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**The lesser-known Kumaon Meadow Blue *Polyommatus dux* Riley, 1926
(Lepidoptera: Lycaenidae: Polyommatae: Polyommataini)
from Uttarakhand, Western Himalaya**

**Малоизученная голубянка *Polyommatus dux* Riley, 1926
(Lepidoptera: Lycaenidae: Polyommatae: Polyommataini)
из Уттаракханда, Западные Гималаи**

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Key words: Lycaenidae, *Polyommatus*, high altitude distribution, Kumaon Himalaya, wing surfaces.

Ключевые слова: Lycaenidae, *Polyommatus*, высотное распределение, Кумаон, Гималаи, рисунок крыла.

Abstract. In spite of that Western Himalaya (Garhwal and Kumaon) geographically seems to be Oriental, the fauna of this high mountainous area has strong affinities with the Palaearctic region. The inner valleys of Kumaon Himalaya are close to Tibet, what is characterised by Sino-Himalayan xero-mountain elements, including the genus *Polyommatus* Latreille, 1804, one of the most diverse lycaenid genera in the Palaearctic region. In the Himalayas *Polyommatus* is represented by the diverse *stoliczkanus* species group. Here we report on *Polyommatus dux* Riley, 1926 from Kumaon Himalaya (type locality), what is an unusual member of the group displaying a hindwing ventral wingsurface with extensive structural colouration. Since the description the species has not been recorded. Therefore our finding is the second record since its discovery. On the basis of new material, the external habitus of the male is diagnosed and genitalia structures are described. Field observations are briefly recorded, imagines in nature are documented and the phenomena related to the butterfly wing surfaces are briefly discussed. The species is vulnerable to climate change driven range restriction and extinction threats, and thus considered as a candidate for flagship species for ecological studies in nature conservation investigations in the high-altitude region of the Kumaon Himalaya, India.

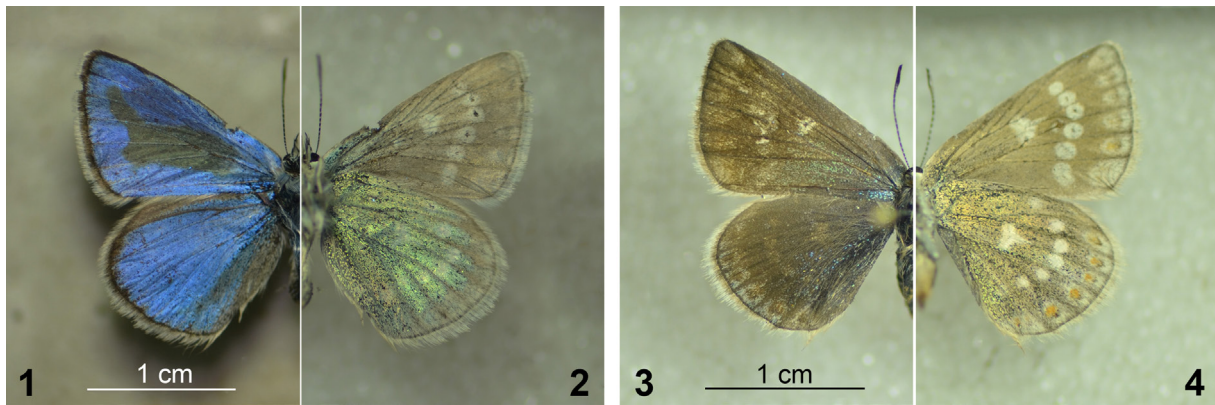
Резюме. Несмотря на то, что Западные Гималаи (Гархвал и Кумаон) биогеографически частично относятся к Ориентальной области, фауна этого высокогорного района тесно связана с Палеарктикой. Фауна внутренних долин гималайского Кумаона близка к таковой Тибета, для которого характерны китайско-гималайские ксерофильные горные элементы, включая род *Polyommatus* Latreille, 1804, один из самых разнообразных родов Lycaenidae в Палеарктике. В Гималаях *Polyommatus* представлен разнообразной группой видов *stoliczkanus*. В работе

приведены сведения о находке *Polyommatus dux* Riley, 1926 в типовом местонахождении (Кумаон, Индия, Гималаи), который является необычным видом этой группы с обширной структурной окраской нижней стороны заднего крыла. С момента описания вид не был зарегистрирован, поэтому наша находка – вторая со времени его открытия. На основе нового материала даны переописание и диагноз вида, описаны структуры гениталий самца. Приведены сведения о наблюдениях бабочек в природе, кратко обсуждены факторы, влияющие на окраску крыльев. Вид уязвим и находится под угрозой исчезновения в результате сокращения ареала, вызванного изменением климата, и, таким образом, может рассматриваться как экологический индикатор в природоохранных исследованиях в высокогорном регионе Гималаев (Кумаон, Индия).

