Preliminary Assessment of the Moth (Lepidoptera: Heterocera) Fauna of Rincon de Guadalupe, Sierra de Bacadéhuachi, Sonora, Mexico

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Abstract—*The Sierra de Bacadéhuachi is a poorly sampled extension of the Sierra Madre Occidental (SMO) located in east-central Sonora near the town of Bacadéhuachi. Sampling of moths using mercury vapor and ultraviolet lights occurred in summer and fall 2011, and spring 2012 at Rincón de Guadalupe, located in pine-oak forest at 1680 m elevation. Approximately 400 taxa of moths were identified from this locality. Species occurrences demonstrate connections to the famously diverse Yécora area, to the higher, more mesic SMO in Chihuahua, as well as the Rocky Mountains to the north. Several unidentified and presumably new moth species from Rincón de Guadalupe await further study and description. Two species previously known only from the type specimens (destroyed in WWII) were rediscovered at Rincón de Guadalupe. A complete list of the moths identified from Rincon de Guadalupe is available as a Research Species List in the Madrean Archipelago Biodiversity Assessment (MABA)/Southwest Environmental Information Network (SEINet) online database (Madrean.org).*

Introduction

The Sierra de Bacadéhuachi is considered the westernmost massif of the Sierra Madre Occidental (SMO), and is located east of the Pueblo de Bacadéhuachi, Municipio de Bacadéhuachi, Sonora. While technically not a Sky Island, the range represents the northernmost extension of the SMO and serves as a conduit for SMO species to move north into the Sky Island region. Thus, species records from this area, of which there are historically few, are of interest to biologists working in the Sky Island region. The range is located only 34 km west of the border with Chihuahua, and 165 km south of the Arizona border. The Yécora plateau of the SMO is approximately 120 km to the SE. This area has historic significance as the location of Rincón de Guadalupe (RG), a rustic enclave of buildings constructed between 1920 -1940 in the pine-oak forest on property owned by the Catholic Diocese of Sonora. The main facility located in Arroyo Campo Los Padres (29°50'40"N, 108°58'37"W, 1680 m elevation) was used as a base of operations for the field activities reported herein.

The Sierra de Bacadéhuachi vegetation ranges from lowland foothills thornscrub up through desert grassland to oak woodland and finally pine-oak forest. The area immediately around RG is dominated by pine and oak, and bisected by a perennial stream. Eleven species of *Quercus* and five species of *Pinus* are recorded from the area along with *Cupressus arizonica*, *Fraxinus velutina*, and *Platanus wrightii*. The most speciose families in the preliminary flora of the Sierra de Bacadéhuachi are Asteraceae (54 taxa), Fabaceae (47 taxa), and Poaceae (36 taxa) (Van Devender and others, *Preliminary Flora of the Sierra Bacadéhuachi, Sonora, Mexico*, this volume).

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Methods

A combination mercury vapor/ultraviolet light or ultraviolet light alone was used to attract the majority of moth species collected. A few exceptions, such as *Coloradia prchali*, were netted during the day. The light stations were run from dusk until dawn in the summer and fall when the nights remained warm, and until approximately 1AM in the spring after which it became too chilly for moths to fly. Sampling was conducted throughout the night and specimens were spread on site and dried in an oven to ensure as many different "cryptic" taxa as possible were recorded and to get representative examples of sexually dimorphic species for identification. In addition, several photographers documented diversity at the lights with photo vouchers of living moths, all of which are available records in the Madrean Archipelago Biodiversity Assessment (MABA) database (Madrean.org).

