Insights into the impacts of rural honey hunting in Zambia

Christine Rose Coppinger[1*]

christine@remoteafrica.com

Cell: +260 973 468 796

Bruce Robert Ellender[2]

bru.ellender@gmail.com

Cell: +260 973 468 792

Dara A. Stanley[3]

dara.stanley@ucd.ie

Juliet Osborne[4]

J.L.Osborne@exeter.ac.uk

[1]Trident Foundation, Jivundu Research Station, North-Western Province, Zambia; [2]South African Institute for Aquatic Biodiversity, Private Bag 1015, Grahamstown 6140, South Africa; [3]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4, Ireland; [4] Environment and Sustainability Institute, Exeter University, Exeter EX4 4QD, UK

***Corresponding author**

Summary: 1849 words (exclusive of tables, figures and references)

Acknowledgements

Thanks to Remote Africa Safaris for their support and for allowing me to conduct research on their property.

Data Sharing

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Introduction

Honeybees are integral in socio-ecological landscapes with 1.6 million tonnes of honey produced globally, of which ~518,000 are traded (IPBES, 2016). Honeybees support livelihoods (Clauss, 1991; Crane, 1999; Jumbe, Bwalya, & Husselman, 2008) and archaeological evidence suggests that bee products were even exploited by Neolithic humans (Roffet-Salque et al., 2015). Honeybees provide ~50% of global crop pollination (Kleijn et al., 2015) and are the most frequent floral visitor in natural habitats (Hung, Kingston, Albrecht, Holway, & Kohn, 2018).

While recent impacts of *Varroa* mite infestations on Western honeybees are documented, wild pollinators and honeybees are additionally impacted by habitat destruction and associated stressors (IPBES, 2016; Simon G Potts et al., 2010). Africa loses 3.4 million hectares of natural forest annually (FAO, 2011), undoubtedly negatively affecting wild honeybees although little regional evidence exists (Dietemann, Walter, Pirk, & Crewe, 2009). The situation in Zambia reflects continental trends: growing populations cause extensive land transformation (Baudron, Mwanza, Triomphe, & Bwalya, 2007; Rudel, 2013) with 1,134,616ha of forest cover lost between 2001-2015 alone (Global Forest Watch, 2017). Factors contributing to deforestation include fuel production, agricultural intensification, shifting slash-and-burn agriculture, fire and development (FAO, 2011; Mickels-Kokwe, 2006; Rudel, 2013). While non-timber forest product (NTFP) exploitation could sustainably promote economic benefits to rural communities (Chirwa, Syampungani, & Geldenhuys, 2008; Raina, Kioko, Zethner, & Wren, 2011), they are often extracted unsustainably (e.g. commercial harvesting of edible caterpillars causes extensive tree felling to speed collection, contrary to sustainable traditional methods (Mbata, Chidumayo, & Lwatula, 2002)).

Some of the most significant and widely exploited NTFPs are honeybee products, sourced from indigenous *Apis mellifera scutellata* honeybees, supporting livelihoods in Zambia through beekeeping and wild-harvest (Clauss, 1991; Fischer, 1993; Mickels-Kokwe, 2006). However, the impacts of traditional beekeeping are concerning as ~273,000 trees are reportedly felled annually to construct traditional hives in North-Western Zambia (Mickels-Kokwe, 2006). Despite some information on beekeeping impacts, little is known about wild-harvest honey hunting impacts (collecting honey from feral hives) on the conservation status of honeybees and their woodland habitats. *Apis mellifera scutellata* honeybees, usually nesting in tree cavities (Dietemann et al., 2009), are subdued with smoke, sometimes after felling the tree (Figure 1), to facilitate honey extraction (Mickels-Kokwe, 2006). Observations on the destructiveness of these methods prompted a preliminary investigation into their impacts and an assessment of honeybee nesting preferences in two representative vegetation types, a mixed mopane/riverine woodland, and miombo woodland in Zambia.

