



Research, part of a Special Feature on [Why does hunting in tropical regions matter?](#)

## The human health and conservation relevance of food taboos in northeastern Madagascar

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**ABSTRACT.** Anthropologists and ecologists investigating the dialectical relationship between human environments and the cultural practices that shape and are shaped by them have been talking past each other for too long: the one looking purely at metaphor and the other purely at function. Our mixed-method data analysis set out to explore whether it was possible to determine empirically the human health and conservation value of the local Malagasy taboo system. This involved qualitative examination of the content of taboo origin stories collected through ethnographic approaches, when the story was remembered. The ethnographic substance of these stories included historicizing events, accounts of symptoms associated with breaching taboos, and incentives for abiding by taboos. We then used quantitative comparisons in an effort to understand the motivation for adhering to taboos. We provide evidence that the conservation value of taboos may be limited but that the social value of taboos may be rooted in concerted attempts to preserve a physical, spiritual, moral, and cultural immunity. Furthermore, we found that there was a sophisticated traditional etiological knowledge, based in nuanced understandings of ecology and epidemiology, which likely protects local people from zoonotic disease, allergies, and toxins. We suggest that the prohibitions mandated by the traditional taboo system against consuming particular wildlife species is a moral framework, which is driven to a significant degree by personal security and health-related incentives.

**Key Words:** *allergies; Betsimisaraka; bushmeat; hunting; traditional epidemiological knowledge; traditional etiological knowledge; Tsimihety; wildlife; zoonotic disease*

### INTRODUCTION

If earlier historical Western conceptions of taboos were framed in terms of magic, superstition, or irrational spiritual belief, modern theorists have reinterpreted these conceptions as rational, part of moral and normative rules that served clear social regulatory functions (Zuesse 1974). However, close observation makes plain that taboos are far more complex than this. Modern anthropology, in which the study of taboo has long been a lively topic (Steiner 1956, Douglas 1966), sees them primarily as part of the making and maintenance of social classifications and boundaries, and hence, more generally as integral to the ordering of the lived world. Taboos also appear to have a pragmatic purpose: they express the desire to master perceived threat and danger to bodies personal and social. Wariness about crude instrumental assumptions has made socio-cultural anthropologists reluctant to define taboos in directly utilitarian terms, i.e., as about avoiding filth. Rather, they tend to be seen as symbolic expressions of key cultural values, like defining the meaning of “dirt” or “dirty” in the first place, even as they express practical intentions as well. In recent years, with the rise of more historical approaches to nonwestern culture, a more deliberative dimension of taboos has been entertained, one that would seek a rapprochement of their symbolic and pragmatic significance (e.g., Meyer-Rochow 2009). The time might be ripe for these trajectories, one moving from superstition to symbolism, the other rooted in social-ecological function and adaptation, to coalesce in a more integrated vision. Certainly, the challenge posed to us by the nature of taboo seems to demand such conceptual reconciliation.

Taboos mark out boundaries, identities, and solidarities, and consolidate a sense of the shared historical, cultural, and physical substance of particular groups of kin (Golden and Comaroff 2015). In her analysis of the institution of new food taboos in African independent churches in colonial times, Comaroff (1985)

sought to extend the meaning of taboos by refusing to see them as static, timeless, and abstract, and by highlighting their role as purposeful “acts” engaged in at specific historical junctures, which represent efforts to control a threatening social environment, and which can reveal what Lambek (1992:261) referred to as “powerful dialectics of encompassment and resistance.” In like manner, Jarosz (1994) suggested that taboos in Madagascar restricting agricultural labor on certain days may have played a unifying role in local social systems and have served as a means to express resistance against colonial work calendars. However, the function of taboos is not only symbolic. Taboos may also serve, intentionally or otherwise, to benefit human health and/or environmental conservation. Golden and Comaroff (2015) addressed the underlying social, economic, and religious drivers of changes to the taboo system. This study aims to explore more speculatively whether taboos can serve an adaptive significance to human health through illness risk prevention, or via an ecological function for resource conservation. We use a mixed-methods approach to highlight the nature of traditional etiological knowledge systems, and to argue that, in addition to their role within classificatory systems, taboos are used by local Malagasy to master threats to bodies both personal and social. These threats come in many forms: as assaults on social security as well as breaches of immunity, both physical and spiritual.

### BACKGROUND

To date, protected areas and conservation laws are often seen as the most important tools in managing biodiversity (e.g., Bruner et al. 2001). The laws that regulate an individual’s relationship to his or her environment often operate across varying spatial scales of influence. International governing bodies, national regimes, and local communities promulgate conservation laws and regulations. On occasion, national governments and community-

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level authorities are assisted in the development of these conservation policies by nongovernmental organizations (e.g., Kull 1996). In addition to external legislation, individuals are also governed by personal and collective codes, simultaneously moral and spiritual, which can act in concert or opposition to other existent policies (e.g., Kombe and Kreibich 2000, Cinner et al. 2009). Taboos are one such form of moral and spiritual code, and in Madagascar they are often highly specific to an individual and his/her biography.

In fact, in Madagascar, although international and national regulations are of the largest scale and have the broadest reach, and they are often backed by the enforcing powers of the state, it is the household-level dynamics, regulated most intimately by “fady,” i.e., the system of taboos in Madagascar that are fundamental to social and cultural practice, that have the greatest influence over actual behavior. This insight is confirmed by Gezon (1999:77) who, on the basis of her study in northern Madagascar, states that the household unit is a more direct, consequential political framework shaping actual behavior than is the “impersonal nature of state relations.” This is particularly true in the remote areas of the eastern rainforest. To clarify, in terms of the number of people reached, it is evident that a given international or national regulation will affect a larger population than will a particular, local cultural taboo. However, the strength of adherence to a given regulation is not determined by the geographical scale of its reach, or even by the threat of distant enforcement. This is because, in the absence of community support, a law is only as strong as the power of the sanction that the individual associates with the governing body that underwrites the law. Taboos carry their own internal enforcement, backed as they are by local histories of evidence and association. Therefore, it is logical that locally rooted stories, which commemorate historical observations and document the negative consequences of transgressing taboos, lead to stronger adherence. To underline this point, knowledge of the origin of the taboo, memorialized by an oral story, was significantly associated, in our research in Madagascar, with nearly seven times higher adherence to the taboo than to taboos lacking an origin story (Golden and Comaroff 2015).

Conceptions of environmental processes, as well as rules to manipulate these processes are linked to a given cultural worldview, and, these values and rules tend to be “closely integrated with moral and religious belief systems, so that knowledge, practice and beliefs co-evolve” (Gadgil et al. 1993:151). Each form of law that regulates individual decision making is dynamic and exists in constant relation to the others and the wider social and physical context. Although the motivation for taboos may not be specifically driven by a conservation ethic, and most anthropologists would argue strongly against such a functional conceptualization of taboos, ecological and human health benefits may nevertheless be forthcoming as a result of their operation (Colding and Folke 2001, Tengö et al. 2007, Jones et al. 2008). Indeed, there have been a series of studies showing that protection can be provided for a particular species through a high prevalence of fady that focus on it (Lingard et al. 2003; Table 1 in Jones et al. 2008). This is especially important because most biodiversity exists outside of protected areas (Murphree 1994).

