Sand Dune of Ruby, Arizona, an Anthropogenically Created Biodiversity Hotspot for Wasps and Their Velvet Ant Parasitoids

Justin O. Schmidt
Southwestern Biological Institute, Tucson, Arizona

Abstract—*A large artificial sand dune composed of finely crushed mine tailings was produced by deep mining operations at Ruby, Arizona. Today, the ghost town of Ruby is an important historical location and biodiversity refuge, with the newly formed dune forming the core of the refuge. The dune provides ideal nesting habitat for at least 13 species of sand-loving wasps, including cicada killers (Hymenoptera: Sphecius) that are sometimes present in record breaking populations. Following the colonizing wasps were at least 14 species of velvet ants (Hymenoptera: Mutillidae) that parasitize the wasps. Host wasp species range in size from about 9 to 1000 mg; various opportunistic velvet ant species exploit the entire host range of available wasps, resulting in velvet ants ranging in size from 6 to about 250 mg. These findings indicate that colonization of the man-made Ruby dune by both wasps and their parasitoids occurred rapidly after dune formation.*

Introduction

Ruby was a prominent mining town in the Atascosa region of south-central Arizona near the border with Sonora. The town was named Ruby in 1912, not for the gemstone, but for Julius Andrews's wife, Ruby, who he certainly must have felt was a true gem (Weiser 2010). The town formed around vast, rich ore deposits that were mined on a small scale during the late 19th and early 20th Centuries. Starting in 1926 with the purchase of the mine by the Eagle-Picher Lead Company, the settlement became a boomtown through the 1930s, before closing in 1941. At its peak production in 1934-37, the mine was the largest producer in Arizona of lead and zinc and third largest in silver. Culturally, Ruby was a well operated company town reaching a population in its heyday of over 1200 inhabitants, and became best known for a pair of gruesome double murders in 1920-21 (Ring *et. al*. 2005; Weiser 2010).

A byproduct of the mine was a huge sand dune generated from the pulverized tailings of the mined ore. The sand tailings were dumped in the canyon next to the mine, eventually filling it to a height over 15 m and creating two lakes upstream. Although the exact date of the sand dune's creation is not clear, it undoubtedly began reaching its present size during the period of 1926-1940. Consequently, this man-made island of sand among the Sky Islands of the Madrean Archipelago is extremely recent in geologic terms. Currently the dune is home to a myriad of sand-loving wasps, mainly sphecid wasps (Crabronidae and Sphecidae) plus various paparazzi-like parasitic insects that follow their activities and exploit their nest and larval stores. The most abundant of these parasites are the velvet ants (family Mutillidae). Sphecid wasps, sometimes called hunting wasps, prey on various insects and spiders, which they usually subdue via a paralyzing sting. In most cases the hapless inactivated prey is subsequently transported to a nest constructed by the wasp. Nests consist of several cells, each of which serves as the incubator for a wasp larva that feeds on the provisioned prey. When cells are completed with adequate food supplies, they are sealed and abandoned, leaving the larvae to develop on their own to form the next generation (O'Neill 2001).

Sphecid wasp nests are exploited by a variety of other wasps, flies, and others having a parasitic lifestyle. Aggregations of sphecid wasps, as in a limited sand dune area, present an abundance of resource opportunities, thereby often attracting large populations of many species of parasites. At Ruby, the most conspicuous of these parasites are the velvet ants. Not true ants, rather wasps with wingless ant-like females and winged males, velvet ants are among the hardest, most colorful, and best-defended insects known (Schmidt and Blum 1977). They are technically parasitoids because the larvae consume and kill the prey rather than just feeding, usually non-lethally, on a host as does a typical parasite. The hosts of many velvet ant species are unknown, in large part as a product of their lifestyles of entering the hidden cells of their hosts where they lay an egg on the quiescent host pupa or prepupa. Velvet ants frequently are considered opportunists that accept a wide variety of different species and sizes of hosts. Hosts are mainly bees and wasps (Brothers 1972).

