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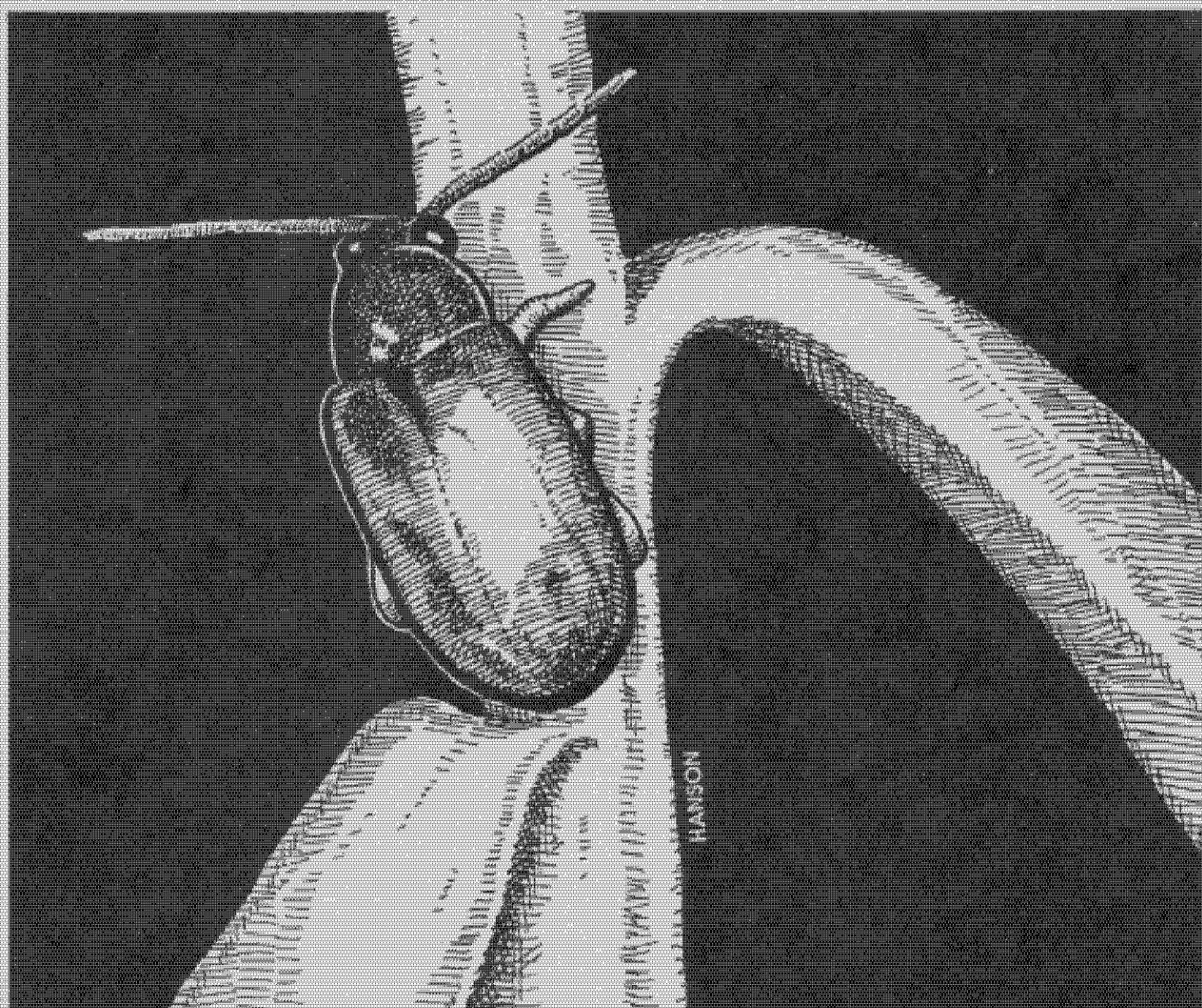
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Morphology of three imported *Aphthona* flea beetles used as biological control agents of leafy spurge



Dedicated to Edward U. Balsbaugh Jr. (d. 1992) who was an enthusiastic and inspiring teacher with a strong commitment to students. He was a renowned authority in Chrysomelidae taxonomy and advanced the knowledge of flea beetles throughout the world. He served as an associate professor of Entomology from 1965 to 1976 at South Dakota State University.

Morphology of three imported *Aphthona* flea beetles used as biological control agents of leafy spurge

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Beetles in the genus *Aphthona* have been imported into South Dakota as biological control agents of leafy spurge (*Euphorbia esula* L.).

Identification, abundance, comparative life cycles, and reduction-of-host studies are in progress at selected sites in South Dakota for three species of the genus *Aphthona* (*A. nigriseutis*, *A. cyparissiae*, and *A. flava*). Evaluation depends upon correct identification in the field. But since they are not natives, these three beetles are not familiar to workers

attempting to recapture them at release sites in South Dakota. The insects must also be distinguished from native flea beetles common to the release sites in South Dakota.

The following morphological study of the three imported *Aphthona* flea beetles supplies a detailed description of selected structures that will distinguish each of the three imported species and will separate them from a common native flea beetle (*Glyptina atriventris*) found at South Dakota release sites.

KEY TO THE SOUTH DAKOTA GENERA OF ALTICINAE

(Adapted from Balsbaugh, Jr. and Hays 1972)

- 1 Apical segment of posterior tarsi strongly swollen distally2
1' Apical segment of posterior tarsi not swollen4

- 2 Elytral punctate-striae or punctate-substriae; procoxal cavities closed, pubescence erect or suberect, long brown or gray setae*Distigmoptera* Blake

[Only a single specimen of *D. borealis* Blake has been recorded from South Dakota from *Solidago*.]

- 2' Elytra punctate, not punctate-striae or punctate-substriae3

- 3 Size large (4.0-8.0 mm.), convex; lateral margins narrow or lacking; antennae moderately stout, usually less than one half body length; frons vertical; eyes small, distant (interocular spaced one-half width of head); interocular depression indistinct*Kuschelina* Bechyne

[Three species of *Kuschelina* are in the SDSU H.C. Severin insect collection from South Dakota. Two are rare, with only a single collection of each from the state. *K. gibbitarsa* is common throughout the state. No host data are recorded; all were collected by sweeping.]

- 3' Size small (3.0-6.0 mm.), depressed; lateral margins explanate; antennae slender, at least one-half body length; front oblique; eyes large, closely set (interocular space less than one-half width of head); interocular depression distinct*Capraita* Bechyne

[Three species of *Capraita* are in the SDSU H.C. Severin insect collection from South Dakota. No host data are given; all were collected by sweeping.]

- 4 Apical spur of posterior tibiae terminating in a single point5

- 4' Apical spur of posterior tibiae distally bifurcate or broadly truncate*Dibolia* Latreille

[Two species of *Dibolia* are in the SDSU H.C. Severin insect collection from South Dakota. *D. libonoti* Horn is rare; only a single collection is recorded from South Dakota. *D. borealis* Chevrolat is commonly collected from *Plantago* spp.]

5 Antennae 11-segmented6

5' Antennae 10-segmented*Psylliodes* Latreille

[Two species of *Psylliodes* are in the SDSU H.C. Severin insect collection: *P. punctulata* Melsheimer has been collected statewide; *P. convexior* LeConte is represented by only a single specimen collected from Gregory, South Dakota.]

6 Tarsal claws simple or appendiculate7

6' Tarsal claws bifid*Blepharida* Chevrolat

[Only a single species, *B. rhois* (Forster) is in the SDSU H.C. Severin insect collection; it has been collected statewide feeding on sumac (*Rhus* sp.) leaves in August.]

7 Pronotum with prebasal transverse impressions, or with short, paired, latero-basal, longitudinal impressions, or with both transverse and longitudinal impressions8

7' Pronotum lacking distinct impressions 14

8 Elytral punctation confused; pronotum with prebasal transverse pronotal impression not laterally delimited by longitudinal furrows; color dark, usually metallic; green, blue, purple, bronze, or brown-blue; prebasal pronotal impression a single weakly impressed, continuous transverse arch; setae of anterior pronotal angles placed in the angle (Part) *Altica* Fabricius

[There are 10 species of this genus in the SDSU H.C. Severin insect collection. *A. subplicata* is the most common species collected statewide and is associated with willows (*Salix* spp.); on some hosts over ten thousand individuals can be observed on a single branch. The species in North America are in need of a taxonomic review.]

8' Elytra regularly punctate-striate9

9 Elytra pubescent10

9' Elytra glabrous (apical margin occasionally with a few setae) 11

10 Prebasal transverse pronotal impression laterally interrupted by short longitudinal impressions(Part) *Epithrix*

[Associated with plants of the family Solanaceae. *E. cucumeris* (Harris) has been collected from *Solanum nigrum* in South Dakota.]

10' Prebasal transverse pronotal impression not laterally interrupted by short longitudinal impressions(Part) *Orthaltica* Crotch

[Only a single species, *O. melina* Horn, is in the SDSU H.C. Severin collection from South Dakota.]

11 Pronotum with prebasal transverse impression12

11' Pronotum lacking prebasal transverse impression but having pair of short, lateral, basal longitudinal sulci*Mantura* Stephens

[Only a single species, *M. floridana* Crotch, is in the SDSU H.C. Severin collection from South Dakota.]

12 Prebasal transverse pronotal impression laterally interrupted by short longitudinal impressions13

12' Prebasal transverse pronotal impression not laterally interrupted by short longitudinal impressions(Part) *Orthaltica* Crotch

13 Color shining black or dull yellow-brown without metallic luster(Part) *Epithrix* Foudras

13' Color metallic green, blue, purple, bronze; or dull yellow-brown with faint green luster along suture near scutellum*Crepidodera* Chevrolat

[Only a single species, *C. nana* (Say), is in the SDSU H.C. Severin insect collection; it is a common species occurring statewide on *Salix*.]

14 Elytra regularly punctate-striae15

14' Elytra impunctate, or very faintly punctate-striate, or with punctures confused16

15 Middle and posterior tibiae with corbel*Chaetocnema* Stephens

[There are 12 species of *Chaetocnema* in the SDSU H.C. Severin insect collection. Three well-known species, *C. confinis* Crotch (sweetpotato flea beetle), *C. pulicaria* Melsheimer (corn flea beetle), and *C. ectypa* Hom (desert corn flea beetle) have been collected by sweeping in areas where leafy spurge is found. The two com infesting species are restricted to the eastern portion of South Dakota, the sweetpotato flea beetle has been collected statewide].

15' Middle and posterior tibiae without corbel*Glyptina* Le Conte

[There are five species of *Glyptina* in the SDSU H.C. Severin insect collection, all of which may be associated with leafy spurge. The only species found associated with release sites to date has been *G. atriventris* Hom. *G. atriventris* is a common flea beetle on choke cherry (*Prunus virginiana*) in South Dakota].

16 Anterior coxal cavities open17

16' Anterior coxal cavities closed*Systema* Chevrolat

[There are five species of *Systema* in the H.C. Severin insect collection. Two species, *S. elongata* (F.) (elongate flea beetle) associated with cocklebur (*Xanthium*) and *S. blanda* (Melsheimer) (palestriped flea beetle), are commonly found in pastures that contain leafy spurge. The species *S. variata* Schaeffer, found statewide, is the most common member of the genus *Systema* in the Severin collection.]

17 Basal posterior tarsal segment shorter than one-half length of hind tibia18

17' Basal posterior tarsal segment long (greater than one-half length of hind tibia)
.....*Longitarsus* Suffrian

[There are six species of *Longitarsus* in the SDSU H.C. Severin insect collection. Only *L. testaceous* Melsheimer and *L. melanurus* Melsheimer are commonly collected in South Dakota.]

18 Longer than three mm.19

18' Shorter than three mm.20

- 19 Frons with prominent calli surmounted by distinct sulci, frons unevenly punctate; pronotum pale or dark; elytra without vittae; elytra impunctate to vaguely punctate-striae; frontal calli small and separated by faint line*Aphthona* Chevrolat

[Before the introduction of the recent species of *Aphthona*, only the single species *A. texana* (Crotch) had been collected in South Dakota. *A. texana* has been collected as far west as Wall, and numerous collections have been made in the southeastern portions of South Dakota. Host data are not recorded, all material in the H.C. Severin insect collection is from sweeping.]

- 19' Frons calli reduced, lacking distinct superior sulci, frons punctate; pronotum completely dark; elytra entirely dark, or each with sinuous vitta, or vittae reduced to two spots
.....*Phyllotreta* Stephens

[There are 11 species of *Phyllotreta* in the H.C. Severin insect collection. The species *P. cruciferae* Goeze is the most commonly found member of this genus in South Dakota; some of its hosts include cabbage, turnip, spinach, and potatoes. Other well-known species in South Dakota are the striped flea beetle (*P. striolata* (F.)), horseradish flea beetle (*P. armoraciae* (Koch)), and the western black flea beetle (*P. pusilla* Horn).]

- 20 Elytra without vittae21

- 20' Elytra vittae(Part)*Disonycha* Chevrolat

[There are eight species of *Disonycha* in the H.C. Severin insect collection. The most common species in South Dakota is *D. triangularis* (Say); other common species include *D. xanthomelas* (Dalman) (spinach flea beetle), *D. alternata* (Illiger) associated with willow (*Salix*), *D. uniguttata* (Say), *D. procera* Casey and *D. punctigera* LeConte.]

- 21 Anterior tibiae without apical spurs22

- 21' Anterior tibia with apical spurs; prebasal pronotal impression of a single weakly impressed, continuous transverse arch; setae of anterior pronotal angles placed in the angle
.....(Part) *Altica* Fabricius

- 22 Pronotum widest at middle, mesosternum truncate at apex between middle coxae
.....*Luperaltica* Crotch

[There is a single species, *L. nigripalpis*, in the SDSU H.C. Severin insect collection; this species has only been collected once, from Elk Point, South Dakota, and can be considered rare.]

- 22' Pronotum widest at base, mesosternum emarginate at apex between middle coxae
.....(Part) *Disonycha* Chevrolat

Aphthona nigriscutis

Original distribution: Described from Hungary (Julien, 1987). Collected from release site near Brandon, Manitoba, and released at multiple sites in South Dakota.

Distribution in U.S. as biological agent: Colorado, Idaho, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Washington, Wyoming.

Color: Dorsally yellow-rust, monochromatic with black mesoscutellum; elytral suture not darkened; female antennae bicolored, apical segments darker than scape, pedicel, and first three funicle segments; male antennae lightly bicolored, apical segments not as dark as in female; length 2.2 to 2.8 mm, male normally in lower size range.

Antennae: Antennae filiform with 11 segments; female scape, pedicel, and first four funicle segments lighter in color than last four funicle segments; scape larger than first funicle segment; pedicel thicker than funicle segments two through five; funicle segments two and three subequal in length, elongated, wider at apex and narrowing toward base; funicle segments four through eight wider than funicle segments two and three; apex of last funicle segment narrows; all segments with numerous setae, each funicle segment with a pair of large setae located on outer and inner margin of upper apex of each funicle; male antennae similar to female.

Mouthparts: Mandibles with three denticles; molar with small acorn-like tubercles on inner surface; labrum with two curved sclerites (tormae); setae cover lower section; cardo without toe or rounded keel, ends in rounded knob-like structure, widest at junction with stipes, single large seta located on outer margin; center area with rounded depression, seven microsetae surrounding rounded depression; stipes with five small setae and a single large seta, dispersed among small setae are seven microsetae; maxillary palpi four-segmented,

covered with numerous setae of various sizes; last segment pointed; galea with six small setae on base; numerous elongated tubular structures on apex; lacinia with brush-like structures on apex; labium with three-segmented labial palpi; first segment without setae; second segment with five setae of various sizes; last segment with numerous microsetae, a single large seta located below apex; ligula apex with long setae, four setae on ventral surface and four rounded pore-like structures; prementum with large median region bordered by dark lateral carina, center area with eight setae, carina upper region curves toward base of labial palpal base with paired setae on apex; postmentum divided by prementum with a single seta located on ventral surface.

Mesothorax-metathorax: Mesothorax reduced, scutellum plated, lobe-like and pointed toward metathorax, sclerotized (darkened) with 26 microsetae, and row of setae along anterior margin; scutum plated with numerous tube-like microsetae forming a vertical band near notal wing process; metathorax notum with median groove surrounded by raised carina, sloping ridge of carina sclerotized without setae; scutum with row of setae near posterior notal wing process similar to those located on mesoscutum; metascutum and metascutellum with numerous tube-like microsetae scattered on outer margins; scutellum divided into two sections by paired median carina and curved shaped carina; postnotum (postscutellum) a narrow plate; some plating on scutum, triangular ridge on under surface joining anterior carina forming a common border; postphragma well developed.

Elytra-hindwing: Elytra ovoid, apex broadly rounded; inter-row spaces with erect hairs; subapical suture with pit-like depressions; elytral disk punctation not placed in rows, scattered over disk; elytra suture darkened, lateral rim present, angles with aristate pores; hindwing with prominent costa, subcosta,

radius (radical sector, radial cell), medial and cubital veins; folded at apex with numerous microsetae.

Legs: First and second pair of legs with elongated femur, slender tibia, and four-segmented tarsi; first tarsal segment on legs one and two only slightly longer and thicker than second tarsal segments; third tarsal segment lobe-like with median groove on ventral surface; fourth tarsal segment longer and narrower than other tarsal segments, with claws; tibia longest segment on all legs; prothoracic tibia with spur and associated comb-like row of setae (13) at junction of tarsi; prothoracic femur wider than tibia, trochanter with numerous acorn-like setae, coxa with well developed spur; mesothoracic tibia similar in structure to prothoracic tibia, with spur and comb-like setae at junction of tarsi (12), femur, trochanter, and coxa similar to prothoracic leg; metathoracic tibia with spur, spur larger than spur on first and second tibia, tibia grooved, with comb-like setae on both dorsal and ventral surface; there are setae that have a tubular-like base, these are spaced far apart and terminate at end of ventral groove; hind femur with inner saltatorial apodema, with scattered setae on dorsal surface; trochanter small with acorn-like setae; coxa elongated with blunted spur.

Abdomen: *Strena* completely darkened, fifth segment of female rounded, with a median longitudinal impression, fifth segment of male with a median lobe and dark median linear impression that can be seen as a dark line, both the median lobe and median linear impression are good characters to separate males from females; sternites of both sexes with first and fifth sternites wider than other sternites, all sternites with numerous setae of various sizes; tergites with seven segments with numerous setae of various sizes, these arranged in precise clusters either across the center of the sternite or in the center on each side of the median line on segments one through five; segments six and seven with setae larger and scattered over entire sternite, sternites six and seven much longer than sternites one through five, rounded at posterior

margin. The arrangement of the clusters differs from *A. cyparissiae* and *A. flava*.

Female reproductive structures, spermatheca-styli: Spermathecal capsule with sclerotized wall; spermatheca outer surface with numerous spermathecal folds covering receptacle, folds prominent from ring collar, fading toward spermathecal duct attachment; spermathecal pump a closed tube with prominent folds on distal end, these folds fading, leaving an area devoid of folds; receptacle longer than wide; spermathecal gland duct an elongated tube with thick borders, with a club-shaped gland valve, gland valve with small tube extending from center of gland valve to spermathecal gland; spermathecal gland duct extends beyond gland valve, much smaller in diameter in this region; styli paired, elongated, joined at anterior portion, nine setae on distal portion of each stylus, apex sclerotized, each stylus with a sclerotized section on anterior portion of each stylus, sclerotization extends in a narrow band and joins sclerotized area located at apical region of stylus; each stylus with eight circular pores scattered from apex to anterior region and acorn-shaped setae located along outer and inner margins (number differs between styli); eighth sternite with distal portion broom-shaped with six large setae along upper border, upper border without sclerotization, sclerotization covers rest of sclerite, rod-like stem with two sections, sclerotization similar to lower section of broom-like sclerite, membrane covers entire sternite.

Male reproductive structures. aedeagus: Aedeagus lanceolate with rounded flanges at basal foramen, apical orifice small; apex tapering to a blunt point without groove on dorsal surface in median line region, without sclerotized tooth-like projection; median dorsal plate not well delineated; aedeagus with numerous micropores scattered over apical section; whole aedeagus wrapped in a thin membrane; tegmen Y-shaped with fairly broad lateral forks curving upward and with broad strut tapering toward a truncate tip and roundly elevated median line.