Introduction

The Himalayan ranges are one of the important biodiversity hotspots in Indian subcontinent embracing interesting studies on Lepidoptera [Mani, 1986; Das et al., 2018]. The lycaenid (Lycaenidae) butterfly fauna of Himalaya needs taxonomic and systematic revision, especially the Palaearctic part where lots of species complexes remain unresolved in genera like *Polyommatus* Latreille, 1804 [Bálint, 1992a, b]. The subtribe Polyommata, represented by *Polyommatus* and further genera in the region, is the largest and most taxonomically challenging group within the Palaearctic Lycaenidae, with about 400 known species worldwide [Vila et al., 2011].

From Himalaya, 21 species of *Polyommatus* have so far been reported, of which ten species are found in India [Bálint, 1995; Tshikolovets, 2005; Varshney, Smetacek, 2015]. In Himalaya, most of the species were recorded



Figs 1–4. *Polyommatus dux* from Kumaon Himalaya, India, collected in 2017.

1–2 – male: 1 – upperside (the spot in the wing surface median area is due to mishandling the specimen during the preparation procedure), 2 – underside; 3–4 – female: 3 – upperside; 4 – underside.

Рис. 1–4. *Polyommatus dux*, Кумаон, Индия, Гималаи, 2017.

1–2 – самец: 1 – верхняя сторона (пятно в средней области крыла связано с повреждением во время препарирования), 2 – нижняя сторона; 3–4 – самка: 3 – верхняя сторона; 4 – нижняя сторона.

from Central and Western regions between 3000 to 4000 m altitude where *stoliczkanus* species group of *Polyommatus* is the most diverse [Bálint, 1995]. One of these species, Kumaon Meadow Blue *Polyommatus dux* Riley, 1926, was known only on the basis of the type material. The description of *P. dux* was based on the holotype male specimen collected by H.G. Champion during the month of June–July in 1924 along Gori River, Milam village [Riley, 1926], additionally two males and three females paratypes also originated from Milam and Burfu villages (Kumaon, Uttarakhand, India) [Bálint, 1999]. Furthermore, no subsequent occurrence of the species was recorded since its description from India [Singh, 2009; Smetacek, 2012; Singh, Sondhi, 2016; Sondhi, Kunte, 2018].

The present account provides a detailed redescription of *P. dux* which is being reported from India (type locality) after 91 years, also describing the hitherto undocumented male genitalia structures. The used terminology follows the works of Mehta [1933]. A brief account is also given on the first field observation of the species. The structural coloration and the reduced marking typifying the hindwing ventral surface of the species are briefly discussed.

Polyommatus dux Riley, 1926
(Figs 1–9)

Polyommatus dux Riley, 1926: 278. D'Abbrera, 1995: 500; Bálint, 1999: 28.

Polyommatus eros dux: Evans, 1932: 232.

Polyommatus (group *stoliczkanus*) *dux*: Bálint, Johnson, 1997: 24.

Material. 1♀, Uttarakhand, Pithoragarh, Martoli, 3223 m, 3.10.2017; 1♂, Uttarakhand, Pithoragarh, Milam, 3497 m, 4.10.2017. Specimens are deposited to National Zoological Collection, Zoological Survey of India.

Redescription. Male (Figs 1–2). Forewing costa length 11 mm ($n = 1$). Forewing apex is somewhat produced and elongated in shape.

Upperside (Fig. 1). Forewing: ground colour shining blue, with thread like black marginal border. Thin black or brown costal line, slightly increasing in size towards apex. Veins with somewhat white scale suffusion and at terminal area veins with black scaling. Cilia of anteterminal area blackish and terminal cilia white. Hindwing: costal and anal areas with grey scaling, rest of ground colour as in forewing. Vein 7 completely black. Marginal black, thread like.

