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Community Perceptions of the Crop-Feeding Buton Macaque (*Macaca ochreata brunnescens*): an Ethnoprimatological Study on Buton Island, Sulawesi

Jane L. Hardwick[1] · **Nancy E. C. Priston**[2] · **Thomas E. Martin**[3] · **David G. Tosh**[4] · **Abdul H. Mustari**[5] · **Kirsten E. Abernethy**[6]

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Abstract Human–wildlife overlap is increasing worldwide as a result of agricultural expansion. This can reduce human tolerance of wildlife, especially if wildlife threatens human food sources. The greatest threat to the declining populations of the endemic Buton macaque (*Macaca ochreata brunnescens*) is habitat destruction, but as a common crop-feeding species, there is also an additional risk of retaliation killings from farmers. Finding means of reducing this risk will thus help secure the long-term future of this range-restricted subspecies. Here, we investigate variability in farmers' perceptions of primate crop-feeding and mitigation techniques in three farming communities on Buton Island, Indonesia, which differ in wealth and agricultural resources. We

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✉ Jane L. Hardwick
jane.hardwick@griffithuni.edu.au

[1] Environmental Futures Research Institute, Griffith University, Nathan, QLD 4111, Australia

[2] Anthropological Centre for Conservation, the Environment and Development, Oxford Brookes University, Oxford, OX3 0BP, UK

[3] Operation Wallacea Ltd, Old Bolingbroke, Lincolnshire PE23 4EX, UK

[4] Centre of Environmental Data and Recording, National Museums of Northern Ireland, Cultra, Holywood, Co. Down BT18 0EU, UK

[5] Faculty of Forestry, Department of Forest Resources Conservation and Ecotourism, Kampus Fahutan IPB Darmaga, Bogor, 16680 West Java, Indonesia

[6] Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, TR10 9FE, UK

employ a mixed methodology, collecting qualitative social data from focus groups and quantitative observational data to measure macaque crop-feeding occurrences. Our findings indicate that the least wealthy community used lethal control methods more frequently than the comparatively wealthier communities, even when the crop-feeding problem was less severe. The least wealthy community also expressed high levels of fear of macaques, and had the most negative perceptions of them. This community also had no knowledge of the macaques' conservation status or their ecological roles. We recommend that efforts to protect Buton macaques focus on education and the use of effective nonlethal mitigation techniques, such as electric fencing. We also suggest that initiatives to support such measures may be most effectively directed toward communities with relatively low economic wealth and high reliance on subsistence agriculture, especially where crop-feeding wildlife is feared, even when such communities do not experience the highest losses from crop-feeding wildlife.

Keywords Crop feeding · Ethnoprimatology · Farming · Human–wildlife conflict · Indonesia · Mitigation · Pests · Primates

Introduction

When human and wildlife populations overlap in space and resources, tensions can arise between the two. Such tensions are commonly termed "human–wildlife conflict," although this phrase may be misleading given the implication that wildlife is consciously antagonistic toward humans (Hill 2015, 2017; Peterson *et al.* 2010). Such tensions are frequent, and while the magnitude and frequency of issues surrounding human–wildlife coexistence vary greatly, they occur worldwide and are a key driver of biodiversity loss (Dickman 2010). Therefore, the need to reconcile human activities and population growth with wildlife needs is a key challenge for conservation biologists.

Tensions between humans and wildlife can be particularly acute when people perceive that their personal security is threatened. Tolerance and positive perceptions of wildlife can decline if food sources, such as agricultural crops, are reduced, damaged, or threatened by wildlife or if people fear for their safety (Campbell-Smith *et al.* 2010; Nyhus and Tilson 2000). People living subsistence lifestyles are likely to experience greater effects and express greater concern about wildlife damaging their livelihoods than those who are not dependent on their own agricultural activities to survive (Peterson *et al.* 2010). When food sources are at risk, farmers may need to increase labor by spending more time protecting their land, and participation in illegal and/or dangerous activities, such as retaliatory killing, may become more common (Ogra 2008).

Although many taxa cause damage to, or feed on, agricultural crops, from elephants (Chiyo *et al.* 2011) to rodents (Arlet and Molleman 2007), primates are well documented as pests to farmers and community gardeners for their crop-feeding habits. Macaques (*Macaca* spp:. Priston *et al.* 2012), vervets (*Chlorocebus* spp.: Saj *et al.* 2001), and baboons (*Papio* spp.: Hill 2000) are some of the major genera involved. Humans and nonhuman primates have overlapped spatially and ecologically for millennia (Hahn *et al.* 2000), but as habitat degradation and conversion of land for human use intensifies, wild primates are increasingly incorporating agricultural crops into their diets (Hill 2017), leading to a growing threat to the long-term conservation of

many species (Dickman 2013). Retaliation killing has been recorded as a response to crop-feeding primates (McLennan 2008; Sinha *et al.* 2006) and this can lead to declines in primate populations, a particular concern for threatened species. For example, only small, fragmented populations of lion-tailed macaques (*Macaca silenus*) remain in southern India (Kumar *et al.* 2008) after widespread hunting was employed to mitigate crop losses (Green and Minkowski 1977; Zinner *et al.* 2013). Conserving primates is important, both to prevent extinctions generally and to ensure wider ecosystem health. It has been estimated that 95% of tropical tree species produce seeds that are dispersed by frugivores, of which primates play an essential role (Chapman and Chapman 1996). The loss of vertebrate seed dispersers from forests could affect seedling populations, altering future forest structure (Chapman and Onderdonk 1998). Some species also aid habitat conservation as flagship species (Supriatna and Ario 2015). For these reasons, finding measures to increase the peaceful coexistence between human and nonhuman primates is an important conservation goal.