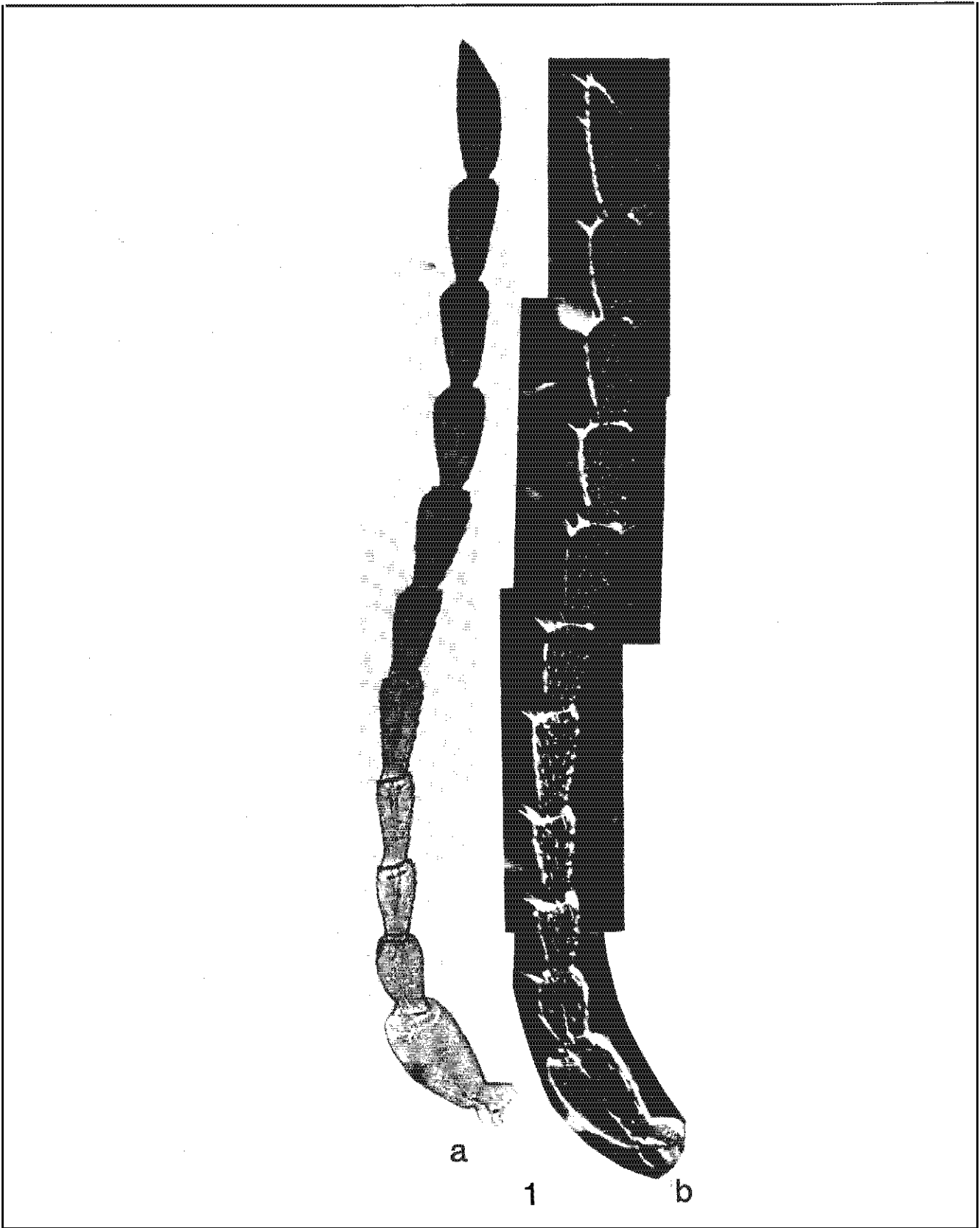


Figure 1. *Aphthona nigriscutis* female. a, antennae (plain light); b, antennae (phase light).

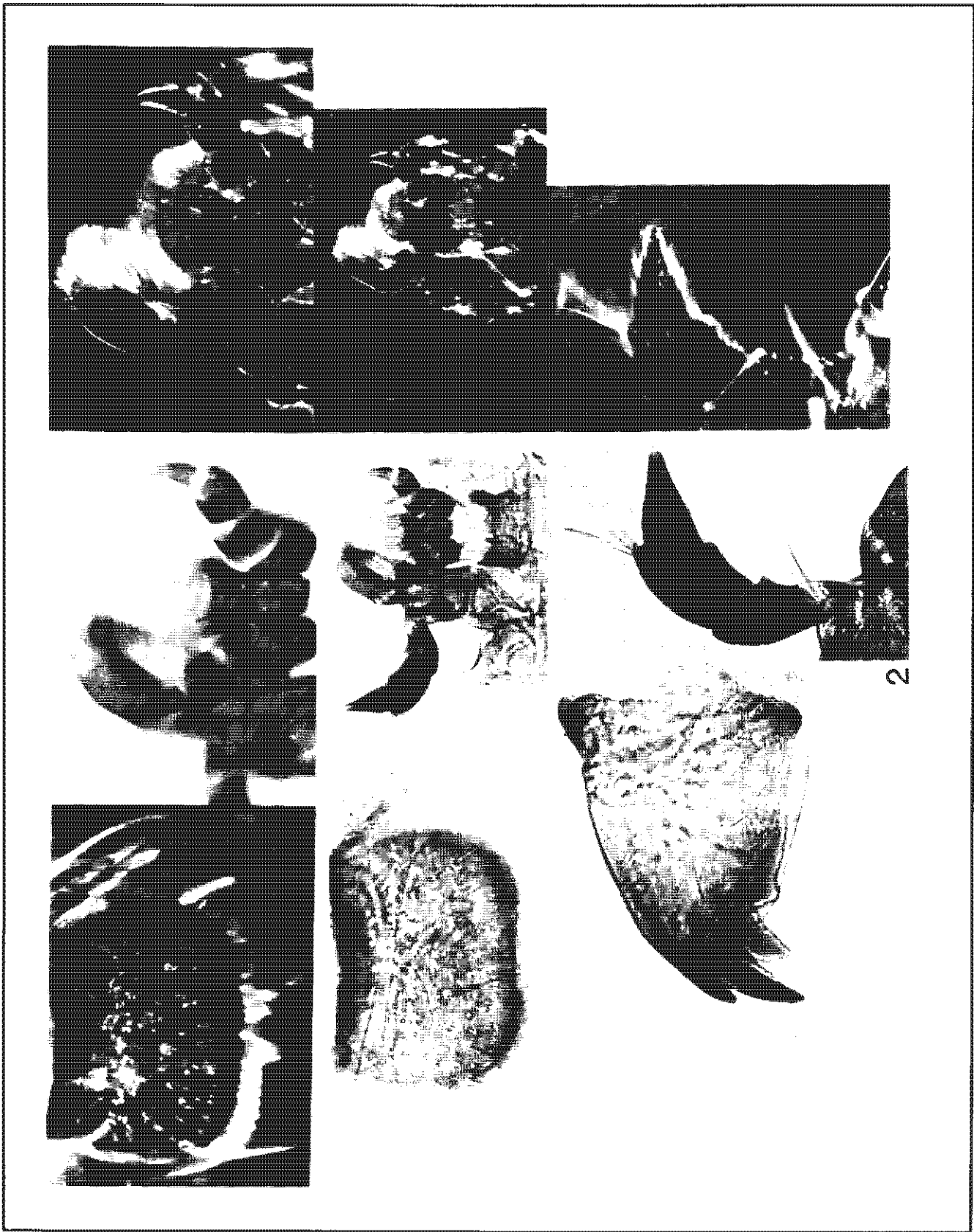


Figure 2. *Aphthona nigriscutis* male, mouthparts.

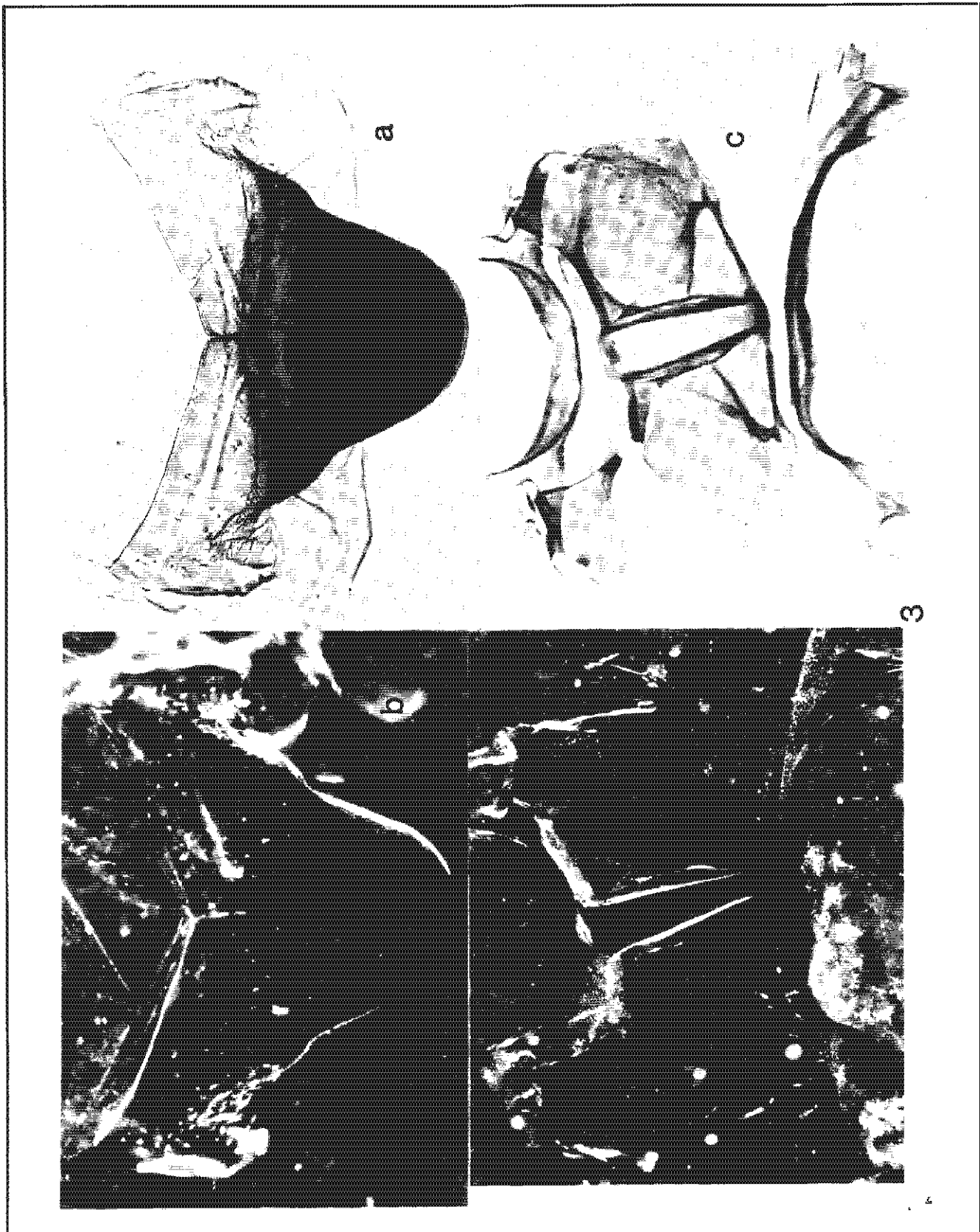


Figure 3. *Aphthona nigriscutis* female. a, mesoscutum and mesoscutellum (plain light), b, mesoscutum and mesoscutellum (phase light); c, metascutum and metascutellum (plain light); d, metascutum and metascutellum (phase light).



Figure 4. *Aphthona nigriscutis* male. a, mesoscutum and mesocutellum (plain light, high power); b, mesoscutum and mesocutellum (phase light, high power); c, metascutum, metascutellum (plain light, low power); d, metascutum, metascutellum (phase light, low power).

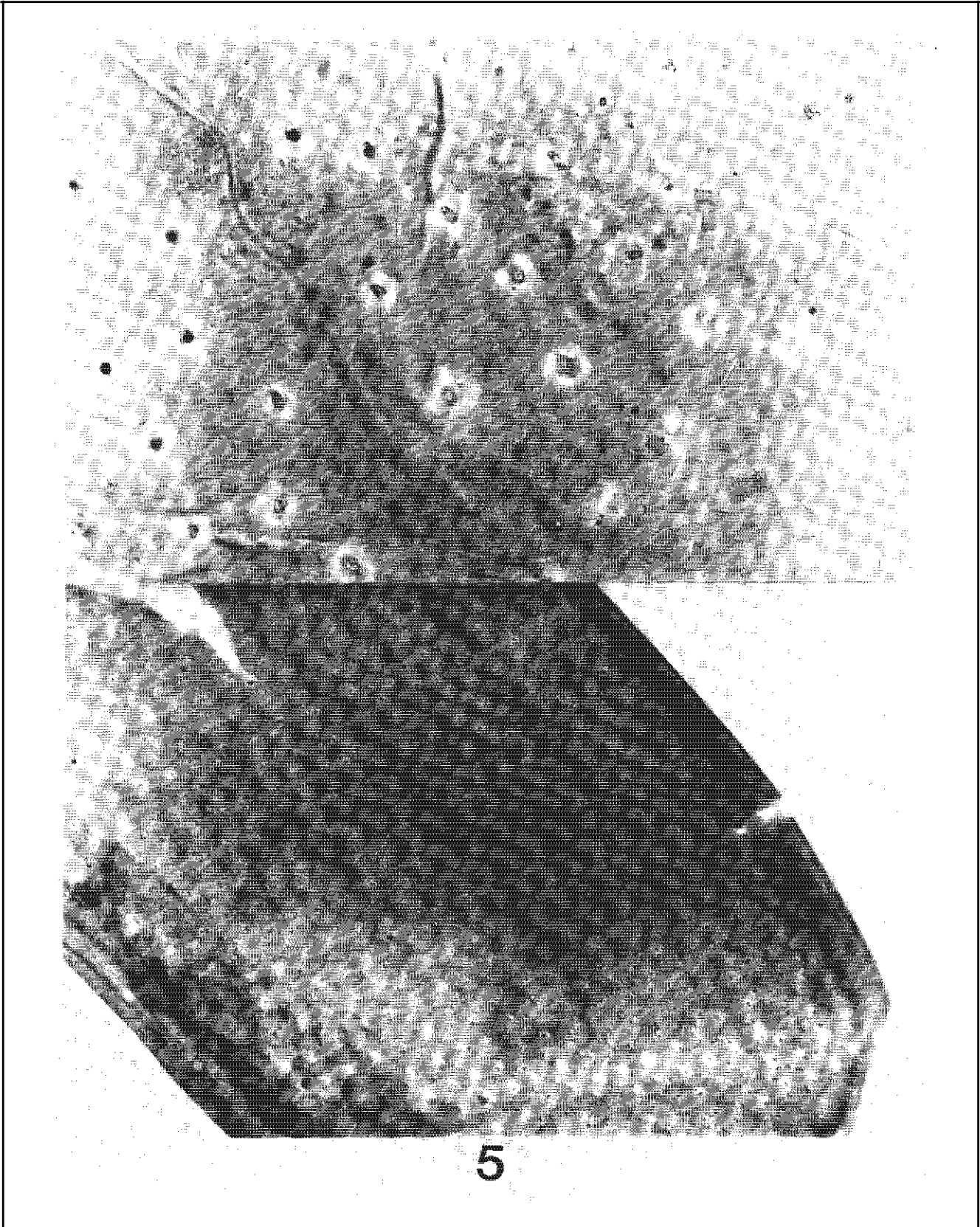


Figure 5. *Aphthona nigriscutis* female, elytra, showing inter-row spaces, erect hairs.

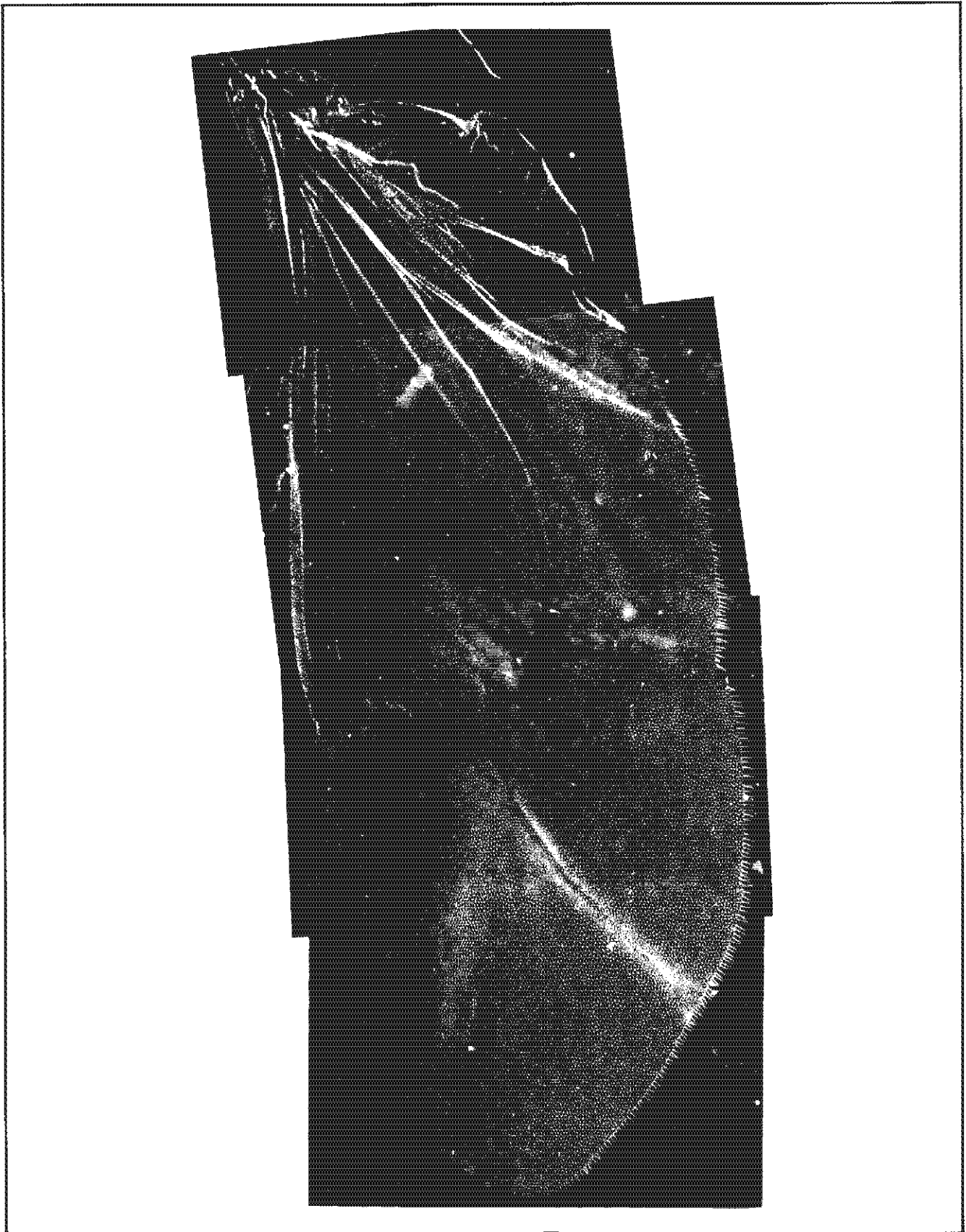


Figure 7. *Aphthona nigriscutis* hindwing (unfolded).

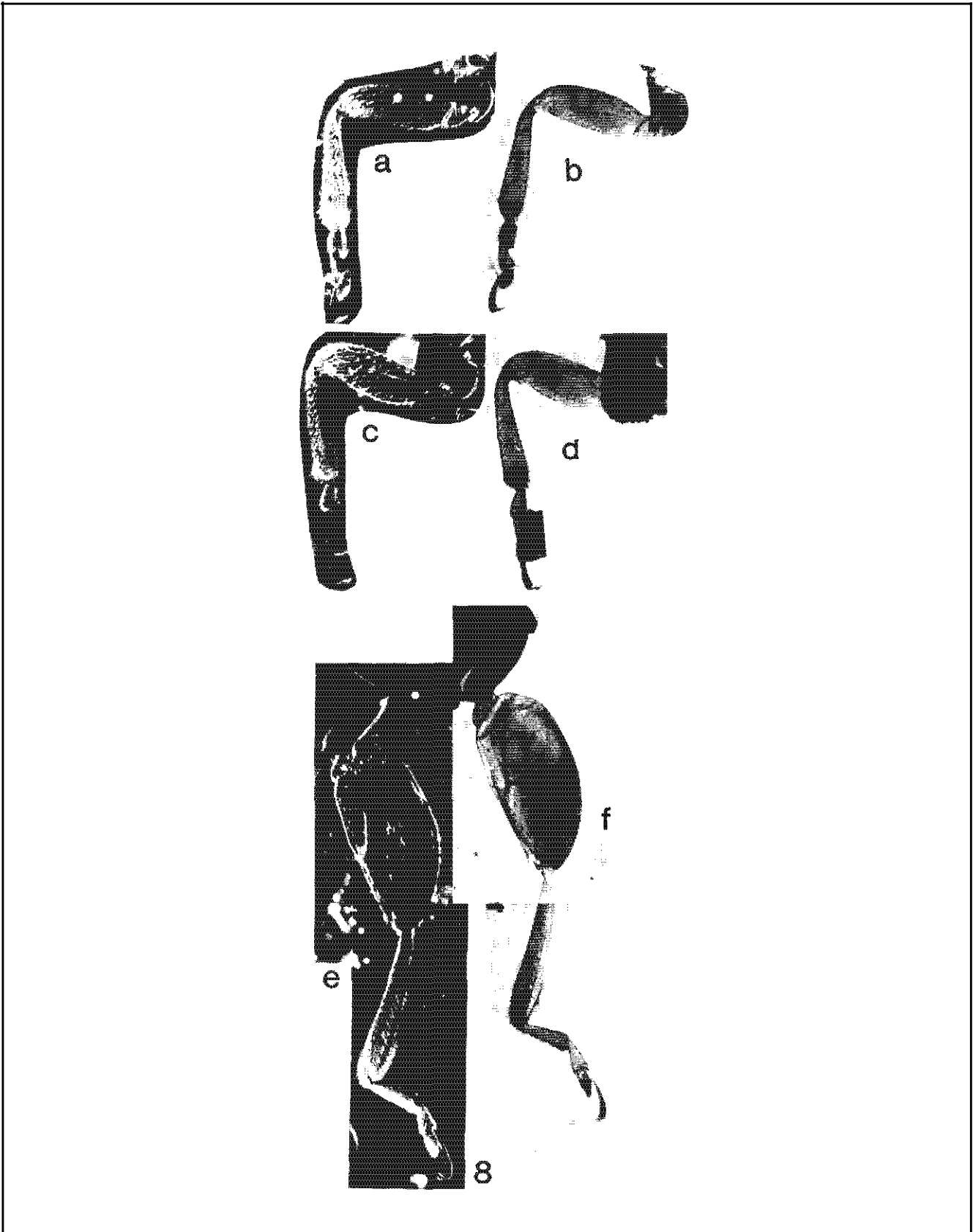


Figure 8. *Apthona nigricutis* female. a, first leg (phase light); b, first leg (plain light); c, second leg (phase light); d, second leg (plain light); e, third leg (phase light); f, third leg (plain light).