Materials and Methods

Study Site

The study took place within two protected areas: the Tafika private photographic safari concession in the Mwanya Game Management Area adjacent to South Luangwa National Park, Eastern Province (lat -12.856735° , long 32.010758°); and the Lusaka East Forest Reserve (LEFR) in the Lusaka City suburbs, Lusaka Province (lat -15.435324°, long 28.409041°) (Figure 2). Both sites were situated near (< 2km) local communities: Mkasanga Village and the Bauleni Suburb respectively. Each region represented one of the two primary woodland types in Zambia: a mixed mopane/riverine woodland in the Tafika concession and miombo (*Brachystegia-Julbernardia-Isoberlinia*) woodland in the LEFR (Figure 2). The Tafika concession was surveyed over a week during September 2016 and the LEFR over a week during August 2017.

Data collection

To make relevant habitat comparisons and survey similar numbers of trees (and therefore similar numbers of possible nesting sites) in each of the vegetation types, 100 ha and 20 ha sampling plots were required in mopane/riverine and miombo woodlands respectively since tree densities were higher in the miombo than in mopane. In each plot, average tree density was estimated by counting all mature trees (≥3m high; trunk diameter at breast height i.e. 1.3m height ≥ 25 cm) within a representative 10 ha plot in the mopane and 5 ha plot in the miombo and up-calculating to estimate the number of trees per plot.

In each plot, the observer exhaustively inspected mature trees for bee nests: active, inactive (no bees in residence) and poached, recording tree species. Poaching impact was recorded in the following categories: 1) whole tree felled; 2) a branch chopped off; 3) hole cut to aid comb extraction. Chi squared tests of independence were conducted in Microsoft Excel to test whether occupation rates and poaching impact were significantly different between habitats.

Results

Roughly 846 trees were surveyed across the two plots, 416 in the miombo and 430 in the mopane. Average tree densities were 4.3 trees/ ha for mopane and 20.8 trees/ ha for miombo.

Nesting rates and tree preference

Of the 430 trees sampled in the mopane plot, 21 trees (4.9%) had evidence of bee nests, including eighteen (85.7%) inactive and three (14.3%) active nests. In the miombo, eight trees (1.9%) of the 416 surveyed had evidence of bee nests and no active nests were found (Figure 3a). The mopane had significantly higher occupation rates than miombo ($\chi^2 = 5.599$, $df = 1$, $p = 0.02$).

Honeybees showed preferences for certain tree species: in mopane, 71.4% of nesting trees were *Kigelia africana* and 19% were *Bauhinia thonningii*. In miombo, *Julbernardia globiflora* and *Brachystegia* spp. most commonly had evidence of bee nests (each constituting 37.5% of nesting trees) (Table 1).

Poaching and re-occupation rates

Of the nesting trees, twenty trees (95.2% of nesting trees, 4.7% of all surveyed trees) were poached in the mopane compared to eight (100% of nesting trees, 1.9% of all surveyed trees) in the miombo. Of the poached trees in the mopane, three (15% of poached, 0.7% of all surveyed) were felled, eight (40% of poached, 1.9% of all surveyed) had branches removed and nine (45% of poached, 2.6% of all surveyed) had holes cut to access nests (Figure 3b). In the miombo three of the poached trees (37.5% of poached, 0.7% of all surveyed) were felled, three (37.5% of poached, 0.7% of all surveyed) had branches removed and two (25% of poached, 0.5% of all surveyed) had holes cut to access nests (Figure 3b). The extent of damage inflicted by honey hunters was not significantly different between the two habitats

($\chi^2 = 2.377$, $df = 3$, $p = 0.50$). Only two (10%) of the poached nests were re-occupied in the mopane (both only had holes cut to extract honey) with none being reoccupied in the miombo.

Discussion

Where others have noted deforestation and bee colony destruction impacts by honey hunters (Oldroyd & Nanork, 2009; Tornyie & Kwapong, 2015), no studies have quantified forest damage inflicted by honey hunters. This study suggests that limited damage is inflicted on woodlands by honey hunters: only 4.7% of mature trees in the mopane had evidence of honey hunting activity with only 0.7% of all trees felled completely. The impact appeared similarly low in the miombo: 1.9% of trees had evidence of poaching and 0.7% of all trees were felled.

