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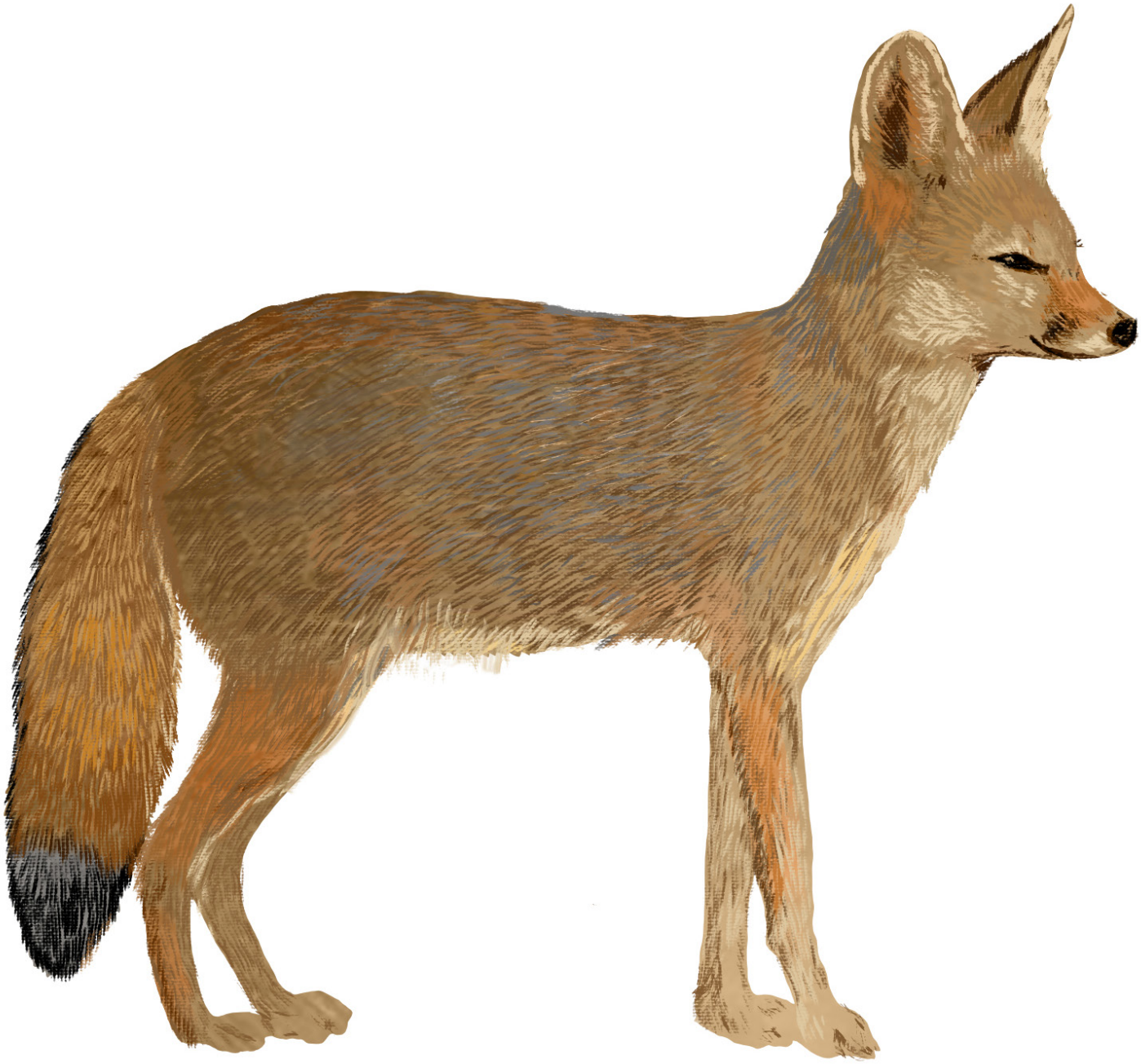

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Cover: Bengal Fox *Vulpes bengalensis*—digital illustration. © Alagu Raj.

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ARTICLE

Taxonomic review of genus *Gazalina* Walker (Thaumetopoeinae: Notodontidae: Lepidoptera) from India

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Abstract: The taxonomic position of the genus *Gazalina* Walker remained ambiguous and it continuously reshuffled its position in the family Notodontidae and subfamily Lymantriinae of family Erebidae. The present study has been carried out to elucidate its taxonomic position in accordance with the morphological, molecular, larval, and behavioural characteristics of its species. A detailed account of two species namely *Gazalina chrysolopha* (Kollar) and *Gazalina apsara* (Moore), the type species of this genus, has also been given. The CoI sequence of *Gazalina chrysolopha* (MH795522) and *Gazalina apsara* (MH790288) from the present study were compared with the available reference sequences in Genbank by using BLAST. Its placement under the subfamily Thaumetopoeinae of the family Notodontidae has been justified.

Keywords: *Apsara, Chrysolopha,* diagnosis, genitalia, Lymantriidae, phylogenetic, processionary moths, sequence analysis, taxonomic, wing venation.

Punjabi: ਸਾਰ: ਗਜ਼ਾਲੀਨਾ ਵਾਕਰ ਦੀ ਵਰਗੀਕਰਨ ਸਥਿਤੀ ਅਸਪਸ਼ਟ ਰਹੀ ਅਤੇ ਇਸਨੇ ਆਪਣੀ ਸਥਿਤੀ ਵਿੱਚ ਲਗਾਤਾਰ ਪਰਿਵਾਰ ਨੋਟੋਡੋਨਟੀਡੇ ਅਤੇ ਪਰਿਵਾਰ ਇਰੇਬਿਡੇ ਦੇ ਉਪ-ਪਰਿਵਾਰ ਲੀਮੰਨਟਰੀਨੀ ਵਿੱਚ ਫੇਰਬਦਲ ਕੀਤਾ। ਮੌਜੂਦਾ ਅਧਿਐਨ ਇਸ ਦੀਆਂ ਸਪੀਸੀਜ਼ ਦੀਆਂ ਰੂਪ ਵਿਗਿਆਨਿਕ, ਅਣੂ, ਲਾਰਵਲ ਅਤੇ ਵਿਹਾਰਕ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਦੇ ਅਨੁਸਾਰ ਇਸ ਦੇ ਵਰਗੀਕਰਨ ਦੀ ਸਥਿਤੀ ਨੂੰ ਸਪੱਸ਼ਟ ਕਰਨ ਲਈ ਕੀਤਾ ਗਿਆ ਹੈ। ਦੋ ਕਿਸਮਾਂ ਅਰਥਾਤ ਗਜ਼ਾਲੀਨਾ ਕ੍ਰਾਈਸੋਲੋਫਾ (ਕੋਲਰ) ਅਤੇ ਗਜ਼ਾਲੀਨਾ ਅਪਸਰਾ (ਮੂਰ), ਜੋ ਕਿ ਇਸ ਜੀਨਸ ਦੀ ਕਿਸਮ ਸਪੀਸੀਜ਼ ਹੈ, ਦਾ ਵਿਸਤ੍ਰਿਤ ਬਿਰਤਾਂਤ ਕੀਤਾ ਗਿਆ ਹੈ। ਮੌਜੂਦਾ ਅਧਿਐਨ ਤੋਂ ਗਜ਼ਾਲੀਨਾ ਕ੍ਰਾਈਸੋਲੋਫਾ (ਐਮ.ਐਚ795522) ਅਤੇ ਗਜ਼ਾਲੀਨਾ ਅਪਸਰਾ (ਐਮ.ਐਚ790288) ਦੇ ਸੀਓਆਈ ਕ੍ਰਮ ਦੀ ਤੁਲਨਾ ਜੀਨ ਬੈਂਕ ਵਿੱਚ ਉਪਲਬਧ ਸੰਦਰਭ ਕ੍ਰਮ ਨਾਲ ਧਮਾਕਾ ਵਿਧੀ ਦੀ ਵਰਤੋਂ ਕਰਕੇ ਕੀਤੀ ਗਈ ਹੈ। ਇਸਦੀ ਪਲੇਸਮੈਂਟ ਨੂੰ ਨੋਟੋਡੋਨਟੀਡੇ ਪਰਿਵਾਰ ਦੇ ਉਪ-ਪਰਿਵਾਰ ਥੌਮੇਟੋਪੋਈਨੇ ਅਧੀਨ ਜਾਇਜ਼ ਠਹਿਰਾਇਆ ਗਿਆ ਹੈ।

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Author contributions: Study design and article drafting—ASK & GPKB; molecular analysis—GPKB; Lab & field work—ASK, GPKB & NK.

