Grylloblatta campodeiformis (Grylloblattodea: Grylloblattidae) uses saproxylic habitats in subalpine forests of western Alberta, Canada: implications for conservation

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Abstract—*Grylloblatta campodeiformis campodeiformis* Walker (Grylloblattodea: Grylloblattidae) was commonly collected during summer from trees killed by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae), in subalpine forests of Alberta, Canada. Gut content analysis revealed that the grylloblattids fed on subcortical invertebrates. This newly reported habitat association shows that this species is not limited to strictly alpine habitats and glacial margins, and thus may be more widespread and common than suggested by earlier reports.

Grylloblatta campodeiformis Walker (Grylloblattodea: Grylloblattidae), the northern rock crawler, is an elusive and poorly studied species that is the emblem of the Entomological Society of Canada. The species has a disjunct distribution. The nominate subspecies is known from a few localities from the Cascades to the Rocky Mountain ranges of British Columbia and Alberta, Canada and Montana, United States of America, but two other subspecies, *G. campodeiformis athapaska* Kamp and *G. campodeiformis nahanni* Kamp are known only from northern British Columbia (Schoville and Graening 2013).

Populations of *G. campodeiformis* inhabit alpine and subalpine hypolithic habitats, comprised of underground cavities and narrow spaces between the stones mixed within the soil (Kamp 1973). This hypolithion habitat is discontinuous and present only on stable slopes with sufficient soil to support a subsurface biota, and is frequently bordered by unconsolidated talus that rock crawlers only use in a transient manner (Kamp 1973). *Grylloblatta* Walker also inhabits snowfields, the bases of rockslides, glacial springs, caves (particularly lava tubes) at low elevations, and can be found occasionally beneath rotting logs (Walker 1914; Ford 1926; Hearle 1927; Kamp 1973; Mann *et al*. 1980). Rock crawlers are nocturnal predators and scavengers that actively search for small, invertebrate prey in the hypolithion (Pritchard and Scholefield 1978). They also venture onto snowfields, foraging for “insect-fallout” carried and deposited there by wind (Mann *et al.* 1980).

The distribution and activity of *G. campodeiformis* are determined by unusual but highly specific requirements for temperature (optimal: 0–3 °C; tolerable extremes: −6 °C to 20 °C) and humidity (70–90%) (Mills and Pepper 1937; Kamp 1973). Environmental extremes of the alpine environment are likely ameliorated in the hypolithion by the snowpack; however, in the spring and fall, when cooler surface temperatures generally prevail elsewhere, *G. campodeiformis* is more likely to be observed away from the hypolithion. Late summer and early fall is the most challenging time for this species, because conditions can be warm and dry, in the absence of large snowpacks (Kamp 1973; Huggard and Klenner 2003; Schoville and Graening 2013).

Here we report the capture of *G. campodeiformis campodeiformis* from new localities and habitats, document the gut contents of some individuals, and discuss the implications of new information

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for the ecology and conservation status of the species.

We unexpectedly collected numerous *G. campodeiformis campodeiformis* while surveying the saproxylic insect fauna associated with pines killed by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae), in whitebark pine, *Pinus albicaulis* Engelmann (Pinaceae), and lodgepole pine, *Pinus contorta* var. *latifolia* Engelmann, in lower subalpine forests in western Alberta. The two northernmost sites were in Willmore Wilderness: Featherstonehaugh (53.790°N, 119.761°W; 1550–1650 m; south aspect) and Deveber Creek (53.725°N, 119.548°W; 1500–1550 m; south aspect); the two southernmost sites were north of Crowsnest Pass: Gould Dome Mountain (49.914°N, 114.648°W; 1920–2060 m; west aspect) and Dutch Creek (49.851°N, 114.622°W; 1890–1930 m; north aspect). All sites had closed canopies of mature Engelmann spruce, *Picea engelmannii* Perry *ex* Engelmann (Pinaceae), subalpine fir, *Abies lasiocarpa* (Hooker) Nuttall (Pinaceae), *P. albicaulis*, and *P. contorta*.

Two trap types were used at each site to sample saproxylic assemblages inhabiting standing, dead whitebark and lodgepole pines (snags) killed by the mountain pine beetle one to four years previously (Esch *et al.* 2016). Flight intercept traps, consisting of a cloth funnel and ethylene glycol-filled collecting jar hanging below a 20-cm by 30-cm sheet of Plexiglas, were attached perpendicularly to tree boles, 1.3 m above ground (see Kaila 1993 for illustration). Emergence traps consisted of a sleeve of 0.5 mm insect screen enclosing a 1-m section of bole (centred at 1.3 m) and fastened to the bole at both ends with wire and staples, and foam was used to seal any gaps and prevent arthropods from entering the trap via the bole surface (see Esch *et al.* 2016 for detailed description and photograph). The screen at the bottom of each trap was shaped into funnel to direct emerging insects into an ethylene glycol-filled collecting jar attached to the lower point of the screen funnel. In total, 12–24 traps were installed on trees of each pine species at each site, in various combinations of trap type and snag age (time since death). In total, 84 snags were sampled. Traps remained attached to snags for 9–12 months. Accumulated trap captures were collected every two to three weeks from July to September 2008 and again on 24 July 2009 at northern sites, and from August to late September 2009 and again on 16 May 2010 at southern sites.