Ethnoprimatology is the study of interactions between human and nonhuman primates, combining nonhuman primate behavior and ecology with anthropological approaches (Fuentes 2012; Hockings *et al.* 2015; Riley 2006; Sponsel 1997). It offers a means for researching conservation issues relating to human–wildlife tensions. The successful use of this cross-disciplinary approach typically involves the evaluation of people's perceptions in societies that can influence, and be influenced by, primates, alongside quantitative measures of primate behavior (Riley and Ellwanger 2013). The desired outcome of this approach is to provide recommendations that will both protect and conserve wildlife while also ensuring the welfare of local communities, a goal that becomes more realistic when both human and nonhuman aspects of specific conservation problems are combined (Fuentes and Hockings 2010). Solely implementing conservation policies to protect wildlife populations that local communities consider to be pests can have negative effects on these communities. Indeed, this can increase the human–wildlife tensions that communities face, adding to economic losses and increasing community disaffection toward local policymakers (Hill 2000; Lee and Priston 2005).

Gaining an understanding of community perspectives of wildlife is vital for the design of effective mitigation strategies (Hill 2000). Primates are opportunistic feeders and their high intelligence can influence the attitudes and actions that people have against them (Naughton-Treves and Treves 2005). Therefore, to ease tensions between humans and nonhuman primates for management implementations, it is important to consider the full range of ecological, economic, and sociocultural factors within individual communities, as well as the differences in scientific and moral values surrounding primates (Dickman 2010; Hill 2002). Key themes identified by previous ethnoprimatology and more general farmer–wildlife overlap research include education, gender, and fear. Positive views of conservation increase with education and knowledge of conservation issues in some cases (Fiallo and Jacobson 1995; Wang *et al.* 2006), but in others there is no effect (Campbell-Smith *et al.* 2010; Shibia 2010). Similarly, other factors, such as the gender of farmers, also tend to be situation dependent; women can be more supportive of conservation than men (Arjunan *et al.* 2006) but women can also be more afraid of wildlife (Campbell-Smith *et al.* 2010), which could lead to women being less in favor of protection than men are. When farmers are fearful of primates, it can lead to lethal control (Campbell-Smith *et al.* 2010). However, reports of nonhuman primate aggression toward humans have seldom

been reported in rural communities and are more commonly recorded in the contexts of tourism or food provisioning (Hockings and McLennan 2016).

On Buton Island, Sulawesi, Indonesia, populations of Buton macaques (*Macaca ochreata brunnescens*) are predicted to decline by 30% over the next 40 yr., with the prime cause being habitat loss (Manullang and Supriatna 2008). This range-restricted subspecies, endemic to two islands off the southeastern peninsula of Sulawesi (Buton and Muna), is thus considered to be of conservation concern, and listed as Vulnerable by the IUCN (Manullang and Supriatna 2008). Consequently, it is listed as a protected species under Indonesian law (Priston 2005). The macaques have partially adapted to habitat loss by using a range of disturbed habitats. These include farmland, resulting in the macaques being defined as destructive crop raiders, with crop losses measured as up to 70% on some subsistence farms (Priston 2005; Priston *et al.* 2012). This can lead to lethal retaliatory measures. Although the frequency of such events remains unknown, one such event was documented in 2002, when a farmer caused the death of 11 macaque group members at one location where the macaques frequently overlap with farmers (Priston 2005). Unlike the case of the Tonkean macaque (*Macaca tonkeana*) on mainland Sulawesi, where cultural taboos mitigate instances of local people harming them (Riley 2010), there are no traditional rules directly protecting the Buton macaques (Priston 2005). However, spiritual beliefs do protect parts of the forest, which has some limited potential to indirectly protect some populations of Buton macaques by conserving some of their habitat (Riley and Priston 2010).

Given that negative human–primate interactions can arise from the behavioral traits of primates and the attitudes and actions of humans, the ethnoprimatological approach may be useful to develop a better understanding of these interactions. We explore the severity of crop feeding by macaques, along with variation in farming community wealth levels, with an overarching aim to determine if these attributes influence how macaques are perceived by farmers, to inform conservation management strategies for this threatened primate. Additionally, we examine whether community knowledge of macaque conservation, feelings of fear regarding macaques, and gender responses differ between communities. Although these have all been identified as potentially important factors influencing perceptions of crop-feeding wildlife, their effects have rarely been synthesized within a single study, especially in the context of Southeast Asia. We use a method that incorporates observational primate behavioral data with farming community focus group data to examine the following research questions: 1) Are crop-feeding macaques one of the greatest problems facing farming in the communities, and if not, what are the major challenges? 2) Do any of the following factors influence farmers' perceptions of and actions toward the Buton macaque: frequency of crop-feeding occurrences, community wealth, level of conservation knowledge/education, and gender of farmers? 3) What mitigation techniques do farmers employ and how successful do farmers find these?

