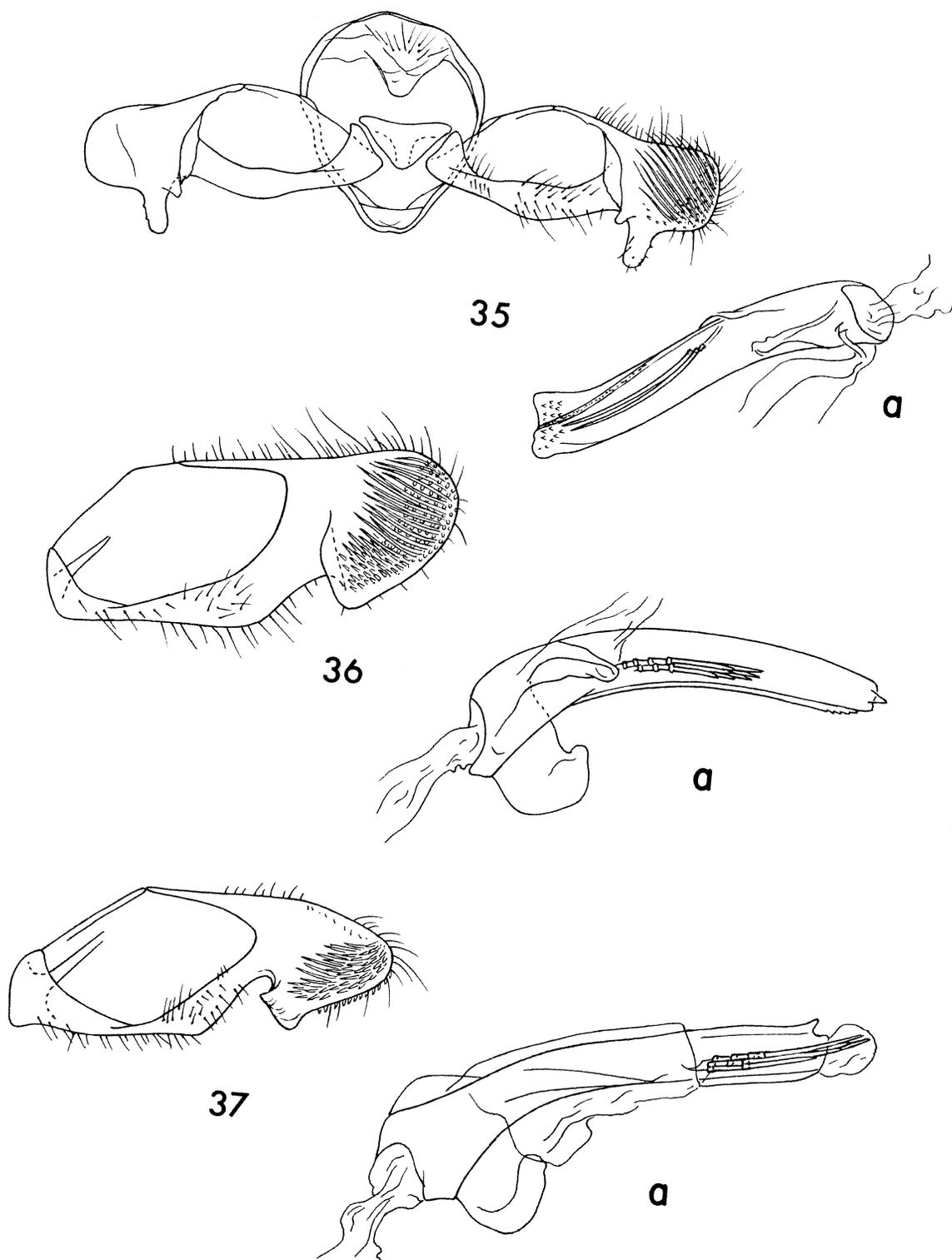


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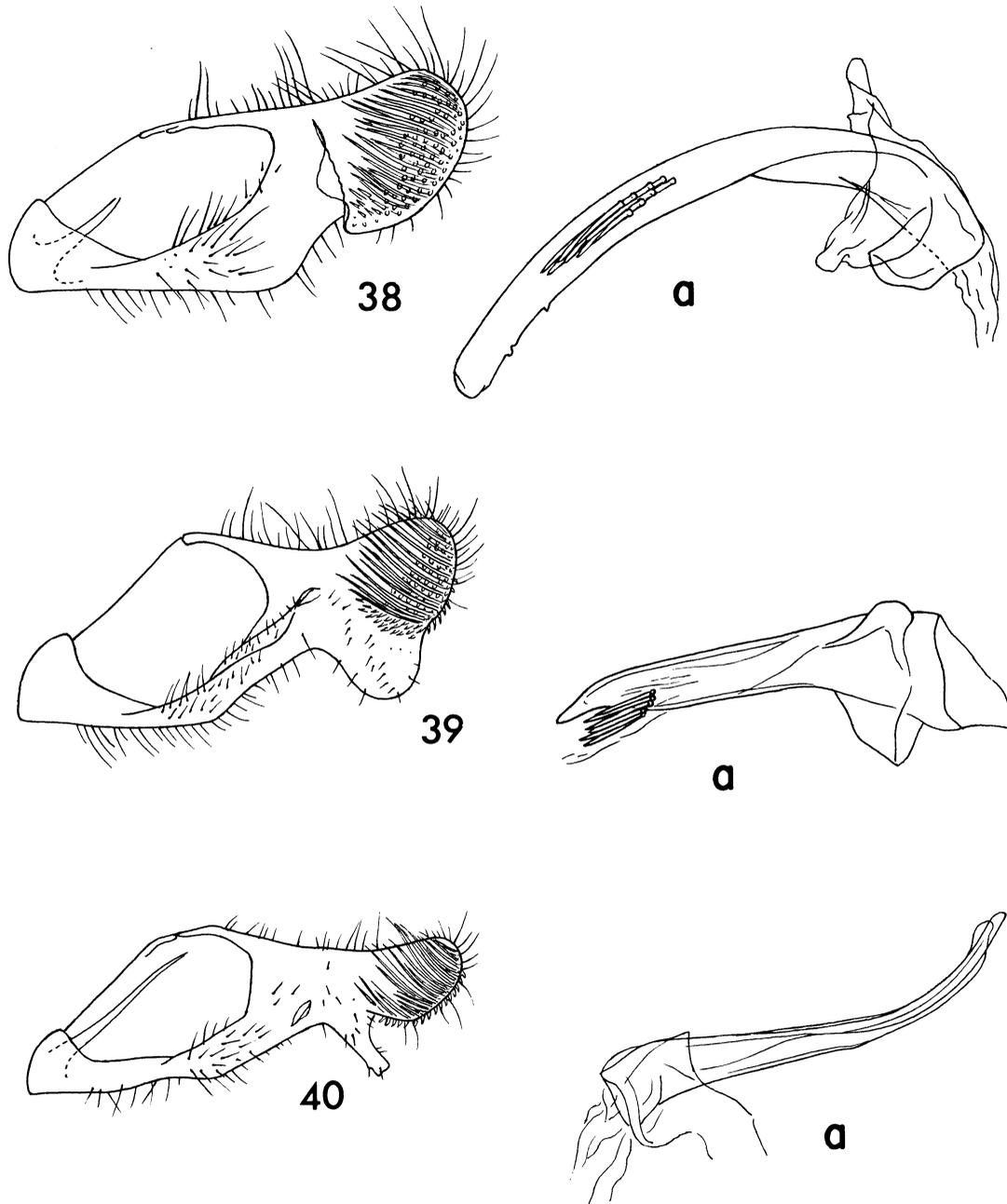