A total of 34 nymphal and adult rock crawlers were trapped over all sites, and all are new locality records for this species. Furthermore, the Wilmore Wilderness collections represent new northernmost records of *G. campodeiformis campodeiformis*. Rock crawlers were rather common, present in 13–20% of sampled trees at each site. About 90% of specimens were collected in emergence traps, and the remainder in flight intercept traps. Usually one or two specimens were collected per tree, but four specimens were collected from one tree and 14, mostly nymphs, from another. Most (88%) of the specimens were collected during winter through early summer at both sites. No specimens were collected in the Crowsnest Pass before winter, but in Willmore Wilderness four specimens were collected in the first half of September 2008. Altogether, 23%, 69%, and 8% of specimens were collected in one to two, two to three, and three to four-year-old snags, respectively. In all, 21 specimens were collected from lodgepole pines (11% of trees sampled) and 13 from whitebark pines (18% of trees). Voucher specimens are deposited in the arthropod collection of the Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta, Canada.

In a separate earlier study, two authors (D.W.L. and J.R.S.) collected a single *G. campodeiformis campodeiformis* adult in a forested site near Hinton, Alberta (53.199°N, 117.525°W, 1400 m) in June 1989 using a pitfall trap. The site was located in the foothills, ~5 km from the nearest alpine habitat, and had been clear-cut 10 years earlier study. The site was dominated by regenerating *P. contorta* and contained an abundance of small diameter, dry logging slash. From 1989 to 1993 and again in 2005, hundreds of pitfall traps were deployed in this general area from May to September, but no other grylloblattids were captured.

Although rock crawlers have occasionally been found under logs (Mills and Pepper 1937; Kamp 1973), the presence of many individuals under the bark of snags is the first known record of *Grylloblatta* using deadwood habitats. Examination of the gut contents (cuticle fragments) of four adult females and six nymphs of *G. campodeiformis campodeiformis* revealed that they were feeding on saproxylic

Araneae, Acari, Collembola, and Coleoptera, including Cantharidae, the striped ambrosia beetle, *Trypodendron lineatum* Oliver (Curculionidae), and other Curculionidae. No plant material was present in the guts. Bark and ambrosia beetles (Curculionidae: Scolytinae) were by far the most abundant insects collected in traps. Interestingly, flightless winter craneflys, *Chionea* Dalman (Diptera: Tipulidae), one of the most common known prey items of *G. campodeiformis campodeiformis* (Pritchard and Scholefield 1978), were also collected in some emergence traps.

Assemblages of saproxylic invertebrates are abundant and diverse but also may be temporally and spatially ephemeral (Langor *et al*. 2008). Snags killed by mountain pine beetle were relatively rare and dispersed throughout the sites. The high occupancy rate of snags by rock crawlers indicates they are either relatively abundant or are capable of travelling long distances and orienting to isolated snags; the latter seems unlikely given their flightlessness and apparent low vagility. However, the antennae of *G. campodeifromis* have many olfactory sensilla (Pritchard and Scholefield 1978) so grylloblattids may be able to detect odours associated with snags as being indicative of good foraging sites.

Our findings show that *G. campodeifromis campodeifromis* populations are not limited to edges of alpine snowfields and glaciers as generally reported. In fact, we believe that this notion is based on an incomplete understanding of rock crawler natural history. We propose instead that *G. campodeifromis campodeiformis* is relatively common in high elevation forests within its range. These populations are likely not constrained to habitat patches 300–1000 m in diameter, as previously suggested (Kamp 1979). Hypolithic habitat suitable for rock crawlers is apparently abundant below the forest line in much of the northern Rocky Mountains. It is possible that rockslides frequently connect alpine and lower elevation forest habitats or act as local retreats when surface temperature and humidity are unfavourable. Nonetheless, our data show that these grylloblattids can persist in forests of both mountains and foothills that are spatially remote from alpine habitats. This corroborates the findings of Huggard and Klenner (2003), who report *G. campodeiformis* as commonly collected in pitfall traps in subalpine and temperate forests in southern British Columbia.

Schoville and Graening (2013) classified *G. campodeiformis* as "near threatened" (International Union for Conservation of Nature 2012), although they recognised the general dearth of knowledge of range limits and local population sizes. This species was previously known from ~ 50 localities and, although some of these populations are likely endemic to their respective peaks, our findings suggest that an abundance of suitable and potentially occupied habitat exists below and between such peaks. Our data suggests a need for a more thorough study of the distribution of *G. campodeiformis campodeiformis*, but also that in the meantime the International Union for Conservation of Nature listing for this species might better be lowered to *least concern*.

It has been previously suggested that populations of *G. campodeiformis campodeiformis* are likely not as rare on the landscape as is commonly assumed (Hearle 1927; Kamp 1973), and our data support this conclusion. We suggest that the relative rarity of this species and its congeners in collections can be explained by the fact that rock crawler habitats are difficult to access, that surface activity is nocturnal, and that grylloblatids retreat into the hypolithion to escape warm, dry conditions (*i.e.*, weather conducive to insect collecting). Furthermore, as we have discovered, they use the high-altitude subcortical environment, which is at least as poorly sampled as is the hypolithion. Thus, we encourage collectors to spend more time searching deadwood habitats in future quests to find these enigmatic insects.

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