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Final Report: A biodiversity risk assessment and recommendations for risk management of Long-tailed Macaques (*Macaca fascicularis*) in New Guinea

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1. Executive Summary

The Indo-Pacific Conservation Alliance (IPCA) in collaboration with Cenderawasih University (UNCEN) carried out an extensive literature review and field study of *Macaca fascicularis* (Long-tailed Macaque or Crab-eating Macaque) populations which were introduced into Papua (Irian Jaya), Indonesia in the recent past. On the basis of known behaviours of this species, many in the biodiversity conservation community in the province understood these animals to be an invasive pest and thus a potentially serious threat to the native flora and fauna of the island of New Guinea[1].

The research was led by Mr. Neville Kemp, M.Sc. Field studies began in the Jayapura area in late September 2002, continuing through the end of June 2003. This report includes the results of our extensive literature review on the known characteristics and behaviours of *M. fascicularis* in its native range (including ecological and feeding preferences, social behaviour, predation on and competition with other species, and diseases) and on the status of *M. fascicularis* as an exotic invasive species in Mauritius, Palau, and Hong Kong.

The main section of this paper describes the distribution and characteristics of macaques in Papua based on our distribution and population assessment surveys and community interviews. We carried out a monitoring study to determine various factors (ex. population dynamics, feeding preferences, etc.) pertaining to Papua macaques' ecological impact. We also conducted a plot-based comparative study in which paired sites of both primary and secondary forests, with and without *M. fascicularis*, were censused to assess how macaques impact the native flora and fauna. We examine economic data to provide a rough estimation of macaques' negative impact on rural livelihoods, and discuss public health concerns posed by macaques.

In the last section of the paper, we evaluate options to manage, reduce, or eliminate the risks associated with macaques in New Guinea. This includes a detailed appraisal of the advantages and disadvantages of three strategies: containment, control, and eradication, and what will be required to carry them out.

The main conclusions of this study follow.

1.1. *Macaca fascicularis* as an alien and potentially invasive species in New Guinea

Since the island of New Guinea is far outside the native range of *Macaca fascicularis*, Papua macaques are by definition an *exotic* or *alien* species. Because their populations and/or ranges in Papua are not expanding rapidly at present (due to limiting factors including current lack of access to unfragmented forest habitat), they are, strictly speaking, not yet an *invasive* species in Papua. We conclude, however, that given suitable conditions, macaques have a very high potential to become invasive (i.e., colonize new forest areas and rapidly expand their populations) in New Guinea.

[1] The term New Guinea refers to the entire island as a biogeographic entity. Our use of the name Papua refers solely to the western half of the island (i.e. "Irian Jaya"), a province of Indonesia. This understandably causes some confusion with the eastern half of the island, the independent state of Papua New Guinea (PNG), particularly since the southern half of what is now PNG was referred to as "Papua" in colonial times. However, Gelpke (1993; discussed in Pickell, 2002) concludes that the most plausible etymology of the term Papua is that it arose from a Biak islander phrase to refer to what are now the Raja Ampat islands in the far western reaches of the island. The term "Papua" would thus seem to originally apply to the western half of the island, i.e. Papua / Irian Jaya.

Macaca fascicularis is an alien or exotic species in at least four locations: Mauritius (Sussman and Tattersall, 1986), Angaur, Palau (Poirier and Smith, 1974), Hong Kong (Walker, 2002) and Papua. The species has become invasive in at least two of these locations, Mauritius and Angaur (Cheke, 1987; Anon, 2002), both of which are tropical islands. Angaur is located relatively near to New Guinea and shares many ecological and climatic characteristics with the island; this similarity of habitat and climate is an important criterion in predicting the potential invasiveness of a species (Wittenberg and Cock, 2001).

There are several other criteria that can help predict the potential invasiveness of *M. fascicularis* in Papua, and which are of consideration in assessing the risk management of the species. Low (1999) suggests there are four main factors that cause an alien species to become invasive. These are: (1) the species is an ecological generalist that can adapt to new conditions and/or habitat; (2) there are previously vacant ecological niches in the new habitat; (3) the alien species is not threatened by predators or diseases that control populations in their native range; and (4) the species is favorably adapted to or shows a preference for disturbed habitat. In the case of *Macaca fascicularis* and New Guinea, all these factors are operative:

- *Macaca fascicularis* can adapt to a wide variety of habitat types including coastal habitat, swamp forest, lowland rainforest, to montane forest and ranging from sea-level to at least 1,800 meters above sea level (Wheatley, 2001). All of the habitats reported to support *M. fascicularis* from their native range are present throughout lowland New Guinea. There are also many common floristic elements common to both western Indonesia/mainland Southeast Asia and New Guinea (as the easternmost part of Malesia). In terms of availability of suitable habitat, therefore, *M. fascicularis* can thrive throughout almost all of lowland northern New Guinea. Given its agility and ability to access higher elevations, it is possible that the species could disperse across the central mountains into southern New Guinea as well.

