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Status and Potential of the Peroryctidae Family to Improve Food Security in Papua New Guinea

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Abstract

As the importance and threats of wildlife resources in Melanesia are widely recognized, their appropriate use is critical to achieve sustainable development in the country. An underestimated relationship between the status of the species with forest condition and food security is discussed. Being as nutritious as conventional imported red meats, bandicoots are also considered as the most rapidly breeding marsupial. The taxonomy, morphology, habitat, and reproductive characteristics of the family Peroryctidae (bandicoots) are succinctly described in order to elucidate the species potential in continuous controlled harvests in the wild and its eventual farming, until now successful abroad with one species from a related family. This effort requires the application of proper regulations that guarantee continuous harvests in accordance to the population dynamics.

Keywords: wildlife, food security, bandicoots, meat sources, forest degradation

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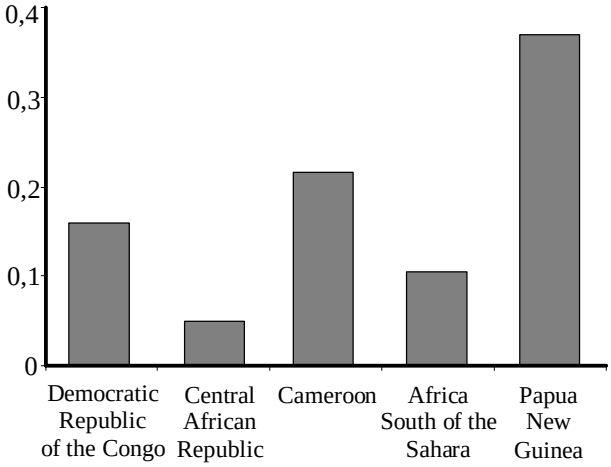
Introduction

Well adapted, underutilized resources that have the potential to strengthen food security in the country have been poorly assessed, and their implied short and long term costs and benefits poorly understood (NARI 2003). Wildlife depletion has an impact on food security (Nasi *et al.* 2008), and the connection between this last with population growth and social security are now well recognized (Austin 2010).

The order *Marsupialia*, once widespread worldwide, is still successful in Melanesia and Australasian regions. The family *Peroryctidae* (*bandicoots*) is almost restricted to Melanesia with nine species found in rainforest, grasslands and abandoned farms (Table 1). The need of protein is a strong factor that drives deforestation around Papua New Guinea (PNG) villages. This ancestral practice is turning to be harmful as human demography increases and the market presses towards resources overuse, beyond their resilient capacity. Bandicoots can periodically offer high quality meat at increasing rates without disturbing the forest. Unlike other more threatened species (tree-kangaroos, cassowaries, echidnas), they are still relatively common outside heavily hunted areas. Bandicoots can potentiality offer high quality meat at increasing rates without degrading the forest. Villagers often cannot afford investment on livestock, chicken or poultry farms, bandicoot farming may well provide a good option. The paper discusses the possibilities, advantages, constraints, and recommendations for the sustainable management of these species including their farming in PNG.

Hunting in New Guinea as an asset and a problem

Bush meat is a huge industry. In West and Central Africa it amounts K107,692,000–525,641,000 year^{-1} (Davies 2002), in the Amazon basin K 448,718,000 year^{-1} (TCA 1995), and the overall international trade is of K10 billion year^{-1}. Hunting provides 20–80% of overall protein intake by rural households in Central Africa (Inamdar *et al.* 1999). Bush meat has been also a fundamental source of protein in Melanesia, where villagers often cannot afford investment on livestock, chicken or poultry farms. Bush meat is accessible, highly transportable, has a high value:weight ratio, is preserved at low cost, and has good storage qualities when smoked (Inamdar *et al.* 1999). Although being a significant industry (Williamson 2002), several developing countries lack the capacity to collect taxes or enforce hunting regulations. Statistics on its trade are also difficult to obtain as reports use to be informal or misleading, without differentiating self consumption from commercial hunting (Nasi *et al.* 2008).



Source: Nasi *et al.* (2008)

Figure 1 Average daily wild meat consumption (kg day^{-1}) per country.

