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Traditional Knowledge of Stingless Bees (Hymenoptera: Apidae: Meliponini) in the Peruvian Amazon

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Abstract This paper describes the traditional knowledge on the management of stingless bee colonies and the use of honey by Indigenous and non-Indigenous communities of the department of Loreto, in the Peruvian Amazon. Semi-structured interviews and collection of voucher bees were carried out from June to August 2016 and from November to December 2017. The informants were selected through intentional non-probabilistic sampling (snowball sampling). During the study, 21 communities were visited, of which some of the community members in thirteen communities kept stingless bees. A total of 17 species of stingless bees are reported as used in the communities for either rearing or harvesting of honey from the forest with *Melipona eburnea* being the most common species. The way communities classify, manage, and use bees depends on how they perceive these insects, informed by knowledge processed and incorporated from other communities. In these communities, they use honey and pollen, with honey being the main product. Fourteen health conditions are treated with honey, with the most treated conditions being related to respiratory ailments, fertility, and reproduction. The study provides a basis for incorporating stingless bees into conservation and sustainable production policies.

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Introduction

Meliponiculture—the keeping of stingless bees—to extract honey and wax has been practiced by cultures around the world for thousands of years (Costa-Neto and Ramos-Elorduy 2006; Crane 1999). Before the Spaniards arrived in South America in 1492, Indigenous groups were well acquainted with stingless bees (Crane 1999; Medrano and Rosso 2010; Quezada-Euán et al. 2001, 2018). Different Amerindian cultures attributed multiple properties to stingless bee products, including nutrition, medicine, handcrafts, religion, economy, and mythology (Quezada-Euán et al. 2018). Honey was the single most used product, followed by pollen, wax mixed with plant resins, propolis, and larvae (Alves and Alves 2011; Quezada-Euán et al. 2018). In Brazil, Indigenous communities, such as the Kayapó, consider stingless bees as part of their cosmology and a model of social organization (Posey 1986), while the Enawene-Nawe and Quilombola classify bees based on their structural, morphological, ecological, ethological, and social characteristics (Alves and Alves 2011; Santos and Antonini 2008).

In South America, honey is generally obtained from the forest by harvesting it directly from the nest, leaving behind destroyed colonies on the ground (Kerr et al. 2001; Quezada-Euán et al. 2018). Certain communities, such as the Kayapó in Brazil and rural communities in Peru, practice a conservation method in which they transfer the nest to locations near their homes to periodically extract honey (Alves and Alves 2011; Camargo and Posey 1990; Rasmussen and Castillo-Carrillo 2003).

In Latin America, in addition to the use of honey, larvae (Pauleti et al. 2000; Quezada et al 2018), pupae, pollen, cerumen, and propolis are also consumed to a lesser extent (Carbalho et al. 2014; Costa-Neto 2005;

Vit et al. 2014). Propolis and cerumen, in particular, are used in the manufacture of hunting and fishing tools, musical instruments, handicrafts, etc. (Quezada et al., 2018). Bees also have mythological, religious, cosmological, spiritual meanings (Cappas and Souza 1995, Rodrigues 2006; Santos et al. 2008) and are used as a model of social organization (Camargo and Posey 1990; Quezada et al. 2018).

From Peru, more than 175 different species of stingless bees are known (Rasmussen, personal observation), a number that has increased with recent studies (Baumgartner and Roubik 1989; Castillo-Carrillo et al. 2016; Pedro and Camargo 2003; Rasmussen and Castillo-Carrillo 2003; Rasmussen and Gonzales 2009). In the latest survey, Rasmussen and Delgado (2019) reported 69 species alone for the Loreto region of northeastern Peru. The first Peruvian account of stingless bee management included surveys from Indigenous and non-Indigenous communities (Rasmussen and Castillo-Carrillo 2003). Later reports described honey consumption and beekeeping practices in more detail (e.g., Castillo-Carrillo et al. 2016; Elizalde Vilela et al. 2016; Perichon 2013).

This study aims at documenting the current state of traditional knowledge on how Indigenous and non-Indigenous communities in the department of Loreto use stingless bees, to establish the scientific bases that allow defining policies for the preservation of stingless bees and the use of honey from these bees.

