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Two lost undescribed ice crawler species from the Pacific Northwest—*Grylloblatta* "*olympica*" and *G.* "*vancouverensis*", species incognitus (Insecta, Notoptera, Grylloblattidae)

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Introduction

> *…close observation of small things can open intellectual windows with wide views.*
>
> —Larry Slobodkin (2003, pg 29)

Species of the genus *Grylloblatta* (Insecta, Notoptera, Grylloblattidae) (Fig 1) have a restricted geographic distribution limited to northwest North America. They are all flightless ground-inhabiting species usually found in close association with caves, lava tubes, talus fields, cloud forests, cirque basins, bluffs of river gorges and other steep topographic breaks that provide cool shaded habitat with an abundance of colluvial-rock material on the surface, in montane and foothill regions. Many of the species can be found at high elevation in subalpine and alpine zones where they are associated with periglacial, permanent snowfields and other nival habitats that experience deep annual snowfalls (Fig 2). In these locales they are often found actively foraging at night for wind-blown (aeolian) debris deposited on snowfields (Papp, 1978; Edwards, 1987), a rich source of energy and nutrients in low productivity landscapes (Edwards & Banko, 1976), hence their name ice crawlers. The lower-elevation range of grylloblattids is poorly understood because the geographic distribution of the populations is very patchy, and few entomologists collect in winter months during their primary surface-active season. On the west slope of the Cascade Mtns. in central Washington they can be found from about 305–2770 m (1000–9000 ft) elevation, and in California's southern Sierra Range as high as 3960 m (13000 ft). The lowest reported site in the Rocky Mtns. is in Idaho near Helmer (Latah Co.) at about 850 m (2800 ft) (Fig 9). These low elevation records are from areas with low snowfall and moderate winter temperatures. Although grylloblattids may be carnivorous when conditions allow (e.g. ice worms, Enchytraeidae, *Mesenchytraeus*), they may be better described as opportunistic omnivores, scavenging for dead insects, and even

Fig 1: *Grylloblatta campodeiformis*, adult female. Photo courtesy of Henri Goulet (Canadian National Collection, Ottawa).

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consuming plant material, possibly pollen, algae or fungi (e.g. snow mold), at certain times and places when necessary. Many of their habitats have very low annual productivity, and the life span of an individual is suspected to be quite long for an insect (5–10 yrs). The adults of most of the species are fairly large for an insect (females can be about 30 mm total body length), and not hard to see when encountered.

Grylloblattids are rare in collections, probably because they are often hard to find even at locales where they are known to occur, and many populations are most active on the soil surface in the cold season between October and April, when few entomologists are active in the field. Although known populations are patchily distributed on the landscape, and individuals have low dispersal power, they are probably much more widespread and common than current collection records suggest. Winter surveys, both hand collecting and pitfall trapping, will greatly aid our understanding of these secretive insects, including published reports of surveys specifically for them by experienced collectors that result in no records. One objective of this report is to provide a brief overview of *Grylloblatta* diversity, and life cycle and habitat characteristics as a source of encouragement for entomologists to look for and collect them at all months of the year, especially in new areas where they are suspected to occur, and using methods that preserve specimens suitable for DNA analysis. Two of the most exciting tasks for field entomologists is prospecting for new species or attempting to recollect extremely rare or lost species, such as the two species incognitus highlighted here.

Species names in quotes in this report refer to populations of unknown identity, which may be undescribed species (or subspecies). Reference to them as species in this report is premature.

Fig 2: *Grylloblatta campodeiformis* alpine cirque habitat, Valley of the Lakes, Crystalline Creek, Vowell River, Purcell Mtns., Parson, BC, 05 Aug 2001. Photo by James Bergdahl.

Fig 3: Classic grylloblattid habitat in the eastern ranges of the Olympic Mtns., Washington, 23 Aug 1992. This is also the domain of the narrowly endemic flightless carabid beetles *Nebria kincaidi* Schwartz, *N. danmanni* Kavanuagh, and *Scaphinotus johnsoni* Van Dyke. Photo by James Bergdahl.

Classification, Systematics, and Diversity

Class Insecta
Order Notoptera Crampton, 1915
Suborder Grylloblattodea Brues & Melander, 1915
Family Grylloblattidae Walker, 1914
Genus *Grylloblatta* Walker, 1914

In 1914 E.M. Walker formally described the world's first grylloblattid species from two adult specimens he and T.B. Kurata collected at about 2000 m (6500 ft) in Banff National Park (Alberta, Canada) on 29 June 1913*. Walker erected a new family, Grylloblattidae, for the species (*Grylloblatta campodeiformis* Walker, 1914), and placed it in the order Orthoptera. The species is so unique morphologically, Crampton (1915) promptly proposed placement of the taxon within its own order, Notoptera, and then subsequently published many papers (1917–1935) relocating the genus on many branches of the phylogenetic tree of early insects, including a debate with Walker on the subject. Over the years a close evolutionary relationship between grylloblattids and Orthoptera, Dermaptera, Phasmida, Blattaria, and Plecoptera has been suggested, however recent analysis of molecular and morphological data indicate they are most closely related to the recently-described equally-enigmatic Mantophasmatodea (Klass et al., 2002; Terry & Whiting, 2005). Arillo & Engel (2006) subsequently combined the two groups as suborders within Notoptera. Mantophasmatidae now includes 16 extant described predaceous species in 10 genera found in western South Africa, Namibia, and Tanzania, and three extinct (fossil) genera (some from Baltic amber) (Wipfler et al., 2012). Like grylloblattids, extant mantophasmatids are unique among other closely related taxa in being apterous (flightless), and in having no ocelli (simple eyes; Grimaldi & Engel, 2005).

Notoptera is clearly a very ancient group—the earliest Grylloblattodea date back to the beginning of the Late Carbonifer-

*Vickery (1998) reports the world's first grylloblattid ever collected is actually in the Lyman Entomological Museum (McGill University, Ste-Anne-de-Bellevue, Quebec, Canada) and was taken at Ground Hog Basin, Selkirk Mtns., British Columbia, Canada, 6000 ft (1829 m), 22 July–07 August, 1905. This alpine cirque is perched on the north side of the lower Goldstream River basin, between the towns of Revelstoke and Mica Creek, in the North Selkirk Mtns. near the Big Bend of the upper Columbia River. Vickery (1998) implies that the editor(s) of Vickery & Kevan (1986) for some unstated reason removed this important record from their manuscript.

Fig 4: Looking west down Deception Creek/Dosewallips drainage, eastern Olympic Mtns., Brinnon, Washington, 20 Sep 1998. Photo by James Bergdahl.

Fig 5: There are few glaciers on Vancouver Island today, however there are many massifs with many permanent snowfields, such as on the north side of Mt. Able, Island Range, near Woss, Vancouver Island, British Columbia, 01 Sep 1997. Photo by James Bergdahl.

ous (Paleozoic era). Forty-four (44) families have been described from the fossil record, however Vickery (1998) questions if all of these should be classified as members of Grylloblattodea. Andre Nel (Museum National d'Histoire Naturelle, Paris, France; pers. comm.) confirms the group is presently a polyphyletic "melting pot" based on plesiomorphies (primitive characters), not synapomorphies (derived characters). Many of the fossil species are based on descriptions of flight wings. Fossils indicate notopterans experienced a spectacular radiation in the Permian (about 280 million year ago) before the breakup of Pangaea. In the Late Permian the "largest single extinction event the Earth has witnessed to date" unfolded (MacLeod, 2013) and most of these families went extinct by the Early Triassic (about 240 million years ago; Aristov et al., 2013). My personal observations of the ecology and behavior of grylloblattids in the field reminds me of diplurans, some of the most ancient "insects" regularly seen in the Pacific Northwest.

Given the age of the group it is difficult to speculate on their ancient history in the Pacific Northwest. It is possible *Grylloblatta* has descended from a lineage that has been resident in the Rockymontania (=Laramidia, or West America) region since the break up of Pangaea. The other likely scenario is that they colonized western North America from their modern center of diversity in eastern Asia (e.g. Russia) via a land bridge that connected Asia and western North America in the Bering Sea region (Beringia), forming the continent Asiamerica. This land bridge was intact over many millions of years during the Tertiary when it had a temperate or boreal climate, and during the Pleistocene when it was covered with arctic tundra/steppe. The geographic distribution of many insect taxa with amphi-Pacifiic distributions across the North Pacific region today is probably a product of intercontinental dispersal across Beringia when Asiamerica was intact. Rafting of grylloblattids across the North Pacific is another option (e.g. Schoville et al., 2013). Although this may seem much less probable, large pieces of floating debris launched during the huge Japanese tsunami of March 2011 ended up on beaches in the Pacific Northwest about 8 months after this massive offshore earthquake event.

Grylloblattidae now includes 28 described extant species placed in five genera:

Northeast Asia

Galloisiana (11 species—Japan, South Korea, North Korea, China, Russia)
Grylloblattina (1 species—Russia, Maritime Provinces)
Grylloblattella (2 species—Russia, Siberia: Altai and Sayan Mtns.)
Namkungia (1 species—South Korea)

North America

Grylloblatta (13 species—USA: California, Oregon, Washington, Idaho, Montana, Wyoming; Canada: British Columbia, Alberta).

Publications on *Grylloblatta* species-level taxonomy experienced a long lasting doldrum from 1980 to 2006, due in part to the death of J.W. (Bill) Kamp (University of British Columbia) in the early 1980s. Kamp had many of the *Grylloblatta* specimens available at the time in his possession, including some important "types", many of which have never been recovered and are now considered permanently lost. According to Geoff Scudder, the entire *Grylloblatta* collection at the University of British Columbia was lost at that time (Karen Needham, UBC Spencer Museum, pers. comm., 01 December 2013).

A comparative molecular (DNA) analysis of many Asian and North American grylloblattid species by Jarvis & Whiting (2006) provides evidence that *Grylloblatta* is monophyletic, and sister to the Russian genus *Grylloblattina*. Schoville & Graening (2013) recently reviewed the distribution and conservation status of the 13 described species of *Grylloblatta*. They also provide collection records for at least 16 additional *Grylloblatta* populations of uncertain status from western North America that are in need of formal description. Many of these populations are known from very few records from isolated mountain ranges and may represent undescribed species. The regional occurrence of the described

Grylloblatta species is as follows: California (8 species), Oregon (3), Washington (2), Idaho (1), Montana (1), Wyoming (1), British Columbia (2) and Alberta (1). Schoville & Graening's (2013) survey suggests the California Sierra has the most undescribed taxa, but they are also represented in most of the other states and British Columbia. The widespread species *Grylloblatta campodeiformis*, which ranges in the Rocky Mtns. between Yellowstone National Park (Wyoming) and northern British Columbia's Stikine Ranges near the Yukon border, may eventually be subdivided into a number of species or many more subspecies than presently recognized. Major sectors of the possible range of this species complex are in great need of comprehensive sampling, such as southeast British Columbia, northwest Washington, and all of Idaho. The southern extent of their range in Idaho and Wyoming has not been systematically investigated.

Part of the challenge for *Grylloblatta* taxonomists is finding adult males from the many populations for comparative morphological analysis of aedeagi. For unknown reasons adult females typically outnumber males in collections about 9:1. Often only a few adult specimens are found, and they are all females. "There is no reason to believe that the sex ratio departs from unity" (Edwards, 1982). This discrepancy may be due to a "niche separation" between the sexes that makes adult males more difficult to find, or for some reason adult females live longer (>1 yr?) and multiple cohorts are active at any one time. Nagashima et al. (1982: 46) report than when *Galloisiana nipponesis* males attempt to mate with immature adult females in a lab setting, the females in some cases "tumbled out and ate the males". If this behavior regularly happens in the wild in *Grylloblatta* populations it could also play a role in adult males being harder to find!