Taboos and other everyday rituals, which restrict certain activities or mandate certain behaviors, could either harm or benefit human health or livelihoods. Some evidence has shown that taboos that restrict working certain days on agricultural fields may lead to 5% lower rice production and 6% lower rice consumption (Stifel et al. 2011). K. Freudenberger (*unpublished manuscript*) has shown how the slaughtering of cows at funerals may exacerbate the effects of poverty, at least, from a livelihood perspective because cows in Madagascar are often viewed as a personal savings account. This death ritual, although it may promote a sense of spiritual appeasement, along with the loss of a producer in the household, adds the additional loss of a reserved form of wealth. Other taboos, particularly food taboos, may benefit human health through restricted exposure to disease (Douglas 1966, Ferro-Luzzi 1980, Harris 1987, Ross 1987). It is our aim to examine whether food taboos in northeastern Madagascar serve a conservation or human health function.

## METHODS

Interviews with Malagasy male heads of households living adjacent to the Makira Natural Park lasted 45 minutes to 1 hour and were conducted in respondents’ homes in Betsimisaraka or Tsimihety, the local dialects. Only men were interviewed because the original study design was targeted to understand patterns of hunting (a discussion of the effects of this sampling frame can be found in Golden and Comaroff 2015). In addition to a variety of other questions concerning wildlife harvest (Golden 2009, Golden et al. 2014), ethnomedicinal use (Golden et al. 2012a), and the eating of nonfood items, i.e., geophagy, or the consumption of earth or soil (Golden et al. 2012b), the survey covered numerous topics, including household composition and economy, resource extraction behaviors, educational achievement, and religious and ethnic group affiliations. Quantitative information on the annual consumption rates of individual wildlife species was collected each year and has been validated as an accurate survey instrument (Golden et al. 2013). Golden and his local Malagasy collaborators also collected a variety of information on taboos and the cosmology of animist beliefs in this region (Golden 2014). This research, over the course of seven years, has elucidated a complex system of food taboos against a rich background of other knowledge sources in relation to which the current project is framed.

During the more unstructured phases of the interview, respondents were requested to list all of their food taboos and describe the reasons or story behind these taboos. In Malagasy cultures, people can very readily recount a list of their food taboos. Such individual and familial records of taboos can then be compared with the annual consumption rates of wildlife species to determine adherence to taboos. If the origin story of the taboo was known, it was recorded by the researchers in the local language. Taboos here are often commemorative in some way of events. Our mixed-method data analysis set out to explore whether it was possible to determine empirically the perceived human health and conservation value of the local Malagasy taboo system. And further, we set out to determine if these perceived functions were rooted in scientific, biomedical knowledge systems, as ascertained from the published literature. This process involved qualitative evaluation of the content of taboo origin stories collected by means of ethnographic approaches. The ethnographic assessment of these stories included historicizing

narrated events, documenting symptoms associated with particular taboos, as well as tabulating evidence of the breaching of taboos and the incentives for abiding by them. We then used quantitative methods of comparison to understand the relative weight of categories of taboos, in an effort to understand the motivation for adherence where the story was known.

Finally, when there was an origin story for a food taboo with respect to a wildlife species, we categorized these stories into groups according to their stipulated purpose: religious, educational, personal security, physical health, spiritual immunity, and conservation (Table 1). Of course, there is something of an arbitrary quality to this classification because, as noted above, taboos are all linked to the overall mystical system; domains of life are thus closely interconnected, and defiance of any of them evokes spiritual sanctions. Religious taboos were those in which certain species were forbidden by religious order; educational taboos involved a species teaching humans to do something; personal security included taboos marking the fact that a certain species had saved humans in the past; physical health included examples of things that had caused severe illness or allergy; spiritual immunity included examples that avoided practices seen to break bodily boundaries that led to worry, bad luck, or future misfortune; and, conservation included examples when there was recognition that eating a species would threaten its overall survival.

**Table 1.** Categories ascribed to taboo origin stories.

Type of story <sup>†</sup>	Prevalence within taboos	Notes
Spiritual immunity	37%	Round foods believed to inactivate spiritual immunity/protection
Physical health	21%	All symptoms relevant to zoonotic disease or allergies
Personal security	19%	Plants or animals that alerted humans to protect their well-being
Direct indigenous descendant	17%	This original ethnic group was called the “Anjoatsy”
Religion	4%	87% attributed to proscriptions from the Adventist church
Education <sup>‡</sup>	< 1%	How humans have learned helpful skills from animals
Conservation	< 1%	Recognition that eating the animal would threaten its survival

Presented here are the categories of origin stories through which the presence of a taboo was explained.

<sup>†</sup>Stories were ascribed to these seven categories based on the content of the origin stories. Very few stories were not able to be classified into these categories.

<sup>‡</sup>Three common stories contained evidence that humans had learned from animals and protected them out of gratitude. A common story was how the indri taught local people how to use ethnobotanical medicines from the forest.

### TABOO RETENTION: IS THERE A HUMAN HEALTH BENEFIT?

Of the 6166 food taboos recorded in 818 households (5% of households had no food taboos at all) by Golden and his Malagasy research collaborators, 1199 (19%) had a specific story attached, pointing to the origin of the taboo. These stories were collected in 559 households, meaning that nearly 65% of the population had retained at least one taboo story (mean 1.4, SE 0.08 stories per household). Of these 1199 taboo stories, 17% were linked to a strong conviction that a family (n = 24 households) was a direct descendant of the original people in this region, known as Anjoatsy. These ancestors are regarded as sacred (“masina”) and spiritually potent, and membership in this lineage of descendants requires strict adherence to the taboos associated with them.

Aside from the group of people who explained all of their taboos through sacred ancestry, the rest of the population explained taboo origin stories in ways that could be broadly grouped into the six categories introduced above, although the consequence of not adhering to an established taboo was always defined in similar terms, illness or death. More than 77% of stories, combining spiritual immunity, physical health, and personal security, related to health and well-being.

The preventive logic of taboos was often symbolically mediated in quite complex ways. The local Malagasy stories often illustrate a sophisticated understanding of germ theory, whereby microorganisms, too small to be seen by the eye, are believed to be the root of contagion and disease. And, typifying the Malagasy traditional epidemiological knowledge of germ theory, some medicines are called “aody fefino” or “fence medicines.” These medicines are taken prophylactically to ward off future disease, and symbolically, are seen to “fence” off particular ailments.

In this same vein of prevention, 37% of food taboos are related in some way to the round shape of the foods. Local people attest that the consumption of round items inactivates the power of “aody andro,” medicines that serve to protect the health of the consumer and bestow good luck (Golden et al. 2012b). These were categorized by the researchers as relating to spiritual immunity because of the strong local conviction that obeying these taboos appeased the spiritual world and alleviated the anxiety and worry of future health problems. The most common explanation of the taboo on round foods related to the power of the circle symbolically in protecting an individual’s destiny, primarily through warding off witchcraft and other harmful spiritual vehicles. The definition of round was particular to certain food items, and not all fruits, berries, and other seemingly circular items were included. Specific spherical shapes were targeted, e.g., chickpeas, or metaphorical definitions of “rounded” entities, such as a hornless zebu, a breed of cattle.

More than 19% of stories explaining the origin of the taboo demonstrated a personal security motive, in which the animal had saved humans in the past and thus, humans in the present were obliged to reciprocate by saving it now. Although the origins of the personal security stories are often seen to stem from an animal alerting the subject to the arrival of bandits, thieves, or murderers, the consequences of breaking the taboo always related specifically to illness or death.

