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Cover: Long-tailed Shrike *Lanius schach* resting on a dry branch after courtship. Digital illustration on Procreate. © Aakanksha Komanduri.

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COMMUNICATION

New record of invasive moth *Phalera* cf. *bucephala* (Linnaeus, 1758) (Lepidoptera: Notodontidae) on *Salix alba* (Salicaceae) from Ladakh, India

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Abstract: The Suru Valley of district Kargil, UT Ladakh, India is part of the Trans-Himalayan region. Over the past two decades, the region has been experiencing climate change, resulting in outbreaks of many invasive insect species in the area. The present study documents a new invasive moth *Phalera* cf. *bucephala* (Linnaeus, 1758) on *Salix alba* and its biology in the region. This species is polyphagous, infesting a wide range of plant species, including those of the genus *Salix*. Observations indicate that adults emerge in late June, with females laying eggs within 2–3 days. After an incubation period of 10–15 days, larvae hatch in July and pupate in August and September. The insect overwinters in the pupal stage underground, beneath decomposing leaves, grasses, and debris. There are four larval stages, all of which are active feeders, leading to complete defoliation of the host plant within 30 days of emergence. Currently, *P.* cf. *bucephala* is confined to the Suru Valley of district Kargil but may potentially spread to neighbouring areas.

Keywords: Alien invasive species, climate change, insect outbreaks, Kargil, forest, plant defoliation, polyphagous pest, Suru Valley, Trans-Himalaya.

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Author contribution: MH identified the insect species up to the species level, captured photographs of insect specimens and study sites, and prepared the manuscript along with NFK. BA and MA assisted in collecting insect specimens, preparing the manuscript, photo editing in Photoshop, and related tasks.

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INTRODUCTION

The Suru Valley of Kargil is situated in the Trans-Himalayan region of the cold arid desert of Ladakh, India. This valley extends widely along the sides of the Suru River and its tributaries, from Minjee Village to Parkachik Village. It is renowned for the cultivation of willow and poplar plants, which are crucial for both firewood and construction purposes. Locally, willow branches, known as Kralboo, are extensively used in roofing just below the mud slab in traditional Ladakhi architecture. Both fresh and dried leaves, as well as tender twigs, are used as fodder for livestock during early spring and periods of grass shortage. These uses underscore the significant economic value of willow and poplar plants in the region (Hussain et al. 2024). In recent years, the Ladakh region has been experiencing insect pest outbreaks on many economically important plants, including willow and poplar species (Raghuvanshi 2016; Hussain et al. 2021a,b, 2024). These outbreaks are likely to be influenced by climate change and other environmental factors (Johnson & Haynes 2023; Tabassum et al. 2024). Over the past two decades, these infestations have been increasingly documented (Raghuvanshi 2016; Hussain et al. 2024). According to a literature review, six invasive species—Brown Tail Moth *Euproctis chrysorrhoea* Linnaeus, 1758; Migratory Locust *Locusta migratoria migratorioides* (Linnaeus, 1758); Spotted-wing Drosophila *Drosophila suzukii* (Matsumura, 1931); Giant Willow Aphid *Tuberolachnus salignus* Gmelin, 1790; Aspen Leaf Miner *Phyllonorycter populifoliella* (Treitschke, 1833); and *Pheosia albivertex* (Hampson, 1983)—have been recorded in the region (Kumar et al. 2009; Raghuvanshi et al. 2016; Hussain et al. 2021b, 2024). In the current study, *P.* cf. *bucephala* has been recorded in the Suru Valley of Kargil, Ladakh, India.

The genus *Phalera* causes various degrees of infestation to a variety of trees and shrubs, including willow, poplar, sessile oak, apple, mountain ash, and walnut, causing complete defoliation to the host plant (Bochniarz 2022). The genus is primarily distributed across the Palearctic, Oriental, Australian, Central Asian, and Ethiopian regions, including Korea and China, and can be found at altitudes of up to 2,200 m (Schintlmeister 2008; Wu & Fang 2012; Bochniarz 2022). Worldwide, the genus encompasses approximately 87 species, with 11 species previously recorded in India (Smetacek 1999; Chandra et al. 2018; Singh 2019). This new record brings the total number of documented *Phalera* species in India to 12.