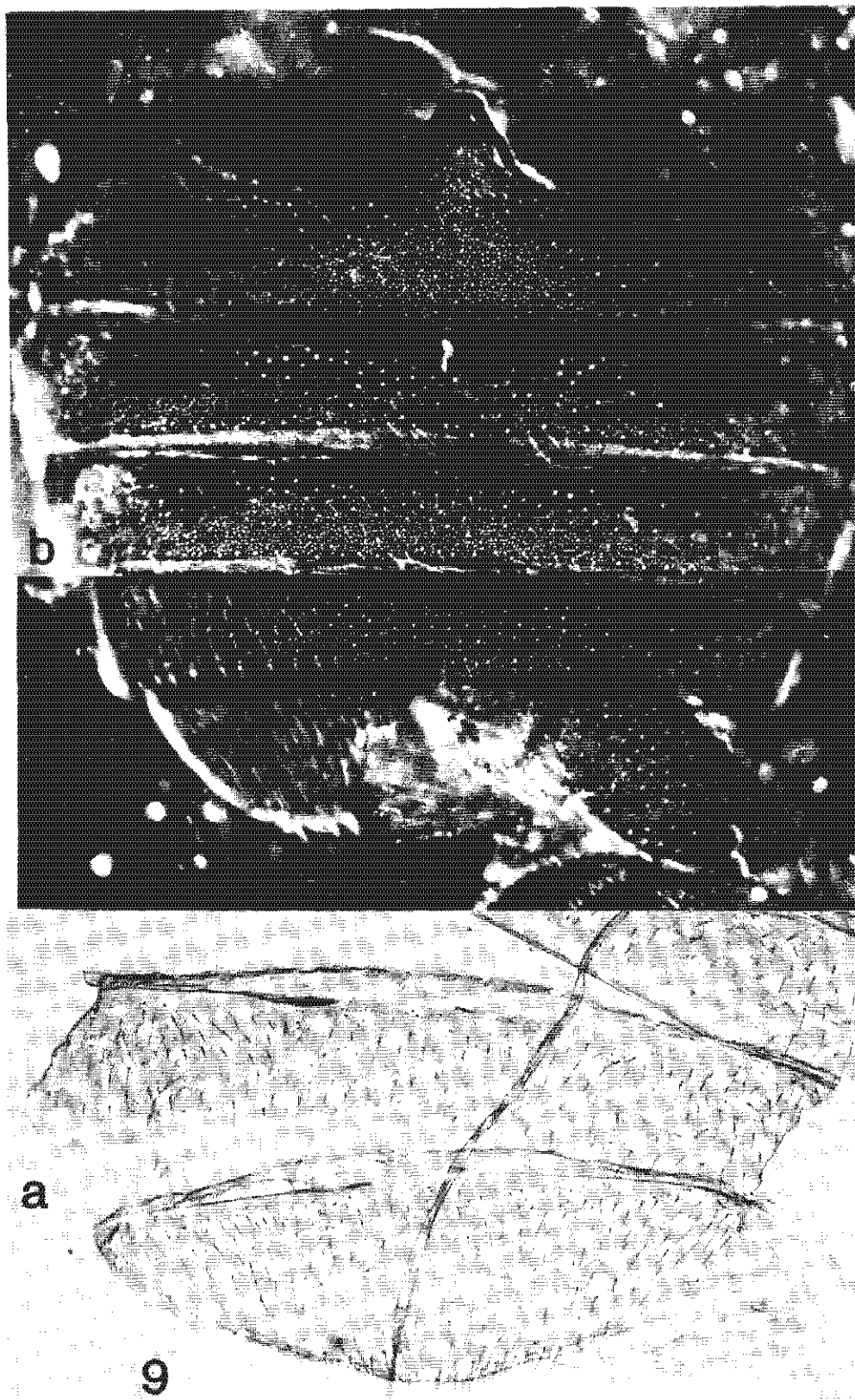


Figure 9. *Aphthona nigriscutis* female, abdomen. a, last two segments of sternum (plain light); b, all segments of sternum (phase light).



Figure 10. *Aphthona nigriscutis* male, abdomen. a, tergites showing clusters.

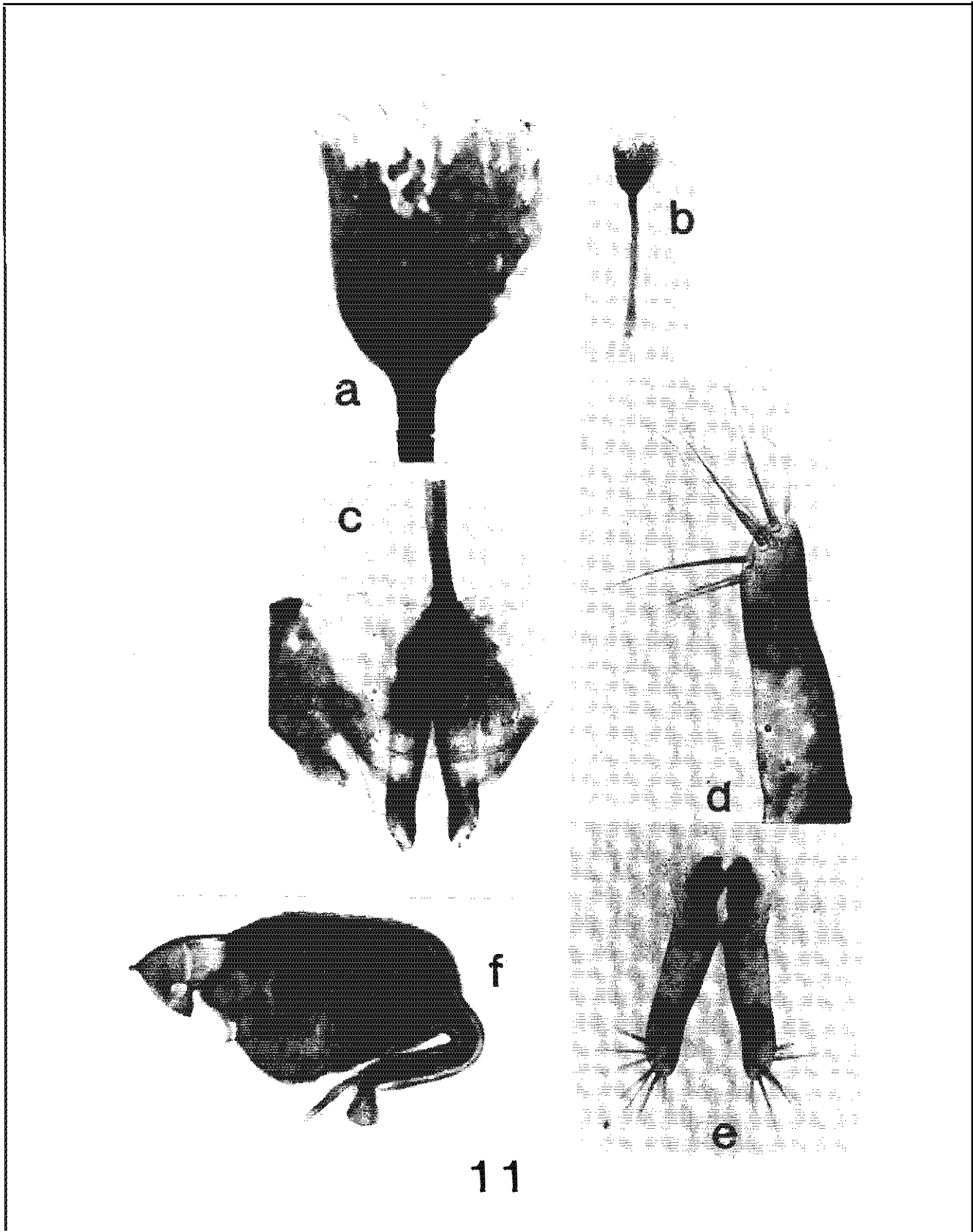


Figure 11. *Aphthona nigriscutis* female. a, eighth sternite (high power showing broom shape); b, eighth sternite (low power) showing complete sternite; c, eighth sternite overlaying stylets; d, single stylet showing stylet setae and circular pores (high power); e, paired stylets (low power); f, spermatheca.

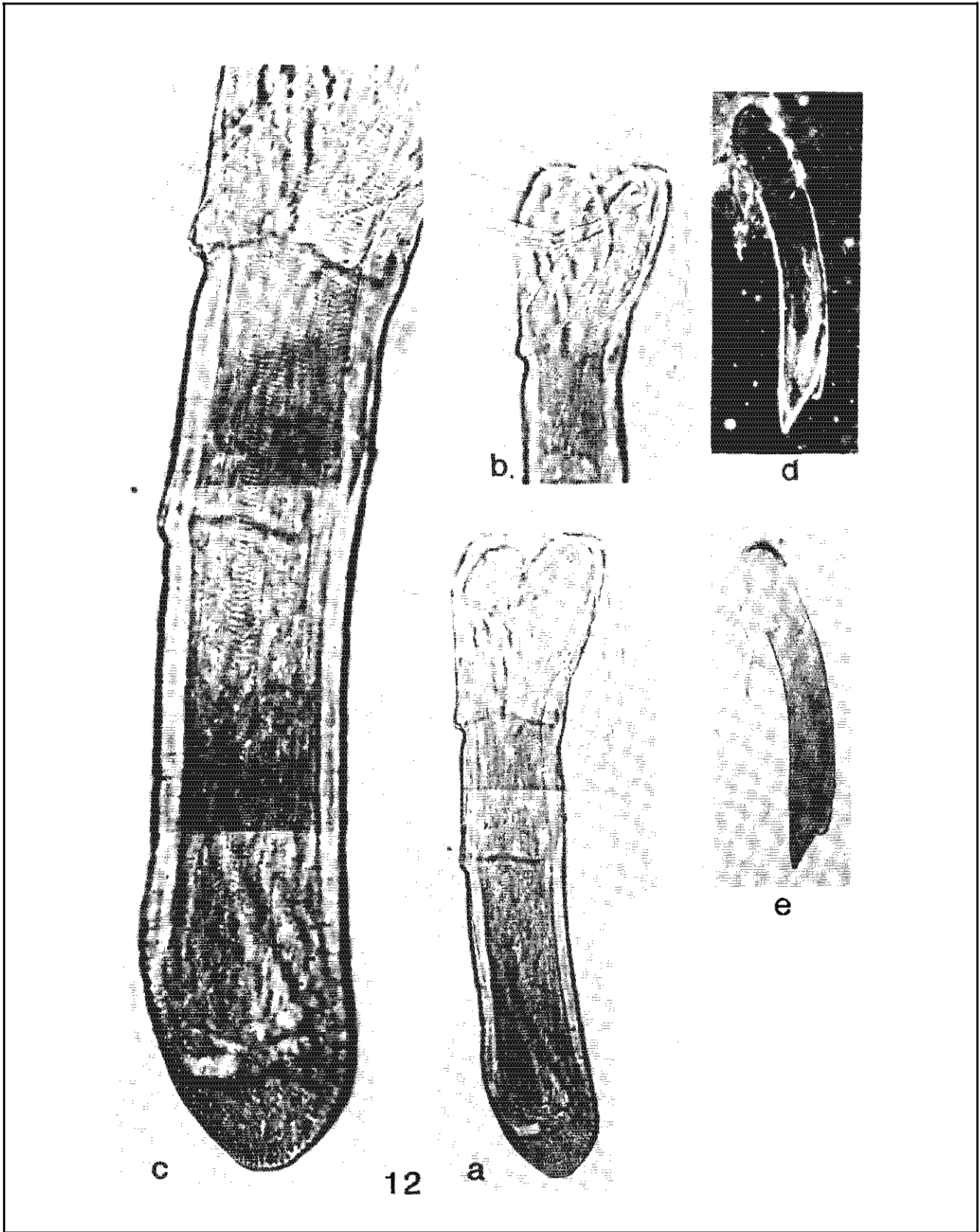


Figure 12. *Aphthona nigriscutis* male, aedeagus. a, whole aedeagus; b, Y-shaped tegmen; c, aedeagus (high power) showing rounded truncate tip and pores; d, aedeagus (phase light) lateral view; e, aedeagus (plain light) lateral view.

Aphthona cyparissiae

Original distribution: Described from Austria, Hungary, and Switzerland (Julien, 1987). Collected from release site near Weyburn, Saskatchewan, and released at multiple sites in South Dakota.

Distribution in U.S. as biological agent: Colorado, Idaho, Montana, Minnesota, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Wisconsin.

Color: Dorsally reddish-yellow, monochromatic with mesoscutellum lightly darkened in posterior region, not as dark as in *A. nigriscutis*, darker than *A. flava*; female antennae bicolored, apical segments darker than scape, pedicle, and first three funicle segments; male antennae without contrasting bicolor condition; length 2.2 to 2.7 mm, male normally in lower size range.

Antennae: Antennae filiform with 11 segments; female scape, pedicle, and first three funicle segments lighter in color than last five funicle segments; scape larger than first funicle segment; pedicle smaller and thicker than funicle segments two and three; funicle segments two through four subequal in length and width, elongate, widest at apex narrowing at base; funicle segments five through nine subequal in length, wider and darker than funicle segments two through four; last funicle segment with apex narrowing to a point; each funicle segment with paired setae at apex, these larger than other funicle segment setae; all antennal segments with numerous scattered setae, hairy in appearance; male antennae similar to female.

Mouthparts: Mandibles with three denticles; molar with small acorn-like tubercles on inner surface; labrum with two curved sclerites (tormae); apex with 32 blade-like setae, these split into two sections with 16 setae on each side of labrum apex, with a single long seta positioned on lateral margin of labrum at end of row of blade-like setae; cardo with elongat-

ed toe and rounded heel, widest at junction with stipes, with single large seta on outer margin, rounded clear area where muscles attach in upper inner region; microsetae scattered over upper region of cardo; stipes with five small setae and a single large seta; stipes with several microsetae in region of large seta; maxillary palpi four-segmented, covered with numerous setae, last segment pointed; galea with five small setae on base, with numerous elongated tubular structures on apex; lacina apex with long setae; labium with three-segmented labial palpi, first segment with single small seta, second segment with seven setae, last segment with numerous microsetae; ligula with four tubular structures in center, apex with fine pointed spine-like structures; prementum with large medial carina between labial palpi, carina with paired setae located on upper apex; prementum with a total of 10 setae, area between carina with numerous microsetae; postmentum rectangular, inner borders with single microseta.

Mesothorax-metathorax: Mesothorax reduced, scutellum larger than scutum, plated, lobe-like, darkened like *A. nigriscutis* but lighter; microsetae scattered over scutellum; scutum with row of microsetae forming vertical band near notal wing process, divided by median line, narrower at median line area; metathorax notum with median groove surrounded by raised carina, groove sclerotized and darkened, lighter than scutum of *A. nigriscutis*, much darker than scutum of *A. flava*; scutum larger than scutellum, with row of setae near posterior notal wing process similar to row of setae on mesoscutum; metascutum and metascutellum with numerous tube-like microsetae scattered on outer margins; metascutellum divided into two sections by carina; postnotum (postscutellum) a narrow plate; mesoscutum and metascutum plated in some sections; triangular ridge on undersurface open at apex, well developed, connected to posterior carina; postphragma well developed; male with mesoscutellum lighter in color than female, otherwise similar to female.

Elytra-hindwing: Elytra ovoid, apex broadly rounded, inter-row spaces with erect hairs, rows of punctation on disk coalesce; subapical suture and median suture each with pit-like depressions; elytral disk with coalescent punctation scattered, not forming distinct rows; elytral suture darkened; lateral rim present, angles with aristate pores; hindwing with prominent costa, subcosta, radius (radial sector, radial cell), medial and cubital veins; hindwing folded at apex under elytra, covered with microsetae.

Legs: First and second pair of legs with elongated femur, slender tibiae and four-segmented tarsi; first tarsal segment longer, thicker than other tarsal segments on legs one and two, on third pair of legs first tarsal segment almost twice as long as first tarsal segment on legs one and two; third tarsal segment lobe-like with median groove on ventral surface on all legs; fourth tarsal segment narrower than other tarsal segments, with claws; tibia longest segment on all legs; prothoracic tibia with spur and associated comb-like row of setae (18) at junction of tarsi; prothoracic femur wider than tibia, trochanter with numerous acorn-like setae; mesothoracic tibia similar in structure to prothoracic tibia, with spur and comb-like setae at junction of tarsi (17), femur, trochanter, and coxa similar to prothoracic leg; metathoracic tibia with spur, spur larger than spur of first and second tibia, tibia grooved, with comb-like setae on both dorsal and ventral surfaces, beyond comb-like setae there are setae that have a tubular-like base, these spaced far apart and terminate at end of ventral groove; hind femur with inner saltatorial apodema, with scattered setae on dorsal surface; trochanter small with acorn-like setae; coxa elongated, with blunted spur.

Abdomen: Sterna completely darkened, fifth segment of female rounded with median longitudinal impression; fifth segment of male with median lobe and dark median linear impression seen as a dark line; lobe area lightly sclerotized, appearing as a white spot; sternites of both sexes with first and fifth sternites larger than other sternites; all sternites with numerous setae of various sizes; tergite with seven segments with numerous setae of various sizes, these arranged

in precise clusters, either across center of tergite or in center of each side of median line; tergite seven with setae larger than on other tergites, setae scattered over entire tergite, larger and longer than other tergites, rounded at posterior margin; arrangement of clusters on tergites differs from clusters on *A. nigricutis* and *A. flava*.

Female reproductive structures, spermatheca-styli: Spermathecal capsule with sclerotized wall; spermatheca outer surface with numerous spermathecal folds covering receptacle, folds deep and prominent at ring collar, becoming shallow and appearing to be absent near spermathecal duct attachment; spermathecal pump a closed tube with prominent folds on distal end, these folds fading, leaving an area devoid of folds; receptacle longer than wide; spermathecal gland duct and elongated tube with thick borders, with a club-shaped gland valve; gland valve with small tube extending from center of gland valve to spermathecal gland; spermathecal gland duct extends beyond gland valve, much smaller in diameter beyond gland valve; styli paired, elongated, joined at anterior portion, nine setae on distal portion of each stylus, apex with sclerotized inner border, a larger sclerotized portion located on inner margin of anterior region of both styli; each stylus with circular pores (16 on right styli, 12 on left) scattered from apex toward anterior attachment region; 15 acorn-shaped setae located along outer and inner borders of styli (number differs between styli); eighth sternite with distal portion rounded with sclerotized area divided, with 11 large setae on upper border above sclerotized region; rod-like stem with two sections, not sclerotized; membrane covers entire sternite.

Male reproductive structures, aedeagus: Aedeagus lanceolate with rounded flanges at basal foramen, apical orifice small, apex bifurcate with two rounded lobes, without sclerotized tooth-like projection on inner margin of left lobe; median dorsal plate not well delineated; aedeagus with numerous micropores scattered over apical section; whole aedeagus wrapped in a thin membrane; tegmen Y-shaped with fairly broad lateral forks curving upward and with broad strut tapering toward a truncate tip and roundly elevated in median line.

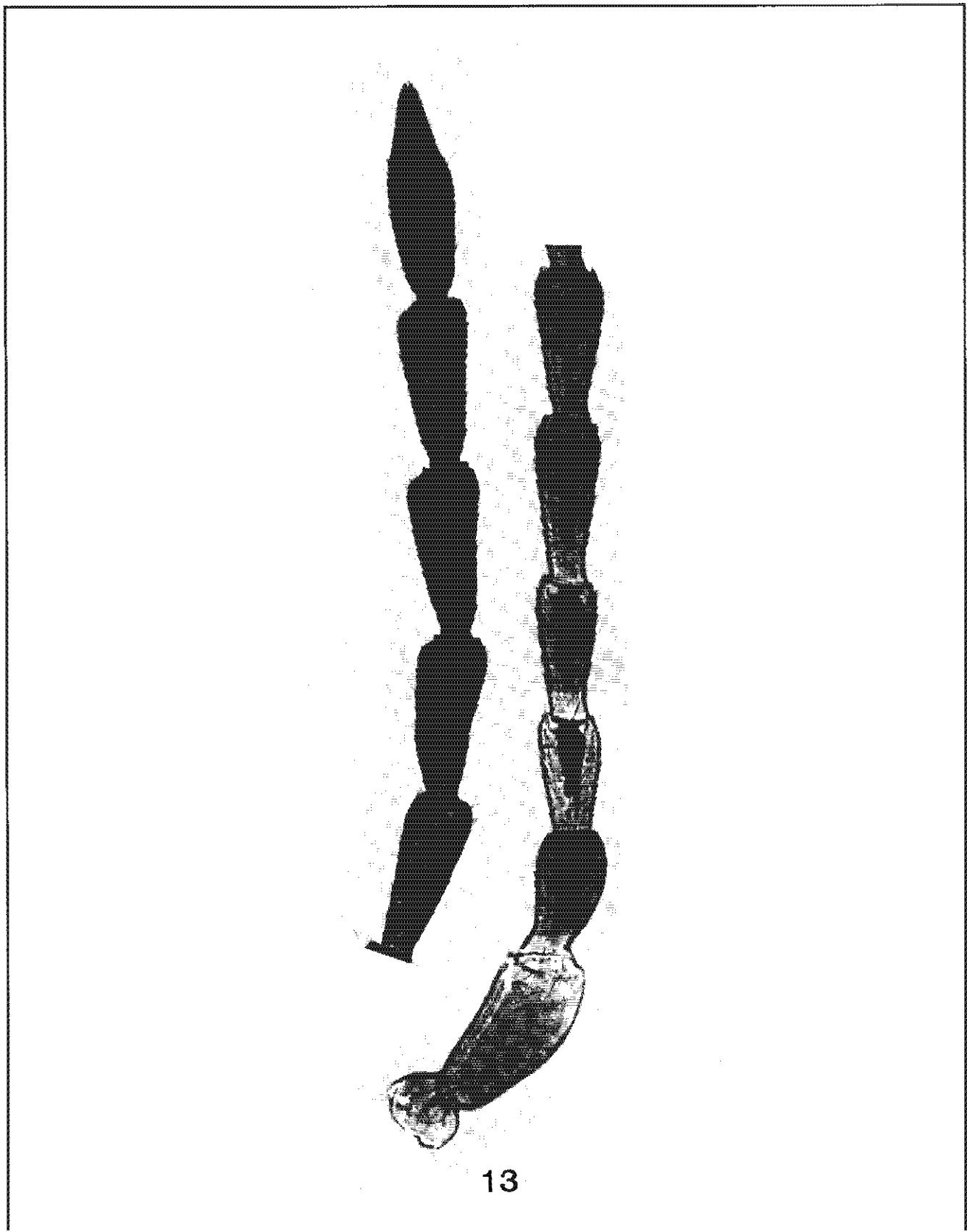


Figure 13. *Aphthona cyparissiae* female. a, antennae (plain light); b, antennae (phase light).

