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SHORT COMMUNICATION

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First records of *Brephidium exilis* (Boisduval) (Lepidoptera: Lycaenidae) from south-western part of the Arabian Peninsula suggests possible further dispersal into North Africa

Rudi Verovnik[1], Marko Kosmač[2], Alrabea A. E. Ishag[3] and Hathal M. Al Dhafer[3]

[1]*University of Ljubljana, Biotechnical Faculty, Department of Biology, Ljubljana, Slovenia*
[2]*Idrijska cesta 18e, Ajdovščina, Slovenia*
[3]*King Saud University Museum of Arthropods (KSMA), Department of Plant Protection, College of Food and Agriculture Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia*

During surveys in February and September 2022 focused on the butterfly fauna of the mountainous southwestern part of the Kingdom of Saudi Arabia, we unexpectedly discovered the alien species Western Pygmy Blue (*Brephidium exilis*) at two locations. These are the first records of this species in the southwestern part of the Arabian Peninsula, where its main range was previously restricted to the Arabian Gulf region. Adults were observed at atypical elevations and in forested areas. These findings indicate greater ecological plasticity of the species and possibly suggest its further dispersal into North Africa and the Mediterranean region. While long distance dispersal from Arabian gulf region seems the most reasonable origin, human introduction via transfer of host plants could not be excluded.

CORRESPONDENCE
Rudi Verovnik

EMAIL
rudi.verovnik@bf.uni-lj.si

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The alien species Western Pygmy Blue, *Brephidium exilis* (Boisduval), was first recorded in the Arabian Peninsula in 1995 in Sharjah, United Arab Emirates (Larsen 2000). It originates from North America, where it is widespread in the Sonoran dry zone of Mexico and the United States (Pyle 1981; Scott 1986). In the Arabian Peninsula, it was probably introduced as immature stages with plant cultivars imported from the U.S.A. (Pittaway et al. 2006). Similarly, it was accidentally introduced to Hawaii around 1979, where it became well established using introduced host plants (Jamieson and Denny 2001).

In its native range, the species is found primarily in lowlands and utilises coastal areas with halophytic vegetation, as well as ruderal sites such as roadsides, railroad tracks, disturbed sites, and undeveloped lands (Pyle 1981). Its preferred host plants are *Atriplex* spp., *Suaeda* spp., and *Salsola* spp. which thrive in such environments (Graves and Shapiro 2003), but a variety of other Amaranthaceae and Aizoaceae are also used (Saphiro 1973). Both *Atriplex* spp. and *Salsola* spp. (Amaranthaceae) have been recognised as host plants in the United Arab Emirates, followed by the discovery of *Zaleya pentandra* (L.) C. Jeffrey (Aizoaceae) as a host plant in northern Oman (Otto 2014).

Its known range in the Arabian Gulf includes: Qatar – Sabah Al Ahmad Sea City (Pope and Nithyanandan 2014); United Arab Emirates – Sharjah (Larsen 2000), Ajman, Al-Ain, Dubai, Das Island, Fujairah, Marawah Island (Gillett 2002; Feulner 2003); eastern Saudi Arabia – Dhahran, Al Qatif (Pittaway et al. 2006); northern Oman – Al Buraimi – Mahdah (Gillett 1999), Muscat, Qurm (Vis 2010), and Sohar (Otto 2014) (Figure 1). There are recent reports published on GBIF for Bahrain, Qatar, the Al Wusta region of Oman – near Mahout (de Vries and Lemmens 2022), Israel near the Dead Sea (Surkes 2021) and near Eilat (iNaturalist 2023a), and Egypt near Port Ghalib (iNaturalist 2023b). Except for Al-Ain and Mahdah, which are further inland, all Arabian observations are from coastal regions at low elevations. We present the first observations of the species from the south-western part of Saudi Arabia in different ecological settings and discuss possible routes of this expansion.

In 2022, we began targeted field surveys of the butterfly fauna of the south-western part of the Kingdom of Saudi Arabia, particularly in the provinces of Jizan and Asir. The region, as well as the whole country, is poorly studied in terms of butterfly fauna. The last review was published three decades ago (Pittaway 1986), but interesting new records and the description of a new subspecies *Spialia colotes torbenlarseni* Tshikolovets, 2022 (Tshikolovets 2022) have been added recently. The butterfly fauna of the region is exceptionally rich compared to other parts of the Arabian Peninsula, with 92 species reported in a review by Larsen (1984), lagging only behind the Yemen and Aden regions. Tshikolovets (2022) added six species, making the region the second most diverse in the Arabian Peninsula. This could be due to the great habitat diversity resulting from more regular rainfall and rugged terrain with a wide range of elevations.

Our first encounter of the Western Pygmy Blue (*B. exilis*) occurred on 19 September 2022 near Al-Baha in Khairah Forest Park north-west of the city in a deep, narrow valley at an elevation of 2130 m (Figure 1). The exact location (20.055833° N, 41.388056° E) is characterised by ruderal vegetation along the road and a dry stream, partially overgrown by dense brambles. There were numerous Grass Jewels, *Freyeria trochylus* (Freyer) at the micro-location, similar in size and coloration, making *B. exilis* difficult to identify in flight. A single male collected was thus identified after the conclusion of the field work, so we have no information on species abundance at this site.

