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Source: The Journal of the Lepidopterists' Society, 68(2) : 130-140

Published By: The Lepidopterists' Society

URL: https://doi.org/10.18473/lepi.v68i2.a6

Journal of the Lepidopterists' Society
68(2), 2014, 130–140

HOST PLANT RECORDS OF *ANTHERINA SURAKA* (BOISDUVAL, 1833) (SATURNIIDAE) IN MADAGASCAR

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ABSTRACT. The larval stage of *Antherina suraka* (Boisduval) (Saturniidae) consumes leaves of plant species from 23 families. These host plant species belong mainly to families in the subclass Rosidae, although those in the family Oleaceae and Apocynaceae from another subclass (Asteridae) are nearly as numerous as those in the family Rosaceae. Documentation and field surveys from 2008 to 2011 in different regions of Madagascar enabled an update of the list of the host plants of *A. suraka*. As few records of host plants exist and no immature stages were found in the dry areas, in contrast with other regions of Madagascar, further studies of *A. suraka* in these special ecosystems will provide interesting ecological data. The discovery of several host plant species endemic to Madagascar showed that, although *A. suraka* has adapted to feed on non-native species in disturbed sites throughout its range, it remains reliant on native forests. Determination of its host availability in each region constitutes an important step in prioritizing the conservation of the edges of the remaining endangered forests, as it might help establish sericulture that can reduce deforestation by improving the livelihood of local people.

Additional key words: silkworm, food plants, deforestation, conservation.

Madagascar, the fourth largest island in the world located 400 km off the southeast coast of Africa, is known for its high biodiversity with an extraordinary level of endemism (Myers et al. 2000). Nearly 80 % of its plants (Schatz 2001) and vertebrates are not found anywhere else in the world (Goodman & Benstead 2005). It was separated 150–160 million years ago from mainland Africa and 88–95 million years ago from India (Rabinowitz et al. 1983, Storey et al. 1995, Wells 2003). Thus, the island has been isolated for 85 million years, which has allowed its living inhabitants to evolve independently, giving rise to adaptive radiations in many taxa and high levels of endemism at the genus or species level (Paulian & Viette 2003). In addition, biodiversity has been enhanced in relatively recent times by colonization by some living groups, including insects such as swallowtail butterflies (Papilionidae) (Zakharov et al. 2004, Condamine et al. 2013). The topography ranges from the mountainous central part of the island to the flat littoral areas and also features various geological barriers such as rivers, volcanic mountains and karsts, which offer additional opportunities for biological diversification. The climate regionally differs depending on elevation and the dominant winds. Both the variety of topography and climate led to the extremely high diversity of habitats. Thus, authors such as DeWit (2003) have characterized Madagascar as a continent.

However, this unique biodiversity in Madagascar is severely endangered because of destructive practices such as slash-and-burn agriculture, gathering wood for fuel, timber logging and mining activities (Mittermeier et al. 1999, Fritz-Vietta et al. 2011). Protecting the forests requires integrating local people into conservation projects, as they rely heavily on forest resources. Efforts are being made to implement integrated conservation management. One solution is to provide a new income stream for local farmers (Marcus 2001), as implemented by a non-governmental organization, Conservation through Poverty Alleviation International (CPALI), which works in the Northeast of Madagascar and trains farmers for silk production of local species of silkworms, thus reducing overexploitation of the remaining forests of Madagascar.

Worldwide, the main commercial silk-producing species are the domesticated silkworm, *Bombyx mori* L. (Bombycidae), and several wild silkworms from other families, mainly Saturniidae (Peigler 1993). In Madagascar, the Saturniidae or Emperor Moths are important primarily for their beauty, attracting insect collectors from around the world, but they have surprisingly been unused traditionally for silk production (Peigler 2004). Instead, a species of *Borocera* (Lasiocampidae) commonly called Landibe, has been mainly used throughout the country since ancestral times for manufacturing different garments, from funeral shrouds to traditional ceremony clothes (Razafimanantsoa et al. 2012).

This study focused on *Antherina suraka* (Boisduval, 1833) (Saturniidae), a species endemic to Madagascar and the Comoros Islands (Paulian 1951, Griveaud 1961, Viette 1965). Our investigation of host plant utilization by this species was restricted to the island of Madagascar, where *A. suraka* has been recently identified as a potential source for commercial wild silk production (Razafimanantosoa et al. 2006).

Collecting records in the Botanical and Zoological Park of Tsimbazaza (Parc Zoologique et Botanique de Tsimbazaza, PBZT) and the French National Museum of Natural History (Musée National d'Histoire Naturelle, MNHN) show that *A. suraka* is widely distributed throughout the island. Few specimens of *A. suraka* in these collections are labeled with any host plant data and their exact origins are rarely specified. This lack of information is not surprising as most of the specimens were collected as adults at lights, like other wild silk moths observed by Peigler (2004). Adding information about the host plant range of a phytophagous insect will aid significantly in understanding its natural history. In the literature, the larvae of *A. suraka* are recorded as consuming leaves of a variety of plant species (Bouvier 1936, Paulian 1951, Griveaud 1961, Stone 1991, Kurz 1991, Bowers 1993, Lampe 2010, Meister 2011) growing in diverse habitats. Of the plant species mentioned by these authors, only a small percentage were recorded from dry areas, although *A. suraka* is present in both dry and humid areas, two of the main types of vegetation in Madagascar. Further field exploration would therefore be necessary to complement these host records.

