

Title: Taxonomic study of six species of Genus *Junonia* Hübner, 1819 (Insecta: Lepidoptera: Nymphalidae) from Northwest Himalayan region in India.

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Title: Taxonomic study of six species of Genus *Junonia* Hübner, 1819 (Insecta: Lepidoptera: Nymphalidae) from Northwest Himalayan region in India.

Abstract: Characters of external genitalia are considered as one of the important criteria to understand the taxonomy of insects. In the present study, various taxonomic characters of the male and female external genitalia and wing venation of six species under genus *Junonia* Hübner viz., *orythia* (Linnaeus), *iphita* (Cramer), *almana* (Linnaeus), *lemonias* (Linnaeus), *hierta* (Fabricius), *atlites* (Linnaeus) has been described and illustrated in detail. Besides, brief diagnosis, identification keys based on external genitalia, morphological variations and taxonomic remarks has been given for all taxa.

Keywords: taxonomy, external genitalia, Old and New world topics, Western Himalaya

Introduction: Genus *Junonia* Hübner, 1819 is a speciose genus, of butterfly family Nymphalidae, with extant members predominantly of tropical affinity. The genus contains 33 species that are distributed throughout all major biogeographical regions of the world, except the Palaearctic (Kodandaramaiah and Wahlberg, 2007). However, the true number of species and their relationships has been an on-going debate in the scientific community for the last 100 years (Turner and Parnell 1985; Borchers and Marcus 2014).

Harvey (1991) recognized only three tribes within Nymphalinae: Nymphalini, Kallimini, and Melitaeini and placed *Junonia* Hubner under Kallimini. Whereas, Wahlberg et al. (2005) divided Nymphalinae into six tribes: Coeini, Nymphalini, Junoniini, Victorinini, Kallimini and Melitaeini based on the DNA sequence data and placed the Genus *Junonia* Hubner under tribe Junoniini.

Six species of Genus *Junonia* Hubner viz., *orythia* (Linnaeus), *iphita* (Cramer), *almana* (Linnaeus), *lemonias* (Linnaeus), *hierta* (Fabricius), *atlites* (Linnaeus) are distributed throughout Indian Subcontinent. Perusal of literature reveals that no consolidated account is available on species wing venation and genitalia of genus *Junonia* Hubner (Kumar et al. 2007). To this date, the taxonomy of *Junonia* is somewhat unstable (Kodandaramaiah & Wahlberg, 2007; Neild, 2008; Brévignon, 2009; Kodandaramaiah, 2009). There is considerable geographic variation within *Junonia* species, and possible on-going hybridization between species, suggesting that *Junonia* may be a ring species, but also making this a very difficult group to define taxonomically (Borchers and Marcus 2014).

Numerous studies at the molecular level have been initiated but no emphasis has been laid down on the genitalic attributes of the species of this genus (Vanlalruati et al., 2011; Gemmell et al., 2014; Win et al., 2015). Recent taxonomic review of tribe Junoniini from Myanmar given by Win et al. (2016) has only dealt with adult descriptions whereas, important taxonomic characters of the external genitalia and wing venations has not been discussed.

In many insects, genitalia often provide the only way to reliably distinguish species using morphology (Siemund and Ahrens 2015). Hence in order to fill the taxonomic gaps, the male and female external

genitalia and wing venation of the six species of the Genus *Junonia* has been illustrated, described and discussed in detail.

Materials and Methods:

The material examined for the present study has been obtained from the preserved entomological collections lying in the Department of Zoology and Environmental Studies, Punjabi University, Patiala and Zoological Survey of India, HARC, Solan. To study wing venation, the methodology given by Common (1970) was followed. For the study of external male and female genitalia, the methodology given by Robinson (1976) was followed.

Terminological review: The terminology given by Sibatani et al. (1954) and Klots (1956) for the male and female genitalia has been followed:

Male Genitalia: Various authors like Bethune Baker (1891), Petersen (1904), Pierce (1909), Eyer (1924), Sibatani et al. (1954), and Ogata (1957) had presented different terminological reviews on the male genitalia in Lepidoptera. The term 'tegumen' is used to denote the dorsal part of the ninth abdominal segment. Pierce (1909) established the term vinculum for the ninth abdominal sternite, but later on (1914), he synonymised it with the term 'saccus' (Bethune Baker, 1891) which signified both saccus and vinculum. In the present study, the terms used are as follows: saccus, lateral-dorsal projections of the saccus, and lateral-ventral projections of the tegumen.

Nevertheless, the subdivision of valvae has always been the point of debate. The valvae terminology reviewed by Sibatani et al. (1954) and Klots (1956) are applied in the present work. The terms used are as follows: costa (dorso-proximal region of the valvae), sacculus (ventro-proximal region of the valvae), ampulla (medio-dorsal region), and harpe (posterior projection of the sacculus, on the innerside of the valvae). The terminology for the copulatory organ of male Lepidoptera is followed as given by Klots (1956). The terms used are as follows: aedeagus (sclerotized tubular structure), vesica (membranous tube), ductus ejaculatorius (a duct along which spermatozoa move from the testes).

Female Genitalia: All the terms adopted by Klots (1956) are used, except the term genital plate used by Pierce (1909) is here replaced by sterigma as the latter denotes the fused ante- and post-vaginal

lamellae. Moreover, it is more commonly found mentioned in the literature and widely used by specialists (Carneiro et al. 2013).

Genus *Junonia* Hubner, 1819

Common name: Buck eye, Pansies or Commodores

Junonia Hübner, [1819] Verz. bek. Schmett. (3): 34

General Characteristics:

Adult Diagnosis: Broad-winged butterflies with a relatively small body, ground-colour dull grey-brown, red brown or black; head broad; eyes naked; palpi long, projecting beak-like; antennae about half the length of the forewing; latter triangular, costal margin strongly curved, apex more or less obliquely truncate, termen concave; wing shape variable in seasonal forms, wing more strongly angulate in dry-season form than in wet-season form; upper discocellular obsolete, middle one deeply concave, lower discocellular absent, discal cell open; hind wing triangular, apex round, tornal angle often produced into a lobe; precostal erect and then almost rectangular bent outward, sometimes bearing a short spur on basal side.

Immature stages: Larva cylindrical, with branched thorns; head with short bristles; pupa suspended, with small wartlike tubercles on the back.

Distribution and Natural History:

The genus is distributed over all major bio-geographical regions of the world except the Palaearctic (Kodandaramaiah and Wahlberg, 2007).

Commonly known as the pansies and buck-eyes, the members of genus *Junonia* are sun loving butterflies and can be found flying during the hottest hours of the day. Although having a preference for the riverine habitat, these butterflies are generalist species and are found venturing into wide variety of habitats. The wings have characteristic eye spots (ocelli). Their flight is very fast, remaining close to the ground. The flashy colour on the underside of these butterflies makes them nearly invisible while they sit on bare ground to indulge in mud puddling in the sun. They have a definite preference for salts from the ground and are often seen puddling in the rocky terrains near the

source of water. These fast flying butterflies are fast fliers, and are fond of sitting with spread wings on the ground.

Identification keys to species of genus *Junonia* Hubner, 1819 from India:

- | | |
|---|----------------------------|
| 1. Valvae C- shaped..... | 2 |
| — Valvae longer than broad..... | 3 |
| 2. Uncus hidden between a pair of valvae..... | <i>hierta</i> (Fabricius) |
| — Uncus not hidden between a pair of valvae..... | <i>orythia</i> (Linnaeus) |
| 3. Tegumen dome shaped..... | 4 |
| — Tegumen relatively flat..... | 5 |
| 4. Ampulla bear two long deeply curved spines..... | <i>almana</i> (Linnaeus) |
| — Ampulla differentiated into a small spine..... | <i>lemonias</i> (Linnaeus) |
| 5. Ampulla and harpe broad, ampulla spatulate..... | <i>iphita</i> (Cramer) |
| — Ampulla and harpe narrow, ampulla folded upon itself..... | <i>atlites</i> (Linnaeus) |

Junonia orythia (Linnaeus, 1758)

(Figure 1)

Papilio orithya Linnaeus, 1758 Syst. Nat. (Edn 10) 1: 473.

Wing expanse: 40-60 mm.

Diagnosis: Adult (Male): Upper side of forewing dark brown from base to post discal area, an oblique white band from costa to termen, apical area pale brown, two eye spots in post discal area; upper side of hind wing with ground colour shining blue, black angular patch below discal cell curving towards inner margin, two eyespots in post discal area; underside from dull ochraceous to dark brown depending upon to seasonal form.

Female: Similar as male, but basal half of hind wing entirely black, and eye spots more prominent.

Male genitalia (Figure 2): Tegumen well developed, arched, moderately sclerotized; semicircular tegument fold present on antero-lateral margins; latero-ventral projections of tegumen broad;

saccus distinct and moderately sclerotized; latero-dorsal projections V-shaped, narrow, extending dorsally; anterior projection of saccus tubular in lateral view and posterior elongation absent; uncus differentiated from tegumen by a light sclerotization, broad proximally with distal portion descending into a sharp narrow pointed tip, sinous and sparsely setose and approximately as long as tegument; gnathos attached to caudal margin of tegumen, more or less rhomboid in shape and moderately sclerotized with two halves remain separate from each other; subschaphium developed into a u-shaped pad, densely setosed; valvae broad proximally, well sclerotized, costa convex, broad and strongly sclerotized, ampulla well developed into an arm, sparsely setose, ventral margins serrated and slightly folded upon it, sacculus convex, sparsely setose and well sclerotized, harpe developed into an arm, well sclerotized, bears serrations, extends slightly beyond ampulla and partially overlaps latter laterally; aedeagus curved, approximately as long as valvae, more or less cylindrical and narrows into a tip posteriorly; ductus ejaculatorius enters from lateral side.

Female genitalia (Figure 3): Sterigma composed of coupling of lamella antevaginalis and lamella postvaginalis (no sharp distinction between these two) which after fusion forms a sclerotized rectangular plate forming a u-shaped arc; ductus bursae very small, funnel like, membranous, leading to corpus bursae after a narrow constriction; corpus bursae very long, extends far cephalad into abdomen, membranous, balloon shaped, narrow at its base but dilating gradually towards apex, signa absent; ductus seminalis enters dorsally at base of ductus bursae and its entry marked by prominent sclerotization; eighth segment fully developed, moderately sclerotized, pair of anterior apophysis present, extending cephalad with spatulate and clubbed anterior tip; anal papillae moderately sclerotized, heavily setose with short setae, posterior apophysis present, similar to anterior apophysis.

Material examined:

Punjab Shivaliks:

Hosiarpur: 1 Female, 17.vii.1999, Saleran dam (Shivalik); 1 Female, 10.ix.1999, Hosiarpur;

Ropar: 1 Female, 10.vii.2000, Ropar; 1 Male, 20.vii.2000, Ropar;

Chandigarh: 1 Female, 22.iv.1997, Sukhna Lake;

Haryana:

Panchkula: Female, 4.viii.1996, Morni hills.

Jammu & Kashmir:

Baramulla: 2 Male, 11.x.2013, Uri; 1 Female, 10.x.2013, Uri; 2 Male, 29.ix.2013, Eco-park; 1 Female, 29.ix.2013, Eco-park;

Srinagar: 1 Male, 2.x.2013; Botanical Garden; 1 Female, 2.x.2013, Botanical Garden; 1 Female, 9.x.2013, Harwan Garden;

Himachal Pradesh:

Kangra: 2 Male, 30.vi.1992, Bhagsunag; 3 Female, 30.vi.1992, Bhagsunag; Male, 9.x.1999, Pong Dam; 1 Male, 27.vi.1992, Palampur; 1 Male, 27.vi.1992, Palampur; 5 Female, 3.v.2015, Andreta, Palampur; 6 Female, 4.v.2015, Andreta, Palampur; 1 Female, 6.v.2015, Andreta, Palampur; 3 Male, 3.v.2015, Andreta;

Kullu: 1 Male, 3.x.1993, Bajaura; 1 Male, 28.vii.1992, Bajaura; 1 Male, 13.ix.1992, Chowai; 3 Female, 13.ix.1992, Chowai

Shimla: 1 Female, 29.viii.2013, Ghat ka Jubad, Chail WLS; Male, 29.viii.2013, Ghat ka Jubad, Chail WLS; 1 Male, 24.vi.1996, Kumarsein; 1 Female, 14.vi.1992, Mahog, Chail; 1 Male, 24.vi.1996, Kingal;

Solan: 2 Male, 25.x.1992, Nauni; 1 Male, 3.x.1996, Nauni;

Chamba: 1 Male, 15.vi.1991, Karian; 1 Male, 17.xi.1995, Chamba; 1 Male, 28.v.1992, Chamba ghat; 1 Male, 28.iv.1996, Hardaspur; 1 Male, 29.iv.1996, Tissa; 1 Male, 28.vi.1992, Dal lake, Mcleodagnj; 1 Male, 9.ix.2010, Khajjiar; Female, 22.v.2010, KKWLS; 1 Male, 14.vi.1991, Sarol;

Uttrakhand:

Dehradun: 1 Male, 9.vii.1995, Kempt falls, Mussorie; 1 Male, 3.vi.1992, Mussorie; 1 Male, 13.vi.1995, Rampur, Chakrata; 12 Male, 5.vi.1992, Mussorie, 2 Female, 5.vi.1992, Mussorie; 5 Female, 3.vi.1992, Mussorie; 8 Male, 3.vi.1992, Mussorie;

Nanital: 1 Male, 22.v.2014, Mukteshwar;

Distribution: Madagascar, Tropical Africa (dry), Arabia, India, Ceylon, Burma, New Guinea, N.Australia

Remarks: This is a widely spread species. The wet season forms have prominent eyespots while the dry season forms have these eyespots reduced in size. No major variation in the genitalia could be found. Kumar et al. (2007) had erroneously reported a pair of well-developed signum on the copus bursae of female genitalia of the nominate species. The corpus bursae of the female *J. orithya* lack signum and is entirely membranous.

