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Prophysaon coeruleum Cockerell, 1890, blue-gray taildropper (Gastropoda: Arionidae): new distributional records and reproductive anatomy

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The genus *Prophysaon* is composed of 9 recognized species of slugs native to temperate forests of western North America (Turgeon et al. 1998). Differences in the anatomical characteristics of the distal genitalia have been used to identify 2 species groups (subgenera; Pilsbry 1948): *Mimetaurion*, which includes *P. vanattae, P. obscurum, P. fasciatum*, and *P. humile*; and *Prophysaon*, which includes the remaining species (*P. andersoni, P. boreale, P. coeruleum, P. dubium*, and *P. foliolatum*). The genus has a disjunct geographic distribution: most species occur along the Pacific Coast from southeastern Alaska to northern California, but a few are present in the Rocky Mountains of northern Idaho and western Montana (Smith 1943, Pilsbry 1948, Frest and Johannes 2000, Leonard et al. 2003). One species (*P. humile*) is restricted to the Rocky Mountains portion of the distribution.

*Prophysaon coeruleum* Cockerell (1890) is a small, poorly known slug of conservation interest with previously known range from western Washington to northwestern California (Pilsbry 1948, Kelley et al. 1999). The species has been designated as a “survey and manage” species under the Northwest Forest Plan (USDA Forest Service and USDI Bureau of Land Management 1994) due to its close association with older forests, few known localities, and lack of information on its natural history and ecology (McGraw et al. 2002). Considerable geographical variation is present in Oregon, and the name *P. coeruleum* may apply to a species complex (Kelley et al. 1999). Herein we report on previously unknown populations of *P. coeruleum* from southwestern British Columbia and northern Idaho.

We collected *P. coeruleum* during surveys for terrestrial gastropods on Vancouver Island, British Columbia, Canada, and in Washington and northern Idaho, United States. On Vancouver Island we carried out time- and area-constrained surveys along 100-m-long and 1-m-wide transects in different forested habitats at 3 sites near Victoria (56 transects searched for a total of 72 person-hours) in March and in October–November 2002. In northern Idaho we visually searched approximately 30 sites for a total of ca. 200 person-hours between April and October from 1999 to 2002. In Washington we conducted surveys on approximately 300 sites in the eastern Cascade Mountains and on >130 sites between the Cascade Crest and the Pacific Ocean. In addition, one of us (TB) had access to the results of hundreds of surveys conducted for “survey and manage” mollusks by the U.S. Forest Service on National Forests within those areas.

To confirm identification, we examined the reproductive system of the specimens with a stereo-zoom microscope under 7.5–60X magnification (one specimen from site 2; two specimens from site 3 in Appendix). Specimens

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**Key words:** Prophysaon coeruleum, distribution, phylogeography, reproductive anatomy, British Columbia, Idaho, Pacific Northwest, Rocky Mountains, Washington.
were deposited in collections at the Carnegie Museum (CM), at the Royal British Columbia Museum (RBCM), and in the personal collection of T. Burke. Some specimens were sent to Dr. Thomas Wilke at George Washington University to be included in a genetic study.

In British Columbia we found *P. coeruleum* along 2 of the 56 transects searched. These localities were about 500 m apart on Rocky Point Peninsula in the District of Metchosin, about 20 km southwest of Victoria on Vancouver Island (records 1–2 in Appendix). These records extend the known distribution of the species approximately 120 km northwest from Washington State and represent the 1st records from Canada (Fig. 1). Since 1999, two of us (KO and LS) have carried out surveys for forest-dwelling gastropods throughout Vancouver Island and on the southern coastal mainland of British Columbia without locating this species (about 170 sites surveyed, some intensively over several years). The species appears to have a very restricted distribution in Canada.

In Idaho we found *P. coeruleum* at 2 of approximately 30 sites surveyed. The 2 sites were about 30 km apart in the Coeur d’Alene Lake watershed. These observations extend the species’ known range approximately 400 km eastward and represent the 1st records for the Rocky Mountains (Fig. 1). Apparently, the population in Idaho is disjunct from the more western populations, as the intervening Columbia Basin consists of arid shrub-steppe habitat unsuitable for forest-dwelling gastropods (Barnosky et al. 1987, Franklin and Dyrness 1988).