Information about host plants is important as it can serve as a tool to locate or rear a species for further biological studies or to maintain mass-rearing of the insect for economic purposes such as sericulture. Collating the distribution records of all host plants with distribution records for *A. suraka* would provide a versatile and useful tool for implementing conservation measures. Nonetheless, circumspection is recommended in this regard as the presence of a host species in a region does not necessary imply that the population of *A. suraka* living there optimally utilizes that species. As an example, over 90% of individuals of *Rothschildia lebeau* (Guérin-Méneville) (Saturniidae) recorded in a dry forest in Costa Rica were found living on only three species out of the 11 food plants recorded for the species in this region (Janzen 2003). Thus, larvae of *A. suraka* might use an alternative host plant as palatability of leaves might vary with altitudinal gradients (Erelli et al. 1998) and environmental conditions such as light availability (Osier & Jennings 2007) and drought (Gutbrodt et al. 2011).

The aim of the current study was to update the list of the host plants utilized by *A. suraka* throughout its range by recording larvae consuming leaves in specific regions of Madagascar and to collate these records with previous reports. The list of food plants recorded during our study is by no means exhaustive; rather, it is an attempt to shed additional light on the natural history of *A. suraka*, a spectacular representative of the endemic fauna that may provide, via silk production, a new income opportunity for the riparian farmers, which may

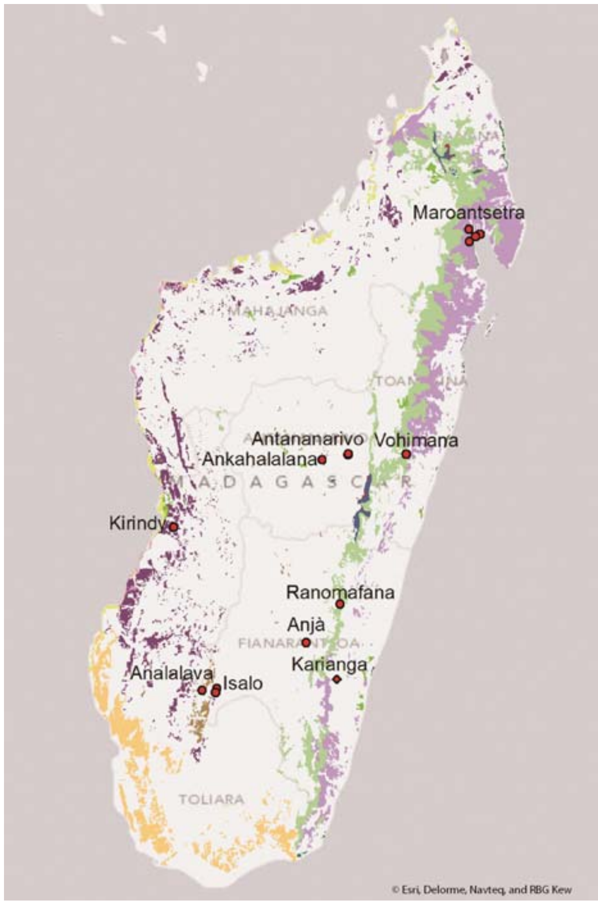

FIG. 1. Collecting sites of *Antherina suraka* (Saturniidae) in Madagascar. Dot colours: red - collecting site; light purple - evergreen humid forest (low altitude); green - evergreen humid forest (mid-altitude); blue - evergreen humid forest (low mountain); brown - evergreen sclerophyllous woodland; dark purple - deciduous, seasonally dry, western forest; tan - deciduous, dry, southern forest. Base map from World Light Gray through ArcGIS® software; primary vegetation map by Du Puy and Moat (1996). Copyright © Esri and the Royal Botanical Garden, Kew, All rights reserved.

FIGS. 2–7. **(2)** *Antherina suraka* live cocoon collected among grasses under a host plant. **(3)** *Antherina suraka* female on alert. **(4)** *Antherina suraka* third-instar larva feeding on leaf of *Weinmannia* sp. (Cunoniaceae) in Vohimana Forest in Madagascar. **(5)** *Antherina suraka* final-instar larva on *Maesa lanceolata* (Primulaceae) in Ranomafana National Park. **(6)** *Bakerella grisea* (Loranthaceae) in Ranomafana National Park, on which larvae of *Antherina suraka* were found but did not survive. **(7)** *Antherina suraka* final-instar larva on *Ischnolepis tuberosa* (Apocynaceae) in Anjà Forest.

Table 1. Sites visited during investigation of from 2008 to 2011.

