Journal *of* Melittology
Bee Biology, Ecology, Evolution, & Systematics *The latest buzz in bee biology*
No. 97, pp. 1–13 9 June 2020

Traditional uses and relative cultural importance of *Tetragonula iridipennis* (Smith) (Hymenoptera: Apidae: Meliponini) in Nepal

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Abstract. Indigenous and non-indigenous peoples in tropical and subtropical areas of the world use stingless bees for diverse purposes. Literature records indicate that people from different regions in Nepal use *Tetragonula iridipennis* (Smith), the only stingless bee species that occurs in the country. However, ethnobiological knowledge on this bee remains poorly documented. Herein we report for the first time on the local indigenous nomenclature, traditional knowledge, and management practices among four ethnic communities (Chhetri, Brahmin, Tharu, and Kirat) in Nepal. We also offer a preliminary quantitative analysis of the relative cultural importance of this species among these ethnic groups. We conducted ethnographic research across the Terai and Pahad regions (8 districts and 6 zones) of Nepal and recorded 18 specific uses in food, medicine, crafts, and religious beliefs. Based on the relative importance index, *T. iridipennis* is most culturally important for the Tharu people, a finding that supports the reliance of this ethnic group on local natural resources in their everyday life. All participant communities largely exploit this bee through extractive management practice of wild populations. We discuss the conservation status and future directions for the sustainable use of this stingless bee in the country.

INTRODUCTION

Indigenous and traditional knowledge may provide us with information for proposition of alternative conservation practices to enhance health, abundance, and diversity of pollinators (*e.g.*, IPBES, 2016). In addition, incorporating traditional knowledge into bee surveys might facilitate rapid assessments of the local fauna while provid-

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doi: http://dx.doi.org/10.17161/jom.vi97.13620

ISSN 2325-4467

Figures 1–4. Natural and extracted nests of *Tetragonula iridipennis* (Smith) observed in different regions of Nepal. **1.** Senior author (kneeling) collecting samples of bees surrounded by local people. The nest was found inside the trunk of a living Sal tree [*Shorea robusta* (Roth.), Dipterocarpaceae] at Kusum, Banke. **2.** Senior author (right) and Mr. Banjade with log hives collected from nearby Sal forest and kept in his balcony, Ashrukot, Argankanchi. **3.** Mr. Thagunna and his grandson with a log hive at Mahendranagar, Kanchanpur. **4.** Senior author pointing to the nest entrance on a log hive placed in a backyard of the beekeeper at Ashrukot, Arghakanchi.

ing additional ecological or biological information not initially available to scientists (Gonzalez *et al*., 2018). However, such knowledge is still limited for most bees and biological studies rarely incorporate it. Stingless bees (Apidae: Meliponini) are social, honey-making bees that are an integral part of many cultures, both past and present. They occur in tropical and subtropical regions of the world, although the Western Hemisphere is home to 80% of the more than 500 species known worldwide (Michener, 2007; Ascher & Pickering, 2020). Several species are deeply embedded in the indigenous knowledge of many societies, as they represent a natural source of food, craft materials, folk medicine, and alternative income (*e.g*., Stearman *et al*., 2008; Ayala *et al*., 2013; Villanueva-Gutiérrez *et al*., 2013; Reyes-González *et al*., 2014; Vit *et al*., 2015; Gonzalez *et al*., 2018). While cultural and ethnobiological data on stingless bees is available for a number of Indigenous and non-Indigenous populations across the Americas, particularly in Mesoamerica (Quezada-Euán *et al*., 2018), such information is still limited or non-existent for stingless bees in other regions.

Despite the relatively small number of stingless bee species in the Eastern Hemisphere, the majority of which are distributed across the Indo-Malayan and Australasian Regions (Rasmussen, 2013), the fauna of this area remains largely unexplored (Rasmussen *et al*., 2017; Engel *et al*., 2017). In addition, the traditional knowledge of bees from this region are yet to be documented. For example, literature records on

Table 1. Political division and geographical information for the sites in Nepal where we conducted interviews. Latitude and longitude (in decimal degrees) are averaged over all nests or sites searched within a district. Elevation is given as the range for all nests or sites searched.

