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Ten Thousand Tonnes of Small Animals: Wildlife Consumption in Papua New Guinea, a Vital Resource in Need of Management

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Ten Thousand Tonnes of Small Animals: Wildlife Consumption in Papua New Guinea, a Vital Resource in Need of Management

Introduction

Across the globe, many nations have gone through a period of unmanaged wildlife consumption characterized by massive population crashes and extinction of vertebrate species. The dramatic declines of useful animal resources because of this over-consumption have often been followed by a determined effort to regulate and manage wildlife consumption, often too late to avoid extinction and even more often too late to enable the resource population to recover to harvestable levels. Even with the lessons learned in the past, there is still little proactive effort in many countries in which people still rely on hunted animals as a major protein source to create management plans before species populations collapse or become extinct. Despite the hard lessons learned worldwide, it seems governments lack the will to manage wildlife resources and people lack the motivation to regulate their behaviour so long as free wildlife is readily available.

In North America, growing populations and improved technologies led to the extinction of the Passenger Pigeon (*Ectopistes migratorius*), which was the most abundant bird on earth (Halliday 1980). Its population is estimated to have been in the tens of billions, yet in little over a century of hunting, it was reduced to zero and the last Passenger Pigeon expired in a zoo in 1914. Also in North America, the Bison (*Bison bison*) was the most abundant mammal on earth, numbering 30-60 million animals when Europeans arrived in North America. It too was hunted nearly to extinction by the late 19th century and only through visionary and draconian measures was it saved from extinction (Roe 1970, Berger and Cunningham 1995). Waterfowl in North America provided an abundant food source for millions of people, but again over hunting brought their populations to near-extinction levels. The evident crash in numbers led to tight government regulation which saved most species from extinction (the Labrador Duck, *Camptorhynchus labradorius*, being the only taxon that went completely extinct). However, despite a century of regulation, waterfowl numbers for most species (with the exception of a few that have adapted well to human-modified landscapes) are estimated at about an order of magnitude less than when guns and Europeans were introduced to the North American ecosystem, though this is confounded by loss of wetland habitats. The list of examples where unmanaged hunting leads to extinction, extirpation, or at least dramatic reduction of vertebrate populations is nearly as long as the list of species that are hunted by humans.

In the three examples from North America, one can see the range of likely outcomes of delaying management until a crisis is evident. The Passenger Pigeon is now extinct. The Bison is totally protected and occurs only in special reserves and parks where its continued existence depends completely on careful human intervention; it is little more than a zoo animal. Waterfowl are more secure but subject to intensive regulation. Hunters must purchase a federal Duck Stamp (US$15.00) each year, at least one state hunting license (these usually vary in price from US$10 to US$130), and adhere to rigorous bag and season limits. Violation of these regulations can result in fines into the tens of thousands of dollars or jail time for repeat violators. Waterfowl hunting survives only as a recreational activity-- a sport for those who can afford it. Wild waterfowl are no longer a staple in anyone's diet. Indeed, virtually all hunting in North America has become a recreational activity (with the exclusion of a few remote human populations and some Amerindian communities), whereas wildlife was at one time a dietary staple.

The point of these examples is to emphasize that without management, wildlife consumption can and often does lead to the extirpation of many species, particularly those most valued by hunters. If the most abundant birds and mammals could be wiped out by a relatively small human population on the vast North American continent in the 19th century, it is plausible that a similar fate awaits wildlife in places where hunting contributes to the daily subsistence needs of rural people in the 21st century. If one believes that the dietary consumption of wildlife can be offset by domestic livestock (as has happened in North America), this might not be an issue for concern by development and health planners. However, when wildlife is a resource without a feasible replacement, it behooves policy makers and planners to consider how to manage wildlife resources so that they provide a sustainable and unfailing source of meat to sections of populations who rely on hunted meat for most of their protein intake. With a view to assessing the needs for sustainable management of wildlife resources in Papua New Guinea (PNG), we conducted a study of hunting by members of several communities in two language groups in PNG. Here we report the results of our preliminary investigations, discuss the gaps in our knowledge and consequent needs for expanded research, and highlight concerns for donors, development planners and policy makers in PNG.

We took as a starting point in our study, and in this report, the argument that rural people in PNG rely on hunted animals for their livelihoods, and that in order to help people maintain health and food security, we wished to understand hunting practices and the population ecology of prey species. There is a large literature on hunting in PNG,[1] and we wish to contribute to this literature in three ways. First, with this paper, we wish to contribute to the development of a rigorous methodology for the examination of the population ecology of prey species and the human ecology of hunters. Second, with a co-authored paper on the policy environment in PNG, we wish to contribute to the national discussion over the conservation of resources. Finally, with a third co-authored paper, we wish to contribute to the international discussion of the term “bush meat.” While some of these contributions will be touched upon in this paper, our main goal here is to present our preliminary data, discuss methodological issues, and highlight the importance of wild meat to many people in PNG.

Background: The Study Area

Field work was conducted in and on the periphery of the Crater Mountain Wildlife Management Area (CMWMA), a 2700km^2 Wildlife Management Area gazetted in 1994 under the *Fauna (Protection and Control) Act*. The CMWMA has been the area and subject of extensive biological and anthropological studies, long before it was a WMA (Glick 1963, 1964, 1967a, 1967b; Gillison 1980, 1983, 1991, 1993, 1994; Gillison and Gillison 1977). Since its creation, the CMWMA has become one of the most active field research areas in Papua New Guinea, with over fifty peer-reviewed publications derived from the area, and six PhD dissertations (Mack 1995; Wright 1998; Johnson 2000; West 2000; Bickford 2001; Ellis 2002), two MSc theses (Sinclair 2000; Igag 2002), and several Honours theses. Although by no means complete, these combined biological and anthropological research efforts make the CMWMA one of the best locations for the synthesis of the biological and social sciences in Papua New Guinea.