Junonia iphita (Cramer, 1779)

(Figure 4)

Papilio iphita Cramer, [1779] Uitl. Kapellen 3 (17-21): 30, pl. 209, f. C, D, TL: China

Wing expanse: 55-80 mm.

Diagnosis: Adult (Male): Upper side of forewing dull brown, a broad brown colour band traversed from costa to inner margin, two apical white spots present near costal margin; hind wing upper side dull brown, broad brown colour band in continuation from forewing, sub-marginal series of eyespots along terminal margin; under side of forewing dark brown, basal area traversed by three greyish fasciae, a discal prominent dark brown line traversed across; underside of hindwing eye spots not as prominent as above.

Adult (Female): Similar as male.

Male genitalia (Figure 5): Tegumen U-shaped from dorsal, moderately sclerotized, more or less obliquely slanting towards uncus; semicircular tegument fold present on anterolateral margin. Saccus well developed and distinct; anterior projection of saccus tubular, reaches cephalad up to mid of sixth sternite, slightly curved upward; latero-dorsal projections of saccus narrow, prominent, bears a strong convex curvature and produced into an anteriorly directed crest at point where valvae articulate with latter; uncus stout, well sclerotized, sparsely setosed, angulate from mid dorsal portion, posteriorly descending into sharp pointed tip directed ventral; gnathos paired, roughly rectangular, glued to tegumen by a membrane; valvae well developed, sclerotized, broad

proximally, costa well sclerotized, more or less triangular in shape, ampulla well developed into a laterally flattened arm, sparsely setose and margins spinous, sacculus also well developed, harpe sparsely setose, slightly sclerotized, produced into a spatulate arm with serrated margins and overlaps ampulla laterally; aedeagus long, slender, uniform width throughout its length following apex descending into a sharp pointed tip.

Female genitalia (Figure 6): Eighth sternite reduced and well sclerotized; antevaginal lamella and postvaginal lamella collapse, form a sclerotized plate giving rise to tubular, dorso-ventrally compressed, well sclerotized sterigma; ostium bursae crescent shaped; ductus bursae long and membranous; ductus seminalis enters at base of ductus bursae (region marked with prominent sclerotization) from latero-dorsal side; corpus bursae large, membranous, balloon shaped, narrow at its base but dilating gradually towards apex, signa absent; a pair of well sclerotized and thin anterior apophysis arises from anterolateral margin of 8th tegument. 8th tegument and sternite not fused; anal papillae not small, lightly sclerotized, densely setose with fine setae, pair of posterior apophysis present, well sclerotized, slightly longer than anterior apophyses; both pairs of apophysis are oriented horizontally along abdomen.

Material examined:

Haryana:

Panchkula: 1 Female, 15.x.1995, Morni Hills;

Himachal Pradesh:

Kangra: 3 Male, 30.vi.1992, Dal Lake, Mcleodganj; 1 Female, 30.vi.1992, Dal lake, Mcleodganj; 3 Female, 28.vi.1992, Dal Lake, Mcleodganj; 15 Male, 28.vi.1992, Dal Lake, Mcleodganj; 1 Male, 3.vii.1993, Dal Lake, Mcleodganj; 2 Male, 26.iv.1992, Dal Lake, Mcleodganj; 1 Male, 27.vi.1992, Dal Lake, Mcleodganj; 2 Female, 30.vi.1992, Bhagsunag; 1 Male, 22.viii.1992, Parchu-Palampur; 1 Male, 16.ix.2014, Andreta; 1 Male, 4.v.2015, Andreta, Palampur; 3 Male, 6.v.2015, Andreta, Palampur; 1 Male, 2.v.2015, Andreta, Palampur; 1 Male, 4.v.2015, Andreta.

Mandi: 2 Male, 11.vii.1992, Sarkaghat; 2 Male, 21.iv.2014, Riwalsar; 3 Male, 22.v.2013, Riwalsar lake.

Kullu: 1 Female, 22.vi.1993, Manikaran; 1 Male, 13.ix.1992, Chowai; 1 Male, 8.vi.1995, Chowai; 1 Female, 30.vii.1996, Katrain.

Shimla: 2 Male, 14.vi.1996, Taklech; 1 Female, 14.vi.1996, Taklech; 2 Male, 12.ix.1992, Taklech; 2 Male, 14.vi.1992, Mahog (Chail).

Solan: 2 Male, 14.ix.1991, Nauni; 1 Female, 14.ix.1991, Nauni; 2 Male, 15.ix.1991, Nauni; 2 Male, 12.ix.1991, Nauni; 1 Male, 30.ix.1996, Parwanoo; 1 Male, 24.x.1996, Parwnoo; 2 Male, 14.x.1995, Nauni; 2 Male, 20.iv.1992, Dharampur; 2 Male, 25.xi.1995, Sadhupul; 1 Female, 25.xi.1995, Sadhupul; 1 Male, 22.vii.1992, Dharampur; 1 Male, 16.ix.1991, Kandaghat.

Chamba: 1 Male, 17.xi.1995, Chamba; 1 Female, 17.xi.1995, Chamba; 1 Male, 28.v.1997, Tissa, 1 Male, 16.viii.1991, Khajjiar; 1 Female, 16.viii.1991, Khajjiar; 3 Male, 13.vi.1991, Mehla; 1 Male, 22.iv.1996, Dalhousie; 1 Male, 16.viii.1991, Khajjiar.

Sirmour: 1 Female, 11.xi.1991, Poanta Sahib; 5 Male, 11.xi.1991, Poanta Sahib; 1 Male, 2.xi.1991, Poanta Sahib; 4 Male, 1.xi.1991, Poanta Sahib.

Uttrakhand:

Dehradun: 12 Male, 5.vi.1992, Pumping station, Mussorie; 5 Female, 3.vi.1992, Pumping station, Mussorie; 2 Female, 5.vi.1992, Pumping station, Mussorie; 8 Male, 3.vi.1992, Pumping station, Mussorie; 1 Male, 6.vi.1992, Kempty falls; 2 Female, 4.vi.1993, Kempty falls; 4 Male, 4.vi.1993, Kempty falls; 2 Female, 6.vi.1992, Kempty falls; 3 Male, 6.vi.1992, Kempty falls; 2 Male, 9.vii.1995, Kempty falls; 1 Male, 5.vi.1993, Mussorie; 1 Male, 10.vii.1993, Pumpng station, Mussorie; 6 Male, 6.vi.1993, Pumping station, Mussorie; 2 Male, 10.vii.1995, Pumping station, Mussorie; 1 Female, 10.vii.1995, Pumping station, Mussorie; 2 Male, 7.vi.1993, Spring road, Mussorie; 1 Female, 7.vi.1993, Spring road, Mussorie; 3 Male, 12.vi.1995, Chakrata; 1 Female, 12.vi.1995, Chakrata; 1 Female, 13.vi.1995, Chakrata; 1 Female, 2.vi.1992, Mussorie, 1 Female, 9.vi.1993, Dehradun; 1 Female, 8.vi.1993, Dhanolti, 1 Female, 5.vi.1992, Mussorie; 1 Male, 6.vi.1992, Mussorie; 1 Male, 6.vi.1993, Mussorie; 1 Male, 4.viii.1996, Bhilaru pumping station, Mussorie; 1 Male, 11.vii.1995, Mossy falls, Mussorie; 2 Male, 31.x.1991, Dehradun; 2 Male, 9.vi.1993, Bandal Nadi, Mussorie; 1

Female, 11.vii.1995, Mossy falls, Mussorie; 1 Male, 4.vi.1996, Bhilaru Pumping station, Mussorie; 2

Male, 30.x.1991, Dehradun; 1 Male, 13.vi.1995, Ranital;

Almora: 2 Male, 11.vi.1996, Deghat.

Chamoli: 1 Female, 10.vi.1992, Gopeshwar.

Bhageshwar: 1 Male, 10.vi.1992, Loharkhet.

Nanital: 1 Male, 22.v.2014, Mukteshwar; 5 Male, 23.ix.2014, Bhimtal; 1 Female, 23.ix.2014, Bhimtal;

4 Male, 24.ix.2014, Mukteshwar; 2 Male, 22.ix.2014, Bhimtal.

Distribution: Ceylon, S.India, C.India, Himalayas, NE.India, Burma, Sumatra, W.China, S.China

Discussion: This species is quite common throughout its range. The males exhibit roosting behaviour.

No major variation in the external genitalia could be found.

Junonia lemonias (Linnaeus, 1758)

(Figure 7)

Papilio lemonias Linnaeus, 1758 Syst. Nat. (Edn 10) 1: 473, TL: Canton, China

Wing span: 40-60mm

Diagnosis: Adult (Male): Upper side of forewing brownish, two pale ochreous bars with black margins traverse discal cell, a prominent blue centred orange ringed eyespot near tornus encircled by pale ochre spots which extend obliquely towards costal margin, two more ochre spots near apex, termen sinous; upper side of hind wing brownish with two blue centred orange eye spots, upper eyespot prominent, second eyespot indistinct, two dark sinous sub-marginal lines, termen sinous; underside very variable according to seasons, series of eye spots on hind wing well developed in wet season forms but very obscure in dry season forms.

Male genitalia (Figure 8): Tegumen strongly built, broad, moderately sclerotized, obliquely slanting towards uncus; tegument fold present in semi-circular shape on antero-lateral margin of tegument; uncus broad distally, strongly sclerotized, as long as tegumen, sickle shape with pointed tip, deeply grooved in centre at point of origin of uncus giving a y-shape from dorsal view;

gnathos lightly sclerotized, more or less triangular, separated from tegument by a membrane, pair remains separate; saccus well developed, anterior projection tubular, directed upward, tip blunt; latero-dorsal projections of saccus narrow, arced and short; valvae well developed, sclerotized, longer than broad, directed in a diagonal fashion and hides pointed tip of uncus, costa well developed and sclerotized, ampulla developed into a small arm bearing bifid claw, curved ventrally, sacculus well sclerotized, harpe simple and sparsely setose with long setae, bears minute spines; aedeagus not long, slender, descending into a pointed tip posteriorly.

Female genitalia (Figure 9): Eighth sternite reduced and strongly sclerotized; antevaginal lamella and postvaginal lamella fused together and form a funnel like heavily sclerotized sterigma; ostium bursae crescent shaped; dustus bursae membranous but lightly sclerotized at basal portion; ductus seminalis entering at basal part of ductus bursae from latero-dorsal side, entrance marked by sclerotization; corpus bursae oval, large and somewhat elongated, membranous and signa absent; anal papillae not small, moderately sclerotized and beset with dense setae, remain withdrawn under inter-segmental membrane of 8th and 9th segment and protrude only during egg laying; a pair of thin but prominent and sclerotized posterior apophysis present; a pair of anterior apophysis, shorter than posterior apophysis, arise from antero-lateral margin of 8th tergum, heavily sclerotized and bear spatulate club shaped tip.

Material Examined:

Punjab Shivaliks:

Ropar: 1 Male, 28.ix.1996, Ropar,

Gurdaspur: 1 Male, 2.vi.1995, Dinanagar; 2 Female, 1.viii.1996, Dinanagar.

Haryana:

Panchkula: 4 Male, 4.viii.1996, Morni Hills, 1 Male, 4.ix.1996, Morni Hills; 1 Male, 25.viii.1995, Kalka; 1 Male, 29.ix.1991, Kalka; 2 Male, 23.viii.1993, Kalka; 1 Female, 27.viii.1995, Kalka; 1 Male, 27.x.1995, Morni hill; 1 Male, 25.viii.1996, Morni hills; 1 Female, 4.viii.1996, Morni hills; 2 Male, 14.x.1993, Morni Hills; 1 Male, 27.viii.1995 Morni Hills.

Himachal Pradesh:

Shimla: 1 Male, 12.vi.1992, Shimla; 1 Male, 8.ix.1992, Kumarsain, Narkanda; 1 Male, 24.vi.1996, Kingal.

Solan: 1 Male, 5.iv.1993, Chail Palace; 1 Female, 25.vi.1995, Sadhupul; 1 Male, 22.viii.1992, Dharampur; 1 Male, 18.x.1995, Parwanoo; 1 Male, 26.viii.1995, Nalahgarh; 1 Female, 25.vi.1995, Sadhupul; 3 Male, 24.viii.1993, Kasauli; 3 Male, 22.viii.1992, Dharampur; 1 Female, 3.x.1996, Nauni; 1 Male, 12.xi.1991, Nauni; 2 Male, 14.ix.1991, Nauni.

Sirmour: 3 Male, 2.xi.1991, Poanta Sahib; 1 Female, 3.xi.1991, Nahan; 1 Female, 2.xi.1991, Poanta Sahib.

Kangra: 6 Male, 2.vii.1992, Kangra; 2 Female, 2.vii.1992, Kangra; 1 Male, 3.vii.1992, Kangra; 1 Male, 3.vii.1992, Kangra; 2 Male, 3.vii.1992, Jwalamukhi; 2 Male, 3.vii.1991, Jwalamukhi; 8 Male, 27.vii.1992, Kangra; 8 Female, 27.vii.1992, Kangra; 3 Male, 3.v.2015, Andreta, Palampur; Male, Female, 21.iv.2015, Riwalsar; Male, 22.iv.2015, Riwalsar; 3 Male, 6.v.2015, Andreta, Palampur; Female, 3.v.2015, Andreta, Palampur; 2 Male, 4.v.2015, Andreta, Palampur;

Chamba: 10 Male, 28.vi.1992, Dal Lake, Mcleodganj; 3 Female, 28.vi.1996, Dal Lae, Mcleodganj, 1 Female, 20.vi.1992, Kellar, Pangji; 1 Female, 26.iv.1992, Mcleodganj; 1 Male, 20.vi.1993, Tissa Bridge; 1 Female, 20.vi.1993, Tissa Bridge.