Development Region	Zone	District	Latitude	Longitude	Elevation (m)
Eastern	Mechi	Jhapa	26.6	88.0	105–205
Central	Narayani	Chitwan	27.7	84.4	191–197
Western	Lumbini	Kapilbastu	27.6	83.0	112–132
		Arghakhanchi	28.0	83.0	547–965
Mid-western	Bheri	Banke	28.3	81.4	144–195
		Bardiya	28.3	81.3	165–212
Far-western	Seti	Kailali	28.2	81.7	207
	Mahakali	Kanchanpur	29.0	80.1	220–378

stingless bees from Nepal only mention them in the context of beekeeping activities with honey bees (Crane, 1999; Partap, 1999; Bhatta, 2009), without details on their uses or cultural values.

Bhatta *et al*. (2019) studied the stingless bee fauna of Nepal and found a single species of *Tetragonula* Moure, which they tentatively identified as *Tetragonula iridipennis* (Smith). *Tetragonula* is the most species-rich, common, widely distributed, and economically important group of stingless bees in the Eastern Hemisphere. It is also a taxonomically challenging group due to the superficial similarity among species and the existence of cryptic species (Engel *et al*., 2017). For example, at least two phenotypically and behaviourally distinct forms appear to exist under *T. iridipennis*. One form occurs throughout India and has the brood cells arranged in clusters. The other form occurs only in northeast India (states of Assam and Meghalaya) and has the brood cells arranged in layers or combs (Francoy *et al*., 2016). The few nests studied by Bhatta *et al*. (2019) in Nepal had brood cells arranged in clusters, and thus they resembled the form widely distributed in India.

The present contribution is a complement to the aspects of the nesting biology, host plants, and distribution of *T. iridipennis* in Nepal documented by Bhatta *et al*. (2019). Herein, we report for the first time the Indigenous knowledge, uses, and exploitation practices of this stingless bee species by four ethnic communities in Nepal. In addition, we offer a quantitative assessment of the relative cultural importance of *T. iridipennis* for each community and discuss future directions for the conservation and sustainable use of this species in the country.

MATERIAL AND METHODS

We conducted this work during the summer of 2016 across the Terai and Pahad regions (8 districts and 6 zones) of Nepal (Table 1). At each location, we found bee nests with the assistance of local people (Figs. 1–4) and used semi-structured interviews to obtain data on the common names, nesting substrates, management practices, and local uses. We sought cultural consultants using the snowball-sampling method (Bailey, 1987; Bhatta & Bardecki, 2014), in which a network of experts is built on the recommendation of informants themselves. We interviewed nine male local villagers ranging in age from 43 to 73 years (58.6 ± 10.9), one from each district, except for

Banke, where we were able to work with two of them. Among consultants, two were from the far-western development region (FWDR), three from the mid-western development region (MWDR), two from the western development region (WDR), and one each from the central (CDR) and eastern development regions (EDR). Consultants were from four ethnic communities: Chhetri, Brahmin, Tharu, and Kirat. Three of the consultants interviewed in Kailali, Bardiya, and Kapilvastu districts are Tharu, an indigenous ethnic people living in the lowlands of Nepal (Meyer & Deuel, 1998). We recorded interviews using a Sony IC Recorder (ICD-BX112) and gathered ethnographic information while using the "walk-in-the-woods" method (Phillips & Gentry, 1993), in which consultants were actively involved in looking for known locations of nests. Whenever consultants found a nest, we asked them for the local name, local uses, and other information about the bee behavior. In addition, we used participant observation (Dewalt & Dewalt, 2002; Bhatta, 2013) to facilitate the interviews process. As the senior author (C.P.B.) is a native of Nepal and has experience working with community-based organizations in the country, informal conversations with the informants helped to understand both 'explicit' and 'tacit' details about the research in question (Kong *et al*., 2003; Bhatta & Bardecki, 2014).