The purpose of this investigation is to document the colonization of the Ruby sand dune by sand-loving wasps and their associated parasitic velvet ants.

Materials and Methods

All surveys were conducted exclusively on the Ruby dune proper from about mid-August through mid-September 2009-2011. The dune is located at 31° 27' 30.90" N, 111° 14' 00.04" W, elevation 1267 m. It measures approximately 334 x 143 m in length and width and has a total surface area of 4.00×10^4 m^2 (4.00 hectares) (fig. 1). Within the dune are various areas including broad flat bare areas, small sparsely grassed stable hummocks elevated about a meter above the plain, larger eroding buttes 1-3 m in height, and deep eroding cliffs

In: Gottfried, Gerald J.; Ffolliott, Peter F.; Gebow, Brooke S.; Eskew, Lane G.; Collins, Loa C., comps. 2013. Merging science and management in a rapidly changing world: Biodiversity and management of the Madrean Archipelago III; 2012 May 1-5; Tucson, AZ. Proceedings. RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

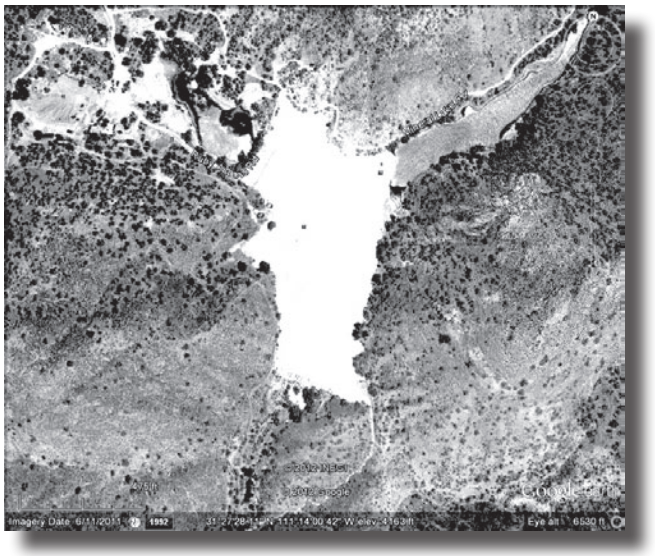

Figure 1–Google Earth image of Ruby dune and surrounding area.

where the dune meets the lower valley floor of the drainage basin. The sand throughout is very fine, uniform, and densely packed.

Wasps were collected manually and by insect net during daylight hours, placed on ice, and transported to the lab where their live weights and identities were determined. Voucher specimens are deposited in the University of Arizona Entomology Collection.

Results

Thirteen species of sand wasps were recorded on the dunes. Six of these were very common to abundant. The largest and most conspicuous sand wasp in Ruby, and perhaps of Arizona, is *Sphecius convallis*, the Pacific cicada killer, so named because it paralyzes cicadas to provision its larvae. These huge bright yellow and light brown wasps attain lengths of 4 cm and weigh more than 1 g, with males usually much smaller than females (Coelho 1997). Ruby appears to have the largest population of these wasps known with well over a thousand individuals present during good years. Anybody visiting the dunes during their active period cannot avoid noticing these wasps, especially the males actively patrolling territories and searching for females.

The second largest wasp on the dune is the "great black wasp", *Sphex pennsylvanicus*, which weighs on average an estimated 300 mg and hunts katydids. This conspicuous species is common around the cliffs and buttes regions of the dune, though its numbers are considerably fewer than the cicada killers. *Ammophila* sp., a caterpillar hunter, weighs about 100 mg and can be observed resting on the sand or hovering just above it in many locations around the dune. Its slender shape, but not color pattern, makes this common wasp conspicuous. The large bembicine wasp, *Bicyrtes viduata*, actively flies and chases others in large aggregations in the flat areas near the dune center. This abundant and striking black and yellow wasp weighs on average 83 mg and paralyzes Hemiptera as prey. A smaller bembicine wasp, *Microbembix* sp., is even more abundant, perhaps being the most common species on the dune. This 26 mg wasp, resembling a small *Bicyrtes*, nests in the flat central dune area as well as other areas. It provisions its young with dead arthropods and fragments. A final abundant member of the big six common wasps is *Tachysphex* near *terminatus*. Unlike its larger wasp co-inhabitants, this tiny wasp, weighing only about 9 mg, is neither flashy, nor conspicuous. It is most prominently found around the hummock area of the dune where it provisions its nest with immature katydids and other orthopteran relatives.