Mandi: 1 Male, 7.vii.1992, Sarkaghat; 1 Male, 24.iv.1992, Sarkaghat; 1 Male, 28.viii.1992, Sarkaghat; 2 Female, 28.viii.1992, Sarkaghat; 1 Male, 21.viii.1992, Sarkaghat; 1 Male, 6.vi.1992, Sarkaghat; 5 Male, 26.vi.1992, Riwalsar; 1 Female, 22.ix.1992, Kanda pattan; 1 Female, 26.vi.1992, Riwalsar.

Kinnaur: 1 Female, 19.vi.1992, Kalpa.

Uttrakhand:

Dehradun: 2 Male, 29.x.1991, Dehradun; 2 Male, 30.x.1991, Dehradun; 1 Male, 4.vi.1992, Mussorie.

Tehri-Gharwal: 2 Male, 9.vi.1993, Bandal Nadi

Bhageshwar: 1 Female, 10.vi.1995, Loharkhet.

Nanital: 1 Male, 4.vii.1994, Kathgodam.

Distribution: Ceylon, Himalayas, Assam, Bengal, S.India, C.India, Saurashtra, Burma

Remarks: Discal ocellus on the upper side of the hind wing near the apex is variable in size and could be moderate to very large having two irises, one large and other small. In the dry season forms the wings are more falcate and have reduced eye spots on the underside of the wings than the wet season forms. The males exhibit roosting behaviour.

Junonia almana (Linnaeus, 1758)

(Figure 10)

Papilio almana Linnaeus, 1758 Syst. Nat. (Edn 10) 1 : 472, TL: Canton, China

Wing span: 60-65 mm

Diagnosis: Adult (Male): Upper side tawny, costal margin of forewing brown, two transverse brown lines across cell base, three dark bands across costal margin of forewing, two prominent eyespot in post discal area; hind wing suffused with dull brown scales, tawny beyond middle, a large prominent eyespot in discal area near costal, another discal eyespot small and obscure, two black submarginal lines across termen of forewing and hind wing; under side of wings seasonally variable with eyespots well developed in wet season form and eyespots obscure in dry season form.

Male genitalia (Figure 11): Tegumen broad, well developed, moderately sclerotized, u-shaped from dorsal view; tegument fold present on anterio-lateral margin of tegumen; saccus well developed, sclerotized, anterior projection slender, curved upward, latero-dorsal projections short, narrow; uncus distally broad, as long as tegumen, sickle shaped, well sclerotized, strongly built, sparsely setose; gnathos roughly triangular, lightly sclerotized, differentiated from tegument by light sclerotization; valvae longer than broad, sparsely setose, positioned diagonally, caudal part of pair of valvae hides tip of uncus, costa well developed, sclerotized, ampulla differentiated into bifid claw like processes, strongly curved inward, sacculus well developed, not articulated with latero-dorsal projection of saccus, harpe slightly sclerotized and sparsely setose, spatulate, overlaps ampulla, bears a small spine ventrally, serrated margins; aedeagus not long, well sclerotized and slender.

Female genitalia (Figure 12): Eighth sternum reduced, surrounded and sustained by strong sclerotization of vaginal lamella (anterior and posterior vaginal lamella) which in this case forms tubular sterigma; eighth tergum well developed; sterigma well developed and strongly sclerotized; ostium bursae crescent shaped; ductus bursae long, funnel shaped and membranous, lead to long and membranous corpus bursae after a narrow membranous constriction; corpus bursae long, balloon shaped, membranous and narrow at base but gradually dilating towards apex; signa absent; anal papillae not large, moderately sclerotized, densely setose with short setae, kept retracted under intersegment membrane of 8th and 9th segment and emerge only during egg-laying; anterior and posterior apophyses present, thin but well sclerotized tips spatulate; posterior apophysis slightly longer than anterior apophysis.

Material examined:

Punjab Shivaliks: Female, 27.ix.1999, Dholbana (Shivaliks); Female, 15.ix.1999, Dholbaha; Female, 15.ix.1999, Dholbaha; Male, 25.ix.1999, Kahanpur; Female, 4.vi.2000, Balsua; Female, 7.v.2000, Ropar; Female, 7.v.2000, Ropar; Female, 6.v.2000, Ropar; Female, 25.ix.1999, Kahanpur(Shivalik); Male, 27.ix.1999, Dholbaha; Female, 7.v.2000, Ropar; Female, 30.x.1999, Dherian; Female, 30.x.1999, Hosiarpur; Male, 30.x.1999, Hosiarpur; Female, 6.v.2000, Ropar; Male, 4.vi.1996, Punjabi University Patiala.

Solan: 1 Male, 29.vii.2000, Kansal; 2 Female, 29.vii.2000, Kansal; 1 Female, 5.xi.2000, Kansal.

Shimla: 1 Female, 6.xi.1970, Shimla.

Kullu: 3 Male, 10.10.1993, Vasistha; 1 Female, 22.10.1993, Vasistha; 1 Female, 18.10.1993, Vasistha; 1 Male, 10.11.1993, Vasistha.

Sirmour: 1 Male, 15.iii.2008, Simbalwara.

Chamba: 1 Male, 22.4.1996, Dahousie; 1 Female, 24.v.2010, Khajjiar.

Mandi: 2 Male, 19.10.1996, Sarkaghat.

Kangra: 1 Female, 2.x.2000, Pong dam; Male Female, 2.v.2015, Andreta, Palampur; Male, 2 Female, 4.v.2015, Andreta; Male, 6.v.2015, Andreta, Palampur; 2 Female, 3.v.2015, Andreta;

Una: 1 Female, 2.7.1996, Gagret.

Kinnaur: 1 Male, 24.x.1996, Kalpa.

Dehradun: 1 Male, 18.6.1992, Vikasnagar; 1 Male, 19.6.1992, Vikasnagar; 1 Female, 19.6.1992, Vikasnagar; 1 Male, 29.10.1991, Dehradun; 1 Female, 2.viii.2000, F.R.I.

Distribution: Ceylon, India, Burma, Malaysia, Java, Sumatra, Formosa, Philippines, Hong Kong, Andaman, Nicobar

Remarks: The size of the dorsal apical eyespot on the discal area of the hind wing may vary from moderate to very large. The wings in the dry season form are more falcate than wet season form. The eyespots on the underside of the wing are prominent in wet season form whereas these eyespots are obsolete in dry season form.

Junonia hierta (Fabricius, 1798)

(Figure 13)

Papilio hierta Fabricius, 1798 Ent. Syst. (Suppl.): 424, TL: "South India"

Wing span: 45-60mm

Diagnosis: Adult (Male): Upper side of forewing pale yellow, apical portion black with two pre-apical white streaks, inner margin of wing black; hind wing basal half black with a prominent large blue spot, remaining area pale yellow, termen black and sinous.

Female: Forewing similar as male except a black band covers end cell and a prominent eyespot in lower discal area; hind wing similar as male but two small eyespots present in discal area and two subterminal black lines across termen.

Male genitalia (Figure 14): Tegumen strongly built, broad, well sclerotized, u-shaped from dorsal view, semicircular tegument fold present in anterio-lateral margin, latero-ventral projections broad; appendices angularis present; saccus well developed, anterior projection slender, stout, short, not curved dorsally, tip blunt; latero-dorsal projections of saccus well developed, not arched, not narrow, well sclerotized, merge with latero-ventral projection of tegumen; uncus well sclerotized, sleek, broad proximally, descends into sharp pointed tip, slightly sinuous, sparsely setose; gnathos

present, not conspicuous, roughly triangular, lightly sclerotized; valvae well developed, moderately sclerotized, sparsely setose, c-shaped, stout; costa well sclerotized, round; ampulla spatulate, setosed, serrated margin due to presence of claw like spines; sacculus well developed, round and well sclerotized, harpe spinous apically, overlaps ampulla laterally; aedeagus slender gradually narrowing towards posterior to a pointed tip, well sclerotized and curved slightly; ductus ejaculatoris enters ventrally.

Female genitalia (Figure 15): Eighth sternum not reduced and moderately sclerotized, latter surrounded and sustained by strong sclerotization of vaginal lamella, which in this case form a U-shaped groove like sterigma; fusion of antevaginal lamella and postvaginal lamella forms a heavily sclerotized sterigma; ostium bursae crescent shaped; ductus bursae membranous and very long; ductus seminalis enters at base of ductus bursae from dorso-lateral side; corpus bursae slender, narrow at base but gradually dilating towards apex, signa absent; anal papillae moderately sclerotized and densely setose with short setae, kept retracted under inter-segmental membrane of 8th and 9th segment and emerge only during egg-laying, equipped with a pair of posterior apophyses; anterior apophysis present, arise from anterior lateral margin of 8th tegument, shorter than posterior apophysis, crimped, both pair of apophysis have spatulate tips.

Material examined:

Sirmour: 1 Male, 14.11.1993, Renuka.

Shimla: 1 /Male, 6.9.1992, Saketi.

Kullu: 1 Male, 22.10.1993, Vasistha; 1 Female, 10.10.1993, Vasistha.

Solan: 2 Male, 14.9.1991, Nauri; 1 Male, 26.5.1992, Nauri; 1 Female, 24.8.1995, Kasauli; 1 Male, 16.9.1995, Kandaghat; 1 Female, 19.11.1995, Nauri.

Kinnaur: 1 Male, 29.9.1991, Kalpa.

Panchkula: 1 Female, 25.8.1995, Pinjore.

Dehradun: 2 Male, 12.6.1995, Chakrata; 2 Male, 4.6.1993, Kempty falls; 1 Female, 4.6.1993, Kempty falls; 1 Male, 12.5.1995, Chakrata.

Distribution: India, Ceylon, Burma, Cambodia - W.China, S.China, Andaman, Nicobar

Remarks: This species prefers hottest temperatures and is a quick flier. No prominent variation in genitalia is observed.

Junonia atlites (Linnaeus, 1763)

(Figure 16)

Papilio atlites Linnaeus, 1763; *Amoenitates Acad.* 6: 407; TL: Asia

Wing span: 55-65mm

Diagnosis: Adult (Male): Upperside greyish in colour, a pair black transverse lines across mid cell, another pair of black traverse lines across end cell, a wide irregular transverse band across discal area interrupted by a series of six oval ocellated spots, of which first, second and third from costal margin are larger and brighter; Hind wing upperside grey with numerous tranverse black lines around basal area, transverse band as in forewing except only five ocellated spots are present.

Underside numerous transverse line around basal area in fore wing and hind wing, a prominent dark brown line across discal area, only three eyespots on fore wing and two eyespots in hind wing are distinct.

Adult (Female): As male but larger and darker.

Male genitalia (Figure 17): Tegumen well developed, u-shaped, well sclerotized, dome shaped; tegument fold well developed on anterolateral margins of latero-ventral margins of tegument; uncus well developed, broad at base, moderately sclerotized, curved obtusely from middle towards ventral side, slender, sharp pointed tip sparsely setose; saccus present, well developed; anterior projection long and curved upward; latero-dorsal arm sclerotized, narrow and strongly arched, extends upwards till they merge with lateroventral projections of tegumen; gnathos present, conspicuous, well sclerotized, bean shaped, connected to tegument by lightly sclerotized membrane; valvae longer than broad, oriented diagonally, well sclerotized and setose; costa well developed; ampulla simple, leaf like with serrated margins; sacculus well sclerotized; harpe sclerotized and

sparsely setosed, flap like with serrated margins, partially overlaps ampulla; aedeagus slender, well sclerotized, not long and tip pointed.

Female genitalia (Figure 18): Eighth sternite highly reduced; sterigma composed from coupling of antevaginal lamella and postvaginal lamella forming a sclerotized oval arc housing ostium bursae; sterigma forms a sclerotized lobe running cephalad leading to ductus bursae; eighth tergum well developed; ductus bursae membranous, long and funnel like; ductus seminalis entering dorsally from posterior of ductus bursae, after a narrow constriction leads to corpus bursae; latter long membranous and gradually expanding anteriorly; anal papillae not large, more or less rectangular, densely setose; antero-lateral margin of anal papillae bears posterior apophysis; anterior apophysis present on anterolateral margin of 8th tergum; former shorter than posterior apophysis and sinous, both pair of apophysis have clubbed and spatulate tips.

Distributions: NE.India, Himalayas (foot), Peninsular India (wetter regions), Ceylon, Burma

Discussion: This species is not so common in western part of the Himalaya.