Methods

Study Area

The study was conducted from June to August 2016 and again from November to December 2017 in 21 different lower basin river communities in the department of Loreto, Peru, including: eight communities in the Ucayali River, six in the Marañón River, four in the Napo River, and three in the Nanay River (Figure 1). The local communities include Indigenous Kukama-Kukamiria and non-Indigenous River dwellers (*ribereños*) whose economies all rely on subsistence activities such as agriculture, fishing, hunting, collection of turtles, honey, raising chickens and, in some cases, pigs and other domestic animals. The nutrient-rich soil of these communities remains under water from three to five months per year. There are two main seasons: one with heavy rainfall from October to April and the other with low rainfall from May to September, which coincides with the low-water period of the rivers, except in the case of the Napo River whose high-water period goes from February to August, while the low-water period ranges from March to September. The area is covered with highly diverse vegetation of primary forests, secondary forests, and cultivated species, which jointly provide a valuable source of food, resins, and nesting habitats for numerous stingless bees.

Interviews

First, we sought and obtained consent for the study from the local authorities. Once approved the process of selecting informants in the communities was based on an intentional non-probability sampling technique called snowball sampling (Sadler et al. 2010), which started with meeting one family or household of stingless beekeepers that led to further meetings with other known beekeepers. We included only those families that had stingless bee colonies or those who said they kept stingless bees during the past ten years. A semi-structured survey was then handed out to each

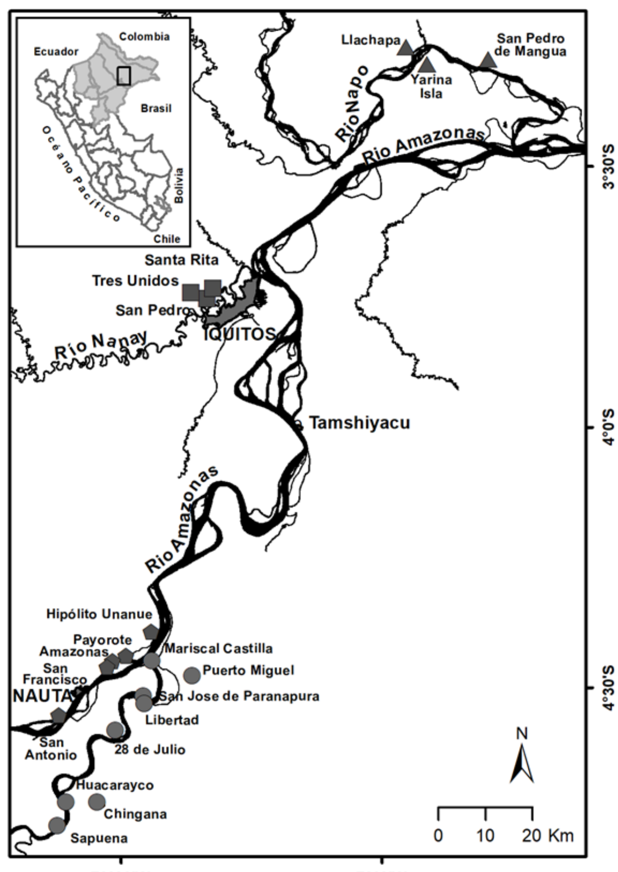

Figure 1 Map of the study areas, with distribution of the communities in the four river basins in the Peruvian Amazon region.

informant family while visiting their stingless bee colonies if they still had colonies. From each live colony, five bee specimens were collected, and entrance photos were taken for subsequent identification. Each family that informed us they had kept stingless bees in the past was shown a 15 x 20 cm photographic plate that illustrated different bee species and hive entrance, to ensure the correct species was recognized and identified by the informant. The survey included eight specific questions:

Diversity:

1. Which types of bees (species) do you keep now?
2. Of the species you have kept in the past 1-10 years, why did you stop with those?
3. Why do you keep the type (species) of bees you do now?

Management:

1. Where in the house do you keep bees?
2. Which colony product or resource do you collect and what do you use it for?
3. How much honey do you harvest and how often?
4. In which phase of the moon do you harvest honey?
5. Which human conditions do you cure or treat with honey?

The interview was directed at families rather than at a specific household member and no differentiation was made between whether men or women considered bees in similar ways. In the studied areas, river dwellers have coexisted for generations with the Indigenous communities and no differentiation was observed in the handling or use.