Despite apparently low impacts of honey hunting on the studied woodlands, it is noteworthy that poaching rates of hives were extremely high (mopane: 95.2%, miombo: 100%) with only a single nest undisturbed in the mopane, contrary to poaching rates of stingless bee nests in Uganda as low as 13% (Kajobe & Roubik, 2006). Secondly, felling rates of nesting trees were higher in the miombo (37.5% of poached trees) compared to the mopane (15% of poached trees), possibly indicating the role of management activities and land-use in determining the poaching impacts to nesting trees and honeybee colonies within the two study plots. Research showing higher honeybee genetic diversity and colony density in nature reserves than in agricultural landscapes (Jaffé et al., 2009) supports the theory that forest protection benefits honeybees. Although both plots were within conservation areas, there was more active forest protection in the more rural mopane area. Conversely the miombo area was situated near a larger, urban community, with minimal active protection. Despite these differences, poaching impacts were not found to significantly differ between the two habitats. Future studies should cover broader geographical areas, selecting replicate plots in each habitat, each within varying land-use to more accurately assess impacts.

Within the study plots, poaching impacts were proportional to nesting density (nests/ha), especially when forest conservation activity was minimal. Nesting densities were within the range found in other studies (listed in Kajobe & Roubik, 2006): 21 nests/100ha in the mopane and 40 nests/100ha in the miombo. Kajobe & Roubik (2006) argue that smaller survey areas tend to over-estimate nest densities as nests are likely to be clustered in space despite uniform presence of appropriate nesting trees. To account for this, transects for this study uniformly covered the pre-selected plots, ensuring that all mature trees could be inspected. Although more nests/ha were found in the miombo after surveying a smaller area than the mopane, nesting densities were not significantly different between the two habitats. Furthmore, other important factors affecting nest density should not be overlooked e.g. mature tree density (Tornyie & Kwapong, 2015) and the abundance of forage (Eltz, Brühl, van der Kaars, & Linsenmair, 2002). The miombo had much greater mature tree densities and is generally presumed to provide more abundant honeybee forage (Mickels-Kokwe, 2006). These considerations indicate that miombo forests could support higher honeybee nest densities and therefore be generally more vulnerable to the impacts of honey hunters.

The intensity of destructive honey hunting practices could itself be a determinant of honeybee nest densities within the landscape, not conforming with Kajobe & Roubik's study (2006) that found honeybee nests to be common despite predation. High poaching rates (only a single undisturbed nest in mopane) could contribute to the destruction of nesting cavities affecting absconding rates and nest distribution within the landscape. This hypothesis is supported by the low reoccupation rates of poached nests (10% of poached nesting trees in mopane and none of the poached miombo trees) when these were significantly damaged (the two reoccupied nests only had holes cut for honey extraction). However, these phenomena are likely affected by the abundance of alternate nesting habitats outside of areas heavily exploited by honey hunters which was not quantified during this study.

Although Tornyie & Kwapong (2015) found that tree size rather than species influenced nest site selection, this study did find certain tree species containing bee nests more frequently. This could potentially help to direct conservation efforts towards tree species that may be more vulnerable to the impacts of damaging honey hunting practices (e.g. *Kigelia africana* and *Bauhinia thonningii* trees in mopane and *Julbernardia globiflora* and *Brachystegia* in miombo). Other factors could impact nest site selection (e.g. entrance orientation, cavity volume (McNally & Schneider, 1996)) which should be accounted for in future studies to determine whether tree specific conservation would effectively mitigate against damaging honey hunting practices.

Conclusions

It should be noted that the results of this study are preliminary being based on only one study plot per habitat type and more research is needed at a broader landscape scale to further test the following hypotheses introduced by this preliminary study: 1) poaching rates are high and are proportional to nest densities; 2) poaching rates and the destructiveness of honey hunting practices are likely to be influenced by forest conservation efforts; 3) the destructiveness of honey hunting practices influences nest reoccupation rates.