More than 17% of stories described the origin of the taboo as specifically linked to protecting human physical health. Many

stories of animal-food taboos described a drunken or sick feeling that would emerge from eating a certain item, or told how their ancestors' skin changed color as a result, or that they bled from their eyes, ears, or nose. These stories, and the particular symptoms they detail, could point to a very sophisticated traditional understanding of zoonotic disease exposure, i.e., diseases that transfer from animals to humans.

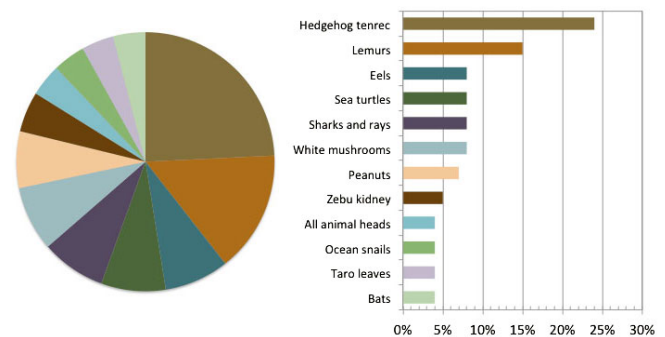
Rationales for species-specific avoidance vary widely, both in Madagascar and across the world: the species might connote toxicity, might be a sacrosanct symbol, might be an embodiment of human ancestry, or might have an inauspicious behavior or physical appearance (Colding and Folke 2001, and citations therein). Also, beliefs in the spiritual retribution for violators of taboos are common across the world, above all, the striking of transgressors with illness (Ichikawa 1993). In Madagascar, people claim to obey taboos as remembrances of the ancestors, so that the latter will bless them with good harvests, good health, wealth, and numerous children (Cole 1997) or they also seek to avoid ancestral wrath, and tend to regard displeased ancestors as the ultimate cause of most illnesses (Cole and Middleton 2001). In this study, through detailed analysis of the origin stories of taboos, we have found that certain species are likely to be subjects of food rules because of zoonotic disease risk, allergic response, or toxicity.

In fact, breach of taboo, especially the consumption of prohibited foods, has loomed large in cultural etiologies of disease from time immemorial. Traditional customs, perceptions, and beliefs often have focused on the human health consequences of certain taboos, especially food taboos (Ferro-Luzzi 1980, McKay 1980, Wilson 1980, Osemeobo 1994). Meat, although often providing key nutrients (Neumann et al. 2003), also contributes substantial risk in developing world contexts to the consumer (Fessler and Navarrete 2003). It has often been suggested that the reason for the Hebrew pork taboo was a matter of hygiene or disease avoidance, the avoidance of trichinosis, for example (Douglas 1966), although many anthropologists have disagreed, seeing the taboo as the result of a larger classificatory system that unites and separates various categories of human and animal beings, the sacred and the profane, and so on (Douglas 1966). However, it has also been pointed out that certain cultures have taboos against meat eating during pregnancy, and although this removes an important source of protein and micronutrients, it also protects the body when it is highly vulnerable to food poisoning (Fessler and Navarrete 2003). Meat, and especially wild meats in Madagascar, although nutritious (Golden et al. 2011), are also a cause for concern for zoonotic disease transfer (e.g., Duplantier et al. 2005, Iehlé et al. 2007).

With these questions in mind, we aimed to investigate some of the most common food taboos in the Makira region of northeastern Madagascar (Golden and Comaroff 2015; Fig. 1) to determine if there was evidence from the medical and public health literature to reveal these species as a potential source of illness risk from toxins, allergy, or zoonotic disease. These research questions were not posited before Golden and his local Malagasy collaborators entered the field, but rather developed over years of hearing stories detailing the risks of transgressing food taboos. We will present evidence of environmental risk potential found in certain wild foods. Real events associated with these risks may

have informed the development of particular local food taboos over time, established through empirical observation, and maintained through historical memory and commemoration through oral narratives.

**Fig. 1.** Species composition of all food taboos attributed to potential connections to zoonotic disease, allergies, and toxicity. Presented here is the species composition of illness-related food taboos as a proportion of all food taboos attributed to potential connections to zoonotic disease, allergies, and toxicity. Food items with fewer than three mentions in our research are not included in this table.



#### Tenrecs and bubonic plague

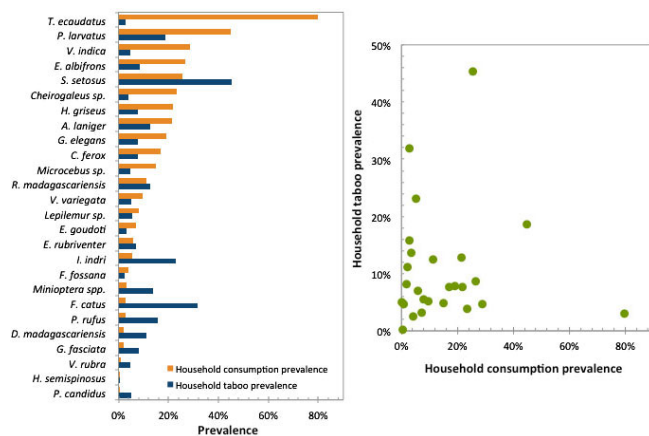
One major environmental risk in Madagascar is the zoonotic transfer of bubonic plague, still widely prevalent in a country with the heaviest plague burden in the world. In 2012, there were 256 cases and 60 deaths, the highest record anywhere since the Middle Ages (BBC 2013). Again, beginning in September of 2014, another plague epidemic struck with at least 283 cases and 74 deaths (WHO 2015). Many attribute the persistence of the disease in Madagascar, particularly in forested areas, to the hedgehog tenrec, locally called "sokina," *Setifer setosus*, which is a very efficient reservoir for this disease (Duplantier et al. 2001, 2005, Andrianaivoarimanana et al. 2013). Tenrecs are hedgehog-like animals, which are endemic to Madagascar and comprise 34 different species that are all physically similar. Interestingly, we found that the hedgehog tenrec was the most common wildlife food taboo in the Makira region (Fig. 1). According to local stories, ancestors would bleed, vomit, and have foamy mouths following hedgehog tenrec consumption, similar to symptoms of bubonic plague (Stenseth et al. 2008). Very interesting to note is that the hedgehog tenrec and the common tenrec (*Tenrec ecaudatus*) are very similar in physical appearance and yet highly dissimilar in disease risk potential. Whereas 45% of the population has a food taboo for the hedgehog tenrec, only 3% of the population has a food taboo for the common tenrec. The high burden of bubonic plague in Madagascar could explain this phenomenon. In general, such evidence suggests that many taboos might be based on practical experience and close empirical observation, and arise from incentives for maintaining health and perhaps a traditional knowledge of zoonotic disease transfer.