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Figures 30 through 34.—Male genital characters in *Rhyacionia*: (30,31) *sonia*, valvae inner aspect and (30a) aedeagus lateral; (32,33) *aktita*, valvae inner aspect and (32a) aedeagus lateral; (34) *subcervinana*, valva inner aspect and (34a) aedeagus lateroventral.

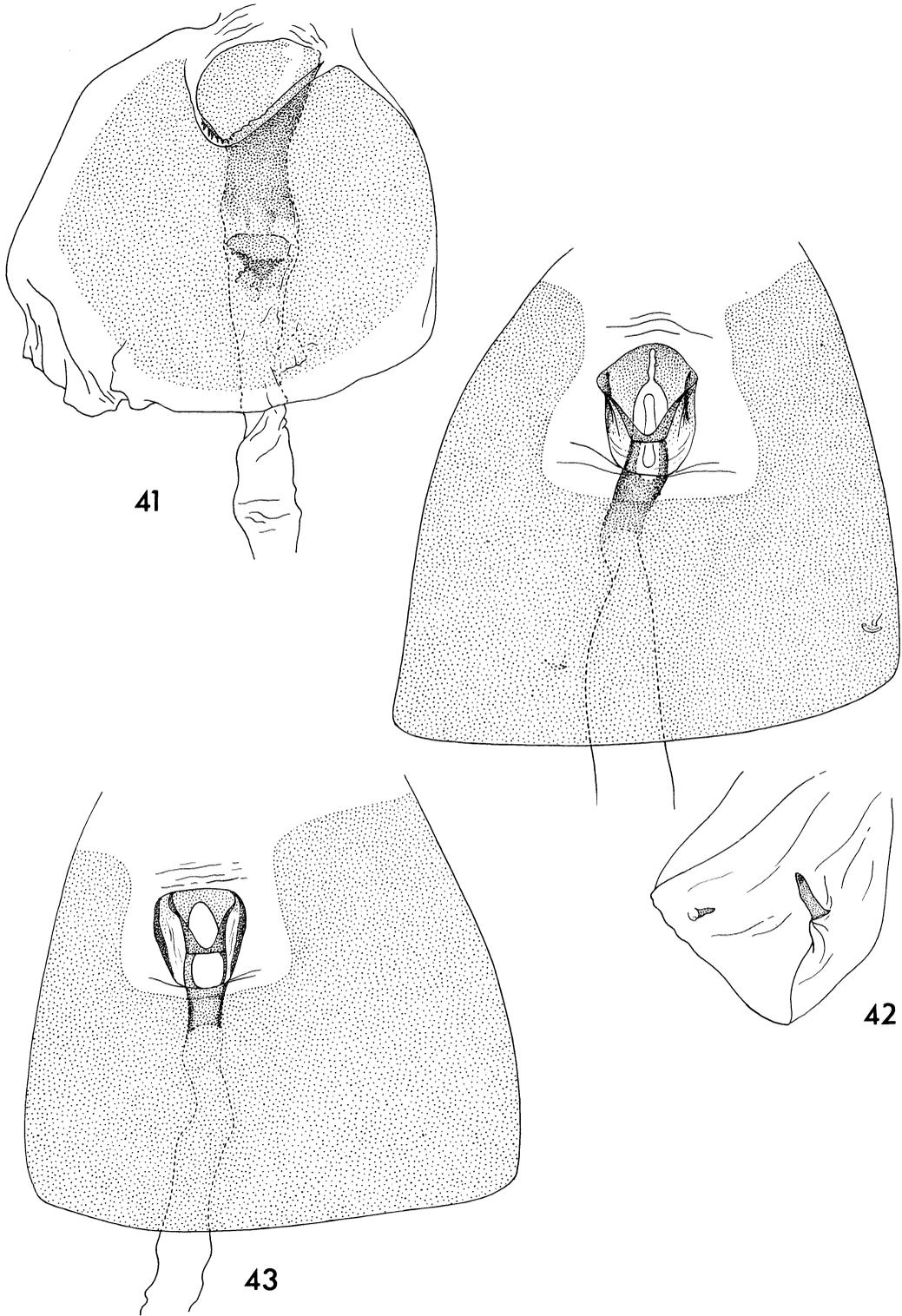


Figures 35 through 37.—Male genital characters in *Rhyacionia*: (35) *pallifasciata*, ventral aspect, valvae spread and (35a) aedeagus ventrolateral; (36,37) *aureola*, valvae inner aspect, flattened in (37) and (36a,37a) aedeagi lateral.