Results

About 400 species of moths were identified from all three sampling expeditions to Rincón de Guadalupe. Given that this collection represents only three periods of activity and a total of nine collecting nights in a single locality of the Sierra de Bacadéhuachi, the diversity of this area appears to be exceptionally rich. The total moth diversity for all areas and all months known from the Huachuca Mountains 170 km to the north is 1500 species— 900 "macrolepidoptera" (Powell and Opler 2009) and 600 "microlepidoptera." This relatively well surveyed area (316 km^2) is biologically diverse with vegetation ranging

from desert grassland up to pine-oak forest in an elevational range of 1361 m (Bowers and McLaughlin 1966) similar to the Sierra de Bacadéhuachi. But given the strong influence and connections with the SMO, it is expected that further sampling of the Sierra de Bacadéhuachi in foothills thornscrub, desert grassland, and oak woodland along the 700 to 2370 m elevational gradient (range of 1670 m) at other times of the year will ultimately bring the number of moth taxa to well over that recorded for the Huachucas.

Summer Sampling (July 31-August 3, 2011)

This initial sample during the monsoon period documented around 205 species. The number of tropical taxa more typically associated with tropical deciduous forest (TDF) was surprising. These included the extremely large tailed saturniid moth *Dysdaemonia boreas*, a common monsoon species in TDF where the larval foodplants in the family Bombacaceae occur, and another saturniid moth, *Copaxa multifenestrata*, which was previously thought to be restricted to extreme southeastern Sonora where the caterpillars are thought to feed on plants in the family Lauraceae. Also recorded were tropical sphingids *Xylophanes ceratomoides* and *X. tersa*, and one of the largest tropical sphinx moths, the *Forestiera*-feeding *Sphinx leucophaeta*. A single specimen of the metallic, tropical wasp-mimic tiger moth, *Phoenicoprocta lydia*, was also an unexpected record. Northern range extensions for several species more typical of the Yécora plateau (120 km to the south) were also significant new records: *Coloradia prchali* and *Copaxa muellerana*, (both Saturniidae), *Epicrisias eschara*, *Ammalo* nr. *paranomon*, and *Amastus* (two species; all Erebidae; Arctiinae) These records also reflect the association of this area with higher and more mesic regions in the SMO in Chihuahua to the east. A noteworthy southern record of the large silkmoth *Hyalophora gloveri* was also obtained for a Rocky Mountains species with only a handful of Sonoran records.

While noctuids (cutworm moths) were not particularly speciose in August, some of those that were collected were important records and several are thought to represent new and undescribed species. Unusual northern records include *Cropia europs*, *Dypterigia dolens* (both Noctuidae: Amphypirinae), *Coenipeta bibatrix* (Erebidae: Erebinae), and *Metria sinaloa* (Erebidae: Catocolinae). *Schinia simplex*, a lovely green noctuid (Heliothinae) found in the Rocky Mountain region nearly to Canada, was an unexpected southern record, as there are no SE Arizona records of the species. A new species of *Richia* nr. *cofrensis* (Noctuidae: Noctuinae) was collected along with possibly new *Licnoptera* nr. *gulo*, a new *Panthea* nr. *gigantea* (both Noctuidae: Pantheinae), a new *Bryolymnia* nr *biformata* and a new *Elaphria* sp. (both Noctuidae: Amphipyrinae). The possibility that they had not been recorded as new species previously, *Zale* nr. *obsita* and Z. nr. *sabina* (Erebidae: Catocolinae) were also collected. However, these may be found to belong to the nominal taxa after DNA barcoding. *Zale sabina* has a single Arizona record, while *Z. obsita* has been recorded in southern Texas. Voucher specimens were forwarded to Don Lafontaine, an Erebid/Noctuid expert at the Canadian National Collection (CNC) in Ottawa, Canada, for DNA barcoding and further analysis. A specimen of *Paraceliptera guerreronis* (Erebidae: Erebinae) and a specimen of the shiny white *Chasmina mexicana* (Noctuidae: Stiriinae) collected on the August trip also proved to be very significant records. Both of these moths were described earlier in the 1900s from much farther south (Guerrero state) by the German lepidopterist M. Draudt and figured in the famous German lithograph series on Lepidoptera by Seitz. The original type and paratype specimens of these moths were destroyed in 1945 during WWII in the bombing of Dresden, Germany. The specimens collected at RG represent the first specimens collected since the type series and are currently with Don Lafontaine for DNA barcoding and study. These specimens will likely be designated neotypes of the two species. In addition to noctuids, two undescribed species of slug moths (Limacodidae) were collected at RG and specimens sent to specialist Marc Epstein in Sacramento, California. These specimens have been tentatively assigned to the genera *Natada* and *Miresa*.