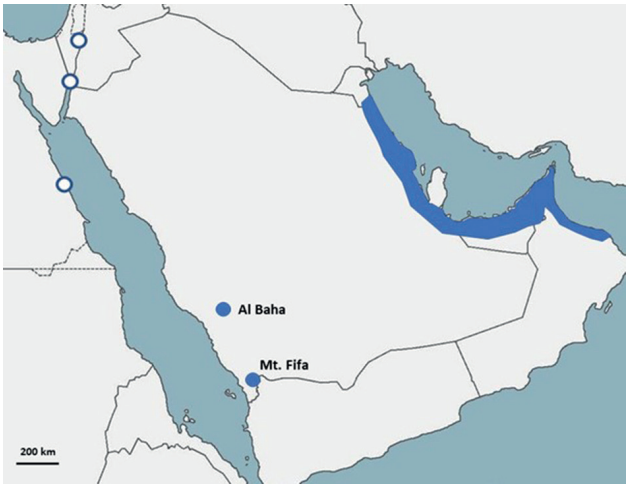

Figure 1. Distribution of the Western Pygmy Blue, ***Brephidium exilis*** (Boisduval, 1852), in the Arabian Peninsula based on published records and field observations in south-western Kingdom of Saudi Arabia. Open circles denote recent species observations accessed in GBIF.

The surrounding slopes are covered with dense juniper forest on steep, rocky, and stony slopes.

In the further course of our surveys, we checked many *F. trochylus* in order to find more sites for *B. exilis*. We surveyed a total of 80 locations during two field trips in 2022 (Table S1 in Supplementary Information), 19 locations in Tihamah area at lower altitudes and closer to the Red Sea where *B. exilis* might be expected, but no *B. exilis* was found. We found *B. exilis* again on 24 September 2022 (Figure 2) near the mountains on the southern slopes of Mount Fifa, about 350 km south of the first location (Figure 1). We investigated a well-wooded wadi (small valley with a dry riverbed) that had recently been cleared of trees in the lower reaches at approximately 400 m elevation

Figure 2. Underside of a male of the Western Pygmy Blue, ***Brephidium exilis*** (Boisduval, 1852), collected on southern slopes of Mt. Fifa on 24 September 2022.

(Figure 3). The exact site was again characterised by ruderal vegetation (17.204444° N, 43.068611° E) dominated by the Thorn Apple *Solanum incanum* L. (Solanaceae). There were also several prostrate plants at the micro-location that could belong to *Z. pentandra*, and the two males that were collected flew in their immediate vicinity. However, we did not take plant samples, so the determination will have to be verified in future surveys.

Apart from the great distance and predominantly inhospitable deserts that separate the new finds from the species known range in the Arabian Gulf (Pittaway et al. 2006), the most surprising feature of the new finds is the habitat in which they were observed. In particular, in the Arabian Peninsula, all records are from low elevations and near the sea in alkaline habitats dominated by the species' host plants (Pittaway et al. 2006; Otto 2014). At the first site we found *B. exilis* under very mesic conditions (for the Arabian Peninsula) in a forest – dominated habitat at high

Figure 3. Habitat on the southern slopes of Mt. Fifa where the Western Pygmy Blue, ***Brephidium exilis*** (Boisduval, 1852), was found on 24 September 2022.

altitude near the escarpment of the Asir Mountains, almost diametrically opposed to the Arabian Gulf habitats. This suggests a much greater ecological plasticity of the species. However, the species is known to be highly mobile despite its small size and can reach the south-eastern part of Oregon, southern Idaho and as far east as the prairies of Arkansas, Missouri, and Nebraska during its summer migrations, thus crossing the Cordillera at high altitudes (Pyle 1981). Also, as we visited the location only once, there is a possibility the population there is not permanent.

The two chance finds provide an important clue as to how these tiny blues appeared on the other side of the Arabian Peninsula. Both sites are quite remote, so that an introduction through the transport of host plants with larval stages is less likely, but cannot be excluded without host plant identification. Furthermore, no ornamental plants of the most commonly used host plant *Atriplex* spp. were found at the sites, which also speaks against this hypothesis. Therefore, we consider it more likely that *B. exilis* reached the western part of the peninsula through strong summer winds and weather fronts, as already suggested by Pittaway et al. (2006) as the most likely dispersal mechanism. This is a well-known mechanism used by many other desert species, most notably the Pioneer White *Belenois aurota* (Fabricius) (see Larsen 1982 for other taxa). This suggests that *B. exilis* is likely to become further established in the south-western Arabian Peninsula and spread towards North and East Africa and the Mediterranean. Recent records from northern Red Sea coasts in Egypt (Figure 1) and Israel corroborate this hypothesis, and could be part of the same expansion from the Arabian gulf. However, given that two of these records originate from the parklands in tourist facilities, these could also be attributed to separate anthropogenic introductions. Both climatic conditions and potential habitat are suitable, in particularly along the coasts of Red Sea and the Mediterranean in North Africa. Further surveys are needed to follow this potential dispersal and to elucidate the biology of the species at its new western edge of its range.

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AVAILABILITY OF DATA AND MATERIAL

The specimens are deposited in the collection of the King Saud University Museum of Arthropods (KSMA).

AUTHORS' CONTRIBUTIONS

RV, MK and HD were involved in designation of surveyed locations. RV, MK and AI have done the field surveys. RV wrote the manuscript. All authors read and approved the manuscript.

ORCID IDs

Rudi Verovnik – https://orcid.org/0000-0002-5841-5925
Hathal M. Al Dhafer – https://orcid.org/0000-0002-4911-2332

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