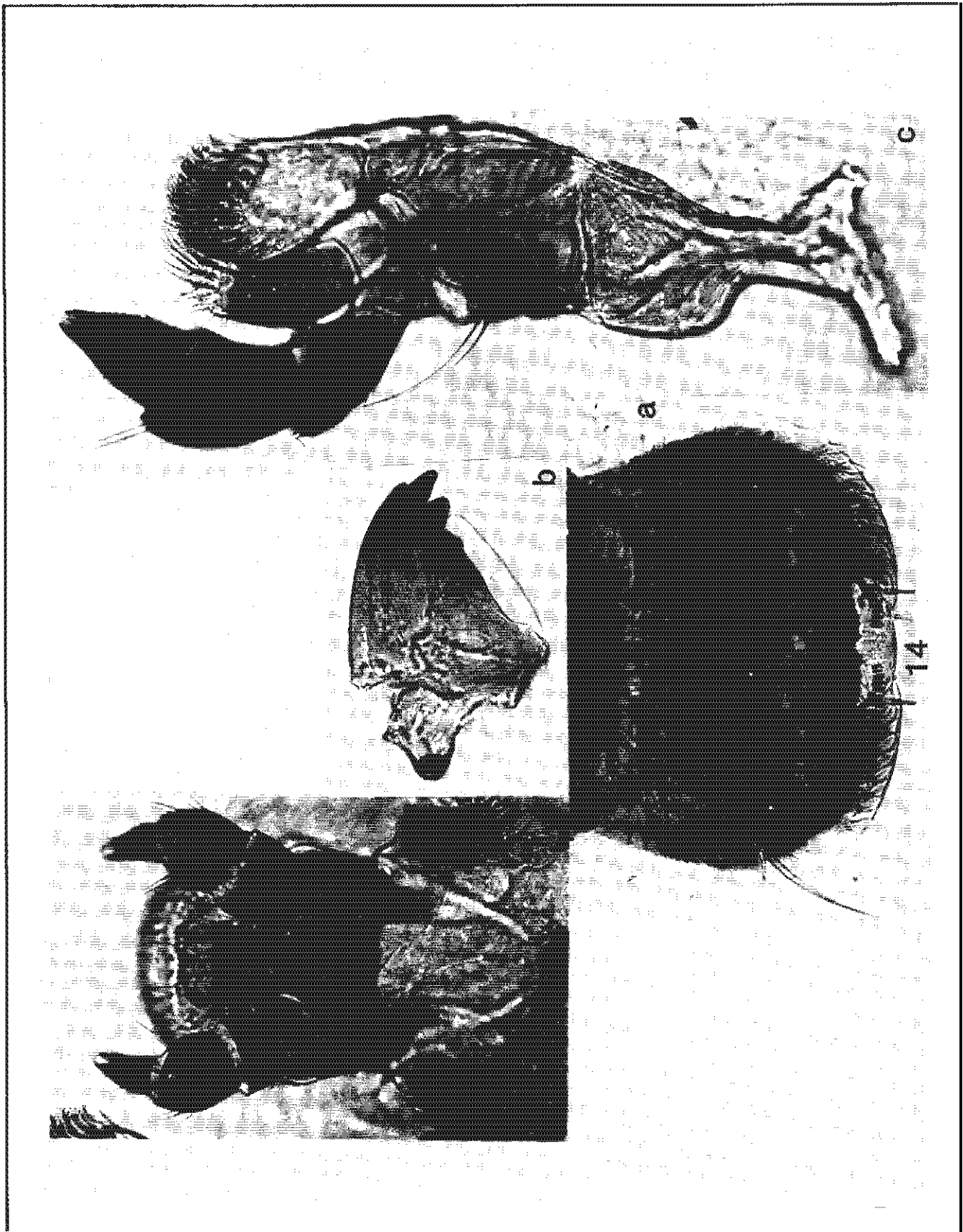


Figure 14. *Aphthona cyparissiae* female. a, labrum; b, mandible; c, maxillae; d, labium.

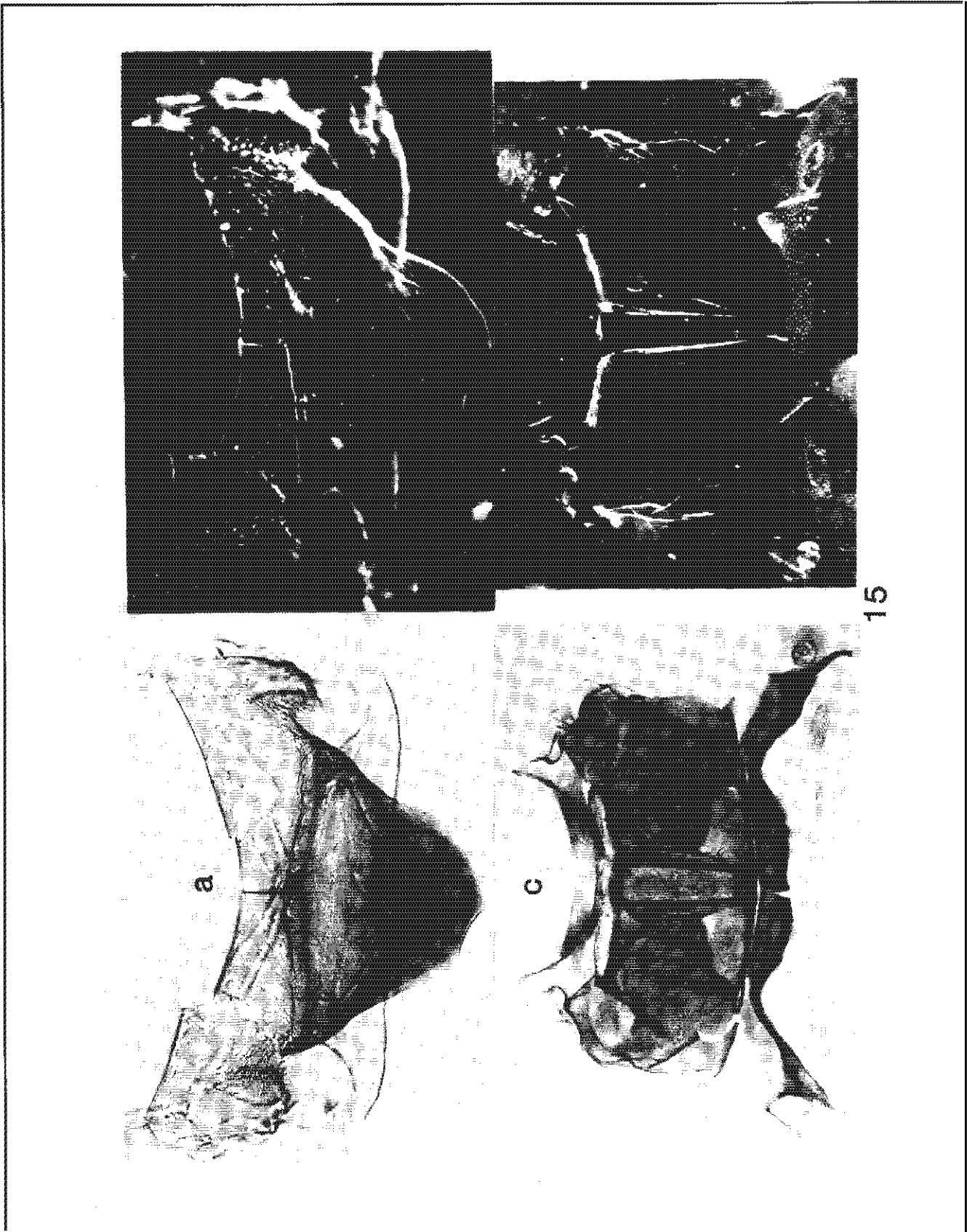


Figure 15. *Aphthona cyparissiae* female. a, mesoscutum and mesoscutellum (plain light); b, mesoscutum and mesoscutellum (phase light); c, metascutum and metascutellum (plain light); d, metascutum and metascutellum (phase light).

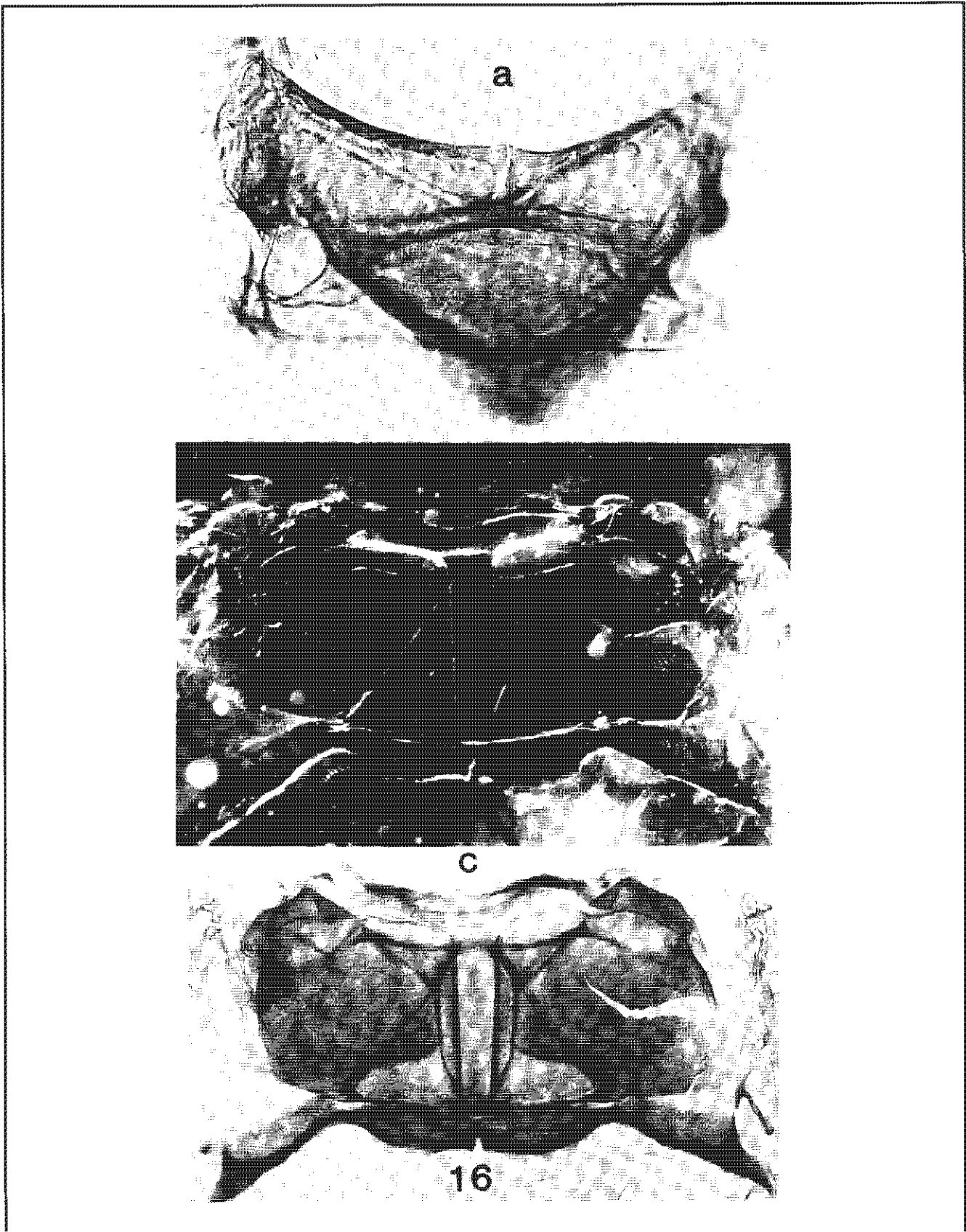


Figure 16. *Aphthona cyparissiae* male. a, mesoscutum and mesoscutellum (plain light); b, metascutum and metascutellum (phase light); c, metascutum and metascutellum (plain light).

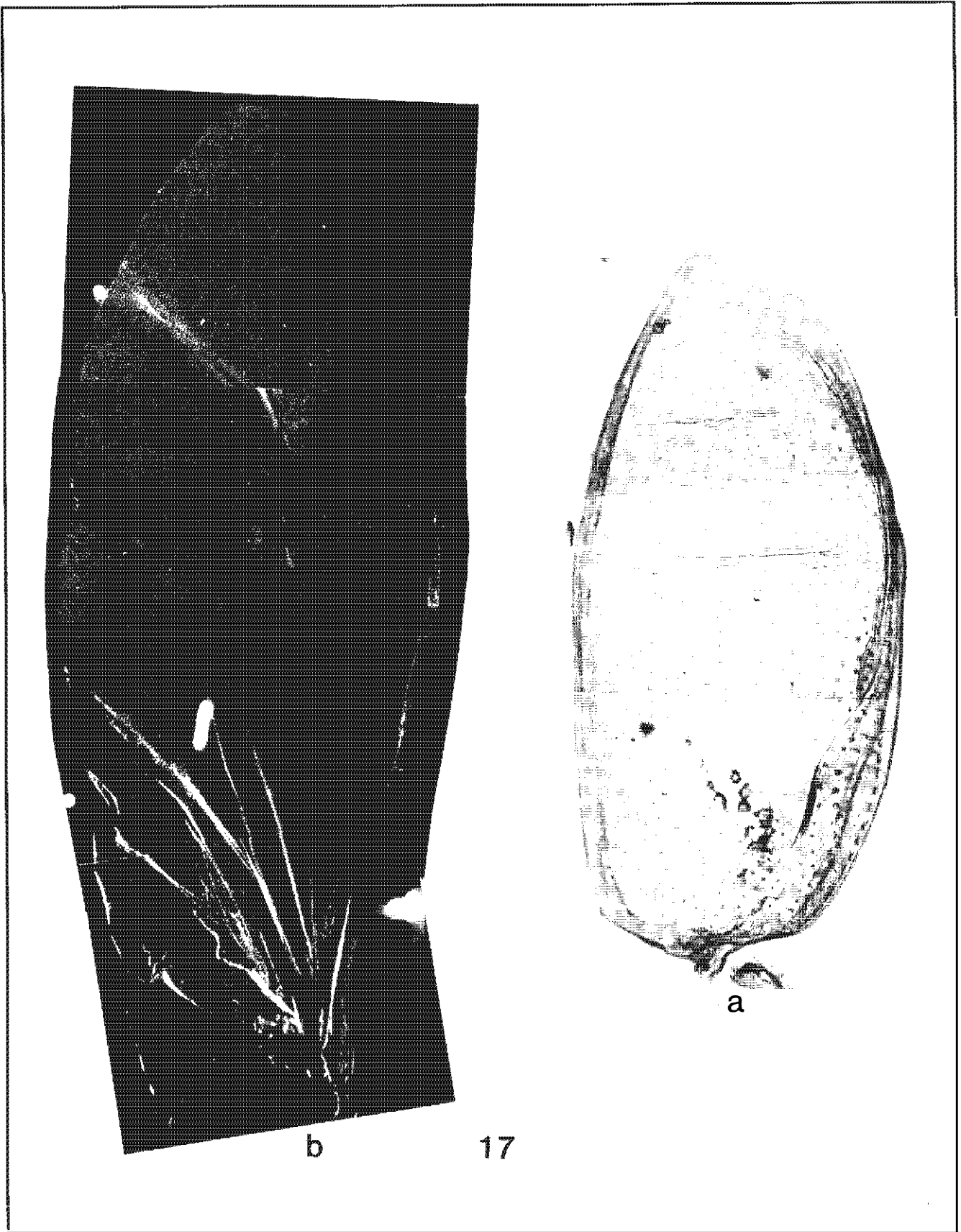


Figure 17. *Aphthona cyparissiae* female. a, elytra; b, hindwing.

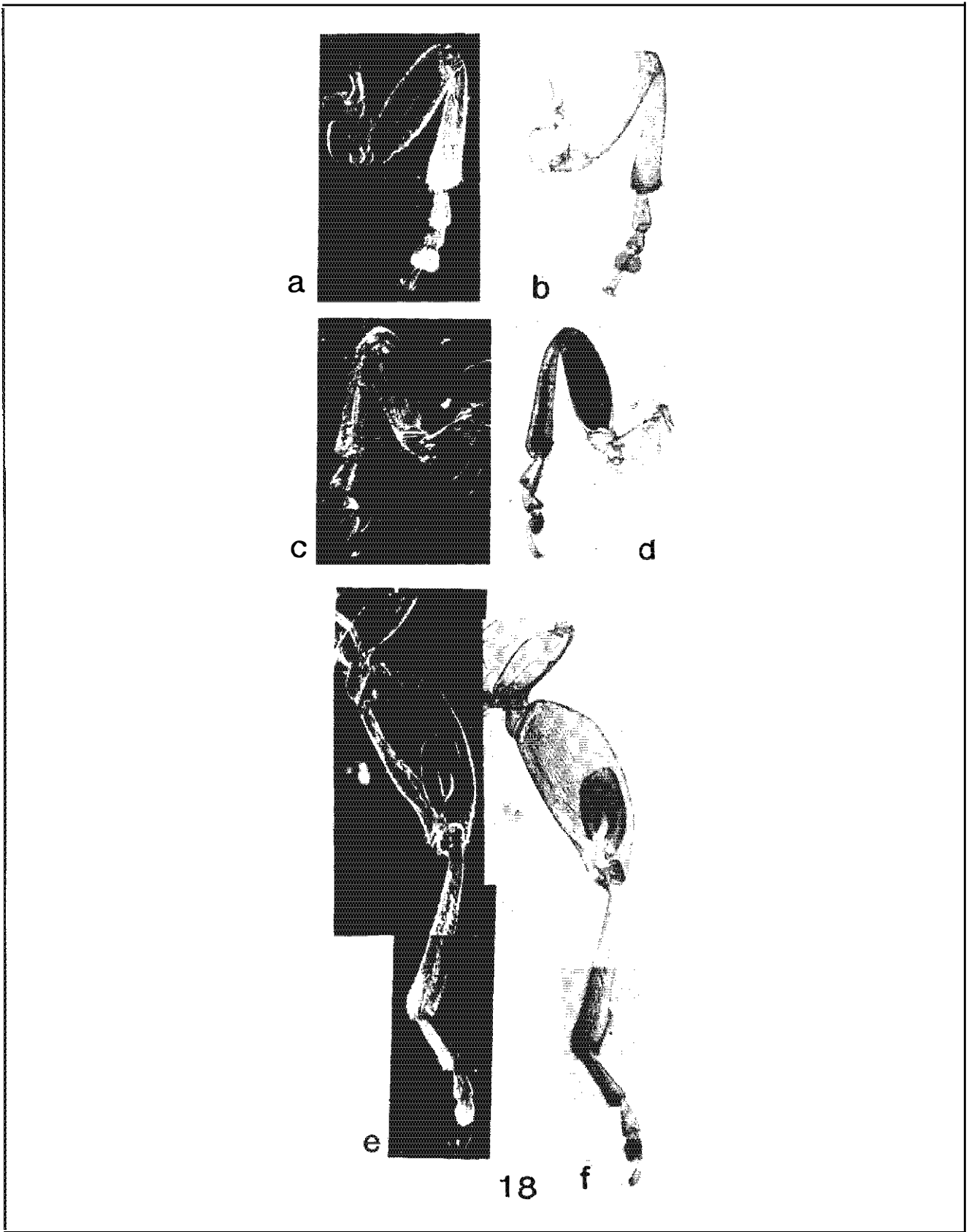


Figure 18. *Aphthona cyparissiae* female. a, first leg (phase light); b, first leg (plain light); c, second leg (phase light); d, second leg (plain light); e, third leg (phase light); f, third leg (plain light).