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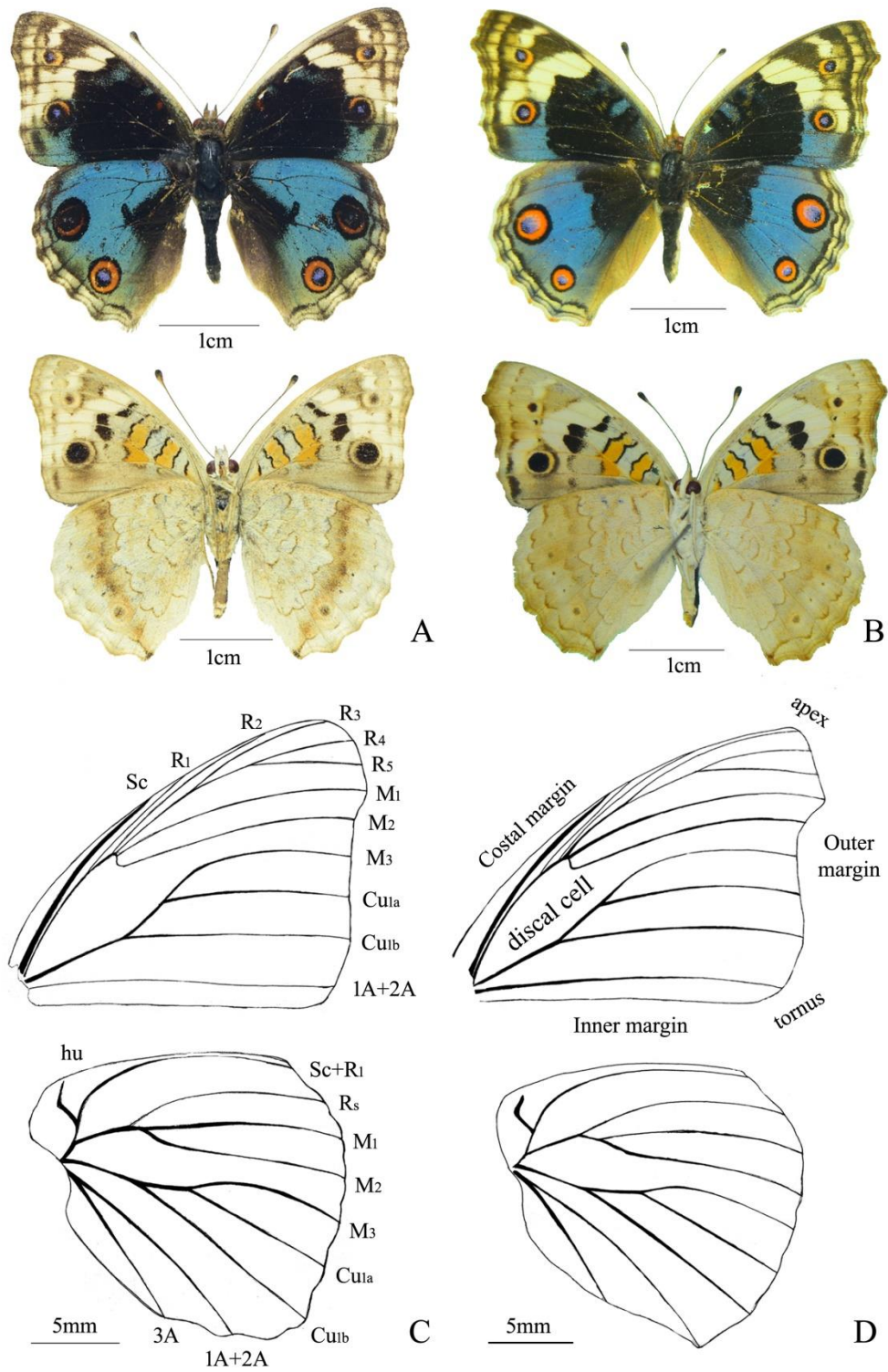


Figure 1. *Junonia orythia* (Linnaeus, 1758): A, Male; B, Female; C, wing venation (male); D, wing venation (Female).

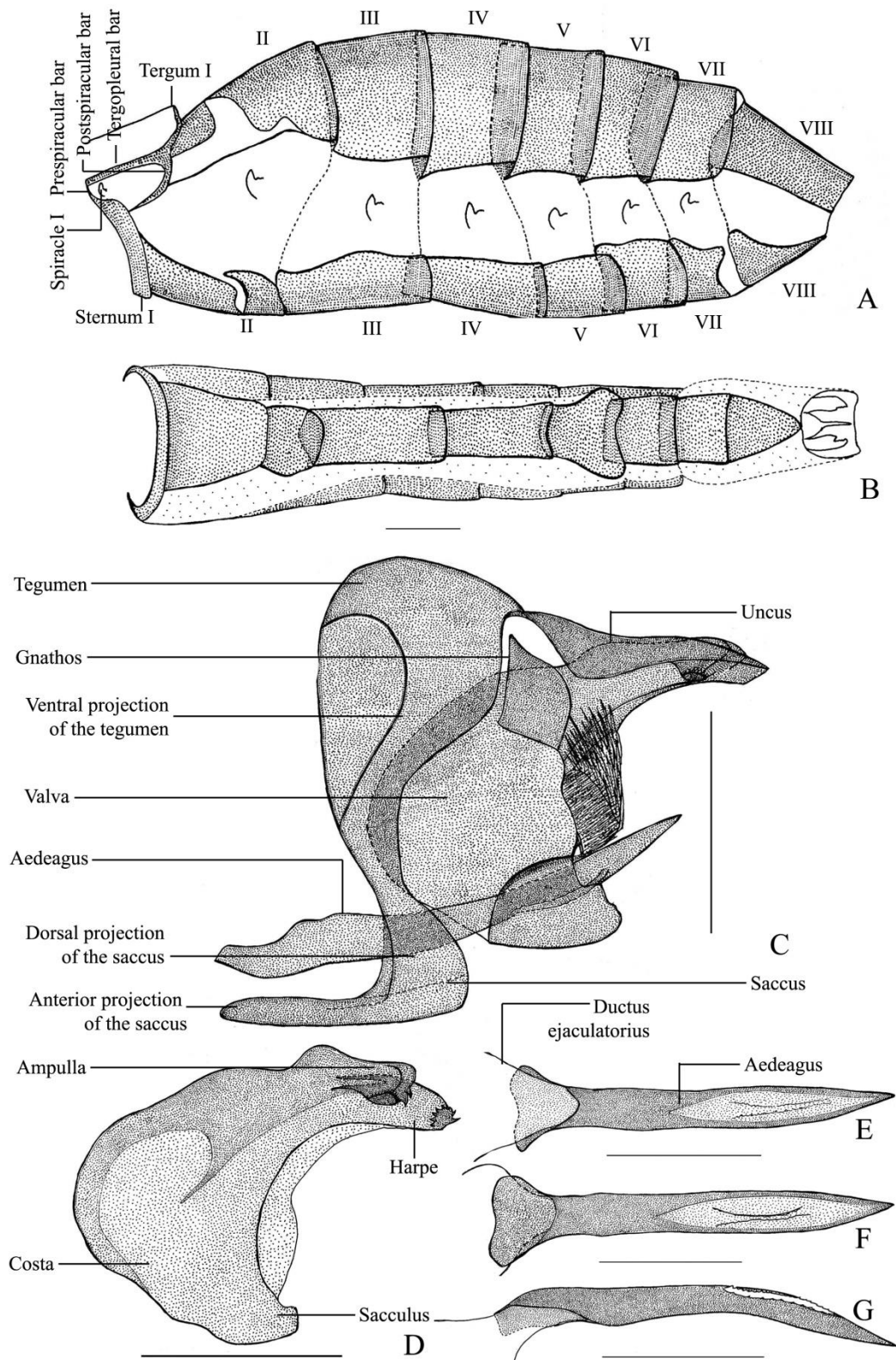


Figure 2. Male genitalia of *Junonia orythia* (Linnaeus, 1758): A-B, abdomen (dorsal and ventral view, respectively); C, male genitalia (lateral view); D, right valva (inner view); E-G, aedeagus (dorsal, ventral and lateral view respectively). Scale bar 1mm.

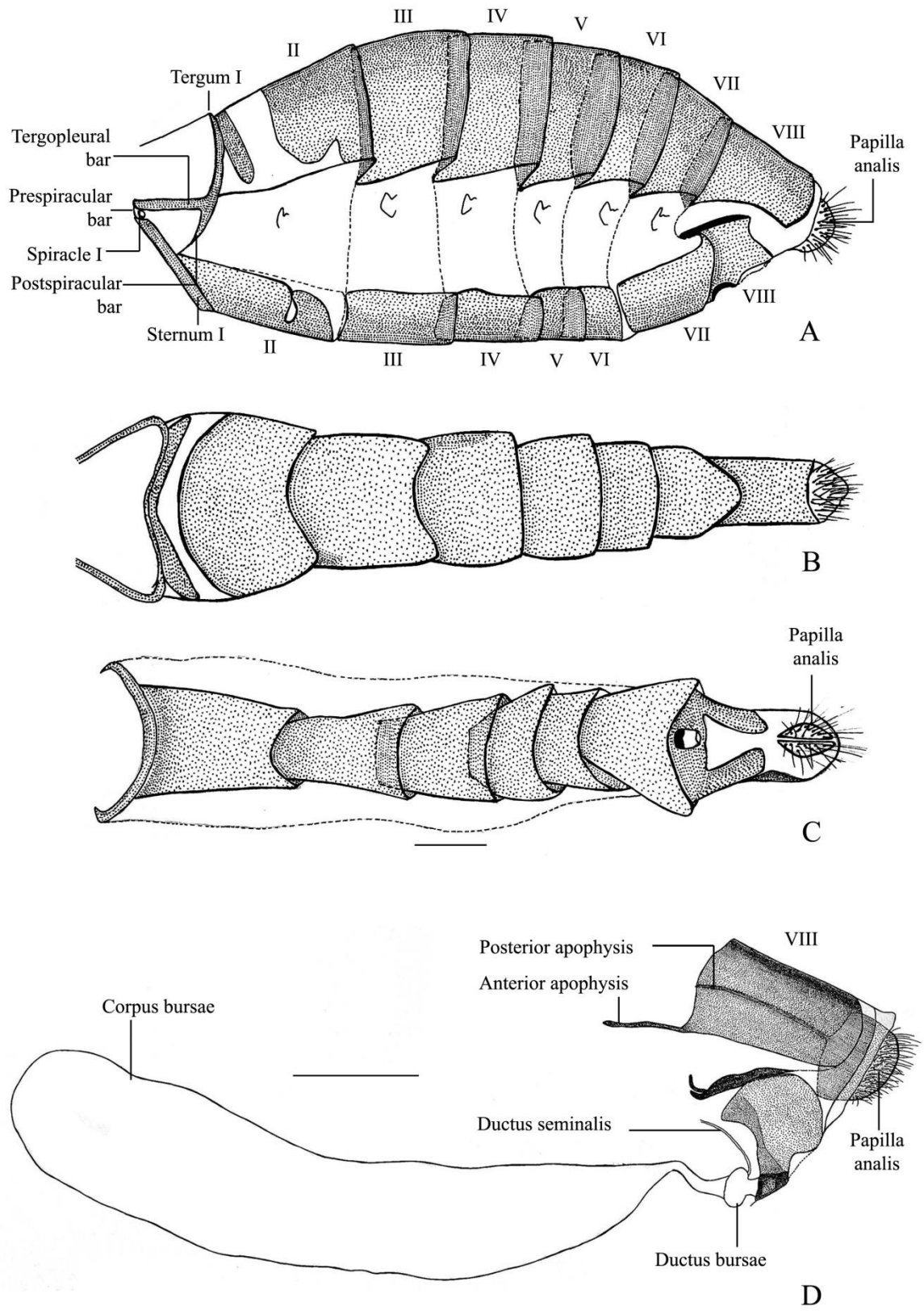


Figure 3. Female genitalia of *Junonia orithya* (Linnaeus, 1758): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.

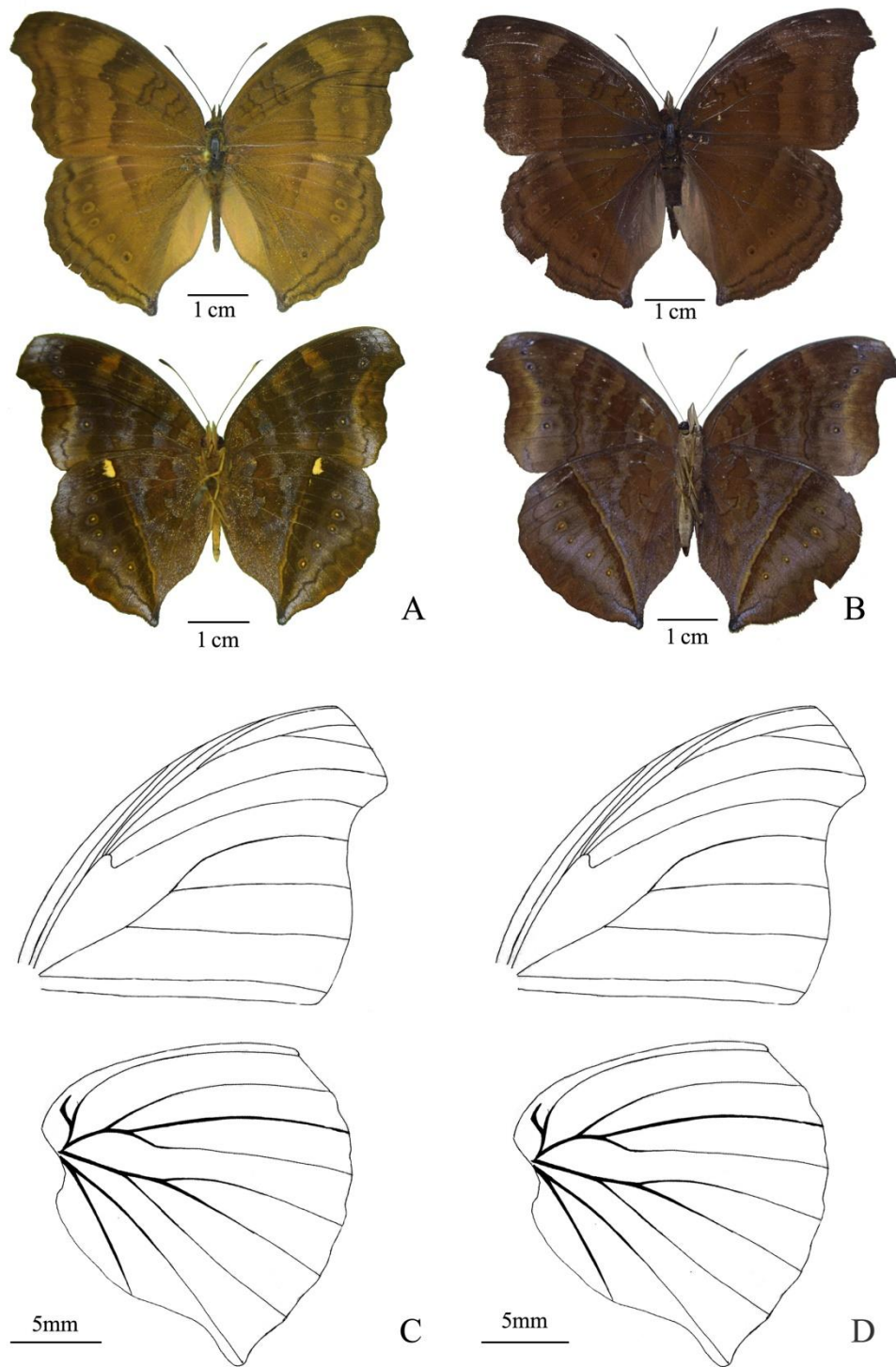


Figure 4. *Junonia iphita* (Cramer, 1779): A, Male (wet season form); B, Female (dry season form); C, wing venation (male); D, wing venation (female).