Region	Site	Subsite	Latitude/Longitude/ Altitude	Year of Collection
Evergreen humid forest				
North - East	Maroantsetra	Ambalamahogo	-15.354833/49.55575 /35m	2010
		Anantoraka	-15.476/49.661028 /13m	2010
		Vodiriana	-15.553778/49.560778 /26m	2010
		Maroantsetra Town	-15.438914/49.739508 /10m	2009 and 2010
Central - East	Vohimana Forest	Near the Researcher Village	-18.92147/48.51195 /792m	2008, 2010 and 2011
South - East	Ranomafana National Park	Along the National Road	-21.258138/47.419027 /792m	2010
	Karianga	Karianga Town	-22.416667/47.366667 /263m	2008
City green patch				
Central	Antananarivo City	Ambatomaro		2009 and 2010
		Ambohitsaina	-18.91548/47.553083 /1323m	2010
		Ambohimiandra	-18.92855/47.545217 /1293m	2010
Rupicolous vegetation (on rocky area)				
South-Central	Anjà Forest		-21.85015/46.83545 /984m	2009 and 2010
Fire-resistant forest				
Midwest	Arivonimamo	Ankahalalana	-19.00814/47.12083 /1334m	2010
South-Central	Isalo National Park	Oasis	-22.62273/45.35155 /838m	2010 and 2011
		Mangily circuit	-22.5612667 /45.3705000/	2011
Deciduous dry forests				
South-West	Analalava Forest	South Tanambao	-22.583916/45.1279833 /712m	2010 and 2011
South-West	Kirindy Reserve	Research Center	-20.0671/44.6574667 /55m	2010 and 2011

TABLE 2. Larval food plant species for *Antherina suraka* recorded from the literature and local farmers. Naturalized plants defined as non-native species established in Madagascar and on which leaves *A. suraka* larvae were found, versus non-native species on which they were fed in captivity. Classification and origins of the plants compiled from tropicos.org, including the Madagascar catalogue (Missouri Botanical Garden, 2013).

Scientific Name	Origin	Family	Location of Record	Source of Record
		ASTERIDAE		
Mascarenhasia sp.	Native	Apocynaceae	Isalo/Analalava	Information from villagers
Nerium oleander L.	Naturalized	Apocynaceae	Unmentioned but probably in gardens mainly in Antananarivo	Bouvier 1936, Griveaud 1961, Meister 2011
Strophanthus sp.	Native/naturalized	Apocynaceae	Unmentioned	Griveaud 1961, Meister 2011
Polyscias bakeriana (Drake) R. Vig.	Native	Araliaceae	Maroantsetra	CPALI
Maesa lanceolata G. Don.	Naturalized	Primulaceae	Vohimana, Mantadia, Mandraka, Ranomafana, Ambatofinandrahana	Griveaud 1961, Razafimanantosoa et al. 2005, Ranaivosolo (pers. com.), LRK 630
Fraxinus pennsylvanica Marshall	Non-native	Oleaceae	Rearing facility	Peigler (pers. com.)
Ligustrum sinense Lour.	Naturalized	Oleaceae	Antananarivo	Farmers who rear them
Ligustrum japonicum Thunb.	Naturalized	Oleaceae	Antananarivo	Farmers who rear them, Meister 2011
Ligustrum ovalifolium Haask.	Non-native	Oleaceae	Unmentioned	Meister 2011
Ligustrum vulgare L.	Non-native	Oleaceae	Unmentioned	Meister 2011
Syringa vulgaris L.	Non-native	Oleaceae	Rearing facility	Peigler (pers. com.)
		CORE EUDICOTS		
Liquidambar sp.	Non-native	Altingiaceae	Unmentioned	Probst (pers. com. in Stone 1991), Meister 2011
		ROSIDAE		
Mangifera indica L.	Naturalized	Anacardiaceae	Antananarivo	Griveaud 1961
Rhus typhina L.	Non native	Anacardiaceae	Rearing facility	Peigler (pers. com.)
Schinus molle L.	Naturalized	Anacardiaceae	Antananarivo	Griveaud 1961, Meister 2011
Carpinus betulus L.	Non-native	Betulaceae	Unmentioned	Meister 2011

TABLE 2. Continued

Scientific Name	Origin	Family	Location of Record	Source of Record
		ROSIDAE (continued)		
Brassica sp.	Naturalized	Brassicaceae	Unmentioned	Griveaud 1961
Terminalia catappa L.	Naturalized	Combretaceae	Maroantsetra	CPALI
Fagus sp.	Non-native	Fagaceae	Unmentioned	Probst (pers. com. In Stone 1991), Meister 2011
Quercus sp.	Non-native	Fagaceae	Rearing facility	Kurz 1991
Eugenia sp.	Native and naturalized	Myrtaceae	Large distribution	Griveaud 1961, Meister 2011
Psidium guajava L.	Naturalized	Myrtaceae	Large distribution	CPALI
Crataegus laevigata (Poir.) DC.	Non-native	Rosaceae	Unmentioned	Meister 2011
Crataegus monogyna Jacq.	Non-native	Rosaceae	Unmentioned	Meister 2011
Eriobotrya japonica (Thunb.) Lindl.	Naturalized	Rosaceae	Antananarivo	Rakotoarisoa pers. com.
Malus floribunda Siebold ex Van Houtte	Non-native	Rosaceae	Rearing facility	Lampe 2010
Malus "hillieri"	Non-native	Rosaceae	Unmentioned	Meister 2011
Prunus sp. (plum, cherry)	Naturalized	Rosaceae	Rearing facility	Kurz 1991
Rosa sp.	Naturalized	Rosaceae	Rearing facility	Bowers 1993
Salix babylonica L.	Non-native	Salicaceae	Unmentioned	Meister 2011
Salix caprea L.	Non-native	Salicaceae	Unmentioned	Meister 2011
Acer campestre L.	Non-native	Sapindaceae	Unmentioned	Meister 2011
Litchi chinensis Sonn.	Naturalized	Sapindaceae	Unmentioned	Mamy Ratsimbazafy (pers. com.)
Vitis vinifera L.	Naturalized	Vitaceae	Unmentioned	Meister 2011

help to reduce the constant human pressure on the endangered unique forests of Madagascar.