The CMWMA spans an elevational gradient from c. 80m a.s.l. in the Purari lowlands of Gulf Province to 3300m at the summit of Crater Mountain in Eastern Highlands Province. Habitats thus range from lowland rainforest through hill forest to montane forest and up to subalpine scrub at the summit. The area lies within the mid-elevation high rainfall zone (Hyndman and Menzies 1990) and is mostly closed forest with scattered patches of second growth from old gardens, landslips and other natural disturbances. The forest is diverse and structurally complex (Wright et al. 1997; Weiblen 1998; Takeuchi 1999) and host to a high diversity of vertebrate wildlife (Mack and Wright 1996).

[1] For an analysis of wildlife exploitation in the Karimui-Daribi areas directly to the south west of Maimafu, see Hide 1984; for debates about hunting and gathering, see Dwyer and Minnegal (1991) and Roscoe (1990, 2002); for examinations of energetics, see Dwyer (1983, 1984) and Morren (1977, 1986); for data on classification, see Morren (1989) and Sillitoe (2002). Sillitoe (2001) has also written about the conservation related aspects of hunting.

Background: The Communities

Fewer than 5000 people live in the CMWMA, for a maximum estimated population density of 1.8 persons per km². During June – August 2003, we conducted research with the two distinct ethnic groups who live within the boundaries of the CMWMA, Pawaia and Gimi people.

Pawaia speak the Fas/Pawaian language and live to the south of Crater Mountain in what is referred to as the Pio-Tura area of Papua New Guinea (Pio is the Fas/Pawaian name for the Purari River and Tura is the name that is used to refer to Pawaia people by others in the region). Our study began in Haia village, a settlement in the Pio-Tura area that serves as a seasonal base for some760 people. It has an airstrip, a clinic, a radio, a church, and a school, and is roughly 100 km from Goroka, the capital of the Eastern Highlands Province, and Baimuru, a town in the Purari delta near the Gulf coast, and is not accessible by road. While Haia is the largest settlement in the area, our work also took place with people who have settlements at the Oo River and at Soliabedo. Pawaia people have extensive customary land holdings stretching across the Karimui District in the Simbu Province, the Baimuru District in the Gulf Province, and the Lufa District in the Eastern Highlands Province.

Pawaians practice a number of subsistence activities that include the collection of wild foods from the forests, shifting cultivation, cultivation of trees and palms which are located in dense forests and close to settlements, sago cultivation and production, pig husbandry, fishing, and hunting (Hide 1984; Ellis 2002). Seasonal mobility is an important characteristic of Pawaia subsistence and social life. It is important in terms of subsistence because people follow the fruiting cycle of plants and tress so as to collect wild foods and so as to hunt specific animals when they are more accessible and easier to trap. It is important socially because men must begin to pay bride price for prospective wives early on in their relationship and continue paying throughout their married lives. This bride price payment is delivered in the form of labor, meat, and the like, and keeps men and then men and their families moving throughout the year. Socially, Pawaia belong to large extended family groups that have no name and to smaller family groups called *dja*. For the purposes of this paper we will use the terms "clan" and "sub clan" to describe these groups. Rights to land are attributed to this smaller group and men within it work to organize seasonal mobility and to make important social decisions.

The Gimi people with whom we worked live in what is known as Maimafu village, a settlement of between 700 and 800 people in the Lufa District of the Eastern Highlands Province. Maimafu has an airstrip, a community school, an aid post, and several Seventh Day Adventist churches, and is roughly 70 km from Goroka. While treated as a single administrative unit by the national government, Maimafu is really a series of ridge-top hamlets inhabited by numerous extended family groups. Gimi have two main levels of identification which correspond with the anthropological terms "clan" and "sub-clan". A clan is a group of men who trace their lineage back to a distant ancestor or to an ancestral migration from Labogai to the current location of Maimafu. These ancestors are mythological in nature. A sub-clan is a group of men who trace their lineage back to an actual ancestor who lived during historical memory. Land rights begin with the clan, with men claiming that their "clan owns" a particular bit of forest because of the narrative of migration found in the mythological stories. They are actualized at both the clan and sub-clan level, with clan members having rights to particular parts of the forests for hunting, and sub-clan members making collective decisions about garden plots, new house building, and the like (West 2000).

Gimi meet their subsistence needs through shifting cultivation, limited animal husbandry (predominantly chickens and goats as pig husbandry and consumption are prohibited by the Seventh Day Adventist religion), gathering wild foods from the forests, and hunting. In contrast to Pawaia people, who have little in the way of cash income, Gimi people grow coffee and have, until recently, made a significant amount of money from its sale. Over the past three years, the price of aviation fuel, which is needed to fly coffee out of the village airstrip, has risen dramatically and has cut sharply into the Gimi profits from coffee sales.

Background: The Fauna

The vertebrate fauna of the CMWMA is very diverse thanks to its elevational gradient and the large expanses of intact forest. The fauna within the general area has been more intensively studied than any other region of Papua New Guinea (Diamond 1972; Hide 1984). Through extensive field work at the Crater Mountain Biological Research Station (Mack and Wright 1996, 2005), and a series of month-long biological surveys across the CMWMA, D. Wright and A. Mack (unpublished data) have confirmed the presence of at least 292 bird species and 63 mammal species within the boundaries of the CMWMA. The area has one of the most diverse microhylid frog faunas of PNG (Bickford 2001). As well as being diverse, the fauna appears to have at least fairly robust populations of all the expected taxa that are often extirpated from other areas experiencing greater human disturbance. The light levels of anthropogenic clearing in the WMA only modestly impact the composition of the avian community (Marsden et al. in review) and the most significant impacts are likely to come from hunting and dogs (see below).