To analyse the cultural use of stingless bees by the different communities, we grouped all mentioned uses into a number of categories (#C) and specific uses (#U) and employed a "uses totalled" or "researcher tally" method (Phillips, 1996). We divided all recorded specific uses (18 total) into four categories: food, medicine, crafts, and others/beliefs (Table 2). To calculate the relative cultural importance (RCI), we followed Gonzalez *et al*. (2018) in using a modified index from that developed by Bennett & Prance (2000) to calculate the relative importance of medicinal plants. Such an index is calculated on the sum of the proportion of the number of use categories (C) and the proportion of the number of specific uses (U) multiplied by 50 ([C + U] × 50). Thus, this index is expressed in a scale from 0 to 100 (Appendix). For example, the ethnic community in EDR used *T. iridipennis* in two of the four use categories, and it thus has a C of 2/4 = 0.5. They reported only 2 out of the 18 total uses recorded, thus it has a U of 2/18 = 0.11. Therefore, for the ethnic community in EDR, *T. iridipennis* had a RCI of (0.5 + 0.11) × 50 or 30.5. We chose this index because it is simple to calculate and requires the least amount of data collection (*i.e*., small number of informants and short field surveys) in comparison with other indices. It is worth noting that this index does not distinguish relative degrees of importance for different uses or between current and previous uses (for a discussion see, Hoffman & Gallaher, 2007). We used a Kruskal-Wallis test and *post hoc* Dunn's multiple comparison test with Bonferroni adjustment to assess for differences in the RCI among communities.

The Institutional Review Board of The University of Kansas reviewed this study (#00004310) and designated it as exempt. Voucher specimens are deposited in the Snow Entomological Collection, University of Kansas Natural History Museum, Lawrence, Kansas, USA.

RESULTS

Common Names

The ethnic communities in Nepal have given unique common names to *T. iridipennis* (Appendix). Chhetri people of FWDR and Brahmin people of CDR called them *puttka* while Brahmin people of WDR and Chhetri people of MWDR called them *puttko*

Table 2. Categories of use (#C) and specific uses (#U) documented for *Tetragonula iridipennis* (Smith) by four ethnic communities (Tharu, Brahmin, Chhetri, and Kirat) in Nepal. For each medicinal use, the type of bee product employed is provided in parentheses. Abbreviations: H, honey; P pollen; L, larvae.

Categories of use (#C)	**Specific uses (#U)**
Food	Honey
	Pollen
	Larvae
Medicine	Eye infection (H)
	Would healing (H)
	Skin ointment (H)
	Cleansing digestive tract (P)
	Strong immunity (H)
	Toothache (H)
	Sore throat/flu (H)
	Anti-vomiting (H)
	Facial and hair treatment (H)
	Libido in men (L)
Crafts	Wax for polishing
	Resin as a sealing glue
Others / Beliefs	Feel lucky owning colonies
	Increase fertility
	Sing a song about bees
#C= 4	**#U = 18**

and *puttiko*, respectively. Tharu people in all development regions called them *mangrasha* and Rai (Kirat) people from EDR recognized them as *dammer* bees. Our informants were unable to provide the meaning of the associated common names, except for *dammer*, which refers to the resins produced by dipterocarp trees. In fact, the Kirat people called them "*dammer* bees", as they collect resins from dipterocarp trees.

Traditional Uses

We recorded 18 specific uses of *T. iridipennis* across all ethnic groups and grouped them into four categories of use adopted in this study (Table 2). The first category is "food," where informants mentioned that they consumed the honey, pollen, and/or brood. Tharu people consume bee brood along with honey and pollen. Brahmin and Kirat people only use honey as a food, while Chhetri people use both honey and pollen as a food source. Some informants reported that every season, the skilled villagers might collect up to 2 L of honey per household.