MATERIALS AND METHODS

Areas of investigations selected as potential field sites were based on records from different authors who captured adults of *A. suraka* at these locations (Craig 2007, Rafamantanantsoa 2005, Razafimanantosoa et al. 2006) as well as from local farmers and field biologists who have found the species in these regions. Ten main sites were selected for the study (Table 1). A map of Madagascar was created using World Light Gray base map from ArcGIS® software by Esri, Delorme and Navteq. The sites were plotted on this base map from the coordinates recorded in the field using a handheld Global Positioning System (GPS) device (eTrex - Garmin Inc.). A refined map of primary vegetation of Madagascar by Du Puy & Moat (1996), produced by the Royal Botanical Gardens, Kew, was superimposed on the base map to show the distribution of the selected sites across different ecosystems of Madagascar, as characterized by different climates. The East Coast, directly exposed to the trade winds, has the highest rainfall; the Central Highlands are drier and cooler and the West Coast is considerably drier as the trade winds do not reach it sufficiently to provide significant humidity. Thus, parts of the Southwest and the Deep South experience extremely low rainfall and are semi-desert areas. Consequently, extremely varied vegetation types characterize the island (Figure 1): thicket vegetation covers the extreme south of the country, savanna woodlands and grasslands with patches of dry deciduous forests characterize the west, and these types are separated from the humid evergreen dense forests of the east by chains of mountains along the length of the island. Predominant grasslands cover the Central Highlands.

Eggs, larvae and cocoons of *A. suraka* were collected from November 2008 to January 2009, from March to May 2010 and during February and March 2011. Two teams of investigators, each comprising two or three entomologists, worked simultaneously at different sites during these periods. In addition, local guides assisted the teams during the surveys to facilitate investigation of potential habitats and host plants. Larvae were located by inspecting feeding damage on leaves of all previously recorded host plants. Vegetative parts of the plant on which larvae were found were preserved for identification and use as vouchers, which were deposited at PBZT and the California Academy of Sciences (CAS). As the larvae of *A. suraka* pupate in cocoons scattered on the ground, cocoons were collected under dead leaves of known or suspected larval host plants or on grasses on the surrounding soil (Figure 2). Adults (Figure 3) were captured over a six-hour period (from 21:00h to 03:00h) using light-traps comprising a black-light (Bioquip Inc., 2804 AC/DC, 12 volts, 15 watts) powered by a portable automobile battery and hung or placed close to a white-sheet screen 2 × 1.60 m in dimensions. Specimens were generally killed and stored in glassine envelopes to document the presence of the species in the study areas. When females and males were simultaneously captured, they were kept alive and allowed to copulate in portable net cages.

For confirmation of host plants, field-collected larvae were reared in the laboratory on foliage of the plants on which they were found by placing them on freshly cut twigs with leaves in a container filled with water. Twigs and water were replaced every two to five days depending on the species of plant.

RESULTS

The larvae of *A. suraka* feed on approximately 44 species of plants belonging to 23 families in 15 plant orders (Tables 1 and 2). Host plant species belong primarily in families placed in the subclass Rosidae (28), the highest number of species (7) falling in the family Rosaceae. Other families of Rosidae were represented by one or, occasionally, two or three species. Although only six families of the subclass Asteridae and two of Core Eudicots were accepted as hosts, the family Oleaceae and Apocynaceae of Asteridae comprised the second and third highest numbers of host plants in term of species (respectively 6 and 4) after Rosaceae. Most of the host families listed here for *A. suraka* are shared food plants with other species of Saturniidae (Collins & Weast 1961, Griveaud 1961, Stone 1991, Lampe 2010, Meister 2011). Hostplants of *A. suraka*, *Weinmannia* sp. (Cunoniaceae) and *Eugenia* sp. (Myrtaceae) are, for example, hosts of the Comet Moth, *Argema mittrei* (Guérin-Méneville), another Malagasy-endemic species belonging to the family Saturniidae (Pinhey 1972, Stone 1991).

In total, ten species of plants that are endemic to Madagascar were newly recorded as hosts of *A. suraka* (Table 3). We found larvae of *A. suraka* consuming foliage of *Weinmannia* sp. in the Vohimana forest in 2008 (Figure 4), but when reared on it in the laboratory they failed to pupate. Leaves of *Ischnolepis tuberosa* Jum. & H. Perrier (Apocynaceae, Asclepiadoideae), a species with toxic latex, as well as *Bakerella grisea* (Scott-Elliot) Balle (Loranthaceae), which is a plant parasite, were eaten by the larvae of *A. suraka*. Both species were found in close proximity to the known host *Maesa lanceolata* G. Don (Figure 5). *Ischnolepis*

TABLE 3. Newly recorded food plants of *Antherina suraka*. Vouchers deposited in Botanical and Zoological Park of Tsimbazaza and California Academy of Sciences.