Methods: Field Techniques

During the study period we worked primarily with hunters from ten Pawaia clans and twenty-three Gimi clans. For each clan we identified two young unmarried men to act as coordinators for our study. We then identified several other young men to act as clan-based assistants. Each of these men was from one of the different sub-clans, and they were responsible for attempting to collect as many voucher 'trophies' (animal skulls) as possible from their sub-clan throughout the study period. Each of these 'trophies' was followed up with identification of species, identification of hunter, and local language name. Over the course of the study, the field assistants spent at least one week living with most of the sampled clans in their settlement or in their forest (Pawaia) or in their hamlet (Gimi). During this period, each of the 'trophies' collected was followed up with a hunter data interview and an animal data interview. Roughly every third 'trophy' collected during this period outside the immediate vicinity of the village, presenting a random subset of the kills, was followed up with a location data interview and the collection of a GPS point for the point of kill.

Voucher 'trophies' in the form of skulls were collected for most prey items and retained for reconfirmation of species identifications. Hunters utilized field guides and books (Beehler et al. 1986; Flannery 1995) while being interviewed to help identify prey species. A lexicon of indigenous names was collected and used to double check identifications using the trophies and field guides. We strived to minimize identification errors by first getting the local name (in Gimi or Pawaian) from the hunter, then had the hunter identify the animal in a field guide when possible, and then used the trophy to confirm or reject the hunter's identification.

Methods: Analyses and Projections

Statistics were done with the software Statistix v. 8 or the data analysis tool box of Microsoft Excel.

For projections of overall vertebrate offtake in PNG, we collated data from the 2000 Census for each Province to estimate the number of people living in rural PNG, in traditional housing, without wage-paying occupations and living primarily on subsistence agriculture. From these totals we subtracted an approximate proportion of that population that live near coastal areas on the assumption that marine fisheries will replace wildlife as principal sources of protein. We also subtracted a rough approximation of the population that we estimate lives in densely populated agricultural areas and thus would be lesser consumers of wildlife than the deep rural people of our sample. In other words, we estimated the population that could be very roughly comparable to the population we sampled in terms of wildlife consumption. As well as coastal communities, we also excluded the entire populations of the National Capital District, Manus, East and West New Britain, New Ireland and North Solomons Provinces even though substantial quantities of non-marine vertebrates are consumed in these populations. In other words, we feel our estimates are highly conservative and, if anything, under-estimate the population that consumes wildlife in PNG.

Because this estimate of the wildlife-consuming population is crude and based on census data indicators, we modeled a range of values from the most conservative estimate at 800,000 people to the least conservative estimate at 1,600,000 people. Our most likely value for the population of people consuming significant quantities of wildlife from which our data can be used in projections is 1,300,000 people.

Methods and Terminology: Caveats and Considerations

In this paper we use the term "wild meat" to refer to wildlife consumed by people in PNG (Milner-Gulland and Bennett 2003). We use this term to highlight the differences between wild meat and "bushmeat" (Table 1).

Table 1. Differences between the concepts of bushmeat and wild meat. The term wild meat has been introduced (Milner-Gulland and Bennett 2003) as an ancillary to bushmeat in order to highlight important differences in the socio-economic causes of these two forms of hunting. This table shows some general differences between the two. These are general patterns, so the word "usually" could be placed before the "yes" or "no" in the table.

Attribute	Bushmeat	Wild meat
Hunter eats prey	no	yes
Prey killed on land owned by the hunter	no	yes
Prey transported significant distances	yes	no
Prey sold for cash	yes	no
Middlemen between hunter and consumer	yes	no
Can be regulated by central governments	yes	no
Demand driven by market forces	yes	no
Demand increases with consumers' personal wealth	yes	no

Over the past ten years the conservation community has become increasingly interested in uses of wild animals that can be referred to as bushmeat (Njiforti 1996; Wilkie and Carpenter 1999; Carpaneto and Fusari 2000; Wilkie and Godoy 2000; Apaza et al. 2002; Fa et al. 2002; Milner-Gulland and Bennett 2003; Damania et al. 2005). We take "bushmeat" to be the hunting and capture of wild animals in places where there is a market for them as meat and as trade items. We take "wild meat" to be the hunting and capture of wild animals in places where there is little or no market for them and where they are used predominantly as a meat source for the people who hunted or captured them. Several organizations and projects have sprung up to address the pressing issues of the bush meat trade (e.g., www.bushmeat.org; bushmeat.net; www.thebushmeatcampaign.org). Because of the prominence of the bushmeat trade in the conservation psyche and literature, we have noted that often people make assumptions about hunting in PNG based on bushmeat issues in other countries. The use of wild meat in PNG is fundamentally different from the bushmeat trade in West Africa, Southeast Asia and parts of Latin America, and requires different interventions and policies. Research and management in Papua New Guinea have also lagged behind the other major tropical forest blocks worldwide.

These data are part of a pilot study, of which one main objective was to revise and improve data collection methodology. Thus there are a few methodological shortcomings identified by us that we intend to improve in the main study. These include changes in interview techniques, redesign of the survey questions, extending the study cycle to include at least one calendar year, and a number of sampling protocols that will improve the rigor of the statistical data. However, we do not believe it necessary or appropriate to outline all the planned enhancements in this working paper. Where necessary, we point out methodological considerations that potentially affect our preliminary conclusions. But we believe the data reported here are sufficiently robust to act as significant indicators. The modifications we will make in future field work should yield data that improve our conclusions, but we do not include anything in this working paper that is likely to be dramatically overturned through methodological alterations in the anticipated long-term investigations.

Results: The Hunters

Most of the kills (94.4%) were made by males, the rest (5.6%), comprising only 39 kills, were made by women. Most of the kills by women were of smaller taxa, e.g. rodents and bandicoots. The large taxa -- cassowaries, cuscus and pigs -- are almost exclusively killed by men. Most kills were made by middle aged to older men (Table 2). The majority of kills (74.3%) were made by persons specifically looking for game, i.e. hunting, while roughly a quarter (25.3%) were happened upon in the course of other activities and adventitiously killed; the remainder (0.4%) were unspecified. There was no correlation between the amount of meat a hunter killed and his number of children; hunters with larger families did not bring home more meat. The number of kills was not correlated with the amount of coffee sold; hunters who sold more coffee in the previous year did not hunt more or less than their neighbors who sold less or none (Figure 1).

