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Two Mid-Holocene Tick Remains from Paisley Caves, Oregon

Martin E. Adams[1]

I have written in past issues (Adams 2017a, 2017b) about insect remains recovered from Paisley Caves in southern Oregon. As an archaeoentomologist, one who studies insect remains from archaeological sites, I find this to be an amazing site with excellent preservation that has yielded thousands of insect remains. Doubtless, I will be contributing more to the OES Bulletin from this site. Some of these insect remains can be directly tied to human behavior, others can be used as climatic or environmental indicators, and still others are just "background fauna" —insects that were found at the site simply because that is where they happened to die. Although it is exciting to look at all of the variety of different insect remains present, I have a particular interest in human and animal ectoparasites and was pleased to discover the remains of a tick.

The Paisley Five Mile Point Caves Site (35LK3400), hereafter referred to as Paisley Caves, is a pre-Clovis (>13,500 years old) rock shelter site in Lake County, Oregon, in the northern Great Basin. It consists of a series of eight caves along a western-facing ridge of Miocene-aged basalt and rhyolite in the Summer Lake Basin, and acted as a seasonal hunting and processing camp for Great Basin hunter-gatherer populations. Archaeological excavations of Cave 2 are extensive, and human occupation in that cave spans from at least 13,000 years ago (possibly earlier) to

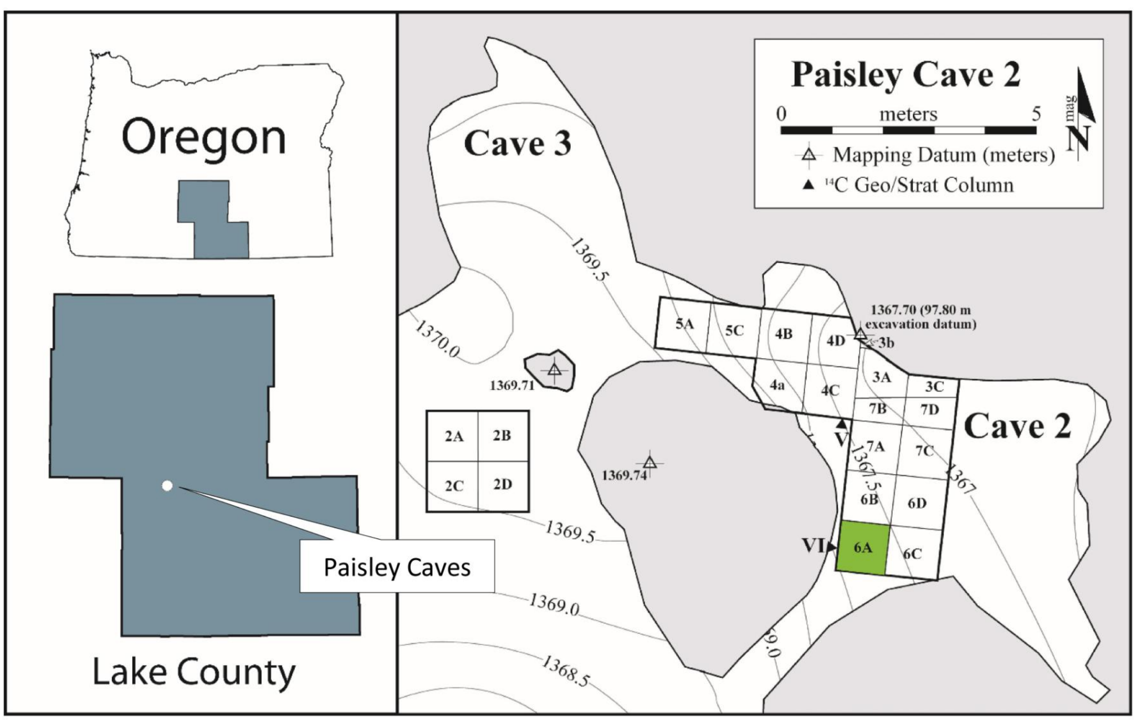

Figure 1. Site location and plan map of the excavation units of Cave 2 at the Paisley Caves site. The shaded excavation unit (6A) is the unit from which the *Otobius megnini* remains were recovered.

[1] Archaeoentomologist, Paleoinsect Research, PO Box 144, Clatskanie, OR 97016. Email: <paleoinsect@gmail.com>, Website: <http://paleoinsect.com>.

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~2,000 years ago, when the roof of Cave 2 collapsed. Humans still occupied Cave 2 from time to time after that, but the artifacts suggest it was much more sporadic than before (Jenkins et al. 2016; Hockett et al. 2017).

Cave 2 is seven meters wide and six meters deep, and excavations consisted of Units 1 through 7, generally divided into four 50 x 50 cm quadrants (Figure 1). From Unit 6A, two tick remains were recovered from level 26 (130 cm below the surface). These remains represent exuviae—the cast-off shell of an exoskeleton after an arthropod molts. The first specimen (Figure 2) is represented by virtually the entire cast-off exoskeleton of the nymph, with all eight legs present and the capitulum (the collective head and mouthparts). The dorsal part of the exuviae was connected only at the anterior end. The second specimen consisted of just a small fragment of the ventral surface of the anterior part of the exoskeleton, with only three legs and the capitulum present (Figure 3). Through classification keys (Cooley and Kohls 1940, 1944; Herrin and Beck 1965; Woolley 1983) and comparisons with specimens on loan from the U.S. National Tick Collection (housed in the Biology Department at Georgia Southern University), I have identified them both as nymphs from the spinose ear tick, *Otobius megnini* (Acari: Argasidae). Based upon the radiocarbon dates from level 16 above (2,335-2,345 calibrated years before present [cal. BP]) and a large layer of tephra in levels 36 and 37 below, from the eruption of Mt. Mazama (7,640 cal. BP), these two tick specimens are estimated to be approximately 4,800 years old.