#### Primates, bats, and zoonotic diseases

There is broad evidence that primates and bats have a disproportionately high zoonotic disease risk potential for a broad suite of viruses and pathogens compared to other types of

animals (Olival and Daszak 2005, Gonzalez et al. 2008, Mackenzie and Jeggo 2013, Brook and Dobson 2015). In Madagascar, we found many taboos that centered on lemurs, a type of primate, and bats (Fig. 1), which may also be attributed to their increased risk of zoonotic disease transmission. Lemurs and humans have nearly 20% parasite similarity and lemurs and Old World monkeys share more parasites in common with humans than do orangutans and New World monkeys (Cooper et al. 2012). Recent reports have shown the high prevalence of potentially zoonotic *Giardia* and *Cryptosporidium* in rainforest lemurs (Rasambainarivo et al. 2013). However, lemurs are frequently consumed in this area of Madagascar (Fig. 2). Bats, particularly flying foxes and other fruit bats, are well known to carry a variety of virulent zoonotic diseases (Daszak et al. 2000, Breed et al. 2010) and are very frequently the subject of food taboos in this region (Fig. 1). Fruit bats are known to be reservoirs for *Paramyxoviruses*, including *Henipah* and *Nipah* viruses and *Morbilliviruses* (Wilkinson et al. 2012). Antibodies to *Paramyxoviruses* have been found in all three fruit bat species of Madagascar (Iehlé et al. 2007). There are also zoonotic reservoirs in insectivorous bats including leptospirosis (Lagadee et al. 2012). Therefore, we have clear knowledge that the primate and bat populations in Madagascar present a disease risk potential, and similar local understanding may explain the etiology of particular food taboos.

**Fig. 2.** Patterns of household taboo and consumption of wildlife. At a community level, there is no significant inverse relationship between the prevalence of species-specific food taboos (blue) and the level of consumption of that species (orange). See Appendix 1 for full scientific and common names.



### Marine species and toxic exposure

Some marine animals, including turtles, eels, sharks, and certain saltwater fish, which are often food taboos (Fig. 1), have been found to possess toxins that are fatal to humans (Champetier de Ribes et al. 1998). Northeastern Madagascar has a history of sharks containing toxic foodborne illnesses that have killed many people (e.g., Boisier et al. 1995). In November 1993, more than 200 people were affected through the consumption of shark meat; the illness, then unknown, had a 100% attack rate and a 30% fatality rate (Boisier et al. 1995). Novel liposoluble toxins, distinct from ciguatoxin, were discovered and named carchatoxin-A and

-B (Boisier et al. 1995). Recently, in November 2013, a similar foodborne illness emerged when local people near Fenerive harvested a shark that was reportedly 120 kg in weight. Approximately 96 people were affected, 12 died, and several more had long-lasting comas (C. D. Golden, *personal observation*). In addition to sharks, eels are also very common food taboos locally (Fig. 1). They have been found elsewhere in the world to have ciguatoxins and in fact, moray eels, hyperabundant locally in the Antongil Bay region of Madagascar, are considered to be the most ciguateric fish among more than 400 species that can host the toxin (Lehane and Lewis 2000). There have also been major case reports of fatal food poisonings from sea turtle meat, or chelonitoxication, with an event in May 2014 causing at least 8 deaths and more than 50 hospitalizations in northwestern Madagascar (L'Express 2014). Although chelonitoxication is a global phenomenon, it is most commonly found in the Indian Ocean and the Western Pacific (Silas and Fernando 1984). Given these high risks of toxic exposure, it is no surprise that many of these same species are common food taboos.

### Plant foods and allergic response

Aside from the zoonotic disease risk and toxin exposure from wild meat consumption, plant food consumption can present risk from toxicity or an allergic response. In fact, Lambek (1992:254) asserted that taboos are “often discovered or allocated in a manner not dissimilar to the way Westerners talk about having allergies... each person is different and must be treated accordingly.” There is much evidence that avoidance of animals is far more common than avoidance of plants in most traditional societies (Ferro-Luzzi 1980, Fessler and Navarrete 2003), and we found that for local Malagasy in this region, animal taboos were more than seven times more prevalent than plant ones (Golden and Comaroff 2015). Of the top 10 most common food taboos, only 1 was a plant (Golden and Comaroff 2015; Fig. 1). At least three types of the reported plant food taboos are known to contain toxins or arouse an allergic response: peanuts (Pansare and Kamat 2009), taro leaves (Payne et al. 1941), and mushrooms (Konno 1995).

### FOOD TABOOS AND CONSERVATION

Taboos are the most adhered to form of local environmental governance in Madagascar and shape behavior with regard to natural resource extraction and consumption (Golden and Comaroff 2015). Throughout the Makira, wildlife is widely hunted with approximately 16% of the population hunting bats, 23% hunting bush pigs, 40% hunting endemic carnivores, 49% hunting lemurs, and 91% hunting tenrecs (Golden et al. 2014). Because migratory resources, like water, air, wildlife, among others, have fluid boundaries, it is difficult to exclude people from using them, and one user is capable of subtracting from the welfare or productivity of other users (Feeny et al. 1990). Thus, adherence to both formal and informal institutions is particularly important for conserving common-pool migratory resources (Feeny et al. 1990).

Using generalized linear models and clustering taboos by individuals, we found that there was no significant association between population-level wildlife consumption patterns in communities and the prevalence of a particular wildlife taboo across heads of household in the community ( $p = 0.968$ ; Fig. 2). Therefore, it is very unlikely that taboos are serving as a direct form of conservation prevention. In this region, 25% of

households have taboos for lemur consumption and adhere to this with rare exceptions. We found that only 2.2% of lemur taboos are not adhered to. At the population level, 49% of households hunt lemurs, demonstrating deviance from national legislation and “dina” community laws cocreated by the Wildlife Conservation Society. Thus, it is possible that the other 42% of households do not hunt lemurs either because of top-down conservation policy, lack of preference or time, or other local management strategies of which the authors are not aware. Therefore, of the 25% of individuals with a lemur taboo, 97.8% of them adhered to this taboo for hunting lemurs whereas at most 42% of individuals adhered to local conservation policies. This study suggests that conservation policies reached a broader proportion of the population, but that the traditional taboo system was the most adhered to regulatory institution. Neither type of regulation is sufficient in itself to protect critically endangered biodiversity from extinction.

The taboo system is widely believed to be compatible with conservation efforts, and certain scholars (e.g., Keller 2009) have claimed that conservationists’ only conception of culture in Madagascar is limited to taboos. This is understandable, because both taboos and conservation policies tend to outline practices that are prohibited. Because of the largely kin-based and individualized system of taboos in this region, this study has demonstrated that most taboos were not widespread enough to serve a strong conservation purpose, contrary to popular conservation discourse in Madagascar (i.e., the entire Betsimisaraka group having a taboo for indri consumption; Mittermeier et al. 2010). In fact, of 1199 stories detailing the motivation for the given taboo, only one story appeared to be based in a conservation ethic: “Our family does not eat Eastern woolly lemurs (‘ampongy’) because they only have one child per birth. They are just like humans and cannot sustain any deaths. For this reason, they have become taboo for us to eat.”

Not having a conservation ethic does not preclude the practical result of having a conservation consequence. Nevertheless, the most common food taboo that is an endangered species, the indri, is only prohibited by 23% of the population (Golden and Comaroff 2015; Fig. 2). We found that although the self-governance of wildlife extraction was inadequate in this area to ensure sustainable resource harvesting according to the Robinson-Redford index (Golden 2009), it was by far the most adhered to form of resource governance.

For taboos to be effective for conservation purposes, there would need to be significant overlap in the species and regions protected under each system. In the case explored in this study, the types of species requiring conservation coverage, i.e., near threatened, vulnerable, endangered, and critically endangered species, were not well-covered by informal institutions. Because taboos are highly heterogeneous within and among communities, it is unlikely that taboos offer real protection. Further, numerous prominent cases have found no ecological benefits to food taboos under real conditions or computer models (Fessler and Navarrete 2003). Colding and Folke (1997) found that 30% of the 70 species subject to food taboos were threatened according to IUCN guidelines. In Makira Natural Park, we found that of the 42 animal species subject to food taboos, 31% were threatened, i.e., vulnerable, endangered, or critically endangered. Thus,

conservation managers should understand and embrace the taboo system but realize it, on its own, is insufficient for adequate conservation coverage. Further, managers should recognize that taboos are dynamic and in a dialectical relationship with environmental conditions and spiritual belief. It is possible that they are not eroding but evolving.