MATERIALS AND METHODS

The survey was conducted in the Suru Valley area of the Trans-Himalayan region of Kargil, UT Ladakh, from June 2021 to August 2023 (Figure 1). The entire stretch was thoroughly inspected, and spatial information about collection sites was recorded using a Garmin hand-held eTrex 32X device (Table 1). To study the biology, the insect was cultured in the zoology laboratory at the University of Ladakh using a technique adapted from the culture of the invasive insect *Pheosia albivex* recorded from Kargil, with some modifications (Hussain et al. 2024). Larval stages were collected by hand from host plants and brought to the laboratory for further study. Specimens were sorted and kept in clean plastic jars (2 × 2 × 3 ft) covered with muslin cloth. They were fed fresh leaves, with twigs inserted in wet sand in a flowerpot covered with muslin cloth or mosquito netting. The culture was refreshed daily. Mature fourth instar larvae were transferred to a jar filled with dry soil, covered with rotten leaves and plant debris, to facilitate pupation. The jars were left undisturbed at room temperature until the adults emerged in June and July of the following year. Adults were sorted by sex based on morphological characteristics and allowed to mate in a large chamber covered with mosquito netting (Hussain et al. 2024). Gravid females were provided with fresh host plant leaves for egg-laying. Adult specimens were identified using keys provided by Wu & Fang (2012) and Dolinskaya (2016). Photographs of eggs, instars, and adults were taken with a stereo zoom microscope (Leica S9i) and a Canon 500D DSLR camera. The images were later edited using Adobe Photoshop 7.0.

RESULTS

Phalera* cf. *bucephala (Linnaeus, 1758)

Material examined: Three males and two females were collected from Khachan, near the trout fish farm in Khachan, Kargil, Ladakh (Geolocation: 34.365° N, 74.969° E, elevation—2,880 m, 23.vii.2021). The specimens were identified as *Phalera* cf. *bucephala* (Linnaeus, 1758) (Figure 2A; Image 1D) and deposited in the Zoology Museum, University of Ladakh on 10 October 2023.

Diagnostic characters

Adult: The body measures 3–3.5 cm in length. Males have feathery, bi-pectinate antennae, while females have filiform antennae. The forewings are grey with a large dark brown patch near the apex and narrow dark