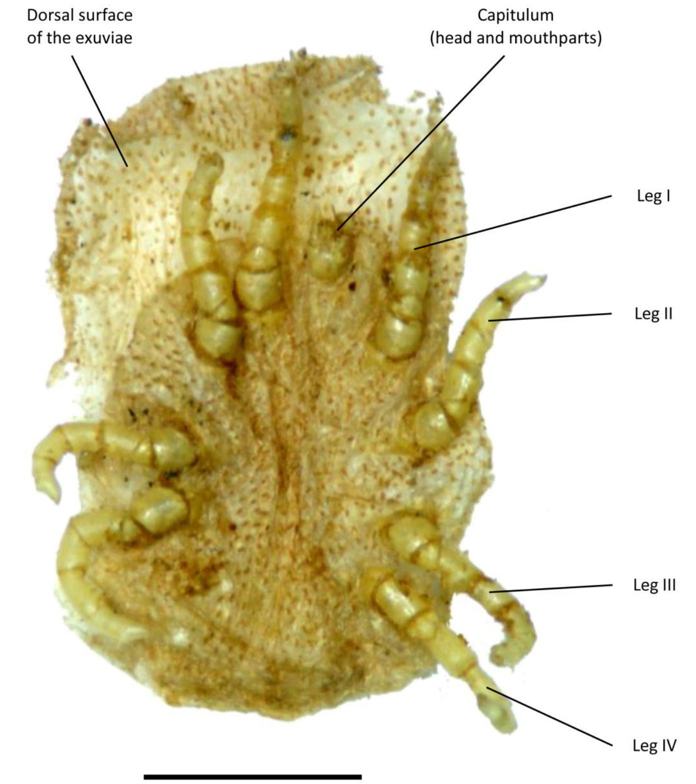

Figure 2. Ventral view of the exuviae of an *Otobius megnini* nymph recovered from Cave 2 at the Paisley Caves site. Scale bar = 2 mm. Photo by Martin Adams.

Archaeologists that study faunal remains at archaeological sites always want to quantify those remains: Do these remains represent two ticks or only one? To answer that, several aspects of *Otobius* systematics, development, and feeding behavior need to be examined. First, there are only two species of *Otobius*—*O. megnini* and *O. lagophilus*, a parasite of rabbits—and although there are anatomical differences between the two nymphs, one developmental difference is that *O. megnini* undergoes two nymphal stages, while *O. lagophilus* undergoes only one. This is important because were these specimens the remains of *O. lagophilus*, they would surely represent two different individuals. However, as *O. megnini*, they might represent two different individuals or only one individual from each of the two nymphal instars.

Within *Otobius megnini*, the differences between the first nymph stage and the second nymph stage are slight (Cooley and Kohls 1944). The first stage nymph is generally smaller with more slender legs, and the hypostome, the toothed projection that allows the tick to hang onto its host when feeding, is smaller as well. Between the two Paisley specimens, the whole specimen (Figure 2) is generally smaller (with thinner legs) than the fragmented specimen (Figure 3), and the hypostome appears smaller though in this form it is difficult to measure. Could this mean that one is a first instar nymph while the other represents the second instar? Could gender play a role in determining this? Nymphs of both stages are sexually immature. In fact, obvious

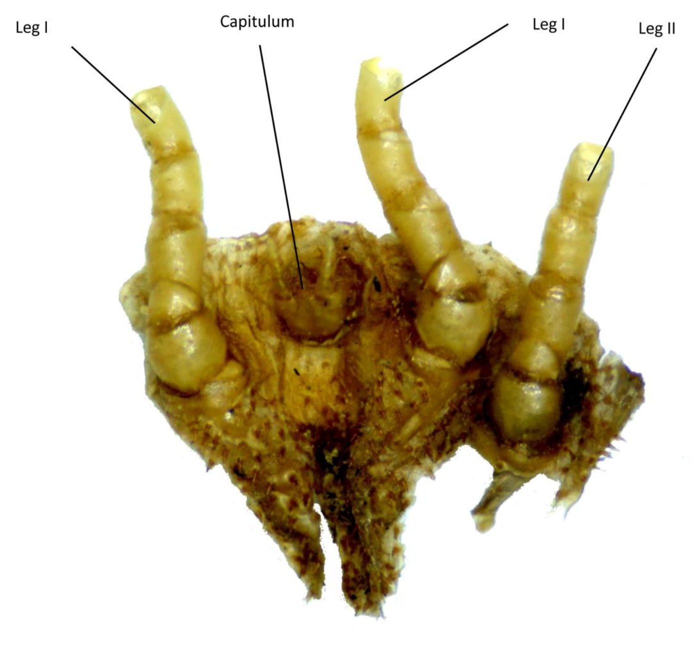

Figure 3. Frontoventral view of the fragmented exuviae of an *Otobius megnini* nymph recovered from Cave 2 at the Paisley Caves site. Scale bar = 2 mm. Photo by Martin Adams.

internal and external sexual characteristics are only present in the adult, and one might infer from the seeming lack of discussion on this aspect of nymph anatomy among any of the *Otobius* references that future male and female ticks in this stage display no obvious size differences. In other words, if both of these were second instar nymphs, the smaller one may not necessarily have developed into a male (the smaller of the two adult genders), nor might the larger one develop into a female.

Unlike other ticks, *Otobius megnini* does not feed in the adult stage. Eggs are laid on the ground, and the tiny larvae make their way deep into the ear canal of the host, spending the next ~200 days feeding inside the ear. It is a one-host tick, remaining in the same host throughout the larval and most of the nymphal stages. The second instar nymph will eventually make its way out of the ear canal and drop to the ground before molting into a sexually mature adult (Rich 1957; Munaó Diniz et al. 1987). Based upon this, that both remains were found on the ground in close proximity to each other, it seems likely that the Paisley Caves remains represent two individual tick nymphs, both in the end stages of the second instar, which dropped out of the host onto the ground and molted into adults. This could be from the same host, as it would not be uncommon for the host to have more than one tick in its ear at the same time. The exuviae of a first instar nymph would likely have remained inside the ear canal.