References

Baudron, F., Mwanza, H. M., Triomphe, B., & Bwalya, M. (2007). *Conservation agriculture in Zambia: a case study of Southern Province. African Conservation Tillage Network, Centre de Coopération Internationale de Recherche Agronomique pour le Développement, Food and Agriculture Organization of the United Nations.* Retrieved from http://www.fao.org/ag/ca/doc/zambia_casestudy.pdf

Chirwa, P., Syampungani, S., & Geldenhuys, C. (2008). The ecology and management of the Miombo woodlands for sustainable livelihoods in southern Africa: the case for non-timber forest products. *Southern Forests: A Journal of Forest Science*, *70*(3), 237–245. http://doi.org/10.2989/SF.2008.70.3.7.668

Clauss, B. (1991). *Bees and beekeeping in the North Western Province of Zambia*.

Crane, E. E. (1999). *The world history of beekeeping and honey hunting*. New York, USA: Routledge.

Dietemann, V., Walter, C., Pirk, W., & Crewe, R. (2009). Is there a need for conservation of honeybees in Africa? *Apidologie*, *40*, 285–295. http://doi.org/10.1051/apido/2009013

Eltz, T., Brühl, C. A., van der Kaars, S., & Linsenmair, K. E. (2002). Determinants of stingless bee nest density in lowland dipterocarp forests of Sabah, Malaysia. *Population Ecology*, *131*, 27–34. http://doi.org/10.1007/s00442-001-0848-6

FAO. (2011). *State of the world's forests*. Rome. Retrieved from http://www.fao.org/docrep/013/i2000e/i2000e00.htm

Fischer, F. U. (1993). *Beekeeping in the subsistence economy of the miombo savanna woodlands of south-central Africa. Network Paper - Rural Development Forestry*

Network. Three Views from Africa.

Global Forest Watch. (2017). Global Forest Watch | Zambia. Retrieved August 30, 2017, from http://www.globalforestwatch.org/country/ZMB

Hung, K. J., Kingston, J. M., Albrecht, M., Holway, D. A., & Kohn, J. R. (2018). The worldwide importance of honey bees as pollinators in natural habitats. *Proceedings of the Royal Society B*, *285*(1870), 20172140. http://doi.org/http://dx.doi.org/10.1098/rspb.2017.2140

IPBES. (2016). *Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production*. (S. G. Potts, V. L. Imperatriz-fonseca, H. T. Ngo, J. C. Biesmeijer, T. D. Breeze, L. V. Dicks, … B. F. Viana, Eds.)*UNEP/GRID Europe*. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. http://doi.org/10.1371/journal.pone.0090102

Jaffé, R., Dietemann, V., Allsopp, M. H., Costa, C., Crewe, R. M., Dell'Olio, R., … Moritz, R. F. A. (2009). Estimating the density of honeybee colonies across their natural range to fill the gap in pollinator decline censuses. *Conservation Biology*, *24*(2), 583–593. http://doi.org/10.1111/j.1523-1739.2009.01331.x

Jumbe, C. B. L., Bwalya, S. M., & Husselman, M. (2008). *Contribution of dry forests to rural livelihoods and the national economy in Zambia*. *XIII World Forestry Congress*.

Kajobe, R., & Roubik, D. W. (2006). Honey-making bee colony abundance and predation by apes and humans in a uganda forest reserve. *Biotropica*, *38*(2), 210–218. http://doi.org/10.1111/j.1744-7429.2006.00126.x

Kleijn, D., Winfree, R., Bartomeus, I., Carvalheiro, L. G., Henry, M., Isaacs, R., … Potts, S.

G. (2015). Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. *Nature Communications*, *6*. http://doi.org/10.1038/ncomms8414

Mbata, K. J., Chidumayo, E. N., & Lwatula, C. M. (2002). Traditional regulation of edible caterpillar exploitation in the Kopa area of Mpika district in northern Zambia. *Journal of Insect Conservation*, *6*, 115–130. http://doi.org/https://doi.org/10.1023/A:1020953030648

McNally, L. C., & Schneider, S. S. (1996). Spatial distribution and nesting biology of colonies of the African honey bee *Apis mellifera scutellata* (Hymenoptera: Apidae) in Botswana, Africa. *Environmental Entomology*, *25*(3), 643–652. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-0030485549&partnerID=40&md5=c09894a4ed90eb24a95564f4f1b950ae

Mickels-Kokwe, G. (2006). *Small-scale woodland-based enterprises with outstanding economic potential: the case of honey in Zambia*. Bogor Barat, Indonesia: Center for International Forestry Research (CIFOR).