Table 1 Status and distribution of bandicoot species in PNG

Species	Status	Adult male average weight (g)	Altitudinal range (masl)	Local name
Family Peroryctidae				
Echymipera clara	Potentially vulnerable	1140–1700	300–1700	Kiyok (Sandaun Pr.) Meya (Madang Pr.)
Echymipera chinista	Potentially vulnerable	1000	40–80	Wek/Mahai sobo (Western Pr.)
Echymipera kalubu	Secure	840–1500	0–2000	Aiyal/Mowyaw(Sandaun Pr.) Gesia/Hou (Chimbu Pr.)
Echymipera ufescens	Secure	No data	0–1200	Pe gesia/Hou (Chimbu Pr.), Aiyal (Sandaun Pr.)
Microperoryctes longicauda	Secure	350–660	1000–3950	Asege/Koiyo gesia (Chimbu Pr.) Bonabe (Chimbu Pr.) Warem (Sandaun Pr.) Pularvee (Cental Pr.) Kumbu (Irian Jaya)
Microperoryctes murina	Unknown	No data	1900–2500	None known
Microperoryctes papuensis	Unknown	150–184	1200–2650	None known
Peroryctes broadbenti	Endangered	Up to 4800	0–unknown upper limit	None known
Peroryctes raffrayana	Secure	865	60–3900	Koiyo (Central Pr.) Duwin (Sandaun Pr.) Ibin (Sandaun Pr.) Wablo (Irian Jaya)
Family Peramelidae				
Isoodon macrourus	Secure	No data	0–1200	None known in PNG Austr: Northern Brown Bandicoot

Source: Flannery (1995)

The need of protein is a strong factor that drives deforestation around PNG villages. Hunting by hand, in snares and deadfall traps, and or bush and *kunai* grass burning, is a widespread practice, and increases linearly with human population growth and nonlinearly with income increase (Fa *et al*. 2003). Even though the country spends large amounts of money importing 41,800 ton of red meat at a value of K130 million (Harris 1984). This ancestral practice is turning to be harmful as human demography increases and the market presses towards resources overuse, beyond their resilient capacity. At Schrader range alone, locals consume more wild meat per day (0.37 kg) than in several African countries (0.1–0.3 kg; Jenkins & Milton 1996). If hunting practices remain high significant declines of wild protein have been predicted in the following decades, with insufficiency of non-bush protein sources to replace them. The health and nutrition status in the country is low, the consumption of protein is low in general, although the protein content of bandicoot meat (24 g $100g^{-1}$) is higher than the average of other sources (Dignan *et al*. 2004). There is no tradition of ruminant livestock grazing in village agriculture. Commercial poultry and pig meat production is heavily dependent on imported feeds (Igua 2001). Spencer and Heywood (1982) described the conflict between rising rice consumption and the push for food self-reliance as 'the paradox at the heart of the food policy in PNG'. That self reliance is undermined by the dependence on foreign foods like tinned fish. The bush meat crisis is mainly a problem resulting from an unmanaged common resource being unsustainably harvested because of inadequate governance and policy frameworks.

Other factors that threat bandicoot populations are habitat fragmentation, inbreeding depression, predation by dogs and cats (vectors of toxoplasmosis disease), and the unknown effect of pesticide contamination. To attain stability the wild population must increase at least 10% in both adult survival and fecundity (Clark *et al.* 1995), however the total disappearance of some species like *Peroryctes broadbenti* and *Rhynchomeles prattorum* (Seram bandicoot) in some areas of PNG has already being reported (Kennedy 1992). Others like *Peroryctes raffrayana* (Figure 2) and *Microperoryctes murina* (Figure 3) are in a secure and unknown status respectively. In Australia the distribution of *Perameles gunnii* changed dramatically in the last 200 years of European settlement (Mallick *et al.* 1997). *Chaeropus echaudatus,* which evolved as a cloven-hoofed animal adapted for running in the late Oligocene or early Miocene (Westerman *et al.* 1999),

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was last seen in 1950 (Normile 2010).

Reproductive particularities and breeding possibilities

Bandicoots are the most rapidly breeding and developing marsupials that have been studied (Lyne 1974), with short gestation periods, and rapid maturity of the young (Flannery1995). They are differentiated from all other marsupials by the combined presence of fused (syndactylous) toes on the hindfeet forming a comb for grooming, and polyprotodont dentition. Most of them are rabbit sized or smaller. They are specially designed for digging out invertebrate food in the ground. The nest is a heap of ground litter covering a shallow depression, with entrances at both ends and a 4 meters long burrow with two entrances. Hollow logs are also used.

The energy spent by marsupials females in rearing their young is higher than for placentals, humans and elephants excepted. Moreover, *bandicoots* are the only marsupials with a rudimentary placenta from which the young are fed before they are born (Boorer 1970).