In modern times, *Otobius megnini* is a parasite of domestic animals and livestock (dogs, cats, cattle, sheep, goats, llamas, horses), as well as wild ungulates and equines, coyotes, mountain sheep, ostriches and lions (Cooley and Kohls 1944; Bishopp and Trembley 1945; Shaw 1947; McIntosh and McDuffie 1956; Rich 1957; Munaó Diniz et al. 1987). As domestic animals were unknown to the hunter-gatherers of Paisley Caves, the wild fauna roaming in the northern Great Basin are likely hosts of this specimen. The most likely wild host in this area would be the pronghorn antelope, *Antilocapra americana* (Meleney and Roberts 1970; Hockett et al. 2017). Additionally, the tick has been recorded as a human parasite (Temple 1912; Nuttall 1914; Kohls et al. 1965; Krinsky 1983; Eads and Campos 1984; Merten and Durden 2000), often as a result of close proximity to the tick's natural hosts. The human occupants of Paisley Caves hunted and processed pronghorn antelope, so it would not be far-fetched to suggest that the host of these tick individuals may have been human. Though irritating to have ticks feeding in one's ear, *O. megnini* is not known to be a vector for any diseases.

Native to North America, particularly in the American southwest, *O. megnini* is now widespread in the continent and has also spread to Hawaii, Central and South America, India, and South Africa (Rich 1957; Munaó Diniz et al. 1987). Still, though it has been recorded in Oregon, it is a relatively rare tick here. Known sightings include Jefferson, Malheur, Sherman, Umatilla, and Wasco Counties (Chamberlin 1937). It is not recorded in Lake County, to my knowledge.

Acknowledgments

The author wishes to thank Lorenza Beati and Colleen Evans from Georgia Southern University for loaning specimens of *Otobius* from the U.S. National Tick Collection, which were used to identify the specimens in this study. Images of the specimens were produced using a Zeiss AxioCam ERc5s attached to an AccuScope 3075 stereo microscope, and I am grateful to Virginia Butler for allowing me to use it in this study. Support for the Paisley Caves Project was provided by NSF Grant #0924606; Danish National Research Foundation; the Centre for GeoGenetics; Natural History Museum of Denmark; University of Copenhagen, Denmark (Eske Willersleve, Director); the Bureau of Land Management and Bill Cannon, the Lakeview District archaeologist; UO Archaeological Field School; UO Museum of Natural and Cultural History; OSU Keystone Archaeological Research Fund; Bernice Peltier Huber Charitable Trust; University of Nevada – Reno Great Basin Paleoindian Research Unit; Association of Oregon Archaeologists; Don Dana; Arthur Hurley; Steve Kohntopp; Robert Engle; Origer Associates, Inc.; and other private contributors.

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Isocapnia spenceri Ricker from the Willamette River, Lane County, Oregon

Cary Kerst

The weather forecast for the night of March 12 was for a warmer night than recent weather. I decided to put a light trap out to see if I could collect some caddisflies, and placed one along the Willamette River at Brown's Landing State Park (N44.19860° W123.16460°). There is a small parking area near River Road about 3 miles southwest of Junction City, Oregon.

Isocapnia spenceri, male and female. Photo by Cary Kerst.

Upon collecting the trap the following morning, I found that there were a number of stoneflies in it. There were 21 males with micropterous wings along with a single female of what appeared to be the same species though much larger and having normal wings. The body length of males was 8 mm while the female was 12 mm. The photo shows the large disparity in size between the male and female. They appeared to be Capniidae, and I sent a photo of a male to Boris Kondratieff at Colorado State University for identification. Boris identified them as *Isocapnia spenceri* Ricker which he indicated was a good find. Jonathan Lee (personal communication) indicated that *Isocapnia* are relatively rare or at least rarely collected.

Zenger and Baumann (2004) list the localities for *Isocapnia spenceri* which range from southeastern Alaska to the central California Sierra Nevada and Coast Range. They examined small micropterous males (7–10 mm), larger macropterous males (9–11.5 mm) and macropterous females (10–14 mm). Brachypterous females are also known. Illustrations in Zenger and Baumann confirm that the males and female from the trap are *Isocapnia spenceri*.

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An 11-sentence approach to improve undergraduate writing: notes from Bi452 Insect Biology at the University of Oregon

Phil Schapker, M.S.

Thesis (one sentence)

To obtain skill in logical argumentation and scientific writing, students at the university level require thoughtful, directed mentorship and meaningful, revision-based practice; a classic method used by high-school English teachers is here promoted.

Supporting Section 1 (one introductory statement followed by two sentences of explanation)

Unfortunately, too many science departments lack an intentional policy to address undergraduate writing on a frequent and consistent basis. When research papers are assigned they are often arbitrarily long, both encouraging fluff and BS on the part of the student, and making it difficult or impossible for the instructor to provide feedback and opportunity for revision. The result is that, by graduation, our science students are still struggling to produce logically structured, coherent arguments, to cite sources correctly, and to write sentences with even basic English grammar.