Brunsfeld et al. (2001) and Layser (1980) provided numerous examples of fungi, plants, and animals that have Pacific coastal and interior Rocky Mountain distributions, which mirror the distribution of western hemlock forest. Leonard et al. (2003) reported on a previously undocumented example of the slug *Prophysaon*...
dubium, Cockerell, from Idaho and cited additional examples of invertebrates that have similar disjunct distribution patterns.

In Washington we found *P. coeruleum* at 2 sites in the Cispus River watershed and at 1 site on Pin Creek, a tributary to the lower Columbia River. The slugs appeared to be most abundant at the Kraus Ridge site in the Cispus watershed (record 5 in Appendix; 11 detections). One of us (TB) has found *P. coeruleum* at this site on several previous occasions. The Iron Creek site (record 6 in Appendix) is about 4 km southwest of the Kraus Ridge site and on the opposite side of the Cispus River. In several visits we have found only a single specimen of *P. coeruleum* at this site. There is a 3rd site in this area, approximately 7 km northeast of the Kraus Ridge site at 442 m elevation, from which a single *P. coeruleum* was collected on 14 November 2001. The specimen was identified by Tom Kogut, Cowlitz Ranger District biologist, but was not collected (T. Kogut personal communication). The species appears to have a very restricted distribution in Washington.

Surveys by the U.S. Forest Service and U.S. Bureau of Land Management found no additional sites in Washington but found several localities for the species in western Oregon and also extended its range into northern California. However, because similar, undescribed species have also been found in the southern Oregon Cascades (Kelley et al. 1999, USDA Forest Service and USDI BLM 2000, Nancy Duncan personal communication), there is some question whether the California specimens indeed belong to this species.

All sites with *P. coeruleum* were in moist forest stands with a deciduous component of bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera*), or in 1 case quaking aspen (*Populus tremuloides*; Appendix). One site was in an old-growth stand (Krause Ridge); the remaining sites were in 2nd-growth stands. Sword ferns (*Polystichum munitum*), indicating moist conditions, were typically present. The sites ranged from near sea level to about 650 m in elevation (Appendix). This species is thought to be associated with older forests and moist plant communities (Kelley et al. 1999). Although not restricted to old-growth forests, it appears to require old-growth attributes, such as abundant coarse woody debris and moist forest floor conditions.

Externally, our specimens conform to the description in Pilsbry (1948): live animals were gray with light blue flecking, the prominence of which varied among localities. On all of the specimens distinct, longitudinal grooves were present on the foot behind the mantle, and the foot margin was narrow with a distinct border above (Fig. 2). The extended length of the specimens ranged between 23 mm and 30 mm when alive and 12.5 mm and 15 mm after preservation.

The genitalia of the new specimens from Idaho and British Columbia resemble those of *P. coeruleum* from Washington illustrated by Pilsbry (1948; Figure 378d), except that the penis is much larger; in 1 of the 2 Idaho specimens it is almost as large as the muscular portion of the epiphallus (Fig. 3). Most of the long, slender portion of the epiphallus is in a tangle immediately anterior to the muscular portion. The ovotestis is large and consists of approximately 24 egg-shaped lobules, with little pigment. The albumen gland is a small, appendix-like structure at the terminus of the common duct; it is not clearly demarcated from the common duct either by color or texture, at least in the preserved animals. The duct of the seminal receptacle is very long and slender and loosely adherent to the common duct. The vagina is slender and long, as is the entire common duct.