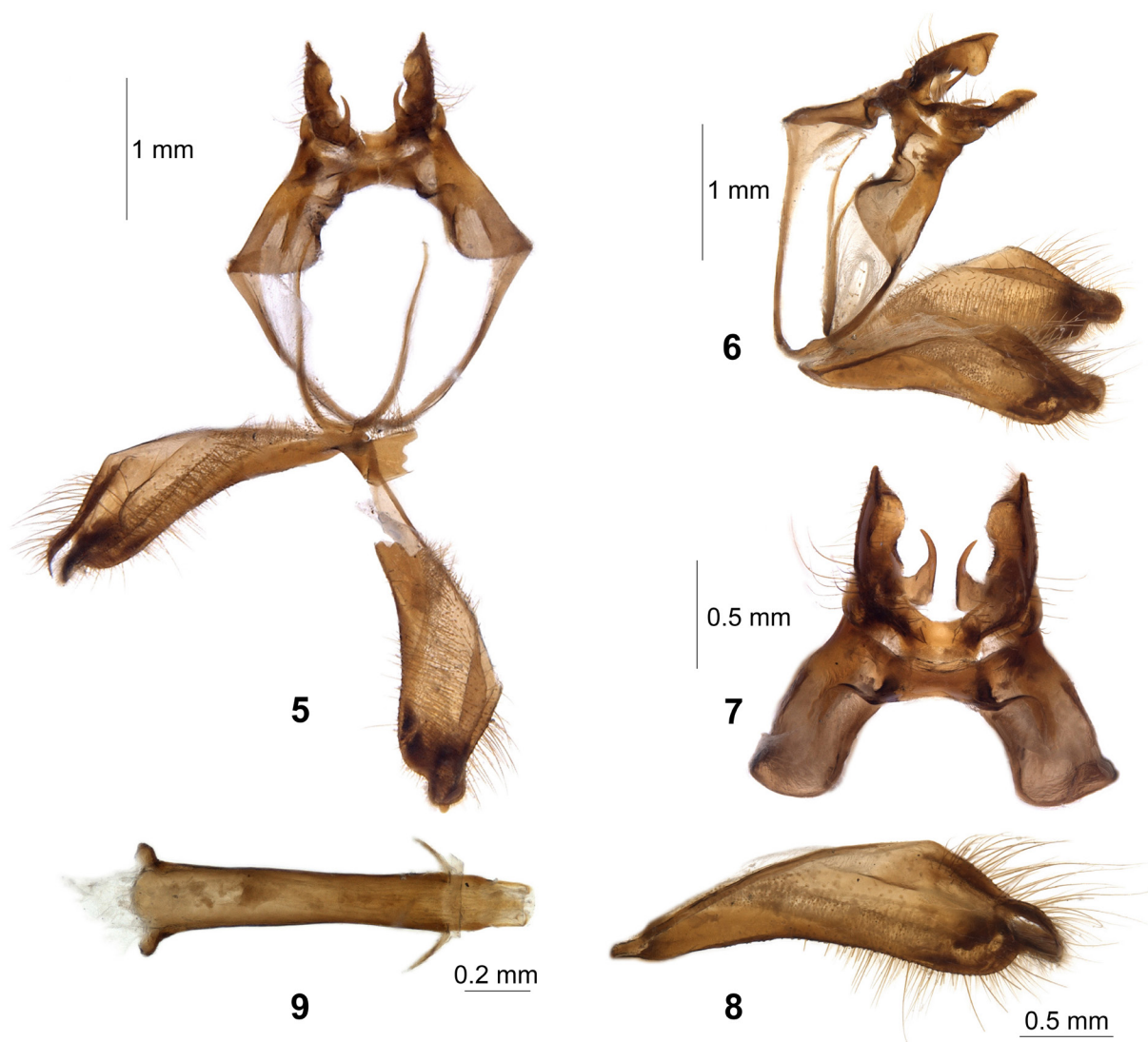
Underside (Fig. 2). Forewing: ground colour is light grey with white scale suffusion, basal area with some iridescent greenish to blue scaling. No spot in cell but sometimes with an obsolete white scaling round spot. A large white end-cell spot without black thin line. A series of seven discal black spots from 1b to 6 interspace, ringed by white scales. Two spots closest to inner margin coalesced in space 1b and spots in 4, 5 and 6 arranged in a line or so on. Marginal area pattern suffused with white scaling, spots obsolete. Veins conspicuous black ending by some white scale suffusion. Black border thread-like, cilia whitish. Hindwing: basal and postbasal area with metallic green scale suffusion up to discal area, sometimes beyond it. Postdiscal spots obsolete or inconspicuous, marginal area diffused with white scales. Terminal and costal border appearing as greyish thin line. Cilia white.

Male genitalia (Figs 5–9). Uncus strong, horseshoe shaped (lobe ventrally curved) and without having any dentation on ventral margin of the lobe. Subuncus slightly hooked, distal part as long as proximal one. Tegumen strong with weak suspensorium. Vinculum also strong, with about same length as juxta. Valva strong, angulated with sclerotized costal process. Aedeagus straight, approximately 1 mm in length, subzonal element four times longer than suprazonal.

Female (Figs 3–4). Forewing costa length 11 mm ($n = 1$), outer margin somewhat longer than in male.