- Although its diet consists mainly of fruit, *M. fascicularis* is an opportunistic omnivore (Poirier and Smith, 1974), exploiting a very wide variety of foods. The species has been shown to take vertebrates on an opportunistic basis (Nowak, 1995), and is suspected of consuming several rare species of lizard on Mauritius (Richard Gibson, *pers comm*.). It is also a known nest predator, taking bird eggs and possibly adult birds as well (Carter and Bright, 2002, Richard Gibson, 2002; Anon, 2001a). Unlike New Guinea's native mammal fauna, *M. fascicularis* has manipulable hands (i.e. opposable thumbs), which allows it to open fruit casings and nuts and thus exploit a great range of food items. As such, macaques are a strong competitor with native species for food resources. This generalist behaviour is extremely advantageous to a species when colonizing new areas (either within their home range, or in new habitat), as they are not limited by specific food requirements. Generalism is a form of ecological superiority and also allows the species to occupy previously vacant niches, thus increasing *M. fascicularis'* invasive potential.

- In its native range, *M. fascicularis* has a number of predators and competitors that control their population (Hoogerwerf, 1970; Wheatley, 1996; MacKinnon *et al.*, 1996). These predators and competitors are absent in New Guinea, except for hunting dogs and (perhaps) large snakes of the family Boidae (boas). The absence of such predators/competitors presents an ecological opportunity that may allow a higher potential reproduction rate and increase the invasive potential of *M. fascicularis*.

- *Macaca fascicularis* shows a particular preference for secondary habitats disturbed by human activity (Wheatley, 1999; Anon, 200a; Bonadio, no date), though it can thrive in primary forest as well. The ever-increasing degree of anthropogenic disturbance within and around remaining tracts of primary forest is increasing the range of potential habitat for *M. fascicularis* in both its native range and in Papua.

On the basis of these criteria, *M. fascicularis* is thus potentially an invasive species in New Guinea.

1.2. The status of macaques in Papua

Populations of introduced *Macaca fascicularis* in Papua are currently limited to a relatively small area in the immediate Jayapura/Kotaraja area in far the northwestern part of the province. There are approximately 60 individual macaques, in six different troops, all more or less in the same general vicinity south of Jayapura city. Information received at the very end of this field study indicated that there may be an additional troop near Entrop that we did not directly document, but if so, their proximity to Jayapura as well as the general habitat are not significantly different from the other troops.

Based on repeated community interviews and direct observation studies, we conclude that no macaque populations are present outside the Jayapura area. We found no evidence that macaques have spread into Papua New Guinea, the highlands of Papua, or the Bird's Head region of Papua.[2] There are, however, reliable reports of individual pet macaques being kept in Manokwari, Wasior[3], and possibly other major towns and cities in Papua. As these animals seem to be all or mainly individuals kept in cages, this probably does not represent a major risk of immediate spread – at least not as great a threat as the wild-roaming populations – but it is alarming nonetheless, given the potential for accidental release/escape of a pregnant female etc. This phenomenon needs to be addressed through environmental education as part of a comprehensive macaque control strategy in Papua.

Macaca fascicularis has adapted to several types of lowland habitat in Papua. The original groups of macaques were found in the sago-dominated swamps of Kotaraja. Little of this habitat now remains due to urban development, although one group is still found there. Other troops are found in degraded secondary forest planted with fruit trees, selectively logged forest (tall secondary forest) and some areas of primary forest. *Macaca fascicularis* are also adapted to living near busy roads, near human habitation, and are commonly seen traveling through *alang-alang* (i.e. anthropogenic *Imperata* grassland) close to their home range forest. Since more and more areas of forest are managed for logging or converted to agriculture in Papua, and because *M. fascicularis* prefers disturbed habitats, these factors will clearly increase their invasive potential in the future.

The diet of *M. fascicularis* in Papua is consistent with those in their native range and other colonized habitats. We documented that their diet consists largely of fruit, especially figs (*Ficus* spp.) and those of planted fruit trees; leaves / young shoots, especially *Intsia bijuga* and *Pandanus* spp.; flowers; roots (cassava), bark (several spp. of liana, *Aglaia and Pometia pinnata*); sago pith

[2] A single macaque individual was sighted by a local hunter along the Tami River area (i.e. outside the Kotaraja area between Jayapura and PNG). We conclude that this was probably an escaped pet and thus presents no danger in itself in terms of spread. The possibility of escape of additional males/female pairs or a gravid female is, however, unacceptably high.

[3] May no longer be extant in Wasior.

(when available after processing by humans; and invertebrates (grasshoppers, sago grubs). Importantly, most of the species used as food sources are widespread throughout lowland forest in Papua. It is therefore highly probable that *M. fascicularis* can easily survive in other areas of New Guinea outside its present range.