Two of the uncertain taxa are especially interesting because their suspected occurrence is based on either lost specimens or a vague published report from a reliable professional. They may represent undescribed species. The original collectors remain anonymous. Therefore, these species are suspect (species incognitus). One is reported from the eastern ranges of the Olympic Mountains, Washington (*Grylloblatta* "*olympica*") and the other from Forbidden Plateau, Vancouver Island, British Columbia (*Grylloblatta* "*vancouverensis*"). Kamp (1979) mentioned the Forbidden Plateau record, and although he does not mention the record from the Olympics, he indicates its existence on the map he provides (Fig 37, p 36). I have intensively collected both the Olympic Peninsula and Vancouver Island over many years in most habitats for carabid beetles (Carabidae), but have never seen a grylloblattid in either region.

The 13 described *Grylloblatta* species are listed below chronologically. No comprehensive key to all of the species has been published to date.

- *G. campodeiformis* Walker, 1914
  - *G. c. campodeiformis* Walker, 1914
  - *G. c. occidentalis* Silvestri, 1931 (considered a species by some authors)
  - *G. c. athapaska*, Kamp, 1979
  - *G. c. nahanni* Kamp, 1979
- *G. barberi* Caudell, 1924
- *G. sculleni* Gurney, 1937
- *G. bifratrilecta* Gurney, 1953
- *G. rothi* Gurney, 1953
- *G. chirurgica* Gurney, 1961
- *G. washoa* Gurney, 1961
- *G. chandleri* Kamp, 1963
- *G. gurneyi* Kamp, 1963
- *G. scudderi* Kamp, 1979
- *G. marmoreus* Schoville, 2012
- *G. oregonensis* Schovile, 2012
- *G. siskiyouensis* Schoville, 2012

Fig 6: Subalpine forest-wetland mosaic, Forbidden Plateau, Vancouver Island, British Columbia, 26 Aug 1997. Photo by James Bergdahl.

Fig 7: Johnstone Strait near Rocky Bay, Vancouver Island, British Columbia, 28 Aug 1997. A 150 km reach of this channel, which separates Vancouver Island from the mainland, is only about 3 km wide. Photo by James Bergdahl.

A number of factors have probably contributed to this diversity, including biological characteristics of *Grylloblatta* (e.g. flightlessness [low dispersal power], fossorial habits, and philopatry), the patchy nature of their habitat on the landscape, dynamic geological events dating back to the Miocene, and major cyclical changes in the climate since the Pliocene (Schoville & Kim, 2011; Schoville et al., 2013; Knowles, 2001).

Fig 8: North side of Tiger Mt. (~900 m, 3000 ft) from Sammamish Plateau, Issaquah, King Co., Washington, 05 July 1996. Hundreds of pitfall samples taken by the author suggest the *Grylloblatta* population there may be restricted to the upper most slopes of this mountain in Seattle's backyard. Photo by James Bergdahl.

Fig 9: Looking north into *Grylloblatta* habitat in the Potlatch River Gorge near Little Boulder Creek, Helmer, Latah County, Idaho, 01 July 2010. Some of the "sky islands" of the Clearwater Refugium are visible on the horizon. Photo by James Bergdahl.

Grylloblatta "olympica" species incognitus—Species Account

In the 1970s and 80s John Edwards (Zoology Department, University of Washington, Seattle) had a number of students who worked on grylloblattids, including Rod Crawford and Dan Mann. Because of the research of Edwards' lab, one of the best-known grylloblattids is *G.* "*rainierensis*", from Mt. Rainier, which surprisingly remains, according to Schoville & Graening (2013), an undescribed species (or subspecies). My work on insects at that time focused on the region's carabid beetles, and I rarely found a grylloblattid in the field. Rod Crawford (UW–Burke Museum) and I are presently working together on an analysis of the spider fauna of the San Juan Islands (Washington) so I asked him last winter if he knew anything about the lost grylloblattids from the Olympics. He told me Dan Mann had collected them back in the 1970s, possibly only a single specimen, which was given to Bill Kamp.

This spring Dan Mann (University of Alaska–Fairbanks) told me that in the mid-70s he gave a graduate student working on mountain goats in Olympic National Park (ONP) some vials with instructions on where to look for grylloblattids, and they eventually returned with booty. Dan thinks there may have been only one specimen, and does not remember the name of the person who found them. His only recollection about the locality is that it may have been in the vicinity of the The Brothers Peak (Duckabush River, Jefferson County), which is on the eastern escarpment of the Olympic Peninsula and one of the most prominent peaks visible on the western horizon of Seattle. Rod also recalls seeing only one specimen, and thinks it may have come from the upper Dosewalips River, the next watershed north of The Brothers. Both Dan and Rod confirm that the specimen(s) was sent to Kamp, and never seen again. As already mentioned, Kamp (1979) published this first Olympic record on his map (Fig 37), but provided no more details.

Sleuthing led me to Victoria Stevens (BC Ministry of Environment, Victoria), who did her dissertation work on mountain goats in the Olympics at UW at that time. In conversations with her this fall she agrees she would have been the most likely person to have collected the grylloblattids since she worked in that area, but she does not recall Dan Mann giving her vials or ever collecting any specimens. Victoria, who worked mostly in the Mt. Constance (Dosewallips) area, indicates a number of other people were doing research for the Park Service on goats then. The person who collected these specimens remains anonymous at this time, and the exact locality is unclear.

Victoria led me to Gay Hunter (Curator, ONP Museum, Port Angeles), who indicates she collected two grylloblattids in ONP many years ago while skiing on the Deer Park Road (northeast ONP) at night, where talus was exposed at about 5000 ft, 22 January 1987. One specimen was small and dead, the other alive and possibly an adult. The status of these specimens is unknown; they are not in the ONP Museum (Gay Hunter, pers. comm.). Gay thinks grylloblattids have been collected in pitfall traps in ONP, possibly from Grand Valley, but she is unable to definitively confirm any existing specimens.

Both Dan Mann (September 1976) and I (September 1998) have collected carabid beetles in the alpine and subalpine zones in Deception Basin (upper Dosewallips watershed) near Mt. Constance (Fig 4), but found no *Grylloblatta*. (Dan did however find the first specimens of an undescribed flightless carabid endemic to the Olympics, *Nebria danmanni* Kavanaugh, 1981!) Sean Schoville confirms he has never seen any grylloblattid specimens from the Olympics in his comprehensive search for museum records. Sean (pers. comm.) looked for grylloblattids in periglacial habitats of Mt. Olympus in summer 2013 but was unable to find any.

Therefore, in summary, the status of our knowledge of grylloblattids in the Olympic Mountains is that they have been found in The Brothers Peak (Duckabush)–Mt. Constance (Dosewallips) area (Fig 3 & 4), and in the Deer Park–Grand Valley area (Dungeness watershed), in the east-central and northeast sectors of the range. No specimens are definitely known to still exist.

Grylloblatta "*vancouverensis*" species incognitus—Species Account

Compared to *Grylloblatta* "*olympica*" the status of *G.* "*vancouverensis*" is much more poorly documented. In fact, except for the vague published record in Spencer (1945), no other documentation of the population exists. Comments about the possible occurrence of *Grylloblatta* on Vancouver Island continue to be published (e.g. Vickery, 1998; Schoville & Graening, 2013).

Spencer (1945) focuses mostly on accounts of pest insects, but mentions some very noteworthy records of *Grylloblatta* in British Columbia, including: 1) the bizarre occurrence of a talus-field population in the dry Ponderosa pine–sagebrush–cactus steppe ecotone at about 390 m (1280 ft) near Paul Peak (Kamloops), 2) the subalpine forests on Grouse Mt. (overlooking the city of Vancouver), and 3) Forbidden Plateau (Vancouver Island). Campbell (1949) provided more information about the exceptionally unique Paul Peak population. Spencer does not provide any information about the source of the Grouse Mt. or Forbidden Plateau records and none have been found since.

Forbidden Plateau is perched on a long spur of rolling, mostly subalpine parkland terrain that extends east towards the town of Courtenay from the main crest of the Island Range. It is now part of Strathcona Provincial Park. The Plateau is a complex mosaic of habitat types including many shallow ponds, small lakes, and streams that form a confusing watershed pattern (Fig 6). There is an abundance of exposed bedrock and talus. Elevations range about 3500–7000 ft. Precipitation, mostly snow, is high, with snow packs commonly reaching 20 ft. Snow is typically present October–May. Because of the coastal location, the tree line is reduced to about 5000 ft. All of these ecological features indicate prime *Grylloblatta* habitat.

In a fairly detailed account of the flora and fauna of Forbidden Plateau, including invertebrates, Hardy (1954) does not mention grylloblattids. Hardy does not explain their methods so it is unclear if they sampled during cold-season months when ice crawlers are expected to be more active on the surface. This project of the Royal British Columbia Museum's (RBCM, Victoria) included Richard Guppy, an extremely competent entomologist who provided a long list of invertebrates collected on Forbidden Plateau. The project first conducted field surveys in 1943, and they may have been the source of Spencer's (1945) record.

Kamp (1979) reports his attempts to recollect *Grylloblatta* on Forbidden Plateau, including close examination of Spencer's field notebooks, but was unable to find any more information. I collected carabid beetles for a day for RBCM on Forbidden Plateau (26 August 1997) and never saw any. The Forbidden Plateau area is now easily accessible all months of the year via roads to either Mt. Washington or Forbidden Plateau Ski areas.

Fig 10: Forest floor at Mt. Spokane State Park subalpine *Grylloblatta* site, about 5500 ft, Spokane, Washington, 11 Oct 2013. Ice crawlers were near impossible to find here summer 2013, but an early October cold snap with snowfall brought them out of hiding. This site is now the proposed location of a number of permanent clearcuts for a new ski area chair lift and runs. Photo by James Bergdahl.

Grylloblatta Habitat Characteristics

Having gestalt for *Grylloblatta* habitat is of course key to finding these elusive bugs in the field, especially when prospecting for new or lost populations. Many articles on *Grylloblatta* emphasize the low annual temperature and high snowfall of the habitats where ice crawlers have frequently been collected in alpine cirque basins (Fig 2, 3 and 5). Some species may prove to be isolated in alpine regions; however there are many populations that occur in forests at mid- and low-elevations whose habitat requirements are poorly understood. In general, the key habitat feature appears to be colluvial soils, especially talus fields where they can retreat to escape temperature extremes, but populations have also been documented in cool shaded forests without much exposed rock. In these areas they are probably retreating into the C-horizon of the soil or into the many cool micro-wetlands provided by large rotten logs. It is important to keep these exceptions in mind when prospecting for new populations. Many populations will probably eventually be discovered in cloud forest-like habitat on more mountain tops (sky islands) in the Coast Ranges (e.g. Mary's Peak), and the foothills of the Cascades, Sierra Nevada and Bitterroot Ranges, such as the small isolated population on Tiger Mountain (Fig 8) near Seattle (King Co., Washington).

There are probably many more low elevation populations yet to be discovered in caves, lava tubes, cool ravines, canyons and other steep topographic breaks (Fig 10). John Edwards' (01 March 1971) remarkable record from about 1000 ft, Rat Trap Pass Road, Suiattle River Valley (ca. Darrington, Snohomish Co., Washington) is an indicator of how much we do not know about *Grylloblatta* habitat. Their occurrence in dry Ponderosa pine–sagebrush regions should not be underestimated. Because many of these mid- and low-elevation habitats have a warm summer–dry climate, winter collecting is imperative. In some regions, other soil invertebrates (e.g. centipedes, ants, or carabid beetles) may displace them from suitable habitats at lower elevations.