Supporting Section 2 (same as above)

My proposed method—the 11-sentence research paper, requiring the consultation of just three scientific articles—comes at first as a great relief for students who dread writing long research assignments, but gets tricky fast. Like this very essay, the students must create both a general introduction and conclusion, leaving only 9 sentences—or 3 sentences for each of 3 articles, properly cited—to form an ordered thesis. The college writing game changes from, "*how big can I make the font, margins, and spacing to meet the page requirement*?" to "*how can I arrange these ideas logically?*" and "*how can I possibly say this in just a couple sentences?!?*"

Supporting Section 3 (same as above)

The results so far have been promising. Because the papers are small enough, I have time to quickly and intensively read and correct each submission, get them back to the students, and require revisions for a final grade. The students, who also give short presentations on their research, have expressed enthusiasm for this type of learning, and are further motivated to succeed because of the possibility that their teacher might submit their papers to the Bulletin of the Oregon Entomological Society!

Conclusion

What follows are some of the most successful papers produced by the 2016 and 2017 University of Oregon Bi452 Insect Biology classes, which—though still imperfect—should nevertheless be of interest to the readers of the Bulletin.

Silk Spinning Behavior in Insects

Nicole Zavoshy

While silk is utilized by a variety of different insects, communal silk spinning has only been documented in three orders: Lepidoptera, Embioptera, and Hymenoptera (Edgerly et al. 2002).

Malocosoma americanum (Lepidoptera: Lasiocampidae) egg clusters hatch to create larval communities that spin a single domicile in the shape of a tent to inhabit during their instar stages. Fitzgerald and Weller (1983) observed that the tent consists of various layers of silk produced by a colony of caterpillars, who may or may not be genetically related, and that the size is increased to accommodate for the growth of the larvae over time. The larvae organize during tent expansion to add silk to the structure as a group and were observed to increase the thickness of the tent on the side most illuminated by the sun, indicating photosensitivity.

Adults of the order Embioptera (commonly referred to as "webspinners") have a uniquely modified front tarsus used for the spinning of silk, and create permanent nests with them. Edgerly et al. (2002) conducted a study of three separate species of embiids by taking video footage of the spinning behavior and discovered that, while there are subtle differences between species, the females of all three species use their front right tarsus to produce various strands of silk and then knead and manipulate the threads when constructing domiciles. In some cases, genetically unrelated females were found to communally spin silk to create nests, then cohabitate; while males were rarely found in the domiciles with the females, they did not contribute to the silk spinning at all.

The ant *Melissotarsus emeryi* (Hymenoptera: Formicidae) utilizes silk spinning as a construction material for nests. Unlike other species of ants that harvest larval silk as a building material, Fisher and Robertson (1999) discovered that the adult ants of this species have silk glands located on their heads. A protarsal silk brush on the leg of the ant is used in a "kneading" motion to pull the fibers from the silk glands for incorporation in the nest.

Despite the fact that many different insects are able to produce silk, the aforementioned species are a select few that have evolved the ability to spin the silk communally to ensure increased chances of survival.

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Aggressive Mimicry of the Orchid Mantis

Virginia Rose Seagal

The orchid mantis, *Hymenopus coronatus*, exhibits a behavior known as aggressive mimicry, where they confuse pollinating prey by disguising themselves as flowers and imitating the chemical signals of their prey.

H. coronatus appear to lure in hymenopterans more successfully than the flowers that they imitate. O'Hanlon et al. (2014) tested the chromatic contrast between *H. coronatus* and various orchid species, and found it to be below the detection limit of hymenopterans. It turns out that orchid mantises not only resemble orchid flowers to pollinators in the visual spectrum, but also in the UV spectrum.

Curiously, juvenile orchid mantises attract Oriental Honey Bees (*Apis cerana*) better than the adults. Minuzo et al. (2014) tested the chemicals emitted by the more successful juvenile mantises and compared them to those of the adults. They found that only juvenile orchid mantises emit the pheromones 3HOA and 10HDA from their mandibles, which are chemicals involved in Oriental Honey Bee communication.

Orchid mantises are generally found either among flowers or on leaf foliage, but O'Hanlon et al. (2015) found that mantises' choice of microhabitat has no effect on their predatory success. Orchid mantises were placed either within a patch of orchids or isolated among leaves and their predatory success was observed. Their experiments found that higher numbers of prey approach the orchid mantises when they are on flowers due to the presence of other pollinator attractants, but that their actual success rate is not affected by microhabitat.

Aggressive flower mimicry is a genius illusion by the orchid mantis, as they draw in pollinating honey bees not only by disguise as flowers in the UV spectrum, but simultaneously through honey bee pheromone trickery.

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Gyrinidae: Advanced Water Characteristics

Alyssa Osentowski

The water beetles in the family Gyrinidae have a number of interesting characteristics that make them highly adapted to life in water, such as two pairs of eyes, collapsible laminae, and various leg movement combinations.

The most recognized feature of Gyrinidae is their two pairs of eyes—one on the top and one on the bottom of the head—which allow them to see both above and below water when swimming. Blagodatski et al. (2014) set out to investigate whether there were differences between the overwater and underwater eye pairs. Their results show the eyes above the water contain a bumpy "maze-like" nanocoating making them anti-reflective, while the eyes below water are smooth and the refractive index of the lens closely matches that of water.

Along with their adaptive modification of sight, Gyrinidae are said to have one of the greatest thrust-generating apparati allowing for ultimate propelling in the entire kingdom of Animalia. After conducting several experiments looking at the strokes Gyrinidae take to swim, Xu et al. (2012) discovered that Gyrinidae have collapsible laminae on their legs, which when expanded increase the surface area during a power stroke. They can fold their legs under their body in order to not disrupt their streamlined ellipsoidal body shape, allowing for better coasting with less resistance.

Gyrinid beetles swim in a particular way to obtain optimal propelling capabilities in the presence of resistance and wave drag. Voise and Casas (2010) took video recordings of Gyrinidae swimming and discovered that these beetles have three stroke patterns allowing for speed variance. Since faster speeds lead to greater water resistance, gyrinids alternate between low and high speeds, between 35 cm/s – 60 cm/s, to maximize speed and reduce wave drag (Voise and Casas 2010).