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INTRODUCTION

Walker (1865) established the genus *Gazalina* Walker 1865 with *Gazalina venosata* Walker as its type species from northern India under the family Liparidae. Kirby (1892) followed the same nomenclature. Hampson (1892) reported three species namely *G. apsara* (Moore, 1859), *G. chrysolopha* (Kollar, 1844) and *transversa* Moore, 1879 from India. While dealing with Eastern and Australian moths, Swinhoe (1900) described a new species, *Gazalina intermixta*, under this family. Grunberg (1912) shifted this genus to the family Notodontidae. Later, Swinhoe (1922) revised various genera referable to the family Liparidae and discussed four species—*G. apsara* Moore (formerly *Venosata* Walker), *G. chrysolopha* (Kollar), *G. intermixta* Swinhoe, and *G. transversa* Moore—under the family Liparidae. Kiriakoff (1968) further placed *Gazalina* in the family Thaumetopoeidae, a distinct family. Further, he studied the male genitalia of *apsara* Moore, the type species of this genus, and diagnosed the absence of gnathos, a diagnostic feature of the family Notodontidae (Kiriakoff 1970). Cai (1979) treated it under the family Notodontidae and discussed three species *G. apsara* Moore, *G. chrysolopha* (Kollar), and *G. transversa* Moore in 'Economic Insect Fauna of China'. Miller (1991) again doubted the placement of the genus *Gazalina* Walker. Sugi (1994) described three species—*G. apsara* (Moore), *G. chrysolopha* (Kollar), *G. transversa* Moore—from Nepal under the family Notodontidae. Raman (1998) studied the outbreak of *G. chrsolopha* (Kollar) accounting for it under family Notodontidae. Wu (2002) described four species—*G. apsara* (Moore), *G. chrysolopha* (Kollar), *G. transversa* Moore, and *G. putrificata* Sugi—from China under Notodontidae. Srivastava & Mukhopadhyay (2006) studied the life cycle and bio-ecology of *G. chrsolopha* (Kollar) accounting for it under the family Notodontidae. Sanyal et al. (2011) studied *Gazalina apsara* (Moore) as an indicator species from the Himalaya under the family Notodontidae. Kocak & Kemal (2016) enlisted it under the family Thaumetopoeidae. While dealing with molecular phylogeny, Kobayashi & Nonaka (2016) also discussed the genus *Gazalina* Walker in the subfamily Thaeumatopoeinae. Uniyal et al. (2016) catalogued the genus *Gazalina* Walker under the subfamily Thaumetopoeinae of the family Notodontidae from Gangotri landscape, Uttarakhand, India. Shah et al. (2017) enlisted the genus *Gazalina* Walker under the subfamily Lymantriinae. While studying the medical complications caused by different species of *Gazalina* Walker, Manandhar *et al.* (2018) discussed it under the family Notodontidae. Bhattacharyya et al. (2019) enlisted the genus *Gazalina* Walker under the subfamily Thaumetopoeinae of the family Notodontidae from Neora Valley, West Bengal, India. Recently, Chettri et al. (2021) enlisted *Gazalina chrysolopha* Kollar and *G. transversa* Moore from Sikkim and placed these species under the family Notodontidae. Gurung et al. (2021) described *Gazalina chrysolopha* Kollar as a major pest consuming foliage of trees especially *Alnus nepalensis* D.Don, *Rhododendron arborium* Smith, and other fodder plants; but the taxonomic position was not clear. Khanal & Shrestha (2022) studied the diversity, distribution, and medical significance of *Gazalina* species from Nepal. The morphological characters including external as well as internal genitalic features, behavioural characters, and molecular analysis of two species namely *Gazalina chrysolopha* (Kollar) and *Gazalina apsara* (Moore), the type species of this genus have been compiled in detail to elucidate the position of genus *Gazalina* Walker.

MATERIAL AND METHODS

The adult moths were collected from different localities of Himachal Pradesh and Jammu & Kashmir (India) by using light traps equipped with a 160w mercury bulb and vertical white screen and their behaviour was observed during the collection period. The external morphological characters were studied as such from the preserved specimens. The permanent slides were prepared to study the wing venation. The male and female moths were dissected to examine the external and internal genitalic features and the terminology for naming various genitalic parts given by Klots (1970) was followed. The DNA was extracted from the preserved moth samples using the phenol-chloroform-isoamyl alcohol method given by Sambrook et al. (1989). The mitochondrial cytochrome oxidase subunit I (COI) gene was amplified using the universal primer pair under standard PCR conditions (Folmer et al. 1994).

Forward –

(LCO1490: 5'-GGTCAACAAATCATAAAGATATTGG-3')

Reverse –

(HC02198: 5'-TAAACTTCAGGGTGACCAAAAAATCA-3')

The purified PCR products were sequenced at Amnion Biosciences Pvt. Ltd, Sequencing Dept, #112, Doddenna industrial area, 16A Cross, Vishwaneedam post (D), Bangalore, Karnataka 560091, India.

The sequences were submitted to Genbank for accession numbers as *Gazalina chrysolopha* MH795522 & *Gazalina apsara* MH790288. Multiple sequence

alignment was performed with CLUSTAL x software and a phylogenetic tree was constructed using the maximum likelihood method (ML) in MEGA (version 6) software. The confidence level of each branch was evaluated through bootstrap analysis with 1000 replicates (Tamura et al. 2021).

Systematic Account

Genus *Gazalina* Walker 1865

Walker, 1865, List *Spec. Lepid. Insects Colln. Brit. Mus*., 32: 298; Swinhoe, 1922, *Ann. Mag. Nat. Hist*., 9(9)10 (58): 472.

Oligoclona Felder, 1874, *Reis. Freg. Nov.,* 2: pl. 94.

Ansonia Kiriakoff, 1967, *in Wytsman*, *Genera Insect*., 217(B): 57.

Type Species: *Gazalina apsara* (Moore) = *venosata* Walker

Distribution: India; China.

Diagnosis: Medium-sized moths, usually white in colouration. Labial palpi extremely minute. Antennae bipectinate in males, serrate in females, and pectinations are reduced at the distal end. Forewing with ground colour white, without any distinct markings; discal cell more than half the length of the wing, closed; 1A+2A basally forked; 3A absent; Cu_1 and M_3 from lower angle of cell; M_2 from lower angle of cell; M_1 just above the middle of discocellulars; R_5 from the upper angle of cell; R_4-R_2 stalked from the upper angle of cell; R_1 well before upper angle of cell; Sc from the base of wing not reaching the apex. Hindwing without any distinct markings; discal cell more than half the length of wing, closed; Cu_1 and M_3 from near lower angle of cell; M_2 from near middle of discocellulars; M_1 and Rs stalked from upper angle of cell. Legs dressed with white scales; fore-tibia with an epiphysis, mid-tibia with one pair of tibial spurs; hind-tibia with two pairs of tibial spurs. Abdomen slender, banded with black and white scales; distal segments fringed with long white scales in males, distinct golden anal tuft in females. Male genitalia with uncus of moderate size, gnathos represented by conjoined, triangular processes; saccus absent; juxta well developed; valva simple, basal half broad, distal half narrow; aedeagus of moderate size, vesica without any distinct cornuti. Female with corpus bursae globular; signum absent; ductus bursae narrow, medially constricted; apophysis of moderate length, both pairs with equal length with dilated tips; papilla analis prominent, setosed; pseudo-papillae indistinct; sterigmatic plate well developed.

