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NOTES ON GEOGRAPHIC DISTRIBUTION

First report of the darkling beetle, *Opatroides punctulatus* Brullé, 1832 (Coleoptera, Tenebrionidae) in Idaho, USA, an expanding adventive species in the Pacific Northwest

Armando Falcon-Brindis[1], Henry Trujillo[1], Jason Thomas[2]

1 *Department of Entomology, Plant Pathology, and Nematology, Parma Research and Extension Center, University of Idaho, Parma, Idaho, United States of America*
2 *Minidoka County Extension Office, Central District Extension, Rupert, Idaho, United States of America*

Corresponding author: *Armando Falcon-Brindis (afalconbrindis@uidaho.edu)*

Abstract. *Opatroides punctulatus* Brullé, 1832 is a detritivore tenebrionid beetle native to the Old World that was detected in the United States over 20 years ago. It is well adapted to Mediterranean climates between 30°N and 45°N, characterized by hot, dry summers and cool, wet winters. We confirm the presence of this species in southwest Idaho. This work expands its distribution range >500 km northeast from the previous report. *Opatroides punctulatus* could become a common pest and even displace native Tenebrionidae species.

Key words. Adventive species, Mediterranean-type climate, Opatrini, Treasure Valley, urban pest

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INTRODUCTION

The family Tenebrionidae, commonly known as darkling beetles, encompasses a diverse group of beetles with over 20,000 species distributed worldwide (Aalbu and Triplehorn 2002). Members of this family play key roles in the decomposition of organic matter and contribute to nutrient cycling in various ecosystems (Watt 1974). Within this family, the genus *Opatroides* Brullé, 1832 contains six described species primarily distributed in the Palearctic region, from the Mediterranean basin to North Africa, and parts of the Middle East (Ferrer 2005).

Opatroides punctulatus Brullé, 1832 was first described from Greek specimens. There are three subspecies spread across the Mediterranean basin (*O. punctulatus punctulatus* Brullé, 1832) southern Russia (*O. punctulatus subcylindricus* Ménétriés, 1849), Niger, Mauritania, and Sudan (*O. punctulatus lilligi* Ferrer, 2005). Compared to other *Opatroides* species, *O. punctulatus* has the widest distribution, including records across Europe, North Africa, and India (Ferrer 2005). However, this species (complex) requires integrative taxonomical revision, as the delimitation of subspecies still lacks DNA barcoding support. In this study, we treat *O. punctulatus* as its nominal form sensu Ferrer (2005).

Opatroides punctulatus is often found under leaf litter, wood, and rocks (Bousquet et al. 2018). Although it primarily feeds on plant materials, it can also include meat in its diet. Larvae develop in the soil, where they feed on roots, dead arthropods, and plant tissues. Pupae can be found several centimeters below the ground surface. In its native range (Israel), adults can live up to four months and produce 4–6 generations per year (Kaufmann 1969). In North America, *O. punctulatus* is adventive to California and Nevada (Aalbu et al. 2009; Steiner and Swearingen 2015).

Here, we provide the first report of *O. punctulatus* occurring in Idaho, which expands the known distribution range of this species in North America and raises questions about its establishment, potential threat to agriculture, and ecological impact in the region.

METHODS

The occurrence of *O. punctulatus* was recorded in three locations at the Boise foothills, in southwest Idaho at the westernmost portion of the Snake River Plains, also part of the Treasure Valley. This area belongs to the Malheur-Boise-King Hill Section, which is characterized by thick lacustrine and fluviatile sediments extensively interbedded with basalt flows. The major soil orders include Aridisols and Mollisols (Bockheim and Gennadiyev 2015). This region plays an important role in Idaho's agriculture and also sustains the largest urban areas