Upperside (Fig. 3). Forewing: ground colour uniform brownish, with dark black thin border. Basal area with few iridescent green scales, in general spotless, sometimes having a white discal spot traversed by a thin black line. Veins dark brown. Cilia as in male. Hindwing: brownish ground colour with some shining blue scales at base. Veins dark brown, border black and thread like. Marginal area having some obsolete iridescent blue scales with inconspicuous brown spots ornamented by some crescent orange scaling. Cilia as in male.

Underside (Fig. 4): ground colour as in male. Forewing: basal area with some shining blue scales, discal and postdiscal spots prominent; discal spot whitish and triangular in shape with a black central line, postdiscal spots as in male. A series of obsolete spots at marginal area decreasing in order towards apex with some iridescent orange scales on forewing. Terminal and costal border black or brown. Cilia whitish. Hindwing: ground colour dark brown. Basal and subbasal area as in male, green suffusion extends beyond discal area. Spots more prominent than in male. Triangular-shaped white spot at cell-end, a series of white postdiscal spots. Marginal area suffused with white scales, seven orange spots with a dark brown crescent scaling of each orange spots, may diffused. Cilia white with dark brown thread margin.



Figs 5–9 . Male genitalia structures of *Polyommatus dux*.

5 – full view of genital capsule, dorsal view, valve are moved out and flattened; 6 – genital capsula, dorso-lateral view, aedeagus removed; 7 – uncus and subuncus, dorsal view; 8 – left valva, lateral view; 9 – aedeagus, dorsal view.

Рис. 5–9. Генитальные структуры самца *Polyommatus dux*.

5 – общий вид генитальной капсулы дорсально, клапан выдвинут и сплюснен; 6 – генитальная капсула, дорсолатерально, эдеагус удален; 7 – ункус и субункус, дорсально; 8 – левая вальва, вид сбоку; 9 – эдеагус, вид сверху.

Notes. The specimens were identified on the basis of comparison with the type material examined [Bálint, 1999] and illustrated [D’Abrera, 1995; Varshney, Smetacek, 2015]. In habitus, *P. dux* closely resembles to *P. fraterluci* Bálint, 1995 (Himachal Pradesh, India) because of their reduced underside pattern and extensive metallic scaling in the hindwing basal area. On the basis of this observation, the latter taxon sometimes being considered as a subspecies of *P. dux* [Varshney, Smetacek, 2015]. Further investigations are necessary to clarify the status of these taxa in relation not only between them but within the whole *stoliczkanus* complex. Experimentally it was demonstrated that in *Polyommatus icarus* (Rottemburg, 1775) via cold shock it was easy to alter the underside wing pattern and the wing surface size of the individuals, but the structural coloration was highly stress resistant [Kertész et al., 2017,

2019]. The taxa *P. dux* and *P. fraterluci* seem to be different in their dorsal and ventral structural colorations, hence further investigations are in need to test their colours experimentally.

Distribution. Burfu, Martoli, Milam (District Pithoragarh, Uttarakhand, India) (Fig. 10).

Field observations (Figs 11–14). During the study period, on 3rd October, 2017 at around 16:30–17:00 hrs. a pair of *P. dux* was found chasing each other and nectaring on *Malva pusilla* (Malvaceae) and *Nepeta* sp. (Lamiaceae) at Martoli village (near Burfu) (30.353462°N / 80.191896°E, 3223 m), which comes under Munsyari block of Pithoragarh district, Uttarakhand and associated habitat is designated as Deciduous Alpine Scrub (15/C2) [Champion, Sheth, 1968] (Fig. 11). Another pair of *P. dux* was sighted at Burfu village (30.367164°N / 80.183769°E,



Fig. 10. Map showing the localities of *Polyommatus dux*, from Kumaon Himalaya, India.
Рис. 10. Карта местонахождений *Polyommatus dux*, Кумаон, Индия, Гималаи.



Figs 11–14. Habitat of *Polyommatus dux* and butterflies in nature.

11 – habitat, Kumaon Himalaya, India, southern facing mountain sides at 3200 m, above an abandoned village, extensively grazed by livestock; 12 – male nectaring on *Malva pusilla*; 13 – female nectaring on *Malva pusilla*; 14 – mating pair.

Рис. 11–14. Местообитание *Polyommatus dux* и бабочки в природе.

11 – местообитание, Кумаон, Индия, Гималаи, южные склоны гор с пастбищами на высоте 3200 м, над заброшенной деревней; 12 – самец, питающийся нектаром на *Malva pusilla*; 13 – самка, питающаяся нектаром на *Malva pusilla*; 14 – спаривающиеся особи.