Due to the low number of families interviewed and the similarity in the responses across the communities, all data were combined and analyzed together. To determine the importance of honey in the treatment of different conditions or diseases, we used the Use Value Index (UVI) which was adapted from ethnobotanical studies (Camou-Guerrero et al. 2008).

One set of the collected bee samples was incorporated into the Biodiversity Referential Collection of the Peruvian Amazon Research Institute (IIAP), Iquitos, Peru and the other part was sent to Aarhus University, Denmark, for taxonomic identification.

Table 1 Stingless bee species that the inhabitants of the communities of the lower basins of Marañon, Ucayaly, Napo and Nanay rivers raise or collect honey from the forest.

Scientific name	Local name
Frieseomelitta trichocerata	
Melipona eburnea	"Ronsapilla" (which is the diminutive form for "ronsapa" or bumblebee and "boca de sapo" [literally toad's mouth] for the shape of the hive entrance
Melipona crinita	
Melipona illota	"abeja negra" [black bee] for the color of its body
Melipona grandis	"abeja ceniza" [ash-colored bee] for the color of its body
Melipona cf. *rufiventris*	"abeja colorada" [red bee] for the color of its body
Melipona titania	"abeja gigante" [giant bee]
Partamona sp.	
Plebeia kerri	
Ptilotrigona pereneae	"pishura abeja" [pishura bee] for the shape of its hive entrance. "Pishura" is a regional term used to call the female external genitalia
Tetragona goettei	
Tetragona truncata	"trompa de elefante" "elephant trunk" for the shape of its hive entrance
Tetragonisca angustula	"ramichi", "angelita" or "niña" [little twig, little angel or little girl] for its small size and delicate appearance
Trigona amazonensis	"arambazo", "corta pelo" or "abeja brava" [short hair or fierce bee]
Trigona williana	
Trigona dallatorreana	
Scaptotrigona sp.	

Results and discussion

Diversity

We found that in 13 of the 21 (61.9%) communities surveyed 17 families keep stingless bees. Families (8) in five (23.8%) additional communities had kept at least one colony in the past 1–10 years but have now abandoned this practice (1-4 colonies in the communities with an average of 2.8 colony per community). Interviews represent a total of 25 current of former stingless bee keeping families. The total number of active colonies recorded was 29 distributed among 17 families with each family having one to three colonies. We recorded a total of 17 different species of stingless bees in nine genera that are either kept or harvested for honey from the surrounded forests. The species kept are: 15 colonies (51.7%) of *Melipona eburnea*, five (17.2%) of *M. illota*, three (10.3%) of *M. grandis*, two each (6.8%) of *M. titania* and *Frieseomelitta trichocerata*, and one each (3.4%) of *Trigona amazonensis* and *Tetragonisca angustula.* Informants choose to keep specific species of stingless bees based on the quantity of honey they produce (7; 41.2%); the availability of the species near the community (6; 34.1%); and a lower aggression level (2; 11.8%). The local dwellers name the different bee species based on their morphology, color and size, the shape of the nest entrances, the colony's behavior, or the relation with their surroundings (Figure 2, Table 1). Other Indigenous groups of the Amazon already know about these ways to classify and identify the species of bees (Alves and Alves 2011; Santos and Antonini 2008).

Unlike other regions in the Peruvian Amazon (San Martín, Huánuco, Junín, etc.), where commercial agriculture is developed and the keeping of the honeybee *Apis mellifera* is intensifying, dwellers in the Loreto region knew of *Apis mellifera* but do not keep them and only use their honey when a tree is cut for purposes other than honey extraction (wood extraction, etc.). Although in previous years the Peruvian government, research institutes and universities promoted its keeping, it was not successful in the communities. The main factor attributed by the residents is the sting they cause. No other honey producing insects, such as honey wasps, were reported.

Management

Tree trunks measuring from 1 to 1.5 m with stingless bee colonies are cut and brought from the forest to the home for bee keeping. Here the trunk is attached