## DISCUSSION

Taboos may no longer be limited to the realm of magic, superstition, and irrationality in anthropological discourse (Zuesse 1974), but their more pragmatic functions are still not adequately understood. Although the content and coverage of taboos are dynamic over time, adherence rates can be shown to be very high in this region of Madagascar, demonstrating their deep social value. Through our ethnographic research, we found that most taboos were associated with precise observations of adverse physical effects and seem motivated by clear understandings of allergies, toxins, and local understandings of zoonotic disease and germ theory, highlighting a traditional epidemiological knowledge. However, as much as we would have liked, we did not find strong evidence that taboos were motivated by a conservation ethos.

The marriage of environmental and social systems through a taboo is not dissimilar to the manner in which Australian Warlpiri understand “dreaming” and the way in which dream narratives express the ancestors’ journeys and inform Warlpiri law and customary practice (Holmes and Jampijinpa 2013). Embedded in this law, in the case of the Warlpiri, is a dialectical relationship of social and environmental functioning (Holmes and Jampijinpa 2013). In this way, Holmes and Jampijinpa (2013) compare this law to science, in that it seeks to explain and regulate the functioning of the world.

Similarly, the traditional ecological and epidemiological knowledge of the Malagasy can be viewed as a form of science. Taboos in Madagascar are commemorative of historical events and are deeply connected to empirical observation. Through this empirical observation and hypothesis building, taboos are scientifically managed, with individuals sometimes testing the boundaries of efficacy by transgressing a taboo to determine if there will be physical repercussions. This is similar to what von Heland and Folke (2014) call a social-ancestral contract, in which, through an adaptive process of trial and error, local Malagasy have developed practices and rituals, in this case, taboos, to protect their livelihoods and well-being.

This oral history of empirical observation, whereby people, over the course of time, have witnessed the negative effects of consuming particular food items, produces a coherent system of knowledge (whether allegorical, metaphorical, or hyperbolic) explaining these observations. This scientific record is a legacy of the ancestors. Whereas traditional Western conceptions of time give the individual the power of self-determination and have the actor standing at the beginning of his or her own destiny, looking “forward” into the future. Malagasy people conceive of time quite differently. They view themselves as standing at the midpoint of a line between their ancestors and their future progeny. They face toward the past, quite logically, because it is the only thing that they can see with clarity. It is their historical record that has been observed. Conversely, the future is “behind” them because it has yet to be seen. Three critical differences emerge in differentiating

these worldviews with relevance for our understanding of the importance of taboos to social and cultural practice: (1) the implicit value placed on the ancestors and ancestral knowledge is given the more central importance in the Malagasy sense of the relation between past and future; (2) a sense of reduced self-determination and independent agency in Malagasy culture caused by the powerful, and actively intervening, influence of the ancestors in daily life; and (3) the value of an “observed” history that stands in their direct line of vision and that they are continually referencing for decisions they make in their daily lives. They act, make decisions, and as we have seen, will introduce new versions of received practices, like taboos, if their experience warrants it.

The importance of historical observation emerges again as a critical component to understanding ecological and epidemiological phenomena. The allergic response to certain food items is an illustrative example of the practice of this empirical scientific observation. Because allergies have been found to be, at least partially, rooted in genetics (Sicherer 2000, Dreskin 2006), the taboo system and one’s biological reaction to the transgression of a taboo actually facilitate the formation of what Margaret Lock and Patricia Kaufert (2001) have called “local biologies,” and the construction of kinship in Malagasy society. Therefore, members of a kinship group, related by blood, and thus genetics, may reaffirm their relation to each other through the common symptoms of allergies to a given food. The Western world may see this as a genetic basis for allergies, whereas local communities view this phenomenon as confirmation of the value of taboos and confirmation of familial ties. The significant influence over physical health, spiritual immunity, and personal security could explain why some taboos persist largely intact over time. If there exists a rational and perceived system of value, the social boundary will more likely be respected and maintained. In general, local Malagasy taboos arise from incentives for maintaining health and well-being, both personal and collective, and perhaps a traditional epidemiological knowledge of illness.

The taboo system also serves a limited conservation value. In terms of prevalence or coverage of endangered species, top-down conservation policies affect the largest number of people and the most number of species compared to the local taboo system. Hayes (2006) found in a global meta-analysis, including Madagascar, that areas outside of conservation protection had twice as many rules as parks. Although we did not find more rules protecting endangered species outside of parks, we did find similar results to Hayes (2006), in that personal moral and spiritual codes have the most impact in restricting natural resource use and that informal governance structures were the most effective in natural resource conservation. In Makira, codified policies have the broadest potential reach to protect endangered species, even though taboos are the most adhered to form of behavioral control. The strong adherence to taboos is likely to endure because of the powerful local belief that, if one violates those taboos, automatic sanctions will occur as a matter of spiritual retribution. According to Lambek (1992:248), taboos are at once “objectified negative rules” but also “embodied, that is to say they become part of the lived experience of specific individuals.” They are part of one’s physical, spiritual, moral, and cultural immunity. Obeying taboos is a living memorial of the past and a demonstration of respect and reciprocity for the

ancestors. Rules are only as strong as the bond of respect or fear between the individual and the governing body of a rule. In this case, the strongest governors of extractive and consumptive behaviors are the ancestors and the “kalanoro,” a forest spirit that dictates taboos to individuals through visions or dreams (Golden 2014, Golden and Comaroff 2015).

We suggest that the traditional taboo system of prohibition of the consumption of particular wildlife species is a moral framework, primarily driven by general concerns for personal and collective well-being and security, which focuses on specific, health-related incentives, including a desire to preserve one’s spiritual immunity. Although taboos are more adhered to by local people than national laws that limit wildlife resource use, the types of species protected and the prevalence of household taboos are not sufficient to protect critically endangered biodiversity from extinction. The government and conservation community recognized the weak reach of national policies and thus installed a system of *dina*, a term conventionally used by Merina, the dominant ethnic group in Madagascar, meaning community laws (for a detailed discussion of *dina*, see Golden and Comaroff 2015). In this region of Madagascar, there is scant traditional acceptance or understanding of *dina* because the population draws from an alternative cultural history.

Co-opting the system of *fady* or the system of *dina*, then, is likely not the most productive use of cultural knowledge because it deviates from the logic of cultural systems and their established bodies of knowledge. Instead, using existing relational mechanisms of explanation to frame the rational derivation of benefits and value may reinforce a system of social boundary marking. Health and personal security are clear priorities in the traditional system of value production. By reframing the benefits of protected areas in this way, local people may be more likely to engender support for conservation when parallel goals are envisioned. Furthermore, the preservation of local people’s ancestral terrain and its heritage from extinction is a clear priority that could certainly align well with conservation goals.