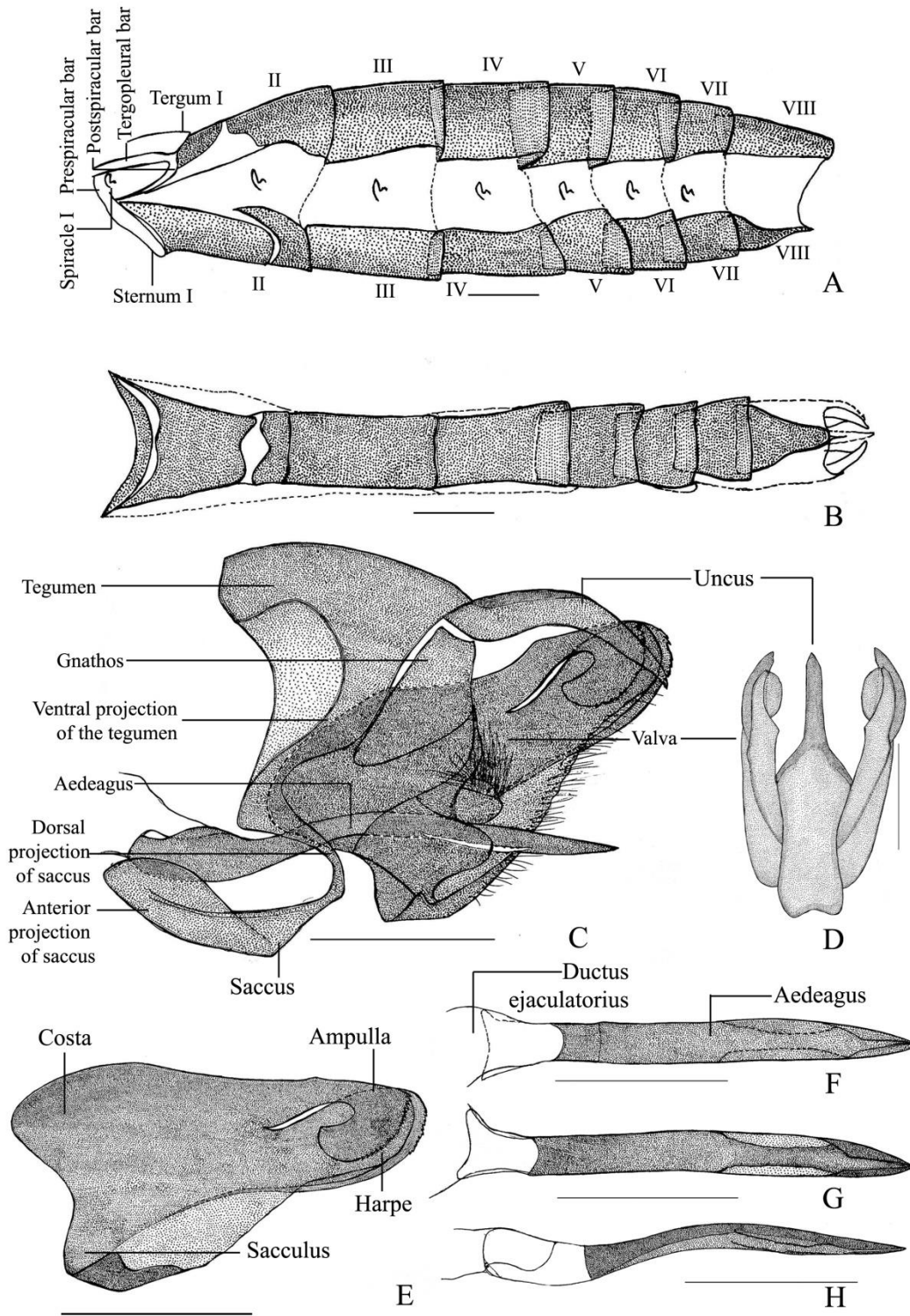


Figure 5. Male genitalia of *Junonia iphita* (Cramer, 1779): A-B, abdomen (dorsal and ventral view, respectively); C, male genitalia (lateral view); D, uncus (dorsal view); E, right valva (inner view); F-H, aedeagus (dorsal, ventral and lateral view respectively). Scale bar 1mm.

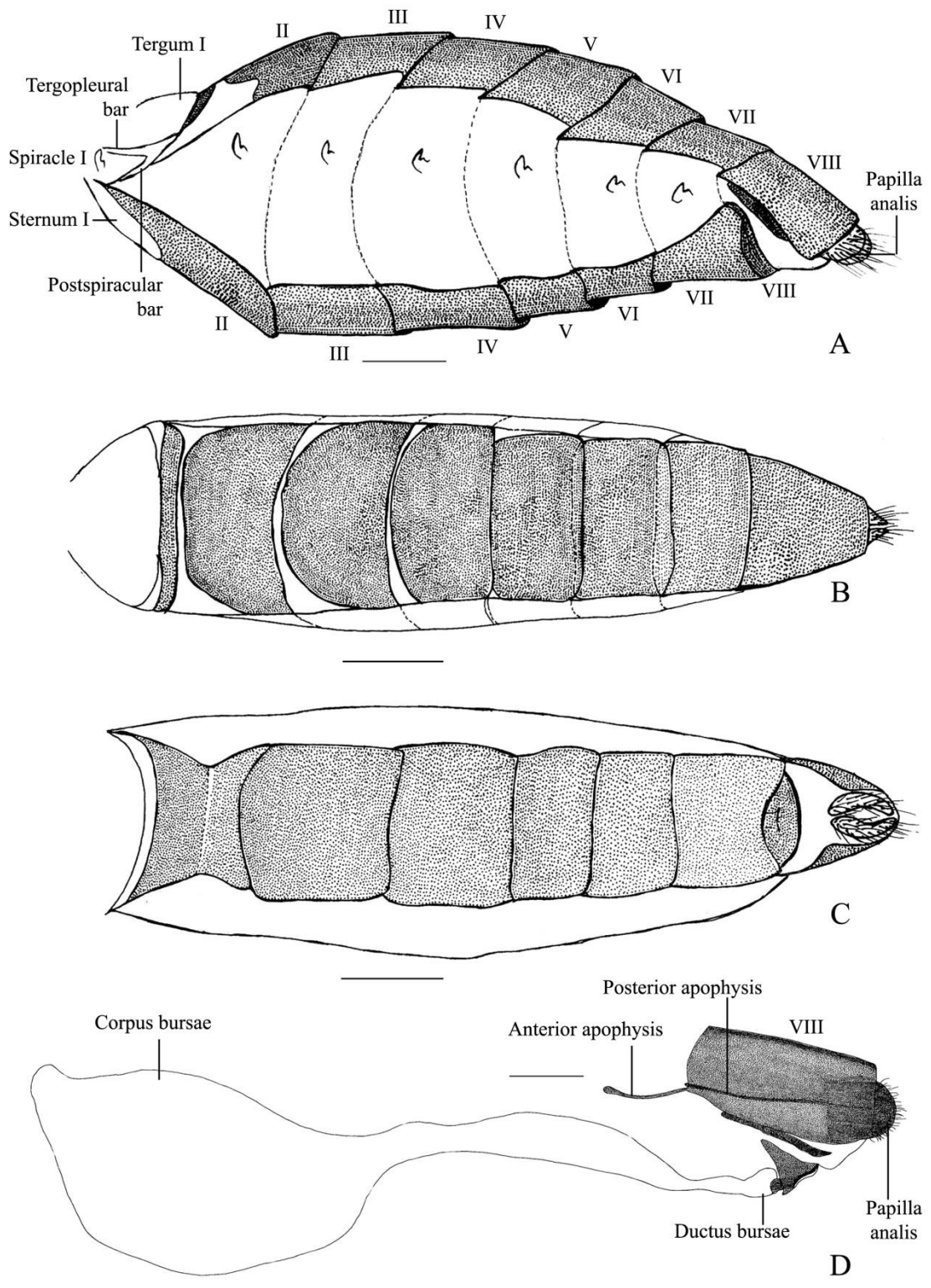


Figure 6. Female genitalia of *Junonia iphita* (Cramer, 1779): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.

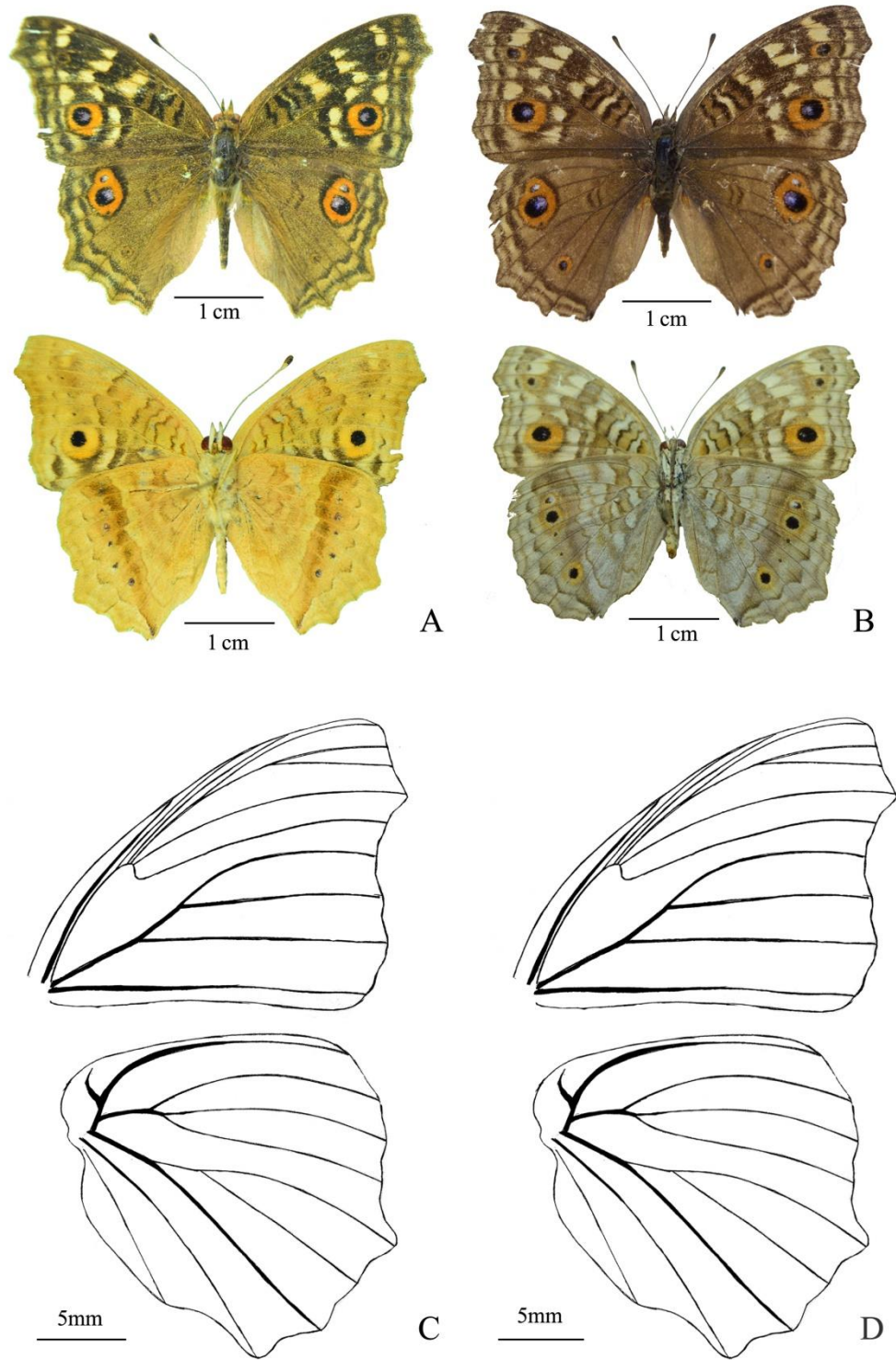


Figure 7. *Junonia lemonias* (Linnaeus, 1758): A, Male (dry season form); B, Female (wet season form); C, wing venation (male); D, wing venation (female).