We were not able to confirm through direct observation that macaques in Papua are nest predators, but since they are documented as such in Mauritius and also based on other evidence we collected, it is reasonable to infer that they probably engage in this behaviour in Papua.

Macaca fascicularis troops in Papua frequently raid crops, taking a variety of vegetables and fruits (cassava, maize, beans, peanut, papaya, bananas, sweet potato, mango, young coconut, pineapple, breadfruit and jackfruit). The people of Papua traditionally plant a variety of fruit and vegetables in gardens, and plantation fruit trees in secondary forest. The main agricultural system used is swidden, with gardens located on the forest edge. This anthropogenic disturbance of native ecosystems will create new potential food sources as well as a suitable habitat to facilitate the possible future expansion of *M. fascicularis* within Papua and PNG.

1.3. Impacts of *Macaca fascicularis* on ecology, health, and rural livelihoods in Papua

We carried out field plot studies in areas of primary and secondary forest, both with and without *M. fascicularis*, to census native fauna and test for discernable impact of macaques on these taxa. Bird, small reptile, and large mammal fauna all have lower diversities and numbers in areas that support *M. fascicularis* when compared to similar habitats that do not support *M. fascicularis*. **Based on statistically significant survey results, there is thus strong evidence that *M. fascicularis* disturbs and/or displaces native Papuan species.** For this reason alone, macaque populations in Papua should be managed to reduce or eliminate this risk.

We document that *M. fascicularis* causes significant economic damage to poor rural farmers in Papua through crop-raiding. If the range and population of *M. fascicularis* increases, this species will cause far more widespread and serious losses to the regional economy.

Macaques carry many diseases and parasites, such as rabies, B-virus, and others. We attempted to test macaque populations in Papua for a number of diseases that are potentially fatal to humans, but because there are inadequate testing facilities in Indonesia, and our inability to obtain export permits for blood specimens, this was not completed. Nonetheless, it is estimated that B-virus (*Herpesvirus simiae*), is carried by about 75 to 90% of all of wild macaques. The pathogen is fairly benign in macaques but is fatal in about 80% of human cases. We were able to test Papuan macaques for rabies, and the results were negative.

The Indonesian Department for Animal Quarantine (DAQ; part of the Ministry of Agriculture) specifically targets *M. fascicularis* and other species of primates as potential carriers of rabies. When macaques arrive in the province and are detected, the DAQ either sends back or destroys the animal. It is clear that DAQ's efforts are seriously limited by lack of capacity and funding, and so macaques almost certainly do enter Papua undetected from time to time.

There is a small potential economic benefit of *M. fascicularis*, primarily the sale of live animals to the pharmaceutical industry and capture of infants for sale as pets. Ethical considerations aside, the economic gains are sporadic and disproportionate compared to the potential losses to rural New Guinea (loss of agricultural harvests, potential spread of disease), which may potentially affect a large proportion of Papuans if *M. fascicularis* becomes invasive in the future. If Papua

macaques carry B-virus or other diseases, their commercial value will be reduced since virus-free populations are abundantly available from other sources.

Other economic benefits that have been suggested include tourism attractions such as a safari park. Traditional zoos with animals confined in cages would attract criticism from animal welfare groups and have comparatively little appeal compared to semi-wild animals. In addition, insofar as safari parks need substantial sources of revenue to start up, and especially considering the current dearth of tourists in Papua, this is not thought to be a serious option.

1.4. Summary conclusions

Current macaque populations consist of six separate troops and inhabit primary and secondary forest "islands" that are currently isolated from the vast forest hinterland of northern New Guinea. Therefore, absent deliberate human intervention, the danger that they will escape into forest hinterland appears unlikely but not impossible in the short-term. Although their forest island habitat does not necessarily prevent their colonization of new areas – since macaques can and do travel through surrounding grassland and agricultural areas – current low population densities and ample food supplies appear to mitigate against this possibility for immediate future. However, if the situation is left unaddressed, it is likely that macaques will eventually expand their range in New Guinea.

Since the ecological consequences of an escape and expansion of the species into the forest hinterland would be potentially catastrophic for native species, because an accidental release or escape is always a danger, and because the risk of population expansion / new colonization increases with the passage of time, we strongly recommend that a concerted containment program and community awareness effort become an immediate priority. This must involve an expanded dialogue process among conservation organizations, local communities, government agencies, landowners, and other stakeholders to reach consensus on the particular strategy for a full and effective population control programme in the very near-term. It will also be essential to work closely with government agencies such as DAQ to help enhance their institutional capacity to monitor and prevent future (re)introductions of macaques and other potentially invasive alien species.