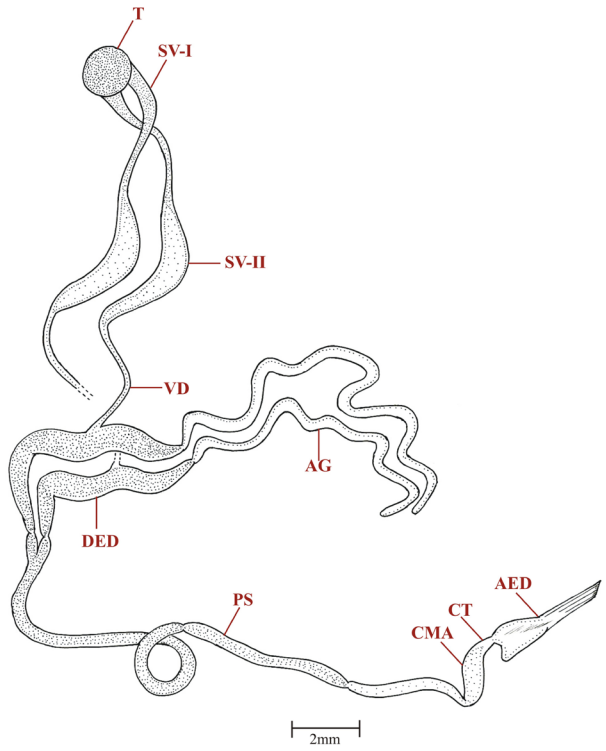


Figure 1. Internal male genitalic organs of *Gazalina chrysolopha* (Kollar). AG—Accessory gland | AED—Aedeagus | CMA—Constrictor muscular area | CT—Cuticular tube | DED—Ductus ejaculatorius duplex | PS—Primary simplex | SV-I—Seminal vesicle—I | SV-II—Seminal vesicle—II | T—Testis | VD—Vas deferens.

Gazalina chrysolopha (Kollar, 1844)

Liparis chrysolopha Kollar, 1844, *Hügel Kaschmir und Das Reich der Siek*, 4: 470.

Gazalina chrysolopha Kollar: Hampson, 1892, *MothsIndia*, 1: 469; Swinhoe, 1922, *Ann. Mag. Nat. Hist.,* (9) 10 (58): 472; Wu, 1999, *Fauna Sinica*, 31: 832.

Dasychira antica Walker, 1855, *List Spec. Lepid. Insects Colln. Brit. Mus*., 4: 867; Swinhoe, 1922, *Ann. Mag. Nat. Hist.,* (9) 10 (58):472.

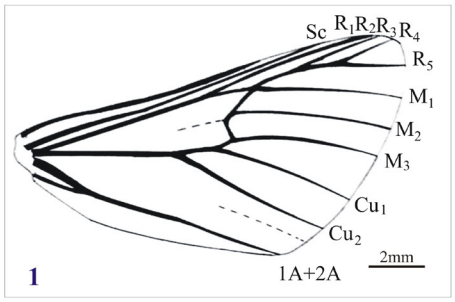
Oligoclona chordigera Felder, 1874, *Reis. Freg. Nov*. 2 (4): 94.

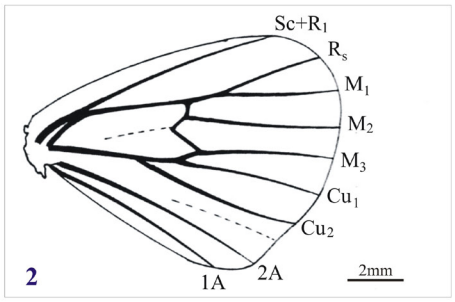
Type Locality: Kashmir, India

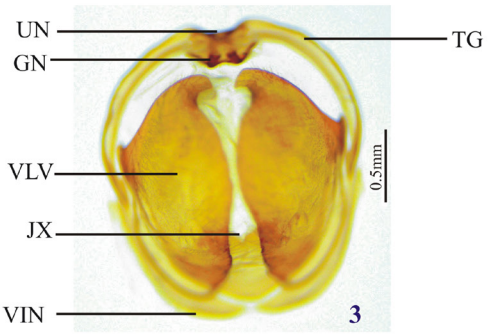
Wing Expanse: Male: 40–46 mm; Female: 52–60 mm.

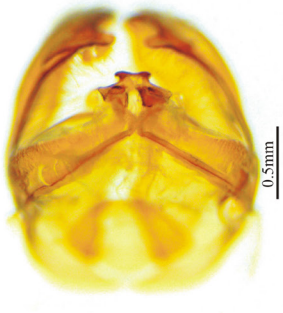
Body Length: Male: 14–19 mm; Female: 18–21 mm.

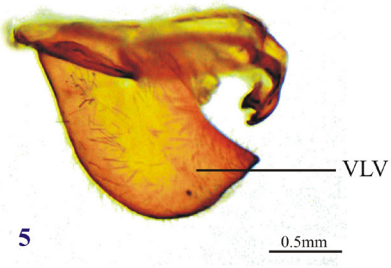
Diagnosis: Forewing whitish, veins distinct with black scales beyond the medial oblique line; vein M_1 not stalked with radial veins. Male genitalia with uncus notched distally; juxta with distal end notched; distal end of valva rounded and produced. Internal male genitalic organs with testis rounded; seminal vesicle-I originating from testis separately; seminal vesicle-II sickle-shaped; ductus ejaculatorius duplex curled; accessory glands free distally; primary simplex divided into three sections.

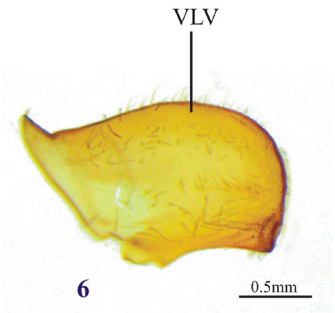


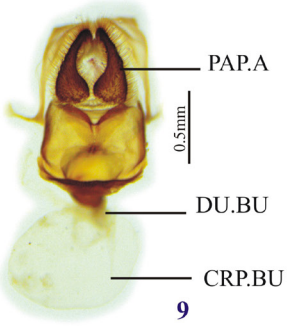












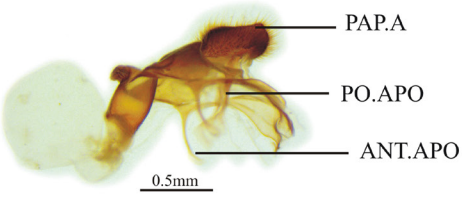


Image 1–8. *Gazalina chrysolopha* (Kollar): 1—forewing | 2—hindwing | 3—male genitalia – ventral view | 4—dorsal view | 5—lateral view | 6—valva | 7—aedeagus | 8—female genitalia. External Genitalia (Image 1–18): 1A—First anal vein | 2A—Second anal vein | AED—Aedeagus | ANT.APO—Anterior Apophysis | CRP.BU—Corpus bursae | CU1—First cubital vein | CU2—Second cubital vein | DU.BU—Ductus bursae | GN—Gnathos | JX—Juxta | M1—First median vein | M2—Second median vein | M3—Third median vein | PAP.A—Papilla analis | PO.APO—Posterior Apophysis | R1—First radial vein | R2—Second radial vein | R3—Third radial vein | R4—Fourth radial vein | R5—Fifth radial vein | Sc—Subcosta | Sc+R1—Subcosta + First radial vein | TG—Tegumen | UN—Uncus | VIN—Vinculum | VLV—Valva.