Oldroyd, B. P., & Nanork, P. (2009). Conservation of Asian honey bees. *Apidologie*, *40*, 296–312. http://doi.org/10.1051/apido/2009021

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, *25*(6). http://doi.org/10.1016/j.tree.2010.01.007

Raina, S. K., Kioko, E., Zethner, O., & Wren, S. (2011). Forest habitat conservation in Africa using commercially important insects. *Annual Review of Entomology*, *56*(1), 465–485. http://doi.org/10.1146/annurev-ento-120709-144805

Roffet-Salque, M., Regert, M., Evershed, R. P., Outram, A. K., Cramp, L. J. E., Decavallas, O., … Pääkkönen, M. (2015). Widespread exploitation of the honeybee by early Neolithic farmers. *Nature*, *527*, 226–230. http://doi.org/10.1038/nature18451

Rudel, T. K. (2013). The national determinants of deforestation in sub-Saharan Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*. http://doi.org/10.1098/rstb.2012.0405

Tornyie, F., & Kwapong, P. K. (2015). Nesting ecology of stingless bees and potential threats to their survival within selected landscapes in the northern Volta region of Ghana, 398–405.

van Breugel, P., Kindt, R., Lilles, J., Bingham, M., Demissew, S., Dudley, C., … Graudal, L. (2015). Potential natural vegetation map of Eastern Africa (Burundi, Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Version 2.0. Forest and Landscape (Denmark) and World Agroforestry Centre (ICRAF). Retrieved from http://vegetationmap4africa.org/

Table 1 Tree species found with evidence of honeybee nests within each of the study areas.

Nesting Tree Species	**Number of trees with nests** *n* (% of nesting trees)
MOPANE	
Kigelia africana	15 (71.4%)
Bauhinia thonningii	4 (19.0%)
Faidherbia albida	1 (4.8%)
Acacia sp.	1 (4.8%)
TOTAL	**21**
MIOMBO	
Julbernardia globiflora	3 (37.5%)
Brachystegia spp.	3 (37.5%)
Ficus spp.	1 (12.5%)
Unidentified	1 (12.5%)
TOTAL	**8**

Figure legends

Figure 1) A tree felled by honey hunters and holes cut at the nest entrance to remove honey combs.

Figure 2) Map showing the situation of the two study areas within Zambia. Vegetation zones are shown and the vegetation types relevant to this study are listed in the legend. Vegetation data sourced from van Breugel *et al*. (2015).

Figure 3a) The numbers of trees without nests, poached nesting trees and undisturbed nesting trees in the two miombo and mopane habitat plots. The broken y-axis omits y-values from 35 to 400 to more clearly show the single tree with an undisturbed nest. 3b) The extent of damage inflicted on bee nesting trees by honey hunters in each of the miombo and mopane plots. "% trees felled" = percentage of nesting trees felled; "% branch chopped" = percentage of nesting trees with branches removed; "% hole cut" = percentage of nesting trees with holes cut to remove honey; "% undisturbed" = percentage of nesting trees not been damaged by honey hunters.