In summary, based on evidence gathered by IPCA and UNCEN in field surveys and literature review, ***Macaca fascicularis* has a negative impact on native New Guinea species and ecosystems. Unless steps are taken in the very near future, *Macaca fascicularis* populations in Papua are highly likely to become invasive in the future. If this occurs, there is a high likelihood of several significant negative impacts on the environment and rural economy, as well as potential hazards to public health. Given the probable consequences of macaques becoming invasive, immediate implementation of a risk management strategy and program to mitigate the above mentioned threats is therefore of the highest priority.**

2. Introduction

The island of New Guinea, composed of the Indonesian province of Papua (formerly Irian Jaya) and the independent nation of Papua New Guinea (PNG), is the largest tropical island in the world and supports approximately 5 – 7% of the planet's terrestrial biodiversity. New Guinea also contains a high degree of endemic (i.e., found nowhere else) and restricted range species. Monkeys do not naturally occur on New Guinea, therefore the island's unique ecosystems and species have evolved in the absence of competition and predation from nonhuman primates. It is thought that this lack of competitive stress from primates is a significant factor that allowed many native New Guinea species such as tree kangaroos and cuscus to fill the ecological niches occupied by monkeys elsewhere, and also why many of New Guinea's birds were able to evolve into so many different and spectacular species.

Since New Guinea's species and ecosystems evolved in the absence of non-human primates, and because *Macaca fascicularis* is known to exhibit highly adaptive behaviours, there was *prima facie* scientific evidence to support the hypothesis that Papua macaques pose a potentially serious threat to the island's native species through competition for food resources and direct predation. It was also known that macaques, as carriers of B-virus (*Herpesvirus simiae*), also pose a potential human health risk, and that the species is an agricultural pest that inflicts serious economic losses on poor rural communities. Because of these considerations, a thorough scientific study was needed to determine the likely impact of macaques on native species and human welfare, and to propose concrete strategies for the control of macaque populations.

Sometime in the recent past, *Macaca fascicularis*, also known as the Long-tailed Macaque or Crab-eating Macaque, was accidentally or deliberately introduced into Papua. The native range of *M. fascicularis* includes mainland Southeast Asia, the Philippines, through western Indonesia, to Timor and Kalimantan. Within this range, they are considered one of the most numerous monkey species on the planet. Populations of *M. fascicularis* in their home ranges are robust and stable, and they are well adapted to a wide variety of habitats and food resources. *Macaca fascicularis* has become an invasive species outside of its natural range on at least two islands, Mauritius and Angaur, Palau. As the native species there have not adapted to compete for food[4] and shelter resources with or avoid predation from nonhuman primates, this renders them vulnerable to pressure from the macaques. In the case of Mauritius, macaques (as well as a number of other introduced and invasive mammal species) are believed to have caused or directly contributed to the extinction of many native and endemic species, notably including the dodo. They are also thought to have been a factor in the long-term alteration of Mauritian habitats (Mungroo and Tezoo, 1999).

In its home range, *Macaca fascicularis* has a very widespread geographical distribution and is considered one of the most numerous non-human primate species (Wheatley, 1999). It is not rare or endangered in its native range because of its abundance and very large geographic range. The species is currently listed under CITES Appendix II which allows regulated commercial trading and export of animals (UNEP-WCMC, 2003); and as "Lower Risk - Near Threatened" in the IUCN Red

[4] Unlike any native New Guinea species (or those on Mauritius or Palau), *M. fascicularis* is a manipulative frugivore (i.e. has opposable thumbs and can open fruit casings, seeds, etc.) and hence can outcompete native species for food items. It is also a documented nest predator (i.e. eats bird nestlings and bird eggs) and opportunistic omnivore.

List (IUCN, 2002), which indicates that the species is not threatened with extinction in the medium- to long-term.[5]

From a global perspective, invasive exotic species are increasingly recognized as major long-term threats to biological diversity where they occur. There is an increasing interest and effort being spent on mitigating negative impacts that invasive alien species are causing or have the potential to cause, as well as in preventing additional exotic species from becoming inadvertently introduced or established. The presence of macaques in New Guinea has raised much concern in the conservation community (Baskin, 2002; Mapes, 2001). It is generally believed by many conservationists and conservation non-governmental organizations (NGOs), as well as the governments of PNG and Indonesia, that extant populations of *Macaca fascicularis*) may become invasive and thus pose a threat to the island's ecosystems and native and endemic species. On the other hand, some animal rights groups have voiced concern for the welfare of the macaque, suggesting that either the animals should be trapped and relocated abroad, or asserting that the threats and risks posed by them are not significant and that New Guinea ecosystems and species will be able to adapt to the recent arrival of *Macaca fascicularis*.

The stated aim of this project was to clarify the present situation with regards to macaques in New Guinea, specifically in Papua province, to provide objective data on the impacts of *M. fascicularis* on native ecosystems and species, and to assess strategies to prevent or mitigate their presumptive negative impact on New Guinea biodiversity, local economies, and human health.

Section 7 is a literature review describing the known characteristics and behaviours of *M. fascicularis* in its native range, including ecological and feeding preferences, social behaviour, predation on and competition with other species, and diseases.