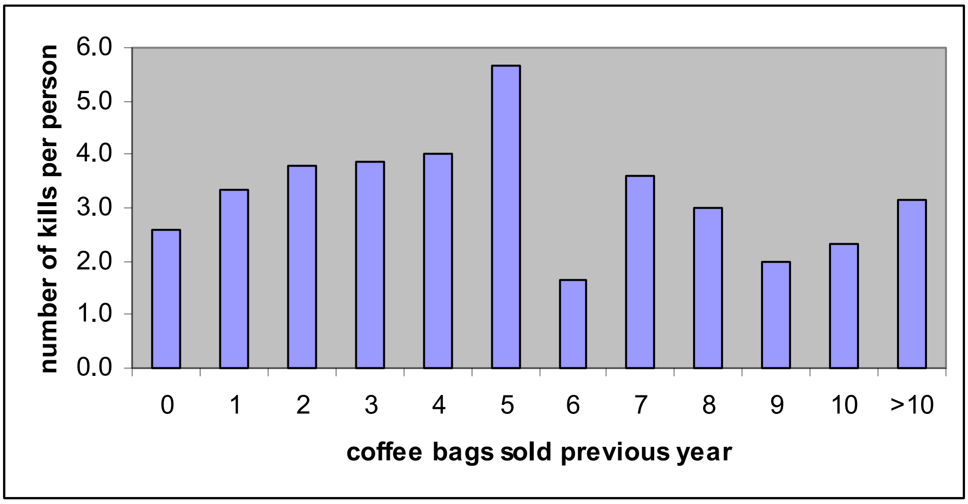

Figure 1. Relationship between amount of coffee sold and number of animals killed in the sample. In the sample 157 hunters made 523 kills and reported their coffee sales in the previous year by number of coffee bags sold. There is no correlation between coffee sales and the number of kills made by people. The y axis is number of kills per person reporting to have sold that amount of coffee in the previous year, since different numbers of hunters sold 0,1, 2 etc bags in the previous year.

Table 2. Age of hunters for each item killed (i.e. some hunters counted more than once if they killed more than one animal). Ages were approximated by the interviewers through questioning and appearance when hunters did not know their exact age.

Age (estimated in years)	Number of items killed
0-15	43
16-25	85
26-35	146
36-45	136
$\geq$ 46	24

Traditional methods were used in nearly all kills, predominantly bow and arrow or various manual techniques (Figure 2). Although 49 hunters reported ownership of shotguns (47 homemade, 2 factory made), in only one case was a shotgun reported as used, and this appears to be an erroneous report because the kill was a small bird. Traps were mainly snares or deadfalls, and all were reported made with traditional locally obtained materials (no wire or monofilament). At least ten kills were made by chopping down a tree in order to obtain the animal. Catapaults (slingshots, made with a Y-shaped branch and inner-tube or surgical tubing) were widely reported as used (Figure 3), mainly for small birds, though some reports of larger animals were included among the catapault kills.

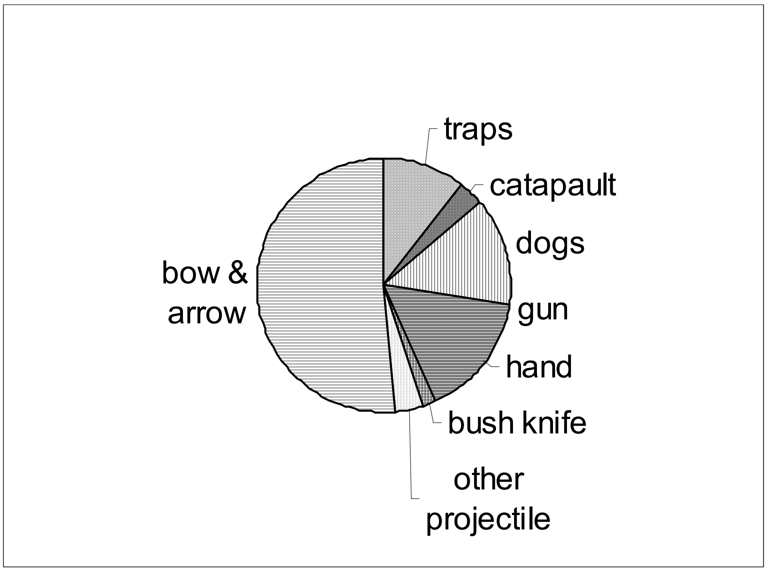

Figure 2. Means by which prey in the study was obtained by hunters. N = 666 kills for which the hunters reported the method of capture. Most were done with traditional bow and arrow and the sole record made with a gun could be erroneous (see text). Dogs made a substantial number of kills and aided in the location of even more kills. Traps were made with bush materials.

Dogs are a major aid to finding and killing prey. Hunters reported that 42.4% of the kills were found with the help of dogs. Of these, 93 were reported actually killed by dogs (Figure 2). In a few instances, hunters found the animal but dogs made the kill.

Results: The Hunted

Data were collected on a total of 695 individual vertebrates representing roughly 135 species of vertebrates that were brought in as trophies. The greatest diversity of species came from birds, yet most biomass came from mammals (Table 3). Despite the wide diversity of taxa included in offtake, most were only killed rarely; 75% of the species were represented by five or fewer individuals.

Table 3. Sample sizes and biomass of different classes of vertebrate in the animals killed by hunters in the CMWMA. Data are derived from 696 trophies collected in the study period. Biomass is calculated by attribution of a mean weight for each species based on field data from the CMWMA (Wright and Mack, unpublished data) and published data on mass (Flannery 1995; Mack and Wright 1996).