Fall Sampling (September 3-5, 2011)

Conducted only a month after the initial sample, this trip yielded 214 identified taxa with almost half of these representing species not recorded in August. Virtually all of the "giant moths" seen a month earlier were absent as were most of the species with tropical affinities. Instead, there was an explosion of smaller moths, particularly those that feed on flowers. The noctuid family of Acontiinae moths, better known as "bird dropping moths," was particularly plentiful with 37 species in several closely related genera. Other noteworthy diversity was noted in the noctuid family Stiriinae, with 14 species records. Especially abundant was the bright orange "Goldenrod moth" *Cirrhophanus dyari*, with more than 100 showing up at the lights. A noctuid collected on this second trip was sent to Chris Schmidt in Canada, who recently revised the genus *Charadra* north of Mexico; He confirmed the moth as new—*C.* nr. *moneta*. An additional specimen of the rare *Chasmina mexicana* was recorded.

Larval activity was noteworthy in the fall sampling, and served as evidence that a flurry of moth activity had occurred with the onset of the monsoon rains. When known, these larvae were photographed and catalogued as records for MABA. Two particularly noteworthy species were *Crinotes beidermani* (Notodontidae), which had virtually denuded the *Ceonothus buxifolius* bushes around the compound, and *Eupackardia caletta* (Saturniidae) that was collected by a local cowboy on *Rhus aromatica*, a previously unrecorded foodplant for this moth.

Spring Sampling (April 1-3, 2011)

Despite cool evening temperatures and dry conditions, a spring sample at RG yielded an additional 122 taxa, 104 of these not being previously recorded. The Geometridae were especially diverse in this sample with 50 taxa collected including two possible new species. Several geometrids that are rarely encountered in the United States, and only in SE Arizona, were found to be common. *Stamnodes apollo*, *Hydriomena mediodentata* and *Pityeja picta* were all abundant here. While the silkmoths (Saturniidae) are typically expected during the summer monsoon, a freshly emerged male *Copaxa lavendera* was an unusual and new record for RG. Like *C. multifenestrata*, the larvae of this moth are usually associated with plants in the Lauraceae. But, this widespread tropical species has also been reared in captivity on *Quercus,* a more likely host plant in this locality. The occurrence of this tropical species so early in the season indicates that winter temperatures must be comparatively mild at RG even though the resident vaqueros reported snow on the ground only a month before. Other interesting records include an unidentified white *Artace* spp (Lasiocampidae) and surprising spring broods (based on the numbers of individuals seen) of *Caripeta pulcherimma* and *Pityeja picta* (Geometridae), both of which occur as univoltine summer species in Arizona, *Pityeja* in the Chiricahuas only.

Discussion and Conclusions

The most surprising aspect of the RG locality has been the number of tropical taxa encountered much further north than previously known, especially given the lack of contiguous records between here and previously documented populations. Particularly striking examples of this are *Chasmina mexicana*, *Copaxa multifenestrata*, *Cropia europs*, *Metria sinaloa, Paraceliptera guerreronis* and *Phoenicoprocta lydia*. This likely is the result of sampling bias in the northern SMO, with more sampling historically occurring in the Alamos area. The tropical Sphingidae encountered are less surprising given their ability to feed and disperse across long distances as adults. *Copaxa lavendera* encountered in the spring sampling was also less surprising as it is rather well known in the Yécora area. Two saturniids previously known from Sonora only from the vicinity of Yécora, *Coloradia prchai* and *Copaxa muellerana,* represent significant range extensions for unusual SMO species. *Coloradia prchali* is an especially unique species, with males being the only members of the genus that are diurnal while the females only fly after dark. This species was only described in 1992 and it remains a near-endemic species for Sonora (with records from nearby Chihuahua) with a very limited range.