Scientific name	Family	Location of record	Fieldwork/Life cycle status	Voucher
	ASTERIDAE			
Ischnolepis tuberosa Jum. & H. Perrier	Apocynaceae	Anja	January 2009/Complete	LRK 629
Foetidia asymetrica H. Perrier	Lecythidaceae	Kirindy	February 2011/Cocoon found under trees	AS1
Pyrostria neriifolia (Homolle ex Arènes) Razafim., Lantz & B. Bremer	Rubiaceae	Kirindy	February 2011/cocoons found under trees	AS2
	CORE EUDICOTS			
Bakerella grisea (Scott-Elliot) Balle	Loranthaceae	Ranomafana	May 2010/failed to pupate	No voucher
	ROSIDAE			
Terminalia tropophylla H. Perrier	Combretaceae	Kirindy	February 2011/Cocoons found under trees	AS3
Weinmannia sp. L.	Cunoniaceae	Vohimana	November 2008/failed to pupate	No voucher
Suregada capuronii Leandri	Euphorbiaceae	Kirindy	February 2011/Cocoons found under trees	AS4
Baudouinia sollyaeformis Baill.	Fabaceae	Kirindy	February 2011/Cocoons found under trees	AS5
Grewia cyclea Baill.	Malvaceae	Kirindy	February 2011/Cocoons found under trees	AS6
Cedrelopsis grevei Baill.	Rutaceae	Kirindy	February 2011/Cocoons found under trees	AS7

tuberosa grows on rocks close to *M. lanceolata* in Anjà. All larvae of *A. suraka* recorded there were feeding on the needle-like leaves of *I. tuberosa* (Figure 7) and all of them successfully eclosed as adults when reared on this plant. No larvae were found on the leaves of *M. lanceolata* during our visit in Anjà in 2009, but the local people recorded them on *M. lanceolata* in 2013. The larvae found feeding on *Bakerella grisea* were on a plant immediately adjacent to *M. lanceolata* at the edge of the rainforest in Ranomafana (Figure 6), but they died without reaching the pupal stage whereas those feeding on leaves of *M. lanceolata* easily reached the adult stage. It thus appears that a female may have deposited some eggs on the leaves of *B. grisea* by mistake. In December 2008, larvae of *A. suraka* were found feeding on leaves of *M. lanceolata* and *Weinmannia* sp. in the Vohimana Forest, but neither larvae nor adults could be found in 2010 at the same sites. Definite host species of *A. suraka* were recorded from the northern (Maroantsetra), central (Vohimana) and southern (Ranomafana) parts of the eastern side of Madagascar, where the evergreen humid forest lies (Table 1). At Karianga, another site in the vicinity of a rainforest, no larvae were found on any leaves inspected in November 2008, but two *A. suraka* adults were captured at light and on a tree during the day.

In the dry forest of Kirindy, between two and seven old cocoons of *A. suraka*, the ages estimated at about one year post-eclosion, were found among grasses below each of the seven plant species discovered as hosts in 2011. Although no larvae were found feeding on the leaves of these plants during our surveys, the presence of cocoons at a distance of 0.25–0.75 m from the trees or even between their twigs was considered to be evidence that *A. suraka* feeds on them. Adding credence to this association is the fact that larvae of *A. suraka* typically wander from the foliage to the bottom of their host tree to find a suitable substrate, such as grasses or dead leaves, in which to spin a cocoon. Because some saturniids may crawl across distances of ten meters or more if no suitable substrate near a host tree is encountered, rearing experiments would be needed to confirm this putative association between *A. suraka* and these host tree species.

In Isalo National Park and Analalava Forest, where various types of vegetation including dry and rupicolous forests as well as fire-resistant ones such as the Tapia (*Uapaca bojeri* Baill., Phyllanthaceae) forest occur, adults of *A. suraka* were captured at light in 2010 and 2011 but no larvae or cocoons were found on or near possible host plants. *Mascarenhasia* sp. (Apocynaceae) was reported by local villagers in Analalava as a host, but this could not be confirmed as no larvae were found feeding on this plant. Adults of *A. suraka* were recorded from another Tapia forest in the Midwest of Madagascar at Ankahalalana (Arivonimamo) in 2001(H. A. Razafindraleva pers. com.), but no specimens were captured during our trapping there in March 2010.

DISCUSSION

As our study was not exhaustive, further investigations should be undertaken to record all of the host plants of *A. suraka*. We had to select sites taking into account accessibility by road and required logistics during the limited time of the year when larvae can be found. Records of specimens of *A. suraka* from the 1940s to 1960s in the PBZT and MNHN insect collections indicated that some other sites, including in the far north and south of Madagascar, need further investigation to update the distribution area of the species and extend its possible host range.

The number of host plant species in the diverse families that we recorded shows that *A. suraka* is polyphagous, as are most other species of Saturniidae (Tuskes et al. 1996, Janzen 2003). The species shows host preferences that may vary in space and time due to microhabitat differences (Janzen 2003) or environmental stresses such as drought and light availability, as mentioned earlier. Also, the natural history of *A. suraka* in dry and sclerophyllous forests is not as well-known as it is in rainforests. We could not determine the period of the year when the larval stages of *A. suraka* can be found in these particular ecosystems, particularly in Kirindy, Analalava Forest, Isalo National Park and Ankahalalana. Only old cocoons, from which pupae were thought to have emerged in the previous year, were found in Kirindy in February 2011. Our rough estimation of the life cycle of the species based on the weather conditions and our capture of adults in April 2010 led us to expect to find larvae in March, April and May; however, larvae would not be expected to survive for extended periods during this season as the leaves of the trees in Kirindy Forest would likely already have senesced or fallen at this time of the year.