Though Gyrinidae are able to occupy both land and water, they are able to maximize their water dwelling with the development of unique characteristics and advanced swimming capabilities.

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Eusocial Behavior in Diploid Coleoptera

Zoë Wong

Though eusociality is often attributed to the high genetic relatedness of haplodiploid organisms, the particular mode of its occurrence in southeastern Australian *Austroplatypus incompertus* (Coleoptera: Curculionidae) provides support for an alternative hypothesis for the evolutionary motivation of eusociality.

Eusociality—the social organization that consists of multiple generations coexisting and cooperatively dividing tasks for the good of the colony—is a rare but tremendously successful strategy that has sparked a considerable amount of research and debate over its evolutionary origins. The kin selection hypothesis, which links eusociality with haplodiploidy, the fertilization system predominant in Hymenoptera, has been the prevailing theory since emerging in the 1960s (Hamilton 1964). Since then, however, contradictory examples including termites, synalpheid sponge-dwelling shrimps, bathyergid mole rats, and the ambrosia beetle, *A. incompertus*, have cast doubt on the causal link between haplodiploidy and eusociality (Wilson 2012).

Despite being discovered in the early 1950s and named in 1968, *A. incompertus* remains challenging to observe because adult beetles are not phototaxic and developing larvae and pupae must be cut out from the heart of living *Eucalyptus piularis* trees in order to be studied (Kent 2010). Kent et al. (1992) reported eusociality in these ambrosia beetles and recorded eusocial colonies that were up to 37 years old and characterized by a reproducing female and unfertilized daughters that eventually lose or remove their last four tarsal segments. The colonies also display cooperative brood care, an outbreeding 1:1 sex ratio, and unfertilized adult females that maintain galleries by protecting against predators and by removing frass and accrued waste products.

Perhaps most interestingly, the ploidy of *A. incompertus* does not support the kin selection hypothesis. Smith et al. (2009) created a polymorphic microsatellite marker and found that both males and females of *A. incompertus* are diploid. This diplodiploid genetic system suggests that environmental, ecological, or other unknown factors play a large role in creating a high enough cost-benefit ratio to drive eusociality.

The observation of eusociality in *A. incompertus* is undeniably intriguing on an entomological level, but has broader implications in how it contributes to the reevaluation of previously held beliefs about genetic explanations for altruism and eusociality.

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Facial Pattern Recognition in *Polistes* Paper Wasps (Hymenoptera: Vespidae)

Dorsa Rahmatpoor

Convergent evolution between mammals and insects gave rise to cognitive specializations in some species of social *Polistes*, commonly known as paper wasps, which enables them to recognize conspecific faces (Sheehan and Tibbetts 2011).

In hopes of discovering the impact of this cognitive specialization on the brain composition, Gronenberg et al. (2008) performed a morphometric analysis on the individual brain compartments of different paper wasp species. While the optic lobes did not exhibit any difference in size, the size of the antennal lobes were reduced in the facial pattern-discriminating species, suggesting a reduction in the significance of olfactory communication (Gronenberg et al. 2008). Due to lack of an explicit effect on the other regions of the brain, Gronenberg et al. (2008) hypothesized that a preadaptation for general pattern discrimination in all species of *Polistes* allows facial pattern-discriminating species to distinguish facial markings with minimal rewiring.

Sheehan and Tibbetts (2011) compared the pattern-recognition ability between two closely related species of paper wasps: *P. fuscatus*, a social species which exhibits facial pattern variabilities, and the solitary *P. metricus*, which lacks facial markings (Sheehan and Tibbetts 2011). Using a negatively reinforced T-maze, Sheehan and Tibbets (2011) demonstrated that *P. metricus* does not individualize conspecific faces and is more successful in recognizing general patterns whereas *P. fuscatus* evidently distinguishes normal conspecific faces faster than the images of caterpillars despite being a caterpillar-predator species. Also, these experiments revealed the failure of *P. fuscatus* in recognizing face images that were missing antennae, which seems to be an important cue in visual recognition for this species (Sheehan and Tibbetts 2011).

In a more recent study, Berens et al. (2017) assessed the brain transcriptome of *P. fuscatus* and *P. metricus* in the context of facial recognition. Using the same method as Gronenberg et al. (2008), Berens and colleagues (2017) trained both species of paper wasps to recognize simple patterns and faces, then isolated the RNA content of their brains. RNA sequencing of 237 distinct transcripts proposed that the expression of a set of brain-specific genes different from the ones responsible for general pattern recognition may be the underlying reason for specialization of *P. fuscatus* in facial pattern recognition (Berens et al. 2017).

The growing knowledge about the complex cognitive behavior of social insects, such as the facial pattern recognition in some species of *Polistes*, promises a better understanding of their evolutionarily successful social networks and may also provide insights into the neural-development of this unique skill in mammals.

Work Cited

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Sheehan, M.J., and E.A. Tibbetts. 2011. Specialized Face Learning Is Associated with Individual Recognition in Paper Wasps. Science 334(6060): 1272–1274. (View the abstract at <https://doi.org/10.1126/science.1211334>.)

Utilization of electric fields for flower selection in *Bombus terrestris*

Robert Pennington

Although we have known about the effects of electric fields on insects for some time, with the exception of monotremes, decision-making resulting from electroreception was thought to be exclusive to aquatic animals; however, newer research reveals that not only are *Bombus terrestris* bees able to detect electric fields, they may actively utilize them to make decisions regarding flower visitation.

A study by Warnke (1976) showed that when subjected to a strong electric field, honey bees become hyperactive and aggressive, often stinging each other to death or destroying their hive in an attempt to hide from the field. Warnke was also able to show that changing weather patterns that presented a strong change in electrostatic potential—such as an approaching thunderstorm—could cause bees to become more aggressive and likely to sting as they made their way back to their hive. However, while the study did point out several changes in general behavior, no specific decision-making or utilization of electric fields by the bees was observed.