Using hundreds of specimen records Schoville & Graening (2013: Table 1) scored the general habitat characteristics of the 13 described species. In summary, they are:

alpine species–*G. scudderi*, *G. bifratrilecta*, *G. washoa*;
alpine and low elevation–*G. sculleni ;*
low elevation–*G. barberi*;
cave only–*G. oregonensis*, *G. gurneyi*;
cave and low elevation–*G. chandleri*, *G. marmoreus*, *G. siskiyouensis*; and
all of the above–*G. campodeiformis*, *G. chirurgica*, *G. rothi*.

Except for total aptery (flightlessness) and the loss of ocelli, traits common to all notopterans (Grimaldi & Engel, 2005), there are no other reported special morphological adaptations typical of cave inhabiting insects in any *Grylloblatta*. Many *Grylloblatta* species that have been collected in caves are also found outside caves (Kamp, 1970). Caves may be magnets for individuals of more broadly distributed, low-density surface populations, and provide an easier place for collectors to find them. If collectors keep resampling the same narrow habitat type, it is difficult to get a true picture of a species' habitat due to sampling bias. The "taxon cycle" (Wilson, 1961) predicts that geographically-restricted cave species are older, relict species descended from species that were once more widespread, and now isolated due to range expansion/contraction cycles caused by climate change (Liebherr & Hajek, 1990; Liebherr & Short, 2006; Ricklefs & Bermingham, 2002). The first clearly documented case of sympatry among *Grylloblatta* species occurs at Oregon Caves National Monument (Josephine Co., Oregon), and more are expected in Oregon and Washington (Schoville, 2012; Schoville & Graening, 2013). A similar "species pump" dynamic (Jockusch et al., 2012; Rovito et al., 2012), common in taxa with narrow habitat requirements and low dispersal power, forced by climate and habitat change and range expansion/contraction cycles, may also be responsible for speciation of alpine *Grylloblatta* (Knowles, 2001; Schoville & Roderick, 2010; Schoville & Kim, 2011; Schoville et al., 2012).

Although many records are near lakes or streams, there is no evidence that any *Grylloblatta* species are obligate hygrophiles. As lovers of stable cool temperatures and high humidity, these areas may support denser populations because of the thermal mass of large bodies of water and their ability to ameliorate temperature extremes. In mountainous terrain, gullies and ravines carved by low-order streams into hill slopes provide channels that funnel cold air descending from high elevations, allowing the establishment of cold adapted montane species at lower elevations (see zonal "fingering" in Franklin & Dyrness, 1973: Fig 28, pg 47). Of course, significant cooling effects also occur on many north-facing slopes.

Grylloblatta Life Cycle Characteristics

Many *Grylloblatta* populations occur in habitats that represent the colder end of the temperature gradient within a region, and some entomologists now refer to ice crawlers as extremophiles (Oregon Public Broadcasting, 2013). One should keep in mind however, that from the perspective of a *Grylloblatta*, the habitats they occur in and are adapted to are normal. These habitats have been in existence for many millions of years in the Pacific Northwest; in fact the ambient temperatures that they prefer are common over much of the cold-season (about October–April) in regions where they occur. Few entomologists refer to insect species that are active only during the warmest months of the year as extremophiles. The use of this term for *Grylloblatta* is perhaps anthropocentric due to our preferred ambient temperature of 75°F, and low humidity.

Like many other insects that live successfully in cold, low productivity environments with a short growing season, *Grylloblatta* have probably evolved a suite of unique physiological and ecological adaptations compared to insects that live in more temperate climes. These include (MacLean, 1975): 1) microhabitat selection, 2) extended (>1 yr) and flexible (opportunistic) life cycles so that survival does not depend on success in any one year, 3) resistance to cold, 4) metabolic adaptations, 5) life-history timing mechanisms, and 6) generalist food habits.

All of these phenomena have been fairly well documented in arctic insects, but most remain poorly documented in alpine insects in general, and in *Grylloblatta*. As in some arctic insect species, young, middle and late instars, and adults may have significantly different ecological and physiological adaptations to their habitat. Many *Grylloblatta* populations are closely associated with talus, where they retreat to escape extreme cold and hot temperatures. Due to the nature of airflow through these fields, ambient temperatures are air-conditioned and remain comparatively stable year-round (Huber & Molenda, 2004). The length of their life cycle, metabolic adaptations and timing mechanism in the field are largely unknown. Some populations appear to have a Type III Q_{10} metabolism (temperature vs. rate of respiration and assimilation) typical of many arctic insects (MacLean, 1975, Figs 3 & 4), with obligate periods of quiescence during the warm season to minimize the period of negative energy balance. This creates the phenomena where some (e.g. lower elevation) *Grylloblatta* populations may be entering a period of summer aestivation when many co-occurring insects (and most entomologists) are emerging from hibernation. Huggard & Klenner's (2003) pitfall studies of *G. campodeiformis* in the forests of south-central British Columbia suggest immatures and adults have significantly different seasonal activity patterns on the soil surface.

None of the *Grylloblatta* species have had their life cycle characteristics analyzed in much detail in the field, nor has there been much speculation on this topic in the literature except for Walker (1937). Although a number of entomologists are now focused on defining *Grylloblatta* lineages and describing new species, there is a huge unmatched need to understand the details of their life-cycle characteristics in the wild, especially those species at some conservation risk due to forestry, climate change, or over-collecting. A number of researchers have documented their preference in lab settings for near freezing temperatures and high humidity, and narrow temperature tolerance (e.g. Henson, 1957). Attempts to coerce lab colonies to mate and lay eggs usually end with very limited success. What lab data indicate about the ecology of populations in the wild has many limitations. Very little is known about the details of key life history features such as their breeding phenology, rate of growth and progression of immature stages through instars, micro-habitat selection, hibernation or aestivation of different instars, the longevity of adults, how many eggs a female lays, etc, all of which should prove to be very interesting due to the group's unique ecology. Two factors contribute to the challenge of acquiring life-cycle information in the field: 1) grylloblattids are so elusive they are usually only found in very low numbers both hand collecting and in pitfall samples, even in localities where they are known to occur, and 2) the physical difficulty of accurately sampling subnival or subterranean habitats.

It is unclear how well the life-cycle characteristics of Asian grylloblattids represent *Grylloblatta* since they are so distantly related. Some noteworthy aspects of *Galloisiana nipponensis* Caudell & King life history in Japan, which occur at very low population density, are (Nagashima et al., 1982): there are 8 post-embryonic nymph stages; there is no winter dormancy, both adults and nymphs can be collected year round; the 1st instar is less cold tolerant than later stages; older stages make tunnels in the soil with their mandibles in which they sit and wait for prey; adults emerge in September–November; the pre-oviposition period of a adult is about 3 months; egg laying begins in December; if the last nymphal instar is unable to emerge September–November, it waits until the next season to do so; eggs may hatch after 5 months or wait more than 3 years, even those in the same brood; some females may not reproduce until the second season, therefore in the fall both old and newly-emerged females are present at the same time; females usually die after their first season of reproduction (within 9 months); and life span ranges between 5–10 years.

Most reported *Grylloblatta* surveys find very few specimens and they are often mostly immature stages. Which instars are collected is rarely reported. Henson (1957) reports *Grylloblatta* may remain in juvenile stages and live as adults for several years. John Edwards and his students collected hundreds of *Grylloblatta* "*rainierensis*" over many years during the warm season in the alpine zone on Mt. Rainier, "but neither eggs nor early instar larvae have been found and these stages probably remain deep in fissures" (Edwards, 1982). Huggard & Klenner (2003) trapped many immature *G. campodeiformis*, but do not report catches for each instar. Their data indicate immatures are mostly active in winter under snow and adults mostly in the summer. They suggest this seasonal partitioning may be due to immatures avoiding surface activity during the summer due to higher and more variable temperatures, and more active predators. Neither Edwards (1982) nor Huggard & Klenner (2003) were able to determine the age of adults. Nagashima et al. (1982) list some key features of the life cycle of *Grylloblatta campodeiformis* reported by Walker (1937): eggs take 1 year to hatch; 1st–3rd instars are completed in a year; 4th–7th instars take 1 year each; 8th instar may be only 6 weeks and sedentary; the pre-oviposition period of a adult is about 1 year; adults live 1–2 years; and total life span is about 8 years.

Grylloblatta are therefore fairly long-lived for an insect. Insect populations of long-lived individuals with low-dispersal power that occur at low density (K-selected) tend to be less resilient, and more sensitive to habitat, climate change, and other perturbations, for a number of reasons. For instance, the long-term survival of their populations may be very sensitive to a small increase in mortality factors since it may take individuals many years to reach maturity and reproduce (MacLean, 1980).

There is likely to be much inter-specific and intra-specific variation in the characteristics of nymphal ecology, breeding, dormancy, etc, depending on the nature of the habitat a population is adapted to. For instance, the life-history characteristics of *Grylloblatta* populations associated primarily with caves or talus fields at lower elevations in ecoregions that typically experience shallow snowfall and moderate temperatures will probably be significantly different than populations occupying high elevation subalpine forest or alpine tundra that develop very deep snow packs that linger very late into summer. In fact, a suite of life cycle adaptations to these extremes may provide key isolating mechanisms where the geographic range of sister-species lineages overlap, such as when different runs (stocks) of a salmon species become genetically isolated within the same river because their spawning seasons are not synchronous.

Schoville & Graening (2013) summarize catch record data for many *Grylloblatta* populations that indicate collectors may find individuals any month of the year across the range of *Grylloblatta*. The seasonality of activity of individuals of the populations is unclear however because it is impossible to assess whether all the months have been adequately sampled. This will require intensive year-round sampling. Sampling under deep snow and in talus is extremely difficult. Most of the populations have been very poorly collected.

Based on information provided by Nagashima et al. (1982) about *Galloisiana nipponensis*, which has 9 instars, Rob Crawford (pers. comm.) estimates that *Grylloblatta* in the Washington Cascades have 8 instars, and suggests the first one may be immobile. In *G. nipponensis* an instar can be determined by carefully counting the number of segments in a cercus (Fig 1) and then subtracting 1; presumably the same techniques works for *Grylloblatta*. The adult *Grylloblatta* from the Rocky Mtns. in my collection have 9 cercal segments. If *Grylloblatta* has at least 8 instars, the average length of an instar is 1 year, eggs take a year to hatch, and some adults live two years, then about 8–10 years may be a reasonable estimate of their life span.

On 11 October 2013, in a 2.5-hour hand-collected sample looking under large-woody debris in old subalpine-fir forest at about 5500 ft on Mt. Spokane (Fig 10), I found 41 *Grylloblatta* specimens. The weather was clear with a very slight breeze, the air temperature was just below freezing, and there was a very thin, discontinuous layer of the season's first snow fall on the ground that had previously been rained on. By slowly and carefully digging down into the top of the C-soil horizon with a variety of tools (see next section on collecting tips), at spots where I found adults on the surface, I found many small instars. My catch, divided into size classes based on head capsule width is: 1st size class (5 specimens), 2nd (5), 3rd (2), 4th (12), 5th (5), and adults (12; 10 females, 2 males). Three days later I returned to the same site and collected 17 adults in 2 hours, which were successfully sent live in moss on ice to Sean Schoville for lab studies. Nagashima et al. (1982) note there is too much variation in head capsule width to use it as a reliable indicator of an instar. Examination of the cerci of the first size class in my sample indicates they are 2nd instar. Assuming that females lay eggs in the fall, these data indicate all instars of *Grylloblatta* "*spokanistan*" can be found simultaneously in the fall in the same soil profiles on Mt. Spokane. If most instars take about 1 year to graduate to the next stage, then multiple year cohorts are present in the population at any one time. The average number of days it takes a *Grylloblatta* instar to graduate in the field is, however, unknown.