Sexual maturity comes at 4 months for females and 5 months for males. The female mates at night and the young are born in the nest during daytime. Birth probably lasts less than 10 minutes, with the young weighing about 0.5 g (Normile 2010). The 1cm young are undeveloped, furless, blind, with hind limbs partially formed, and well developed forelimbs that enable them to make their way into the pouch. Contrasting with the short pregnancy the lactation period lasts eight weeks and the milk composition changes depending on the developmental stage of the young. The pouch of a mature female bandicoot opens backwards for protection for the young while digging holes in search of food (AWCN 2010).

Breeding can take place throughout the year, while they are still suckling their young in the pouch the next litter grows in the womb. The expansion of teats used by the previous litter become too large for the newborn to grasp, but newborns are assured nourishment as at least four other teats have not been used. The young begin to forage with the mother after 62–63 days (AWCN 2010). Mutual avoidance is the predominant social behavior and most bandicoots are essentially solitary. Although Mackerras and Smith (1960) concluded that breeding of *Isoodon macrorus* in small enclosures (6–7m^2) is not viable, Close (1977) reported successful

Source: (http://animaldiversity.ummz.umich.edu)

Figure 2 *Raffray's bandicoot.*

Source: (www.terrambiente.org/fauna/Mammiferi/metatheria)

Figure 3 *Papuan/striped/mouse bandicoot.*

Table 2 Comparative table

Variable	Bandicoots	Domestic rabbits
Habitat	Widespread in New Guinea, maximum diversity in mid-montane rainforest	Introduced to Irian Jaya 50 years ago
Mating	Year round	Year round
Adult size range	0.1 (Microperoryctes murina)–5 kg (Peroryctes broadbenti)	4–5 kg
Average litter size	2.3	in PNG: 3.8–5.9 (surviving: 1.3–4.0)
Gestation period	12.5–15 days	28–31 days
Litters/year	4	12
Life expectancy	Up to 2.5 years (wild) Up to 3 years (captivity)	5–15 years
Diet	Insects, leaves, fruits, roots, fungi	Fodder, concentrates, vitamins
Diseases	Toxoplasmosis	Salmonella, Coccidiosis, Myxomatosis
Threats	Bush burning, overhunting, dogs, rats, and snakes	High temperatures in lowlands, lack of concentrates lack of wire for cages theft, rats, snakes
Secondary benefits	Improve soil properties by burrowing and debris traslocation	Skins, manure

Source: Menkhorst and Seebeck (1995), Scott (1995), Stoddart (1995), Askin (2005), and Muntwiler (2005a, 2005b).

breeding of *Perameles nasuta* in 1.5 ha spaces, especially during spring seasons in Australia.

Table 2 illustrates a comparison on advantages and disadvantages between domestic rabbit farming in PNG which is a placental mammal of worldwide commercial breeding, and a prospected management of native *bandicoots*. Both are r-strategists of high fecundity, small body size, early maturity onset, short generation time, and with the ability to disperse their offspring widely (Caroli *et al*. 2000). Being similarly prolific, the balance turns in favor of bandicoots when required investment is calculated. Moreover, rabbits in PNG are being fed on diets of 70% mill run and 30% copra meal with added protein, minerals, and vitamins (Askin & Grant 1995) which are unavailable in most of the villages. Results on rabbits farming varied and were heavily dependent on consumables and assistance from outside. *Perameles gunnii* breeding was possible on large (more than 1ha) well fenced areas in Australia. Trials with bandicoots in PNG still remain unexplored. A promising alternative in the short term is their management in the wild by hunting regulation, predator's control, and banning of bush burning. By protecting this species (species "umbrella"), many others and their habitats are also benefited.

Estimation of bandicoot populations in the wild

According to the Lincoln–Petersen method a sample of individuals is captured, marked (by toe-clipping or ear banding) in a manner that does not affect survival, and then released back into the population. After a time period judged long enough to allow the marked sample to mix at random through the total population, a second sample is captured. The number of recaptured animals (i.e. marked animals) to first time captures in the second sample gives the Lincoln-Petersen estimate of total population size. The model also assumes that no marks fall off animals between visits and that the researcher correctly records all marks (Seber 2002).

Given those conditions, the estimated population size of bandicoots in an area (Lancia *et al*. 1994) will be:

$$N = (M + 1)(C + 1)/(R + 1) - 1 \qquad [1]$$

where:

N = Estimate of total population size
M = Total number of animals captured and marked on the first visit
C = Total number of animals captured on the second visit
R = Number of animals captured on the first visit that were then recaptured on the second visit

Theory of sustainable harvests

The logistic equation has a rich history (Kingsland 1985) and is a mathematically convenient model that describes the growth of a variety of populations. It assumes that all individuals are equivalent with respect to survival, reproduction and susceptibility to crowding; the carrying capacity (K) is constant; the growth rate of the population responds instantaneously to the population size; and the effect of population size on growth rate is linear.