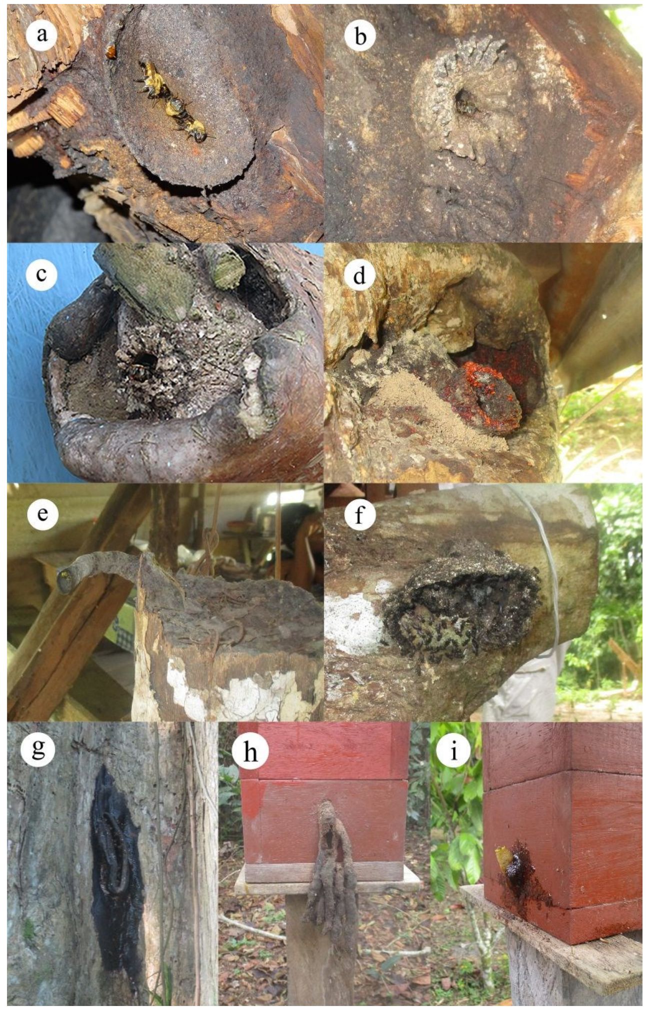

Figure 2 Shape of the hive entrances for some of the species recorded in the study; **A** *Melipona eburnea* "toad's mouth"; **B** *M. illota* "black bee"; **C** *M. grandis* "ash-colored bee"; **D** *M. titania*, "giant bee"; **E** *Tetragona truncata*, "elephant trunk"; **F** *Trigona cf. hypogea*; **G** *Ptilotrigona pereneae* "pishura bee"; **H** *Lestrimelitta* cf *limao*; **I** *Tetragonisca angustula* "little angel or little girl".

to the roof (17; 58.6%). In addition, nests are placed under the floor (8; 27.6%; note these are traditionally houses built on 1 to 2-meter-tall wooden stilts) or hung on fruit tree branches near the house (4; 13.8%). For honey harvest on a regular basis, an opening is made in the trunk and a lid sealed with clay is attached once the honey has been extracted. In addition, four of the 17 families are keeping bees in rustic or semi-rational hives. These people told us that they learned the techniques from other communities. Honey is the most used product in the communities, followed by pollen (known locally as bee 'excrement'), propolis, and jelly (known locally as bee 'acidito') (Figure 3). These products may be used in food, cultural activities, and especially medicine (Figure 4). Larvae serve as human food or as bait for fishing. Honey harvesting primarily takes place in the morning: 11 (64.7%) inform that they harvest honey every 12-18 months and six (35.3%) every eight months. The reported quantity of harvested honey ranges from 300 to 1.800 ml. To harvest honey, the tree trunk is initially opened with an ax, extracting, and squeezing the honey containing pots into buckets. This process destroys the honey pots of cerumen and may kill the larvae and adults in brood cells sometimes connected with storage pots. Five families (29.4%) stated that the emptied honey pots of cerumen are placed nearby the nest at the end of the harvesting period, so bees could retrieve the cerumen and rebuild the nest. Venturieri et al. (2017) in an experiment with *Melipona fasciculata* in Brazil demonstrated the importance of this factor in the recovery of the colony and honey production.

Figure 3 Management and traditional use of native stingless bees in the studied communities; **A** bee hive on stick; **B** bee hive in a rustic box; **C** hive with the opening to extract the honey and lid sealed with clay; **D** nest of bee and honey extraction; **E** cerumen from a nest placed near the hive to be reused by bees; **F** preserved honey for later use or commercialization.