Methods

Study Site

Buton Island is the largest of Sulawesi's attendant islands and is located between the Flores and Banda Seas, ca. 6 km (at the nearest point) off the mainland's southeastern

peninsula (Whitten *et al.* 2002) (Fig. 1a). Conservation and management of protected forests and species on Buton is undertaken by the Konservasi Sumber Daya Alam (KSDA), a department of the Ministry of Forestry in Indonesia (Tonts and Siddique

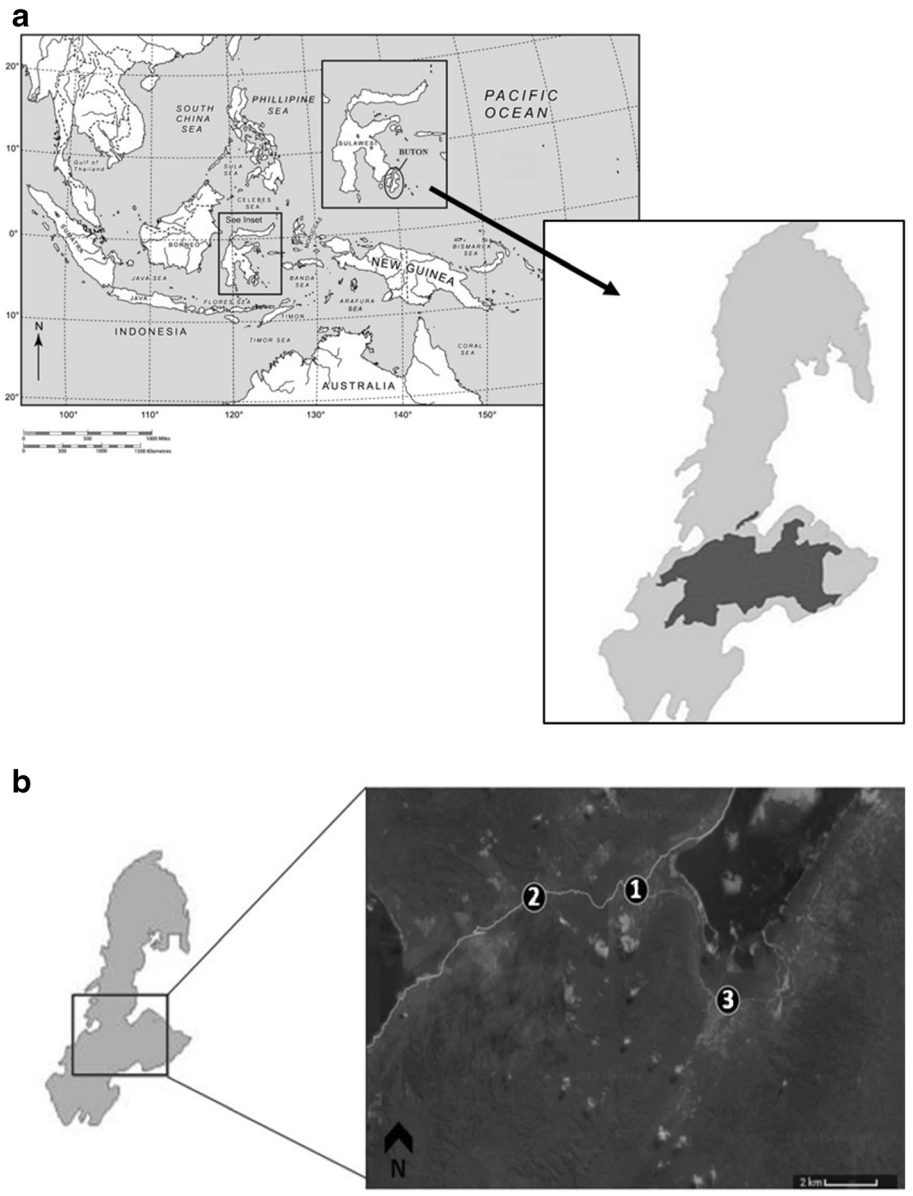

Fig. 1 Maps showing (**a**) the location of Buton Island in southeast Asia and the Sulawesi subregion, and the extent of Lambusango forest reserve (larger highlighted area) and Kakenauwe forest reserve (smaller highlighted area) around which our study areas are located, and (**b**) the precise locations of the three farming communities we studied in south-central Buton Island: 1) Labundo-Bundo, 2) Kaweli, and 3) Lawele. Maps of Buton reproduced with permission from Wheeler (2011). Satellite image adapted from Googlemaps, CNES/Astrium and Digitalglobe (2015).

2011), but lack of enforcement has allowed unsustainable forest clearance to go relatively unchecked (Martin *et al.* 2015). Three reserves exist on the island: Buton Utara (82,000 ha) in the north, and Kakenauwe (810 ha), and Lambusango (28,510 ha) reserves in the south. We conducted research in and around Kakenauwe and Lambusango reserves (Fig. 1).