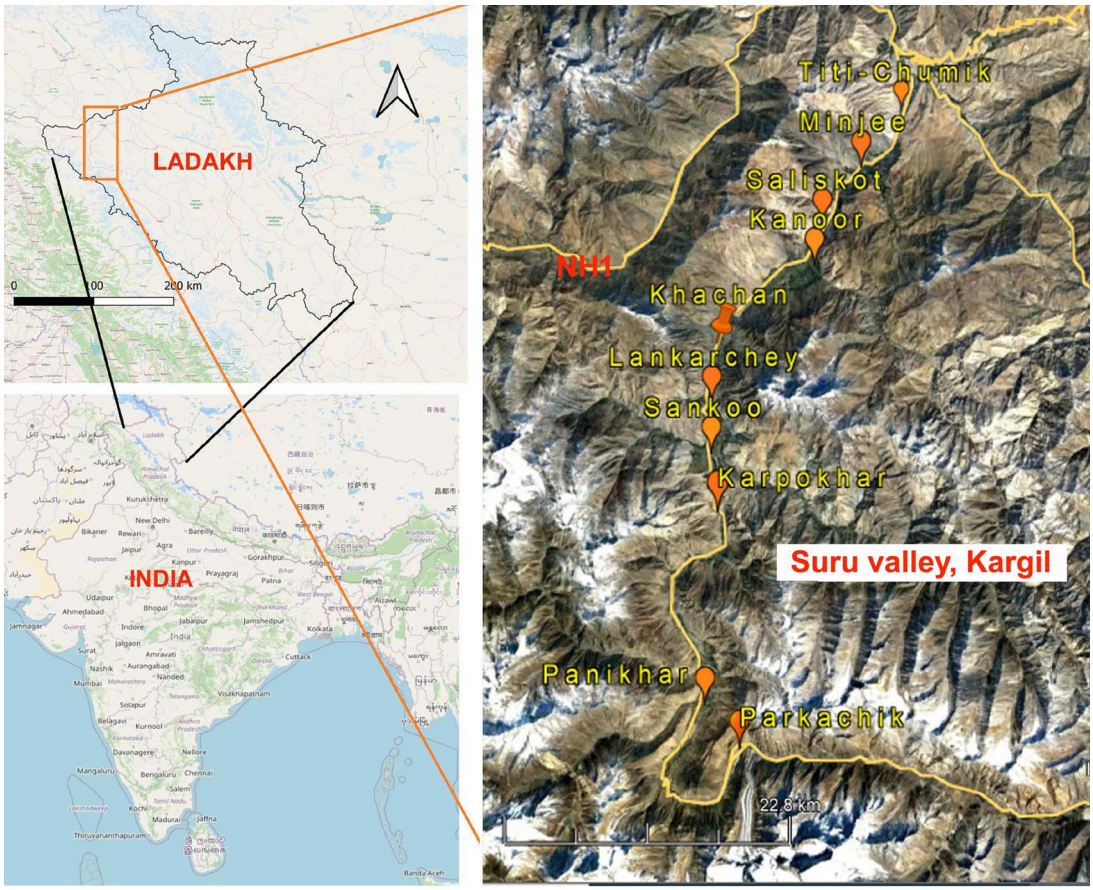

Image 1. Map of study area, Suru Valley of Kargil, Ladakh, India. (Source: QGIS and Google Earth Pro).

bands. The hind wings are creamy white. The thorax is hairy, buff, and grey, and the abdomen is brown. The buff-tip moth exhibits minimal sexual dimorphism, though females tend to be larger and have a bulging abdomen before laying eggs; male genital part, uncus large dome-shaped, apex pointed and highly sclerised, well developed, forming "C" shaped arch on the 1/3 area from the outer side air, saccus processes reduced, juxta enlarged with processes, valva brought with one processes and small hairs (Figure 2D,E; Image 1D).

Egg: Creamy white, spherical with a single black spot at the apex, and a flat base for better adhesion to leaf surfaces. Eggs are 0.8–1 mm in diameter and laid in clusters of 100–150. They hatch in 15–20 days in late July (Figure 2B).

Larvae: *Phalera* cf. *bucephala* represents four larval stages. Newly hatched larvae are slightly yellowish, later turning black with yellow patterns, and measure 0.8–1 cm in length. The body is covered with white hairs, and the head is black. Each thoracic segment has distinct markings, and the last abdominal segments have a brown band. Siblings live in groups, held together by fine threads secreted by the larvae (Figure 2D; Image 1A). Second instar larvae measure 1.5–2 cm, and the third and fourth instar larvae grow to 3–5 cm in length (Figure 2F). Except for newly hatched larvae, all the

Table 1. Sample collection sites, Suru Valley, Kargil, Ladakh.

	Sample collection sites	Geo-location	Altitude (in m)
1	Titi-Chumik	34.523° N, 76.131° E	2,735
2	Minjee	34.487° N, 76.1° E	2,769
3	Saliskot	34.428° N, 76.052° E	2,831
4	Kanoor	34.417° N, 76.05° E	2,827
5	Khachan	34.365° N, 74.969° E	2,880
6	Lankarchey	34. 326° N, 75.96° E	2,929
7	Sankoo	34.281° N, 75.962° E	2,983
8	Karpokhar	34.241° N, 75.97° E	3,071
9	Panikhar	34.092° N, 75.94° E	3,287
10	Parkachik	34.093° N, 75.991° E	3,585