In the "medicine" category, the majority of informants reported that they consumed raw honey immediately after extraction, while 25% said they drink honey mixed with lemon juice when needed to recover from bronchitis, flu, and other respiratory illnesses (Appendix). One of the informants at Mahendranagar, Kanchanpur

said: "*Puttka mauri* [*T. iridipennis*] *is the gift of God. Its honey is useful for many things such as healing the wounds for cattle, to recover from eye infection and many more. It is really a holy creation of God*". Informants use the honey to treat eye infections, toothaches, and sore throat/flu. They believe that the honey expedites wound healing and maintains strong overall immunity. Honey is also used to control vomiting due to excess of alcoholic consumption. In addition, honey is used for facial treatment and hair therapy. Pollen is used to cleanse the digestive system and to expedite the overall digestion process. Tharu people consume bee broods to increase libido in men. An informant from Tharu ethnic group, interviewed at Ghodaghodi Tal, Kailali said: "*Mangrasha* [*T. iridipennis*] *broods are very powerful sources to increase sexual desires and performances in men. We have been taught by our parents and grandparents that it should be consumed by newly married man or the man who have had trouble to have a child*".

"Crafts" is the third category of use. Tharu people from all developmental regions use both cerumen and resins. They use cerumen to polish furniture, metal containers, and even doors and windows in their houses. Resins (propolis) are used as a sealing glue. One of the Tharu informants, interviewed in Gorusinge, Kapilvastu, mentioned that every summer, between April and May, they have a campaign to collect cerumen and resins from nests, which they heat and mix together to make a big ball known as *pattharkhatta*, meaning "*patthar*: stone" and "*khatta*: very strong". The *pattharkhatta* is used locally in potteries and carpentries year around to rub on the finished pots and wooden structures. Extraction of bee products often results in the loss of the entire colony.

The last category, "other/beliefs", includes all miscellaneous uses that do not fall under the previous categories. Some of the specific uses included here illustrate the diverse and intricate historical relationships between people and stingless bees in Nepal. For example, Tharu people feel lucky if the *mangrasha* nests on their property. They also believe that consuming bee broods and honey increases fertility in men. Likewise, Chhetri people use stingless bee honey to make a holy drink [*panchamrit*] during special occasions, such as births and deaths. One Chhetri informant from Kohalpur, Banke, remembers his grandfather singing the following song when he was a child: "*डाँडै माथि टोडको साल तेइ माथि पूत्तकिो, मायाँमा परानी दानि को होला हूतकिो*" [*There are stingless bees nesting on hollow trunks of Sal tree on the top of the hills, when I will find a true love that will love me lifetime with all means*].

Management Practices

All participant communities exploit wild populations of *T. iridipennis* through an extractive practice and lack management practices. Extraction of bee products (honey or propolis) often results in the loss of the entire colony. People sometimes bring logs or tree trunks containing wild colonies closer to their homes (Figs. 2–4), but they do not propagate or manage them.

Relative Cultural Importance

The relative cultural importance index (RCI) ranged from 30.5 in the Brahmin and Kirat communities in CDR and EDR to 91.5 in the Tharu community at FWDR (Appendix). Chhetri people have moderate uses of *T. iridipennis*, although according to the informants, Chhetri people of FWDR have a closer relationship with *T. iridipennis* than those of MWDR. We observed a significant difference in the relative cultural