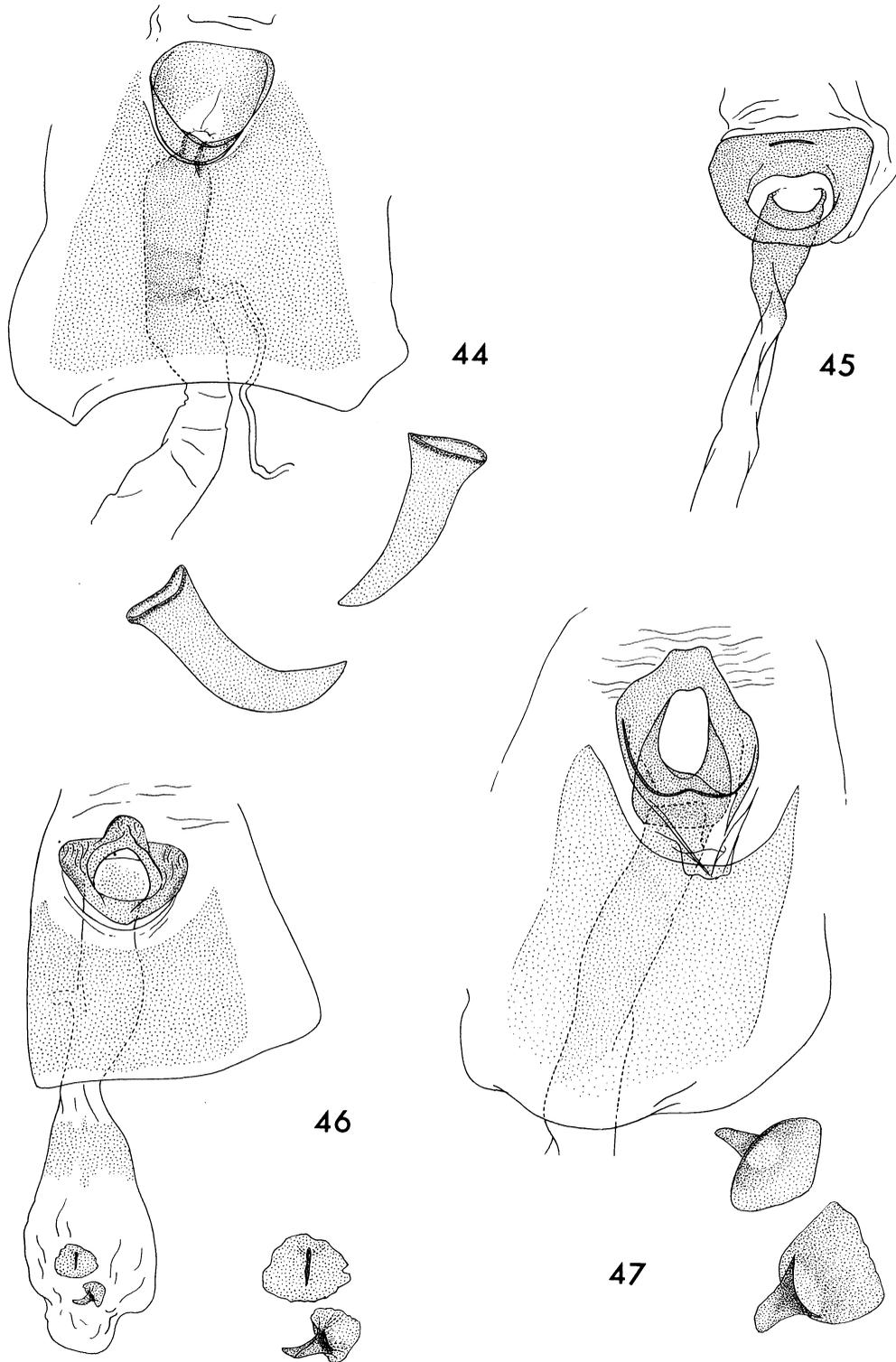


Figures 38 through 40.—Male genital characters in *Rhyacionia*: (38) *Revolcaderos* "aureola," valva inner aspect and (38a) aedeagus lateral; (39) *versicolor*, valva inner aspect and (39a) aedeagus lateroventral; (40) *flammicolor*, valva inner aspect and (40a) aedeagus lateral.

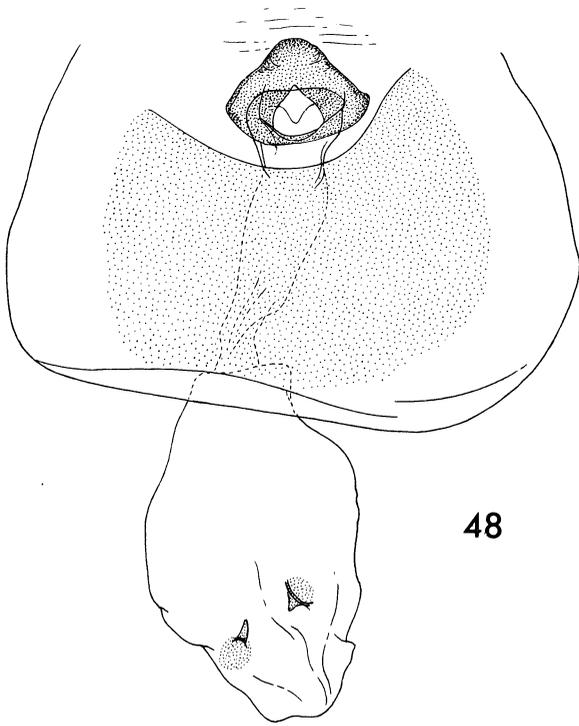
FEMALE ABDOMINAL STRUCTURES, FIGURES 41-61



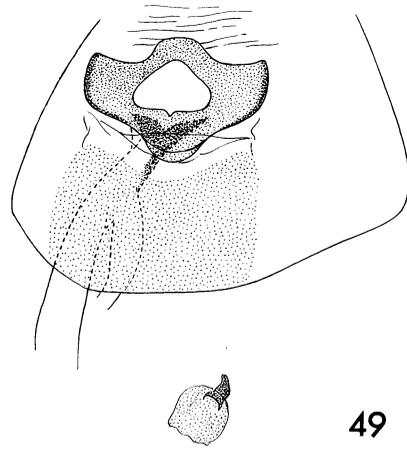
Figures 41 through 43.—Female abdominal structures in *Rhyacionia*, VII sternite, sterigma and ductus bursae, ventral aspect: (41) *buoliana*; (42) *rigidana*, with signa below; (43) *subtropica*.