Buton Farming Communities

We held focus groups in June and July 2014 in three farming communities: Labundo-Bundo, Kaweli, and Lawele (Fig. 1b). We chose these farming communities because they experience different levels of crop feeding by macaques. For Labundo-Bundo and Kaweli we collected observational macaque behavior data between June and August in 2013 and 2014 to gain a quantitative measure of how frequently macaques visited farms and what proportion of the macaques' diet consisted of agricultural crops during this time of year. Additionally, in June 2014, preliminary interviews with the headman of each community gave us an indication of overall crop-feeding problems and demographic information for each community. We chose Lawele as the community experiencing the lowest levels of crop feeding, based on reports from farmers, who informed us that crop feeding was not a problem there. We sourced per capita income data for each farming community from Martin *et al.* (2015), who report data for a random selection of 20 people from each community. This indicated that each community had a different level of wealth (Table I).

Focus Groups

In each community, we recruited three groups of six to eight farmers for focus group discussions. We selected these groups with the assistance of the headman of each village, based on participant age and sex. We held focus group discussions with groups of male farmers >25 yr. old, female farmers >25 yr. old, and mixed-sex farmers between 18 and 25 yr. old (see Electronic Supplementary Material [ESM] Appendix S1). We trained a local translator and a research assistant before holding the focus groups to ensure that we took a standardized approach in each session. We conducted all group discussions in Bahasa Indonesia, and recorded them using a Dictaphone, with permission from all participants. The research assistant took notes on body language and monitored the discussions to ensure all participants felt comfortable and were involved.

Table I Mean annual per capita income for three farming communities chosen for focus group interviews on Buton Island, Indonesia

	Mean per capita income (million rupiah) (± 1 SD)
Labundo-Bundo	24.87 ± 4.09
Kaweli	9.09 ± 2.13
Lawele	13.94 ± 4.52

Data sourced from Martin *et al.* (2015).

The steps used to conduct the focus groups were adapted from Priston (2005) and The Wallace Foundation (2013) (ESM Appendix S2). Focus groups consisted of semistructured questions, open-ended questions, and quantitative ranking activities (see ESM Appendix S3 for focus group guide). During quantitative ranking activities, farmers were asked to rank their responses in terms of importance, or based on the strength of their feelings. To do this, we wrote responses on large pieces of card, and we gave each farmer 10 pebbles. We asked them to place four pebbles on what they felt to be the most appropriate response, three on the second most appropriate response, and so on. To determine income sources, we asked farmers to place pebbles proportionally on each source; e.g., if 50% of a farmer's income was derived from crops, we asked them to place 5 out of 10 pebbles on "crops." We designed the set of questions and activities to 1) understand the livelihoods of the communities, specifically based around their farming activities and people's interactions with wildlife; 2) understand farmers' experiences of, interactions with, attitudes to, feelings about, knowledge of, and behavior toward macaques; and 3) identify current mitigation techniques against crop-feeding wildlife, and the extent to which farmers find these techniques effective.

Focus Group Data Analysis

To analyze the data, we transcribed all the recordings and placed responses into themed categories for each question. We then explored these themes and compared them across the groups and communities, rather than individual farmers. We derived collective responses from focus group discussions. We report percentages based on quantitative focus group activities (ESM Appendix S3).

Macaque Behavioral Observations

We used macaque behavioral data to identify crop-feeding frequencies and gather information on macaque diets (Table II). We recorded observations of behaviors of macaques from two groups that farmers in Labundo-Bundo and Kaweli identified as the main participants in crop feeding. We did not record observations of macaques from the vicinity of Lawele, as farmers there reported infrequent farm visits by macaques

Table II Farm visits and severity of crop feeding by *Macaca ochreata brunnescens* in three communities in Buton Island, SE Sulawesi, based on focus group data collected in June–July 2014, and instantaneous scan sampling data collected in June–August 2013 and 2014

	Frequency of days/week that macaque farm visits occur, based on focus group discussions	Mean (± 1 SD) frequency of days/week that macaque farm visits occur, based on observational data	Mean (± 1 SD) frequency of sightings of macaques in farmland/week, based on observational data	Overall proportion of macaque's diet that consisted of agricultural crops (%), based on observational data
Labundo-Bundo	7	5.7 ± 1.57	11.15 ± 4.45	84.81 (N = 942)
Kaweli	7	5 ± 1.05	12.37 ± 6.16	40.2 (N = 687)
Lawele	<1	No data	No data	No data

(Table II). Four local research guides assisted with semihabituating the macaques a fortnight before data collection began by following the groups throughout the day. The macaques were also subject to habituation in previous studies (Priston 2005; Priston *et al.* 2012). As we observed no other groups during data collection, we assumed that home ranges of macaque groups here rarely overlap. Group 1 inhabited the Kakenauwe reserve, a semidisturbed forest site in the area surrounding Labundo-Bundo. The forest in this area has been subject to periodic logging but remains relatively intact. This group consisted of 34 individuals in 2013 and 35 individuals in 2014. Group 2 inhabited a highly disturbed site surrounding Kaweli, which consists of fragments of heavily logged forest and farms. This group consisted of 14 individuals in 2013 and 10 individuals in 2014. This community is where a poisoning incident was recorded in 2002 (Priston 2005).