By using small tungsten wires attached to nerve sockets on positively charged bees, Sutton et al. (2013) were able to locate mechanosensory hairs on *B. terrestris* that physically bent in electric fields. The results indicated that the bees were able to detect very slight electric fields that stimulated a neural response similar to a mechanical or olfactory signal. The bees used for the experiment were killed beforehand, so behavior regarding electrical fields was not observed.

Clarke et al. (2013) showed that *B. terrestris* are able to detect and avoid flowers visited by other bumblebees based on the flower's charge. In a controlled environment, when the naturally positively charged bumblebees landed on negatively charged flowers, some of the charge was exchanged, and other bees visiting later were less likely to visit the flower with the lessened potential. When the charge on all of the flowers was removed, bumblebees were not able to differentiate between flowers with a sucrose reward and those with an aversive substance.

This could indicate that not only does this species of bee detect electric fields, but they are able to use that detection to choose which flowers have already been visited by other bees, and which flowers will provide them with the greatest reward.

Works Cited

Clarke, D., H. Whitney, G. Sutton, and D. Robert. 2013. Detection and Learning of Floral Electric Fields by Bumblebees. Science 340(6128): 66–69. (View the abstract at `<https://doi.org/10.1126/science.1230883>`.)

Sutton, G.P., D. Clarke, E.L. Morley, and D. Robert. 2016. Mechanosensory hairs in bumblebees (*Bombus terrestris*) detect weak electric fields. Proceedings of the National Academy of Sciences of the United States of America 113(26): 7261–7265. (View the article at `<https://doi.org/10.1073/pnas.1601624113>`.)

Warnke, U. 1976. Effects of Electric Charges on Honeybees. Bee World 57(2): 50–56. (View a preview at `<https://doi.org/10.1080/0005772x.1976.11097592>`.)

Insufficient Pollen for Honey Bee Colonies Contributing to their Decline *Maisie Bailey*

Poor nutrition in honey bee larvae and young adults results in poor performing adult honey bees as well as higher susceptibility to harmful fungi and parasites.

Similarly to humans, young honey bees that are malnourished face obstacles in adulthood. In a controlled study in which larvae were deprived of pollen, Schofield et al. (2015) found that, as adults, pollen-stressed worker bees were smaller, foraged less, and died much sooner than non pollen-stressed worker bees. In addition, pollen-stressed workers performed inaccurate waggle dances, if the worker bee could perform a dance at all.

In order to study the link between nutrition and fungus susceptibility, honey bee larvae were nutritionally deprived and tested for their susceptibility to the fungi *Aspergillus flavus*, *A. phoenicis* and *A. fumigatus* (Foley et al. 2012). Results showed that the larvae became more susceptible to *A. fumigatus*, but not to the others. However, if the infected larvae were fed a diet of dandelion or polyfloral pollen, the fungus retracted (Foley et al. 2012).

The negative effects of parasites can be exacerbated when combined with poor nutrition.Van Dooremalen et al. (2013) found that pollen-deprived honey bees infected with *Varroa destructor*, a parasitic mite, had reduced body weight and irregular protein levels in their abdomens compared to *V. destructor* infected bees supplied with normal levels of pollen. Contrasted with the previous study, when fed an ample amount of pollen post *V. destructor* infestation, the adult bees were unable to gain weight (van Dooremalen et al. 2013).

As the decline of honey bees continues to threaten food crops worldwide, an understanding of honey bee nutrition will be imperative in combating the effects of a continuously changing climate.

Works Cited

Foley, K., G. Fazio, A.B. Jensen, and W.O.H. Hughes. 2012. Nutritional Limitation and Resistance to Opportunistic *Aspergillus* Parasites in Honey Bee Larvae. Journal of Invertebrate Pathology 111(1): 68–73. (View the abstract at `<https://doi.org/10.1016/j.jip.2012.06.006>`.)

Schofield, H.N., and H.R. Mattila. 2015. Honey Bee Workers That Are Pollen Stressed as Larvae Become Poor Foragers and Waggle Dancers as Adults. PloS ONE 10(4): e0121731. (View the article at `<https://doi.org/10.1371/journal.pone.0121731>`.)

van Dooremalen, C., E. Stam, L. Gerritsen, B. Cornelissen, J. van der Steen, F. van Langevelde, and T. Blacquière. 2013. Interactive Effect of Reduced Pollen Availability and Varroa Destructor Infestation Limits Growth and Protein Content of Young Honey Bees. Journal of Insect Physiology 59(4): 487–493. (View the abstract at `<https://doi.org/10.1016/j.jinsphys.2013.02.006>`.)

Andrews Forest Information

The Andrews Forest (in Lane County north of Highway 126 between Blue River and McKenzie Bridge) has been the site of a considerable amount of research by the faculty and students at Oregon State University. Information on the Andrews Forest can be found on the website, `<http://andrewsforest.oregonstate.edu/>`. This includes information on meetings, tours, symposia, species lists, research studies and maps.

Slugs and Snails of Oregon

Ron Lyons

A lot of the creatures discussed in the Bulletin may be difficult to find or only rarely encountered if you are not specifically looking for them. However, most people probably encounter snails and slugs on a regular basis. Unfortunately, a number of the Oregon species are not native.

Josh Vlach from the Oregon Department of Agriculture has put together a 39 page guide that provides a good introduction to Oregon's slugs and snails. Download the PDF from `<http://www.oregon.gov/ODA/shared/Documents/Publications/IPPM/ODAGuideMolluscs2016ForPress.pdf>`, or use the interactive, smartphone friendly version at `<https://www.odaguides.us>`.