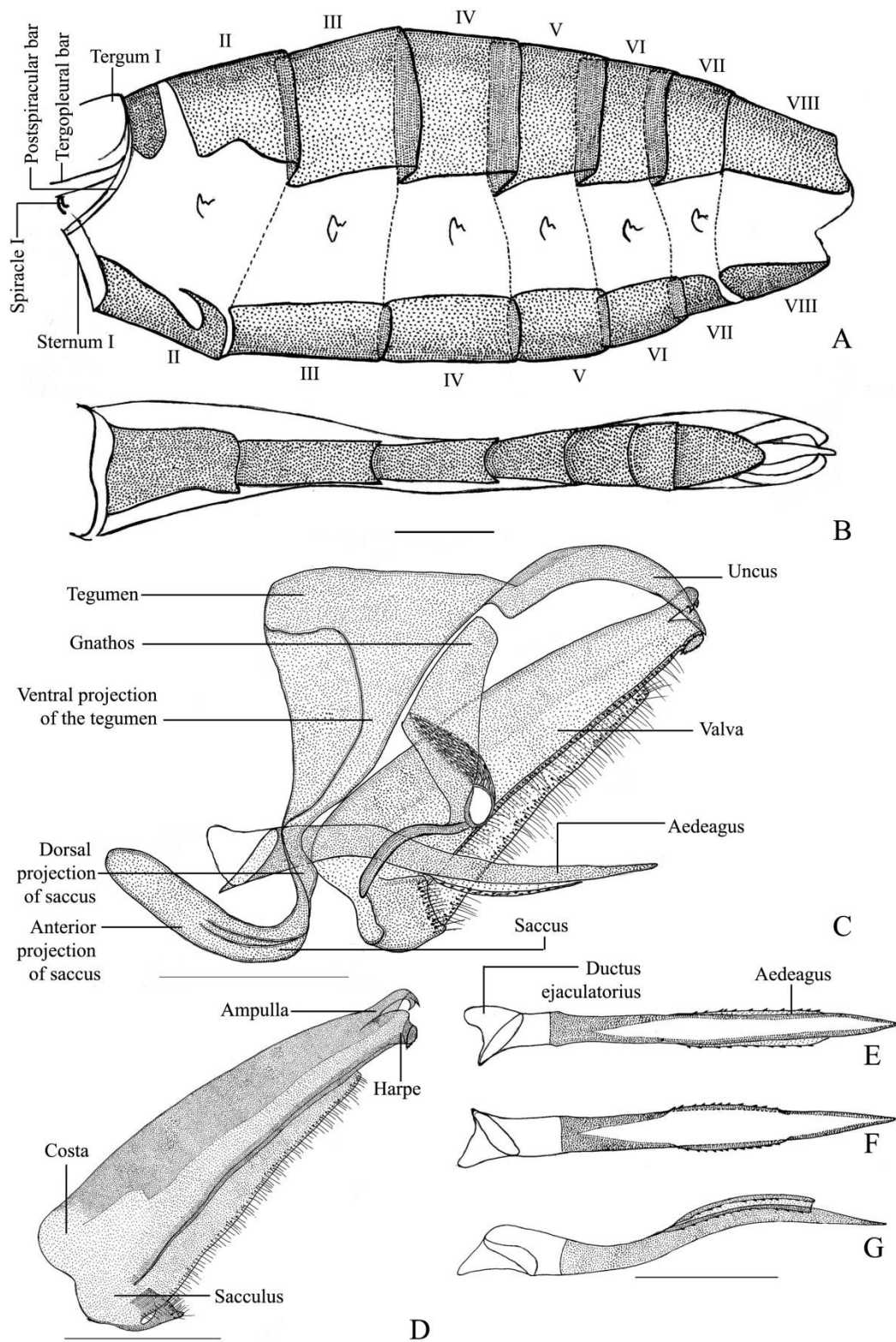


Figure 8. Male genitalia of *Junonia lemonias* (Linnaeus, 1758): A-B, abdomen (dorsal and ventral view, respectively); C, male genitalia (lateral view); D, right valva (inner view); E-G, aedeagus (dorsal, ventral and lateral view respectively). Scale bar 1mm.

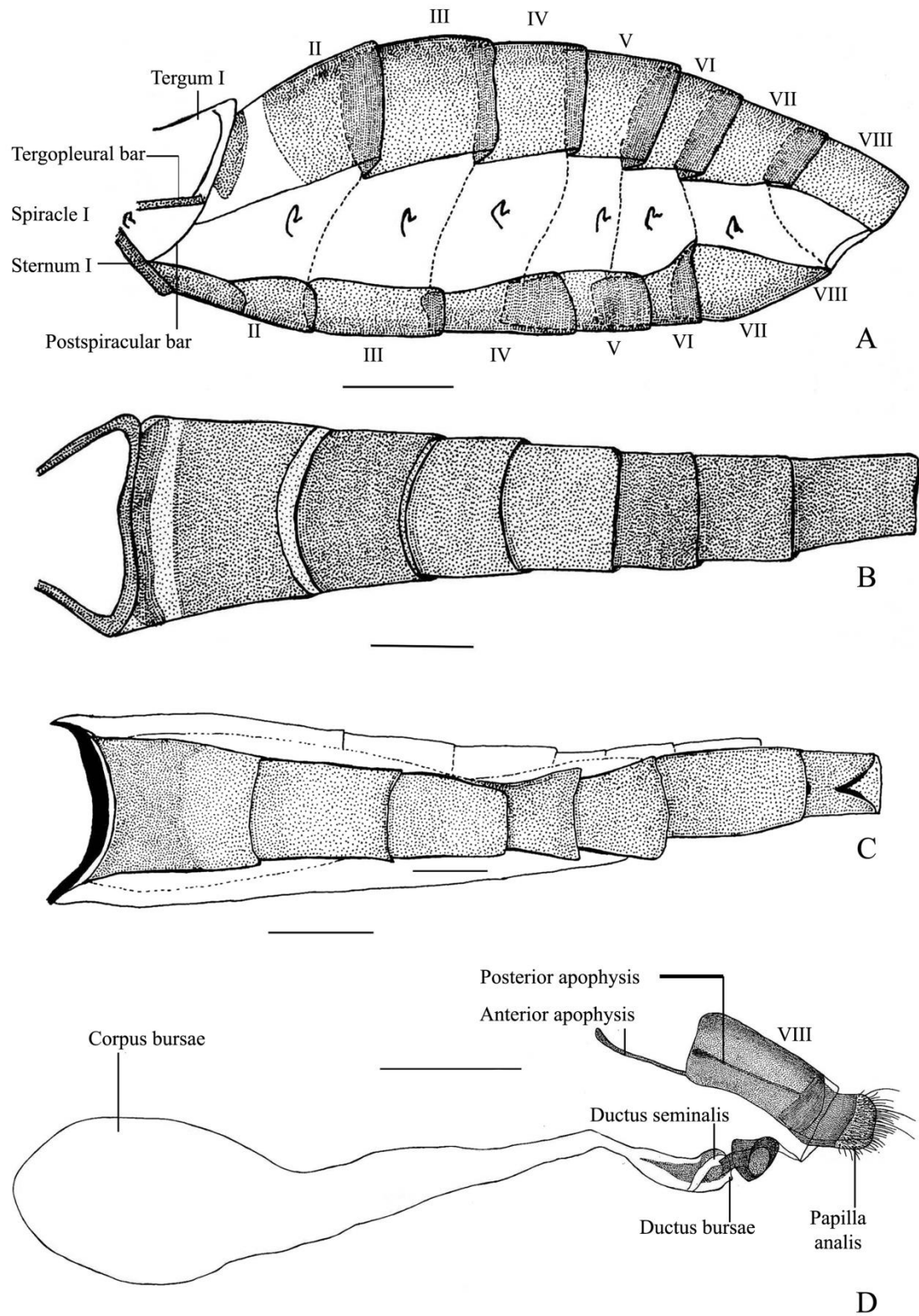


Figure 9. Female genitalia of *Junonia lemonias* (Linnaeus, 1758): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.

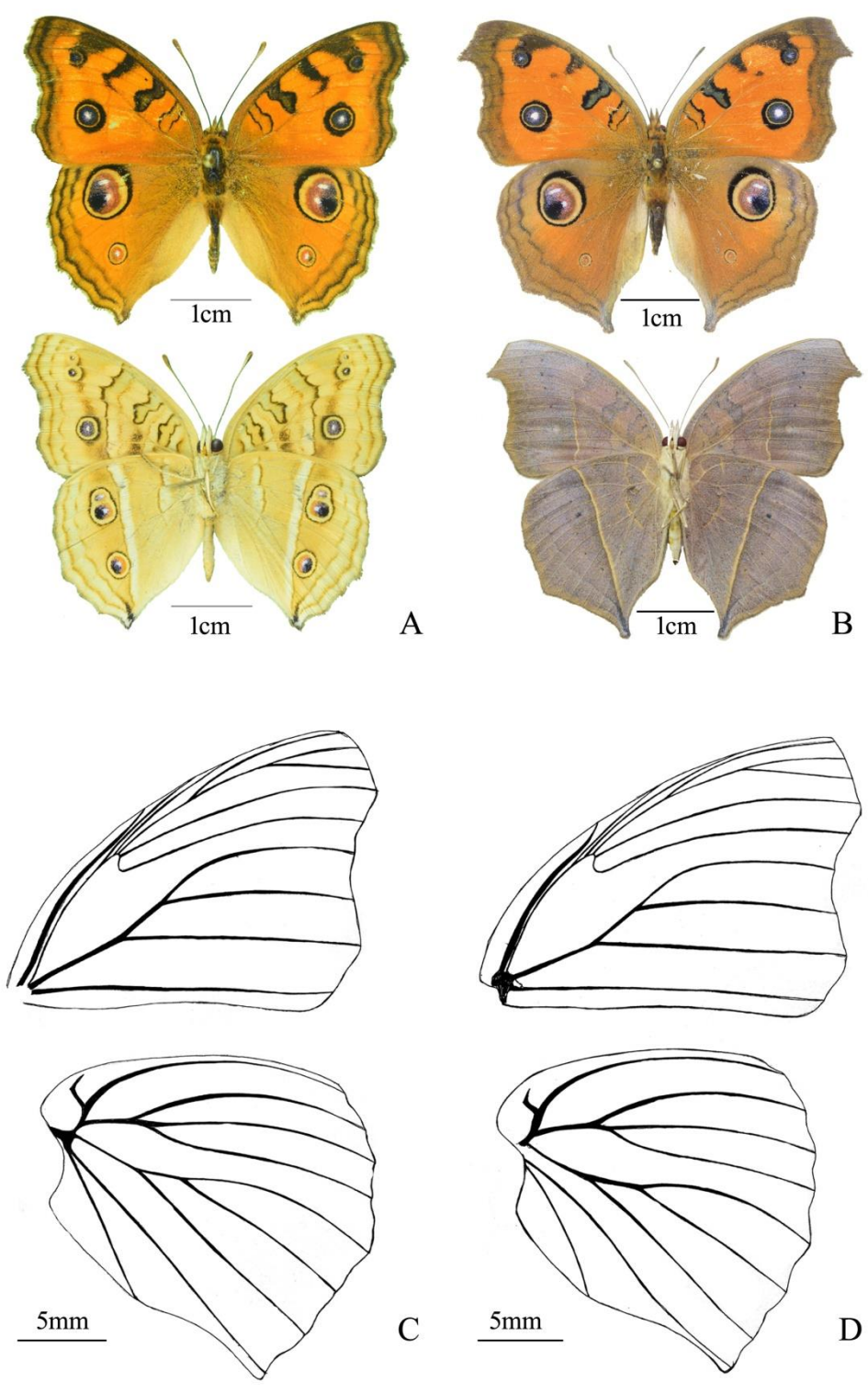


Figure 10. *Junonia almana* (Linnaeus, 1758): A, Male (wet season form); B, Female (dry season form); C, wing venation (male); D, wing venation (female).

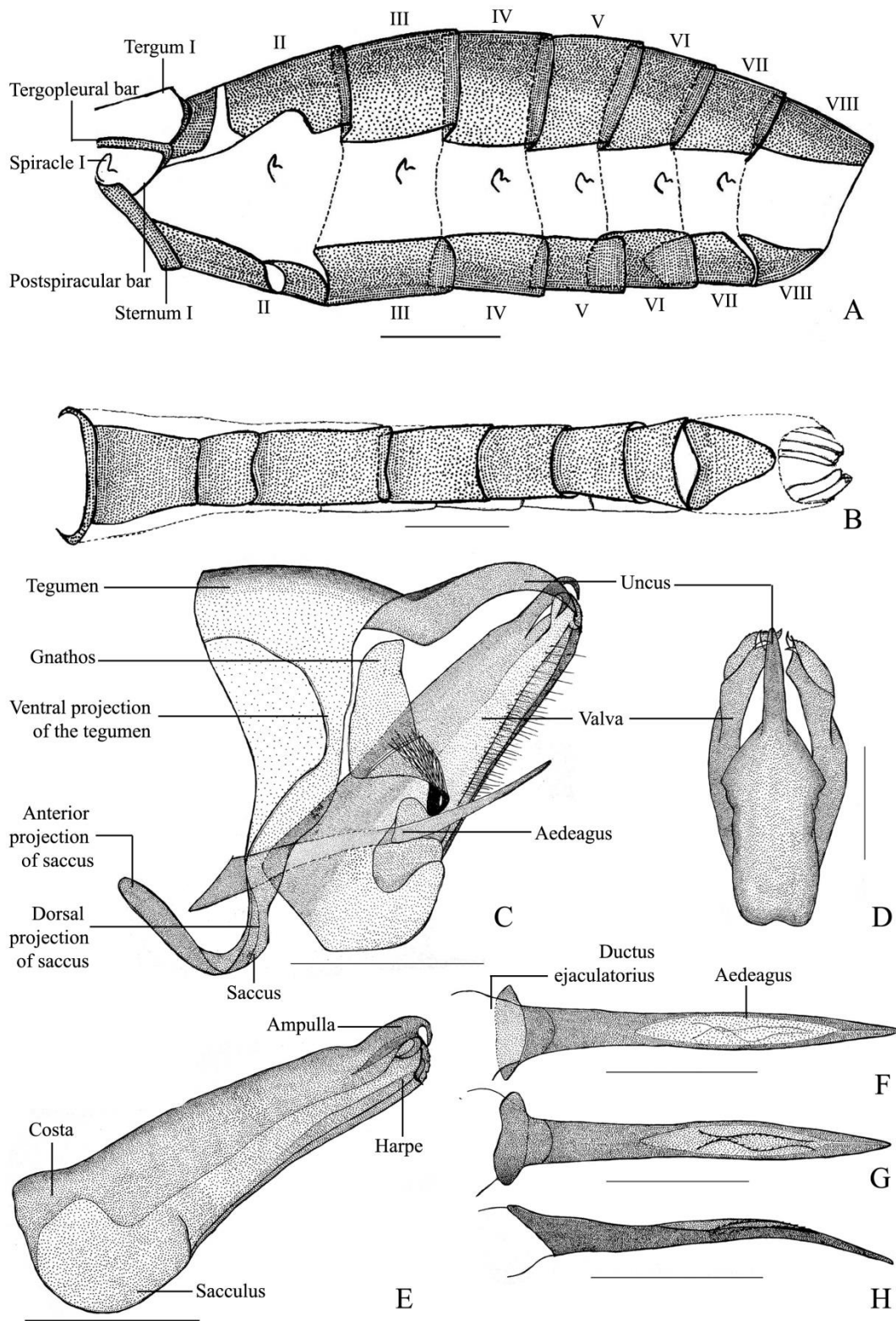


Figure 11. Male genitalia of *Junonia almana* (Linnaeus, 1758): A-B, abdomen (dorsal and ventral view, respectively); C, male genitalia (lateral view); D, uncus (dorsal view); E, right valva (inner view); F-H, aedeagus (dorsal, ventral and lateral view respectively). Scale bar 1mm.