Taxa	No. individuals	No. of species	Approx. biomass (g)
Mammals	354	± 37	1230920
Birds	264	86	554872
Herpetofauna	42	≥ 9	42145
Fish	36	≥ 3	12320
TOTAL	696	135	1840257

Most of the animals captured were identified by the hunters as adults (592) rather than juveniles (104). Of these, 255 were identified as females and 290 as males, with the remaining 151 unassigned to gender. This does not differ significantly from a 1:1 sex ratio (χ^2 = 1.12, P=.281).

Forty-three of the kills identified as females were accompanied by dependent young. Five of these were cassowaries with one chick apiece (in fact male cassowaries do all parental care in, but it is a common misconception among PNG hunters that the females care for the young). The other 38 females (26.6% of all female mammals) with young were mammals, with a total of 61 young, all of which were killed as well.

The total mass of animals consumed was 1840.3 kg of vertebrate biomass. Most biomass came from mammals with birds second in importance (Table 3). Broken down into general categories of animal, the taxa that had the greatest diversity and numbers of individuals did not also constitute the most biomass (Table 4). The most biomass (>80%) came from a handful of genera: *Sus, Casuarius, Phalanger, Spilocuscus, Dendrolagus,* and *Zaglossus*. The remaining <20% of biomass comes from the majority (62.9%) of the individuals killed.

Table 4. Breakdown of major groups of animals found in the survey of 696 prey animals killed by hunters in the CMWMA. Species in the trophy samples are broken down into 17 general taxonomic categories. Over 50% of biomass comes from the only two large species commonly found in Papuan rainforests (pigs and cassowaries), and the next thirty percent comes from cuscus, tree kangaroos, echidnas and bandicoots.

Group	Percent of individuals	Number of individuals	Percent of biomass harvested
Small marsupial	1.3	9	0.1
Bird of paradise	5.8	40	0.3
Flying fox	1.9	13	0.3
Pigeon/dove	5.2	36	0.4
Rodent	8.2	57	0.5
Fish	5.0	35	0.7
Small bird	19.6	136	0.8
Megapode	3.9	27	1.5
Ringtail	2.7	20	1.6
Reptile/amphibian	6.0	42	2.3
Wallaby	3.3	23	2.5
Bandicoot	11.2	78	4.5
Echidna	2.3	16	5.4
Tree kangaroo	2.0	14	6.8
Cuscus	15.7	109	14.6
Cassowary	3.6	25	27.3
Pig	2.0	16	30.5

All the villages except Maimafu (e.g., with the most intact forests and lowest populations) had more mammals than expected, and fewer birds than expected, whereas Maimafu had more birds and fewer mammals than would be expected if captures were occurring at random (χ^2 = 138.33, df= 5, P<.0001). This may indicate that the mammal resource at Maimafu is being depleted, or alternatively birds are preferentially hunted in Maimafu for any possible number of social reasons (Table 5).

Table 5. Numbers of mammals and birds killed by hunters in the different communities in the study. The sample size for Maimafu is larger, but also including disproportionately many more birds than mammals.

Village	Bird	Fish	Herp.	Mammal	Total
Haia	14	2	13	70	**99**
Herowana	14	5	9	78	**106**
Maimafu	199	11	7	103	**320**
Soliabedo	5	3	6	28	**42**
Toyaido	3	4	4	18	**29**
Tsomai	28	10	3	59	**100**
Total	**263**	**35**	**42**	**356**	**696**

Results: Consumption

The majority of kills (79.7%) were consumed in the village or small settlements where interviews were conducted. Smaller numbers were reported as consumed in gardens (20), but a fair number were consumed in more distant bush huts (105) and only a few in the more distant bush camps (7). Only one kill was reported as specifically hunted and killed for trade, and only seven kills were made specifically for brideprice payments. These seven were all among one clan of Pawaia and were comprised of two long-beaked echidnas, two tree kangaroos, two ground cuscus and one forest wallaby.

For 659 of the killed animals with data on who ate them, the meat was divided between 4766 person-meals. The number of people consuming an animal ranged from 1 to 80 (mean =7.3 ± 8.4). We did not collect information on the gender or age of consumers, and this is one of the methodological issues we will address in the follow-up study. The total biomass consumed with these 659 animals was 1586.5 kg, with a mean amount per person-meal of 217 g (± 389). Given the time (225 days) and the approximate size of the communities sampled (300 individuals), the average daily intake per person was 23.5 g/person/day, or 165 g/person/week. These values could range from 116 g/person/week to 330g/week/person for the widest extremes of the assumed sampled population (Appendix 1), but keep in mind that this mean includes small children. The daily intake for adults is likely to be higher.

Results: Where Hunters Meet the Hunted

The sizes of animals taken was significantly different among the villages (F= 8.16, P<.001; Table 6). Maimafu villagers killed more animals and fed more people with them, but the difference is primarily due to an elevated number of small birds killed at Maimafu versus other sites (Table 5).

Table 6. Summary of vertebrate offtake by hunters in six communities in the Crater Mountain Wildlife Management Area.

Village	No. kills	Offtake (kg)	Mean size (kg)	People sharing	Mean meal size (kg/person)
Haia	98	500.8	5.1	585	0.856
Tsomai	100	429.4	4.3	1074	0.400
Soliabedo	43	157.5	3.6	467	0.337
Toyaido	29	96.4	3.3	225	0.428
Herowana	106	249.6	2.4	806	0.310
Maimafu	320	405.9	1.3	1624	0.250

Of kill locations, 184 were in primary forest, 108 in secondary forest, and 63 not classified. Kill sites were classified accordingly[2]:

38	at rivers edge
5	in new gardens
39	in active gardens
30	abandoned gardens
114	near a main trail
61	near a village
39	in bush nothing
9	actually in a village
40	near a bush house

The majority of wildlife offtake is made in or near disturbed areas; only 39 of the kills were listed as being from heavily forested, relatively undisturbed areas, and most were in some sort of garden or near a major trail. Kills were spatially clustered around habitations and garden areas and most kills were made near watercourses or trails.