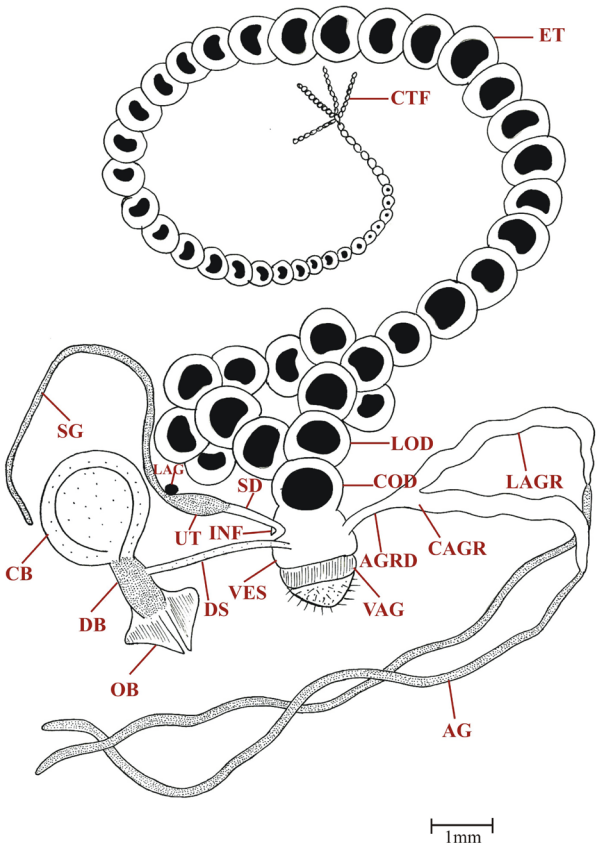


Figure 2. Internal female genitalic organs of *Gazalina chrysolopha* (Kollar). AG—Accessory gland | AGRD—Accessory gland reservoir duct | CAGR—Common accessory gland reservoir | CB—Corpus bursae | CTF—Common terminal filament | DB—Ductus bursae | DS—Ductus seminalis | ET—Egg tube | INF—Infundibulum | LAG—Lagena | LAGR—Lateral accessory gland reservoir | LOD—Lateral oviduct | OB—Ostium bursae | SD—Spermathecal duct | SG—Spermathecal gland | UT—Utriculus | VAG—Vagina | VES—Vestibulum.

Table 1. Morphometry of internal male genitalic organs of *Gazalina chrysolopha* (Kollar).

	Organ	Intraspecific range in length (mm)	Intraspecific range in width (mm)
1.	Testis	0.68–0.71	0.68–0.71
2.	Seminal vesicle- I	1.69–1.72	0.19–0.21
3.	Seminal vesicle- II	2.84–2.86	0.40–0.43
4.	Vasa deferentia	2.28–2.31	0.09–0.11
5.	Ductus ejaculatorius duplex	3.44–3.46	0.38–0.41
6.	Accessory gland	7.24–7.26	0.14–0.16
7.	Primary simplex	10.64–10.66	0.16–0.18
8.	Constrictor muscular area	1.09–1.11	0.25–0.28
9.	Cuticular tube	0.19–0.21	0.10–0.13

Table 2. Morphometry of internal female genitalic organs of *Gazalina chrysolopha* (Kollar).

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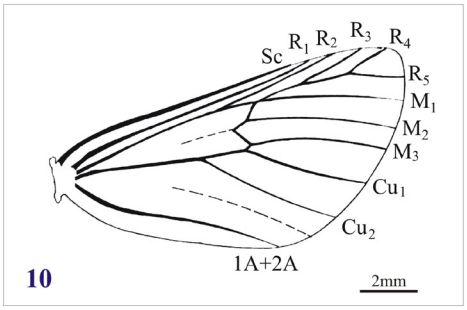
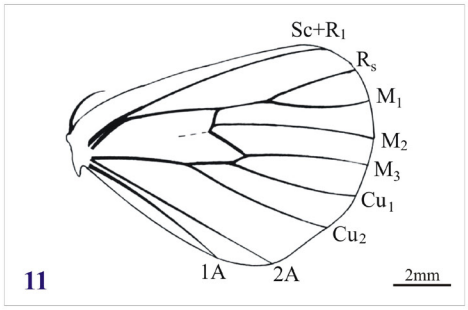
1.	Testis	0.68–0.71	0.68–0.71
2.	Seminal vesicle- I	1.69–1.72	0.19–0.21
3.	Seminal vesicle- II	2.84–2.86	0.40–0.43
4.	Vasa deferentia	2.28–2.31	0.09–0.11
5.	Ductus ejaculatorius duplex	3.44–3.46	0.38–0.41
6.	Accessory gland	7.24–7.26	0.14–0.16
7.	Primary simplex	10.64–10.66	0.16–0.18
8.	Constrictor muscular area	1.09–1.11	0.25–0.28
9.	Cuticular tube	0.19–0.21	0.10–0.13

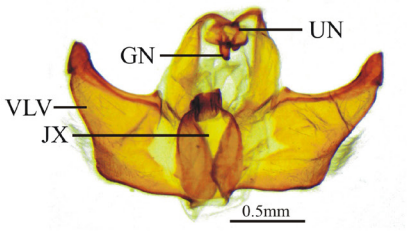
Internal female genitalic organs with eggs rounded, covered by a thin translucent sheath; accessory gland ducts long.

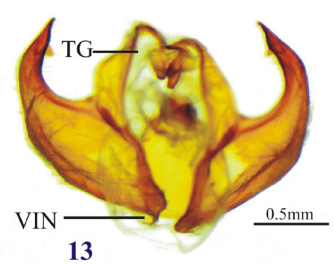
Description: Head with vertex and frons clothed with white scales. Labial palpi fringed with black scales. Antennae with scape covered with white scales, flagellum black. Thorax, collar, and tegula dressed with yellowish-white scales; underside white. Legs dressed with white scales. Abdomen slender, furnished with black scales with white bands; distal segments fringed with long white scales; distinct golden anal tuft in females. Hindwing white. Forewing (Image 1) with Cu_2 beyond two-thirds of cell; Cu_1 from well before lower angle of cell; M_3 from lower angle of cell; M_2 from middle of discocellulars; M_1 from upper angle of cell; R_5-R_3 well stalked from upper angle of cell; R_2 absent; R_1 beyond three-fourth of cell; Sc from base of wing, not reaching to apex. Hindwing (Image 2) with Cu_2 from well beyond two-thirds of the cell; Cu_1 from well before the lower angle of the cell; M_3 from the lower angle of the cell; M_2 from well above the middle of discocellulars; M_1 and Rs well stalked from upper angle of cell; Sc+R_1 from base of wing anastomosing at one-third of cell reaching till apex of wing.

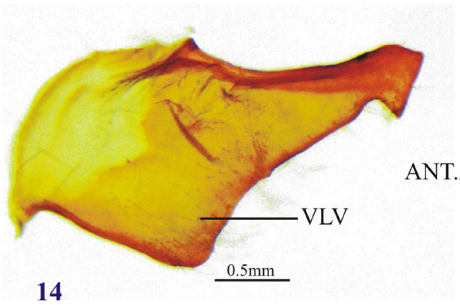
Male genitalia (Image 3–7): Uncus of moderate size, basal half broad, distal end notched giving bifid appearance, setosed and more sclerotized; gnathos represented by well-sclerotized, triangular, setosed paired projections; tegumen U-shaped, moderately sclerotized, both arms of equal width, longer than vinculum; vinculum V-shaped, weakly sclerotized, without any distinct saccus; juxta moderately sclerotized, medially dilated on lateral sides, distal end notched. Valva simple, broad, rounded; moderately sclerotized; setosed; distal end produced on costal side with round, setosed tip. Aedeagus long, narrow; proximal half flap-