A literature review on the status of *M. fascicularis* as an exotic invasive species in three locations, the island of Mauritius in the Indian Ocean, Angaur, Palau in Micronesia, and Hong Kong on the Asian mainland is presented in Section 8. In all these sites, *M. fascicularis* is regarded as a pest species, and its populations are subject to control or eradication measures. These case studies are instructive in understanding how macaques in New Guinea are likely to affect native animals and vegetation in New Guinea, as well as local rural economies and health.

Section 9 describes the distribution and characteristics of macaques in Papua based on our field data. This section includes an evaluation of the historical evidence for the mode and vector of introduction of *M. fascicularis* to the Jayapura area, and presentation of IPCA/UNCEN's Distribution and Population Assessment Surveys methods and results, including population status in Papua.

In Section 10 we present the results of our monitoring study to determine the exact home ranges and population status of all known Papuan macaque troops, including sex ratios and age composition, food and habitat preferences, and other factors pertaining to the species' ecological impact in New Guinea.

Our ecological impact study is presented in Section 11. This assesses the ecological, human health, and economic impact (real and potential) of *M. fascicularis* in New Guinea and includes the

[5] IUCN categories are (in order of highest protection status to least): Critically Endangered; Endangered; Vulnerable; Lower Risk – Conservation Dependent; Lower Risk – Near Threatened; Lower Risk – Least Concern.

results of our rigorous plot-based comparative study in which paired sites of both primary and secondary forests, with and without *M. fascicularis*, were censused to assess how macaques impact the native birds, reptiles, and large mammals/reptiles. We also examine economic data to evaluate the macaques' negative impact on rural livelihoods, and conclude with a discussion of public health concerns posed by the presence of macaques in proximity with humans.

Section 12 discusses detection, prevention, and quarantine issues in Papua and PNG, including what steps are needed at the institutional capacity and policy levels to help prevent future introductions of alien invasive species. Efforts to enhance the institutional capacity of local government organizations to prevent or intercept future introductions of exotic species to Papua (not only *M. fascicularis*) are urgently needed, and should be carried out in parallel with an environmental education effort with communities and policymakers to enhance local understanding of the importance of the endeavor.

Section 13 describes our baiting and trapping trials to illustrate the methods that would be required in the risk management strategies discussed in Section 15.

Section 14 describes the conclusions of a two-day seminar conducted by IPCA and UNCEN in 2003 with various stakeholders to socialize the interim results of this study, including which approaches with government, NGOs, local communities, and other stakeholders are likely to have the greatest effectiveness in any future program to control macaque populations in Papua.

Section 15 presents the options available to manage, reduce, or eliminate the risks associated with macaques in New Guinea. This includes a detailed appraisal of the advantages and disadvantages inherent in the available strategies to manage risk – containment, control, and eradication.

In Section 16, we conclude with a series of priorities that are indicated by this study. This includes the over-arching need to reach consensus among all stakeholders on whichever strategy is ultimately deployed. Without this consensus first being established, any strategy to manage risk will not succeed.

3. Project Justification

Until the present survey, no risk assessment or detailed study on the macaques of New Guinea had been carried out, even though their presence and status as an alien and potentially invasive species has been known for at least a decade. Because there has been an almost total lack of scientific documentation about this macaque population in New Guinea, as well as a general dearth of data on the ecological requirements of most native New Guinea species, potential threats posed by *M. fascicularis* to native species and habitats have hitherto been largely speculative. This survey, carried out by IPCA and UNCEN, was designed to remedy the gap in knowledge and to assess the true risks to native flora and fauna; to local rural economies; and to evaluate and prioritize risk management strategies for exotic macaques in New Guinea.

4. Project Objectives

The objectives of this research project were to:

- Assess the abundance and distribution of the exotic species, *Macaca fascicularis* within New Guinea (Papua and Papua New Guinea).
- Assess the impacts (positive and negative; measured and potential) of *Macaca fascicularis* on New Guinea native habitats and species.
- Assess the impacts of *Macaca fascicularis* on the local rural economy and to the health of local human communities.

As a long-term goal for risk management of macaques in New Guinea, this study aimed to take critical first steps to build support for:

- Mitigation of any potential negative impacts on native habitats and diversity, and thus contribute to the preservation of New Guinea's unique ecosystems.
- Mitigation of any negative impacts on the Indonesian economy (especially the rural economy of local people).

5. Project Implementation

The project was carried out from 1 September 2002 to 30 July 2003 under the auspices of Indo-Pacific Conservation Alliance (IPCA) in close cooperation with Universitas Cenderawasih in Jayapura, Papua. Neville Kemp was the Principal Investigator for the project, and assisted by Mr. Pieter Torobi. John Burke Burnett provided project support, conducted literature research, and co-authored this report.

6. Terminology

The specific terminology used in this report concerning distribution, status, and characteristics of species is described in Appendix 1.