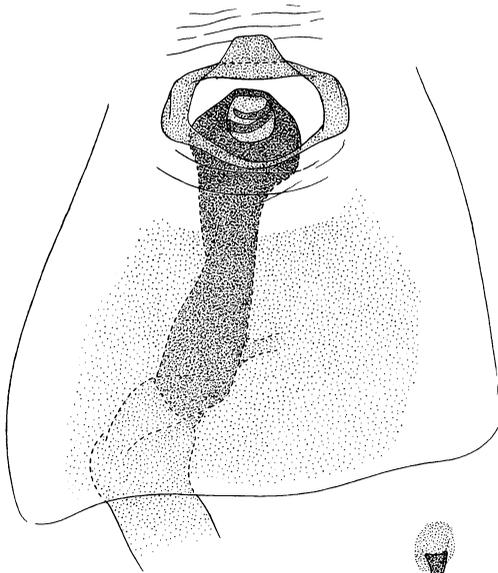
Figures 44 through 47.—Female abdominal structures in *Rhyacionia*, VII sternite, sterigma, ductus bursae, ventral aspect, and signa shown separately 2× enlarged: (44) *multilineata*; (45) *pasadenana*, sterigma and ductus bursae only; (46) *zozana*, including corpus bursae; (47) *neomexicana*.



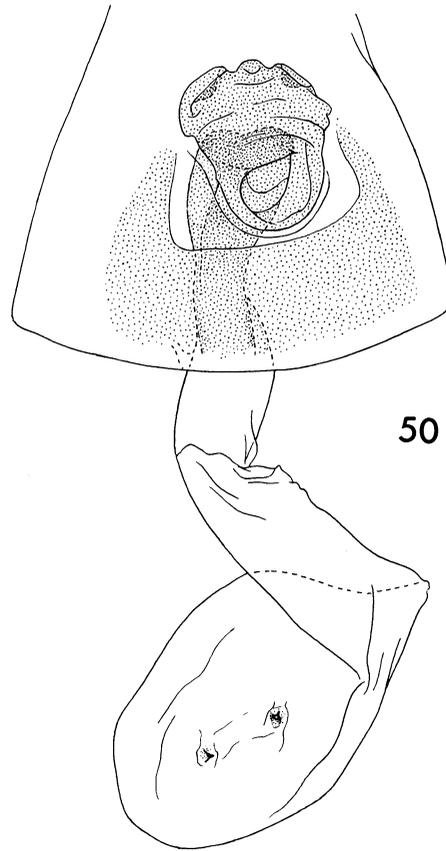
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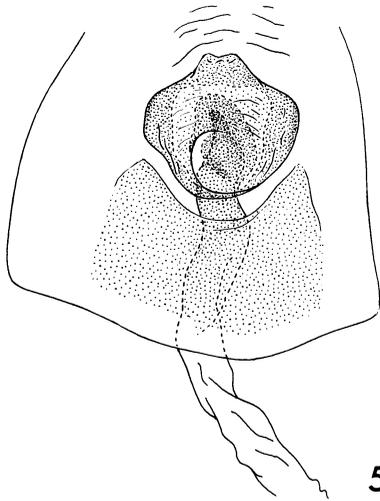


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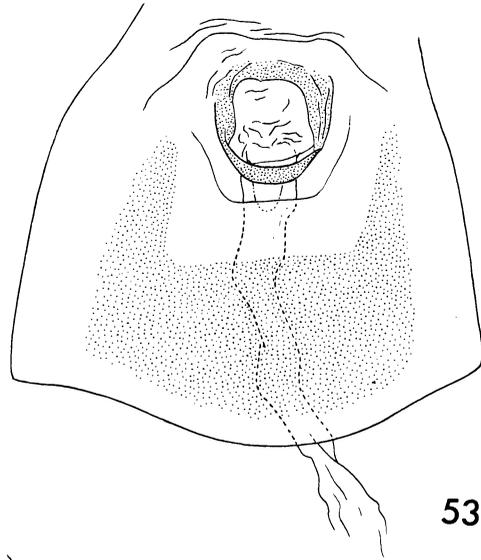


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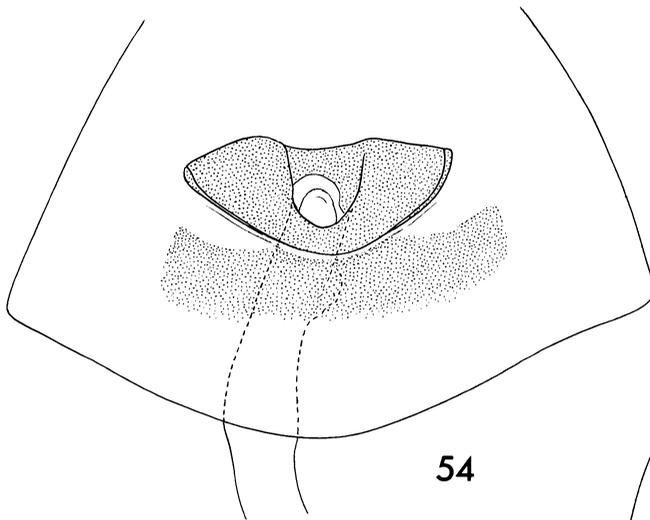
Figures 48 through 51.—Female abdominal structures in *Rhyacionia*, VII sternite, sterigma, ductus bursae, ventral aspect, and signa shown in corpus bursae or separately enlarged 2×: (48) *martinana*; (49) *jenningsi*; (50) *busckana*; (51) *blanchardi*.