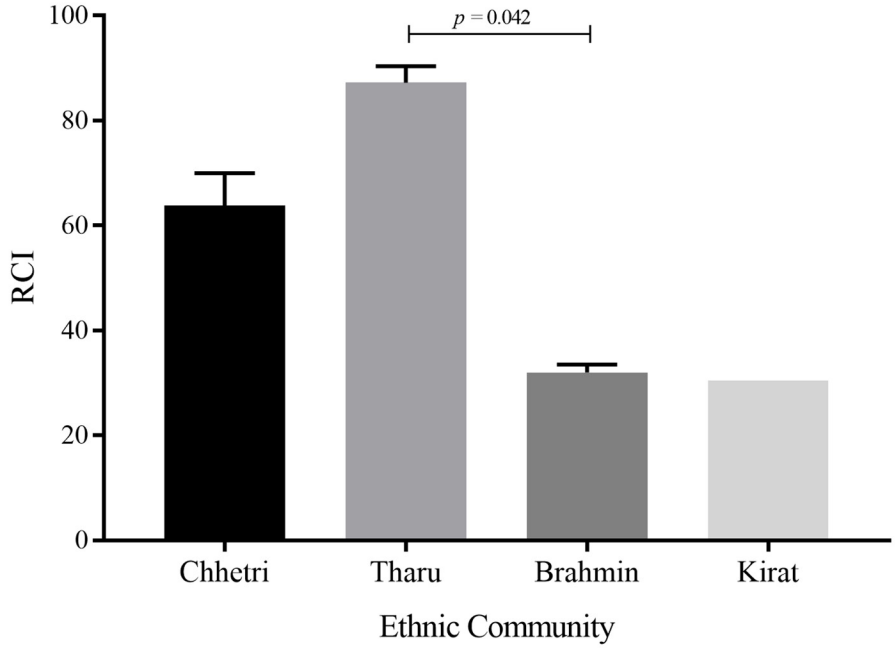

Figure 5. Relative cultural importance index (RCI) for *Tetragonula iridipennis* (Smith) calculated for each ethnic community that participated in the study. Dunn's pairwise tests showed significant differences only between the Tharu and Brahmin.

importance index among the Chhetri, Tharu, and Brahmin (H [3] = 6.25, p = 0.011). Because a single community represented the Kirat people, we excluded it from the analysis. Dunn's pairwise tests showed significant differences only between the Tharu and Brahmin (p = 0.042) (Fig. 5).

DISCUSSION

As in other studies, our consultants demonstrated extensive knowledge of the ecology and natural history of the bees. They knew with great precision the nesting sites, trees, and habitats preferred by the bees and quickly found their nests (Gonzalez *et al*., 2018). The kind of uses for *T. iridipennis* in Nepal fall within those known for other species of *Tetragonula*, as well as for other species of stingless bees in other regions of the world (*e.g*., Quezada-Euán *et al*., 2001; Ayala *et al*., 2013; Reyes-González *et al*., 2014; Vit *et al*., 2015; Gonzalez *et al*., 2018). In India, *T. iridipennis* is also known by some local people as *puttka* or *dammer* bees, and its honey is also used for medicinal purposes, such as in the treatment of burns, eye infections, diarrhea, ulcers, *&c*. (*e.g*., Singh, 2016). *Tetragonula iridipennis* is also culturally important for some indigenous tribes of India, such as the Lepcha or Rong of Sikkim Himalaya, as their traditional hat contains layers of plant fibers that represent the eyes of this bee species (Lepcha *et al*., 2012).

The traditional uses documented here for Nepal provide clear evidence of the cultural importance of *T. iridipennis* to the local communities, particularly to the Tharu people, as indicated by the high values of RCI (81.1–91.5). These high values may reflect their heavy reliance on the natural resources in their everyday life, as the Tharu people are underprivileged and economically less stable than other communities in

Nepal (Dahal, 2003). In fact, Tharu people not only consume honey and bee broods as a source of protein and carbohydrates, but also depend on hunting small mammals and snails (Parajuli *et al*., 2012). Although our sample sizes are small, our analysis of the RCI among communities only revealed significant differences between the Tharu and Brahmin, thus suggesting an overall shared body of knowledge. The low RCI values of the Brahmin (30.5–33.5) are not surprising, as these people are less reliant on the local natural resources because of their higher economic stability when compared with other communities in Nepal. Further studies with greater samples sizes are necessary to draw stronger conclusions.