We used methods for macaque behavioral observations similar to those used in the same study area by Priston (2005) and Priston *et al.* (2012). We located the macaque group of interest each morning at 06:00 h (often at the same sleeping tree) and then followed them (where possible) until 16:00 h. While other studies have found crop feeding can be particularly intense in the early evening, after farmers have left their fields (Ukizintambara 2008), we did not observe macaques after 16:00 h, as several years of research on Buton (Priston 2005; Priston *et al.* 2012) never recorded crop-feeding by macaques after 16:00 h. We used 2-min instantaneous scan sampling every 10 min to record the behavior of each visible individual. During each scan, we recorded the location (forest, farm, plantation, or road) and if a macaque was feeding we recorded the food item, and whether it was naturally occurring or a crop.

Macaque Crop-Feeding Data Analysis

Because our research season was confined to June and July, we could not examine how temporal patterns of crop availability affect macaque crop feeding. However, seasonality in crop planting, ripening, and harvesting is not marked on Buton (Priston 2005; Priston *et al.* 2012). We combined the 2 yr. of observational data and divided the number of days that we recorded macaques in farms by the total number of data collection days, and then multiplied this by seven to calculate the mean frequency of days per week that farm visits by macaques occurred. Additionally, we divided the total frequency of "farm observations" by the number of data collection days to determine the frequency of farm visits by macaques per day and per week (by multiplying this by seven) for each community. If 30 min passed without a sighting, we counted the next observation on a farm or plantation as a new observation. We also determined the proportions of the macaque diets that comprised agricultural crops and naturally occurring foods, based on scans when we recorded feeding.

Ethical Note

Our research methods were approved by the University Ethics Committee (UEC) of Exeter University. Our research adhered to the legal requirements of Indonesia, under the auspices of RISTEK permits 211/SIP/FRP/SM/VI/2013 and 178/SIP/FRP/SM/V1/2014. For focus groups, we used a committee-approved verbal informed consent

procedure (to allow for possible participant illiteracy). When participants approved the use of a digital voice recorder, we documented consent digitally. In all instances, participants provided verbal consent to participating in the study before we commenced data collection. The authors declare that they have no conflicts of interest

Results

Our macaque behavioral data collection resulted in 7495 individual observations over 53 days for Labundo-Bundo and 5833 individual observations over 48 days for Kaweli. The mean number of individuals recorded per scan was 5.8 ± 3.37 (1 SD) in Labundo-Bundo and 5.1 ± 1.81 (1 SD) in Kaweli. The three communities differed in the severity of crop feeding by macaques (Table II), as well as the wealth of farmers (Table I).

In both Labundo-Bundo and Kaweli, macaques entered farmland daily, according to farmers in focus group discussions. However, our observational dataset suggests that Labundo-Bundo has a more severe problem than Kaweli (Table II). Although the frequency of observations of macaques in farms was similar in the two communities, the proportion of macaques' diets that consisted of farmed food was more than twice as high in Labundo-Bundo compared to Kaweli (Table II). Owing to the fragmented forest around Kaweli, we often observed macaques passing through the farmland here without feeding.

The primary farming practice in Labundo-Bundo was cash-crop plantations (Table III), with principal crops consisting of maize, coconut, and cashew nut. Labundo-Bundo had the highest mean per capita income (Table I). The primary farming practice in Kaweli was subsistence farming (Table III), with principal crops consisting of sweet potato, cassava, and banana. Kaweli had the lowest mean per capita income (Table I).

Crop feeding occurred less than once a week on farms in Lawele, based on information determined from interviews with the headman and according to farmers in focus group discussions (Table II). The primary farming practice here was rice as a cash crop (Table III) with cocoa and coconut as secondary crops. The mean per capita income of Lawele was between that of Labundo-Bundo and Kaweli (Table I).

Focus group responses indicated crop production was the most important source of income for all three communities surveyed. Lawele, the largest in terms of area of the

Table III Characteristics of three communities on Buton Island, SE Sulawesi based on data are from interviews conducted with the headman of each community in June–July 2014

	Population	Mean[a] number of people living in each building	Main farming method	Total land area (ha)	% of community dependent on agriculture for all or part of their income
Labundo-Bundo	334	4.28	Monoculture cash crops	420	90
Kaweli	480	6.67	Polycropped subsistence crops	1200	100
Lawele	1477	4.04	Monoculture rice crops	2000	87.5

[a] Mean was calculated based on population size divided by the number of houses in each community.

village and surrounding farms and number of people (Table III), showed the greatest dependence on crop production for income. Here, the mean percentage of farmers' incomes derived from crops was 58% ± 12.12 (1 SD) (116 of 200 pebbles). Dependence on crops as a source of income was comparable in Labundo-Bundo and Kaweli, with mean income proportions of 45.26% ± 1.73 (1 SD) (86 of 190 pebbles) and 41.1% ± 8.15 (1 SD) (78 of 190 pebbles) respectively. Other sources of income included selling animals and/or animal produce including chickens, goats, and cows; running small shops; and laboring. These other income sources contributed 19–25% of annual incomes in all communities.

The greatest perceived problem for farmers, reported in all communities and across all groups, was mammalian pests. Other problems reported included unpredictable weather, crop diseases, insect pests, soil fertility, and irrigation (only farmers in Lawele mentioned irrigation; the other communities did not use irrigation systems). Wild pigs (*Sus celebensis* and *Sus scrofa*) were ranked as the greatest pest species in all communities. The Buton macaque was ranked as the second greatest pest in communities 1 and 2 and as the third greatest pest species in community 3. Community 3 reported both pigs and rats as a greater pest than macaques.