Additional information on slugs can be found in Rory McDonnell's guide from UC Riverside at `<http://anrcatalog.ucanr.edu/pdf/8336.pdf>`.

See T. E. Burke's The Land Snails and Slugs of the Pacific Northwest from the Oregon State University Press © 2013 for more detailed information.

Prophysaon andersoni on cedar siding near Bandon, Oregon, 21 January 2018. Photo by Ron Lyons.

Invertebrate Classes offered by the Siskiyou Field Institute

The Siskiyou Field Institute is located in Selma, in the Illinois Valley about 20 miles south of Grants Pass off Highway 199. Their catalog is available at `<http://www.thesfi.org>`.

Saturday–Sunday, April 28-29, 2018
Spring Butterflies of the Siskiyous
Instructor: Dana Ross, M.S.
This new two-day course offers an introduction to the spring butterfly fauna of southwestern Oregon. We'll spend mornings learning about various aspects of the 50+ species that may be encountered at this time of year. As the day warms up, we will head to the field to observe and net butterflies and hone our identification skills. If you have taken our June course in Lepidoptera, this will be an opportunity to observe a number of new species.

Date: Saturday, May 12, 2018
Pollinator Ecology
Instructor: August Jackson
Enhance your appreciation for our ecoregion's native plant communities by learning how their pollinators ensure fertilization and species survival. Become familiar with a number of prominent pollinators. We'll cover basic concepts of pollination ecology and develop understanding of factors that contribute to our region's unique assemblage of pollinating insects. We'll practice simple methods of identifying common fly and bee genera as we encounter them in the field and observe their behavior.

Dates: Thursday–Friday, May 31–June 1, 2018
A Naturalist's Guide to Beetles of Southwestern Oregon: Late Spring Edition
Instructors: James LaBonte, M.S and Bill Schaupp Ph.D.
Meet the beetles in this late spring update of last year's workshop. Almost 5,000 beetle species are known to live in Oregon and you just never know when a new one will turn up under a rock. Known species include blind soil beetles, wood-boring beetles, dung beetles and fungi-eating beetles. In this "Beetles 101" field course, students can expect to acquire general knowledge about diversity, behaviors, ecological roles, and natural histories of the beetles found at and near Deer Creek Center. Although we'll consider beetles in all accessible habitats, we'll focus on those inhabiting leaf litter and soil, with a presentation on bark beetles from USFS entomologist Bill Schaupp. Field trips, lecture, labs and optional night collecting will give us plenty of opportunities to collect and observe diverse species.

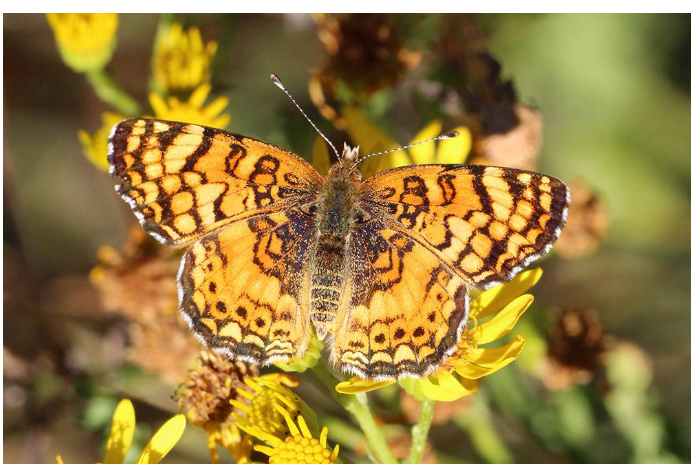
Dates: Monday–Wednesday, June 18–20, 2018
Introduction to Butterflies and Moths of the Siskiyous
Instructor: Dana Ross, M.S.
We will explore the world of Lepidoptera—the butterflies and moths—in this three-day course. Starting with an overview of butterfly moth morphology, life cycles, ecology and behavior, we'll then inspect images and specimens of Siskiyou species in the classroom. Monday and Tuesday afternoons, students will have opportunities to work in the field netting and inspecting butterflies and learning proper netting and collection techniques. Day 3 will be spent entirely in the field near the Cascade-Siskiyou National Monument.

Lepidoptera Activities in 2018

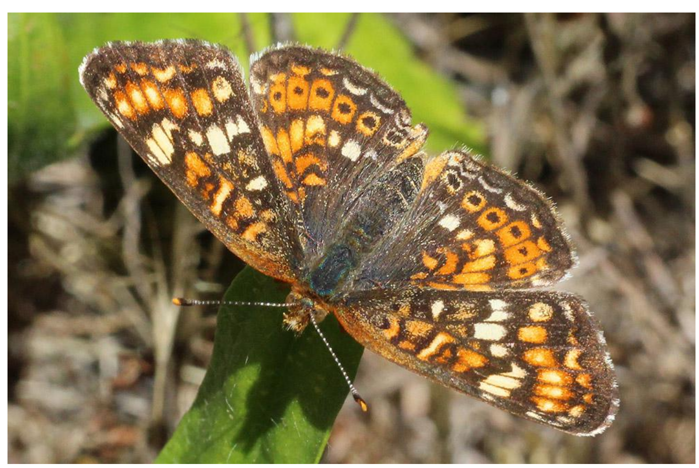
Butterfly Field Trips for Northern and Central California

Paul Johnson provided the following list of field trip/counts of interest to butterfly enthusiasts. In some cases the dates were still uncertain or had not been set yet. If you are interested in participating in any particular event, please email the contact person **beforehand** for updates and information.