Collecting Grylloblattids

I mostly use four tools for hand collecting *Grylloblatta*. The largest one is a standard garden hoe that has had its spade ground down so that it is only 2 in wide. I have shortened the handle to 3 ft so that it will fit in a backpack, yet is long enough I do not have to kneel down to flip small rocks, logs and branches. The three other tools are for finer scale dissection of the soil—a standard 3 prong garden cultivator with a 1-ft handle, a smaller kitchen or barbecue fork, and a tablespoon. The first two can be used for gently raking through duff and dirt, looking for immatures. I avoid picking up the immature instars with my fingers because they are so fragile, lifting them up with the spoon instead.

For pitfalls I use 10-oz Solo brand clear plastic party cups, or something similar. They are cheap and available in most grocery stores. A soil core that fits them perfectly can be cut with a standard circular garden bulb planter. I probe a spot with a 10-inch screwdriver before coring so as to find a place without large rock or root obstructions. In loose soil, two cups can be nested to make resetting them easier. My traplines are usually 6 traps long, placed about 5 paces apart in a straight line. If you stick to this regimen only the first trap needs to be flagged, which reduces their discovery by others. I use 8-in squares of thin, high-density particle board for trap covers (which I cut out a 4 ft × 8 ft sheet of "shower surround" available at home improvement stores). A stick about 1 in diameter and 6 in long can be laid across the cup mouth to elevate the cover a little off the ground. I lay some bigger branches over the top of the cover to help secure it in a position parallel with the ground. When servicing a trapline, I pour the trap contents through a standard kitchen tea sieve into a Solo cup, and then transport the sample back to the lab in a plastic bag, one trapline per bag. Whatever you use for a trap solution can often be reused after it has been sieved once or twice. One of the benefits of running pitfall traps in cool-montane forest in the Pacific Northwest is the low evaporation rate of the trap fluid and low abundance of soil-surface active invertebrates; this allows one to leave traplines unattended for months.

Use discretion when collecting on lands where permits may be required. Sometimes it is fairly easy to acquire insect collecting permits from public agencies, especially for poorly collected taxa such as grylloblattids, if you contact the right people and plan to deposit the specimens in an established entomology research museum. Given the high-risk conservation ranking of many of the species (Jarvis & Whiting, 2006; Schoville & Graening, 2013), and the documented threat of climate warming to cold-adapted species, public agencies should encourage entomologists to better document the *Grylloblatta* populations in their care. I recommend donating grylloblattid specimens from British Columbia to the Royal British Columbia Museum or the University of British Columbia Spencer Museum. A number of museums in the western USA curate significant grylloblattid collections including the University of Washington, Washington State University, Oregon State University, and the California Academy of Sciences. It would help researchers if *Grylloblatta* collections were curated at one central institution, such as OSU. Specimens will be much more useful for research if they are pickled in high-test ethanol, such as 95% Everclear-brand liquor, and stored frozen if possible, which helps preserve DNA suitable for gene analysis.

Many very important records have come from the collecting in winter of very few specimens; for instance the first records from northern Idaho were acquired in late November and late December (in 1959) near Lookout Pass (Interstate 90). An isolated singleton record from Sula, Montana (near Lost Trail Pass, Idaho) was found on 26 January 1947, an area where subzero temperatures are common. Collecting at night is not required; in fact it may be much easier and just as productive to collect during the day, especially in locales that are difficult to access, when there is not much snow on the ground, and at sites that have a lot of rocks and woody debris to look under.

Discussion

Grylloblatta "*olympica*"—The existence of *Grylloblatta* in the Olympics is certain, but there are no specimens available for species determination or DNA analysis. The most likely places to find them there are in eastern ranges, which are accessible by US Forest Service roads off Highway 101 along Hood Canal. Because the range of *Grylloblatta* "*olympica*" is probably concentrated within Olympic National Park, Olympic National Forest, or Wilderness areas, the conservation status of the species is probably fairly secure. Although much of Olympic National Forest has been clear-cut, current forest management policy there greatly restricts any cutting of old-growth stands due to the conservation of spotted owl and marbled murrelet habitat. Although neither may be very good umbrella or indicator species for *Grylloblatta* habitat, the conservation of these endangered birds' habitat has no doubt been of benefit to many native old-forest insects.

Grylloblatta "*vancouverensis*"—The existence of *Grylloblatta* on Vancouver Island is uncertain, but not unlikely. Since *Grylloblatta* are known from the Olympics, the North Cascades of Washington and British Columbia, and British Columbia's Coast Ranges, I think there is a very good chance that they occur on Vancouver Island too. There is an abundance of suitable *Grylloblatta* habitat (Fig 5) and the cross-water dispersal barrier between Vancouver Island and the mainland is very narrow (Fig 7).

Multiple lines of evidence including geology, biogeography, and genetics suggests there were probably many small ice free refugia on or adjacent to Vancouver Island, including the outer continental shelf, Brooks Peninsula, Queen Charlotte Strait, and along the adjacent mainland in places that were sheltered from inundation by the Cordilleran Ice Sheet (Mann & Hamilton, 1995; Hebda & Haggarty, 1997; Fedje & Mathewes, 2005; Marr et al., 2008). An archipelago of refugia would have provided opportunities for stepping-stone dispersal of flightless terrestrial invertebrates along the coast northward from Washington, or southward from documented refugia in southeast Alaska, by rafting on logs and other debris.

I have collected both the Olympic Peninsula and Vancouver Island extensively for carabid beetles (Bergdahl, 1997). There are a number of large flightless carabid beetle species with ecology and habitats similar to *Grylloblatta* that are found only in Canada on Vancouver Island such as *Scaphinotus johnsoni* Van Dyke, *Pterostichus* (*Hypherpes*) *nigrocaeruleus* Van Dyke, and *Playtnus ovipennis* (Mannerheim). The geographic distribution of the last two species appears to be restricted to the southern end of the island south of Alberni Inlet, whereas *S. johnsoni* can be found rarely across most of the island. These carabids, along with many other terrestrial invertebrate species, may have survived the Pleistocene on the Island in glacial refugia, and/or rafted from points of departure in Washington, Oregon and mainland British Columbia after deglaciation.

Schoville et al. (2013) have documented the possibility of inter-island dispersal of grylloblattids within near shore archipelagoes in the northwest Pacific (Japan–Korea region), and some authors report finding *Grylloblatta* in rotten logs. During the Pleistocene and early Holocene *Grylloblatta* must have occurred at lower elevations closer the ocean in the greater Puget Sound region. "Although many islands were once connected to the mainland and some still have species remaining from the days of the connection, it is astonishing what can be accomplished without a land bridge" (MacArthur, 1972: 84).

The insect fauna of Vancouver Island is poorly collected, in part due to its remoteness and the difficulty of road access to many of its regions. It is unlikely much collecting has been undertaken for *Grylloblatta* on Vancouver Island. Kamp (1979) seems to imply that since he was unable to find them on Forbidden Plateau the record is erroneous, however many experienced *Grylloblatta* collectors often find it difficult to relocate known populations.

If a *Grylloblatta* species does occur on Vancouver Island, and assuming its geographic distribution is not extremely localized, its conservation status is probably fairly secure, unless it is dependent on forests. Forbidden Plateau is part of Strathcona Provincial Park, a very large protected area located in the middle of the Island. However, many old-growth forest dependent invertebrate species on Vancouver Island are probably at some survival risk simply because so much of the Island has now been clearcut logged multiple times over the last 150 years, and "inoperable" forest stands, the last of the undisturbed old-growth on steep or inaccessible forestry lands, are now being cut using helicopter logging. Huggard & Klenner (2003) state: "The absence of grylloblattids in clearcuts [near Salmon Arm, British Columbia] in one season or the other suggests that clearcuts with intensive site disturbance cannot maintain all life-stages of the species [*G. campodeiformis*], warranting concern about the effects of harvesting on these insects." Volker & MacKinnon (2000) review many unique ecological features of montane "sky islands" in British Columbia, such as inhospitable climate, small geographic area, isolation, and barriers to dispersal (inter-island immigration and colonization) that apply directly to the management and conservation of *Grylloblatta* habitat and populations throughout the Pacific Northwest. Nagashima et al. (1982) state that *Galloisiana nipponensis* in Japan, which also lives in cool shady forest montane habitats, "may no longer be seen once the trees were cut down and the habitat became exposed to the sun."

Conclusions

I have researched all accounts I can find of these two lost grylloblattid populations because, after many decades of analysis of the Pacific Northwest carabid beetle fauna (Bergdahl, 1995), I find two of the most exciting tasks for field entomologists are prospecting for new species and attempting to recollect extremely rare or lost species, especially those expected to be endemic to the region (Bergdahl & Kavanaugh, 2011). This is trophy hunting at its best, especially when you find what you are looking for. The Pacific Northwest's endemic insect fauna provides zoologists the single best window for understanding the factors responsible for the composition and history of the regional fauna. Phylogenetic analyses of these species' populations using modern techniques will allow reconstruction of some fascinating aspects of their ancient history, and help us understand the processes responsible for species diversification on the landscapes we live in.

In many cases rare species are not that hard to find if one narrows the geographic range of their search and sharpens the habitat characteristics of the localities they actually spend their time sampling. In my experience collecting ground-surface active invertebrates, if one does not find what they are looking for in an intensive 30–45 minute sample, I recommend moving on down the road to another likely site. Since many rare species are habitat specialists, the key to finding them is to develop an intimate understanding (gestalt) of the suite of habitat characteristics a species prefers (easiest to find in). Once some confidence is established in this regard, the true range of a species can be much better assessed over a larger area.

For cryptic species, the range may be much more extensive than existing collection records indicate simply because no one has systematically sampled the right habitat over a larger area at the right time of year. For instance, most of the published accounts of the large-bodied flightless carabid beetle *Pterostichus johnsoni* Ulke, an endemic to the west slope of the Cascades in Washington and Oregon, report the species is found in the spray of waterfalls. Therefore, this is where collectors look for them and more records from waterfalls accumulate in collections. However, if one broadens their search and samples intensively within a region where they are known to occur, it quickly becomes apparent that the species' streamside habitat requirements are much more eurytopic (Bergdahl, 2013). I suspect a similar situation will unfold with many *Grylloblatta* species; that is once more intensive systematic sampling by experienced entomologists occurs over a much larger region at the right time of year it will become apparent that their populations are much more numerous, abundant and widespread than they are given credit for today. Rob Cannings (pers. comm., 28 Feb 2011) provides a reasonable summary for many populations: "I think the general view now is that grylloblattids are all over the place underground in subsurface broken rock and come to the surface at sites where the temperature is right for activity".

Other major gaps in records (and probably collecting effort) where there is a good likelihood *Grylloblatta* occur include: southern Coast and Cascades in Oregon; Wallowa and Blue mountains of northeast Oregon; northeast Washington and north Idaho; the Coast Ranges of mainland British Columbia north of Vancouver; Purcell and Selkirk ranges in the West Kootenay region of southeast British Columbia; the many isolated ranges in central Idaho's Clearwater, Salmon River, Seven Devils and Sawtooth mountains; and northwest Wyoming. It would be miraculous if *Grylloblatta* occurs in northern-most British Columbia but nowhere else between there and the Jasper area (Schoville & Graening, 2013, Fig 1). Chances are a number of populations exist today between these two regions yet to be discovered. Given the proximity of the two northern-most populations to the Yukon border, records from the Yukon would not be a total surprise given that province's long list of insect species that appear to have survived the Pleistocene in glacial refugia (Danks & Downes, 1997). Vickery (1997) suggests any *Grylloblatta* found in the Yukon will probably be a new species. A number of the *Grylloblatta* species in California occur so close to the Nevada border, a first record from that state would not be too surprising either, such as *G. washoa* near Lake Tahoe, and an undescribed population in the White Mountains near Bishop (Schoville & Graening, 2013).