Fairly accurate estimates of distances from the village centres to kill locations were obtained from the GPS fixes of a random subset of the kills (N=326 kill sites). The mean distances people travelled to make kills differed between the villages, with travel from Maimafu and Haia being significantly greater than the other four villages surveyed (Table 7).[3]

Table 7. Distances from villages to kill sites for animals killed in the CMWMA. The distances to kill sites differed significantly among villages with Haia kills being the furthest from the village. A Tukey-test showed that the Group A villages were significantly different from group B villages, but villages within groups do not differ significantly (P<.05).

Village	N	Distance (m)	SE	Group
Haia	63	5546	271.67	A
Maimafu	34	4885	369.81	A
Tsomai	95	2528	221.23	B
Herowana	87	2419	231.18	B
Toyaido	19	1630	494.70	B
Soliabedo	29	1591	400.42	B

Results: National Projections

Because census data and other studies do not explicitly describe where people obtain their dietary protein, it was necessary to make approximations based on surrogate information (e.g. living in rural, traditional households with no cash income) and then subtracting an estimated proportion that would be obtaining protein from marine, commercial or domesticated sources. We varied the latter assumption in the model and obtained values of from 0.8 to 1.6 million people who are deriving a significant portion of their dietary protein from wild meat. We also modeled the projection by varying the assumption of how many people our survey sampled. A matrix of predicted national offtake (Appendix 1) was produced that shows that, under the most conservative assumptions (highly unlikely), human consumption of vertebrates is over 2 million animals weighing 5.62 million kg. With the least conservative assumptions, this would be 12 million animals

[2] Not all categories are mutually exclusive, e.g., a site can be both near a trail and in a garden, etc.
[3] Note these values are just for kills not made in the village. Kills made in the village were not fixed by GPS, so these means represent distances traveled to make a kill, not including incidental kills made in or very close to villages (primarily rats, bandicoots and small birds).

at 31.8 million kg. *Based on the most likely and reasonable assumptions of the mode,l we predict the range of animals consumed is 4.14 to 7.9 million vertebrate animals, comprising 10.95 to 20.90 million kg of biomass.* Using our most likely projection of 13 million kg of wild game being consumed, this would amount to a retail replacement value (in town ignoring transport costs to rural areas) of approximately 75.5 million Kina for tinned fish or 75 million Kina for lamb flaps. In this projection, the consuming population is 1.3 million people. Of these, 40% are under the age of 15 and we exempt as potential wage earners. Thus the potential wage earners in this population would need to increase their income by roughly K100 per year to purchase, at town prices, the equivalent protein in tinned fish to supply their families. But that assumes everyone above the age of 15 has employment. If we add this cost just to the portion of the rural population already employed (PNG Census 2000 data), current rural wage earners would need to devote an additional K1700 of their annual income to the purchase of tinned fish in order to compensate for the loss of wild meat in their diet.

Discussion: Overview of Results

Hunting is still a major activity for many rural men in Papua New Guinea, and it is an important part of customary practice (Dwyer and Minnegal 1991; Dwyer 1994). Over 75% of the men interviewed make trips specifically to hunt at least every two months, and more than 50% of the men interviewed go hunting more than once a month. The cultural reasons and social milieu that affect hunting may be changing rapidly as the global cash economy, missionaries, health care and education extend more pervasively into rural communities. But the overall need for wild meat as part of the human diet and the overall impacts on game populations do not appear to be decreasing in many communities. A large segment of the PNG population lives at the fringe of the cash economy, with little access to cash, and lacks the option of obtaining protein from farmed domestic stock. Those Gimi with greater cash income from coffee were not extracting less wild meat from their forest.

Wild meat is a significant source of protein and nutrition for many rural people in PNG. In this seven month study, over 1800 kg of wildlife was consumed in 4766 "meals", yielding an estimated daily intake of roughly 23 g of wildlife per person. This figure is uncannily close to the value obtained more than two decades ago in the same region -- 22 g/d/person (Hide 1984) -- suggesting at least that consumption of wildlife has not dramatically decreased in importance since that study. Although our sampling method did not include those people who received no share of the wild meat consumed, this clearly represents the majority of people in the studied communities. Wild meat also often contains important nutrients that are not found in many staples, particularly protein, sodium, phosphorus and calcium (Hongo et al. 1989; Brand et al. 1991). Children and pregnant women have particularly strong needs for calcium and other nutrients scarce in root crops, so wild game, even in modest quantities, could be particularly important for certain subsets of the populace.

Unfortunately for the rural people of New Guinea, there simply are few large animals in the forest. Compared to the resources available in other tropical forests (Fa et al. 2002), there is very little available large game in New Guinea forests. Because of this, a disproportionate share of the dietary income of protein from wild game for any one community comes from a very limited number of species. This creates the risk of serious consequences should any of these few species become significantly reduced in population or extirpated. On the other hand, it provides the opportunity wherein successful management of just a few species can ensure in excess of 80% of dietary protein from wild game. Thus research and management priorities should concentrate on these taxa: feral pigs, cassowaries, tree kangaroos, cuscus, echidnas, ringtails and megapodes (if consumption of eggs is considered).