Perceptions of and Attitudes Toward Macaques

When we asked farmers to use words to describe macaques, "naughty" was most commonly used in all focus groups and communities (Table IV). The word is interpreted similarly in Indonesian as it is in English, referring to someone or something acting in a consciously mischievous or misbehaving way. Other common words were *funny*, *smart*, *greedy*, *destructive*, *annoying*, and *thieving*. While people recognized that the primates caused damage (and referred to them as *destructive* and *thieving*), they also emphasized positive characteristics of the macaques (*smart*, *funny*, e*ntertaining*, and *helpful*). The occurrence of positive and negative words varied across the communities (Table IV), with Kaweli and Lawele mentioning a slightly higher proportion of negative words than Labundo-Bundo.

When we asked farmers if they had any positive feelings toward the macaques, they made three positive remarks. The first, "monkeys help cashew farmers," related to macaques feeding on the cashew trees' fruit, which the farmers do not use, and dropping

Table IV Words used to describe macaques (rated as positive +, negative –, or neutral 0) by farmers who ranked these words in order of appropriateness in focus groups conducted in June–July 2014 in three communities on Buton Island, SE Sulawesi

Labundo-Bundo (high crop feeding, high wealth)	Kaweli (intermediate crop feeding, low wealth)	Lawele (low crop feeding, intermediate wealth)
Naughty (−)	Naughty (−)	Destructive (−)
Greedy (−)	Funny (+)	Naughty (−)
Funny (+)	Smart (+)	Annoying (−)
Smart (+)	Destructive (−)	Thieving (−)
Wild (0)	Thieving (−)	Funny (+)
Energetic (0)	Bad (−)	Entertaining (+)

the nuts. This meant farmers do not have to collect cashew nuts by climbing the trees, saving farmers' energy and time. Only the female and young farmer groups in Labundo-Bundo made this remark. The second positive remark, "monkeys spread seeds all around so more plants grow," recognized the macaques' importance to forests as seed dispersers. The male-only group in Labundo-Bundo and the young farmers group in Lawele mentioned this. The third positive remark, "we are happy to watch monkeys," was mentioned only by the female-only and male-only groups in Lawele. We recorded no positive perceptions of macaques in Kaweli, the least wealthy community.

When we asked about negative feelings toward macaques, farmers discussed two remarks. All communities and groups reported that "macaques cause damage to people's crops" and that "macaques are aggressive toward people, which makes people afraid of them." However, the extent of fear expressed, and level of perceived aggression that had been observed, varied between communities. In Labundo-Bundo, where crop feeding was most severe, the level of fear among farmers was low, as no one expressed fear toward macaques. No one reported experiences of physical attacks by macaques, although one farmer had witnessed someone being chased: "I have seen a monkey chase somebody on their motorbike." Farmers were more fearful of macaques in Kaweli, where crop-feeding intensity was intermediate when compared to that in Lawele and Labundo-Bundo, and all three focus groups reported aggression by macaques. We recorded stories of people being physically attacked by macaques: "My neighbor was attacked in his farm," and "I had to throw timber at a monkey because it came to attack me in my farm!" The greatest level of fear was expressed in Lawele, where crop feeding was least severe, as farmers in all focus groups had experienced or witnessed physical attacks. For example: "A monkey scratched and bit somebody we know on their way to school," and "Monkeys attacked a farmer in their cashew tree and made them fall out of the tree."

When we asked farmers how they felt when seeing macaques on their farms, anger was the main theme discussed in five of the six groups from Labundo-Bundo and Kaweli, but not in Lawele. Those in Kaweli expressed anger most strongly, where it was mentioned across all groups. In Lawele, the young farmers expressed fear in this discussion. The other emotion discussed was happiness when watching the macaques in the farms, which was mentioned only by the female-only group and the male-only group in Lawele.

Knowledge of the protected status of macaques varied between communities. In Labundo-Bundo, where crop feeding was greatest, farmers were not aware of the protected status of the species. All groups said that officials had not discussed information on protected species with the local people. In Kaweli, all groups mentioned that forestry department officials had visited the community to warn residents not to kill macaques, but they did not know whether it was illegal to do so. The young farmers in Kaweli mentioned that they could get away with killing macaques because the authorities would not find out anyway. In Lawele, where crop feeding was lowest, all groups were aware that the macaques were a protected species, as they had received information on the illegal wildlife trade and logging from visits by forestry department officials.

Current Mitigation Techniques

Initially, when farmers sight macaques on a farm, the most commonly employed techniques used to scare them away from crops include shouting, chasing, and arm

waving. Across the three communities there were few differences in immediate techniques used to scare macaques away from farms, the only exceptions being in Lawele, where the male-only group mentioned use of a slingshot and the young farmers group mentioned use of a device to make loud noises. Male and female responses differed. Female-only groups never mentioned stone throwing as a response but all of the male-only groups mentioned this.