Figures

Figure 1

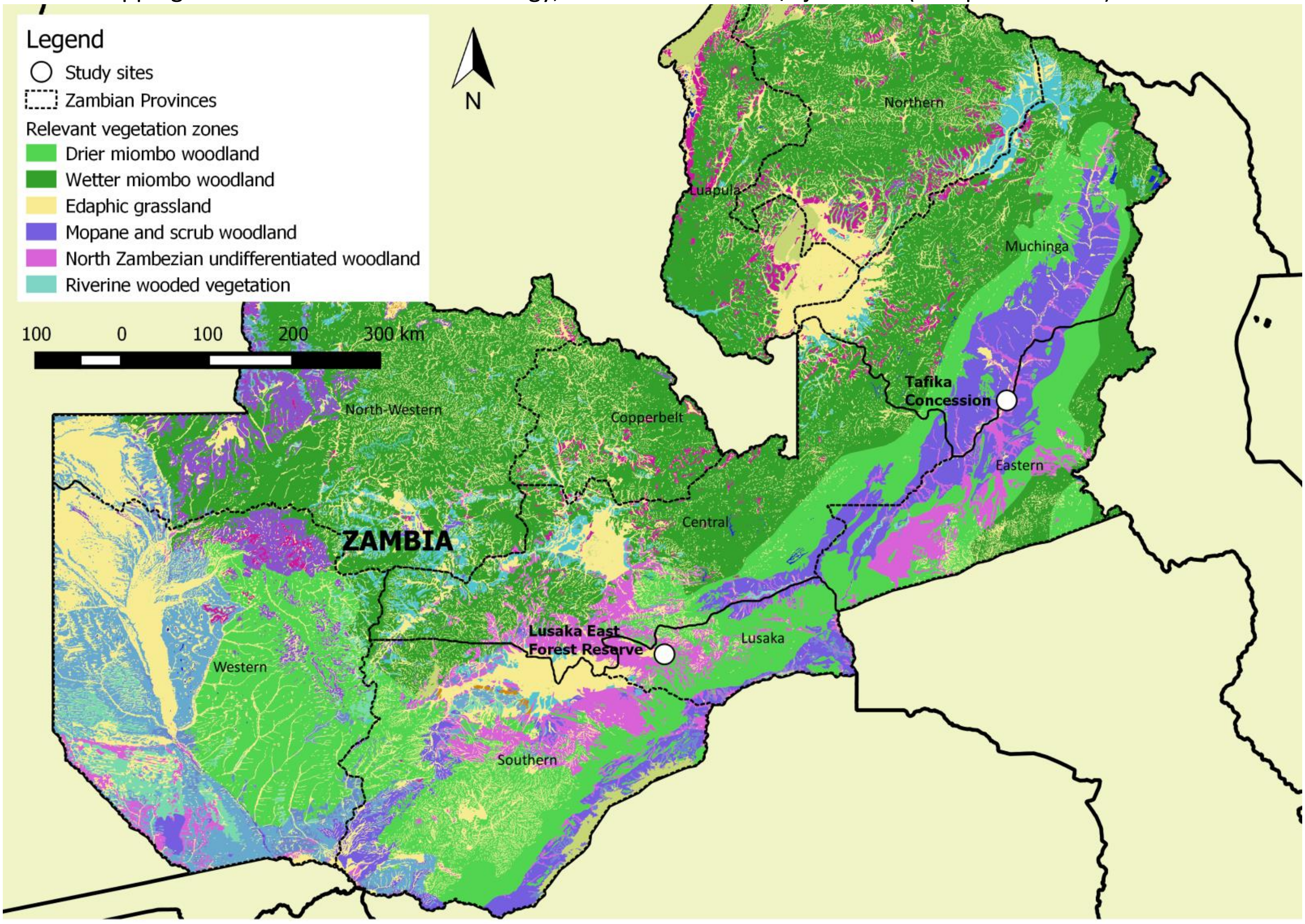
Legend
Study sites
Zambian Provinces
Relevant vegetation zones
Drier miombo woodland
Wetter miombo woodland
Edaphic grassland
Mopane and scrub woodland
North Zambezian undifferentiated woodland
Riverine wooded vegetation
N
100 0 100 200 300 km
Northern
Luapula
Muchinga
Tafika Concession
North-Western
Copperbelt
Eastern
Central
ZAMBIA
Lusaka East Forest Reserve
Lusaka
Western
Southern