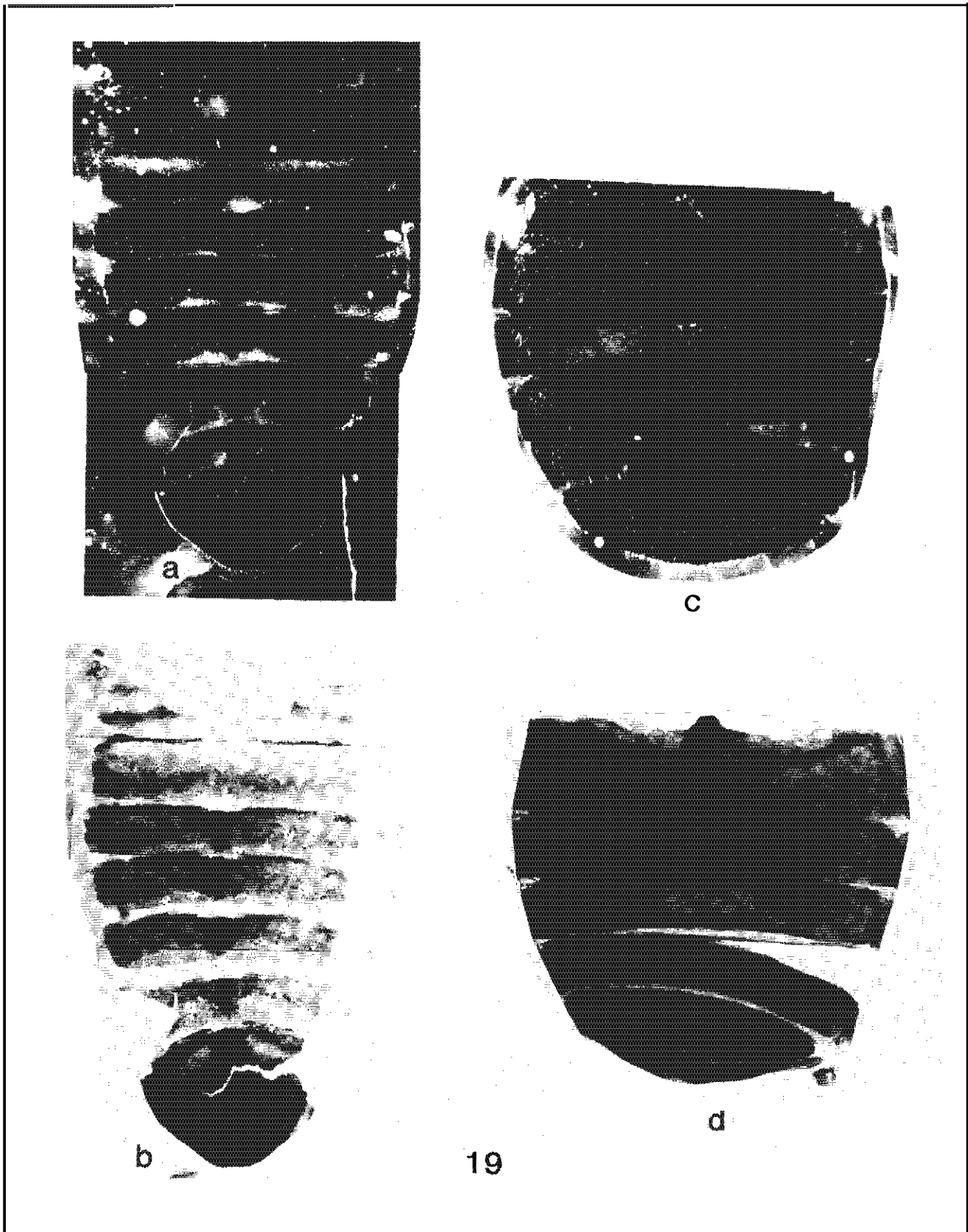


Figure 19. *Aphthona cyparissiae* female, abdomen. a, sternum (phase light); b, sternum (plain light); c, tergum (phase light); d, tergum (plain light).

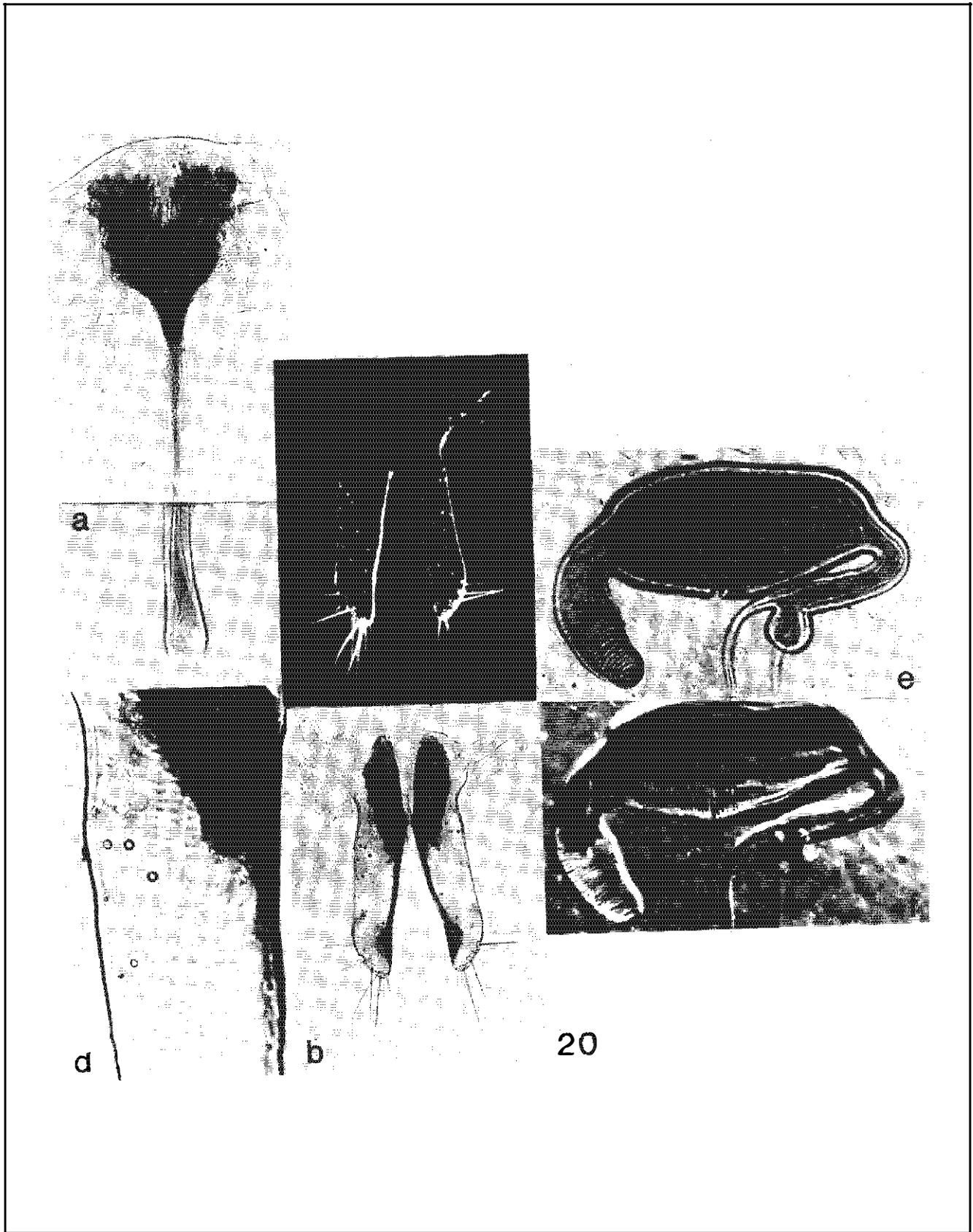


Figure 20. *Aphthona cyparissiae* female. a, eighth sternite; b, stylets (plain light); c, stylets (phase light); d, stylet (high power) showing circular pores; e, spermatheca (plain light); f, spermatheca (phase light).

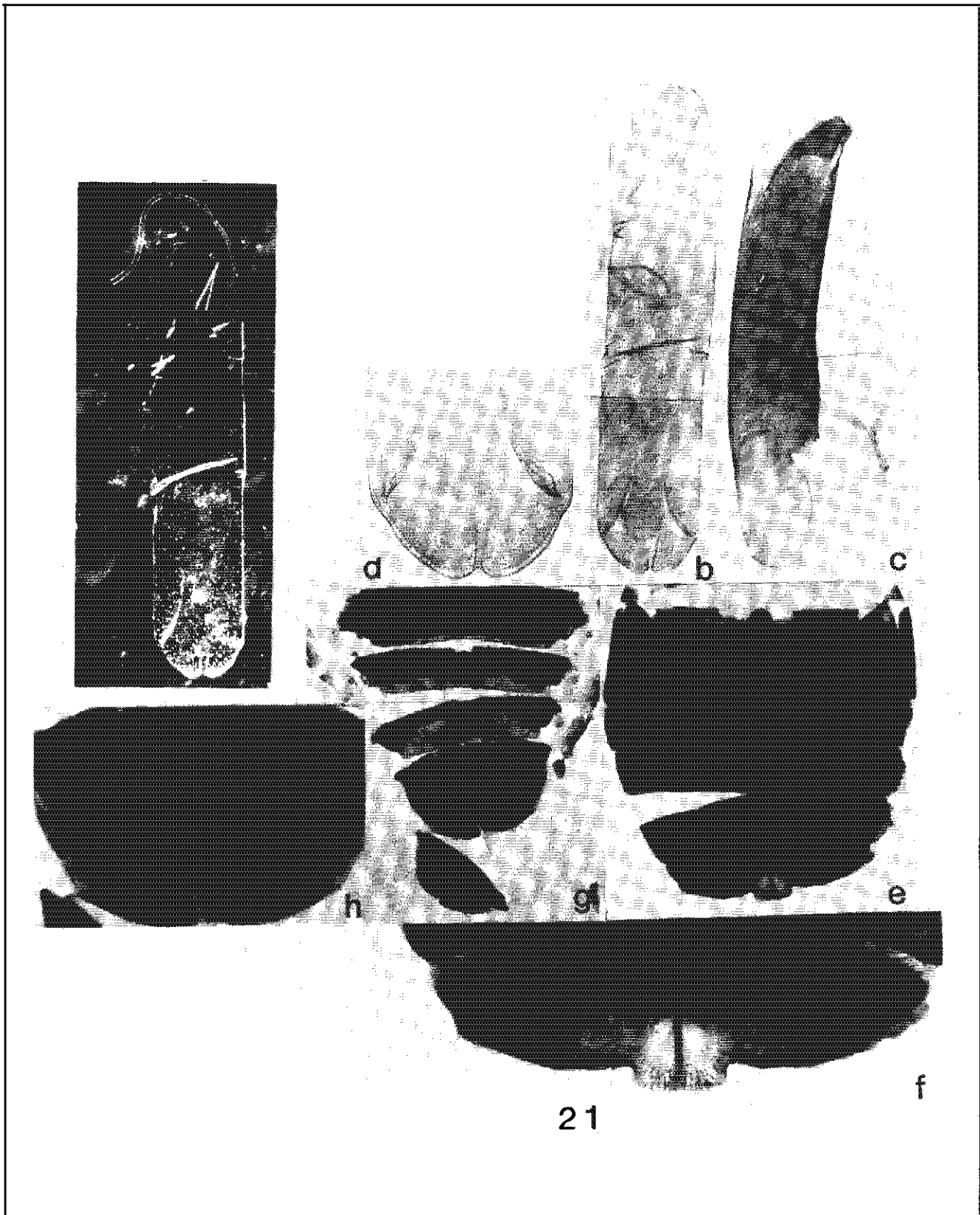


Figure 21. *Aphthona cyparissiae* male. a, aedeagus (phase light); b, aedeagus (plain light) dorsal ventral view; c, aedeagus (plain light) lateral view, showing tergmen; d, aedeagus dorsal ventral view showing bilobed apex; e, sternum; f, fifth segment of sternum showing lobe and median line; g, tergum; h, last segment of tergum (high power).

Aphthona flava

Original distribution: Described from Hungary and Italy (Julien, 1987). Collected from release site near Cardston, Alberta, and released at multiple sites in South Dakota.

Distribution in U.S. as biological agent: Colorado, Idaho, Montana, Nebraska, North Dakota, Oregon, South Dakota, Washington, Wyoming.

Color: Metathorax with dark notal carina enclosing median groove of notum; metathorax and abdominal base rusty-red; mesothorax scutellum not darkened, similar in color to elytra; female antennae bicolored, apical segments darker than scape, pedicle, and first three funicle segments; male antennae without contrasting bicolored condition; length 1.5 to 2.2 mm, male normally in lower size range.

Antennae: Antennae filiform with 11 segments; female scape, pedicle, and first three funicle segments lighter in color than last five funicle segments; scape larger than first funicle segment; pedicle thicker than funicle segments two through five; funicle segments three through five subequal in length, elongate, wider at apex and narrowing at base; funicle segments six through eight subequal in length, wider than funicle segments two through five; last funicle segment with apex narrowing; all segments with numerous setae, each funicle segment with a large seta on outer and inner lateral upper margin; male similar to female, funicle segments three through six and scape darker than in female.

Mouthparts: Mandibles with three denticles; molar with small acorn-like tubercles on inner surface; labrum with two curved sclerites (tormae); cardo with elongated toe and rounded heel, widest at junction with stipes, with single seta on outer margin, rounded clear area in upper inner area; stipes with five small setae and a single large seta; maxillary palpi four-segmented, covered with numerous setae, last segment pointed; galea with six small setae on base, with

numerous elongated tubular structures on apex; lacinia apex with long setae; labium with three-segmented labial palpi, first segment without setae, second segment with five setae, last segment with numerous microsetae; ligula with five tubular structures in center, apex with fine pointed spine-like structures; prementum with large medial carina between labial palpi, carina with paired setae located on upper apex; prementum with a total of 10 setae; postmentum rectangular, outer borders with a single seta at upper corner, two microsetae in center of postmentum.

Mesothorax-metathorax: Mesothorax reduced, scutellum plated, lobe-like and pointed toward metathorax, not darkened as found in *A. nigriscutis* and *A. cryparissiae*, with row of setae along anterior margin, numerous tube-like microsetae scattered over both surfaces of scutellum and on scutum; scutum with a row of setae near anterior notal wing process; metathorax notum with a median groove surrounded by raised carina, sloping ridge of carina not darkened as found in *A. nigriscutis* and *A. cryparissiae*; scutum with row of setae near posterior notal wing process similar to those located on mesoscutum; metascutum and metascutellum with numerous tube-like microsetae scattered on outer margins, scutellum divided into two sections by paired median carina and a curved shaped carina; postnotum (postscutellum) a narrow plate; some of scutum plated; triangular ridge on undersurface open at apex, well developed, connected to posterior carina; postphragma well developed.

Elytra-hind wing: Elytra ovoid, apex broadly rounded, inter-row spaces with erect hairs, rows of punctation on disk coalesce; subapical suture with pit-like depression; elytral disk with coalescent punctation, irregular rows of punctuations in anterior half; elytral suture not darkened; lateral rim present, angles with aristate pores; hind wing with prominent costa, subcosta, radius (radial sector, radial cell), medial and cubital veins; folded at apex with numerous microsetae.

Legs: First and second pairs of legs with elongated femur, slender tibiae, and four-segmented tarsi, first tarsal segment slightly longer and thicker than other tarsal segments; tibiae with spur; hind femur thickened with inner saltatorial muscle; hind tibia with spur larger than spurs on first and second tibiae; first tarsal segment longer than second and third tarsal segments.

Abdomen: Sterna not heavily sclerotized, light colored, not dark like *A. nigriscutis* and *A. cyparissiae*; fifth sternal segment of female rounded with median longitudinal impression but without a dark line as in male; fifth segment of male with median lobe on pygidium and dark median linear impression seen as a dark line; lobe area wider than long, with rows of large setae, same color as rest of fifth segment; sternites of both sexes with first and fifth sternites longer than other sternites, all sternites with numerous setae of various sizes; tergite with seven segments with numerous setae of various sizes, these arranged in clusters either across center of tergite or in center on each side of median line; tergite seven with larger setae than on other tergites, scattered over entire tergite; seventh tergite rounded at posterior end; arrangement of clusters on tergites differs from clusters on *A. nigriscutis* and *A. cyparissiae*.

Female reproductive structures, spermatheca-styli: Spermathecal capsule with sclerotized wall; spermatheca outer surface with numerous spermathecal folds covering receptacle; spermathecal folds present on distal portion of spermathecal pump, there is an area devoid of spermathecal folds between ring collar and first spermathecal fold; spermathecal pump closed at distal end, lightly sclerotized, not as dark as receptacle; receptacle longer than wide; spermathecal gland duct a single-ringed tube with a gland valve, gland valve cup-shaped with small tube extending from center of cup connecting spermathecal gland; spermathecal gland duct extending beyond gland valve, much smaller in diameter than spermathecal duct between gland valve and receptacle. Styli paired, elongate, joined

at anterior portion, with nine setae at distal portion on each stylus, each stylus with a sclerotized section on the anterior portion of stylus, with 10 circular pores scattered over distal portion extending back toward dark sclerotized area; 12 acorn-shaped setae located on outer margin of each stylus; eighth sternite (ligula of Mann and Singh, 1979) with distal portion fan-shaped, with small microsetae on upper border, sclerotization located in center of fan-shaped sclerite, connected to fan-shaped sclerite is a long stem ending in an enlarged, rounded distal portion, a membrane covers entire sternite with muscles attached to stem; muscles located between sternite and styli.

Male reproductive structures, aedeagus: Aedeagus lanceolate, with rounded flanges at basal foramen, apical orifice region bifurcate with two rounded lobes and a sclerotized tooth-like projection on inner margin of left lobe; median dorsal plate not well delineated; aedeagus with numerous micropores scattered over apical section; whole aedeagus wrapped in a thin membrane; tegmen Y-shaped with fairly broad lateral forks curving upward and with broad strut tapering toward a truncate tip and roundly elevated in median line.

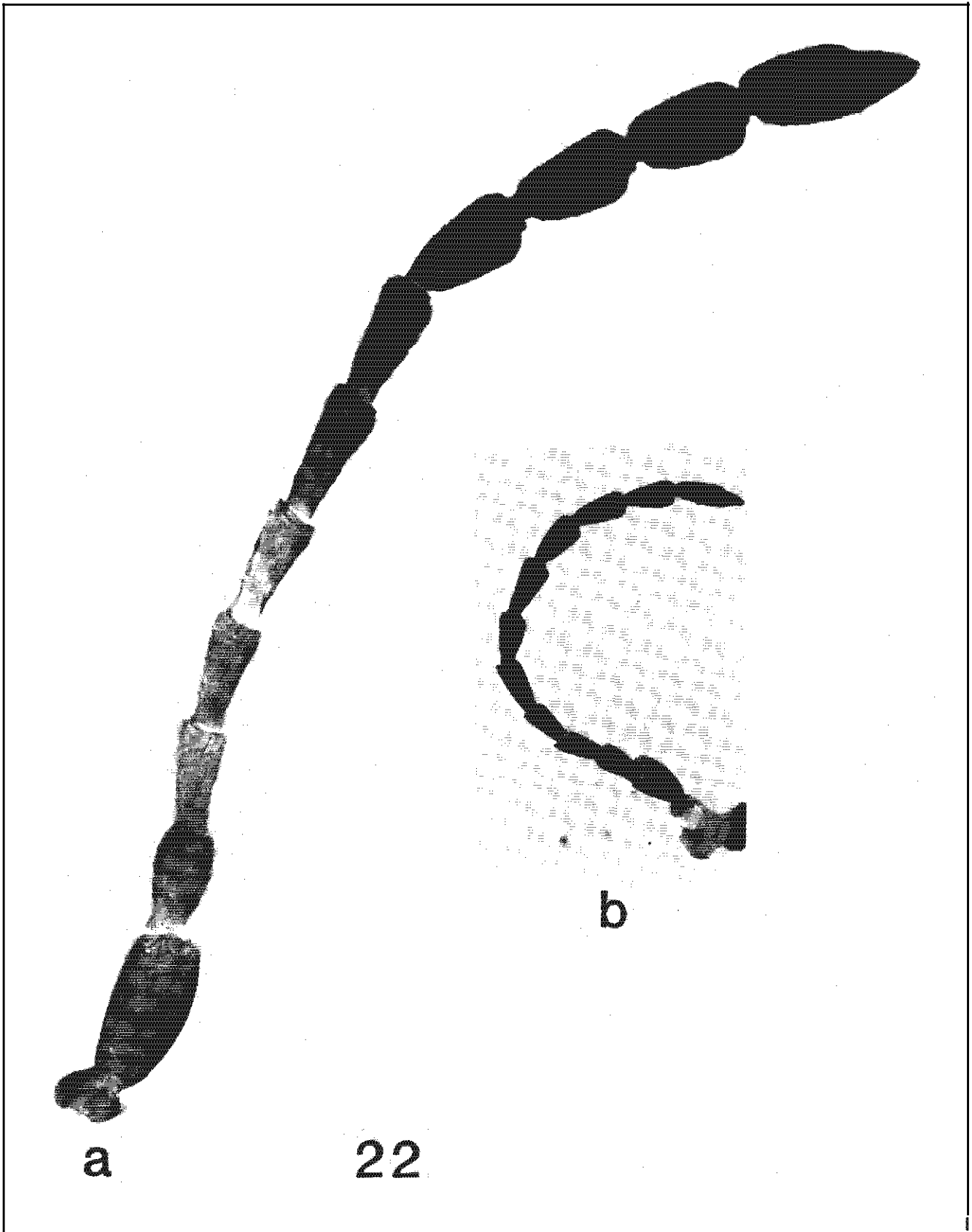


Figure 22. *Aphthona flava* female. a, antennae, male; b, antennae.