The data strongly suggest that hunting patterns are not sustainable in the CMWMA. In the two older villages, Haia and Maimafu, hunters traveled further to make kills than in the younger villages of Tsomai, Solibedo and Toyado. In the most densely populated area, Maimafu, there was an increased component of small birds being killed. Although there are several possible, non-exclusive explanations for this, prudent management must consider the possibility that the difficulty of finding sufficient larger prey helps cause a shift to small prey. Hunting is concentrated roughly within 7 km of settlements. But as resources (notably garden production) become depleted and unable to sustain increasing populations, communities fragment and establish new settlements. The communities of Solibedo and Toyado are relatively young expansions because the Haia area could not sustain its growing human population (M. Opiang, personal communication). Thus these new settlements will establish hunting radii around them, potentially turning the CMWMA into a "swiss-cheese-like" forest, with animal sink areas (the holes) in a matrix of possible source areas (the forest) (Watkinson and Sutherland 1995; Novaro et al. 2000). In a quantitative analysis of cassowary offtake just of captive chicks (Johnson et al. 2004), the authors found it unlikely that the current capture rates could be sustained. Add to this the offtake of adult cassowaries (this study), and there is little doubt cassowary populations will decline dramatically without innovative management.

The roughly 75% of species that are killed less often and/or are small (Table 4) are not under as imminent a threat as individual species. Most of these are probably common enough to sustain these levels of offtake. However, there are exceptions, such as those with rather limited and specific habitat requirements. These would include some of the aquatic taxa, such as ducks (*Anas waigiuensis*), water rats (*Hydromys* spp.), and fish. Species confined to freshwater have very limited populations and are concentrated where hunters spend substantial periods of time. In the past decade, WCS biologists have noted dramatic declines in fish populations in Crater rivers, and local people have noted the increasing rarity of fish in some rivers. The other group of animals that would fall in the specialized habitat category are the cave-dwelling bats. Although they may forage over large areas, their concentration in a few caves that are well-known to hunters, makes them particularly vulnerable. In the crater area, a number of caves have been completely depleted of formerly numerous flying foxes, *Dobsonia magna* (local hunters, personal communication). The one cave that still has a fairly robust flying fox population is one that has had a moratorium on hunting for the past ten years in order to maintain the cave's appeal to ecotourists (Mack and Wright unpublished data; Wright *et al.* 1995).

Other special consideration might need to include taxa that are targeted for cultural or socio-economic reasons independent of their abundance, such as Vulturine Parrots, *Psittrichas fulgidus* (Mack and Wright 1998; Johnson et al. 2004) or Harpy Eagles, *Harpyopsis novaeguineae* (Watson and Asoyama 2001), which are killed for use and sale of feathers in traditional adornment Thus, when identifying conservation and management priorities, simply emphasizing the most numerous taxa in the overall offtake is not sufficient. Special considerations need to be made of cultural uses, specialized hunting practices, and the ecology of species.

Choosing taxa for concentrated management should also possibly include taxa that are both heavily used, but not apparently under threat of depletion, if management can possibly enhance numbers for harvesting, or if focusing on these taxa could ease offtake on more threatened taxa. This category might include things such as rats (Muridae) and bandicoots (Peroryctidae).

Discussion: Research Needs

One of the novel findings from this study is that feral pigs need study. In areas of low human population density, meat from feral pigs is often more important than from domesticated pigs (Hide 2003). Little is known of the natural history and population demography of feral pigs in New Guinea, though there has been considerably more study of management and husbandry of domesticated pigs (Hide 2003). Ignorance of basic natural history could have dramatic implications. For example, if pig populations in New Guinea behave like their closest wild relative in Borneo, *Sus barbatus*, they could be migrating over large areas. Such mobility means that hunting could continue at unsustainable levels for substantial periods with no evident diminution in offtake, as individuals move from source to sink areas(Watkinson and Sutherland 1995). However, in such source-sink dynamics, once a population is depleted below some critical threshold, i.e. where source areas become depleted, then offtake will crash precipitously over a large area and will not rebound quickly. In other studies, feral pigs have not been as important in the diets of people (Dwyer 1985), thus more research is needed across sites to identify where feral pigs might need management to improve their availability.

For virtually all the wild game species consumed by people in Papua New Guinea, we lack the essential natural history data that are minimally needed to formulate even rudimentary management plans. The basic necessary parameters include: lifespan, age of first reproduction, age of last reproduction, annual number of offspring produced, time of reproduction, home range size, and population density. Such data are unavailable for most species, including some that have been under study for years. For example, (Johnson et al. 2004) had to model some of these parameters and use fragmentary data from captive animals or Australian congeners in order to examine the sustainability of cassowary offtake in the CMWMA. Basic natural history field studies are desperately needed for all the heavily exploited and vulnerable taxa included in the diets and offtake of hunters in Papua New Guinea. Data from congeners, even from the rainforests of Australia, are often inapplicable because ecological variables that differ significantly between New Guinean and Australian rainforests affect the important parameters (Kanowski et al. 2001).

These data are clearly incomplete, and provide only an indication of the scope of wildlife use. Studies need to be undertaken that quantify the full spectrum of wildlife consumption over a complete annual cycle. Such studies need to be replicated in numerous communities in order to begin to tease apart the effects of different variables on wildlife consumption (e.g., economic status, past education, religion, etc.). If management planning is to be successful, it must be based on solid knowledge of the socio-historical and political-economic matrix where it is being applied. What management protocols will work and be appropriate depends both upon the natural history of the managed animal population and the socio-historical and political-economic background of those doing the managing.

In addition to a series of year-long field studies in selected communities, it would be effective to simultaneously conduct shorter sampling sessions in a wider array of communities. By sampling communities that vary widely in key variables, it will be possible to begin to tease apart the influence of the key social and environmental variables that impact wildlife consumption. Because it will not be possible to sample both broadly and intensively (> 1 year), we recommend that a hybrid research agenda would be most efficacious, with some sites sampled intensively while other strategically chosen communities are sampled less intensively (e.g. 3 months).