Specimens collected from all of these areas would help phylogeneticists understand the locations of the many localized refugia where *Grylloblatta* must have survived the Pleistocene across western North America (e.g. Brunsfeld et al., 2001; Brunsfeld & Sullivan, 2006; Shafer et al., 2010), and help explain the biogeography of other taxa endemic to this region. Kamp's (1979) "tabula rasa" model (Brochmann et al., 2003) of post-Pleistocene recolonization of much of the territory *Grylloblatta* occupies today is probably too simplistic. Hopefully this report will encourage bug hunters to help contribute towards our understanding grylloblattids, especially by undertaking winter hunting expeditions including night collecting—excellent therapy for cabin fever!

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See Video of Live Grylloblattids and Grylloblattid Hunters!

The 14 November 2013 episode of Oregon Field Guide, a television program produced by Oregon Public Broadcasting, featured Chris Marshall (Curator, Oregon State Arthropod Collection) and Dave Lytle (OSU Assoc. Professor of Zoology) looking for Grylloblattids at Marys Peak and Belknap Crater in Oregon.

Chris Marshall

Watch the segment at <http://www.opb.org/programs/ofg/segment/ice-crawlers/>.

OREGON FIELD GUIDE 25th

The Funnybug Chronicles—Episode 2: "strange if a boreid, stranger if it weren't"

Loren Russell

"Ken, it's a boreid!" This was the third phone call I'd made to Kenneth Cooper since I found the first female, and now I had the male, and an answer to our puzzle. In our first conversation, Ken had suggested that "it would be strange if the funnybug were a new boreid, but much stranger if it weren't." As we went over the traits that I could see (and a list to check again—he was not always convinced that I'd been careful in my observations), he agreed that the funnybug was almost certainly holometabolous. Further, he said, within the Holometabola we could exclude everything but basal mecopteroids and perhaps the neuropteroid complex. And the latter would be a long-shot, Ken kept saying, so if this was not a boreid or a sister-group of boreids we might be looking at the next *Grylloblatta*, a new order. And parsimony, geography and season all suggested the boreid connection.

Kenneth W. Cooper was old-school, a prominent cytologist in his day-job, and also an amazingly diverse and accomplished naturalist and taxonomist. I had first corresponded with him in the mid-1960s when I was an undergraduate at the University of Washington. Ken, then at Dartmouth Medical School, wanted a collection of stream-bank carabids, particularly *Bembidion* from northwest Washington, and offered in exchange beetles he'd collected in Vermont and New Hampshire. I got a thousand or so named specimens in this transaction, placing some in the Hatch Collection and keeping the remainder. All of these specimens ended up at OSU.

I met Ken in person for the first time a couple of years later. I was then finishing my M.S. at UW, and he was on campus chairing an NSF review panel. I was getting ready to move to Oregon, and Ken informed me that he would probably be relocating to the west coast as well—perhaps we could get together in the field. He did, and we did—Ken moved his lab to UC–Riverside and I made collecting trips to the California deserts almost every spring during the '70s. I visited Ken in Riverside on at least four of my trips. These were always memorable—none less than our foray to the slopes of Mt. Baldy, when I lost footing while deploying a beating sheet, slid head-first over a cliff, and caught hold of a manzanita snag (very Beetle Bailey-esque) at the last moment. Ken was out of sight, and Fortune smiled when a tall blond skate-boarder came out of nowhere to give me a hand up to safety. Ken wasn't too distressed—the year before, he'd barely survived a rock slide while collecting insect fossils in the Mojave. He walked out with a broken back. And his fossils.

Ken was a polymath. Over the years, he had worked on an amazing range of insects—beetles, flies, hemipterans, among others. Ken had even described the first known fossil tardigrade, *Beorn leggi*, from Cretaceous amber! So, he was my best contact outside the OSU community. And pertinent to these phone conversations, I knew he'd published several papers on the life history and behavior of boreids, and that he had recently discovered and described the aberrant *Boreus notoperates* (now *Hesperoboreus notoperates*) from the upper slopes of Mount San Jacinto, hundreds of miles to the south of any other boreid.

So (back to the telephone conversation), I had to ask: "Okay, we agree. It's a boreid. Would you like to have this bug? Or would you prefer that I send the material to Norm Penny or George Byers?" Of course I hoped he'd say yes, send it down—I certainly owed Ken, I loved his work, and I hadn't met either of the Mecoptera specialists. But Ken was ahead of me: "Loren, you can do this. I'll help you and critique the paper, but this is a big deal, and someone ought to be on the spot to do more than just describe it…." (What Ken was thinking and didn't say was: "I expect a monograph, you lazy SOB!")

As the Funnybug Chronicles continue, Loren is planning to print commemorative T-shirts (see design below). Anyone interested in getting in on an order should email him at <`loren.russell@comcast.net`>.

Northwest Lepidopterists' Workshop 2013

On 19–20 October 2013, about 40 people gathered in Cordley Hall on the campus of Oregon State University for the 35th annual workshop meeting of Lepidopterists of the Pacific Northwest. The meeting was hosted by Drs. Paul Hammond and David McCorkle and sponsored by the Oregon State Zoology Department and the Oregon State Arthropod Collection (OSAC).

Jim Reed brought some of the students from his entomology class at Klickitat High School, in Klickitat Washington. His classes have been collecting insects and other arthropods for the past 4–5 years from an area about 10 miles around the school. They brought along their collection, an interesting assortment of specimens from a number of orders. There was even a new butterfly record found among their butterflies.

Oral presentations were made by David Maddison, Dana Ross, Jon Shepard, Paul Hammond, Dave Specht, Katy Prudic, Mark Hitchcox, and David Lee Myers. In a parallel session on Saturday afternoon, Chris Marshall, Dana Ross and Katy Prudic led a workshop on butterfly collecting for students.

In the pages that follow I (Ron Lyons) have summarized the various presentations, as well as some of the other business discussed. The summaries have been looked over and enhanced and/or corrected as necessary by the various speakers. Katy Prudic made a number of additions to the summary of her presentation and Mark Hitchcox essentially rewrote his. Resources (in print and online) mentioned at the meeting are included with the relevant material.

The groups of Lepidoptera for emphasis this year were:

- Butterflies: Acmonoid Blues, Swallowtails (and Parnassians)
- Moths: general moths, especially Geometridae of the Macarias Group

David Maddison—Formal Welcome and Entomology Collection Announcements

David Maddison, Director of the Oregon State Arthropod Collection (OSAC), welcomed the group on behalf of the University and OSAC.

David updated the group on the results of the fund-raising campaign, announced at last year's meeting, to raise money for the purchase of new cabinets to house the Lepidoptera and the Hymenoptera collections at OSAC. In this effort, matching funds were generously provided by the College of Science and the College of Agricultural Sciences. With the generous contributions from the lepidopterist community, the campaign exceeded its goal. The extra funds will be used for other things such as new and replacement drawers, modifications to the collection space, and wages for student curatorial assistants.

Chris Marshall, OSAC's Curator and Collections Manager, outlined the various steps in the process to upgrade the cabinets. The actual installation is slated to take place next summer. Chris indicated that he might be asking for volunteers to help in the labor intensive parts of this reorganization.

David talked about the Pacific Northwest Lepidopterists' Fund in honor of Harold E. Rice and encouraged those interested members of the community to submit a grant application (see the Call for Proposals for 2014 on page 25). The deadline for applications is 31 January 2014.

Donations to OSAC are always welcome. Tax deductable monetary donations can be made to the Oregon State University Foundation. Please specify that the funds should go to the Friends of the Oregon State Arthropod Collection. Contact Chris if you are interested in making a specimen donation. Contact Jon Shepard if you are interested in making a donation to the OSAC library.

Katy Prudic—Sex, love, and heat: the developmental plasticity of sex role reversal in the Squinting Bush Brown Butterfly

Katy Prudic, Ph.D., is a research scientist in the Department of Zoology at Oregon State University working in evolutionary ecology. In the first part of her presentation, she discussed some work she and her colleagues (Antonia Monteiro, Hui Cao and Cheonha Jeon) have been doing on the unusual sex role reversal exhibited by *Bicyclus anynana*, the Squinting Bush Brown Butterfly, between its seasonal forms (Prudic et al., 2011; Prudic, 2013).

Classically in animal behavior, sex roles have been thought of as males court and females choose. This concept called Bateman's Principle was first developed in the 1950s, the rational being that males donate much less with their little gametes while females

Northwest Lepidopterists' Workshop 2013 (cont.)

are the ones who have to invest more heavily with larger gametes, brooding, and parental care. However, as more and more animals across the tree of life are studied, researchers are finding that both sexes court and both sexes choose because the assumptions about relative investment were incorrect. Sex roles can vary by species and they can vary within a species across generations.

In butterflies, we know innate sexual behavior can vary across generations. *Pieris rapae* males look for different things in their mates based on which generation they belong to, spring or summer (Obara et al., 2008). In *Leptidea reali* (Lepidoptera: Pieridae), Friberg and Wiklund (2007) showed that female preferences can change as well—she chooses her mate, but her tolerance for different types of mates depends on her seasonal form, spring or summer, and her different needs in those forms. Katy and her collaborators took these findings, which indicated that a single sex might change its preferences, one step further. They hypothesized that both sexes might change based on the environmental conditions the caterpillars experienced.

Their experimental subject was *Bicyclus anyana*, the Squinting Bush Brown Butterfly, a small brown butterfly which normally lives in sand forests on the east coast of Africa from the tropical to the temperate zones. In the southern parts of its range, it exhibits a well-studied seasonal polyphenism with respect to the eyespots in its ventral wings. When the caterpillars are raised at temperatures above 23° C, the butterflies which emerge have large ventral eyespots. This is called the wet season form. When the caterpillars are raised at temperatures under 20°C, the butterflies that emerge have very reduced ventral eyespots. This is called the dry season form. (See San Martin et al. [2011] for a plate that illustrates the seasonal forms.) The ventral spots are used in predator communication to redirect attacks to the wing margins and increase the probability of escape.

The dorsal eyespots, however, do not change in size, as far as we can tell. Several different labs (e.g. Costanzo & Monteiro, 2006) have shown that the dorsal eyespot, in particular its white center, is what matters the most in sexual communication. Wet season females want that center to be large and white on the males. Katy and her colleagues measured the UV reflectance of single cells from the white centers of both wet season and dry season forms. The wet season males had much brighter white centers than their female counterparts; females raised at 17° C had bigger brighter white centers than their male counterparts. Since the courter usually has brighter, more garish sexual ornaments than the chooser, this suggests that there might be a sexual switch in terms of courtship.

Because the sensitive period for the development of the adult phenotype (wet or dry season) actually happens during larval development, they split the larvae from the same egg mass into two groups, and raised one group at 17° C and the other at 27° C to get the two seasonal forms. Then they tested the four possible phenotype combinations for courtship behavior and mate preference. (In this species courtship is ritualized [Nieberding et al., 2008] so it is easy to document courtship behavior. Visit <`http://www.youtube.org/watch?v=_AjNkJuyX0`> to watch a video of *Bicyclus* courtship behavior.)

Regardless of the phenotype of the female, wet season males courted a lot, while the dry season males were not as interested in courting. The behavior of the wet season females was very similar to that of the dry season males—they weren't very interested in courting. However, their dry season counterparts were much more interested in courting regardless of what seasonal form the male target was. There was a lot of activity when wet season males were put in dry season females. These experiments showed there was a change in courtship behavior.

To test mate preference, i.e. who was doing the choosing, they manipulated the visibility of the center of the dorsal eyespot by painting over the white center of the eyespot. As a control they also painted individuals near the white center. In these experiments, wet season females strongly preferred males that had intact eyespots regardless of seasonal form. On the other hand, their dry season counterparts mated equally with males that had eyespots and those that had them manipulated. The wet season males were not choosy—they would mate with anything. However, their dry season counterparts definitely preferred to mate with females that had intact dorsal eyespots.