Location	Date	Contact Person	Email	Highlights
Greater Bay Area				
Pinnacles National Park	3 June	Paul Johnson	paul_johnson(at)nps.gov	high counts for 7 species in 2015
Marin County	3 June	Wendy Dreskin	bdreskin(at)comcast.net	Audubon Canyon Ranch to Ring Mountain
Mount Diablo	5 June	Rich Kelson	rkelson(at)sftp.com	42 species in 2017
Big Creek (Big Sur)	8 June	Mark Readdie	readdie(at)ucsc.edu	Gorgeous UC Nature Reserve
Monterey	9 June	Chris Tenney	tenneyx2(at)mac.com	34 species in 2016
Hastings Reservation	10 June	Chris Tenney	tenneyx2(at)mac.com	Unsilvered Fritillary (nationally unique)
Benicia	14? June	Paul Johnson	paul_johnson(at)nps.gov	Yuma Skipper and 5 swallowtail species
Berkeley	15 June	Jerry Powell	powellj(at)berkeley.edu	41 species in 2017
San Francisco	16 June	Liam O'Brien	liammail56(at)yahoo.com	All-time national record high for Anise Swallowtail in 2011
San Bruno Mountain	? June	Hannah Ormshaw	Hormshaw(at)smcgov.org	3 endangered butterflies possible
Point Reyes	?	Ben Becker	ben_becker(at)nps.gov	Located on beautiful National Park lands
Northern and Central California				
Big Chico Creek	1 June	Don Miller	dgmiller(at)csuchico.edu	CSU, <www.csuchico.edu/bccer>
Cosumnes	16 June	Kyle Bowlin	bowlink(at)saccounty.net	At a Central Valley nature preserve
San Joaquin Co.	16 June	Kathy Schick	kaschick(at)berkeley.edu	39th year of this count
Warner Mtns North	23 June	Joseph Smith	foxglove1985(at)yahoo.com	75 species in 2017
Lava Beds	25 June	Joseph Smith	foxglove1985(at)yahoo.com	National Monument – 47 species in 2017
Yuba Pass	? July	Paul Opler	paulopler(at)comcast.net	72 species in 2017
Butterfly Valley	? July	Chris Tenney	tenneyx2(at)mac.com	3rd year of count – 62 species in 2017
S. Lake Tahoe	15? July	Will Richardson	will(at)tinsweb.org	
Mt. Lassen	14 July	Joseph Smith	foxglove1985(at)yahoo.com	National Park – 80 species in 2017
White Mtns	25 July	Chris Tenney	tenneyx2(at)mac.com	Highest elevation count in California
Glass Mtn	27 July	Kristie Nelson	storm_petrel(at)hotmail.com	2nd year of count – 50 species in 2017
Yosemite	30 July	Sarah Stock	sarah_stock(at)nps.gov	12 national high species counts in 2013



Phyciodes mylitta (Mylitta Crescent) on Marys Peak in Benton County, Oregon on 27 September 2017. Photo by Ron Lyons.



Phyciodes pulchella (Field Crescent) at Lake Earl in Del Norte County, California on 6 June 2013. Photo by Ron Lyons.

North American Butterfly Association (NABA) Eugene-Springfield Chapter

The field trip and meeting schedule for the Eugene-Springfield Chapter including the results from some of their past outings can be found on their website at <http://www.naba.org/chapters/nabaes/>.

Sarah Kincaid will speak on "The Oregon Bee Project/Oregon Bee Atlas" at the meeting on Monday, April 9th, at the Eugene Garden Club, 1645 High Street, Eugene, Oregon. There is a social period from 7–7:30 pm with the presentation beginning at 7:30 pm.

According to the information from the "Upcoming NABA Events" link on the home page, the following butterfly counts are scheduled:
July 1, Sunday – Eugene Fourth of July Count
July 14, Saturday – Frissell Ridge and Iron Mountain

The following field trips are also currently scheduled:
June 9, Saturday – West Eugene Wetlands
July 28, Saturday – Groundhog Mountain or Holland Meadows

Please check their website for changes and/or additions to the event schedule as well as the event details.

Other Oregon Butterfly Counts

The Cascade–Siskiyou National Monument butterfly count will be Saturday, June 16th. If you would like to participate, please email <diannekeller18@gmail.com> **beforehand**.

According to the information from the "Upcoming NABA Events" link on the NABA Eugene-Springfield home page, the following non-NABA butterfly counts are also scheduled:
Thursday, June 28 – Ochocos
Friday, July 6 – Metiolus

Washington Butterfly Association (WBA)

Information on WBA activities can be found on their website, <http://wabutterflyassoc.org/>.

40th Northwest Lepidopterists' Workshop

The 2018 Northwest Lepidopterists' Workshop will be held at Oregon State University in Corvallis on the weekend of October 13-14, 2018. The program will appear in the Fall Bulletin.

The groups of emphasis in 2018 will be:
►Butterflies: *Phyciodes*, *Chlosyne* and Hesperiidae (skippers)
►Moths: Sphingidae

Other Activities and Events

2018 Pacific Branch Meeting

The 102nd Annual Meeting of the Pacific Branch of the Entomological Society of America will take place June 10–13, 2018 at the Atlantis Casino Resort Spa in Reno, Nevada. For the latest information please visit <https://www.entsoc.org/pacific/2018-branch-meeting>.

Nature Photographers of the Pacific Northwest

The spring meeting will be Saturday, April 7, 2018 in the McGuire Auditorium at Warner Pacific College in Portland, Oregon. Doors open at 8:30 am, and the program begins at 10 am. Visit <http://www.nppnw.org/> for details and registration information.

Xerces Society Events

Please check the Xerces website, <http://www.xerces.org/event/>, for events scheduled in the Pacific Northwest or webinars.

At the moment there are 2 webinars that may be of interest.
Promoting Beneficial Insects in Vineyards for Conservation Biological Control on April 3rd
and
Best Management Practices for Pollinators on April 18th

Some events are scheduled for California.

If you would like to help out on a science investigation check out the projects on Monarchs and other butterflies listed on the citizen science page, <http://www.xerces.org/citizen-science/>.