*Responses to this article can be read online at:*  
<http://www.ecologyandsociety.org/issues/responses.php/7590>

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#### **Acknowledgments:**

*This work arose from more than a decade of experience in Madagascar with no possible way to properly recognize and honor all of the people who inspired this work. Although insufficient, we thank all of the local people living near the Makira forest who shared their wisdom and experience, and, in case they ever see this document, misaotra ianareo jiaby amin'ny fanampiana. We thank Evelin Jean Gasta Anjaranirina, Be Jean Rodolph Rasolofoniaina, Laurent Ravaoliny, and many others for their research assistance. The development of this manuscript was supported by UKAID and USAID as part of the Bushmeat Research Initiative under the CGIAR Research Program on Forests, Trees, and Agroforestry. Thank you to Louise Fortmann for reviewing an earlier version of this manuscript. We also thank the Health & Ecosystems: Analysis of Linkages (HEAL) program for helping to make this work*

possible. We are extremely grateful for support provided to HEAL by The Rockefeller Foundation and The Gordon and Betty Moore Foundation.

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#### LITERATURE CITED

- Andrianaivoarimanana, V., K. Kreppel, N. Elissa, J.-M. Duplantier, E. Carniel, M. Rajerison, and R. Jambou. 2013. Understanding the persistence of plague foci in Madagascar. *PLoS Neglected Tropical Diseases* 7(11):e2382. <http://dx.doi.org/10.1371/journal.pntd.0002382>
- Boisier, P., G. Ranaivoson, N. Rasolofonirina, b. Andriamahefazafy, J. Roux, S. Chanteau, m. Satake, and Y. Takeshi. 1995. Fatal mass poisoning in Madagascar following ingestion of a shark (*Carcharhinus leucas*): clinical and epidemiological aspects and isolation of toxins. *Toxicon* 33:1359-1364. [http://dx.doi.org/10.1016/0041-0101\(95\)00051-M](http://dx.doi.org/10.1016/0041-0101(95)00051-M)
- Breed, A. C., H. E. Field, C. S. Smith, J. Edmonston, and J. Meers. 2010. Bats without borders: long-distance movements and implications for disease risk management. *EcoHealth* 7 (2):204-212. <http://dx.doi.org/10.1007/s10393-010-0332-z>
- British Broadcasting Corporation (BBC). 2013. *Madagascar bubonic plague warning*. British Broadcasting Corporation, London, UK. [online] URL: <http://www.bbc.co.uk/news/world-africa-24461474>
- Brook, C. E., and A. P. Dobson. 2015. Bats as 'special' reservoirs for emerging zoonotic pathogens. *Trends in Microbiology* 23 (3):172-180. <http://dx.doi.org/10.1016/j.tim.2014.12.004>
- Bruner, A. G., R. E. Gullison, R. E. Rice, and G. A. B. da Fonseca. 2001. Effectiveness of parks in protecting tropical biodiversity. *Science* 291(5501):125-128. <http://dx.doi.org/10.1126/science.291.5501.125>
- Champetier de Ribes, G., G. Ranaivoson, N. Ravaonindrina, A. L. Rakotonjanabelo, N. Rasolofonirina, J. Roux, and T. Yasumoto. 1998. Un problème de santé réémergeant à Madagascar: les intoxications collectives par consommation d'animaux marins. Aspects épidémiologiques, cliniques et toxicologiques des épisodes notifiés de janvier 1993 à janvier 1998. *Archives d'Institut Pasteur Madagascar* 64(1-2):71-76.
- Cinner, J., M. M. P. B. Fuentes, and H. Randriamahazo. 2009. Exploring social resilience in Madagascar's marine protected areas. *Ecology and Society* 14(1):41. [online] URL: <http://www.ecologyandsociety.org/vol14/iss1/art41/>
- Colding, J., and C. Folke. 1997. The relations among threatened species, their protection, and taboos. *Conservation Ecology* 1(1):6. [online] URL: <http://www.consecol.org/voll/iss1/art6>
- Colding, J., and C. Folke. 2001. Social taboos: "invisible" systems of local resource management and biological conservation. *Ecological applications* 11(2):584-600.
- Cole, J. 1997. Sacrifice, narratives and experience in east Madagascar. *Journal of Religion in Africa* 27:401-425. <http://dx.doi.org/10.1163/157006697X00216>
- Cole, J., and K. Middleton. 2001. Rethinking ancestors and colonial power in Madagascar. *Africa* 71:1-37. <http://dx.doi.org/10.3366/afr.2001.71.1.1>
- Comaroff, J. 1985. *Body of power, spirit of resistance: the culture and history of a South African people*. University of Chicago Press, Chicago, Illinois, USA.
- Cooper, N., R. Griffin, M. Franz, M. Omotayo, and C. L. Nunn. 2012. Phylogenetic host specificity and understanding parasite sharing in primates. *Ecology Letters* 15(12):1370-1377. <http://dx.doi.org/10.1111/j.1461-0248.2012.01858.x>
- Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2000. Emerging infectious diseases of wildlife - threats to biodiversity and human health. *Science* 287(5452):443-449. <http://dx.doi.org/10.1126/science.287.5452.443>
- Douglas, M. P. 1966. *Purity and danger: an analysis of concepts of pollution and taboo*. Routledge, New York, New York, USA.
- Dreskin, S. C. 2006. Genetics of food allergy. *Current Allergy and Asthma Reports* 6:58-64. <http://dx.doi.org/10.1007/s11882-006-0012-9>
- Duplantier, J.-M., J.-B. Duchemin, M. Ratsitorahina, L. Rahalison, and S. Chanteau. 2001. Résurgence de la peste dans le district d'Ikongo à Madagascar en 1998. 2: Réservoirs et vecteurs impliqués. *Bulletin de la Société de Pathologie Exotique* 94:119-122.
- Duplantier, J.-M., J.-B. Duchemin, S. Chanteau, and E. Carniel. 2005. From the recent lessons of the Malagasy foci towards a global understanding of the factors involved in plague reemergence. *Veterinary Research* 36:437-453. <http://dx.doi.org/10.1051/vetres:2005007>
- Feeny, D., F. Berkes, B. J. McCay, and J. M. Acheson. 1990. The tragedy of the commons: 22 years later. *Human Ecology* 18:1-19. <http://dx.doi.org/10.1007/BF00889070>
- Ferro-Luzzi, G. 1980. Food avoidances of pregnant women in Talminad. Pages 101-108 in J. R. K. Robson, editor. *Food, ecology and culture: readings in the anthropology of dietary practices*. Gordon and Breach Science, New York, New York, USA.
- Fessler, D. M. T., and C. D. Navarrete. 2003. Meat is good to taboo: dietary proscriptions as a product of the interaction of psychological mechanisms and social processes. *Journal of Cognition and Culture* 3(1):1-40. <http://dx.doi.org/10.1163/1568-53703321598563>
- Gadgil, M., F. Berkes, and C. Folke. 1993. Indigenous knowledge for biodiversity conservation. *Ambio* 22:151-156.
- Gezon, L. L. 1999. From adversary to son: political and ecological process in northern Madagascar. *Journal of Anthropological Research* 55:71-97.
- Golden, C. D. 2009. Bushmeat hunting and use in the Makira Forest north-eastern Madagascar: a conservation and livelihoods issue. *Oryx* 43:386-392. <http://dx.doi.org/10.1017/S0030605309000131>
- Golden, C. D. 2014. Spiritual roots of the land: hierarchy and relationships of the religious cosmologies of humans and their environment in the Maroantsetra region of Madagascar. *Worldviews: Global Religions, Culture, and Ecology* 18(3):255-268. <http://dx.doi.org/10.1163/15685357-01802010>
- Golden, C. D., M. H. Bonds, J. S. Brashares, B. J. R. Rasolofoniaina, and C. Kremen. 2014. Economic valuation of