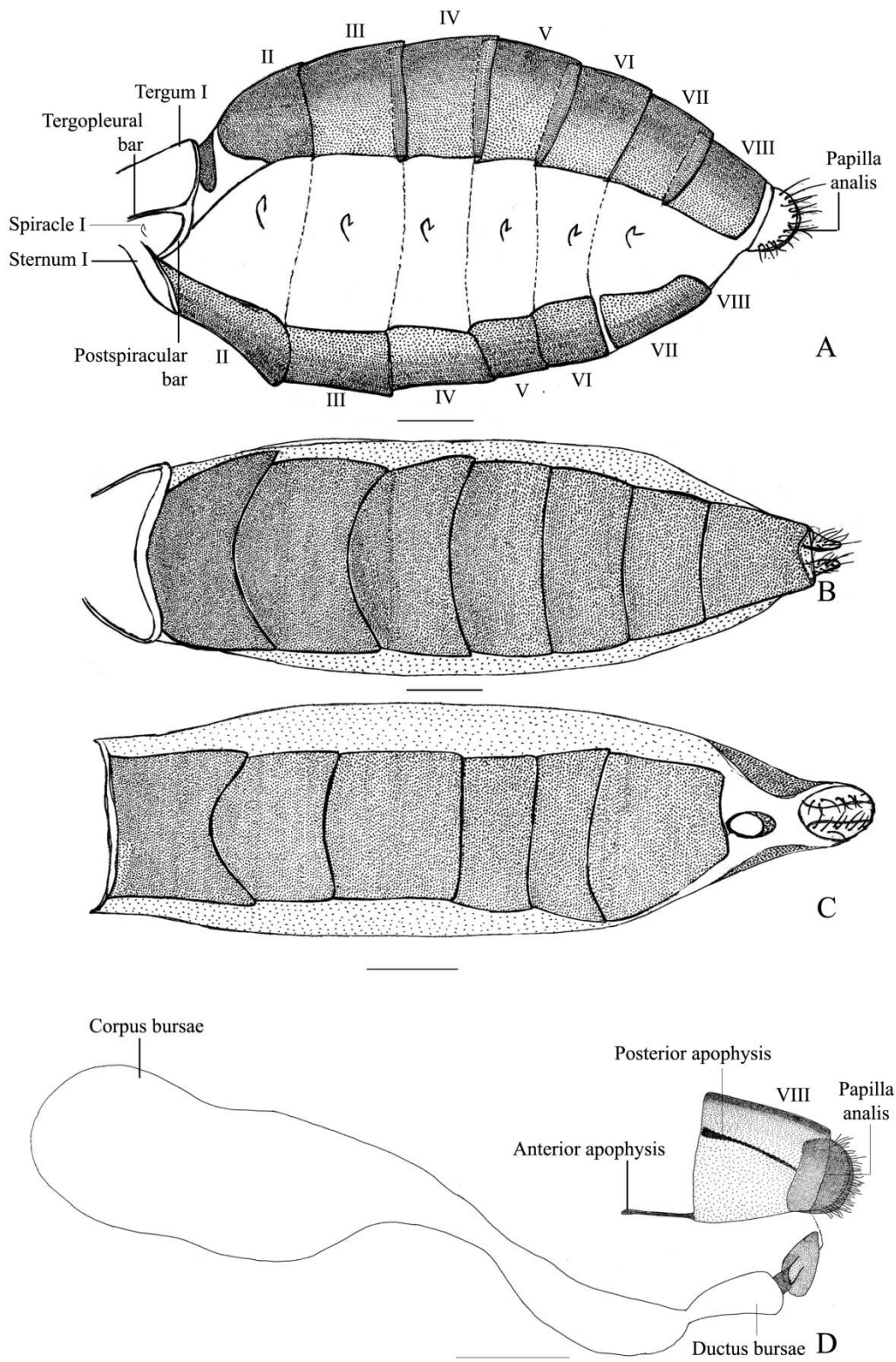


Figure 12. Female genitalia of *Junonia almana* (Linnaeus, 1758): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.

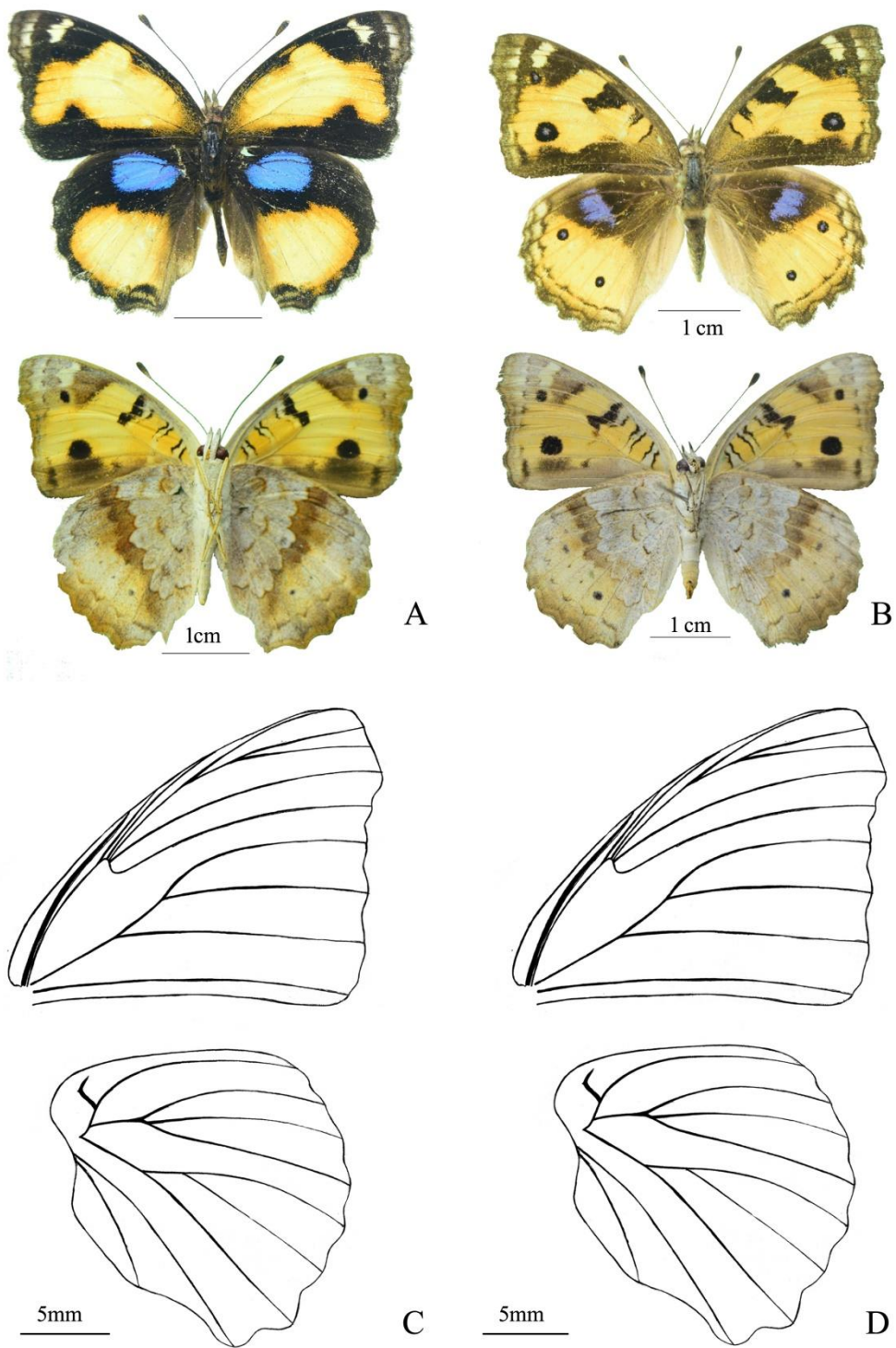


Figure 13. *Junonia hierta* (Fabricius, 1798): A, Male; B, Female; C, wing venation (male); D, wing venation (female).

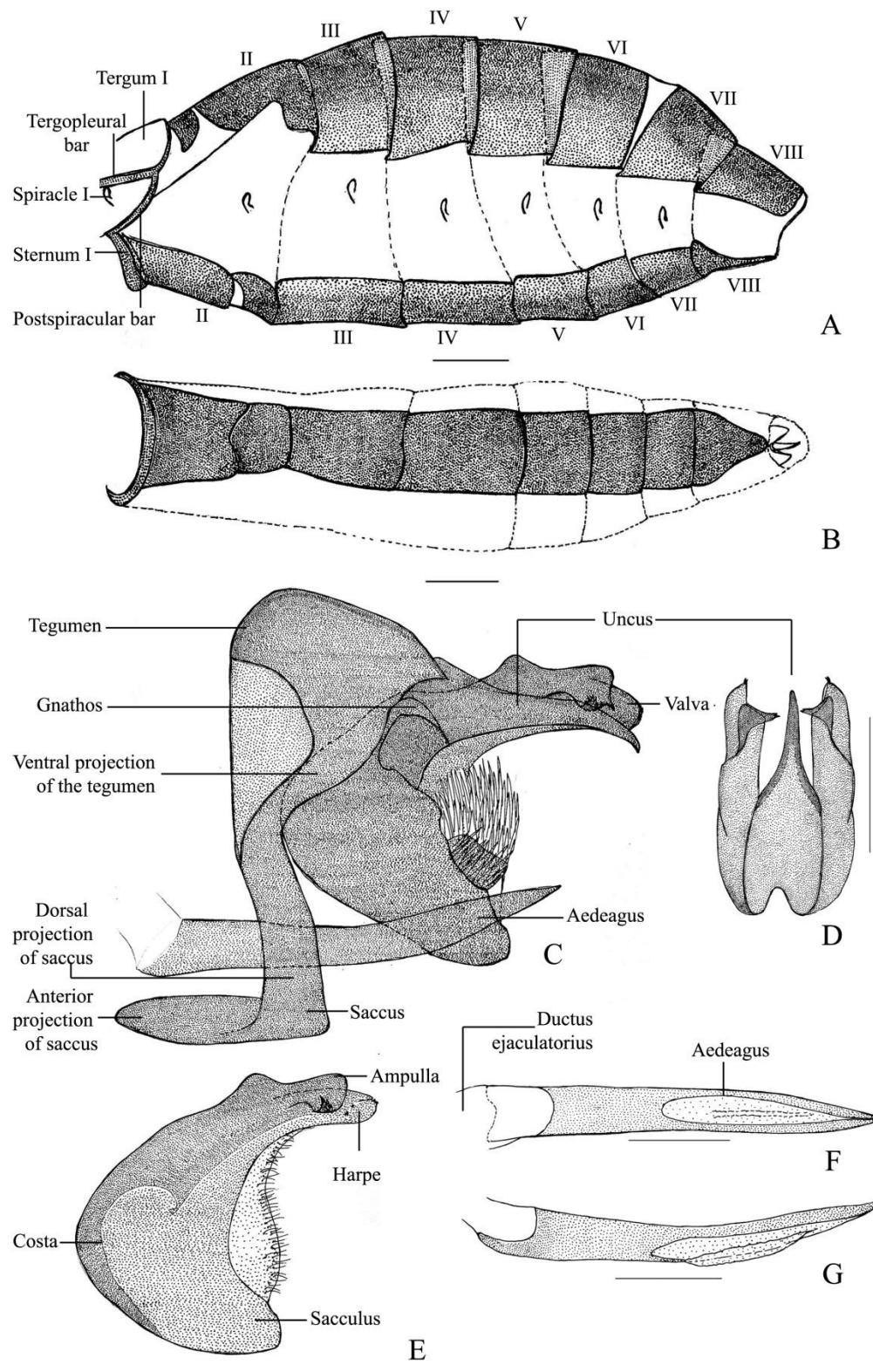


Figure 14. Male genitalia of *Junonia hierta* (Fabricius, 1798): A-B, abdomen (dorsal and ventral view, respectively); C, male genitalia (lateral view); D, uncus (dorsal view); E, right valva (inner view); F-G, aedeagus (dorsal and lateral view respectively). Scale bar 1mm.