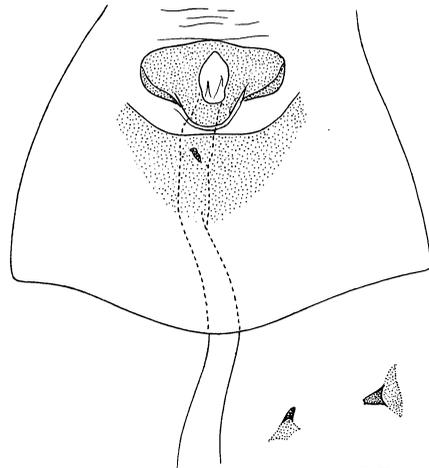
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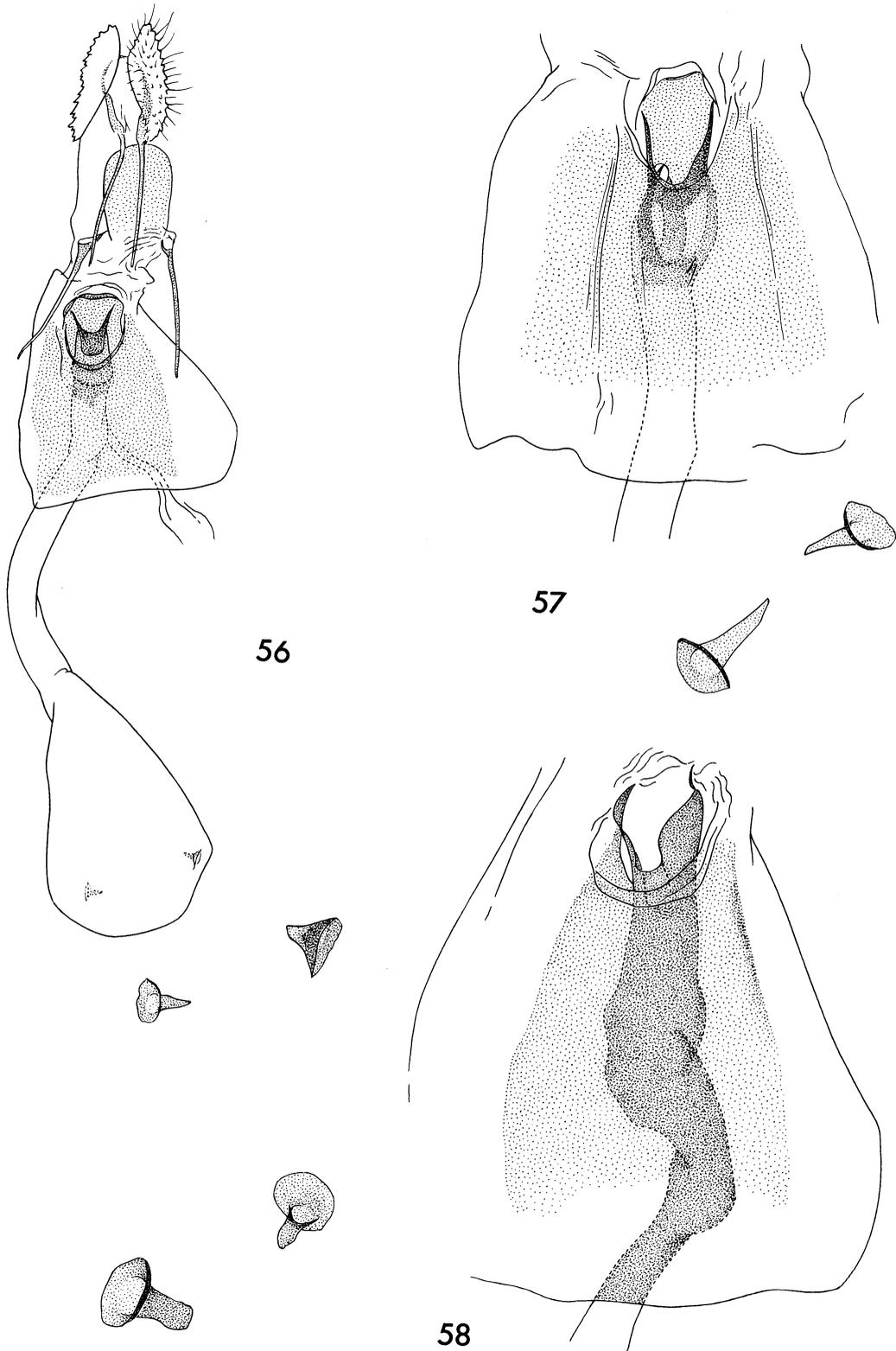


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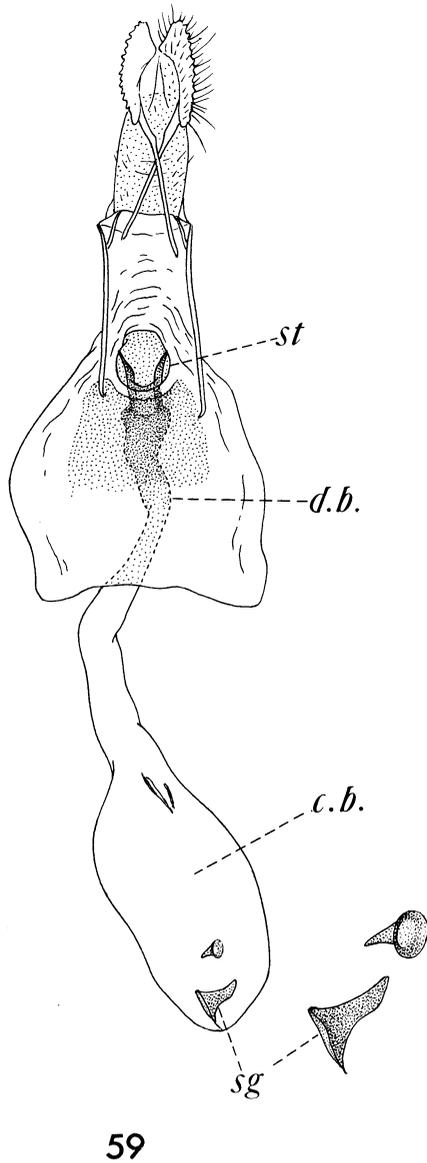