In addition to the common dune wasps, are an assortment of infrequently encountered species. These species, usually observed singly or in low numbers, range in size from a large second species of *Bicyrtes* weighing about 150 mg to the 18 mg *Stenodynerus apache*. Five others species: *Cerceris* sp., *Eucerceris* sp., *Dolichodynerus vandykei*, *Podalonia sericea*, and an unidentified sphecid are present. Others undoubtedly also make the dune home.

A large, diverse guild of velvet ants shares the dune habitat with the sand wasps. These species range widely in size from the 6 mg *Dasymutilla monticola* to the nearly 250 mg *D. klugii* (*D. magnifica* is excluded, as only one specimen was found and the species is generally equal in size to *D. klugii*)(table 1). Twelve of the 14 species form a gradual size gradient from about 6 mg through 80 mg. The conspicuous outliers are the two ecological siblings, *D. klugii* and *D. magnifica,* which are about 3 times as large as the nearest sized species. In addition to filling all available size niches at the species level, the individual velvet ant species span enormous ranges in the size of individuals. For the most abundant species, those with three or four stars of relative abundance in table 1, the average size range

Table 1—Weights, size ranges, and relative abundances of velvet ants in the Ruby dune.

Velvet ant species	Weight (mg)	Weight range (n)	Size range (max wt/min wt)[a]	Relative Abundance
Dasymutilla monticola	5.9	2.9-12.7 (14)	4.38	***
D. asteria ♂♂	10.0	2.8-21.8 (23)	7.79	****
♀♀	11.7	3.8-21.9 (53)	8.82	****
Pseudomethoca praeclara	15.4	15.1-15.6 (2)		*
P. contumex	16	16 (1)		*
D. dilucida	20.1	7.8-46.5 (6)	5.96	**
Timulla near *dubitata*	22.8	22.8 (1)		*
D. ferruginea	~50	Estimate (1)		*
D. chiron	53.5	15.3-122.3 (81)	7.99	****
D. eminentia	63.0	34.6-91.7 (2)	2.64	**
D. zelaya	~63	Estimate (1)		*
D. sicheliana	64.5	31.5-83.0 (3)	2.68	**
D. nogalensis	78.4	45.8-109.5 (8)	2.39	***
D. klugii	239	123-400 (64)	3.25	****
D. magnifica	326	326 (1)		*

[a]No entry indicates insufficient data.

Figure 2–Size extremes in two velvet ant species, *Dasymutilla chiron* and *D. asteria*.

from smallest individual to largest individual is 5.26 (fig. 2). In comparison, the average size range within the most abundant sand wasps at Ruby is under 2.0 (data not shown). These numbers indicate that the sand wasps are more specialized, using a limited number of prey species, and that they additionally might have the opportunity to optimize the prey provisioned for each of their larvae. The wide size range for many velvet ant species reflects the fact that each velvet ant larva can only attain the size allowed by the available food in its cell; that is, the size of the host parasitized by its mother. If the mother's opportunities bring her to a host species with small individuals, the offspring will be small; if she finds host species have large individuals, the consequent velvet ant offspring will be large.