Many species of *Tetragonula*, outside of Nepal, are recognized locally by several indigenous names and are often exploited for honey or wax, and several species [*e.g*., *T. carbonaria* (Smith) in Australia, *T. biroi* (Friese) in the Philippines] are already being used for commercial pollination (Thummajitsakul *et al*., 2008; Rasmussen, 2013). In the Indo-Malayan region, meliponiculture is still in its infant stage (Cortopassi-Laurino *et al*., 2006) and such activity is unknown in Nepal. As documented herein, the participant communities lack management practices for wild populations of *T. iridipennis*. Even when people cut logs containing the natural bee colony and transport them to their home area, they do not propagate or manage them for honey or pollen because they lack this knowledge, which highlights the importance of introducing this practice into local communities. The latter can also explain why colonies of *T. iridipennis* that occasionally occupy cavities in house walls, which are designed to catch swarms of native honey bees in the summer, are never managed (P. Basnet, pers. comm., 26 June 2016, in Kohalpur, Banke, Nepal). Future research could explore how the perceptions or management practices of honey bees could have influenced the development of a more sustainable use of stingless bees in Nepal. It is possible that people are naturally more attracted to honey bees than to stingless bees because the first are more abundant, they are easier to find and capture in the field, and they produce greater quantities of honey.

The majority of consultants (89%) expressed concerns about the future of bees. They believed that the number of colonies is quickly declining due to the current extractive practice (100%), forest fires (89%), use of modern housing materials such as cements and its products (33%), heavy droughts (22%), and the arrival of European honey bees (11%). During our surveys, we had the opportunity to observe forest fires as well as logging activities of several trees containing live colonies of *T. iridipennis*. The destruction of the natural nesting sites of *T. iridipennis* was almost inevitable, as this bee species tends to nest in medium to very large canopy trees used as timber [*Shorea robusta* (Roth.) (Dipterocarpaceae) and *Dalbergia sissoo* (Roxb.) (Fabaceae)] or animal feed [*Terminalia elliptica* (Wild.) (Fabaceae) and *Haldina cordifolia* (Roxb.) (Rubiaceae)] (Bampton & Cammaert, 2007; Joshi & Singh, 2008; Bhatta *et al*., 2019). This is alarming because stingless bees often nest in clusters within a particular habitat (Nagamitsu & Inoue, 1997), and nest density is positively correlated with the density of large trees (Samejima *et al*., 2004).

The cultural significance of this bee species to the participant communities in southern Nepal contrasts with their current extractive practices, which might negatively affect bee populations. However, the level of exploitation of natural populations of *T. iridipennis* might be different depending on the status of the tree species used as nesting site. For example, according to Bhatta *et al*. (2019), *T. iridipennis* also uses tree species that are protected under religious beliefs, such as *Ficus religiosa* (L.) (Moraceae), a Buddha tree (Ingles, 1995); *Senegalia catechu* (L.f.) Hurter & Mabb. (Fabaceae),

a threatened aromatic plant (Sharma *et al*., 2017); and *Bombax ceiba* (L.) (Malvaceae), a species protected as a nesting tree of vultures (Baral *et al*., 2004). Thus, we expect a lower impact on wild populations of *T. iridipennis* in areas where these tree species are more abundant.

The information presented here, although limited, represents the first steps in understanding the cultural importance of stingless bees in Nepal. It is clear that *T. iridipennis* is a highly valued bee that has received little attention in the literature when compared with honey bees. This stingless bee appears to be particularly relevant for vulnerable ethnic communities such as the Tharu, who will benefit the most from learning how to manage the colonies in a sustainable way. To develop a sustainable use of *T. iridipennis* in Nepal, researchers need to begin assessing productive aspects of the colonies (honey, pollen, and wax), as well as other aspects of the biology of this species, such as local nest density, host plants, and its role in pollination of both wild and cultivated plants.