Under certain ideal conditions a population for a time can show a rate of growth that is exponential (growing at an ever-increasing rate). In a real situation, the availability of food and cover, and the effect of predators and diseases have a dampening effect on the growth of the population. The population growth rate at time *t+1* depends on the population size at time *t*. The model of this density-dependent growth (Robinson & Bolen 2002) is:

$$\Delta N/\Delta t = rN\,(K - N)/K - H \qquad [2]$$

where:

ΔN = Change in number
Δt = Change in time
r = The "per head" maximum potential growth rate (the intrinsic rate of population increase)
N = Number of individuals in a population
K = Maximum number of individuals the environment can sustain (carrying capacity)
H = The number of individuals being removed from the population (harvesting rate) continuously (Milner-Gulland & Mace 1998).

The Logistic function gives the number of individuals added to the population in time *t*. The population size at any point can be calculated as long as r, K, and initial N are known. The population can approach the asymptote (Figure 4) smoothly, approach it in an oscillatory manner, cycle indefinitely, or fluctuate chaotically depending on the value of *r* (May & Oster 1976).

With logistic growth, the maximum growth rate occurs when the population size is half the carrying capacity. A Maximum Sustainable Yield (MSY) is attained by maintaining the population level at K/2 and harvesting the annual production. At that point the rate ΔN/Δt is largest. At any population size below K, the population is producing a surplus yield that is available for harvesting without reducing the popula-

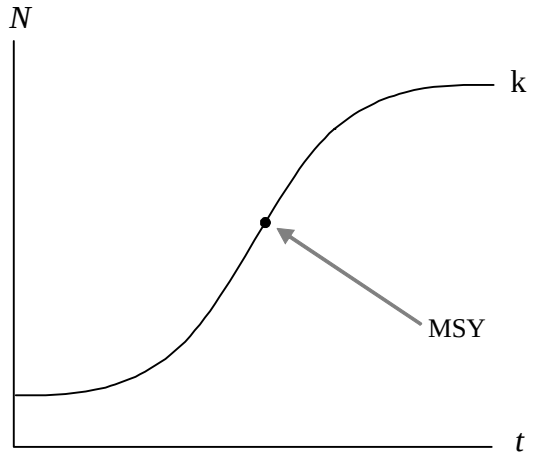

Figure 4 Sigmoid curve of the logistic equation showing the point of Maximum Sustainable Yield.

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tion size because the population returns to equilibrium after a perturbation. However, the logistic growth of a population assumes the following conditions that are not totally realistic: the rate of increase responds immediately to changes in population density, harvest is spread equally throughout the whole population, and the population age and sex structure is stable.

Therefore a general approach is applied in which regulations are set, and then modifications are done according to their effect in the population. The regulations (on harvests/ hunting) can be quotas (or bag limits), season limits, limits on age/sex, restrictions on hunting methods, restriction on areas.

Summary

Options for PNG search of food reliance with sustainability may well be located within the country; unnoticed, unexplored and even undermined. Trials on bandicoot farming even if 'unsuccessful' will render much needed information on the specie; likewise, continuous censuses by capture-recapture method will allow the estimation of total numbers, carrying capacity of the area, immigration, emigration, and rates of increase, natality and mortality; on which continuous harvests can be regulated without risk of depletion. The proposed conservation of these species will also contribute to the conservation of forest lands, improve rural livelihoods and diminish the country dependence on imported processed sources of protein.

Recommendations

Administration related recommendations derived from the paper are the pursuit of cooperative arrangements with international conservation bodies; review and/or increase the number of natural protected areas in the country which currently constitutes only the 2.3% of the country's total area; and integrate wildlife management in (mandatory) forest management and carbon trade plans, including conservation education, an agreed system of law enforcement, and intensive monitoring programs. Research related ones are to identify populations of high conservation priority ("keystone species", "ecosystem engineers" and of "community importance value"); assess population sizes, distribution, ecological requirements and the relative impacts of threatening processes; and collect data on bush meat and animal products at local level government, provincial, and national levels to better understand its role in the country's economy (important part of the informal sector's "hidden economy"), food security and local livelihoods. Regarding traditional practices it is advisable to restrict slash and burn practices for only agricultural fallowing, persuade landowners on the risks of bush burning as a hunting practice, regulate minimum sizes and sex of prey, and restrict the number of domestic dogs and cats to the minimum necessary.

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