Discussion

The recent formation of the Ruby sand dune about 80 years ago provides an opportunity to investigate the speed of colonization of this new habitat. No other large man-made or natural sand dunes are present near Ruby and sand areas in the vicinity are scarce, small, and likely ephemeral areas along washes and stream courses. All wasps are partially limited by food resources (O'Neill 2001), but perhaps a more important factor for many species is availability of suitable nesting sites. If sand for nesting is scarce in the environment, that factor might be the crucial limitation in the life history of the species. The Ruby sand dune is unique in two ways: first, it is a huge sand resource for sand wasps; second, it is extremely recent in geologic time. The importance of the dune as a nesting resource is evident by the extreme population densities of wasps nesting in the dune and the large number of species present. The enormous numbers of cicada killers, a species rarely seen in other areas, is evidence that the environmental constraint on that species is not prey availability or prey carrying capacity, but, rather it is constraints on nesting locations. This flagship species provides a contrast to numerous other sand wasp species on the dune, many of which occur as in small numbers. The question arises, are these less common species limited by prey availability, some other factor, or were they constrained by ability to disperse to the dune from other areas? Are they recent arrivals that have not had adequate time to expand their populations? Long-term studies might well shed light on these questions.

Unlike the sand wasps, all of which can disperse by flight to arrive at Ruby, the velvet ant females are all flightless. That means to follow their wasp hosts and to colonize the dune, they needed to crawl there. Given the potential distances involved and the sizes of the velvet ants, this seems a remarkable feat; especially given that at least 14 species have colonized the dune is less than 80 years. Collections of both sand wasps and velvet ants in the areas of Arizona and Sonora that surround Ruby have been sparse. We, therefore, have little knowledge concerning the distance the velvet ants might have been required to travel to get to Ruby, or the densities of individuals in the pools from which the immigrants came. In other locations around Arizona, velvets ants are infrequently encountered, an exception being in the stabilized dune area near Willcox, Arizona, that has as many or more species than Ruby (Justin Schmidt, personal observations). The Willcox area contrasts Ruby in that it is a much older sand formation and is surrounded by mainly flat surface terrain.

Specific hosts for velvet ants are infrequently known. One exception is the relationship between cicada killers and the two largest velvet ants at Ruby, *D. klugii* and *D. magnifica*. Both of these enormous velvet ant species require equally enormous hosts, and cicada killers fit the bill. Indeed, western cicada killers are recorded as the host for *D. klugii* (Bradley 1920). This restriction to one host species (perhaps, in exceptional cases, *Sphex pensylvanicus* can be an alternate host to produce small individuals) for *D. klugii* is reflected in the narrow size range from smallest to largest individuals of only 3.25. A similar prey limitation might also occur for *D. nogalensis*, the second largest species at Ruby, which also has the small size range in the order of 2.39 among individuals. In contrast to these large species, the small and medium sized velvet ant species exhibit huge size ranges up to an over 8-fold difference is size between smallest and largest individuals in a species. This suggests that these smaller species are not nearly as limited in their range of available hosts, and likely parasitize almost any available host on the dune within a wide size range.

Acknowledgment

I thank Howard and Pat Frederick who generously encouraged this research, made the study site available, and provided background information and advice and Tom Van Devender and John Palting for reviews and comments on the manuscript.

References

Bradley, J. Chester. 1920. Note. Entomological. News 31: 112-13.

Brothers, Denis J. 1972. Biology and immature stages of *Pseudomethoca f. frigida*, with notes on other species (Hymenoptera: Mutillidae). University of Kansas Science Bulletin. 50: 1-38.

Coelho, Joseph R. 1997. Sexual size dimorphism and flight behavior in cicada killers, *Sphecius speciosus*. Oikos. 79: 371-75.

O'Neill, Kevin M. 2001. Solitary wasps behavior and natural history. Ithaca, NY: Cornell University Press. 405 p.

Ring, Bob; Ring, Al; and Cahoon, Tallia P. 2005. Ruby, Arizona–mining, mayhem, and murder. Tucson: U.S. Press & Graphics. 280 p.

Schmidt, Justin O.; and Blum, Murray S. 1977. Adaptations and responses of *Dasymutilla occidentalis* (Hymenoptera: Mutillidae) to predators. Entomologia Experimentalis et Applicata. 21: 99-111.

Weiser, Kathy. 2010. Mining and murder in Ruby, Arizona. Legends of America [Online]. Available: http://www.legendsofamerica.com/az-ruby.html [May 9, 2012].