Why do the males and females change their courtship behavior based on caterpillar rearing temperatures? To investigate this question, Katy and her colleagues looked at the role of mating as it affected longevity. Males give a nuptial gift to the female in the form of the spermatophore, a mass of fat, protein and water nutrients, along with the sperm. The nuptial gift of the wet season *Bicyclus anynana* has been described as "pathetic" as this nuptial gift is much smaller than other butterfly species such as the Cabbage White (Ferkau & Fischer, 2006; Brakefield & Frankino, 2009). When a wet season male donates this spermatophore, its longevity is not significantly affected. (Longevity was measured as the number of days without any nutrient resources, equivalent to intense drought-like conditions.) On the other hand, when a dry season male donates its spermatophore, its longevity is reduced significantly—by 2/3 or 6 days in the absence of any resources. Females who mated with wet season males had the same longevity as virgin females under these same resource poor conditions. However, females who had mated with dry season males almost doubled their longevity under these conditions and laid many more eggs. Rearing temperature results in one of two options for male nuptial gifts: males raised at 17° C provided a larger spermatophore than males raised at 27° C.

Katy and her colleagues concluded that there is developmental plasticity in this species—the sex roles are not fixed genetically.

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You can get different sex roles based on the environment, in this case determined by the temperature that the larva experiences. As a result, sometimes females will be the courters, sometimes males will be the choosers and vice versa.

Katy pointed out that, historically, people have focused more on male behavior than female behavior and so might have missed changes in female behavior. Certainly in some instances, it is to the female's benefit to be more aggressive and in some instances it is to the male's benefit to be more reserved.

In conclusion, Katy noted the potential larger implications of this work. "In insects you have multiple generations a year, you have varied but predictable environmental conditions (spring and summer are different but they are predictably different), there is little or no parental care, and also you have a short time to find a mate. All of these factors indicate that this phenomenon might be much more common than we think it is. This sort of plasticity, developmental plasticity, could be important and is relatively unexplored in sexual selection." She mentioned that there is some preliminary work on birds and fish that may indicate similar things.

At this point, Katy switched topics and discussed some of the changes being made in the eButterfly website, <http://www.e-butterfly.org>, with which she has been heavily involved. She strongly encouraged audience members and their friends interested in Lepidoptera to use the website to organize, store, and share their butterfly sightings, collections and photos.

Editor's Note: For more on Katy and the work she has been involved in with butterflies see the report on last year's meeting in the Winter 2012/2013 issue of the Bulletin of the Oregon Entomological Society, pp 11–13.

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Dave Specht—Seasonal Lepidoptera Activity at Powell Butte

Dave summarized his observations at Powell Butte in east Portland from this past summer. He has been documenting activity there since 2005.

This year, he was able to document the life cycle of *Ctenucha rubroscapus* (Red-shouldered Ctenucha), a black-and-red diurnal moth. He found a number of their fuzzy white larvae in the sedges where he had seen a large population ovipositing in 2012. He also found some pupae. One of these was collected and caged. Later it eclosed, producing the expected moth.

After examining some photographs of blue butterflies closely, Dave realized he had photographed *Everes comyntas* (Eastern Tailed Blue), not *Celastrina argiolus* (Spring Azure) as he had expected.

Dave has not seen *Colias occidentalis* (Western Sulphur) or *Limenitis*

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lorquini (Lorquin's Admiral) at the site for several years. A construction project in the park had disrupted the habitats of both species. This year he saw one representative of each. The population of *Ochlodes sylvanoides* (Woodland Skipper) appeared to be about half as large as last year. It appears that *Phyciodes mylitta* (Mylitta Crescent) had a third brood this year. While *Platyprepia virginalis* (Ranchman's Tiger Moth) caterpillars seemed as numerous as last year, the number of adults was down, suggesting to Dave that he had missed the peak. On the other hand, he found the highest population of *Ctenucha rubroscapus* (Red-shouldered Ctenucha), 291, he had ever encountered.

Dave Specht—2013 Trips to Photograph Butterflies

Dave and Carol showed pictures of the habitat and butterflies they found on three trips—two to the desert southwest in April and May, and one to central Oregon in mid-July.

In April they visited Joshua Tree National Monument and hiked into the 49 Palms Oasis. A highlight of this location for Dave was the presence of *Chlosyne californica* (California Patch). They also visited Bob's Gap, a recommended butterfly site along the Mojave foothills of the east Angeles Crest. Because of extreme drought, there were no annual flowers, and only one butterfly was seen—a Mormon Metalmark. In May, northeast of Las Vegas, they visited the Valley of Fire State Park, where several *Danaus gilippus* (Queen, a Monarch relative) were observed.

In July, they traveled to Central Oregon spending several days exploring the periphery of Summit Prairie in the Ochoco Mountains (Crook County). This was followed by one day each in the Painted Hills area of John Day National Monument, and along the Metolius River (Jefferson County). A few of Dave's 23 butterfly species pictured generated some discussion as to the correct identification.

Dana Ross—Some 2013 Activities

In early March during a lovely warm spell, Dana and his family and some friends spent some time exploring along the Metolius River (Jefferson County), walking north up the road from the lower bridge parking area. They were a lot of overwintering Nymphalids like *Nymphalis antiopa* (Mourning Cloak) and *Polygonias* (Anglewings or Commas) flying about as well as some of the spring butterflies like *Anthocharis sara* (Sara's Orangetip) and *Celastrina echo* (Echo Blue). In addition there were some of the early day-flying moths about like *Brephos infans* and some *Annaphila* moths, little brightly colored Noctuids. The group collected a few of these. One of these moths, *Annaphila arvalis*, collected by Dana's son, Zane, turned out to be the 3rd state record for Oregon according to the records on the PNW Moths website, `<http://pnwmoths.biol.wwu.edu/>`. *An-*

Activity Reports

Dana Ross—Oregon Season Summary

Dana reported on a moth study he and Dick Stentz have carried out over the past two years on the South Fork of Mill Creek near the Wicks Water Treatment Facility southwest of The Dalles in Wasco County. Thirty-seven (37) species were recorded from the county for the first time including *Amphipyra pyramidoides*, *Cosmia calami*, *Orthosia praeses*, and *Orthosia pulchella*, 31 species recorded for the second time, and 8 were found for the third time.

Combining the Mill Creek results with those from another study in the Oak Basin of the Coburg Hills in Linn County, Dana indicated that he had 110 moth records of note—58 first county records, 43 second county records and 9 thirds. While he himself has been focusing on state records and the first through third records in a given county, he indicated that any species is worth incorporation into the summary if you have something like a specimen or a photograph to back it up. Other interesting reports would be species that are rarely collected, those that undergo an interesting outbreak, early or late dates and range extensions. Current information on noctuid moths can be found on the PNW Moths website, `<http://pnwmoths.biol.wwu.edu/>`. Information on the Geometridae is being entered but is not available yet.

Alison Center indicated that there were two new counts for the PNW Region in the recently published 2012 Butterfly Count Report from the North American Butterfly Association (NABA)—one for Little Pend Oreille National Wildlife Refuge in northeast Washington and one carried out by the Eugene–Springfield Chapter of NABA for the Cascade–Siskiyou National Monument in southern Oregon. Hard copies of this report (and previous ones) can be ordered from NABA (visit `<http://www.naba.org/pubs/countpub.html>` for ordering information). The results for the Cascade–Siskiyou National Monument can also be found on the Chapter's website `<http://www.naba.org/chapters/nabaes/>`.

Jon Shepard—Washington Season Summary with notes from British Columbia

Jon Pelham collected the Rocky Mountain subspecies of *Euphyes vestris* (Dun Skipper) a number of years ago in Pend Oreille County Washington. This year it was found during the survey at Little Pend Oreille National Wildlife Refuge in adjacent Stevens County, the second state record and a new county record. There were also county records

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Northwest Lepidopterists' Workshop 2013 (cont.)

Activity Reports (cont.)

for *Satyrium titus* (Coral Hairstreak) from Lincoln County, and *Mitoura rossneri* (Cedar Hairstreak) from Spokane County. New records for Monarchs came from Skagit, Spokane, Lincoln and Okanagan Counties. While some people would argue that you can not tell migrating Monarchs from a wedding release, many records indicate that there was a good Monarch migration north this year. There were also a couple of sightings in British Columbia.

There was a new county record for *Atalopedes campestris* (Sachem) from Klickitat County. Jon saw a specimen in the collection brought into the workshop by Jim Reed and students from his high school entomology class.

Ray Stanford saw *Asterocampus* sp. (Emperor) in the Snake River Canyon in Whitcome County near the Idaho border last year. The exact species has not been determined yet, since no specimens or photographs are available. Areas near the site have been surveyed intensively over the years beginning in the late 1800s with no mention of this species. It is unclear whether these were migrants or the species has become established, since its food plant, hackberry, is present in the area. Ray also saw an individual of *Nathalis iole* (Dainty Sulphur), the second state record for this species. The latter is regarded as a migrant.

In British Columbia, further northwest movement of the *Lycaena editha* (Edith's Copper) was documented. Jon reported that his efforts to collect moths around his home in Nelson, British Columbia this past summer were affected by an outbreak of paper wasps which decimated the local moths, including the micro-moths. Very few moth specimens were found at his light most nights.

Steve Kohler (given by Paul Hammond)—Montana Season Summary

Steve has been attempting to extend the known ranges of butterflies in Montana by exploring remote wilderness areas where we have little or no information. He found *Boloria astarte* (Astarte Fritillary) at Red Mountain, a high alpine site in the Bob Marshall Wilderness in Lewis and Clark County. He has extended the known ranges of a number of butterflies including *Erebia callias* (Colorado Alpine), *Erebia pawloskii* (Yellow Dotted Alpine) and *Oeneis melissa* (Melissa Arctic) in alpine zones on the plateaus on the north side of Yellowstone National Park. Steve continues his effort to obtain a Montana record for *Boloria improba* (Dingy Fritillary), which should occur there.

naphila danistica was also collected, a first for Dana.

Dana gave a short report on a stop he had made in the San Marcos Pass, uphill from Santa Barbara, on a trip to Southern California in the spring. He finished up with a brief report on the Pacific Slope Meeting held at the Malheur Field Station in August, and showed a number of pictures he had taken during the meeting.

Top, Dana and Zane along the Metolius River; bottom, *Annaphila arvalis* collected by Zane along the Metolius River

Northwest Lepidopterists' Workshop 2013 (cont.)

Mark Hitchcox—Recent PNW Trends in Port Interceptions of Non-native Lepidoptera

Mark works at the US Department of Agriculture's Plant Protection and Quarantine program, a division within the Animal Plant Health Inspection Service (APHIS) in Portland. The USDA-APHIS safeguards agriculture and natural resources from the entry, establishment and spread of animal and plant pests, and supports trade and exports of US agricultural products.

Before 2003, APHIS conducted all inspections at US Ports of Entry (land, sea and air) on agricultural imports, including things like plants, ships, containers and passenger baggage. Afterwards, that inspection role shifted over to the Department of Homeland Security (DHS). APHIS and DHS now partner in a joint mission to safeguard the US through Agricultural Quarantine Inspections (AQI). DHS conducts the majority of AQI activities in the US, and APHIS provides port customs agents with inspection and treatment manuals, regulatory guidance, and taxonomic expertise if an insect is found.

When customs agents find something on cargo, the product may be placed on hold while samples are sent to an APHIS identifier for official determination. APHIS determines whether an insect is considered a risk, and if action is required, local officers monitor and certify any required treatments. APHIS identifiers try to get samples identified as quickly as possible so that a regulatory decision can be made. Regional identifiers may also refer the sample to taxonomic specialists through the national identification service. An intercepted sample may not always be identified to the generic or specific level, since a quick turn-around time is important, and in many instances global taxonomic resources are insufficient to make a species-specific determination, especially of larval or egg samples. Due to the historic risks associated with certain insect groups, regulatory decisions may be made after familial-level determination.