- subsistence harvest of wildlife in Madagascar. *Conservation Biology* 28(1):234-243. <http://dx.doi.org/10.1111/cobi.12174>
- Golden, C. D., and J. Comaroff. 2015. The effects of social change on wildlife consumption taboos in northeastern Madagascar. *Ecology and Society* 20(2): 41. <http://dx.doi.org/10.5751/ES-07589-200241>
- Golden, C. D., L. C. H. Fernald, J. S. Brashares, B. J. R. Rasolofoniaina, and C. Kremen. Benefits of wildlife consumption to child nutrition in a biodiversity hotspot. *Proceedings of the National Academy of Sciences* 108:19653-19656. <http://dx.doi.org/10.1073/pnas.1112586108>
- Golden, C. D., B. J. R. Rasolofoniaina, E. J. G. Anjaranirina, L. Nicolas, L. Ravaoliny, and C. Kremen. 2012a. Rainforest pharmacopeia in Madagascar provides high value for current local and prospective global uses. *PLoS ONE* 7:e41221. <http://dx.doi.org/10.1371/journal.pone.0041221>
- Golden, C. D., B. J. R. Rasolofoniaina, R. Benjamin, and S. L. Young. 2012b. Pica and amylophagy are common among Malagasy men, women and children. *PLoS ONE* 7:e47129. <http://dx.doi.org/10.1371/journal.pone.0047129>
- Golden, C. D., R. W. Wrangham, and J. S. Brashares. 2013. Assessing the accuracy of interviewed recall for rare, highly seasonal events: the case of wildlife consumption in Madagascar. *Animal Conservation* 16(6):597-603. <http://dx.doi.org/10.1111/acv.12047>
- Gonzalez, J. P., M. A. Gouilh, J.-M. Reynes, and E. Leroy. 2008. Bat-borne viral diseases. Pages 161-196 in C. J. P. Colfer, editor. *Human health and forests: a global overview of issues, practice and policy*. Earthscan, London, UK.
- Harris, M. 1987. Foodways: historical overview and theoretical prolegomenon. Pages 57-90 in M. Harris and E. B. Ross, editors. *Food and evolution: toward a theory of human food habits*. Temple University Press, Philadelphia, Pennsylvania, USA.
- Hayes, T. M. 2006. Parks, people, and forest protection: an institutional assessment of the effectiveness of protected areas. *World Development* 34(12):2064-2075. <http://dx.doi.org/10.1016/j.worlddev.2006.03.002>
- Holmes, M. C. C., and W. (S. P.) Jampijinpa. 2013. Law for country: the structure of Warlpiri ecological knowledge and its application to natural resource management and ecosystem stewardship. *Ecology and Society* 18(3): 19. <http://dx.doi.org/10.5751/es-05537-180319>
- Ichikawa, M. 1993. Diversity and selectivity in the food of the Mbuti hunter-gatherers in Zaire. Pages 487-496 in C. Hladik, A. Hladik, O. Linares, H. Pragezy, A. Semple, and M. Hadley, editors. *Tropical forests, people and foods: biocultural interactions and application to development*. Parthenon, New York, New York, USA.
- Iehlé, C., G. Razafitrimo, J. Razainirina, N. Andriaholinirina, S. M. Goodman, C. Faure, M.-C. Georges-Courbot, D. Rousset, and J.-M. Reynes. 2007. Henipavirus and Tioman virus antibodies in pteropodid bats, Madagascar. *Emerging Infectious Diseases* 13(1):159-161. <http://dx.doi.org/10.3201/eid1301.060791>
- Jarosz, L. A. 1994. Taboo and time-work experience in Madagascar. *Geographical Review* 84(4):439-450. <http://dx.doi.org/10.2307/215758>
- Jones, J. P. G., M. M. Andriamarivololona, and N. Hockley. 2008. The importance of taboos and social norms to conservation in Madagascar. *Conservation Biology* 22:976-986. <http://dx.doi.org/10.1111/j.1523-1739.2008.00970.x>
- Keller, E. 2009. The danger of misunderstanding 'culture.' *Madagascar Conservation and Development* 4:82-85. <http://dx.doi.org/10.4314/mcd.v4i2.48647>
- Kombe, W. J., and V. Kreibich. 2000. Reconciling informal and formal land management: an agenda for improving tenure security and urban governance in poor countries. *Habitat International* 24:231-240. [http://dx.doi.org/10.1016/S0197-3975\(99\)00041-7](http://dx.doi.org/10.1016/S0197-3975(99)00041-7)
- Konno, K. 1995. Biologically active components of poisonous mushrooms. *Food Reviews International* 11(1):83-107. <http://dx.doi.org/10.1080/87559129509541021>
- Kull, C. A. 1996. The evolution of conservation efforts in Madagascar. *International Environmental Affairs* 8:50-86. [online] URL: <https://christiankull.files.wordpress.com/2011/03/kull-1996-iea.pdf>
- Lagadee, E., Y. Gomard, V. Guernier, M. Dietrich, H. Pascalis, S. Temmam, B. Ramasindrazana, S. M. Goodman, P. Tortosa, and K. Dellagi. 2012. Pathogenic *Leptospira* spp. in bats, Madagascar and Union of the Comoros. *Emerging Infectious Diseases* 18(10):1696.
- Lambek, M. 1992. Taboo as cultural practice among Malagasy speakers. *Man* 27:245-266. <http://dx.doi.org/10.2307/2804053>
- Lehane, L., and R. J. Lewis. 2000. Ciguatera: recent advances but the risk remains. *International Journal of Food Microbiology* 61(2-3):91-125. [http://dx.doi.org/10.1016/s0168-1605\(00\)00382-2](http://dx.doi.org/10.1016/s0168-1605(00)00382-2)
- L'Express. 2014. *Mahajanga - Le bilan de l'intoxication alimentaire s'alourdit*. L'Express, Antananarivo, Madagascar. [online] URL: <http://www.lexpressmada.com/blog/actualites/mahajanga-le-bilan-de-lintoxication-alimentaire-salourdit-10692>
- Lingard, M., N. Raharison, E. Rabakonandrianina, J.-A. Rakotoarisoa, and T. Elmqvist. 2003. The role of local taboos in conservation and management of species: the radiated tortoise in southern Madagascar. *Conservation and Society* 1:224-246. [online] URL: [https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/3368/c\\_s\\_1\\_2-3-marlene.pdf?sequence=1](https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/3368/c_s_1_2-3-marlene.pdf?sequence=1)
- Lock, M., and P. Kaufert. 2001. Menopause, local biologies, and cultures of aging. *American Journal of Human Biology* 13(4):494-504. <http://dx.doi.org/10.1002/ajhb.1081>
- Mackenzie, J. S., and M. Jeggo. 2013. Reservoirs and vectors of emerging viruses. *Current Opinion in Virology* 3(2):170-179. <http://dx.doi.org/10.1016/j.coviro.2013.02.002>
- McKay, D. A. 1980. Food, illness, and folk medicine: in-sights from Ulu Trengganu, West Malaysia. Pages 61-66 in J. Robson, editor. *Food, ecology and culture: readings in the anthropology of dietary practices*. Gordon and Breach Science, New York, New York, USA.