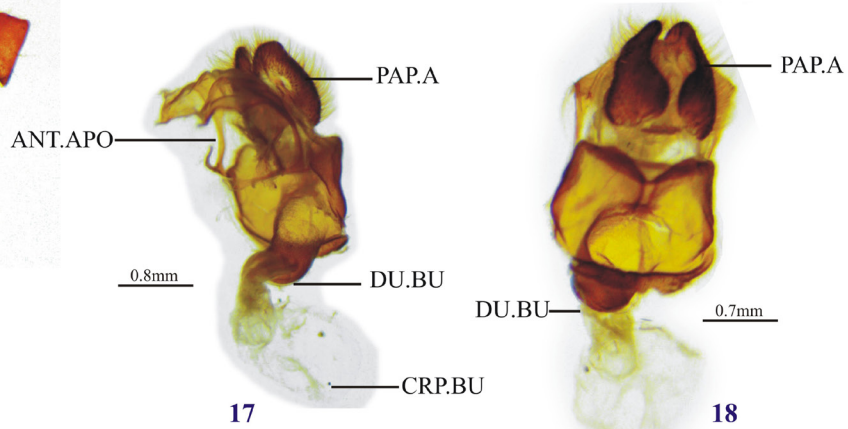


Image 10–18. *Gazalina apsara* (Moore): 10—forewing | 11—hindwing | 12—male genitalia – ventral view | 13—Dorsal view | 14—valva | 15–16—Aedeagus | 17–18—female genitalia. 1A—First anal vein | 2A—Second anal vein | AED—Aedeagus | ANT.APO—Anterior Apophysis | CRP.BU—Corpus bursae | CU1—First cubital vein | CU2—Second cubital vein | DU.BU—Ductus bursae | GN—Gnathos | JX—Juxta | M1—First median vein | M2—Second median vein | M3—Third median vein | PAP.A—Papilla analis | PO.APO—Posterior Apophysis | R1—First radial vein | R2—Second radial vein | R3—Third radial vein | R4—Fourth radial vein | R5—Fifth radial vein | Sc—Subcosta | Sc+R1—Subcosta + First radial vein | TG—Tegumen | UN—Uncus | VIN—Vinculum | VLV—Valva.

like; ductus ejaculatorius entering under this flap; distal half tubular; distal end produced with an extension having serrations; walls of aedeagus near distal end with minute denticles; vesica without any distinct armature. The internal male genitalic (Image 1) attributes along with the morphometric analysis have been studied in detail (Table 1).

Female genitalia (Image 8–9): Corpus bursae large, circular, membranous; signum absent; ductus bursae membranous, narrow, entering into well sclerotized oblong antrum; ductus seminalis originating from the middle of ductus bursae; apophysis of moderate length, semi-sclerotized, posterior apophysis slightly longer than anterior apophysis, both pairs with prominently dilated apices; papilla analis ovoid, well setosed with short and long setae; sterigmatic plate rectangular, notched medially, well sclerotized. The internal genitalic (Image 2) details are tabulated in Table 2.

Material examined: India: Himachal Pradesh: Baijnath, 998m, 32.052°N & 76.648°E, 09.x.2013, 1♂; Baila, 1,520 m, 31.056°N & 76.831°E, 04.vi.2014, 1♂; Basantpur, 2,148 m, 31.208°N & 77.174°E, 09.vii.2013, 1♂; 10.vii.2013, 7♂♂, 8♀♀; Dalhousie, 1,970 m, 32.587°N & 75.971°E, 07.vi.2013, 1♂, 2♀♀; Dilman, 1,552 m, 30.824°N & 77.134°E, 11.viii.2013, 12♀♀; 03.ix.2015, 4♂♂, 2♀♀; Fagu, 2,533 m, 31.085°N & 77.300°E, 04.ix.2016, 4♂♂, 3♀♀; Habban, 2,063 m, 30.915°N & 77.325°E, 07.vii.2014, 1♀; 07.ix.2015, 4♂♂, 4♀♀; Hadsar, 2,300 m, 32. 455°N & 76.613°E , 11.vi.2013, 1♂; Khajjiar, 1,920 m, 32.555°N & 76.065°E, 08.vi.2013, 1♂; Kharouth, 1,300 m, 32.065°N & 76.450°E, 09.vi.2017, 5♂♂, 3♀♀; Naina Tikkar, 1,552 m, 30.804°N & 77.119°E, 01.09.2015, 4♂♂, 4♀♀; Narkanda, 2,708 m, 31.257°N & 77.460°E, 17.vi.2013, 1♂; Nauni, 1,275 m, 30.860°N & 77.173°E, 07.viii.2013, 1♀; Sabathu, 1,265 m, 30.975°N & 76.990°E, 09.viii.2013, 1♂; 15.vii.2016, 4♂♂, 2♀♀; Serighat, 1,520 m, 31.050°N & 77.069°E, 10.viii.2013, 54♂♂, 10♀♀; 26.vi.2017, 5♂♂, 5♀♀; Theog, 1,965 m, 31.118°N & 77.359°E, 20.vi.2014, 1♂, 1♀; 08.ix.2016, 4♂♂, 3♀♀; Jammu & Kashmir: Batote, 1,560 m, 33.121°N & 75.32°E,11.vii.2014, 1♀; Hote, 400 m, 32.825°N & 75.641°E, 04.ix.2013, 2♀♀, Lamberi, 336 m, 33.130°N & 74.260°E, 11.ix.2013, 1♂, 2♀♀. Coll.: Gagan Bali & Navkiran Kaur.

Distribution: India: Himachal Pradesh, Jammu & Kashmir, Sikkim, West Bengal; China.

Comments: Kollar (1844) originally described this species under the genus *Liparis* Ochsenheimer from Kashmir. Hampson (1892) transferred it to the present genus. Haruta (1993) collected *crysolopha* Kollar from Godawari (1,600 m) southeastern Kathmandu. During another expedition, the species was recorded from Dagchu (2,880 m) and Jin (2,340 m) in eastern Nepal (Haruta, 1994). Shah et al. (2017) reported this species from West Bengal. Chettri et al. (2021) enlisted *Gazalina chrysolopha* Kollar from the Tadong region of Sikkim under the family Notodontidae. Dewan et al. (2022) recorded *chrysolopha* Kollar in the Trans Himalayan region of western Nepal and placed it under the family Notodontidae.

***Gazalina apsara* (Moore, 1859)**

Dasychira apsara Moore, 1859, *Cat. Lepid. Ins. Mus. Nat.*, 2: 341.

Gazalina apsara Moore: Hampson, 1892, *Moths India*, 1: 468-469; Swinhoe, 1922, *Ann. Mag. Nat. Hist.,* (9) 10 (58): 472; Wu, 1999, *Fauna Sinica*, 31: 830–832.

Gazalina venosata Walker, 1865, *List. Spec. Lepid. Insects Colln. Brit. Mus*., 32: 398; Swinhoe, 1922, *Ann. Mag. Nat. Hist.* (9) 10 (58): 472.

Oligoclona nervosa Felder and Rogenhofer, 1875; *Reis. Freg. Nov.*, 2(4): 95.

Type Locality: Northern India.

Wing Expanse: Male: 40–42 mm; Female: 54 mm.

Body Length: Male: 14–17 mm; Female: 19–21 mm.

Diagnosis: Forewing whitish, veins without black scales; vein M1 stalked with radial veins from the upper angle of the cell. Male genitalia with uncus having a curved hook-like distal end; juxta with distal end curved; distal end of valva beaked. Internal male genitalic organs with testis ellipsoidal; seminal vesicle-I originating from the testis in the fused state; seminal vesicle-II spindle-shaped; ductus ejaculatorius duplex comma-shaped; accessory glands fused distally; primary simplex divided into four sections. Internal female genitalic organs with eggs are rectangular, without any covering; accessory gland ducts are small.

Description: Head with vertex and frons clothed with white scales. Labial palpi fringed with black scales. Antennae with scape covered with white scales, flagellum black. Thorax, collar, and tegula dressed with yellowish-white scales; underside white. Legs dressed with white scales. Abdomen slender, furnished with black scales with white bands; distal segments fringed with long white scales; distinct golden anal tuft in females. Hindwing white. Forewing (Image 10) with Cu_2 from beyond two-thirds of cell; Cu_1 well before lower angle of cell; M_3 from lower angle of cell; M_2 just above middle of discocellulars; M_1, R_5-R_3 stalked from upper angle of cell; R_2 absent; R_1 well before upper angle of cell; Sc from base of wing, not reaching apex. Hindwing (Image 11) with Cu_2 from well before two-thirds of the