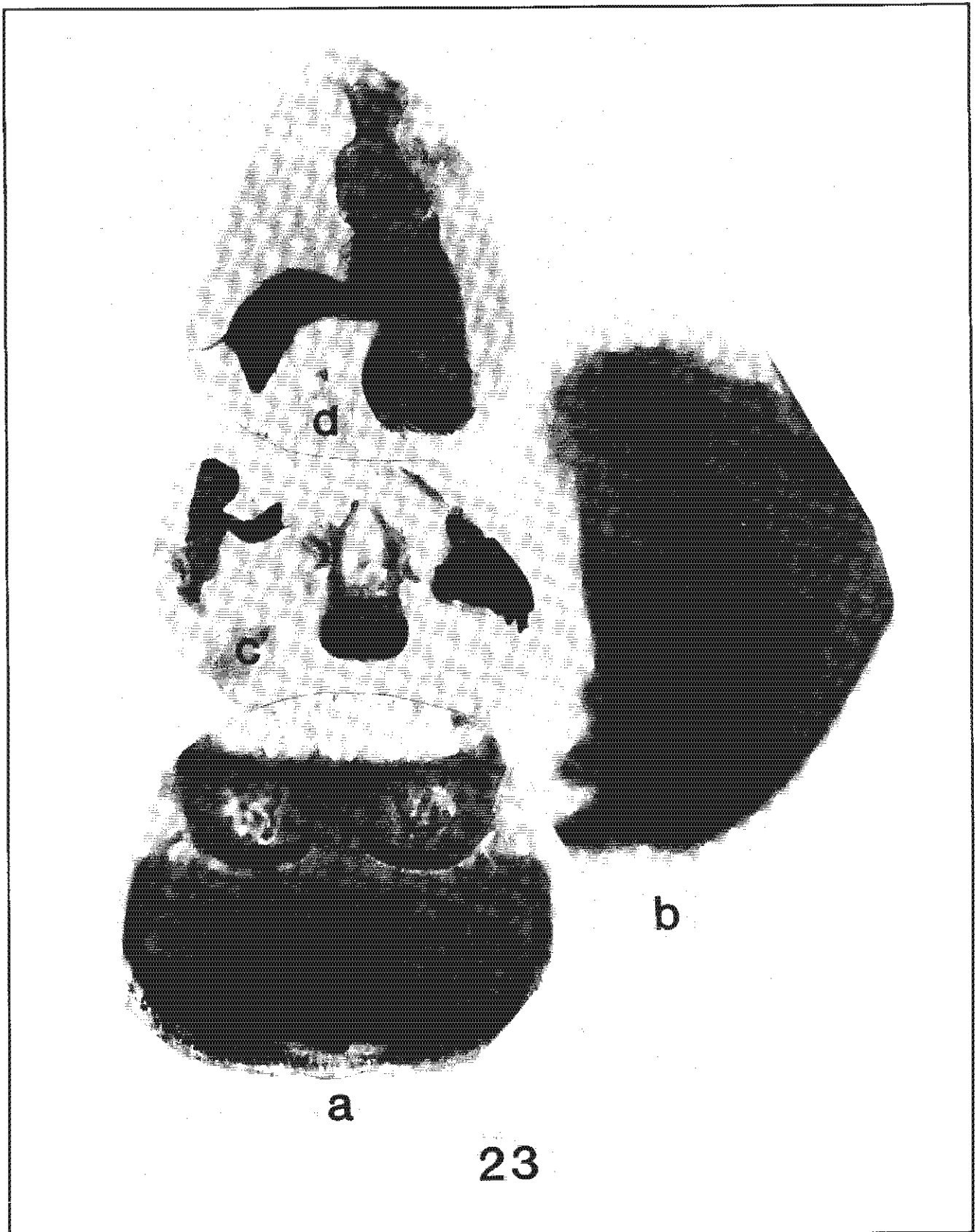


Figure 23. *Aphthona flava* female. a, labrum (high power); b, mandible (high power); c, mouth parts (low power); d, maxillae (high power).

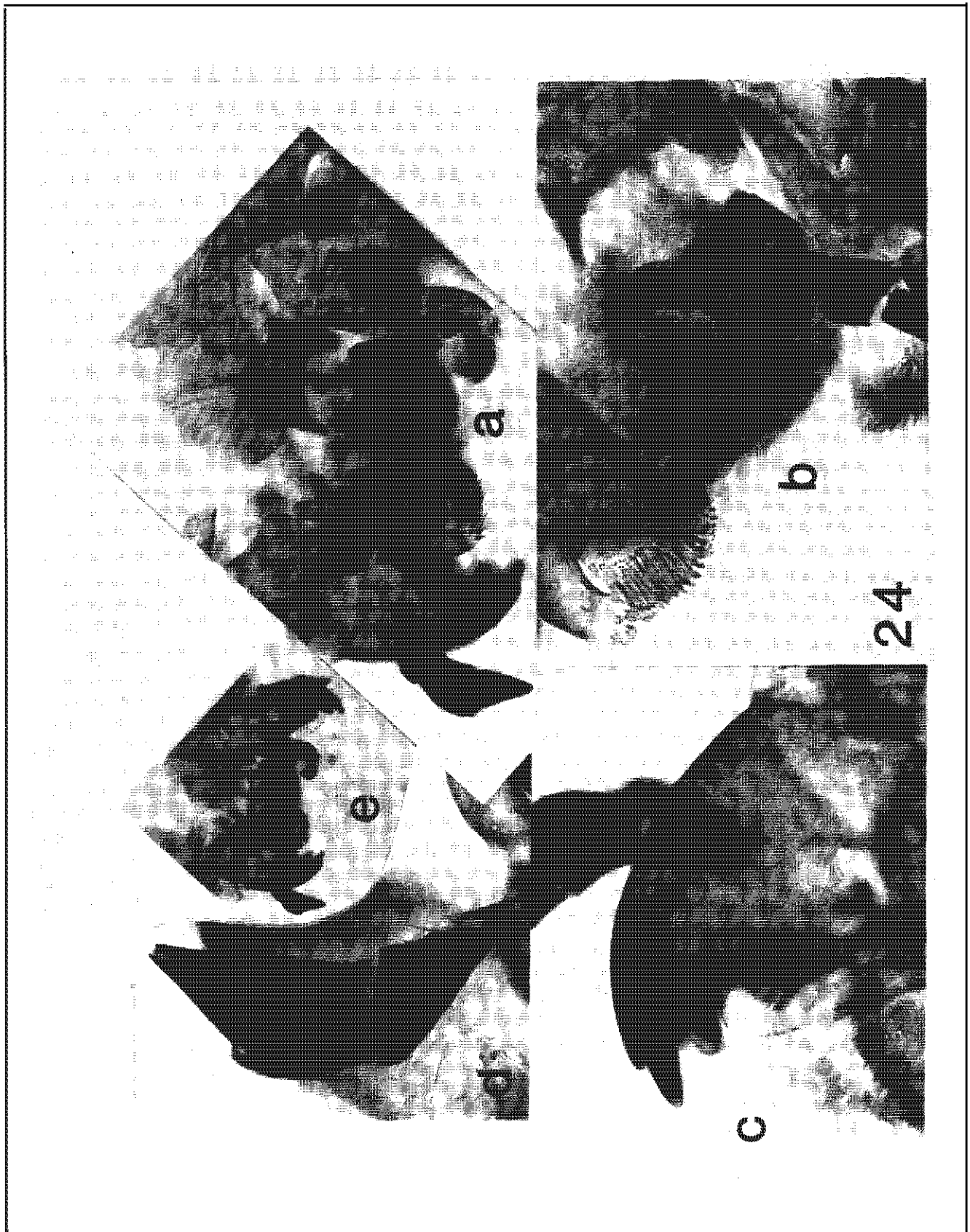


Figure 24. *Aphthona flava* female. a, labium (low power); b, labium (high power); c, mandible; d, maxillae; e, mouthparts (low power).

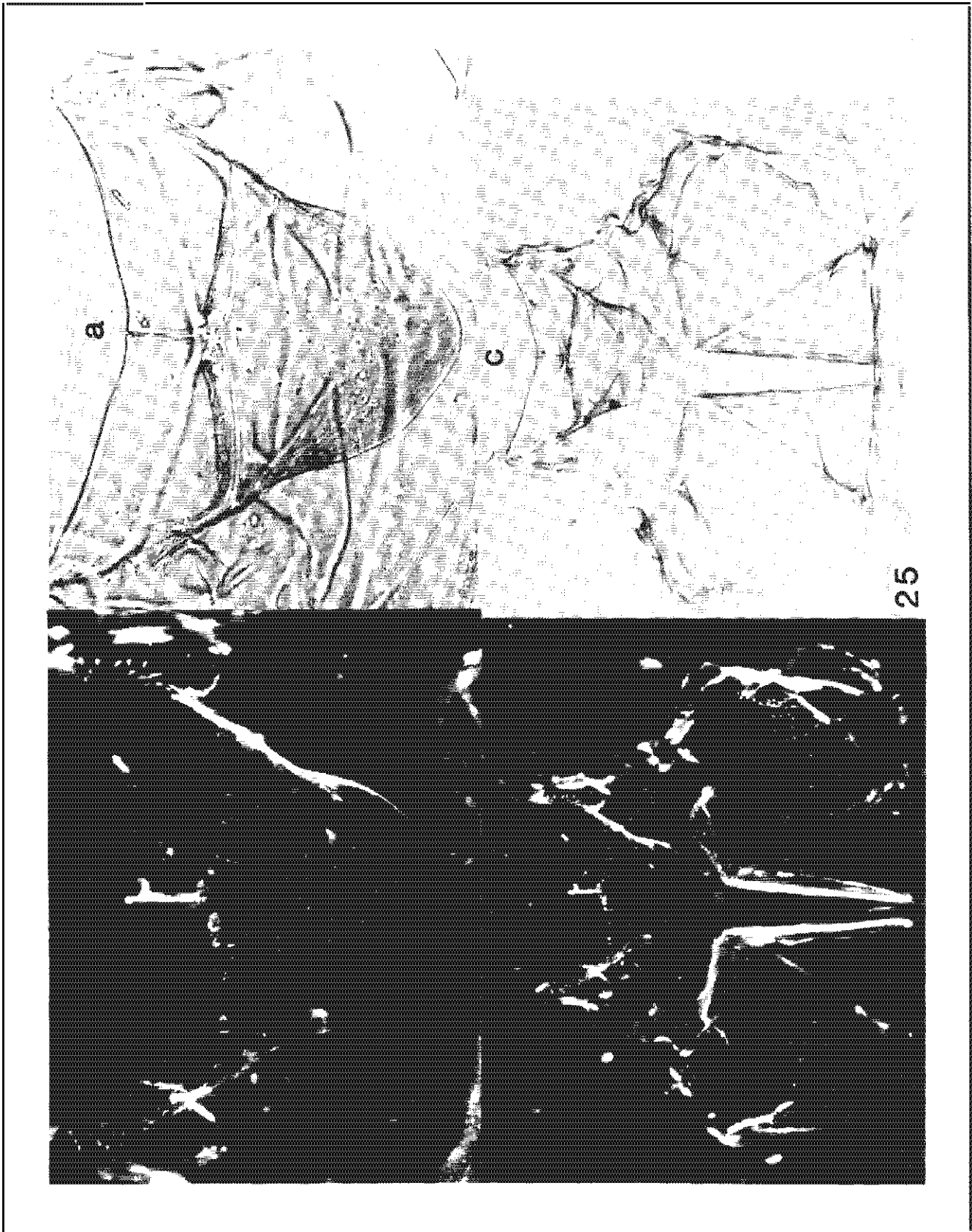


Figure 25. *Aphthona flava* female. a, mesoscutum and mesoscutellum (plain light); b, mesoscutum and mesoscutellum (phase light); c, metascutum and metascutellum (plain light); d, metascutum and metascutellum (phase light).

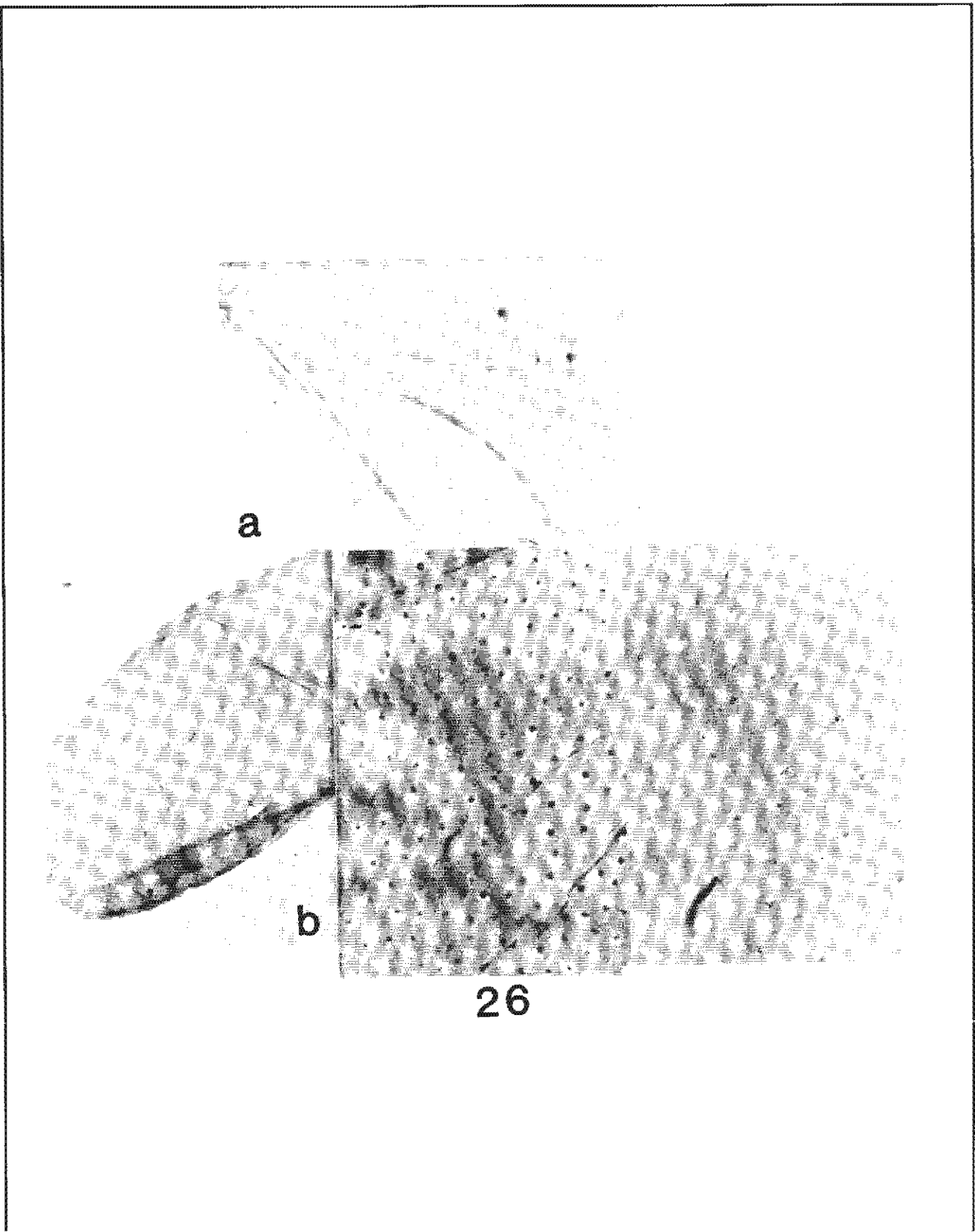


Figure 26. *Aphthona flava* male. a, hindwing showing veins; b, elytra.

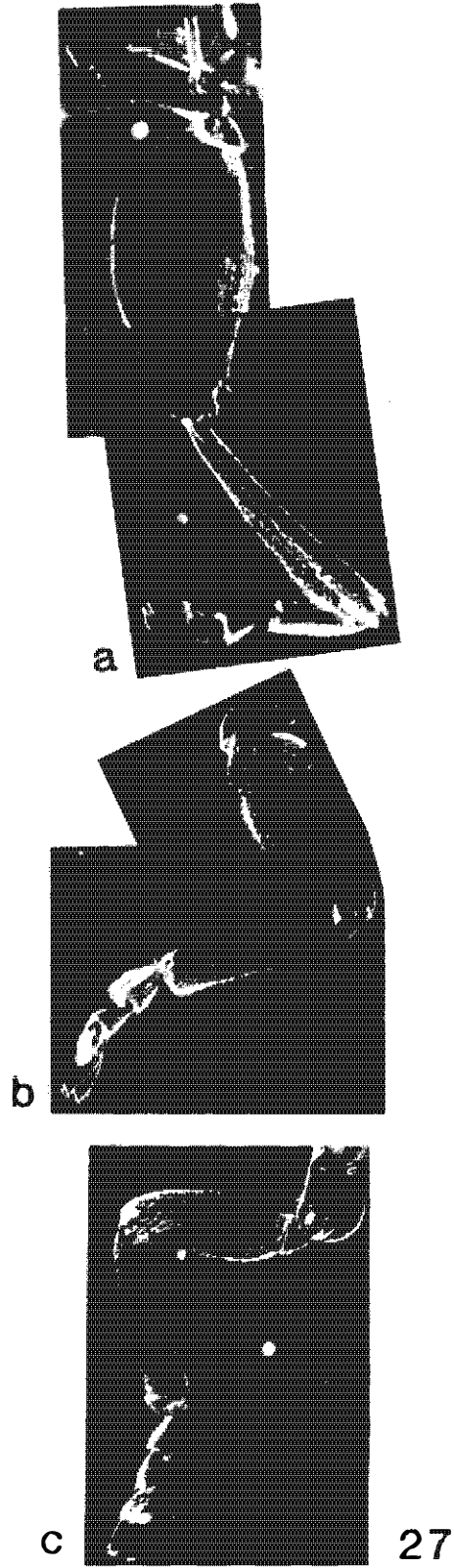


Figure 27. *Aphthona flava* female. a, third leg (phase light); b, second leg (phase light); c, first leg (phase light).

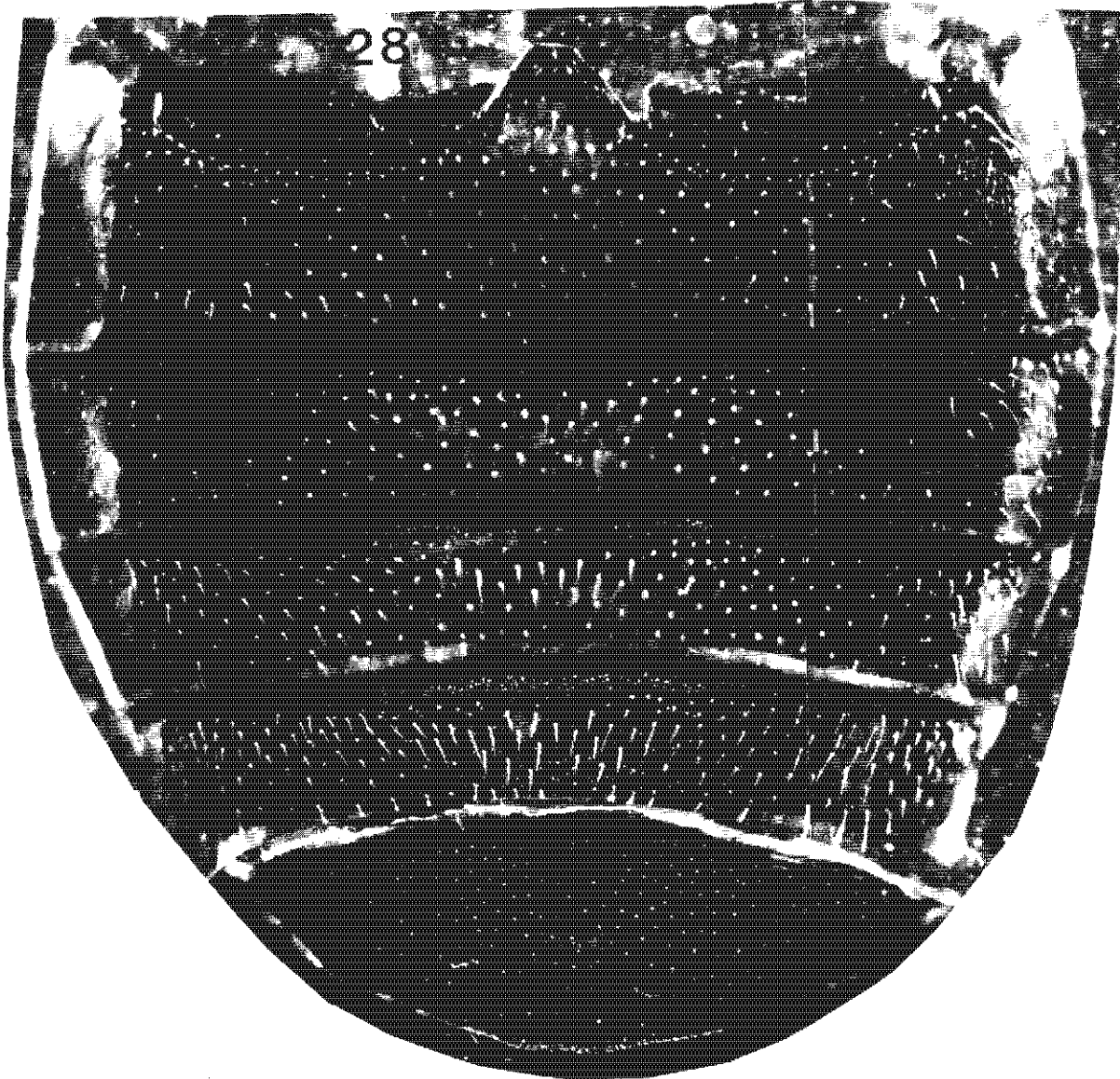


Figure 28. *Aphthona flava* female, abdomen, stemites (phase light).



Figure 29. *Aphthona flava* female, abdomen, tergites (phase light).