All ten newly recorded food plants of *A. suraka*, seven of them in a dry deciduous forest, are endemic species of forests in Madagascar. No local rearing was possible during our stay in the dry areas as we could not find local specimens but future projects that involve rearing *A. suraka* on these hostplants would be necessary to determine definitively whether the species can complete its cycle on these hostplants. Although some populations of *A. suraka* have adapted well to non-native or naturalized plants, such as *Ligustrum* sp. (Oleaceae) and other temperate plants grown for farming (Kurz 1991, Bowers 1993), this study shows that *A. suraka* still relies on vegetation of native forests in different parts of the island. Forest edges are greatly threatened, partly because of slash-and-burn agriculture that tends to encroach upon these ecotones as distant land becomes depleted (Styger et al. 2007). As most of the *A. suraka* larvae and their host plants were found at the edges of forests along paths or roads, the species can probably be used as an indicator of habitat loss in the riparian zones of forests. In addition, it is evident that human disturbance of the surrounding habitats of protected areas can cause more damage within the areas than thought before (Laurance et al. 2012). Difficulty in collecting specimens in some areas where *A. suraka* was found in earlier years may indicate a continuing loss of habitat. Slash-and burn agriculture surrounding protected areas is so common (Styger et al. 2007, Dirac Ramohavelo 2009) that it possibly has an impact on the fauna and flora of most of the study sites. Road construction and other activities related to mining could change the ecotopes of forests such as Vohimana, where the same area in which we collected *A. suraka* turned from an abandoned, formerly cultivated hill at the edge of the forest to an open, red-soil area within one year.

Knowing the geographical distribution of *A. suraka* and its host plants might help to prioritize conservation of forest borders through implementation of silk production activities. Sericulture might help not only to conserve the species but also to improve the livelihood of local people, reducing overexploitation of the forests by virtue of their greater economic security (Razafimanantosoa et al. 2006, Kakati & Chutia 2009, Raina et al. 2011).

The organization, Conservation through Poverty Alleviation International (CPALI, www.cpali.org) has been working on such a project in Maroantsetra for several years by providing a market for the cocoons produced by local farmers. Unlike the common wild silk textile, unwoven textiles from individual cocoons sewn together are used by CPALI to make sheets for curtains, lampshades and jewelry. All members of a family engaged in silk production can benefit from the new silk activities: men and women are involved in planting the host plants and rearing *A. suraka*, and women in particular engage in later processing stages, including preparing and sewing the cocoons together. Expanding such activities to other regions will be feasible if more information on the host plants of various wild silkworm species is gathered. From the data obtained from this study, we suggest that Anjà, Vohimana and Ranomafana are possible areas to establish *A. suraka* rearing projects as the local host plants are already known and the local people are likely to be receptive to new work alternatives since they are already involved in other development projects through community associations. For the remaining areas that are mainly dry deciduous or sclerophyllous forests, and where *Antherina suraka* larvae were difficult to find partly because of high levels of environmental stress on the forest such as frequent forest burns, other alternative conservation plans are needed, as these sites with unique ecosystems contain endemic animals and host plants at potential risk of extirpation or extinction.

ACKNOWLEDGMENTS

We especially thank Rakotoarisoa, Saholy Ramiliarijaona, Herisoa Rakotondrandriambeloson and Ainasoa Raobelina for their valuable assistance during our fieldwork; Dr. Catherine Craig and Mamy Ratsimbazafy of the Conservation through Poverty Alleviation International project for their support in Maroantsetra; the Department of Entomology at the University of Antananarivo for its willingness to serve as host institution in Madagascar; Rokiman Letsara and the personnel of the Botanical and Zoological Parc of Tsimbazaza for identifying plant specimens collected during the study; Dr. Richard Peigler and Ravomiarana Ranaivosolo for sharing information; the Randrianandrasana family for volunteering; Dr. David Voegtlin of the Illinois Natural History Survey for donating light-trapping equipment; Dimbiaina Rakotomahafaly for rearing specimens; M. Jared Thomas for helping with GIS mapping; the staff of National Parks of Ranomafana and Isalo, especially Victor Razafindranaivo, and the local people of Vohimana, Anjà, Ambalamahogo, Anantoraka and Ankahalalana for their cooperation. We are grateful to the Lindbergh Foundation for providing the main financial support for the project; the Rita and Arnold Goodman Fund Fellowship (Women and Gender Global Perspectives), the Department of Entomology at the University of Illinois, and the Tyler Prize for Environmental Achievement for providing the rest of the funding; IdeaWild for donating fieldwork materials and equipment; the Madagascar National Parks and the Directorates of Waters and Forestry, the association L'Homme et L'Environnement, Anjà Miray and the Wildlife Conservation Society for assisting with permit delivery and facilitating fieldwork; and the UIUC Graduate College for partly funding the 2010 conference trip. This study is part of a dissertation for a doctoral degree in Entomology at the University of Illinois at Urbana-Champaign.