7. Literature Review: Characteristics and Behaviours of *Macaca fascicularis*

In carrying out a risk assessment of a species that has already become established outside its natural range, it is essential to first understand the characteristic traits of that species (Wittenburg and Cock, 2001). Given the inherent limitation on field observations that could be carried out in the relatively few months of fieldwork for this project, IPCA carried out a thorough review of the existing literature in order to gain insight as to the nature of *Macaca fascicularis*, both within its native range in Southeast Asia, and as an exotic. Information concerning the habitat preference, feeding behaviour, social behaviour, predation from other species and diseases has been compiled from the literature.

IPCA compiled and reviewed a large percentage of all references concerning *Macaca fascicularis* as an exotic species (in Mauritius, Angaur-Palau, and Hong Kong). Wittenburg and Cock (2001) state in their *IUCN Invasive Alien Species Toolkit* that one of the most reliable *prima fascie* indicators of whether or not a species will become invasive in a particular area is whether or not it has become invasive in other locations, especially those with similar climates, geography and habitats (Wittenberg and Cock, 2001). This information can be used to predict the rate and extent of potential spread of a species (habitat preferences), potential impacts (competition through feeding preference, group/population size and density) and potential natural controls on population (disease, predators and competition from other organisms).

7.1. Distribution and habitat preference

M. fascicularis has been described as one of the world's most numerous and widespread nonhuman primates (Wheatley, 1999), second only to the Rhesus macaque species *M. mullata* of southern to eastern Asia. The natural range of *M. fascicularis* extends from mainland Southeast Asia (including southern Burma, southern and eastern Thailand, Cambodia, southern Laos and Vietnam, and Malaysia), through the islands of the Philippines, into western Indonesia (Figure 1). The islands of Sumatra, Borneo, Java, Bali, and eastern Lesser Sunda Islands (Nusa Tenggara) form its natural range within Indonesia (Poirier and Smith, 1974; Supriatna *et al.*, 1996; Wheatley *et al.,* 1996; Wheatley, 1999).



Figure 1: Native range (in red) of *Macaca fascicularis*.

Some biologists speculate that *M. fascicularis* is truly native only to the islands west of Wallace's Line (the imaginary line dividing the bio-regions of Sundaland [Java, Borneo, Bali and Sumatra], and its arrival in Wallacea [Sulawesi, Moluccas, and the Lesser Sunda Islands] was human-mediated (Low, 2003). In this scenario, *M. fascicularis* may have been introduced to these island groups by humans as pets or food approximately 4,000 – 5,000 years ago. If so, this would roughly correspond to the same time agriculture was introduced to these islands (Wheatley, 1999). Whatever the time or manner of introduction, *M. fascicularis* has long been naturalised in these areas, and they were present before the first European records were made; thus all colonial-era researchers recorded them as natives to those islands.

Macaca fascicularis can survive in a diverse array of tropical habitats. Because of their robust adaptivity, the species has been described as "ecologically diverse". They are known to inhabit mangrove and nipa swamp, coastal forest, and riverine, secondary and primary forest. *Macaca fascicularis* is most successful in and shows a preference for disturbed habitats[6], including riverine forest (exhibiting a tendency for roosting in trees along rivers, a behaviour termed "riverine refuging"[7]; Van Schaik *et al.,* 1996), secondary forest and the forest periphery; and even urban settings (Wheatley, 1999; Anon, 2001a; Bonadio, no date). Wheatley *et al*. (1996) also suggests that the secondary growth caused by natural disturbance along river courses was the original inland native habitat for *M. fascicularis* before anthropogenic forest disturbance became a major factor. *Macaca fascicularis* is highly adaptive to new, dynamic, and often harsh environments. In Angaur they persisted despite intense bombing of their habitat during World War II, as well as several severe cyclones that subsequently depleted their food supplies (Wheatley *et al.*, 1999; Poirier and Smith, 1974).

[6] Unlike its close relative, *Macaca nemestrina*, which seems to prefer primary forest habitats.

[7] Wheatley (1996) suggests that riverine refuging may be related to several factors, including predator avoidance, the distribution and seasonal abundance of food, efficient foraging strategy, the predictability of congregating in a single location, and home range defence. Approaching predators can be more easily detected and avoided by macaques sleeping on the ends of tree branches, since they can jump into the water and swim to safety.

Macaca fascicularis occurs from sea-level to around 1,200 meters, though the species can possibly go much higher.[8] They are an extremely agile species, primarily arboreal, and can climb nearly vertical rock cliffs. Wheatley (2001) reported that while *M. fascicularis* tends not to go too high, they could go to at least 6000 feet (1828 metres). There are many mountain passes in New Guinea below 5000 feet; the species therefore has the potential to cross the central mountain range into the southern half of New Guinea island.