3343 m), on 4th October, 2017, around 09:00 hrs. On the same day, a total of five individuals were also recorded at Milam village (30.435711°N / 80.149915°E, 3497 m), including a mating pair (Figs 12–14). The ambient temperature and humidity were recorded 20–26 °C and 35–42% respectively on those days. The species have been treated as rare by Evans [1932].

Geologically, the area falls within the Trans-Himalayan region (1C, Cold Arid Region of Eastern Himachal and Uttarakhand) [Kumar et al., 2017] that represents high altitude desert type vegetation characterised by barren and rocky areas with small shrubs patches typical of mountain river valleys of Kumaon Himalaya. The vegetation is characterised by extensive patches of dwarf Rhododendron and dwarf Junipers associated with shrubs like Cassiope fastiglata (Ericaceae), Salix hylematica (Salicaceae), Malva pusilla etc., occasionally surrounded by outlying patches of subalpine forest trees like Betula sp. (Betulaceae). The area is under dry and cold climatic conditions with prolonged winter extending from October to April where summer is very short, May to August. The temperature is low due to high elevation; maximum temperature is recorded in the month of July (32 to 35 °C) whereas minimum temperature goes below 0 °C in the month of January (–22 °C). The area receives scanty rainfall with 1242 mm average annual precipitation with 263 mm precipitation in wettest month and 18 mm during driest month, when most of the valley remains under snow-cover.

Discussion

The *stoliczkanus*-group of *Polyommatus* is one of the most complex groups of the genus. It is characterised by xero-mountain elements of the Himalayas, but it is also found in the entire Pamir-Himalaya region, including Nepal [Shields, 1982; Tshikolovets, 2005; Tshikolovets, Pagés, 2016; Tshikolovets et al., 2018]. According to Vila et al. [2011], this group of taxa might have been originated from the Himalayas, and some of them now inhabit wide areas in Eurasia. Many of them are basically high-altitude species occurring at elevation between 3000 to 4000 m, and about 45% of species are endemic [Bálint, 1995]. This group of lycaenids displays three interesting phenomena: (1) in many cases the pigment-based ventral wing pattern is highly reduced, (2) hindwing ventral surface is often with extensive structural coloration and (3) in certain populations the blue female phenotype is the dominant one.

The phenomenon (1) is certainly generated by environmental variables, and it is highly disputable how this trait is fixed genetically [Kertész et al. 2017, 2019]. Phenomenon (2) is not restricted to *Polyommatus*, but several lycaenid butterfly genera in this region display similar metallic green hindwing ventral coloration (e.g. Lycaenini: *Lycaena kasyapa* (Moore, 1865); Polyommataini: *Agriades jaloka* (Moore, 1874), *Albulina arcaseia* (Fruhstorfer, 1916), almost all the Pamiria species (*P. chrysopsis* (Grum-Grshimailo, 1888), *P. galathea* (Blanchard, 1844), *P. omphisa* (Moore, 1874), etc.), *Patricius felicis* (Oberthür, 1896), *P. younghusbandi* (Elwes, 1906)). When physical properties of this phenomenon were investigated it was considered that it was a trait for

high-altitude adaptation [Márk et al., 2009]. However, this is supported only by empirical evidence and not by observation. Probably the phenomenon is indeed a result of a peculiar climate, but host plant utilization or a rare molecular trait, or all together can be also the source of this pattern. We mention that most of the species *Neolysandra* Kocak, 1977, living in the western Palaearctic region and the Siberian-Mongolian *Maculinea cyanecula* (Eversmann, 1848), all possess this peculiar trait. In phenomenon (3) *Polyommatus dux* is also involved as some of the females we know have extensive blue coloration, but entire blue females are not yet detected. We suspect that practically all the other congeneric species (e.g. *P. annamaria* Bálint, 1992, *P. ariana* Moore, 1865, *P. stoliczkana* (C. et R. Felder, [1865]), etc.) possess populations where female blue phenotype dominates, that also mirrors the strong influence of environmental variables [Bálint et al., 2018]. Any future study concentrating on the life history and ecology of *P. dux* would result many interesting data and scientific evidences in relation to these phenomena briefly discussed above.

We recorded *P. dux* at the type locality after 91 years, which is also the second record of the species since its discovery in India. The individuals were abundant after a certain ridge beyond 3200 m in the Milam valley. This suggests that the species is a strict habitat specialist, and most probably endemic to the region. Considering its habitat fidelity and altitudinal range-restriction, *P. dux* can be of utmost important in future monitoring surveys assessing impact of climate atrocities on fragile Himalayan ecosystems, which will further promote habitat-based nature conservation in the area.

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