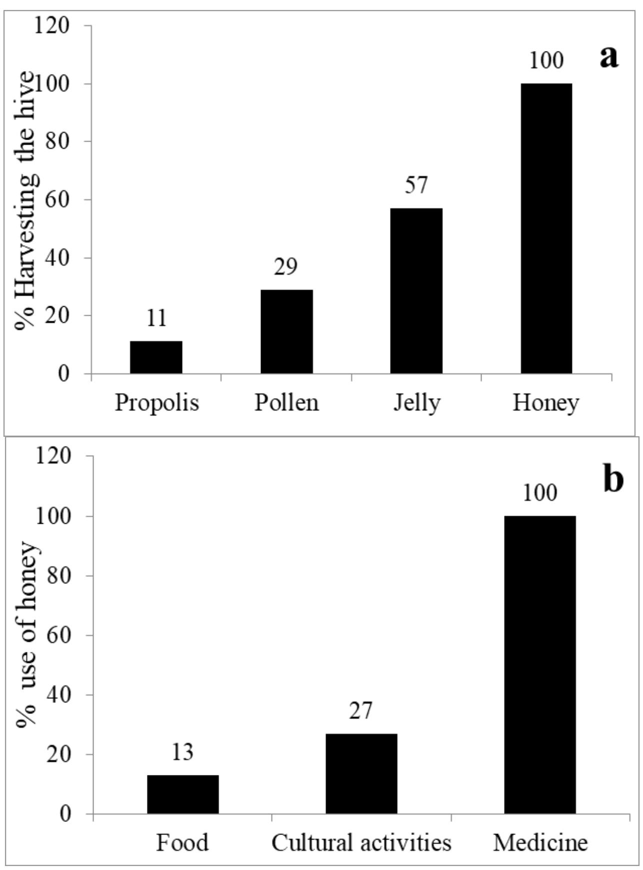

Figure 4 Harvesting of **A** the colmenta and **B** use of honey, in the communities of the lower basins of the Marañon, Ucayali, Napo and Nanay rivers.

In Latin America, there are indigenous communities that carry out sustainable practices when harvesting from native stingless bees: in Peru, members of the Kukamas make openings and then cover the trunk after harvest of the honey, or when a colony tree deteriorates, the whole colony is transferred to rustic wooden boxes (Rasmussen and Castillo 2003); in Brazil, the Kayapos only extract part of the honey, then close the hive, leaving provisions for the colony in order to revisit and harvest later again (Posey and Camargo 1985); the Quilombola, Guarani, and Pankararé perform colony division (Carvalho et al. 2014; Costa-Neto 1998; Rodrigues 2006). However, the sustainable use and the close interaction with native stingless bees is also vanishing in parts of the range (Villanueva-Gutiérrez et al. 2005).

The informants pointed out four reasons explaining why people are abandoning the ancient practice: 1) loss of knowledge on how to keep and use bees in the younger generation; 2) high bee colony mortality caused by extreme floods in the last years; 3) difficulty to locate the now often rare nests in the forest due to selective logging; and 4) low profitability of stingless beekeeping. Similarly, Perichon (2013) found that the number of keepers of wild bees decreased by approximately 50% between 2002 and 2012 in the Northern coast of Peru. One of the causes for this decline is the replacement of beekeeping of stingless species for commercial beekeeping with *Apis mellifera* (Perichon 2013). The increasing loss of stingless bees may be compromising the preservation of biodiversity, cultural heritage, food safety and health, as well as economic opportunities for these communities.

Cultural Uses

We have recorded a total number of fourteen human health conditions that are treated with pure honey or honey mixed with other products from the bee colonies or various plant extracts (Table 2). These mixes are prepared from extracts macerated with sugar cane alcohol (spirit). Older members of these communities explained that these extracts were done by cooking in the past. The main conditions treated with honey are cough, flu, bronchitis, infertility, and other reproductive issues. The honey use value-index ranged from 0.72 to 0.98 (Table 2). Some interviewees said that honey from a certain species is better for treating a specific condition. For instance, honey produced by *Trigona amazonensis* and *Tetragonisca angustula* are used to treat red eye and ocular growths; however, when this specific honey is not available, honey from any of the stingless bees is used as a treatment. Studies carried out in Peru report the use of pure honey or mixed with other products to treat colds, coughs, bronchial tubes, bronchitis, flu, rheumatism, arthritis, vaginal washes, eye infection, fertility of both sexes, anemia, constipation, and wound disinfection (Rasmussen and Castillo 2003; Vileta et al. 2016). In the province of Oro in Ecuador, it is reportedly also used for bruises, tumors, ocular cataracts, pterygium, inflammation, infections, varicose veins, cleaning blood after childbirth, kidney diseases, wound healing, and as a soothing balm before sleeping (Vit et al. 2016). Other Indigenous communities such as the Uwa of Colombia also use honey to treat infertility and reproductive issues (Falchetti and Nates-Parra 2002). Santos and Antonini (2008) report the use of honey from many species of *Melipona* to treat sore throats, bronchitis, erectile dysfunction, diabetes, mycosis, as a worm killer, antidote for snake and dog bites, but most of these were not reported by participants in our study.