In a study of Sumatran *M. fascicularis*, Supriatna *et al.* (1996) found the highest population densities (up to 122 individual per square kilometer) occurred in secondary forests, selectively logged forest, and cultivated areas. Conversely, in the 4 sites of mixed hill (i.e. primary lowland) forest studied, *M. fascicularis* was present in low densities (approximately 4 individuals per km^2) at only one site. Swamp forest and mangrove supported high population densities as well, with 88 and 78 individuals per square kilometer respectively. In the secondary forests of Angaur Island, Wheatley (1999) found densities of 48 individuals per km^2, although levels as high as 108 individuals per km^2 were recorded before the onset of hunting in the years prior to that study.

Because leaves form a relatively small part of the diet of *M. fascicularis*, their home ranges are typically larger than strictly folivorous primate species (Bercovitch and Huffman, 1999), ranging between 50 and 100 hectares depending on the habitat, troop size and abundance of food sources (Crockett and Wilson, 1980).

7.2. Feeding preference

Macaca fascicularis is a diurnal species, periodically active from dawn to dusk. Typically they feed in early morning, rest / sleep in the middle of the day, and are active again in the afternoon. The species can be almost totally arboreal in some cases (Wheatley, 1980) or come regularly to the ground to feed in others (Fittinghoff and Lindburg, 1980). This variability of feeding behaviour is probably dependant on the availability of food in their home range, and preference at any given time of the year.

Approximately 60 to 90% of macaque dietary requirements are supplied by fruits, but they ingest a wide variety of other foods including leaves, bark, buds, flowers, seeds and insects (Bercovitch and Huffman,1999) and are more accurately termed “opportunistic omnivores” (Poirier and Smith, 1974). In Sarawak, eastern Malaysia, they have been recorded taking a wide array of animal material including insects, frog eggs, crabs and other coastal invertebrates (Anon, 2001a). According to a summation of published information about macaques in Nowak (1995), all macaque species will eat insects and other small invertebrates when they are available and occasionally take eggs and small vertebrates. *Macaca fascicularis* has also been recorded eating crabs, crustaceans, shellfish and other littoral animals exposed to the tide (Lekagul and McNeely, 1977). *Macaca fascicularis* is also known to ingest clay – probably for the trace phosphorus minerals that it contains (Bonadio, *no date*).

The proclivity of *M. fascicularis* (as well as many other macaque species) for taking bird eggs (and sometime nestlings) has resulted in their reputation as “nest predators” (Bright and

[8] *M. fascicularis* has been recorded up to 1300 metres above sea-level in Sarawak (Anon, 2001a).

Carter). For example, *Macaca nigra* has been recorded capturing and devouring a nesting parrot in Sulawesi (Sinclair, pers comm., 2002).

Macaca fascicularis also regularly raids agricultural plots stealing cassava, maize, beans and many other domesticated vegetables and fruits. Hence they are considered a major pest by many local communities. With the expansion of agricultural areas and human population, this particular behaviour of *M. fascicularis* may be responsible for the increase in the species' range (Wheatley *et al.*, 1996).

7.3. Social behaviour

Macaques are social animals that live in troops of between 6–100 individuals (Nowak, 1995), although Bercovitch and Huffman (1999) describe troops of between 20–50 animals as more typical of the species. In studies of exotic *M. fascicularis* on Angaur island, troop sizes averaged 40–50 individuals (Poirer and Smith, 1974). The macaque troop size is likely a function of the availability of food and pressure from predators, as well as susceptibility to disease (Bercovitch and Huffman, 1999). *Macaca fascicularis* generally has a larger troop size in disturbed habitats than pristine forest (Bonadio, *no date*; Sussman and Tattersall, 1986). This is attributed to greater abundance of food (seed, fruits etc.) in disturbed habitats, as well as a possible access to agricultural crops along the forest edge.

Macaque troops are multi-male, multi-female, having a dominant male (alpha male) and several dominant females, with the rest of the troop consisting of juvenile sub-groups. Females exhibit a matrineal hierarchy, with higher ranking female sub-groups gaining access to more food, defense protection from males, and having a higher fertility rate. There is much social interaction between female sub-groups, including grooming and the formation of intense kinship ties and alliances which is associated to matrineal relatedness (Bonadio, no date).

Unlike some species in the genus, *M. fascicularis* breeds and produces young throughout the year (polyoestrous; +/- 28 day menstrual cycle; naturally occurring menopause [Thorndike and Turner, 1998]), with individual females typically giving birth every one or two years. Dominant males concentrate their matings around the time of presumed oestrus (de Ruiter, 1994). The sexual ratios within troops are always female heavy, since sub-adult males are frequently driven out of the troop. Female to male ratios of between 2:1– 5.6:1 have been recorded (Poirier and Smith, 1974). Females become sexually productive at around 4 years and can live up to 25 years on average, although the maximum age of *M. fascicularis* in captivity reached 37 years (Jones, 1982).