Farmers across the three communities used six different forms of mitigation to protect farms from pest species (mainly pigs and macaques) (Table V). The most common form of protection, used widely across all three communities, was wooden fences, with thin mesh netting that macaques find difficult to grip and therefore cannot climb. The second most common barrier method reported was electric fences powered by solar panels, but this was effective only against pigs because these fences only prevented access close to the ground. The use of electric fences was most common in Lawele, while few farmers in Labundo-Bundo or Kaweli used this method. Farmers using electric fences charge them during the day and run them only at night. Across all communities, farmers stated that the best option to reduce crop-feeding incidences would be the use of permanent electric fencing, placed to deter both macaques and pigs from their farms. However, many could not afford the materials or the maintenance. Focus groups containing men mentioned guard dogs, but none had found this a very effective method against macaques. For example: “Dogs are sometimes effective but when people go back to the village the dogs always follow, they won't stay in the farms," and “Sometimes the monkeys are more powerful than the dogs so the dogs are scared of the monkeys.” In all communities, the use of snare traps was mentioned, but farmers stated that they use them only as a control method for pigs and that the macaques can open the traps if they get caught. Focus groups also discussed lethal control in the form of poison. This form of control was most widely used against macaques in Kaweli among the male-only and the young farmers groups. In Lawele, farmers across all groups said that they used poison only for pigs and rats, not for

Table V A summary of the use and effectiveness of methods reported by farmers during focus groups conducted in June–July 2014 to prevent crop-feeding macaques from entering farms on Buton Island, SE Sulawesi

Protection method	Effectiveness
Electric fencing	Effective for pigs but not macaques. Most farmers cannot afford to run electricity. Some have solar power but they run the electricity only at night to protect from pigs.
Netted wooden fencing	Cheap but ineffective. Macaques are able to jump over fences without touching the net.
Guard dogs	Dogs can be effective at raising the alarm, but will not stay in the farms when the farmers leave. Sometimes dogs are afraid of macaques.
Human guards	Effective but time consuming and expensive.
Snare traps	Set up only to catch pigs. Macaques are often able to open the home-made snares.
Poison	Can be effective short term if macaques associate the death of a group member with the exact farm but often this is not the case, as poison does not have an immediate effect. Effective in reducing macaque population size.

macaques. In Labundo-Bundo, only one farmer, from the young farmers group, said he had used poison to control macaques (Table V). A difference was evident between male and female farmers in this discussion: no female farmers admitted to using any form of lethal control for macaques, and they stated they would not kill rats or any other animal because they were afraid that either God or the animals would be angry and punish them, and the result would be that more of the problem species would come back to their farms.

Discussion

Buton macaques feed on crops almost daily in some rural farming communities on Buton Island. While the Buton macaque is one of the main species causing problems for farmers, farmers perceive mammalian pests overall, e.g., macaques, pigs, and rats, to be the greatest issue affecting agricultural production. A similar situation was reported in North Sumatra, Indonesia, where almost all interviewees reported crop-feeding wildlife to be a greater limitation to farming than any other factor (Marchal and Hill 2009). The crop-feeding behavior of the Buton macaque causes problems for communities on Buton Island because arable farming is the primary source of income. However, attitudes and actions toward macaques vary across farming communities. The severity of crop feeding experienced, the wealth status of the community affected, the level of fear engendered by aggressive encounters with macaques, and the level of knowledge and education about macaques and conservation may explain this variation.

Factors Influencing Farmers' Perceptions of Macaques

The perceived impact of wealth on people's attitudes toward wildlife conservation is variable. Negative attitudes often tend to be linked to those suffering the greatest losses, such as farmers who rely more heavily on forest produce and crops, independent of wealth (Arjunan *et al.* 2006; Gadd 2005). On Buton, all communities relied heavily on crops for their livelihoods but where the mean income was lowest (Kaweli), farmers showed a lower tolerance toward crop feeders, as the impact on people's livelihoods was greater. Farmers expressed no positive views of macaques in this lower-income community, and they mentioned lethal mitigation, in the form of poisoning, as a solution more than anywhere else. Although a group of only 10 macaques fed on crops here, probably because of retaliation poisonings (Priston 2005), farmers in this community still perceived macaques in a more negative light than those in other communities. While Labundo-Bundo suffered the highest level of crop feeding from a larger group of macaques, farmers here did not have the strongest negative attitudes or perceptions. Poisoning of macaques had occurred in Labundo-Bundo, and probably indirectly (via laying poison for pigs and rats) in Lawele, but farmers barely spoke of it in these two communities, and expressed some positive feelings about macaques.

In previous studies, positive views of conservation had increased with conservation knowledge/education level (Fiallo and Jacobson 1995; Wang *et al.* 2006) or there had been no effect (Campbell-Smith *et al.* 2010; Shibia 2010). As with wealth, the effects of education on attitudes and perceptions depend on various factors. On Buton, the community with the most knowledge of the Buton macaque's conservation status and

ecological importance (Lawele) was also the community where none of the farmers admitted to using lethal control specifically for macaques. Farmers in Labundo-Bundo, where lethal control also did not appear to be a common occurrence, were also aware of the macaque's ecological role. In contrast, this was not common knowledge in Kaweli, where lethal control and negative perceptions were most apparent. These results suggest that a link exists between wealth and conservation education, which could be driving positive perceptions of the Buton macaques. However, some caution is necessary with this interpretation, as people who have been exposed to conservation education may believe that positive responses are more appropriate, even if they do not actually feel that way. It is difficult to tease apart the influence of education on actual perceptions from its influence on peoples' perceived notion of "correct" responses.