Interestingly, the genitalia of the new specimens resemble Pilsbry's (1948) Figure 376c of *P. boreale* from Oregon. However, his brief description of the external morphology does not match these specimens. Pilsbry (1948) noted much individual variation in the shape and size of the bulbous muscular portion of the epiphallus of *P. coeruleum*. Kelley et al. (1999) suggested that, as currently used, the name *P. coeruleum* might apply to a species complex, particularly in Oregon where much variation exists among specimens from different localities. A forthcoming molecular study of *P. coeruleum* (T. Wilkie personal communication), including specimens from across the species range, will provide important information regarding whether the taxa represents a polyphyletic group and will be critically important for developing meaningful conservation planning strategies.

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Fig. 2. Specimens of Prophysaon coeruleum: A, Vancouver Island, British Columbia (locality 1); B, Kootenai County, Idaho (locality 4); C, Cowlitz County, Washington (locality 7); bar = ca. 5 mm.
Fig. 3. Reproductive system of Prophysaon coeruleum from Idaho (CM 64922; locality 3 in Appendix): EP = epiphallus, MB = muscular body of epiphallus, OVTES = ovotestis, PE = penis, SPOV = spermoviduct, SR = seminal receptacle, VA = vagina, VD = vas deferens.

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APPENDIX. Localities for *Prophysaon coeruleum* examined for this study: CM = Carnegie Museum; RBCM = Royal British Columbia Museum; TEB = personal collection of Thomas E. Burke.

1. Rocky Point, Vancouver Island, British Columbia, Canada; elevation <50 m above sea level (asl); 48°20.77′N, 123°34.12′W; ca. 80-year-old stand of bigleaf maple (*Acer macrophyllum*) and Douglas-fir (*Pseudotsuga menziesii*) with sword fern (*Polystichum munitum*) understory; 28 October 2002 (1 specimen collected by K. Ovaska and L. Sopuk): RBCM 003-102-001.

2. Rocky Point, Vancouver Island, British Columbia, Canada; elevation <50 m asl; 48°20.44′N, 123°34.04′W; ca. 70-year-old stand of quaking aspen (*Populus tremuloides*) with sword fern understory at the edge of small wetland adjacent to a large, old coniferous stand; 18 November 2002 (5 specimens collected by L. Sopuck and K. Ovaska): RBCM 003-103-001 (1 specimen); 1 specimen donated for genetic studies by Dr. T. Wilke, George Washington University, Washington, DC, USA; 2 specimens kept alive in the author’s collection.


4. Beauty Creek, Kootenai County, Idaho, USA; elevation 650 m asl; 47°35.65′N, 116°39.0′W; ca. 60-year-old stand of western redcedar (*Thuja plicata*) and black cottonwood with an understory of red-osier dogwood (*Cornus stolonifera*), vine maple (*Acer circinatum*), and pacific yew (*Taxus brevifolia*); 21 April 2002 (1 specimen collected by W. Leonard, T. Burke, and J. Baugh): TEB 02-050.

5. Kraus Ridge, Gifford Pinchot National Forest, Lewis County, Washington, USA; elevation 460 m asl; 46°25.98′N, 121°58.3′W; over 250-year-old stand of western hemlock, Douglas-fir, and bigleaf maple with sword fern understory; 22 June 1995 (1 specimen recorded by T. Burke); 26 September 1996 (2 specimens recorded by T. Burke); 29 May 1996 (2 specimens recorded by T. Burke); 13 November 1997 (5 specimens recorded by T. Burke); 13 December 2002 (1 specimen collected by W. Leonard and T. Burke): sent to Dr. Thomas Wilkie at George Washington University for genetic studies.

6. Iron Creek, Gifford Pinchot National Forest, Lewis County, Washington, USA; elevation 350 m asl; 46°25.55′N, 121°59.03′W; 2nd-growth stand of western hemlock, Douglas-fir, and bigleaf maple with sword fern understory; 7 October 1998 (1 specimen recorded by T. Burke).

7. Tributary to Pin Creek, 0.8 km east of Carrolls, Cowlitz County, Washington; elevation 80 m asl; 46°04.58′N, 122°50.93′W; ca. 50-year-old stand of bigleaf maple, western redcedar, and bitter cherry (*Prunus emarginata*) with sword fern understory; 7 March 2003 (1 specimen collected by W. Leonard): CM 64963.