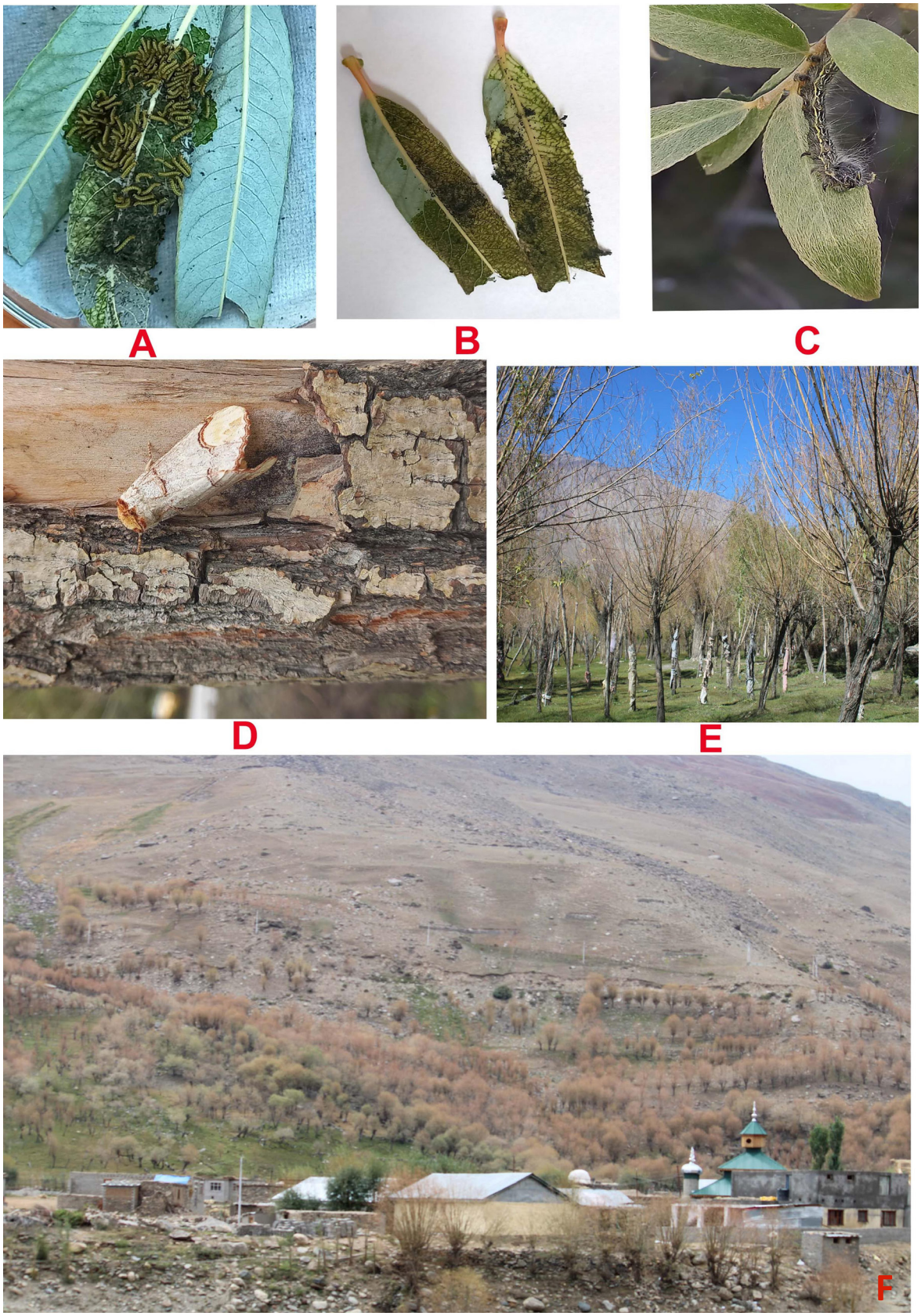

Image 1. *Phalera* cf. *bucephala*: A—newly hatched larvae feeding on the lower surface of the host plant leaves | B—lower surface of host plant leaves scrapped by 1st instar larvae | C—3rd instar larvae on leaf of host plant | D—adult resembling the trunk of host plant | E—defoliated host pants at the study sites, Khachan fish farm | F—defoliated host pants in a study sites, Panikhar. © Mohd Hussain.