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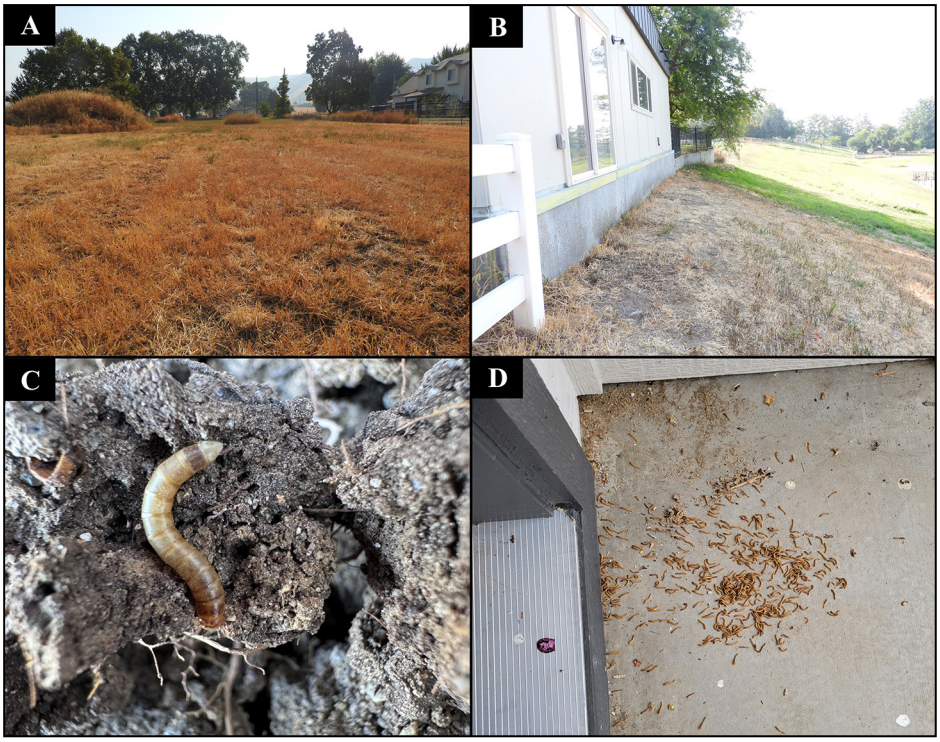

Figure 1. Sampling locations in Idaho. **A.** Emmett **B.** Eagle. **C.** Individual larva of *Opatroides punctulatus* found in the soil**. D.** Aggregation of larvae trying to enter the house.

within the entire state: Boise (236,634 people), Nampa (110,951), and Caldwell (65,920). The annual average precipitation is 29.7 cm, and average temperatures are 4.1 °C (minimum) and 17.8 °C (maximum). The elevation on the west side of the foothills ranges between 700 m and 800 m a.s.l. (US Census Bureau 2021; NOAA 2024).

In August of 2024 our team was contacted by two homeowners having issues with large numbers of beetles entering their homes; after observing images we visited the sites to collect data and specimens. One of the homeowners set seven sticky traps inside their house for three days, and thus we report the number of larvae and adults collected in those traps. The percentage of soil humidity and density of beetles per square foot were recorded in two locations (Emmett and Eagle). In both locations, homeowners were particularly concerned about the large number of larvae entering the households from the surrounding area (Figure 1). Both properties were surrounded by annual grasses and common herbaceous weeds such as *Lactuca serriola* L., *Chondrilla juncea* L., and even the exotic *Bassia scoparia* (L.) A. J. Scott.

In both locations, we dug eighteen 30 cm^2 holes around the houses and counted the number of beetles found within 15 cm depth. The sample distance from the house did not exceed 30 m. Nine samples were collected at each location (N = 18). Samples were randomly collected across three levels of soil moisture based on the grass cover, i.e., dry (0–5% of relative humidity), medium (5.1–10%), and humid (>10%). Such moisture transition is attributed to the irrigation pattern. Thus, dry grass areas have not been irrigated in at least 10 years, whereas green areas receive regular sprinkler irrigation by the homeowners.

We collected an equal number of samples in dry, intermediate, and moist areas around the properties. Three samples were collected in adjacent pasture fields (wheel-line irrigation), but we did not find specimens. Soil moisture levels were measured with a hygrometer (Delta-T Devices, M002803). We inspected inside the houses to see whether the beetles were causing any damage to the property. Given the large amounts of beetles entering the house, the homeowner in Emmett set seven sticky trap cards on the floor (10 cm × 20 cm each) for three days attempting to control the overwhelming number of larvae entering their house. The traps were spread throughout the house. We recorded the number of beetles from the traps. Data analysis and statistical tests were computed in R. v. 4.4.1 (R Core Team 2024). Maps were elaborated in QGIS v. 3.38.3. Pictures were taken with a Dino-Lite digital microscope model AF7915MZT and images were processed in Adobe Photoshop software.