- Meyer-Rochow, V. B. 2009. Food taboos: their origins and purposes. *Journal of Ethnobiology and Ethnomedicine* 5:18. <http://dx.doi.org/10.1186/1746-4269-5-18>
- Mittermeier, R. A., E. E. Louis, Jr., M. Richardson, C. Schwitzer, O. Langrand, A. B. Rylands, F. Hawkins, S. Rajaobelina, J. Ratsimbazafy, R. Rasoloarison, C. Roos, P. M. Kappeler, and J. Mackinnon. 2010. *Lemurs of Madagascar* Third edition. Conservation International, Arlington, Virginia, USA.
- Murphree, M. 1994. The role of institutions in community-based conservation. Pages 403-427 in D. Western, R. M. Wright, and S. C. Strum, editors. *Natural connections: perspectives in community-based conservation*. Island, Washington, D.C., USA.
- Neumann, C. G., N. O. Bwibo, S. P. Murphy, M. Sigman, S. Whaley, L. H. Allen, D. Guthrie, R. E. Weiss, and M. W. Demment. 2003. Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. *Journal of Nutrition* 133(11):3941S-3949S.
- Olival, K. J., and P. Daszak. 2005. The ecology of emerging neurotropic viruses. *Journal of Neurovirology* 11(5):441-446. <http://dx.doi.org/10.1080/13550280591002450>
- Osemeobo, G. J. 1994. The role of folklore in environmental conservation: evidence from Edo State, Nigeria. *International Journal of Sustainable Development and World Ecology* 1:48-55. <http://dx.doi.org/10.1080/13504509409469860>
- Pansare, M., and D. Kamat. 2009. Peanut allergies in children - a review. *Clinical Pediatrics* 48:709-714. <http://dx.doi.org/10.1177/0009922808330782>
- Payne, J. H., G. J. Ley, and G. Akau. 1941. *Processing and chemical investigations of taro*. University of Hawaii, Hawaii Agricultural Experiment Station, Honolulu, Hawaii, USA. [online] URL: <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/B-86.pdf>
- Rasambainarivo, F. T., T. R. Gillespie, P. C. Wright, J. Arsenault, A. Villeneuve, and S. Lair. 2013. Survey of *Giardia* and *Cryptosporidium* in lemurs from the Ranomafana National Park, Madagascar. *Journal of Wildlife Diseases* 49(3):741-743. <http://dx.doi.org/10.7589/2012-10-264>
- Ross, E. B. 1987. An overview of trends in dietary variation from hunter-gatherer to modern capitalist societies. Pages 7-55 in M. Harris and E. B. Ross, editors. *Food and evolution: toward a theory of human food habits* Temple University Press, Philadelphia, Pennsylvania, USA.
- Sicherer, S. H. 2000. Determinants of systemic manifestations of food allergy. *Journal of Allergy and Clinical Immunology* 106(5): S251-S257. <http://dx.doi.org/10.1067/mai.2000.110158>
- Silas, E. G., and A. B. Fernando. 1984. Turtle poisoning. *CMFRI Bulletin* 35:62-75. [online] URL: <http://fundacionio.org/viajar/formacion/docs/turtle%20poisoning.pdf>
- Steiner, F. 1956. *Taboo*. Cohen and West, London, UK.
- Stenseth, N. C., B. B. Atshabar, M. Begon, S. R. Belmain, E. Bertherat, E. Carniel, K. L. Gage, H. Leirs, and L. Rahalison. 2008. Plague: past, present, and future. *PLoS Medicine* 5(1):e3. <http://dx.doi.org/10.1371/journal.pmed.0050003>
- Stifel, D., M. Fafchamps, and B. Minten. 2011. Taboos, agriculture and poverty. *Journal of Development Studies* 47(10):1455-1481. <http://dx.doi.org/10.1080/00220388.2011.561322>
- Tengö, M., K. Johansson, F. Rakotondraso, J. Lundberg, J.-A. Andriamaherilala, J.-A. Rakotoarisoa, and T. Elmqvist. 2007. Taboos and forest governance: informal protection of hot spot dry forest in southern Madagascar. *Ambio* 36:683-691. [http://dx.doi.org/10.1579/0044-7447\(2007\)36\[683:TAFGIP\]2.0.CO;2](http://dx.doi.org/10.1579/0044-7447(2007)36[683:TAFGIP]2.0.CO;2)
- von Heland, J., and C. Folke. 2014. A social contract with the ancestors - culture and ecosystem services in southern Madagascar. *Global Environmental Change* 24:251-264. <http://dx.doi.org/10.1016/j.gloenvcha.2013.11.003>
- Wilkinson, D. A., S. Temmam, C. Lebarbenchon, E. Lagadec, J. Chotte, J. Guillebaud, B. Ramasindrazana, J.-M. Héraud, X. de Lamballerie, S. M. Goodman, K. Dellagi, and H. Pascalis. 2012. Identification of novel paramyxoviruses in insectivorous bats of the southwest Indian Ocean. *Virus Research* 170(1):159-163. <http://dx.doi.org/10.1016/j.virusres.2012.08.022>
- World Health Organization (WHO). 2015. *Plague in Madagascar: need for heightened vigilance*. Mediacentre: AFRO feature. World Health Organization, Brazzaville, Republic of Congo. [online] URL: <http://www.afro.who.int/en/media-centre/afro-feature/item/7385-plague-in-madagascar-need-for-heightened-vigilance.html>
- Wilson, C. 1980. Food taboos of childbirth: the Malay example. Pages 67-74 in J. R. K. Robson, editor. *Food, ecology and culture: readings in the anthropology of dietary practices*. Gordon and Breach Science, New York, New York, USA
- Zuesse, E. 1974. Taboo and the divine order. *Journal of the American Academy of Religion* 42:482-504. <http://dx.doi.org/10.1093/jaarel/XLII.3.482>

**Appendix 1.** Scientific and common names of food taboos.

<b>Scientific name</b>	<b>Common name</b>
<i>Tenrec ecaudatus</i>	Common tenrec
<i>Potamochoerus larvatus</i>	Bush pig
<i>Viverricula indica</i>	Lesser Indian civet
<i>Eulemur albifrons</i>	White-fronted brown lemur
<i>Setifer setosus</i>	Hedgehog tenrec
<i>Cheirogaleus sp.</i>	Dwarf lemurs
<i>Haplemur griseus</i>	Eastern lesser bamboo lemur
<i>Avahi laniger</i>	Eastern woolly lemur
<i>Galidia elegans</i>	Ringtailed mongoose
<i>Cryptoprocta ferox</i>	Fosa
<i>Microcebus sp.</i>	Mouse lemurs
<i>Rousettus madagascariensis</i>	Madagascar rousette
<i>Varecia variegata</i>	Black and white ruffed lemur
<i>Lepilemur sp.</i>	Sportive lemurs
<i>Eupleres goudoti</i>	Falanouc
<i>Eulemur rubriventer</i>	Red bellied lemur
<i>Indri indri</i>	Indri
<i>Fossa fossana</i>	Fanaloka
<i>Minioptera spp.</i>	Insectivorous bat species
<i>Felix catus</i>	Domesticated cat
<i>Pteropus rufus</i>	Malagasy flying fox
<i>Daubentonia madagascariensis</i>	Aye-aye
<i>Galidictis fasciata</i>	Broad striped Malagasy mongoose
<i>Varecia rubra</i>	Red ruffed lemur
<i>Hemicentetes semispinosus</i>	Lowland streaked tenrec
<i>Propithecus candidus</i>	Silky sifaka