To direct pest surveillance activities and outreach efforts, APHIS conducts a periodic review of pest interceptions to identify risks. In 2013, Mark conducted an annual review of Lepidoptera interceptions on shipments destined for Idaho, Oregon and Washington between 1 Oct 2012 and 17 Oct 2013. Table 1 shows a summary of the families of moths and butterflies intercepted and the number of interceptions reported.

For the most part, interceptions involved larval life stages, but also included some eggs and a few adults, and most were found as live interceptions. Noctuid moths were the most frequently reported species. To illustrate some potential issues in the detection, prevention, eradication and/or control of non-native invasive species in the Pacific Northwest, three moths can be selected: *Cydia splendana* (Tortricidae), *Helicoverpa armigera* (Noctuidae) and *Lymantria dispar asiatica*, the Asian Gypsy Moth (Lymantriidae).

Cydia splendana, a European tortricid not known to occur in the US, was intercepted five times on shipments destined for Oregon and Washington. This species is known to be a pest in some regions of the world, as the larvae feed internally on the seeds of oaks and chestnuts. If this moth were to become established in the Pacific Northwest, we don't know what kind of impacts it would have on native and commercial trees. There are several oaks here that could be at risk. Some chestnuts still survive around here, and we also have chestnut orchards. There are issues with other species of tortricids whose larvae feed on filberts here, and there may be a possible risk of a host shift, if the species were ever to establish and spread.

Helicoverpa armigera, the old world boll worm, is not known to occur in the US. It is polyphagus, a pest of several crops, anything from cabbages to apples to wheat. The eggs are typically laid on the flower, but the larvae will eat leaves, stems, and fruits. While larvae are intercepted in vegetable shipments at US ports, the species is not known to be established in the US. *H. armigera* is considered a high priority pest for the CAPS (Cooperative Agreement Pest Surveys) program. The Oregon Department of Agriculture (ODA) has been surveying for it, with no finds to date. Unfortunately, there is a close native look alike, *Helicoverpa zea*, the corn earworm, and the only way to tell them apart for sure is by dissection. Since there is no specific lure for *H. armigera*, the lure that is used is the same one that is used for *H. zea*. Because this lure is very effective at attracting *H. zea*, screening of trap catches to check the specimens becomes a very time consuming process.

Table 1: Summary of lepidopteran family interceptions in imports destined for Idaho, Oregon and Washington, October 2012–October 2013 (Agricultural Quarantine Activity System)*.

Noctuidae	53
Tortricidae	18
Pyralidae	13
Unknown**	12
Pieridae	10
Geometridae	9
Plutellidae	7
Gelechiidae	6
Lymantriidae	5
Arctiidae	3
Crambidae	3
Lycaenidae	3
Gracillariidae	2
Cosmopterigidae	1

* numbers in this table represent interception records, not the number of specimens or individuals found.

** "Unknown" family designates interceptions of "unknown Lepidopteran species", usually egg or early instar larval samples.

Northwest Lepidopterists' Workshop 2013 (cont.)

Surveys for the European Gypsy Moth (EGM) have been carried out in the Pacific Northwest since the 1980s. Occasionally the EGM does make it here from the eastern part of the country where it is established, but eradication efforts have managed to keep it from becoming established in Oregon and the west. The success of this effort is due partly to the fact that female EGMs cannot fly, so any new infestations tend to grow relatively slowly and, if found early enough, can be eliminated. *Lymantria dispar asiatica*, the Asian Gypsy Moth (AGM) is another matter. Although very closely related to EGM, the AGM is native to Russia, China and Japan. Due to the female's ability to fly, and the broad host range (over 500 known plant species), the AGM poses a greater risk to the Pacific Northwest. During cyclical outbreaks in the forests around ports, female AGMs may be drawn in to bright port lights at night, where they lay their eggs on any available sheltered surface, including ships and cargo, some of which are regularly shipped to the Pacific Northwest. Due to concerns over the movement of cargo, and dissemination of egg masses and hatching larvae, DHS and APHIS monitor ports and international shipping pathways along US waterways. Ships considered at risk of AGM exposure are required to be inspected and cleaned at origin. When ships arrive at US ports of entry, they are inspected and, if too many egg masses are found, may need to return to international waters to be cleaned before being allowed to proceed. Federal agencies maintain a cooperative program with several countries to monitor their AGM outbreak populations, and strive to reduce the moth presence on ships and cargo. In addition, APHIS and state cooperators conduct annual surveys for Gypsy Moths in the US.

Unfortunately, recent challenges in funding have affected monitoring levels, and in 2013 the number of traps set out to detect Gypsy Moths was the lowest in several decades. Because female AGMs are strong fliers, a reduced trapping level raises the possibility that, if AGM does get introduced to some remote areas, it may not be detected until the population has become prevalent.

In planning for 2014, APHIS and our state cooperators are continuing to review risk information and plan for monitoring activities. Reviews typically include review of risk factors, including frequency of pest introduction, establishment and spread, likely impacts on plant production, and the availability of technology for monitoring and/or making taxonomic determinations of a target species. There are many insects that are found coming through the ports—some of these are dangerous, some are not, and some, we just don't know. Safeguarding requires the combined efforts of several federal and state agencies, as well as the informed cooperation of businesses and the public.

Entomologists are encouraged to work with APHIS and state agricultural agencies to report detections of any new exotic species that might potentially be plant pests. Before importing plants and organisms from abroad, Mark encourages researchers and travelers to review federal import regulations and permit information by visiting the APHIS website at <http://www.aphis.usda.gov/import_export/plants/plant_imports/index.shtml>.

On the Value of This Meeting

Paul Hammond noted that, when people bring their butterflies and moths together for these workshops, unexpected things are found. For instance, Michael and Dennis Strenge visited Farewell Bend on the Snake River over in Baker County, Oregon, on 16 August 2005. There they collected a big geometrid, *Somatolophia pallescens*, that had never been found in the Pacific Northwest before. It is known from western Colorado, Utah, New Mexico and Arizona (see Rindge, F.H. 1980. A revision of the moth genus *Somatolophia* [Lepidoptera, Geometridae]. Bulletin of the American Museum of Natural History 165 [3]: 291–334 which can be downloaded from <http://digitallibrary.amnh.org/dspace/handle/2246/317>.)

Dennis also brought a little geometrid in the genus *Digrammia* that is probably an undescribed species, since it did not match anything shown in Douglas Ferguson's 2008 publication (The Moths of North America: Geometroidea, Geometridae [Part]. Fascicle 17.2).

In addition, the collection brought in by Jim Reed's entomology class yielded a county record for *Atalopedes campestris* (Sachem) from Klickitat County, Washington.

Somatolophia pallescens collected Oregon: Baker County: Farewell Bend State Park at building light on 16 August 2005 by Michael and Dennis Strenge. Photo by Dennis Strenge.

Northwest Lepidopterists' Workshop 2013 (cont.)

On the Season Summary and PNW Butterfly and Moth Data Forms for Oregon, Washington, Idaho and British Columbia

Jon Shepard has been tabulating data for the Geometridae and some micros which will be the next groups available on the PNW Moths website <http://pnwmoths.biol.wwu.edu/>.

The plan is to add the butterflies eventually as well. Jon pointed out that the emphasis on state and county records in the Season Summaries for the Lepidopterists' Society has resulted in a lot of butterfly records being overlooked. To that end, Jon would like to receive all butterfly records, no matter how common the butterflies are, so that the historic material can be included when the butterflies are added. This would allow better tracking of butterfly populations so that changes, like the decline in *Papilio zelicaon* in the Willamette Valley, could be documented. He will provide community members with a spreadsheet that will show the data in a format that is easy for him to enter. He will take the data in this format, which is different from that used by the Lepidopterists' Society, and reformat them for the Season Summary. Jon indicated that the records that have come to the Lepidopterists' Society for the past 20 years are available online by species at <http://lepsoc.org/>.

Records and information for Oregon should still be sent to Dana Ross. Only butterfly records should be sent to Ann Potter for Washington. Moth records for Washington and all records for British Columbia and Idaho should be sent to Jon.

[Editor's Note: Jon sent the new spreadsheet out in mid-October. If you did not receive a copy please contact Jon at <shep.lep@netidea.com>.]

On Acmon Blue Butterflies in the Pacific Northwest

During the meeting, Paul Hammond made several comments concerning the taxonomy of the butterflies identified as *Plebejus acmon* (Acmon Blue) found in the Pacific Northwest. Many of these butterflies feed on species of *Eriogonum* (buckwheat). Current thinking is that there may be many different, but unrecognized, species lumped under this identification.

A number of years ago, one of the US Fish and Wildlife biologists visited some of the islands off the south coast of Oregon in the Oregon Islands National Wildlife Refuge to check on the birds. He collected some of the little blue butterflies he found in abundance associated with *E. latifolium*, basically a coastal sand dune buckwheat, which reaches up into Curry County and grows on some of these islands. This butterfly turned out to be an Acmon Blue but it is just a little different, and it is unclear if it is just some variety of Acmon Blue or actually a sibling species.

Acmon Blues found locally in the Willamette Valley seem to be mainly lotus feeders. It has not been determined whether these low elevation butterflies are the same as the mountain butterflies, like those found on Iron Mountain, which seem to be associated more with *Eriogonum*.

Many questions about the *Eriogonum* butterflies remain. Eleanor Ryan has compiled a booklet "Butterfly Enthusiast's Guide to Buckwheats of Oregon and Washington" that will help people identify the buckwheats associated with the butterflies they are finding. This booklet is available online at <http://www.parfaitimage.com/temp/>. Hard copies can be purchased for $22 (includes $2 donation to the NABA Eugene–Springfield Chapter) + shipping (about $3 in the US). Please contact Eleanor at <woodnymph3000@gmail.com> if you would like to order one.

For more information on the taxonomy of the blue butterflies associated with various buckwheats, read the summary of David Nunnallee's talk, "Buckwheats (*Eriogonum*) of the Pacific Northwest and Their Butterflies", that can be found in the Winter 2011/2012 issue of the Bulletin on pages 4–6.

Eugene–Springfield NABA Chapter Activities

Lois Hagen, President of the North American Butterfly Association Chapter, indicated that this year members completed their 22nd 4th of July butterfly count in the Eugene area, their 12th count at Browder Ridge–Iron Mountain, and their 2nd count in the Cascade–Siskiyou National Monument. The results of recent counts, including these, are available on their website, <http://www.naba.org/chapters/nabaes/>.

For the past five years, the group has also been monitoring the butterflies in the West Eugene Wetlands, <http://www.eugene-or.gov/index.aspx?NID=647>. They are particularly interested in determining which species are using the resources in this restored area. This year they surveyed every other week from mid April through late September.

Northwest Lepidopterists' Workshop 2013 (cont.)

David Lee Myers—Artistic Photographs of Butterflies

David showed images from a developing body of work that looks at butterflies in their habitats and people's interaction with butterflies. [Editor's Note: At the time of the workshop, some of these works were on display in the Linn–Benton Community College Art Gallery as part of an exhibit of works by 25 art faculty members from Clatsop, Mt. Hood and Linn–Benton Community Colleges. This exhibit will be at Mt. Hood Community College in 2014.] To provide a sense of place for his butterfly subject, he selects several images taken at different distances and creates a montage. In this way he addresses the question he is often asked, "where do you find that?" Since many of his subjects are found in semi-wild habitats, he wants people to recognize that there is a human aspect to the various different habitats.

David does a lot of photography on National Forest and BLM lands. Because he feels that we need more popular support and funding for these lands, he insists that, when his images are on public display, any accompanying label information include the place where the photograph was taken.

David ended with some images which showed the variety in the caudal spots of swallowtail butterflies. Because of genetic and age-related differences, as well as damage, he has become wary of purely visual field identifications for some common species. A couple of the butterflies he thought were one species when he took their photographs, turned out to be different ones when the images were examined later.