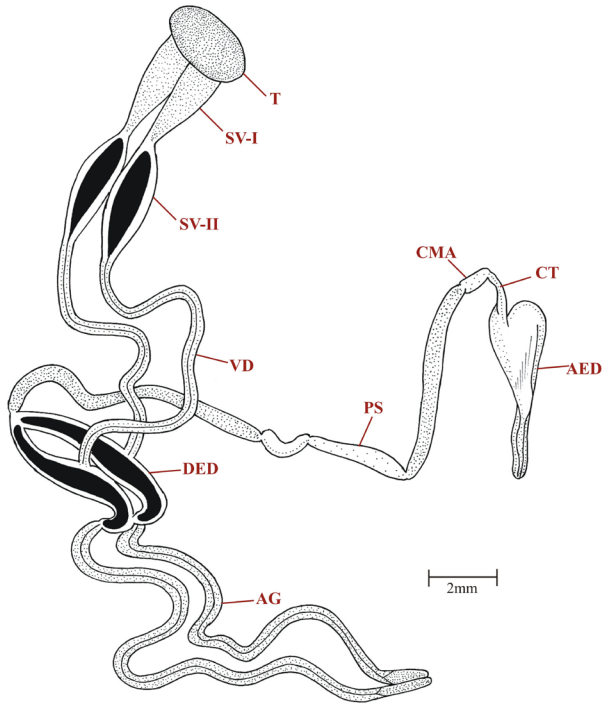


Figure 3. Internal male genitalic organs of *Gazalina apsara* (Moore). AG—Accessory gland | AED—Aedeagus | CMA—Constrictor muscular area | CT—Cuticular tube | DED—Ductus ejaculatorius duplex | PS—Primary simplex | SV-I—Seminal vesicle—I | SV-II—Seminal vesicle—II | T—Testis | VD—Vas deferens .

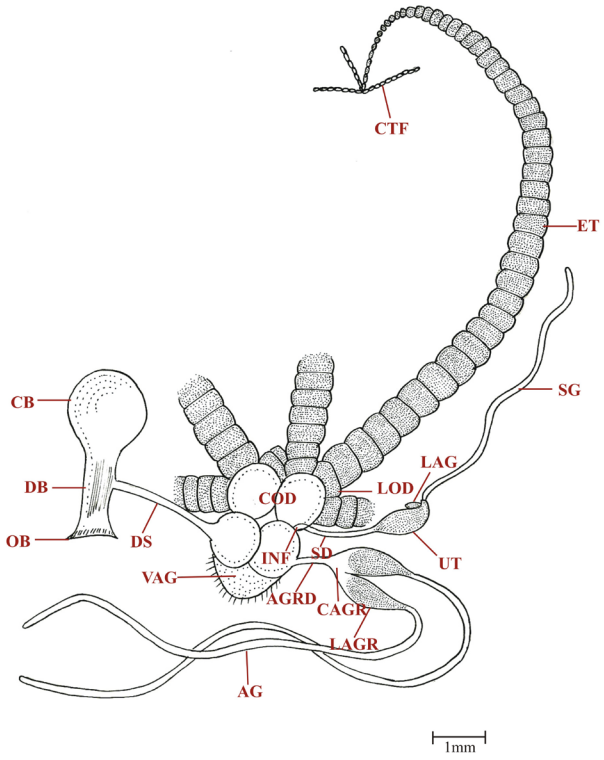


Figure 4. Internal female genitalic organs of *Gazalina apsara* (Moore). AG—Accessory gland | AGRD—Accessory gland reservoir duct | CAGR—Common accessory gland reservoir | CB—Corpus bursae | CTF—Common terminal filament | DB—Ductus bursae | DS—Ductus seminalis | ET—Egg tube | INF—Infundibulum | LAG—Lagena | LAGR—Lateral accessory gland reservoir | LOD—Lateral oviduct | OB—Ostium bursae | SD—Spermathecal duct | SG—Spermathecal gland | UT—Utriculus | VAG—Vagina | VES—Vestibulum.

lower angle of the cell; Cu_1 from well before the lower angle of the cell; M_3 from lower angle of cell; M_2 from well above middle of discocellulars; M_1 and Rs well stalked from upper angle of cell; $Sc+R_1$ from base of wing anastomosing with cell well before its middle.

Male genitalia (Image 12–16): Uncus small, basal half oval, distal half narrow, curved, hook-like, dorsally setosed with short setae, well sclerotized; gnathos represented by small, conjoined triangular processes, setosed with short setae; tegumen moderately sclerotized, both arms dilated laterally beyond middle towards vinculum; vinculum moderately sclerotized, narrow, without distinct saccus; juxta large, oblong, dome-shaped, well sclerotized, distal end having a well sclerotized nearly squarish, curved projection. Valva simple, well sclerotized, basal half broad, saccular margin produced, setosed, distal half narrow, distal end produced on dorsal margin giving weakly bifid appearance. Aedeagus of moderate length, well sclerotized; proximal half flap-like; distal end bifid, one wedge-shaped and other with prominent serrations on inner margins; vesica without any distinct cornuti. The internal male genitalic (Figure 3) attributes along with the morphometric analysis have been summarized in Table 3.

Female genitalia (Image 17–18): Corpus bursae globular, membranous; signum absent; ductus bursae membranous, narrow, medially constricted; ductus seminalis originating from the middle of ductus bursae; antrum well sclerotized, nearly squarish; apophysis of moderate length, almost of equal length, prominently dilated at distal end; papilla analis prominent, broad, well setosed with long and short setae; pseudo-papillae not distinct; sterigmatic plate large, prominently developed. The internal genitalic (Figure 4) details are given in the tabulated form (Table 4).

Material examined: India: Himachal Pradesh: Basantpur, 2,148 m, 31.208°N & 77.174°E, 10.vii.2013, 1♂; Cheog, 2,086 m, 31.068°N & 77.312°E, 05.ix.2016, 4♂♂, 3♀♀; Fagu, 2,533 m, 31.085°N & 77.300°E, 03.ix.2016, 3♂♂, 4♀♀; Ghoond, 2,086 m, 31.075°N & 77.425°E, 01.ix.2016, 4♂♂, 3♀♀; Jhumar, 2,133 m, 32.548°N & 76.146°E,11.vii.2015, 6♂♂, 3♀♀; Mahasu, 2,086 m, 31.100°N & 77.504°E, 30.viii.2016; 3♂♂, 2♀♀; Narkanda, 1,265 m, 31.257°N & 77.460°E, 17.vi.2013,

1♀; Serighat, 1,520 m, 31.050°N & 77.069°E, 11.viii.2013, 1♂, 4♀♀; 25.vi.2017, 4♂♂, 3♀♀; Jammu & Kashmir: Lamberi, 336 m, 33.130°N & 74.260°E, 11.ix.2017, 1♀. Coll.: Gagan Bali & Navkiran Kaur.

Distribution: India: Himachal Pradesh, Jammu & Kashmir, Sikkim; China.

Comments: Moore (1859) described this species under the genus *Dasychira* Stephens from northernIndia. Hampson (1892) shifted it in the present genus and placed *Gazalina venosata* Walker under it. This placement remained stable.

Phylogenetic Analysis

For the construction of the phylogenetic tree related to known species of the genus *Gazalina* Walker, the nucleotide sequences from the present study and the sequences retrieved from the NCBI database were used (Table 1). The nucleotide sequences for the *Gazalina transversa* (Moore) are not available in the NCBI database and thus not included. Multiple sequence alignment was performed with CLUSTAL x software and a phylogenetic tree was constructed using the maximum likelihood method (ML) in MEGA (version 6) software. The high posterior probabilities depicted the confidence of each branch in the phylogenetic tree. A confidence bootstrap value of 100 was observed for *Gazalina chrysolopha* (MH795522.1); *Gazalina chrysolopha* (HQ991385.1) and *Gazalina apsara* (KX863079.1). The phylogenetic tree obtained from the nucleotide sequences belonging to genera of Notodontidae family and subfamily Lymantriinae depicts that the genus *Gazalina* Hübner has a close relationship with the two mentioned taxa and thus has been taxonomically interchanging places between the two.