ACKNOWLEDGEMENTS

This study was supported by summer scholarships and travel grants to C.P.B. from the University of Kansas Entomology Endowment fund. V.H.G.'s participation was supported through NSF-REU program (DBI 1560389). We would like to thank Krishna Thagunna, Ishwori Banjade, and Purmal Basnet for their cooperation during the fieldwork and acting as liaisons with local people. We also thank Amy R. Comfort and anonymous reviewers for comments and suggestions that improved this work.

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Appendix. Common names, categories of uses, and relative importance value of *Tetragonula iridipennis* (Smith) as provided by participants from different human communities across different regions of Nepal. Abbreviations: H = honey; P = pollen; L = larvae; — = non-applicable; #C = number of categories of use; #U = number of specific uses; C = proportion of the total number of categories of use; U = proportion of the total number of specific uses; RCI = relative cultural importance index ([C + U] × 50). See text for description of each specific use.

Human Communities/ Informants	Ethnicity	Bee common name	Food	Categories of use			Relative cultural importance				
				Medicine	Crafts	Other/ Beliefs	#C	#U	C	U	RCI
Far-Western Development Region (FWDR 1)	Chhetri	Puttka	H P	Eye infection, wound healing, skin ointment, cleansing digestive tract, strong immunity	Wax for polishing	Makes holy drink	4	9	1.00	0.50	75
Far-Western Development Region (FWDR 2)	Tharu	Mangrasha	H P L	Toothache, eye infection, sore throat/flu, wound healing, antivomiting, facial and hair treatment, libido in men, and strong immunity	Wax for polishing, resin as a sealing glue	Feels lucky owning colonies, increase fertility	4	15	1.00	0.83	**91.5**
Mid-Western Development Region (MWDR 1)	Tharu	Mangrasha	H P L	Skin ointment, strong immunity, fever/ headache, libido in men	Wax for polishing, resin as a sealing glue	Feels lucky owning colonies, increase fertility	4	11	1.00	0.61	**81.1**
Mid-Western Development Region (MWDR 2)	Chhetri	Puttiko	H P	Headache/fever, eye infection, wound healing, skin ointment, strong immunity	—	Sings a song about puttiko, makes holy drink	3	9	0.75	0.50	62.5

Appendix. Continued.

Human Communities/ Informants	Ethnicity	Bee common name	Food	Categories of use			Relative cultural importance				
				Medicine	Crafts	Other/ Beliefs	#C	#U	C	U	RCI
Mid-Western Development Region (MWDR 3)	Chhetri	Puttiko	H P	Sore throat/flu, wound healing, strong immunity	Resin as a sealing glue	—	3	6	0.75	0.33	54
Western Development Region (WDR 1)	Tharu	Mangrasha	H P L	Eye infection, sore throat/flu, wound healing, anti-vomiting/relief from alcohol, facial and hair treatment, libido in men, and strong immunity	Wax for polishing, resin as a sealing glue	Feels lucky owning colonies, increase fertility	4	14	1.00	0.78	**89**
Western Development Region (WDR 2)	Brahmin	Puttko	H	Wound healing, strong immunity	—	—	2	3	0.50	0.17	33.5
Central Development Region (CDR 1)	Brahmin	Puttka	H	Strong immunity	—	—	2	2	0.50	0.11	30.5
Eastern Development Region (EDR 1)	Kirat	Dammer bees	H	Strong immunity	—	—	2	3	0.50	0.11	30.5

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The *Journal of Melittology* was established at the University of Kansas through the efforts of Michael S. Engel, Victor H. Gonzalez, Ismael A. Hinojosa-Díaz, and Charles D. Michener in 2013 and each article is published as its own number, with issues appearing online as soon as they are ready. Papers are composed using Microsoft Word® and Adobe InDesign® in Lawrence, Kansas, USA.

Journal of Melittology is registered in ZooBank (www.zoobank.org), and archived at the University of Kansas and in Portico (www.portico.org).

http://journals.ku.edu/melittology
ISSN 2325-4467