RESULTS

***Opatroides punctulatus* Brullé, 1832**

Figure 2

New records. UNITED STATES – Idaho • Ada County, Starr; 43.6787°N, -116.4856°W, 753 m a.s.l.; 11.VI.2024; Tracey Johnson obs.; observed in larger numbers in alfalfa bales. • Ada County, Eagle; 43.7269°N, -116.3709°W, 802 m a.s.l.; 09.VII.2024; Armando Falcon-Brindis and Henry Trujillo leg.; collected manually from soil samples;

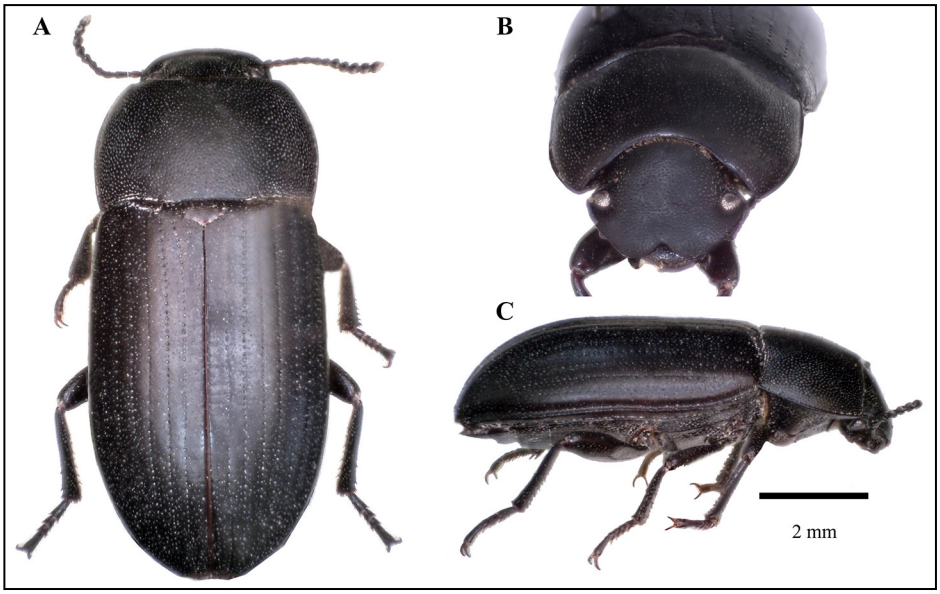

Figure 2. *Opatroides punctulatus*. **A.** Dorsal habitus. **B**. Frontal view. **C.** Lateral habitus.

6 ♀, 5 ♂, Parma Entomology Collection • Emmett, Gem County; 43.8768°N, -116.45407°W, 737 m a.s.l.; 18.VIII.2024; Armando Falcon-Brindis and Henry Trujillo leg.; collected manually from soil samples; 10 ♀, 4 ♂, Parma Entomology Collection (University of Idaho), Canyon County, Parma, Idaho.

The outbreak of *O. punctulatus* larvae was explosive in Emmett, and thus the homeowners vacuumed inside the house every 2 hours. They also called pest control twice, but there was nothing they could do. This issue persisted for about a month (between July and August 2024).

Adults, pupae, and larvae of *O. punctulatus* were found within the first 15 cm of the soil and were more abundant within the organic layer (0–6 cm) which concentrates plant root materials (Figure 3).

Figure 3. Soil profile showing the thick layer of root plant materials.

In total, we found 1,671 *O. punctulatus* beetles collected with sticky traps. Each trap contained 235 ± 52.1 larvae and ranged between 57 and 433 individuals (Table 1).

No beetle damage was found inside or outside the households. Larvae were observed in small cracks against concrete walls, foundations, and flooring, under mats, appliances, and practically underneath any suitable place to pupate. Larvae were able to access the households and garages through small openings and by climbing the internal wall spaces.

The number of beetles per soil sample (0.6 m^2) ranged between 1 and 17 individuals. The density of beetles was significantly different across the soil samples (F = 27.4, df = 2,15, p < 0.001). There was a negative correlation between the total number of beetles and the moisture levels (r = −0.41, df = 16, p = 0.05); thus, most beetles were found in the driest areas with moisture levels below 5%. No beetles were found in soil samples where moisture levels >10% (Figure 4).

Identification. The genus *Opatroides* =can be recognized by the division of the eyes by the epistomal canthus; the lack of pubescence; and a black body color, the epipleura ending before the apex of elytra, and the head is abruptly narrowing behind the eyes, forming a strong angle (Medvedev 1968; Aalbu et al. 2002). *Opatroides punctulatus* is recognized by its size (6–9.5 mm long), the laterally edged pronotum, blunt posterior angles, and fine and sparse punctuation, which becomes stronger and deeper towards the sides (Ferrer 2005).

DISCUSSION

This work expands the distribution range of *Opatroides punctulatus* over 500 km northeast from the previous report in the United States. This beetle species is established in 11 counties of California (Aalbu et al. 2009) and one county in Nevada (Steiner and Swearingen 2015) (Figure 5).