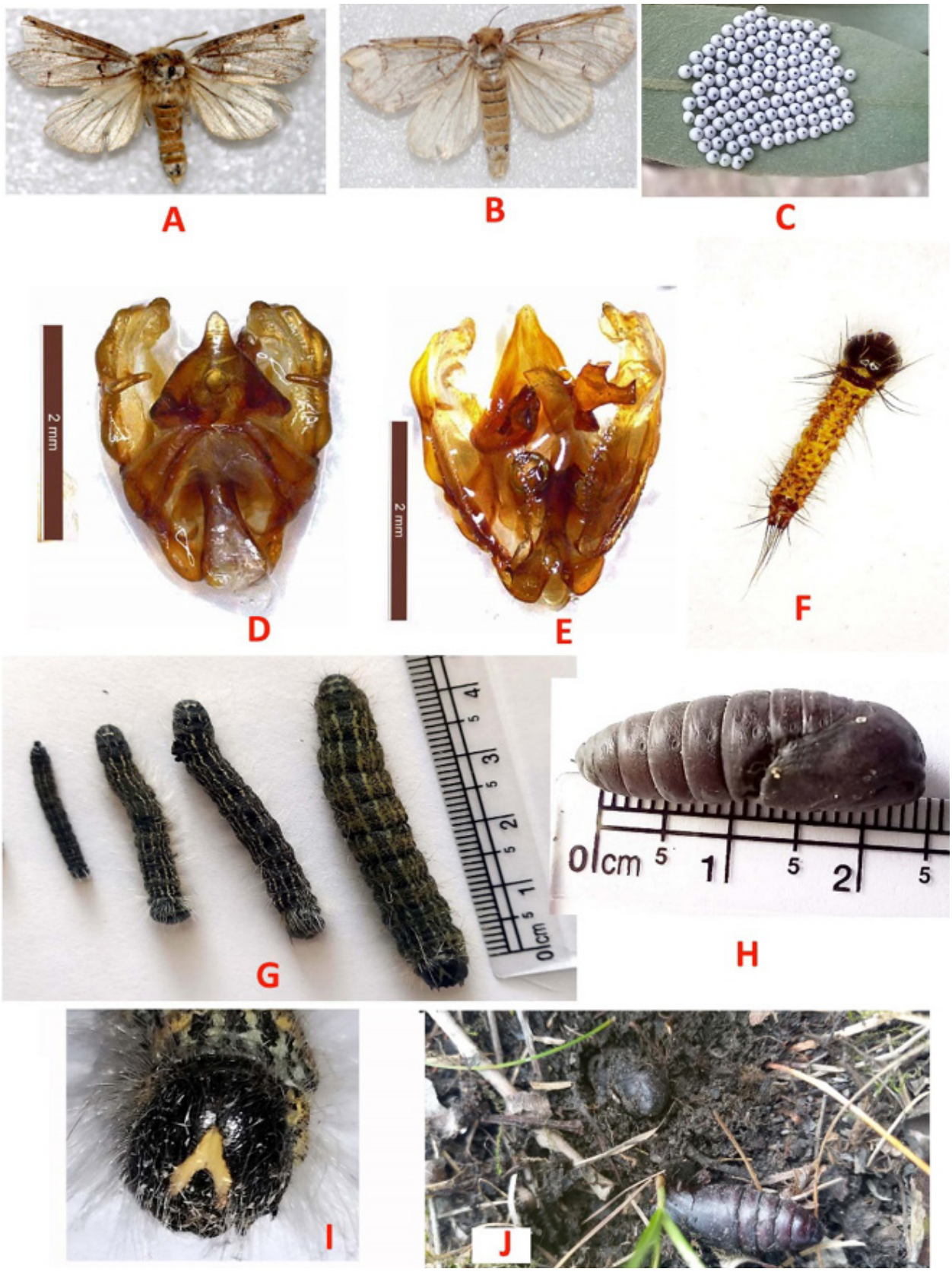

Image 2. *Phalera* cf. *bucephala*: A—adult male | B—adult female | C—eggs on the under surface of host plant leaf | D—male genetilia, Dorsal view | E—male genetilia, ventral view | F—newly hatched 1st instar larvae | G—1st to 4th instar larvae | H—Pupae | G & J—pupae under the ground | I—4th instar larvae head. © Mohd Hussain.

larval stages are black with yellow pattern, rows of white lines running from anterior to posterior end, which are prominently visible in the third and fourth larval stages, body hairy with white hairs (Figure 2F; Image 1C). The head is black with a characteristic inverted "Y" shape line on the anterior head (Figure 2F).