There is vast scientific literature that provides concrete evidence on the biological and chemical properties of medicinal honey around the world. For example, Johnson et al. (2005) reported that Australian *Leptospermum* honey is effective "against antibiotic-resistant microorganisms" that are

Table 2 Diseases treated with stingless bee honey, pure or mixed with other products of the colony or plant extracts, in the Indigenous and non-Indigenous communities of the Peruvian Amazon (data pooled across communities).

Diseases	UVI	Honey products	Plant species
Flu	1	Pure honey or Honey + jelly + pollen	Ginger *Zingiber officinale*, jatoba *Hymenaea oblongifolia*, rumberry *Myrciaria dubia*, lemon *Citrus × limon*, genipap *Genipa Americana*
Cough	0.9		
Bronchitis	0.7		
Asthma	0.2		
Pertussis	0.2		
Infertility and Reproduction	0.8	Pure honey or Honey + jelly + pollen	"Chuchuhuasi" *Maytenus laevis,* jatoba *Hymenaea oblongifolia*, "cumaseba" *Swartzia polyphylla*, clove vine *Tynanthus panurensis*, *M. dubia*
Bone pain and rheumatism	0.4	Pure honey or Honey + jelly + pollen	*M. dubia*, "murure" *Brosimum acutifolium*, "icoja" *Unonopsis floribunda*, "huacapurana" *Campsiandra angustifólia*, "iporuro" *Alchornea castaneifolia*, fever three *Brunfelsia grandiflora*
Eye infection	0.2	Pure honey	Bushy matgrass *Lippia alba*
Cuts and other wounds	0.2		
Eye meatiness	0.1		
Burned	0.1		
Stomach Pain	0.1		

associated with catheter infections when compared to commercially available mupirocin. Research by Ahmed et al. (2013) reported that Malaysian Tualang honey has potent antimicrobial, anti-inflammatory, and antioxidant properties when following randomized control clinical trials. This work also elucidated the chemical profile of this honey that included a high volume of phenols, flavonoids, and 5-hydroxymethyl-furfural. Furthermore, Kato et al. (2012) reported that *Leptospermum* honey harbors two highly abundant molecules including the novel glycoside "leptosin" that was directly linked to the inhibitory activity of myeloperoxidase. This result serves as chemical evidence for the antioxidant activity of this Australian honey.

Conclusions

The diversity of stingless bee species raised by local dwellers is broad, but only three are used frequently, *Melipona eburnea* "toad's mouth", *M. illota* "black bee", and *M. grandis* "ash-colored bee". Indigenous communities of the Amazon region have been practicing beekeeping of stingless bees to extract honey and other products for a very long time. Particularly valuable colonies are cared for and brought back home for continuous use. However, management techniques are not sophisticated or considered sustainable; therefore, it is necessary to carry out actions to conserve and consolidate their use practices, create new or better transfer techniques, have a higher appreciation of colony products, and develop conservation policies. The number of communities that carry on this practice is decreasing, in part because of the gradual loss of traditional knowledge, deforestation, low production and cost of honey, and extreme climatic events (e.g., flooding, drought) increasingly common in the region. Honey and other bee products have a nutritional and often perceived but not validated medical value. Honey from stingless bees is used to treat different diseases and conditions and honey from certain species is used to treat specific illnesses. Based on the frequency of honey use in the treatment of conditions related to the airways, reproductive system, and fertility, it is recommended to validate those claims by scientific studies.

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Declarations

Permissions: Permits to access and carry out research in the communities were obtained prior field work. The Peruvian Government's National Forestry and Wildlife Service granted permits to collect biological materials. Permit Authorization No 0068-2015-SERFOR-DGGSPFFS and RDG-N—141-2016-SERFOR-DGGSPFFS.

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Conflicts of Interest: None declared.

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