Ceiba acuminata is occasional in foothills thornscrub at lower elevations in the Sierra de Bacadéhuachi and must be the host plant of the *Dysdaemonia boreas* taken in early August. While seemingly out of place among the pines, Peter Hubbell reported that tropical moths often stray into the upland pine-oak forest in Guatemala (pers. comm. through T. Van Devender). As the adults of the Saturniidae do not feed, they have rather limited dispersal abilities. However, they do have significant fat energy reserves and they tend to fly up hill as do many Lepidoptera and other insects, so the specimen must have started life further down the slopes of the Sierra deBacadéhuachi. The occurrence of this large tropical moth so far north is further evidence of the warmer temperatures in SMO versus northern pine-oak forests that allow 'tropical' plants to survive in close proximity to the oak/pine elevation. The *C. multifenestrata* record may also indicate a "pocket" of unsurveyed tropical vegetation near RG as this species is known to feed only of Lauraceae, a rather rare and restricted plant family in Sonora with no records of members being in the Sierra deBacadéhuachi. As the related (but more widespread) *C. lavendera* feed on both Lauraceae and Fagaceae, it is possible that *C. multifnestrata* is utilizing a plant in another family, but the complete lack of records of the species between RG and Alamos remains confounding.

The connection between RG and the main Sierra Madre of Chihuahua was evident through several species more commonly encountered in Chihuahua than in Sonora. These include the two species of *Amastus* and the *Ammalo* nr. *paranomon* as well as *Copaxa lavendera*. The beetle *Chrysina adelaida* (Coleoptera; Scarabeidae) recorded during both the summer and fall samplings at RG is a SMO species restricted in the Yécora area in Sonora and more commonly encountered in mountains of Chihuahua.

Unusually high numbers (hundreds of individuals) of the bright orange and black tiger moth *Epicrisias eschara* were encountered at RG in August. This moth does not occur in the United States and its life history (larva and foodplant) remains unknown. The moth was originally described from south of Mexico City (Dyar 1912) and was previously known to occur along the SMO axis as far north as Yécora. In 2010, two specimens, indicative of a small population, were documented in the Sky Island of Sierra La Madera and sampling at RG indicates a robust population in the Sierra de Bacadéhuachi. It would be interesting to correlate the distribution of this moth with a particular host plant, and to see if the plant species also decreased in abundance between RG, Sierra La Madera, and Arizona.

The rediscovery of two taxa "lost" to science was exciting, especially given that the original types were described from Guerrero state nearly a century ago. This and the number of new taxa identified at RG are indicative of how incomplete our knowledge is of biodiversity in northern Mexico. New species recorded from RG include at least two members of the Erebidae and six members of the Noctuidae. All specimens of the Prominants (Notodontidae) were sent to Jim Miller, AMNH, New York, for review, and he tentatively believes at least four of these are undescribed, including a new *Disphragus* sp and *Psilacron* sp. Geometridae from the spring sampling are also likely to include two undescribed species in the genus *Hydriomena* (Geometridae: Laurentiinae), and the Limacodidae sample also included two undescribed taxa.

The intent of this initial survey of moths is to provide a starting point in the MABA database for future bioinventories of the Sierra de Bacadéhuachi and a comparison to other locations, particularly the Sky Island area to the north. SE Arizona's Sky Islands, while fairly well- inventoried for the last 100 years, still yield new species of moths every few years. The gap in our knowledge of species really lies to the south in the Sky Islands of Sonora and in the northern SMO proper. It is not at all surprising that more than a dozen species new to science have been identified from RG, given the paucity of sampling that has occurred in this area. It is a good reminder of the exciting biology and endemicity that has developed in this region, where the new world tropics and the temperate zones meld together. As land use change in the northern sierra escalates to meet human needs, it becomes critically important that we know what is there so we can preserve some of it for the future. The relatively pristine state of RG compared with much of the heavily logged SMO makes it a standout for preservation from both natural history and human cultural history perspective.

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