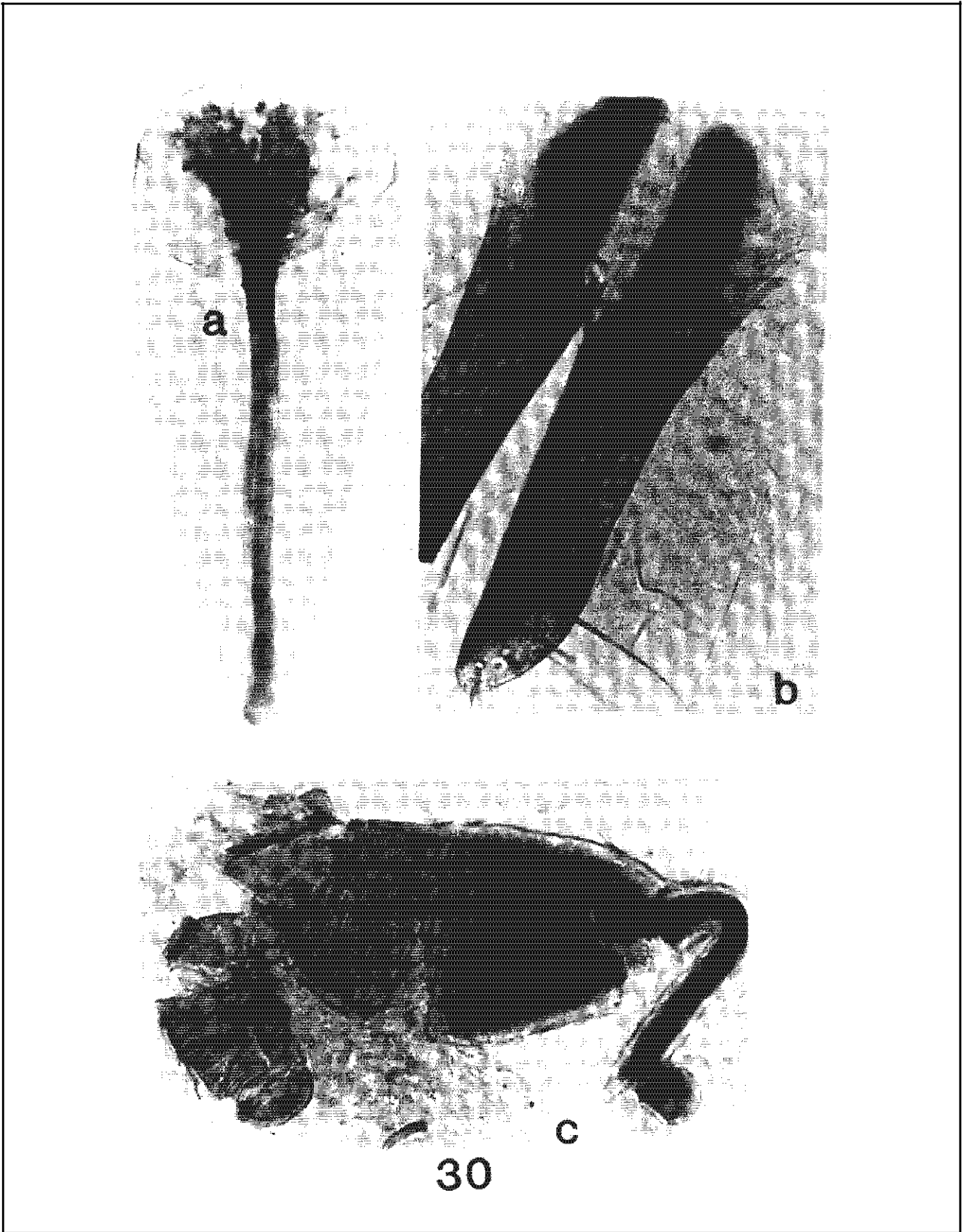


Figure 30. *Aphthona flava* female. a, eighth sternite; b, stylets; c, spermatheca.

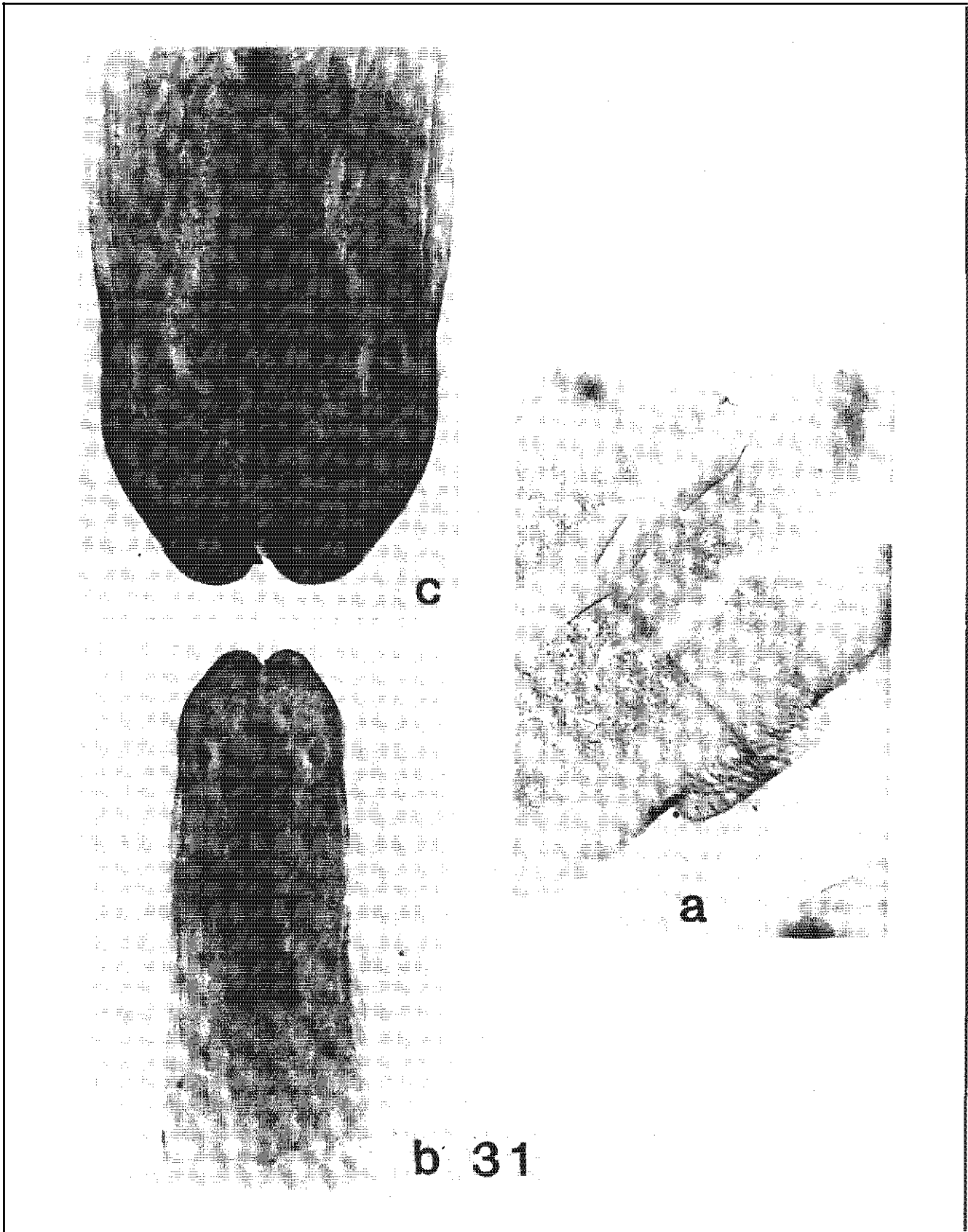


Figure 31. *Aphthona flava* male. a, strenite showing lobe; b, aedeagus apex (low power); c, aedeagus (high power) showing spine-like tooth.

Glyptina atriventris

Original distribution: Native of South Dakota.

Distribution as biological agent: Not studied as a possible biological agent.

Color: Metathorax with a light-colored notal carina enclosing median groove of notum; metathorax and abdominal base brown; mesoscutellum reduced, light colored; female antennae with lighter colored segments near scape, blending and becoming darker toward apical segments.

Antennae: Antennae filiform with 11 segments; female scape longer than first funicle segment; funicle segments two through four subequal in length, elongate, wider at apex, narrowing at base; funicle segments five through nine wider than funicle segments two through four; last segment longer than other funicle segments, apex narrowing to a point; male antennae similar to female.

Mouthparts: Mandibles with three denticles; molar with small acorn-like tubercles on inner surface; labrum with two curved sclerites (tormae); cardo with elongated toe and rounded heel, widest at junction with stipes, with single seta on outer margin, rounded clear area in upper inner area; stipes with five small setae and a single large seta; maxillary palpi four-segmented, covered with numerous setae, last segment pointed; galea with six small setae on base, with numerous elongated tube-like structures on apex; lacinia with brush-like structures on apex; labium with three-segmented labial palpi, first segment without setae, second segment with five setae, last segment with numerous microsetae; ligula with five tube-like structures in center, apex with fine pointed spine-like structures; prementum with large medial carina between labial palpi, carina with paired setae; prementum with a total of 11 setae; postmentum rectangle-shaped, outer borders with a single seta at upper corner, two microsetae in center of postmentum.

Mesothorax-metathorax: Mesothorax reduced, scutellum lightly plated, with rounded posterior margin, not sclerotized (darkened), similar in color to *A. flava* with row of setae at anterior margin; scutum plate lighter in color than scutellum, with numerous tube-like microsetae forming a vertical band near notal wing process; metathorax notum with median groove surrounded by raised carina, sloping ridge of carina sclerotized without setae; scutum with row of setae near posterior notal wing process similar to those located on mesoscutum; metascutum and metascutellum with numerous tube-like microsetae scattered on surface; scutellum divided into two sections by paired median carina and curved shaped carina; postnotum (postscutellum) a narrow plate; plating on metascutum broken, not covering all of surface, triangular ridge on undersurface joining anterior carina, forming a common border; postphragma well developed.

Elytra-hindwing: Elytra ovid, broadly rounded posteriorly with inter-row spaces with erect hairs; punctuations in distant rows; elytral suture absent; lateral rim present, angles with aristate pores; hindwing with prominent costa, subcosta, radius (radical sector, radial cell), medial and cubital veins, folded at apex with numerous microsetae.

Legs: First and second pair of legs with elongated femur, slender tibia, and four-segmented tarsi; first tarsal segment longer than tarsal segment two; tarsal segment three lobe-like; tarsal segment four long and narrow with well developed claw; prothoracic tibia with spur and associate comb-like row of setae at junction of tarsi; prothoracic femur wider than tibia, trochanter with numerous acorn-like setae, coxa with well developed spur; mesothoracic tibia similar in structure to prothoracic tibia, with spur and comb-like setae at junction of tarsi; femur, trochanter, and coxa similar to prothoracic leg; metathoracic tibia with spur, spur larger than spur on first and second tibia; tibia grooved with comb-like

setae; hind femur with inner saltatorial apodema, scattered setae on dorsal surface; trochanter small with acorn-like setae; coxa elongated with blunted spur.

Abdomen: Sterna completely darkened, fifth segment of female rounded, with a median longitudinal impression, fifth segment of male with a median lobe and dark median linear impression that can be seen as a dark line, both the median lobe and median linear impression can be used to separate males from females; sternites of both sexes with only the fifth sternite wider than other sternites; sternites with numerous setae of various sizes; tergites with six segments with numerous setae of various sizes arranged in clusters; tergite five with two longitudinal light stripes; the arrangement of the clusters is distinctive for the species.

Female reproductive structures, spermatheca-styli: Spermatheca longer than wide, receptacle sclerotized, darkest in area next to ring collar, lighter in area closer to junction of spermathecal duct; receptacle folds present but not readily observed due to heavy sclerotization of receptacle; spermathecal pump long, sclerotized similar to receptacle, folds obscured due to heavy sclerotization; gland valve not club-shaped, rounded, similar in structure to spermathecal duct but larger, a smaller spermathecal gland tube projects from center of spermathecal valve, gland valve and spermathecal tube not as heavily sclerotized as spermathecal duct; spermathecal duct beyond spermathecal valve much smaller in diameter than spermathecal duct between valve and receptacle; styli paired, elongated, joined at anterior portion with seven large setae and a single smaller apical seta; each stylus with two sclerotized sections, sclerotized area at apical portion covers area with stylus setae, sclerotization at anterior portion of stylus covers the styli where they are connected, sclerotization extends in a narrow band and joins sclerotized area located at apical region of stylus; each stylus with nine circular pores scattered over stylus; six acorn-shaped

setae located along outer margin of each stylus; eighth sternite with distal portion fan-shaped, with large setae along upper border, upper border without sclerotization, sclerotization located in lower region at junction of rod-like long stem, stem with small enlargement at apex, membrane covers entire sternite with muscles attached; this structure appears to function as an egg guide.

Male reproductive structures, aedeagus: Aedeagus not notched at apical region, apical region bluntly pointed and slightly asymmetrical with two elongated internal sperm glands; apical pygidium with marginal ducts and furrows; basal foramen with large flange-like lobes; tegmen forming tegmen ring, parameres, and manubrium; aedeagus enclosed in a membrane.

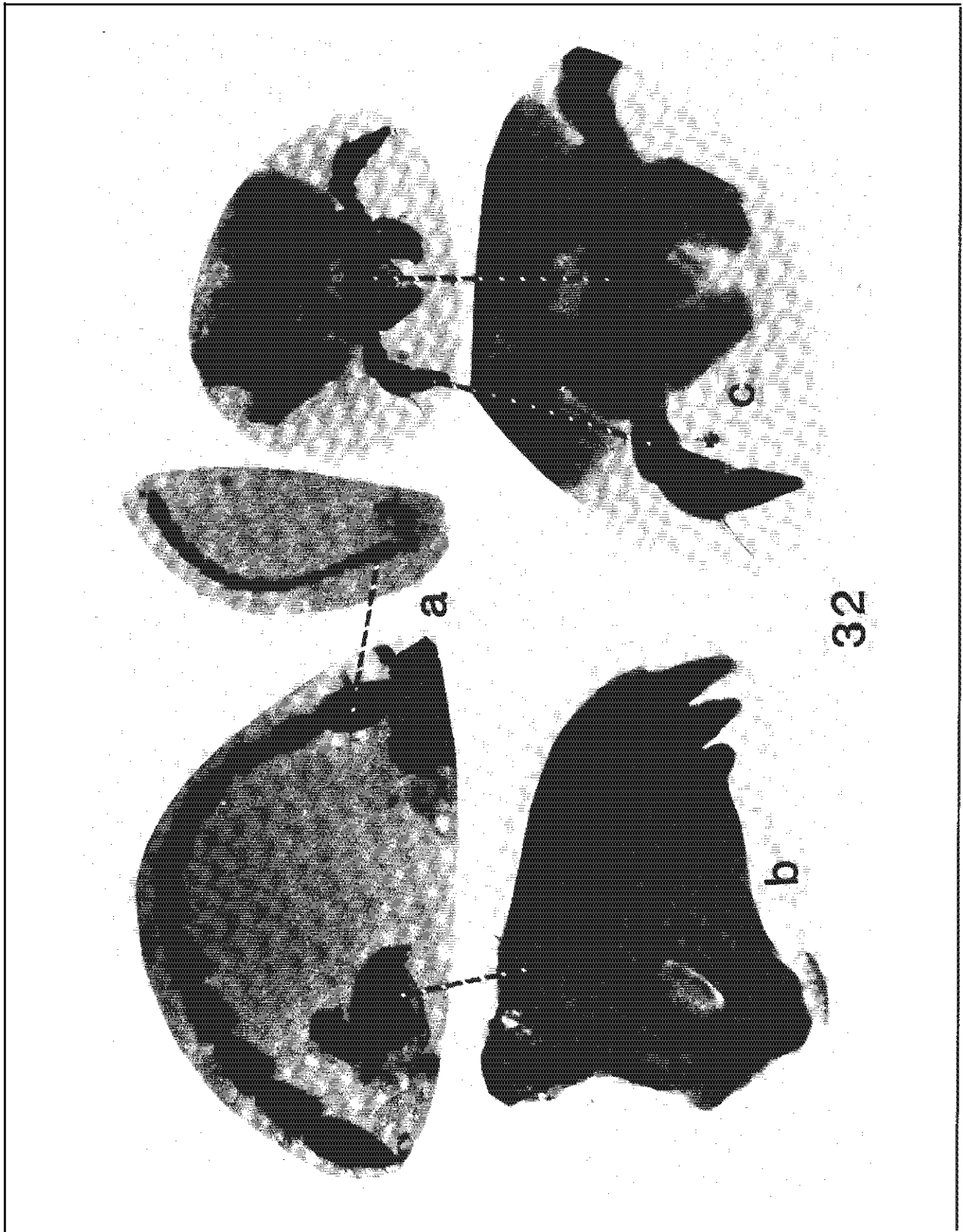


Figure 32. *Glyptina atriventris* . a, antennae; b, mandibles; c, mouthparts.

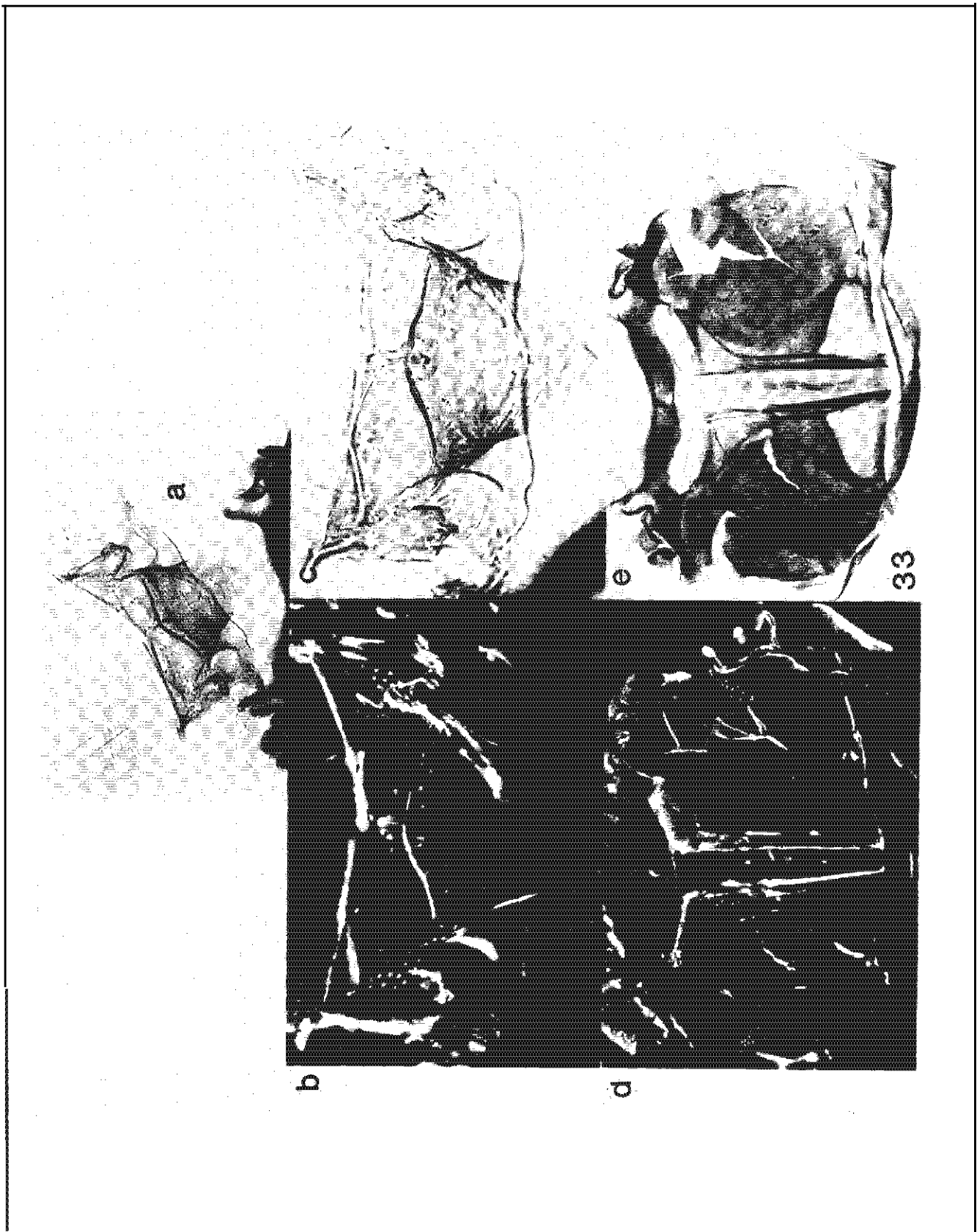


Figure 33. *Glyptina atriventris*. a, mesoscutum and mesocutellum (plain light, low power); b, mesoscutum and mesocutellum (phase light); c, mesoscutum and mesocutellum (plain light); d, metascutum and metascutellum (phase light); e, metascutum and metascutellum (plain light).