LITERATURE CITED

BOISDUVAL, J. B. A. 1833. Faune entomologique de Madagascar, Bourbon et Maurice. Lépidoptères. Avec des notes sur les moeurs par M. Sganzin. 8: 1–122, pls. 1–16.

BOUVIER, E.-L. 1936. Étude des Saturnoïdes normaux: famille des Saturniidés. Mémoires du Muséum National d'Histoire Naturelle, Paris 3: 1–354 + XII pls.

BOWERS, C. 1993. Breeding notes on *Antherina suraka*. Exotic Entomology Group Newsletter, pp. 41–43.

COLLINS, M. M. & R. D. WEAST. 1961. Wild Silk Moths of the United States: Saturniinae. Collins Rapid Company, Cedar Rapids, Iowa. 138 pp.

CONDAMINE, F. L., F. A. H. SPERLING, & G. J. KERGOAT. 2013. Global biogeographical pattern of swallowtail diversification demonstrates alternative colonization routes in the Northern and Southern hemispheres. J. Biog. 40: 9–23.

CRAIG, C. L. 2007. CPALI Project report to the National Geographic Society: wild silk production for communities in the Eastern Forest Corridor. Madagascar, 22 pp.

DEWIT, M. 2003, Madagascar: heads it's a continent, tails it's an island.

Ann. Rev. Earth Planet. Sci.31: 213–248.

DIRAC RAMOHAVELO, C. 2009. Stratégies villageoises pour la gestion des paysages forestiers du Menabe Central, Madagascar. Thèse de doctorat, École Polytechnique Fédérale de Lausanne. 152 pp.

DU PUY, D. J. & J. F. MOAT. 1996. A refined classification of the primary vegetation of Madagascar based on the underlying geology: using GIS to map its distribution and to assess its conservation status. Pp. 205–218 + 3 maps. *In* W. R. Lourenço (ed.), Proceedings of the International Symposium on the Biogeography of Madagascar. ORSTOM editions, Paris.

ERELLI, M. C., M. P. AYRES, & G. K. EATON. 1998. Altitudinal patterns in host suitability for forest insects. Oecologia 117: 133–142.

ESRI, DELORME, NAVTEQ. World light gray base map. Information available at http://services.arcgisonline.com/ArcGIS/rest/services/Canvas/World_Light_Gray_Base/MapServer and at http://www.esri.com [Accessed: February, 2013].

FRITZ-VIETTA, N. V. M, H. B. FERGUSON, S. STOLL-KLEEMANN, & J.U. GANZHORN. 2011. Conservation in a biodiversity hotspot: insights from cultural and community perspectives in Madagascar. Pp. 209–233. *In* Zachos, F. E., and J. C. Habel (eds.), Biodiversity hotspots—distribution and protection of conservation priority areas. Springer. Heidelberg. 546 pp.

GOODMAN, S.M. & J. P. BENSTEAD. 2005. Updated estimates of biotic diversity and endemism for Madagascar. Oryx 39: 73–77.

GRIVEAUD, P. 1961. Insectes: Lépidoptères Eupterotidae et Attacidae. Faune de Madagascar 14: 1–64 +XII pl.

GUTBRODT, B., K. MODY, & S. DORN. 2011. Drought changes plant chemistry and causes contrasting responses in lepidopteran herbivores. Oikos 120: 1732–1740.

JANZEN, D. H. 2003. How polyphagous are Costa Rican dry forest saturniid caterpillars? Pp. 369–379. *In* Basset, Y., R. Kitching, S. Miller and V. Novotny (eds.), Arthropods of tropical forests: spatio-temporal dynamics and resource use in the canopy. Cambridge Univer. Press, Cambridge. 490 pp.

KAKATI, L. N. & B. C. CHUTIA. 2009. Diversity and ecology of wild sericigenous insects in Nagaland, India. Trop. Ecol. 50: 137–146.

KURZ, O. 1991.The breeding of *Antherina suraka* Boisduval (Lepidoptera: Saturniidae). Metamorphosis 2: 9–10.

LAMPE, R. E. 2010. Saturniidae of the World: their life stages from the eggs to the adults. München, Pfeil. 368 pp.

LAURANCE, W. F., D. C. USECHE, J. RENDEIRO, M. KALKA, C. J. A. BRADSHAW ET AL.. 2012. Averting biodiversity collapse in tropical forest protected areas. Nature 489: 290–294.

MADAGASCAR CATALOGUE. 2013. Catalogue of the Vascular Plants of Madagascar. Missouri Botanical Garden, St. Louis, U.S.A., and Madagascar Research and Conservation Program, Antananarivo, Madagascar. Available at: http://www.tropicos.org/project/mada [Accessed: September 2013].

MARCUS, R. R. 2001. Seeing the forest for the trees: integrated conservation and development projects and local perceptions of conservation in Madagascar. Human Ecol. 29: 381–396.

MEISTER, F. 2011. A guide to the breeding of tropical Silk Moths: Die Zucht von tropischen Wilden Seidenspinnern (Lepidoptera: Saturniidae). translated by F. Haase. Verlag Dr. Friedrich Pfeil. Munchen, Germany. 220 pp.

MITTERMEIER, R. A., G. R. KONSTANT, C. G. MITTERMEIER, R. B. MAST, & J. O. MURDOCH. 1999. Madagascar. Pp. 189–203. *In* Mittermeier, R. A., N. Myers, P. R. Gil and C. G. Mittermeier (eds.), Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Conservation International, Cemex, S.A., Mexico, 431 pp.