Table 1. Number of larva and adult beetles found per sticky trap. The traps were set for three days across a 150 m^2 house.

Sample	Larvae	Adults
1	284	3
2	381	4
3	202	2
4	181	1
5	110	4

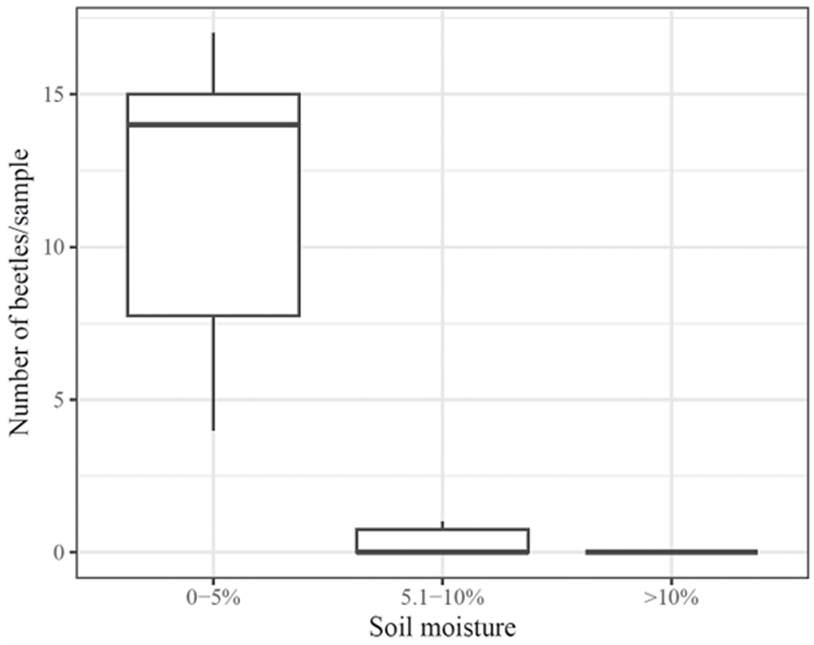

Figure 4. Number of beetles across different soil moisture levels. Black horizontal lines within the boxes indicate the median. Whiskers indicate the upper and lower quartiles.

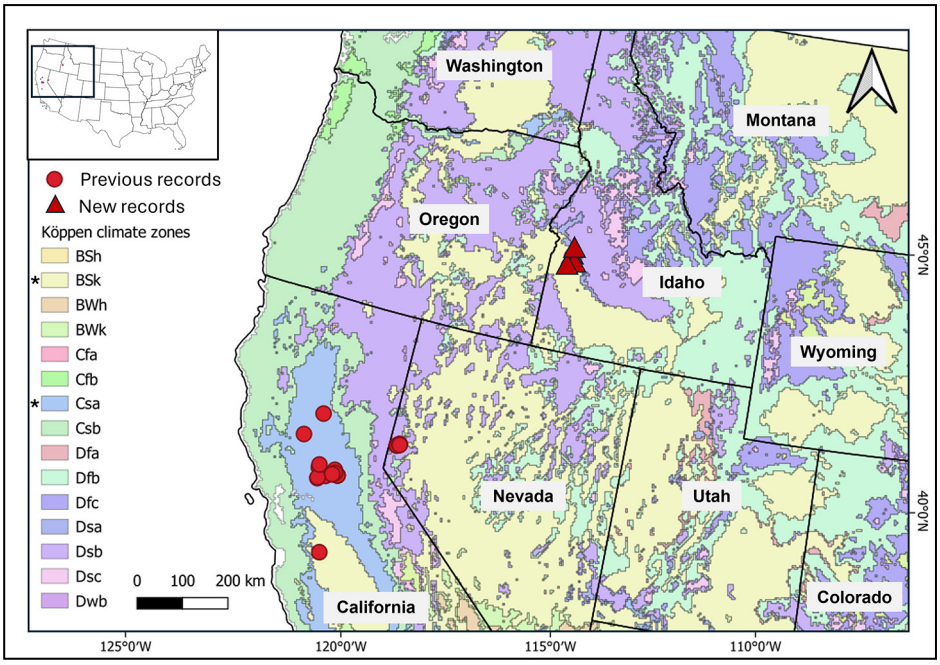

Figure 5. Occurrence records of *Opatroides punctulatus* in the United States. Köppen climate classification. *Climate types where *O. punctulatus* has been recorded. Arid (B), temperate (C), and continental (D) climate groups. Map at 1-km resolution (Beck et al. 2018).