Many primates, particularly macaques, are successful crop feeders because of their intelligence, adaptability to changing environments, and their wide dietary range (Lee and Priston 2005; Sillero-Zubiri and Switzer 2001). If local communities feel threatened by wildlife, it is difficult to reach and maintain coexistence (McLennan and Hill 2012). We found that lethal control was used when crop feeding and aggressive behaviors from macaques were both reported as problems (Kaweli), whereas farmers rarely spoke of lethal control when crop feeding was a problem but aggression was not (Labundo-Bundo) or where aggression was a problem but crop feeding was not (Lawele). We believe this as an important factor to consider in management solutions.

We found some variation across the focus groups within communities, most notably in the responses between male-only and female-only groups. On Buton, none of the female farmers admitted to using lethal mitigation. Instead, women discussed how they were afraid to use lethal control because of superstitious or religious reasons. Generally, female farmers were much more tolerant of macaques, and more inclined to have protective attitudes toward them than male farmers, a finding that has also been reported elsewhere (Arjunan *et al.* 2006). Male farmers mentioned very few positive perceptions of macaques, and mainly did so only when speaking about how farmers and macaques can share cashew nut crops. Macaques feed only on the fruit of the cashew tree and drop the nut, allowing farmers to collect the nuts more easily. This interaction has already been reported on Buton (Riley and Priston 2010). Other reports of "low-conflict crops" are scarce, but farmers in Guinea-Bissau perceived crop-feeding chimpanzees (*Pan troglodytes*) as beneficial when they fed on cashew fruits for the same reason (Hockings and Sousa 2011). However, negative perceptions can persist, as primates still cause some damage to the cashew trees (Hockings and Sousa 2011) and in our study we heard of an aggressive encounter between a male farmer and a macaque when the farmer was harvesting a cashew tree.

Mitigating crop feeding by primates can be difficult. This is especially true in large countries with many remote regions, like Indonesia, where some communities may feel a lack of support and guidance from the government. Local forestry departments often receive the blame for this. For example, in North Sumatra, local forestry departments have faced criticism for not showing an interest in farmers' problems with crop-feeding orang-utans (*Pongo abelii*: Campbell-Smith *et al.* 2010). However, even where mitigation efforts are applied, there is rarely a simple solution. Successful deterrents must be multifaceted, needing to be effective, sustainable, and locally appropriate while also being cost effective, easy to manage, and requiring minimal labor (Hsiao *et al.* 2013). We discussed potential measures for farm protection with farmers on Buton Island and

their main response was that permanent electric fencing positioned to deter both macaques and pigs, with solar power (as many people do not have electricity in their homes to charge a battery), would have the greatest effect in reducing crop-feeding incidences. This strategy, however, would require external investment to be sustainable and has maintenance costs that many donors are not willing to pay over an extended period (Osborn and Hill 2005). This is also a problem for other potential solutions, such as the use of repellents on crops or setting up feeding stations to attract macaques away from human settlements.

Other than farm protection methods, if local communities could derive economic benefits from the macaques then they might have more incentive to protect them, along with other wildlife. This was an important condition for the sustainable coexistence of human communities in Uganda and chimpanzees (McLennan and Hill 2012). Currently, there is very little tourism on Buton Island but with input from conservation professionals, an ecotourism site could have the potential to increase protection of the forests and the species within them, as well as providing an income and educational opportunities for local communities. Reduced reports of primate killings were recorded in an area of protected forest in Tangkahan in Sumatra after it was turned into an ecotourism site and locals were trained as guides (Singleton *et al.* 2002). However, on Buton Island this would require heavy investment to develop the infrastructure necessary to support ecotourism businesses. Therefore, ecotourism does not appear to represent a short-term solution.

The chief obstacle to implementing successful management solutions for crop feeding appears to be accessing the secure, long-term funding that any meaningful solution would inevitably require. Such long-term conservation funding may, however, become increasingly accessible in the near future from programs such as the United Nations REDD+ scheme (UN-REDD Programme 2016). Although large-scale programs such as REDD+ have been criticized for paying insufficient attention to land rights and the needs of local stakeholders, and for corruption issues (Edwards *et al.* 2012; Sunderlin *et al.* 2014), they nevertheless represent significant funding sources that must explicitly involve project components that aim to directly protect biodiversity within target areas (Edwards *et al.* 2012; Martin *et al.* 2015). REDD+ projects are designed to have lifespans of up to several decades, and thus may represent a way to help small communities coexist with wildlife.

Conclusion

Human–wildlife resource overlap is a global problem that requires an understanding of perspectives and characteristics of the different communities and individuals involved (Brooks *et al.* 2013; Priston 2005). Heterogeneity between our three study communities in their dependence on agriculture was linked to attitudes and behaviors toward primates, and potentially other crop-feeding species. Our study suggests that to reduce retaliation killings, efforts to protect Buton macaques should be prioritized in communities that suffer high crop losses and relative poverty, and fear macaques. This finding may have wider implications for long-term conservation schemes. Affordable and nonlethal mitigation techniques will require careful design and testing, but if successfully developed, could be a key asset in ensuring the coexistence of farmers and macaques in the future.

Data Availability

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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