Next year, David would like to photograph people working in various habitats—taking care of them, restoring them and/or doing research in them.

A sample of David's work can be found at <http://davidleemyersphoto.com/>.

Pacific Slope Meeting of the Lepidopterists' Society

Eight workshop participants (Paul Hammond, Mark Hitchcox, David McCorkle, Chris Marshall, Jim Reed, Dana Ross, Jon Shepard, and Ray Stanford) attended the recent Pacific Slope Meeting at the Malheur Field Station this past August. Various people shared their impressions, recollections and the highlights of that meeting.

Dana indicated that it was late in the season and things were slowing down. He and Jim Reed found a number of *Satyrium titus* (Coral Hairstreak) individuals on the Steens Mountain Loop.

Paul drew people's attention to one of Dana's pictures taken near the summit looking down along the steep east side of the mountain. Paul indicated that some of the little glacial cirques visible in the picture had a permanent source of water from melting snow which created small, lush, wet areas where *Vaccinium* (huckleberry) grew. These areas were the habitat of *Colias pelidne* (Pelidne Sulphur) in the Steens.

While examining the Field Station's butterfly collection, Paul was interested to find a specimen of the *Speyeria cybele leto* (Great Spangled Fritillary) from the nearby Donner and Blitzen River. Jim Reed found it flying on one his local field trips. There are few records of this species from the southeastern portion of the state.

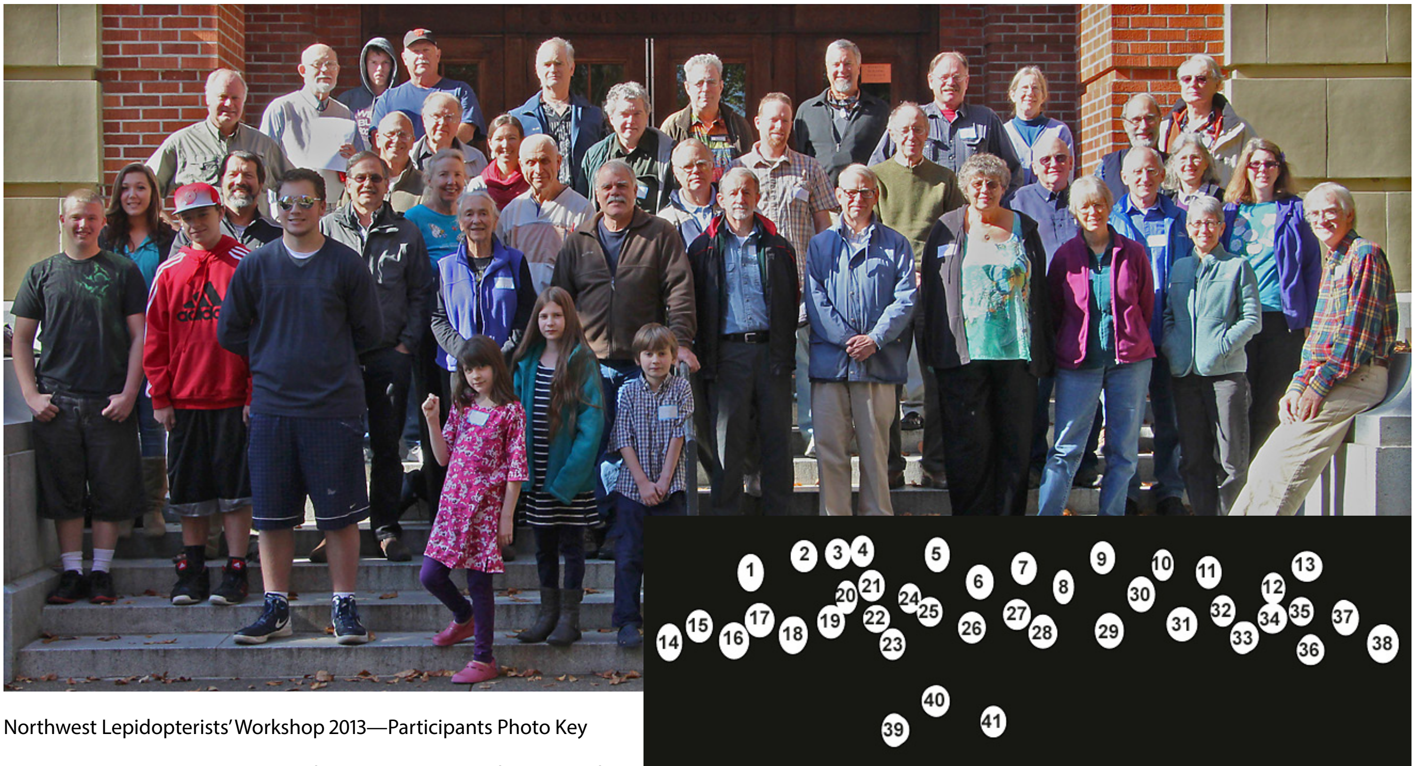
A short report on this meeting by David McCorkle was published on page 8 of the Fall Bulletin along with a group photo.

On the Workshop Date

A number of people were unable to attend this year due to the early timing of the meeting. Past workshops have usually been held on a weekend closer to Halloween, but the actual date depends to a large extent on a desire to avoid holding the meeting on the same weekend as an Oregon State home football game because of the number of fans that come to Corvallis for these games. Since OSU policies also require a staff person to be on hand, it also depends on the availability of either David Maddison or Chris Marshall on the selected date. The people in attendance preferred having the workshop earlier in October rather than later in November when the date is decided. Chris Marshall indicated that, from the university standpoint, earlier in the fall term was also better for him and David as their time commitments were less restricted and meeting space was easier to come by.

Next year, the date of the workshop will be emailed out to potential attendees when it is determined in the spring. The date will also be posted on the OSAC website and an announcement will appear in the Bulletin of the Oregon Entomological Society (online at <http://odonata.bogfoot.net/oes/>).

Northwest Lepidopterists' Workshop 2013 (cont.)



Northwest Lepidopterists' Workshop 2013—Participants Photo Key

1) Dave McNeese
2) Jon Shepard
3) Jake Forgey
4) Bruce O'Hara
5) Ron Sleeter
6) Ross Tewksbury
7) Ray Stanford
8) Mark Hitchcox
9) Dana Ross
10) Gary Lindberg
11) Lori Humphreys
12) Alan Richards
13) David Lee Myers
14) Logan Foix
15) Samantha Moss
16) Scotty Harrington
17) Jim Reed
18) Mason Knowland
19) Rick Ahrens
20) Terry Stoddard
21) Dave McCorkle
22) Carol Specht
23) Eleanor Ryan
24) Candace Fallon
25) Dave Specht
26) Don Severns
27) Dennis Strenge
28) Alan Jenkins
29) Paul Hammond
30) Bill Neill
31) Ann Albright
32) Dennis Deck
33) Sue Anderson
34) David Hagen
35) Ann Musche
36) Lois Hagen
37) Alison Center
38) Ron Lyons
39) Hunter McNeese
40) MacKenzie McNeese
41) Trevor McNeese

Next Year: Northwest Lepidopterists' Workshop 2014

In 2014 the groups of emphasis will be:

- Butterflies: Acmonoid Blues and Hairstreaks
- Moths: general moths, Pyralidae

On the Oregon State Arthropod Collection (OSAC) Library

Jon Shepard is interested in making the OSAC library a center for lepidopteran literature. He wants to fill out some of its current holdings and obtain copies of the various regional journals. Most of the regional journals are not present in the OSU library so their acquisition will make the OSAC library more comprehensive. (While Jon's primary interest is Lepidoptera, he is working on improving all aspects of the library's journal holdings so there are other publications he is also interested in getting.) If you want to make a literature donation please contact Jon at <shep.lep@netidea.com>.

Acknowledgements

I would like to extend my many thanks to all the presenters for their comments, corrections, and changes to the various summaries I prepared from the meeting record. I know all the feedback improved the accuracy and usefulness of the material. Thank you all very much.

Ron Lyons

The Pacific Northwest Lepidopterists' Fund in Honor of Harold E. Rice: Call for Proposals for 2014 Season

"In honor of Mr. Rice, we [the Oregon State Arthropod Collection (OSAC)] have allocated funds to support the community of Pacific Northwest lepidopterists to which Harold belonged. In particular, we hope the fund will encourage and facilitate the valuable research, work and contributions made each year by individuals, who like Mr. Rice, were not employed fulltime as lepidopterists, yet spend much of their personal time and resources collecting and studying these amazing creatures." (excerpted from the Fund's write-up)

This fund, which provides one or two awards for up to $500 each, is given annually to encourage activities directly related to PNW Lepidoptera and/or activities related to the improvement of OSAC's Lepidoptera collection. More information, as well as directions for how to apply, can be found by downloading the PDF from <http://osac.science.oregonstate.edu/PNWLepidopteristsFund.pdf>.

If you have any questions (e.g. am I eligible?, would this project qualify?) or need some advice on writing your proposal (e.g. how specific do I need to be?), please contact Chris Marshall at OSAC, <Christopher.Marshall@oregonstate.edu>.

For full consideration applications must be received by 31 January 2014.

North American Butterfly Association (NABA) Pacific Northwest Chapters

To keep abreast of the activities of the Oregon Eugene–Springfield Chapter visit their website at <http://www.naba.org/chapters/nabaes/index.html>. Meetings are scheduled for 10 February and 14 April 2014.

To keep abreast of the activities of the Washington Butterfly Association visit their website at <http://www.naba.org/chapters/nabaws/>.

News from the Xerces Society: In Pursuit of Rare Bumble Bees

Volunteers are vital to bumble bee conservation. This year Xerces citizen scientists submitted 82 records of rare bumblebees across North America. These include important new records of *Bombus affinis* (Rusty-patched Bumble Bee), *Bombus terricola* (Yellow-banded Bumble Bee), and *Bombus occidentalis* (Western Bumble Bees), all of which have experienced precipitous population declines. These findings are significant because many bumble bees face an uncertain future. Recent analyses by the Xerces Society show that nearly half of the bumble bees in North America may be imperiled.

Visit <http://www.xerces.org/bumblebees/> for information on Project Bumble Bee. This page includes a link to a nice three minute narrated video of Rich Hatfield searching for the Western Bumble Bee on subalpine meadows in the Mt. Hood National Forest.

The new Bumble Bee Watch website <http://www.bumblebeewatch.org> will launch fully early in 2014. Until that time, you can submit your observations by email or ask to be notified when the site is ready. See the placeholder page for details.

Recent Paper on the Columbia Clubtail (Odonata: Gomphidae)

Gomphus lynnae (Columbia Clubtail) is a relatively newly recognized dragonfly species, having been described by Paulson in 1983. The species is now known to occur along the Columbia River watershed in several areas in eastern Oregon and Washington.

Ken Tennessen and Steve Valley (2013) recently published a list of all the known localities of *Gomphus lynnae*. The authors discuss the various sites where it has been found and offer suggestions for other areas that need to be explored. In addition, they give a detailed description and illustration of the last instar nymph.

References

Paulson, D.R. 1983. A new species of dragonfly, *Gomphus* (*Gomphurus*) *lynnae* spec. nov., from the Yakima River, Washington, with notes on pruinosity in Gomphidae (Anisoptera). Odonatologica 12(1): 59–70.

Tennessen, K. and S.A. Valley. 2013. New Records for *Gomphus lynnae* Paulson (Odonata: Gomphidae), with a Description of the Nymph. Proceedings of the Entomological Society of Washington 115(4): 333–341.

Name Correction

In the Fall 2013 issue of the Bulletin on page 9 there was a picture of the participants at the 2013 Pacific Slope Meeting of the Lepidopterists' Society. I misspelled Mark Hitchcox's last name in the caption. I apologize to Mark for this error and for any confusion it may have caused among the readership.

Ron Lyons