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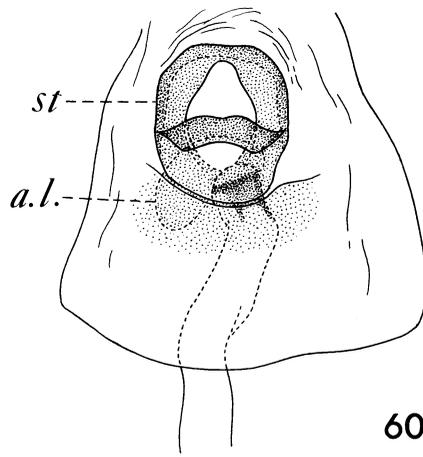
Figures 52 through 55.—Female abdominal structures in *Rhyacionia*, VII sternite, sterigma and ductus bursae, ventral aspect: (52) *fumosana*; (53) *frustrana*; (54) *sonia*; (55) *aktita*, with signa shown separately 2× enlarged.



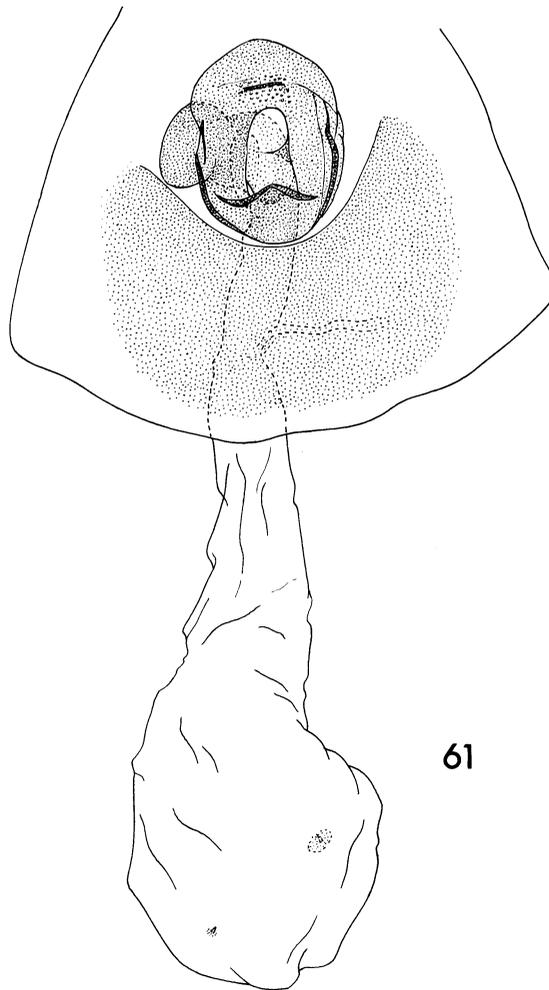
Figures 56 through 58.—Female abdominal structures in *Rhyacionia*: (56) *subcervinana*, VII to IX sternites and associated genital structures with signa shown separately 3× enlarged; (57) *pallifasciata*, VII sternite, sterigma, ductus bursae and signa shown separately enlarged 2×; and (58) *Revolcaderos "aureola,"* VII sternite, sterigma, ductus bursae and signa shown separately enlarged 2×.