For strong validation of the molecular analysis, three different phylogenetic trees were constructed using three different genera, i.e., *Phalera* Hübner, *Cerura* Schrank, and *Clostera* Samouelle of the family Notodontidae as out groups. The trees (Figure 5–8) with outgroup as *Phalera bucephala* (MN696381) and *Clostera restitura*

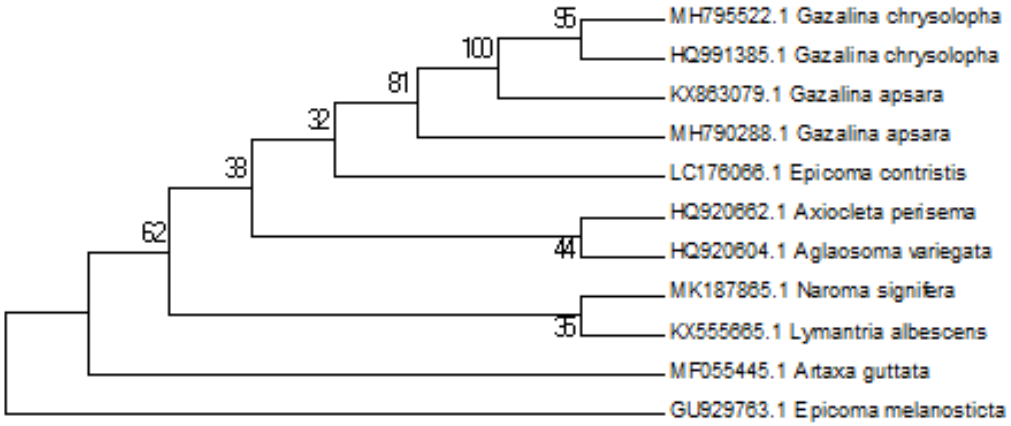


Figure 5. Phylogenetic tree of the sequences studied and sequences retrieved from the NCBI.

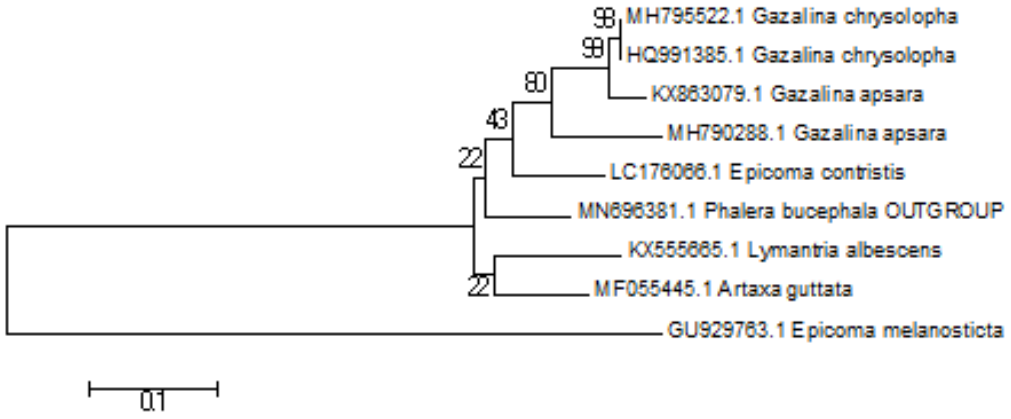


Figure 6. Phylogenetic tree of the sequences studied and sequences retrieved from the NCBI using *Phalera bucephala* as outgroup.

(OR064768) provide a vague analysis as outgroups merge within the clades formed by the other sequences. While the outgroup *Cerura vinula* (MN696387) formed a separate clade with *Epicoma melanosticta* (GU929763) having a significant bootstrap value of 100.

DISCUSSION

Walker (1865) established this genus with *venosata* Walker (*apsara* Moore) as its type species from North-India under family Lymantriidae. The taxonomic position of genus *Gazalina* Walker remained ambiguous due to its continuous reshuffling between subfamily Lymantriidae of family Erebidae and family Notodontidae.

Gardner (1943) recorded secondary setae on the mandibles of *Thaumetopoea cheela* Moore (Thaumetopoeinae) and Godfrey (1984) noted the presence of two distinct mandibular setae in Dudusinae. But in genus *Gazalina* Walker, the mandibular setae are altogether absent (Gardner, 1943). The presence or absence of these setae can also be utilized for stabilizing the systematic position of the present genus. Kiriakoff (1970) considered the subfamily Thaumetopoeinae of processionary moths as a self-standing family, i.e., Thaumetopoeidae. The rank of Thaumetopoeinae, whether it is a subfamily or it receives a family status, had been a long controversy till Miller (1911) concluded to give it the subfamily rank. On the basis of cladistic analysis, he considered it as a homogeneous clade within Notodontidae. Schintlmeister (2008) in his work to recognize Thaumetopoeidae as a distinct family due to its probable link with Lymantriidae. But, he did not give the basis on morphological cladistics or molecular phylogeny to his notion. Zahiri *et al*. (2010) also recognized this subfamily well nested within Notodontidae based on molecular phylogeny. The subfamily Thaumetopoeinae is composed of approximately 100 species in 20 genera occurring in Africa (including Madagascar), the Mediterranean, Europe, Asia, and Australasia in a belt from the Middle East to Taiwan, New Caledonia, and Australia (Schintlmeister, 2013). Kobayashi & Nonaka (2016) analysed the 28S ribosomal RNA genes to infer molecular phylogeny and recognized ten subfamilies in the family Notodontidae. They discussed the genus *Gazalina* Walker under subfamily Thaeumatopoeinae. On the basis of morphological and molecular phylogenetic analyses of the group, Basso (2017) identified three major clades in subfamily Thaumetopoeinae. The first clade includes the Australian genera *Epicoma* Hübner and *Ochrogaster* Stephens and possibly seven other still unexplored genera, for a total of 30 known species. The second clade includes the African genera *Anaphe* Walker, *Epanaphe* Aurivillius, *Hypsoides* Butler, *Paradrallia* Bethune-Baker, and five other genera, for a total of 55 species. The third clade includes the African, Asian, and European genera *Gazalina* Walker and *Thaumetopoea*

Table 3. Morphometry of internal male genitalic organs of *Gazalina apsara* (Moore).

	Organ	Intraspecific range in length (mm)	Intraspecific range in width (mm)
1.	Testis	0.78–0.81	1.34–1.36
2.	Seminal vesicle– I	1.49–1.52	0.54–0.56
3.	Seminal vesicle– II	1.88–1.92	0.53–0.56
4.	Vasa deferentia	3.89–3.91	0.14–0.18
5.	Ductus ejaculatorius duplex	2.93–2.96	0.45–0.48
6.	Accessory gland	8.43–8.45	0.18–0.21
7.	Primary simplex	9.99–10.01	0.20–0.25
8.	Constrictor muscular area	0.48–0.51	0.23–0.26
9.	Cuticular tube	0.59–0.61	0.13–0.16

Table 4. Morphometry of internal female genitalic organs of *Gazalina apsara* (Moore).

	Organ	Intraspecific range in length (mm)	Intraspecific range in width (mm)
1.	Common terminal filament	0.35–0.38	0.09–0.11
2.	Egg tube	13.83–13.86	0.64–0.66
3.	Pedicel	Absent	Absent
4.	Lateral oviduct	0.94–0.96	0.74–0.77
5.	Common oviduct	0.99–1.01	0.74–0.76
6.	Spermathecal gland	5.44–5.47	0.74–0.77
7.	Spermathecal duct	0.93–0.96	0.74–0.78
8.	Utriculus	0.88–0.91	0.35–0.38
9.	Lagena	0.09–0.11	0.08–0.11
10.	Infundibulum	0.09–0.12	0.74–0.76
11.	Corpus bursae	1.14–1.16	0.98–1.01
12.	Ductus bursae	1.18–1.21	0.64–0.66
13.	Ostium bursae	0.14–0.17	0.34–0.36
14.	Ductus seminalis	1.64–1.66	0.11–0.14
15.	Bulla seminalis	Absent	Absent
16.	Accessory gland reservoir duct	0.68–0.71	0.74–0.76
17.	Accessory gland reservoir	0.88–0.91	0.34–0.36
18.	Accessory gland	4.19–4.22	0.74–0.76
19.	Vestibulum	0.34–0.37	1.58–1.61
20.	Vagina	0.43–0.46	1.59–1.62