Pupa: *P.* cf. *bucephala* overwintered in pupal stage. Pupae purple-brown in colour, measuring 2.5 cm in length. Pupation occurs under the ground at a depth of 3–4 inches in September, no cocoon formation (Figure 2E,G).

Biology: *P.* cf. *bucephala* is univoltine, completing one generation per season in the study area. Adults emerge from pupae in mid-June and are active until August, with peak abundance in July. Females lay eggs soon after copulation, in clusters of 100–150 (Figure 2B). The first instar larvae hatch after 10–15 days and go through four developmental stages in 40–45 days (Figure 2F). Mature larvae leave the host plant to pupate and overwintered under rotten leaves and plant debris (Image 1E,G).

Host: *P.* cf. *bucephala* is polyphagous, preferring plants from the Rosaceae, Salicaceae, and Fagaceae families (Wu & Fang 2012; Hausmann & Scalercio 2016; Morozov et al. 2016; Morimoto & Pietras 2020). In this study, it was recorded on *Salix alba* in the Suru Valley of Kargil, UT Ladakh, India.

Nature of Damage: Only the larval stage feed on the leaves of the host plant causing complete defoliation by mid-August (Image 1E,F). Newly hatched larvae scrape from the under surface of the leaves for 2–3 days, then eat from the margins toward the midrib, leaving only the veins (Figure 2A–C).

Distribution: *P.* cf. *bucephala* has been documented in China, Korea, Russia, Europe, Africa, and Italy (Wu & Fang 2012; Hausmann & Scalercio 2016; Morozov et al. 2016). This study records its presence in India from the Trans-Himalayan region of Kargil, UT Ladakh, India, where it is well-distributed from Minjee to Parkachik Village of Suru Valley.

DISCUSSION

The Suru Valley, located in the Trans-Himalayan region of Kargil, Ladakh, boasts rich biodiversity, with numerous insect species documented in the valley so far (Behera 2014). Ladakh is experiencing a warming trend due to climate change, resulting in the presence of many invasive insects in the region (Chevuturi et al. 2018; Hussain et al. 2021a, 2024). Recently, Hussain et al. (2024) recorded an invasive insect pest on *Populus alba* in the Dyanguchey Village of the Suru Valley. In the present study, a new invasive moth species, *P.* cf. *bucephala*, has been recorded from the valley on *Salix alba*. Therefore, this area in the Ladakh region provides ideal conditions for the introduction and succession of insect species. The genus *Phalera* comprises approximately 87 species worldwide and is well-distributed in the Palearctic region, including China, Mongolia, Korea, Russia, Europe, and northeastern Africa (Wu & Fang 2012; Morozov et al. 2016; Bochniarz 2022; ADW: Phalera: Classification 2024). In India, the genus has been documented in the eastern Himalayan region and its surrounding areas; however, it is the first time the genus is being recorded from Trans-Himalaya, Kargil Ladakh (Chandra et al. 2018). The larvae of *P.* cf. *bucephala* feed on the leaves of various trees and shrubs, including willow, poplar, sessile oak, apple, mountain ash, and walnut, causing complete defoliation within a short period (Bochniarz 2022). Upon reaching maturity, the larvae leave the host plant and crawl in masses on the ground for pupation, causing a nuisance in the study area during crop harvesting in July and August. In Ladakh, the host plant, *Salix alba* holds great economic value locally, with its branches (Kralboo) widely used in house construction for roofing under the mud slab. The leaves and tender twigs are used as fodder for livestock in early spring during grass shortages. During the survey, it was observed that the insect covers the entire valley from Minjee to Parkachik. Therefore, it may be declared an invasive pest and timely control measures should be implemented. The insect is polyphagous, and without timely control measures, it may spread to other areas, including fruit-growing regions like Kargil City, Shilikchey, Hardas, and other adjoining areas of the Kargil District.

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