59



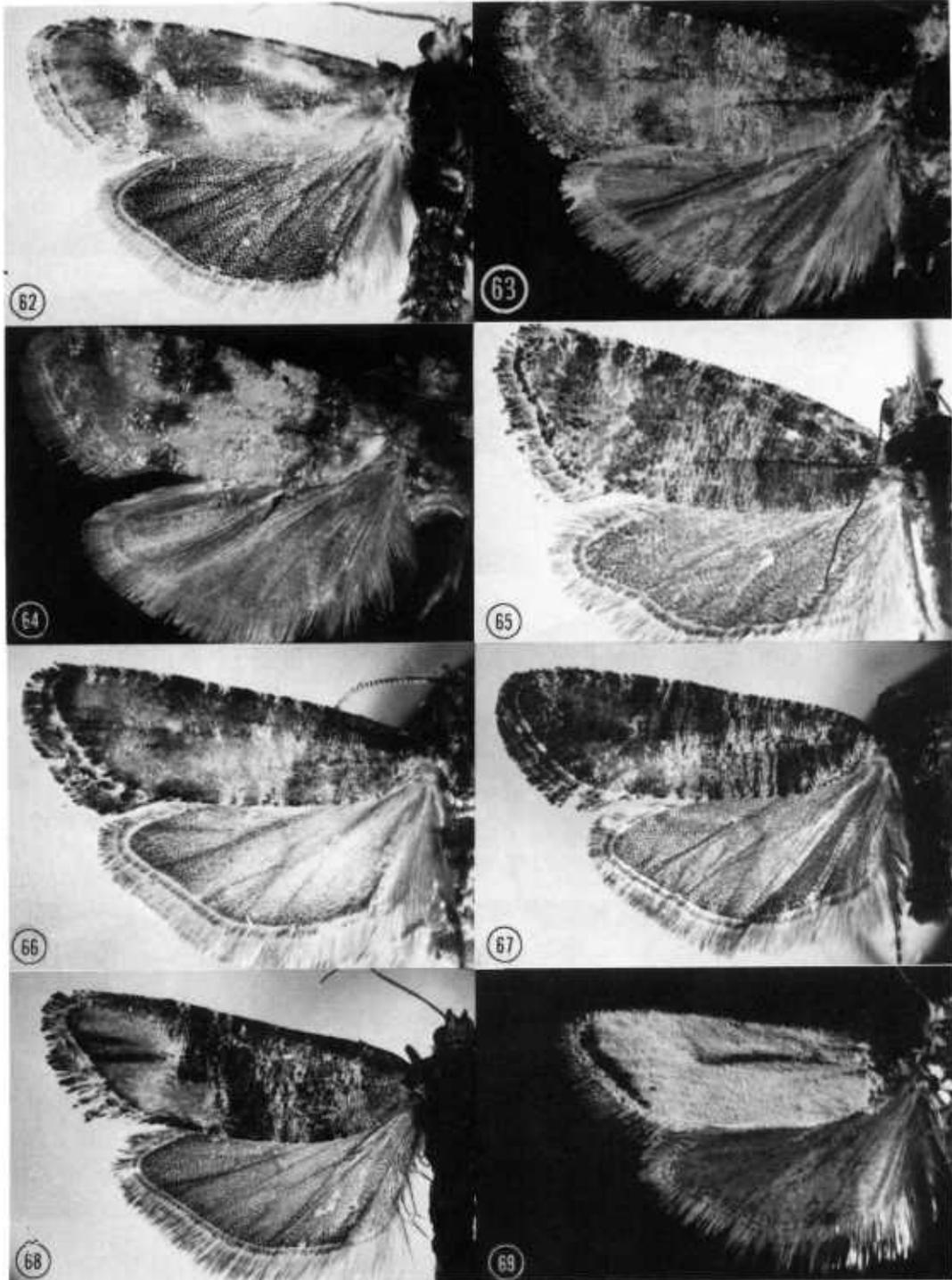
60



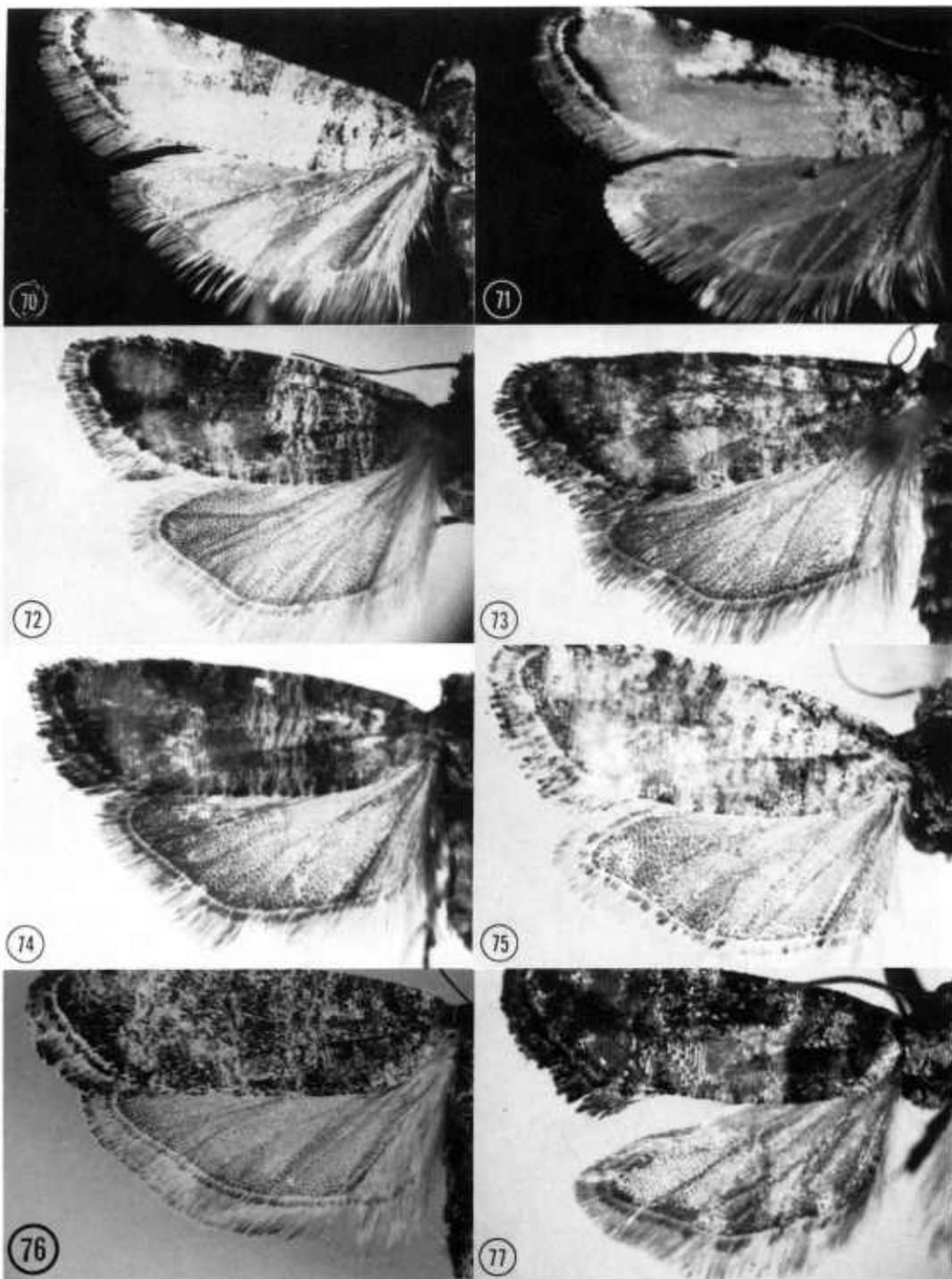
61

Figures 59 through 61.—Female abdominal structures in *Rhyacionia*: (59) *aureola*, VII to IX sternites and associated genital structures with signa shown separately 2× enlarged; (60) *versicolor*, VII sternite, sterigma and ductus bursae; (61) *flam-micolor*, VII sternite, sterigma and bursa copulatrix. *a.l.* = accessory lobe, *c.b.* = corpus bursae, *d.b.* = ductus bursae, *sg.* = signa, *st.* = sterigma.