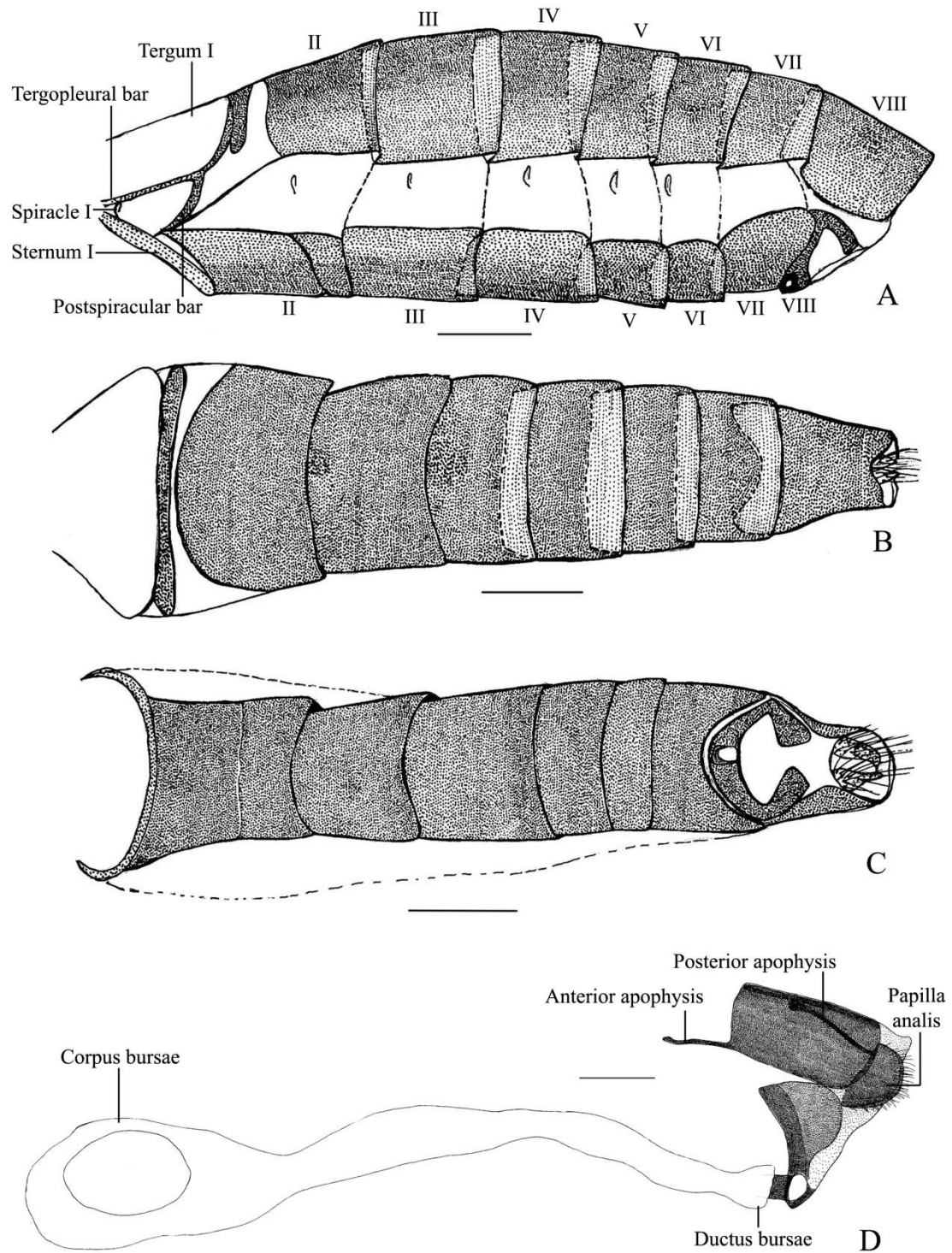


Figure 15. Female genitalia of *Junonia hierta* (Fabricius, 1798): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.

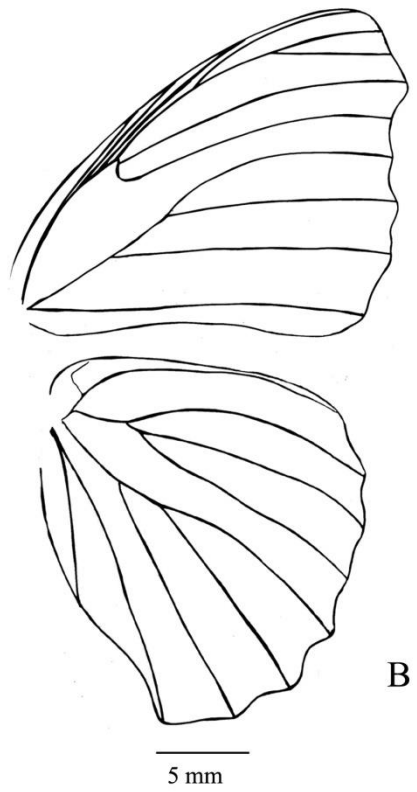
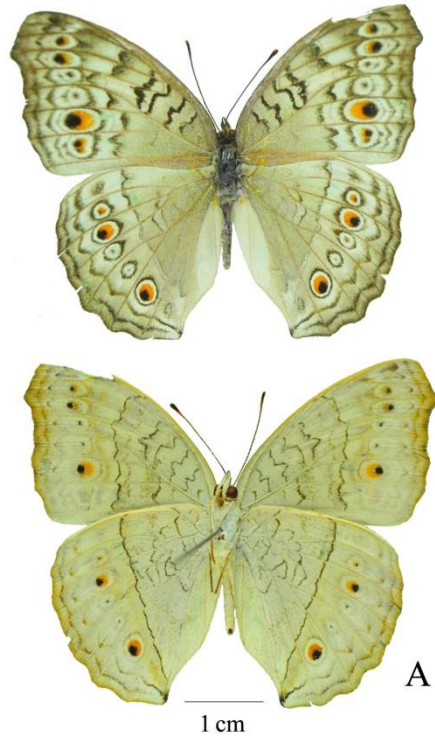


Figure 16. *Junonia atlites* (Linnaeus, 1763): A, Adult; B, wing venation.

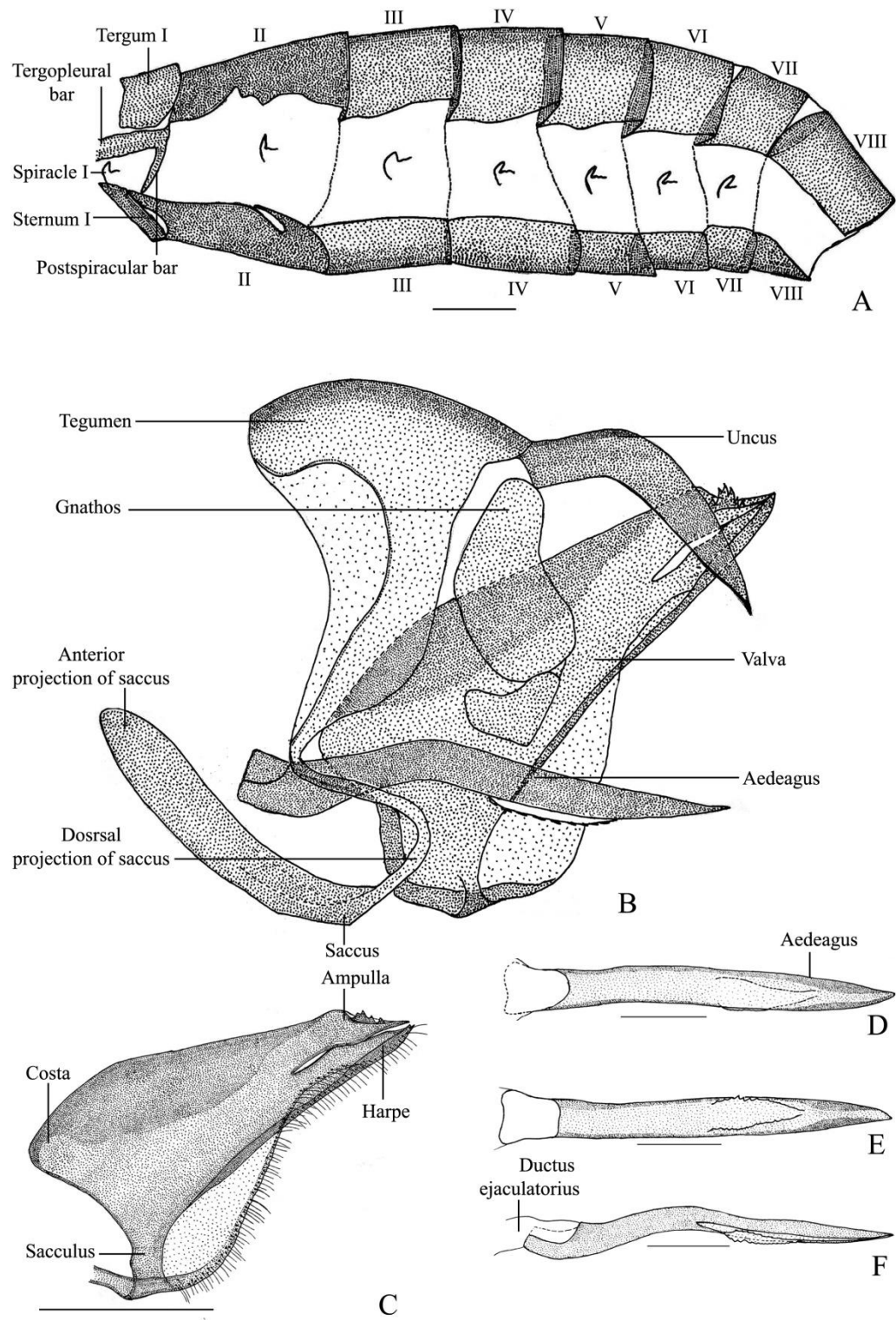


Figure 17. Male genitalia of *Junonia atlites* (Linnaeus, 1763): A, abdomen (lateral view); B, male genitalia (lateral view); C, right valva (inner view); D-F, aedeagus (dorsal, ventral and lateral view respectively). Scale bar 1mm.

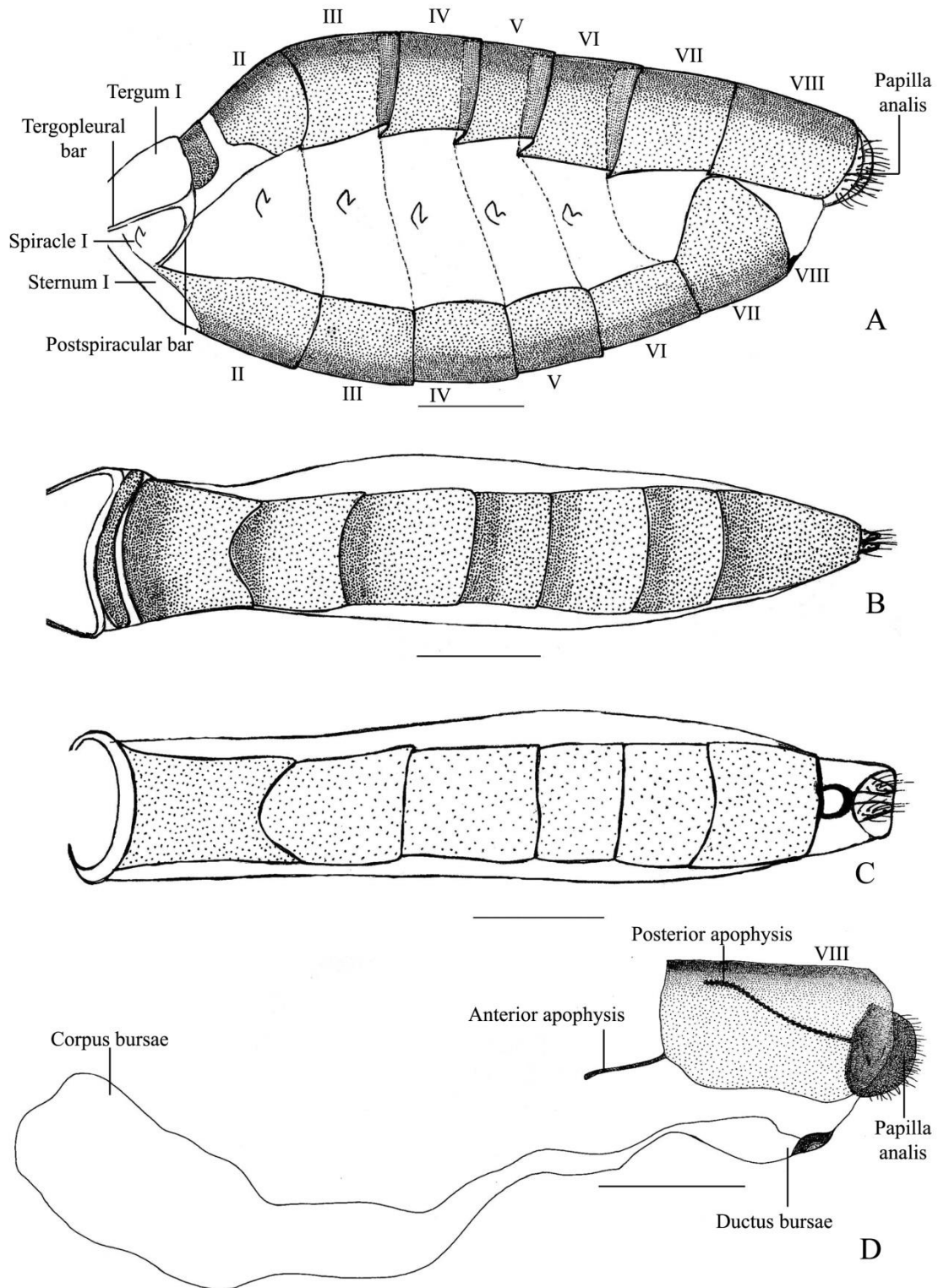


Figure 18. Female genitalia of *Junonia atlites* (Linnaeus, 1763): A-C, abdomen (lateral, dorsal and ventral view); D, female genitalia (lateral view). Scale bar 1mm.