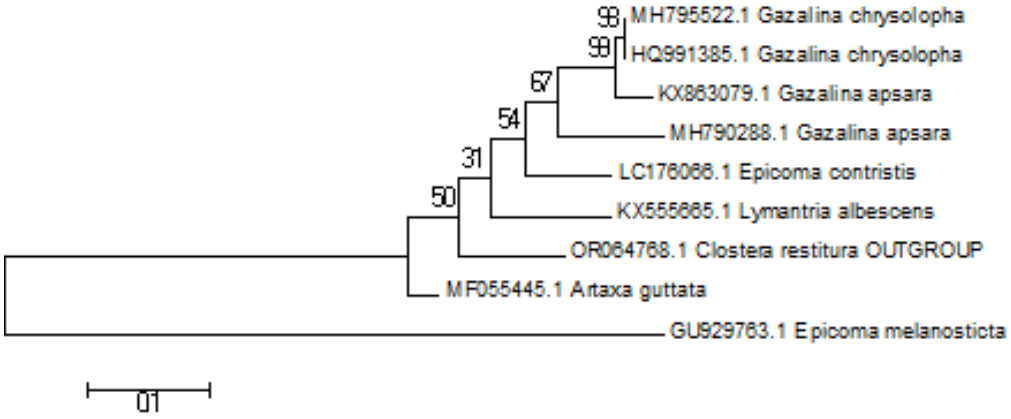


Figure 7. Phylogenetic tree of the sequences studied and sequences retrieved from the NCBI using *Clostera restitura* as outgroup.

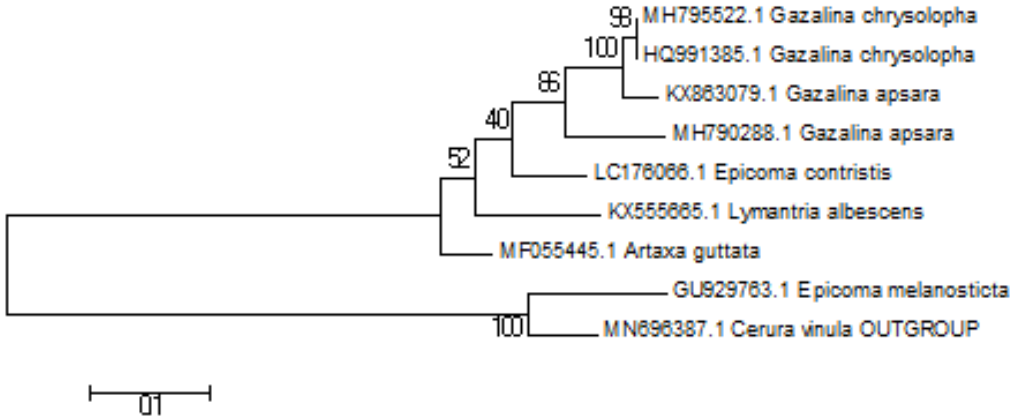


Figure 8. Phylogenetic tree of the sequences studied and sequences retrieved from the NCBI using *Cerura vinula* as outgroup.

Hübner for a total of 18 species. The species within the third clade (*Gazalina* spp. and *Thaumetopoea* spp.) are associated with economically important trees such as Fagaceae (oaks, Quercus), Pinaceae (pines, Pinus) and Anacardiaceae (pistachio, Pistacia) and can occasionally occur at high densities (outbreaks) in the northern part of their range, such as the Mediterranean basin and Europe for *Thaumetopoea* (Battisti et al. 2015) and the Himalaya foothills for *Gazalina* (Rahman & Chaudhry 1992). Battisti et al. (2017) talked about the traits which are shared by all species in this subfamily, most notably is the presence of urticating setae on larvae, adults, or both. The eggs are laid in clusters, and larvae are gregarious during the entire larval stage. In most species of processionary moths, the larvae build silken tents, from which they forage for food in a typical head-to-tail procession. This behaviour of moving in procession has been documented for all the species of these three clades of this subfamily.

The Co I sequence of *Gazalina chrysolopha* (MH795522) and *Gazalina apsara* (MH790288) from the present study were compared with the available reference sequences in Genbank maintained by NCBI by using BLAST. The BLAST results showed 86% similarity of *Gazalina apsara* with sequence (KX863079) from Pakistan and more than 96% similarity of *Gazalina chrysolopha* with sequence (HQ991385) submitted by Ashfaq et al. (2017) from Pakistan which signifies the geographic proximity. The interesting fact is that these sequences also showed more proximity with different genera of the subfamily Lymnatriinae and supported the ambiguous placement of the genus *Gazalina* Walker under Notodontidae. For example, the comparison of obtained sequences with sequences of species of three different genera namely *Epicoma* Hübner, *Axiocleta* Turner, and *Aglaossoma* Walker referable to the subfamily Thaumetopoeinae of the family Notodontidae and three different genera, i.e., *Artaxa* Walker, *Lymantria* Hübner, and *Naroma* Walker of the subfamily Lymantriinae, the similarity index lies between 80–84 %

Table 5. Details of species included in this study, their locality and accession number.

	Species	Locality	Submitter	Accession no.	Date of collection
1.	*Gazalina chrysolopha*	Himachal Pradesh Pakistan	Kaur. N Akhtar. S	MH795522 HQ991385*	08.vi.2016 05.viii.2010
2.	*Gazalina apsara*	Himachal Pradesh Pakistan	Kaur. N Ashfaq. M	MH790288 KX863079*	06.vi.2016 05.vii.2012
3.	*Epicoma contristis*	Australia	Kobayashi & Nonaka	LC176066*	12.ix.2016
4.	*Epicoma melanostica*	Australia	Mutanen	GU929763*	25.vii.2016
5.	*Axiocleta perisema*	Australia	Robinson	HQ920662*	13.ii.1980
6.	*Aglaosoma variegate*	Australia	Carale, J.	HQ920604*	01.iii.1995
7.	*Naroma signifera*	Afro tropical region (Gabon)	Ecotrop field class	MK187865*	27.ii.2011
8.	*Lymantria albescenes*	Japan	Stewart	KX555665*	17.vii.2016
9.	*Artaxa guttata*	China	Hao et al.	MF055445*	30.iv.2020

*Sequences retrieved from the Genbank.

with Thaumetopoeinae of the family Notodontidae and more than 84% with the subfamily Lymantriinae of the family Erebidae (Table 5).

This suggested that the genus *Gazalina* Walker can be placed under the subfamily Lymantriinae on the basis of molecular analysis. As far as behavioral aspects are concerned, the adult moths referable to the genus *Gazalina* Walker show no movements with disturbance and feign dead similar to that of typical lymantrids. The adult moth possesses distinct anal tuft which is a characteristic feature of adults of subfamily Lymantriinae. The external morphological characters including genitalic features completely conform to the characterization of subfamily Lymantriinae except its wing venation which seems to be trifid. The internal genitalic studies on the basis of bulbous constrictor muscular area, small and transparent cuticular tube and its subapical entry position into aedeagus in males and presence of oval lagena and origin of ductus seminalis from middle of ductus bursae in females make both the studied species congeneric. However, these can be differentiated on the basis of certain features such as shape of testis, seminal vesicle-II, ductus ejaculatorius duplex, division of primary simplex in males and shape of eggs, utriculus and length of accessory glands in females. Though *Gazalina* possess a stable generic position, but its placement in a proper family still remains a taxonomic mystery and accounts for more studies and validation.

CONCLUSION

Walker (1865) established the genus *Gazalina* Walker with *venosata* Walker (*apsara* Moore) as its type species from northern India under family Lymantriidae. The taxonomic position of this genus remained ambiguous due to its continuous reshuffling between the subfamily Lymantriidae of the family Erebidae and the family Notodontidae. Though the sequence analysis in present study showed the proximity of its species with species of different genera of the subfamily Lymnatriinae and supported the ambiguous placement of the genus *Gazalina* Walker under Notodontidae. But on the basis of morphological, molecular, larval, pupal and behavioural characteristics and thorough review of previous works particularly of Kobayashi & Nonaka (2016) and Basso (2017), the genus *Gazalina* has been placed under the subfamily Thaeumatopoeinae of Notodontidae.

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