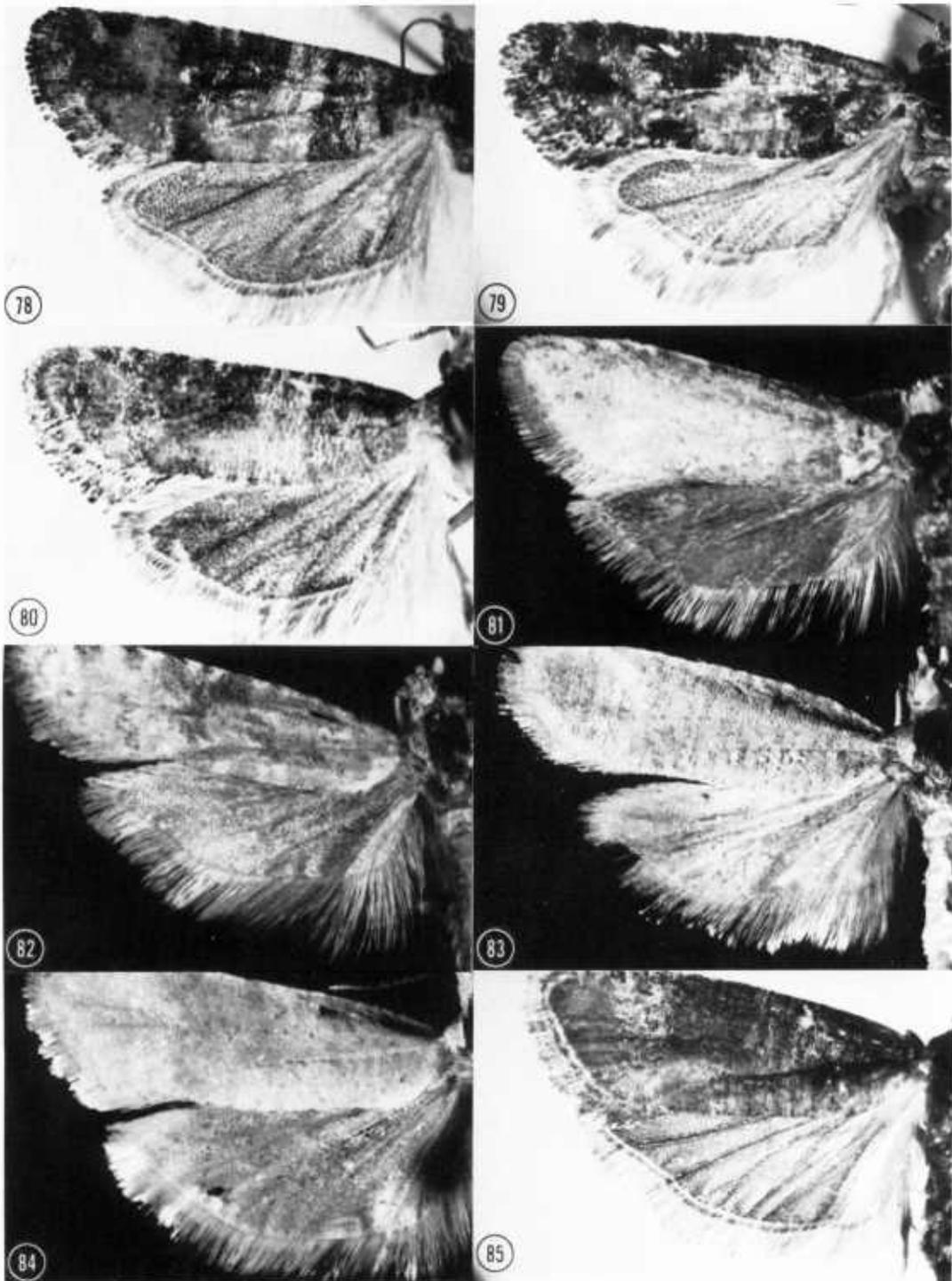
ADULTS OF *RHYACIONIA*, FIGURES 62-85



Figures 62 through 69.—Adults of *Rhyacionia*: (62) *buoliana* ♂, Livingston Co., Michigan; (63) *rigidana* ♂, Spring, Harris Co., Texas; (64) *subtropica* ♀, Everglades National Park, Fla.; (65) *multilineata* ♂, 10 km NW Newcastle, Wyo.; (66) *pasadenana* ♂, Lobos Cr., San Francisco, Calif.; (67) *zozana* ♂, 5 km NE Tuolumne City, Calif.; (68) *neomexicana* ♀, Sitgreaves National Forest, Ariz.; (69) *salmonicolor* ♂, Davis Mts., Tex.



Figures 70 through 77.—Adults of *Rhyacionia*: (70) *monophylliana* ♂, Chuchupate Ranger Station, Ventura Co., Calif.; (71) *martinana* ♂, 8 km NW Prescott, Yavapai Co., Ariz.; (72) *adana* ♂, Higgins Lk., Mich.; (73) *jenningsi* ♀, Sitgreaves National Forest, Ariz.; (74) *busckana* ♀, Bluemont Jet., Va.; (75) *blanchardi* ♀, Conroe, Montgomery Co., Tex.; (76) *fumosana* ♀, Slope Co., N. Dak.; (77) *frustrana*, Marysville, Pa.



Figures 78 through 85.—Adults of *Rhyacionia*: (78) *bushnelli* ♂, Fort Bayard, N. Mex.; (79) *sonia* ♀, holotype; (80) *aktita* ♂, Conroe, Montgomery Co., Tex.; (81) *subcervinana* ♀, Vernon, British Columbia; (82) *pallifasciata* ♂, Fort Valley, Coconino Co., Ariz.; (83) *aureola* ♂, 13 road km W El Palmito, Sin., Mexico; (84) *versicolor* ♂, Fort Valley, Coconino Co., Ariz.; (85) *flammicolor* ♀, 16 km W El Salto, Dgo., Mexico.