Discussion: Policy Considerations

Hunting cannot be regulated through government mandated licensing or bag limits as is done in most of the developed world. Wild meat resources belong to traditional resource owners on virtually all forested lands in PNG. The national regulations that are most applicable are under the *Fauna (Protection and Control) Act*. There are two main problems with the Act. First, the listing does not adequately reflect in many cases taxa that are threatened or in need of protection. Second, there is little means for enforcement of the Act. As there is little point in enforcing protection of taxa requiring no protection, the logical first step would be to upgrade and revise the protected species listed to reflect those most in need of protection. Subsequently, consideration could be given to the question of how to enhance enforcement of the Act.

Wildlife Management Areas are a legal structure through which communities can exercise greater control over management of their wildlife resources. Many communities desire to register land as Wildlife Management Areas, but the government provides insufficient funding to the Department of Environment and Conservation in order to undertake the necessary steps. Greater support needs to be provided to the Department so that it can expedite the backlog of applications and inquiries about WMA gazettal. Within WMAs, local communities need to work along with social scientists and ecologists to devise management protocols that are locally appropriate and most likely to ensure a sustainable wild meat resource base. We believe that different management techniques, such as closed areas, closed seasons, regulation of techniques (e.g. no guns), bag limits, regulating who hunts, etc., which have proven effective in other places and with other game, can be adapted to the PNG context. If undertaken in collaboration with the people who own the resource, and designed in ways that are most appropriate for each community, we believe rural people can maintain a steady and reliable source of meat that does not require cash expenditure.

Summary

Wild meat is an important resource in Papua New Guinea that has received little attention in terms of planning and management. We report some preliminary results of field work studying offtake of wild game in several communities in the Crater Mountain area. Our results demonstrate and reinforce the conclusion that wild meat is a significant component in people's diets, and hunting is an important activity. Mostly middle-aged men hunt almost every month, leading to provision of wild meat in the area of 20 g/day per person. Their offtake spans a wide diversity of vertebrate species, but only a handful of the larger species comprise the majority of meat consumed because the other species are either small or rarely killed. For all these important species (wild pigs, cassowaries, macropods, cuscuses, ringtails, megapodes, echidnas and bandicoots), our knowledge of basic population parameters is inadequate to formulate even rudimentary management plans. Scientifically-based management is needed, and that need is becoming urgent, because there are indicators that, for at least some of these key resources, offtake is unsustainable and standing stocks can expect to be depleted if appropriate interventions or management cannot be implemented soon. A conservative extrapolation from this study suggests that hundreds of thousands of people in PNG consume millions of animals each year. This offtake probably amounts to tens of thousands of tons of wild meat each year. Depletion of this resource would create a significant financial burden in the parts of PNG where people have the least nutritious diets and the poorest health care. We recommend research priorities that will help avoid the problems that can be anticipated with the continued lack of planning and management.

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Appendix 1. Predicted offtake of animals (N X 10^6) and biomass (kg X 10^6) for mainland PNG based on data collected in Crater Mountain WMA. The predicted values appear in the table under different assumptions ranging from a population of people consuming wildlife at levels comparable to this study on mainland PNG ranging from .8 to 1.6 million people (across the top). Because a number of assumptions need to be made in the prediction (see Discussion) a range of values are modeled. The most conservative estimates are in the lower left corner and the least conservative estimates are in the upper right corner. The range we consider most reasonable (see discussion) are enclosed in the central box.

Millions	POPULATION Crater	MAINLAND 800000	900000	1000000	1100000	1200000	1300000	1400000	1500000	1600000
number of animals	150	6.02	6.77	7.53	8.28	9.03	9.79	10.54	11.29	12.04
offtake biomass	150	15.92	17.91	19.90	21.89	23.88	25.87	27.86	29.85	31.84
number of animals	175	5.16	5.81	6.45	7.10	7.74	8.39	9.03	9.68	10.32
offtake biomass	175	13.65	15.35	17.06	18.76	20.47	22.18	23.88	25.59	27.29
number of animals	200	4.52	5.08	5.65	6.21	6.77	7.34	7.90	8.47	9.03
offtake biomass	200	11.94	13.43	14.93	16.42	17.91	19.40	20.90	22.39	23.88
number of animals	225	4.01	4.52	5.02	5.52	6.02	6.52	7.03	7.53	8.03
offtake biomass	225	10.61	11.94	13.27	14.59	15.92	17.25	18.58	19.90	21.23
number of animals	250	3.61	4.06	4.52	4.97	5.42	5.87	6.32	6.77	7.23
offtake biomass	250	9.55	10.75	11.94	13.14	14.33	15.52	16.72	17.91	19.11
number of animals	275	3.28	3.70	4.11	4.52	4.93	5.34	5.75	6.16	6.57
offtake biomass	275	8.68	9.77	10.86	11.94	13.03	14.11	15.20	16.28	17.37
number of animals	300	3.01	3.39	3.76	4.14	4.52	4.89	5.27	5.65	6.02
offtake biomass	300	7.96	8.96	9.95	10.95	11.94	12.94	13.93	14.93	15.92
number of animals	325	2.78	3.13	3.47	3.82	4.17	4.52	4.86	5.21	5.56
offtake biomass	325	7.35	8.27	9.19	10.10	11.02	11.94	12.86	13.78	14.70
number of animals	350	2.58	2.90	3.23	3.55	3.87	4.19	4.52	4.84	5.16
offtake biomass	350	6.82	7.68	8.53	9.38	10.24	11.09	11.94	12.79	13.65
number of animals	375	2.41	2.71	3.01	3.31	3.61	3.91	4.22	4.52	4.82
offtake biomass	375	6.37	7.16	7.96	8.76	9.55	10.35	11.15	11.94	12.74
number of animals	400	2.26	2.54	2.82	3.10	3.39	3.67	3.95	4.23	4.52
offtake biomass	400	5.97	6.72	7.46	8.21	8.96	9.70	10.45	11.19	11.94
number of animals	425	2.13	2.39	2.66	2.92	3.19	3.45	3.72	3.98	4.25
offtake biomass	425	5.62	6.32	7.02	7.73	8.43	9.13	9.83	10.54	11.24

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