Biological invasions in the United States cost approximately more than a billion dollars annually, where over 6,500 species have established in the country representing a threat to food security and native species (USGS 2024). Accidental introduction through commercial exchange of goods (usually plant materials) has historically been the main driver of insect invasions (Allendorf and Lundquist 2003). Although the arrival route of *O. punctulatus* in the United States has not been determined, the first observation in 2003 came from the surroundings of the Sacramento River, in northern California (Aalbu et al. 2009). In this regard, the association between the initial records and the Sacramento River Deep Water Ship Channel suggests a potential pathway to cargo ships to access the port of Sacramento from the San Francisco Bay area. The dispersion of this beetle into Idaho is not clear, but it might be attributed to agricultural trade, especially since many ranchers in the Treasure Valley buy hay to feed cattle mostly imported from California.

No previous research has reported the soil moisture levels where *O. punctulatus* was found. Aalbu et al. (2009) and Steiner and Swearingen (2015) attributed the presence of this species to high moisture levels in the soil. However, here we consistently found that this species is not found in areas with moisture levels >10%. It is important to interpret our moisture results with caution, as they were marginally significant (p = 0.05). Future research should consider a more extensive sampling including moisture data and the content of organic matter in the soil, as they could help to understand the micro-habitat requirements of this invasive species.

Interestingly, all occurrence records of *O. punctulatus* in the United States, including this study, come from urban areas. The findings provided by Steiner and Swearingen (2015) reinforce the fact that *O. punctulatus* is acting as a facultative opportunistic species, even associated with ant nests in disturbed habitats in Nevada. Moreover, the authors point out the fact that *O. punctulatus* is possibly displacing native tenebrionid beetles into the same habitats. Its potential as a pest in the United States has been highlighted by Aalbu et al. (2009) and Steiner and Swearingen (2015), suggesting that *O. punctulatus* could become a turf pest and a household nuisance. The present work supports the latter but also brings questions about its potential as a nuisance for alfalfa growers, as the first report came from an alfalfa field in Ada County. In its native range, this species can be a pest of cereals, cotton, grapes, melons, pumpkins, soybeans, and tobacco, all of which are also grown in the United States (Medvedev 1968; Kaufmann 1969; Sugonyaev 1994; NASS 2023). However, both economic and ecological impacts of *O. punctulatus* in non-native environments remain largely unexplored. Moreover, data to understand its potential distribution and responses to new habitat conditions, humidity, temperature, and climate are lacking.

Opatroides punctulatus naturally occurs in Mediterranean climates between 30 °N and 45 °N, characterized by hot, dry summers and cool, wet winters (Ferrer 2005). These conditions, also present across the Pacific Northwest, could have facilitated its establishment in the United States. Thus, finding *O. punctulatus* in Oregon and Washington would not be surprising since a large portion of those states is covered by Mediterranean climates. Similarly, most occurrence records in California correspond to a Hot-Summer Mediterranean Climate (Csa), and one is from a Cold-Semiarid Climate (BSk), which coincides with the climate subtype present in the occurrence locations of Nevada and Idaho (Figure 5). It is well known that climate change is an important jeopardy increasing the establishment of invasive species (Hellmann et al. 2008; Mainka and Howard 2010), especially since climate is the dominant factor driving species presence–absence (Thuiller et al. 2007). In this regard, changes in precipitation and temperature have a direct effect on both native and invasive insect species, facilitating the es-

tablishment of the latter under the right conditions (Finch et al. 2021). It would be worth looking into bioclimatic models helping to predict range expansion and shifts on *O. punctulatus* due to climate change.

The fact that homeowners can spend $100–$200 USD on pest control and cleaning tasks to get rid of this species is concerning and should be considered to conduct further research. We recommend gathering more occurrence data to create accurate distribution forecasting through ecological niche modeling in the Pacific Northwest, especially since this species could become a common pest in residential areas and crops such as cereals and hay.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: AF-B. Data curation: AF-B. Formal analysis: AF-B. Funding acquisition: AF-B. Investigation: AF-B, HT, JT. Methodology: AF-B, HT. Resources: AF-B. Supervision: AF-B. Visualization: AF-B. Project administration: AF-B. Software: AF-B. Validation: AF-B. Writing – original draft: AF-B. Writing – review and editing: AF-B, HT, JT.

Author ORCID IDs

Armando Falcon-Brindis https://orcid.org/0000-0003-2496-2178
Henry Trujillo https://orcid.org/0009-0007-9216-0181
Jason Thomas https://orcid.org/0000-0002-7170-7041

Data availability

All data that support the findings of this study are available in the main text.

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