MYERS, N., R. A. MITTERMEIER , C. G. MITTERMEIER , & G. A. B. DA FONESCA, J. KENT. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

OSIER, T. L. & S. M. JENNINGS. 2007. Variability in host-plant quality for the larvae of a polyphagous insect folivore in midseason: the impact of light on three deciduous sapling species. Entomol. Exper. Appl. 123: 159–166.

PAULIAN, R. 1951. Papillons communs de Madagascar. Institut de Recherche Scientifique. Antananarivo, 90 pp.

PAULIAN, R. & P. VIETTE. 2003. Introduction to terrestrial and freshwater invertebrates. Pp. 503–510. *In* Goodman, S. M., and J. P. Benstead (eds.), The Natural History of Madagascar. Univer. Chicago Press, Chicago. 1709 pp.

PEIGLER, R. S. 1993. Wild Silks of the World. Amer. Entomol. 39: 151–162.

———. 2004. The Silk Moths of Madagascar. Pp. 155–164. *In* Kusimba, M., J. C. Odland, and B. Bronson (eds.), Unwrapping the textile traditions of Madagascar. UCLA Fowler Museum of Cultural History, Los Angeles. 196 pp.

PINHEY, E. C. G. 1972. Emperor moths of South and South-Central Africa. C. Struik, Capetown. 150 pp, pls. 1–43.

RABINOWITZ, P. D., M. F. COFFIN, & D. FALVEY. 1983. The separation of Madagascar and Africa. Science 220: 67–69.

RAINA, S. K., E. KIOKO, O. ZETHNER, & S. WREN. 2011. Forest habitat conservation in Africa using commercially important insects. Ann. Rev. Entomol. 56: 465–485.

RAFAMANTANANTSOA, C. 2005. Inventaire entomologique du corridor Mantadia-Zahamena, Madagascar. Pp. 117–121. *In* Schmid, J., and L. E. Alonso (eds.), Une évaluation rapide du corridor Mantadia-Zahamena, Madagascar. Bulletin RAP d'Evaluation Rapide 32. Conservation International. Washington D.C. 151 pp.

RAZAFIMANANTOSOA, T., O. R. RAVOAHANGIMALALA, & C. L. CRAIG. 2006. Report on a feasibility study: indigenous silk moth farming as a means to support Ranomafana National Park. Madagascar Conserv. Devel. 1: 34–39.

RAZAFIMANANTSOA, T. M., G. RAJOELISON, B. RAMAMONJISOA, N. RAMINOSOA, M. PONCELET, J. BOGAERT, E. HAUBRUGE, & F. J. VERHEGGEN. 2012. Silk moths in Madagascar: a review of the biology, uses and challenges related to *Borocera cajani* (Vinson, 1863) (Lepidoptera: Lasiocampidae). Biotech. Agron. Soc. Environ. 16: 269–276.

ROYAL BOTANICAL GARDENS, KEW. The CEPF Madagascar Vegetation Mapping Project. Available at: http://www.vegmad.org/datasets.html [Accessed: February 2013]

SCHATZ, G. E. 2001. Generic tree flora of Madagascar. (Flore Générique des Arbres de Madagascar). Missouri Botanical Garden and Royal Botanic Gardens, Kew, U.K. 516 pp.

STONE, S. E. 1991. Foodplants of world Saturniidae. Mem. Lepid. Soc. 4: 1–186.

STOREY, M., J. J. MAHONEY, A. D. SAUNDERS, R. A. DUNCAN, S. P. KELLEY, & M. F. COFFIN. 1995. Timing of hot spot-related volcanism and the breakup of Madagascar and India. Science 267: 852–855.

STYGER, H., M. RAKOTONDRAMASY, M. J. PFEFFER, E. C. M. FERNANDES, & D. M. BATES. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. Agricul. Ecosys. Environ. 119: 257–269.

TROPICOS.ORG. 2013. Missouri Botanical Garden. Available at http://www.tropicos.org [Accessed: September 2013].

TUSKES, P. M., J. P. TUTTLE, & M. M. COLLINS. 1996. The Wild Silk Moths of North America : a Natural History of the Saturniidae of the United States and Canada. Comstock Pub. Associates, Ithaca, N.Y. 250 pp + IX.

VIETTE, P. 1965. L'*Antherina suraka* (Boisduval) de l'archipel des Comores (Lepidoptera Attacidae). Bull. Soc. Entomol. France 70: 30.

WELLS, N. A. 2003. Some hypotheses on the Mesozoic and Cenozoic paleoenvironmental history of Madagascar. Pp. 16–34. *In* Goodman, S. M. and J. P. Benstead (eds.), The natural history of Madagascar. The Univ. Chicago Press, Chicago, 1079 pp.

ZAKHAROV, E. V., C. R. SMITH, D. C. LEES, A. CAMERON, R. I. VANE-WRIGHT, & F. A. SPERLING. 2004. Independent gene phylogenies and morphology demonstrate a Malagasy origin for a wide-ranging group of swallowtail butterflies. Evolution 58: 2763–2782.

Submitted for publication 19 May 2013; revised and accepted 6 September 2013.