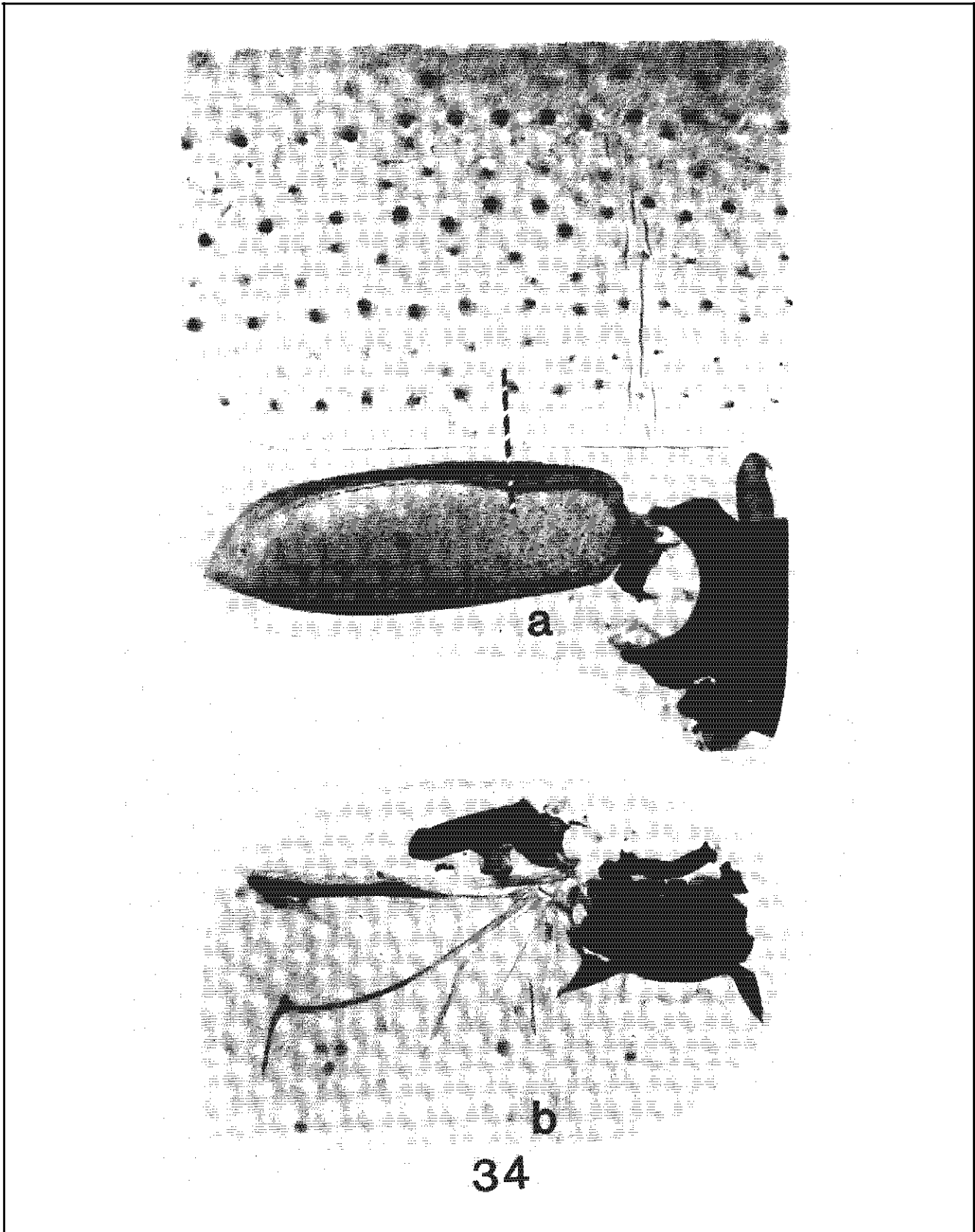


Figure 34. *Glyptina atriventris* female. a, elytra showing absence of subapical suture and pit-like depressions; b, hindwing showing veins.

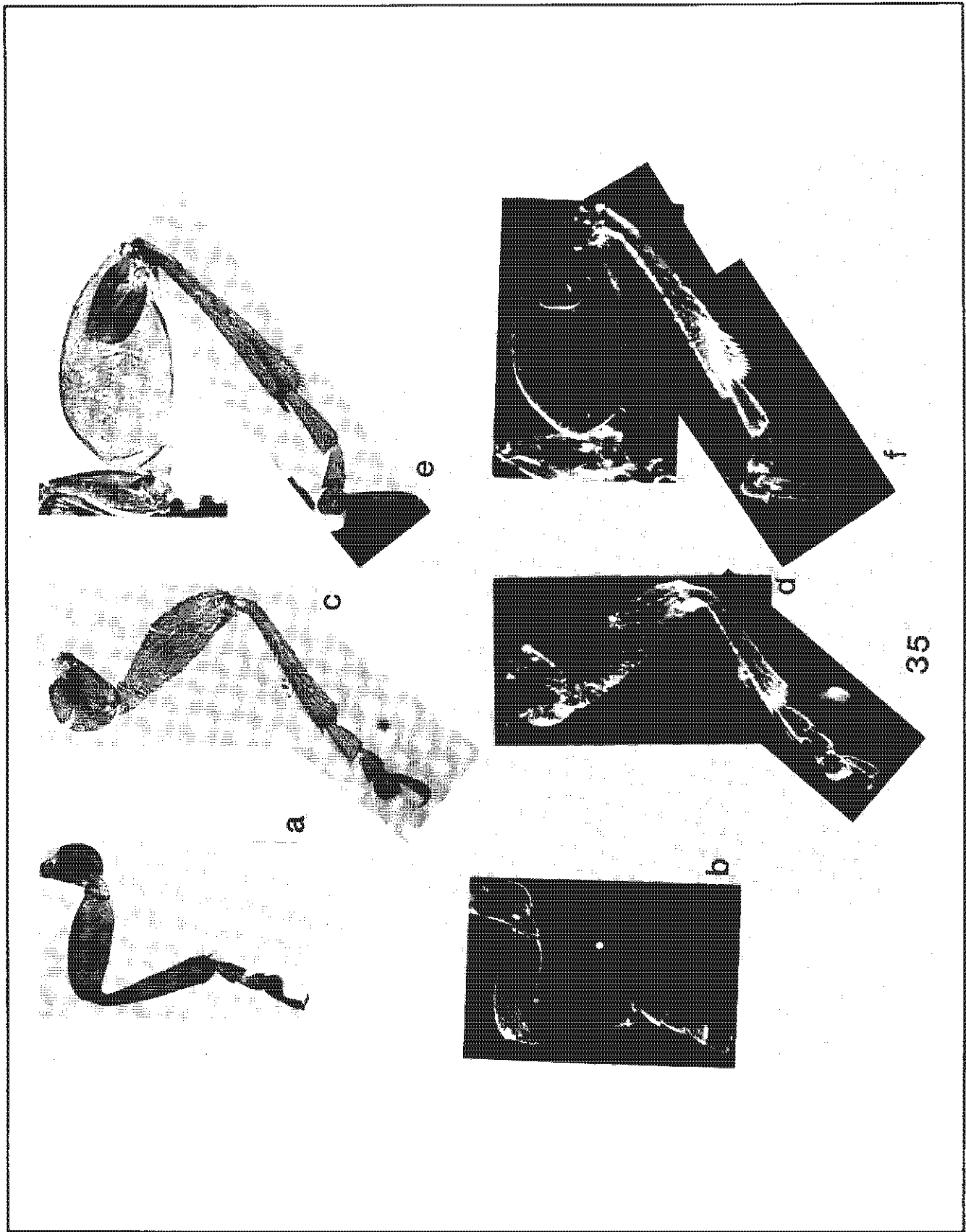


Figure 35. *Glyptina atriventris* female. a, first leg (plain light); b, first leg (phase light); c, second leg (plain light); d, second leg (phase light); e, third leg (plain light); f, third leg (phase light).

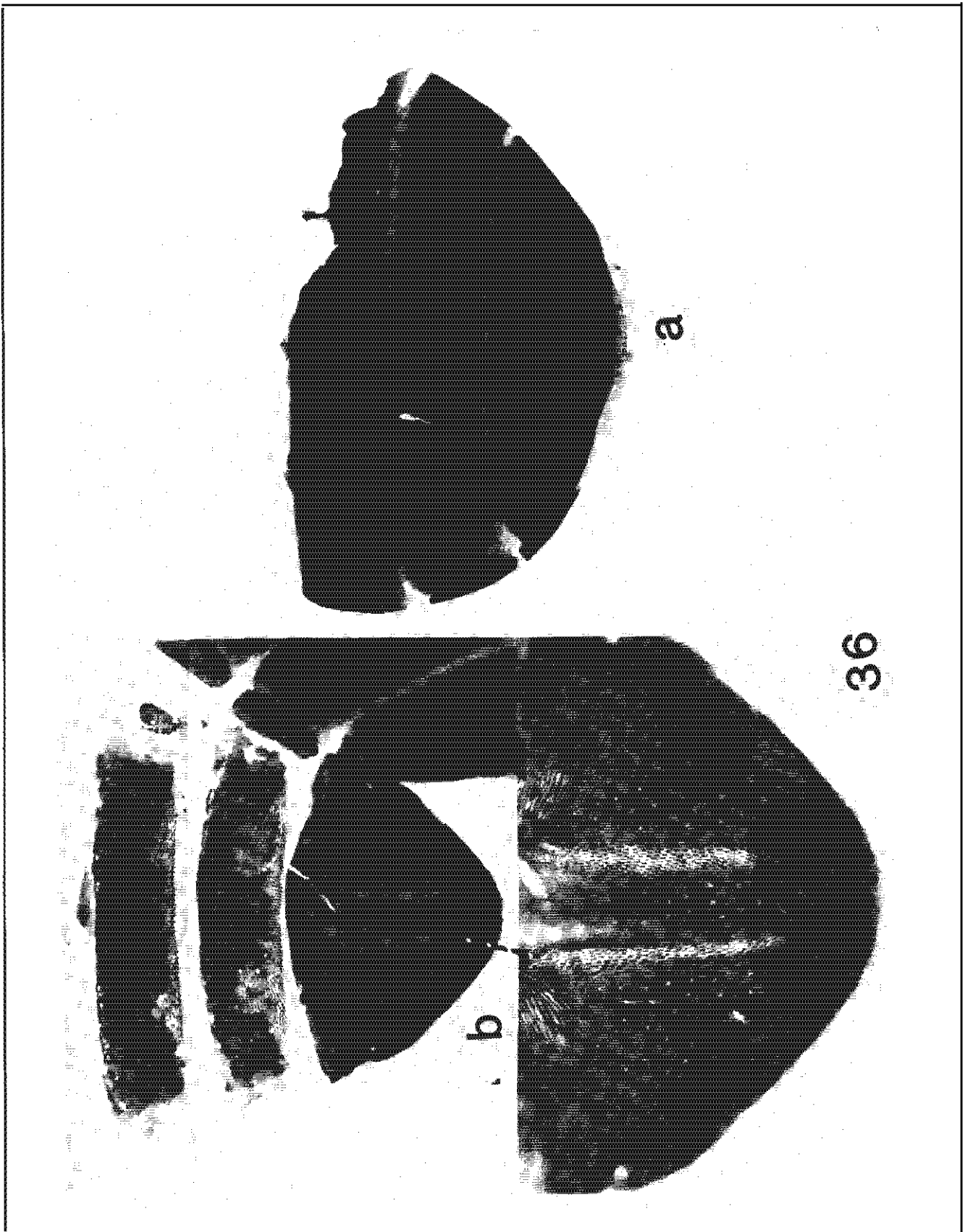


Figure 36. *Glyptina atriventris* female. a, last three segments of sternum; b, last three segments of tergum.

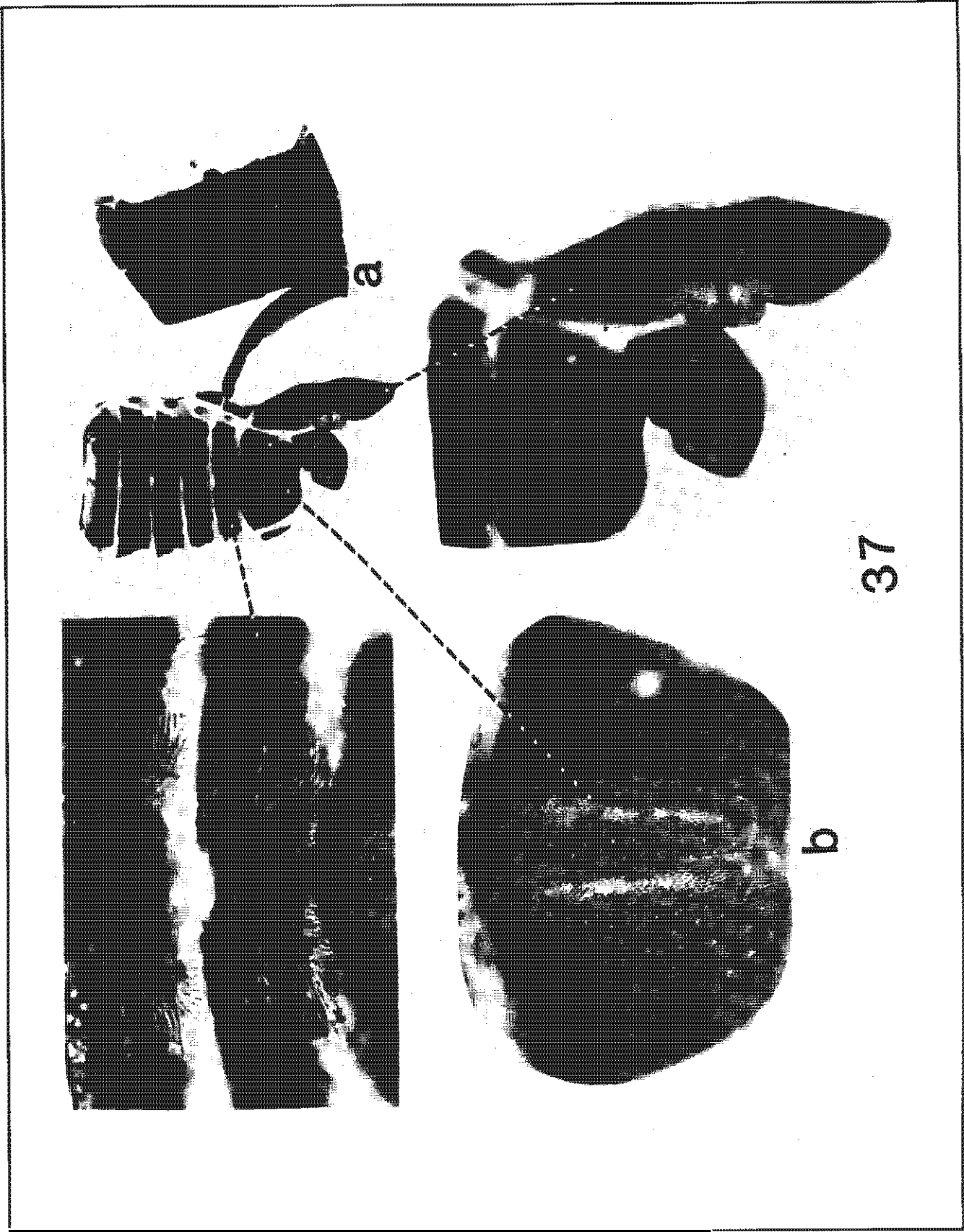


Figure 37. *Glyptina atriventris* male. a, sternum; b, tergum.

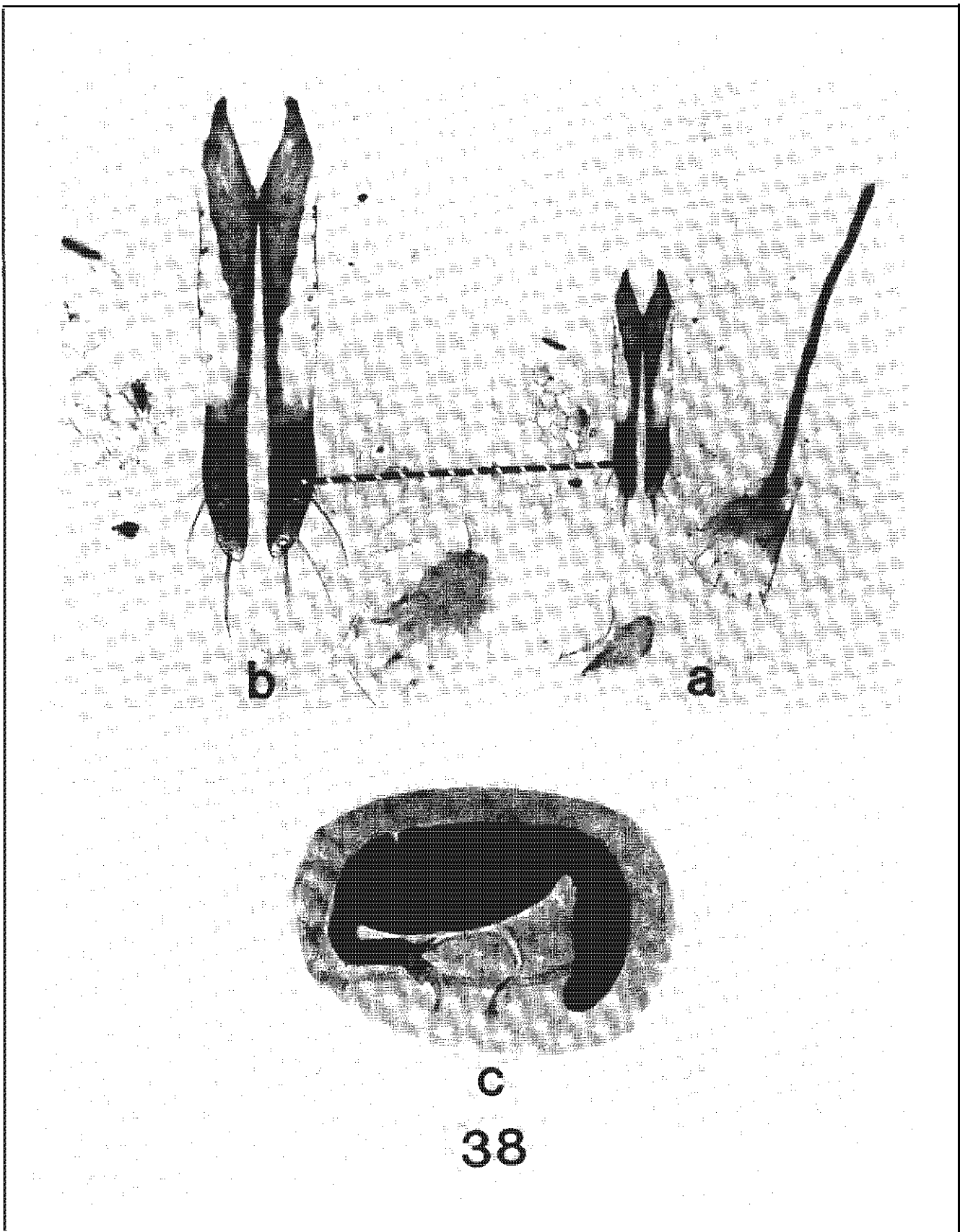


Figure 38. *Glyptina atriventris* female. a, eighth tergite and stylets; b, stylets (high power); c, spermatheca.

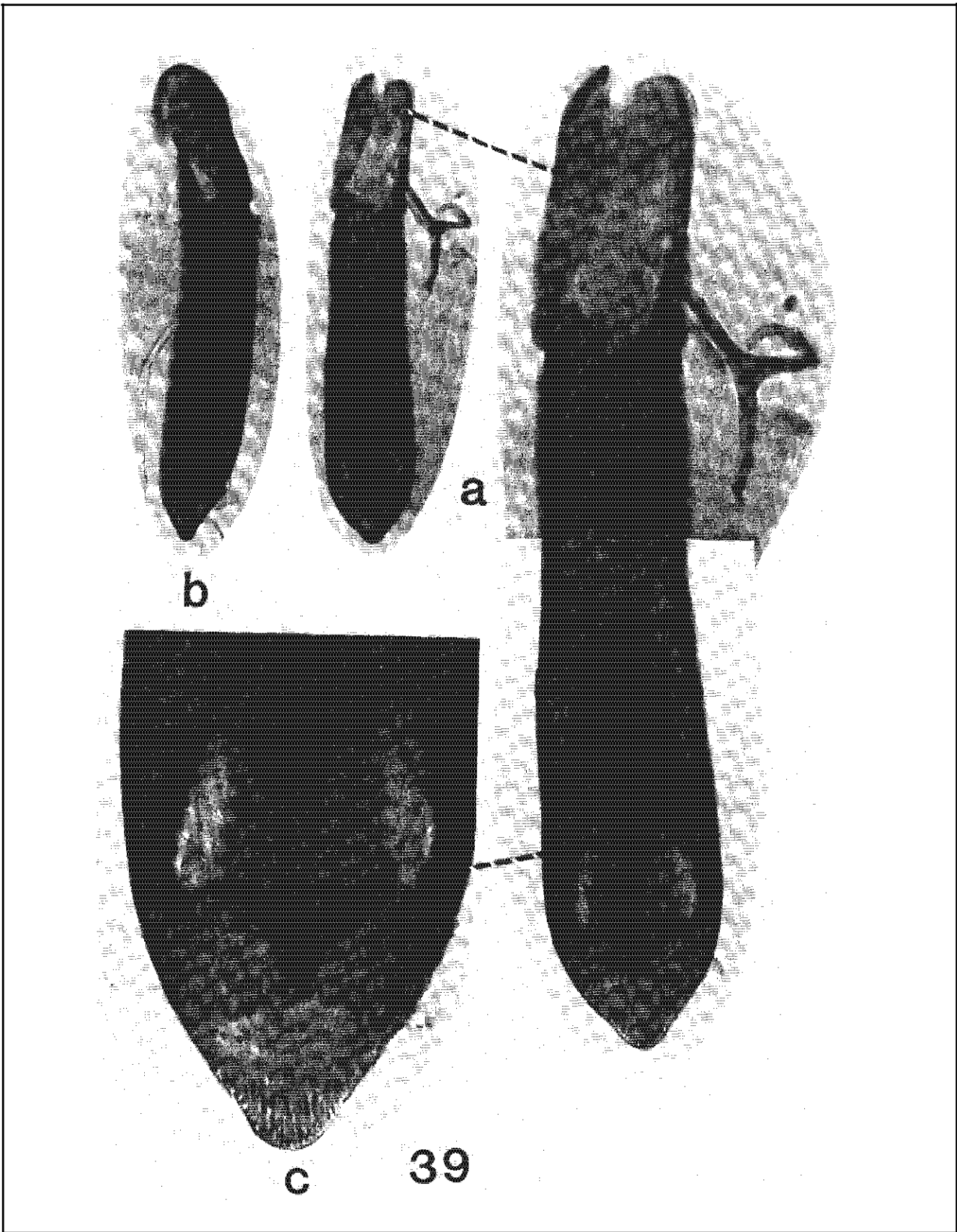


Figure 39. *Glyptina atriventris* male. a, aedeagus (low power and high power); b, aedeagus lateral view; c, aedeagus (high power) showing pores and rounded apex.

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