Figure 2

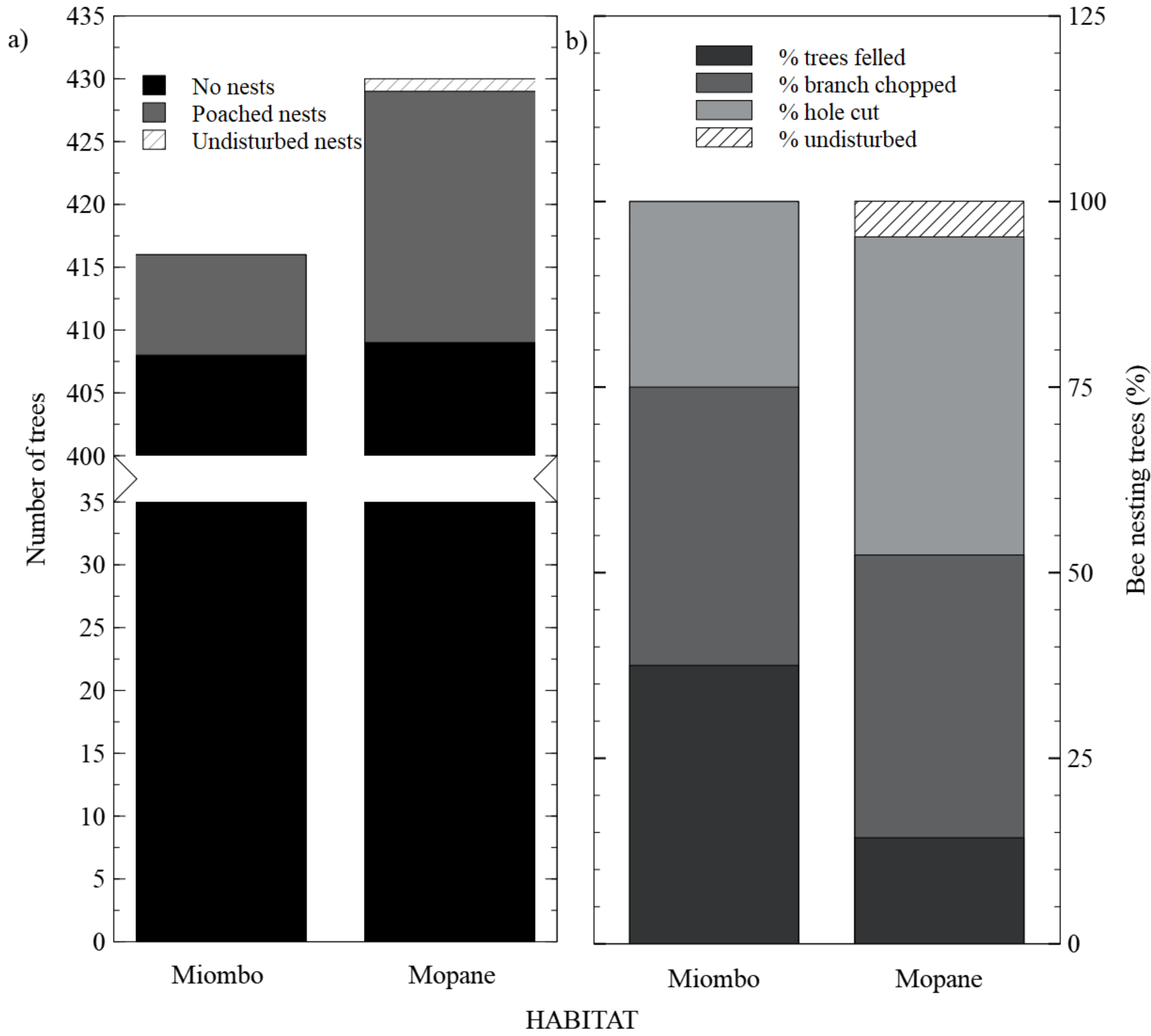
a)
No nests
Poached nests
Undisturbed nests
Number of trees
435
430
425
420
415
410
405
400
35
30
25
20
15
10
5
0
Miombo
Mopane
b)
% trees felled
% branch chopped
% hole cut
% undisturbed
125
100
75
50
25
0
Bee nesting trees (%)
Miombo
Mopane
HABITAT

Figure 3a & b