7.4. Predation and competition from other species

Hoogerwerf (1970) confirmed predation of *M. fascicularis* (as well as two other species of monkey) by the presence of hairs in all faeces samples obtained from panthers (*Panthera pardus*) in Ujung Kulon National Park in Java. Wheatley's (1996) observation of mobbing of sun-bears by *M. fascicularis*, suggests that *M. fascicularis* is also habituated to predation by this species. Further, it is likely that predation by large carnivores and snakes (and possibly large raptors) has an effect in controlling macaque populations in its native range. Ridley (1906) noted that *M. fascicularis* tended to avoid sleeping in small bushy trees, speculating that this was to avoid being surprised by snakes at night.

Throughout its native range, *M. fascicularis* lives sympatrically with a number of other non-human primates. In west Malaysian rain forests, the home ranges of *M. fascicularis* typically may overlap with that of any two or three species of Sumatran langur, two species of apes (three in Northern Sumatra), and another species of macaque, *M. nemestrina*. Other studies, however, indicate that these species are more typically allopatric (MacKinnon *et al.*, 1996). This co-existence of various primate species undoubtedly creates competitive pressure for resources, which will in turn will limit the carrying capacity (or the maximum population size with a home range) of *M. fascicularis*.

7.5. Diseases

Within their native range in Indonesia, the Philippines and Malaysia, macaque individuals have been tested and documented to have a high positive response for many viral antibodies, indicating that diseases are highly prevalent within wild populations (Matsubayashi *et al*., 1992). These diseases, for which macaques may be either reservoirs or potential vectors to humans, may include B-virus (Cercopithecine herpesvirus 1 [CHV-1] or *Herpesvirus simiae*), rabies, Simian Varicella Virus, Cytomegalovirus, Rhesus Rhadinovirus, Ebola (Reston type – apparently non-pathogenic in humans), Hepatitus E, and other viruses (see Baskin, 1999).

We focus on B-virus since it is the most common and potentially pathogenic virus in wild populations of *Macaca fascicularis*. B-virus is carried by all species of macaques of the genus *Macaca*, and the estimated prevalence in individual adult wild macaques is 73–90% (Anon., 2003a; Ostrowski *et al*., 1998; Baskin, 1999).[9] Cohen (2002) states that "all macaque monkeys should be considered sero-positive for B-virus".

B-virus is generally benign in macaques, only causing vesicles and ulcers in the mouth and conjunctivitis (Baskin, 1999), yet all carriers can shed viruses and transmit the disease to humans and other primate species. The virus is transmitted within macaque populations through sexual activity and bites; thus mature animals are more likely than juveniles to harbour the virus (Ostrowski *et al*., 1998). The percentage of virus-carrying monkeys that are shedding virus at any given time is unknown; some individuals probably shed virus constantly, whilst in others it may be intermittent. It is impossible to visually determine if a macaque is infected (or shedding) or not.

In humans, B-virus is highly pathogenic[10], manifesting as a rapidly ascending encephalomyelitis that is fatal in about 55% to 80% of cases (Anon, 1995; Baskin, 1999; CDC, 2003a).[11] Humans who survive B-virus infection suffer permanent and irreversible brain damage (B Virus Working Group, 1987; Anon, 1995; Baskin, 1999; Brown, 1997). B-virus is a rare disease in humans and generally only those who work with macaques in laboratories or zoos are at high risk. However, this is simply a function of exposure – any humans that come into direct contact with wild macaques are potentially at risk. Laboratories working with wild-derived macaques have

[9] Populations of *Macaca fascicularis* at the "Monkey Forest" in Ubud, Bali were tested by the CDC and had an 81.6% sero-positive rate (Huff, 2003).
[10] The Center for Disease Control (Atlanta) categorizes B-Virus as a Biosafety Level 3 pathogen (CDC, 2003b).
[11] Initial symptoms (which can occur anywhere from 5 days to 10 years following exposure) are a flu-like illness. If not immediately treated, this is followed by the abrupt onset of severe central nervous system failure in which medical treatment is almost entirely ineffective. In fatal cases, the result is massive hemorrhaging of the brain stem and complete liquification of the spinal cord. Those that manage to survive the disease are typically left with severe brain and nervous system damage (CDC, 2003c).

rules that all individual animals are presumed to be shedding B-virus and handled accordingly; precautions must be taken at all times to avoid being bitten, scratched, or exposed to any ocular, oral, or genital secretions through cage scratches, mucosal splash, or needlestick injuries (Cohen, 2002). Pathology in humans, when it occurs, typically onsets 5 to 30 days following exposure; humans who are exposed must begin an immediate regimen of antiviral medication (acyclovir or valacyclovir [Anon, 1995; Cohen, 2002]).

Macaques are also potential carriers of rabies. All wild macaques from rabies-infected areas are assumed to be at risk. Papua is currently rabies-free, but Indonesian authorities are aware of the potential for macaques to act as a vector for the disease.

7.6. Positive aspects of *M. fascicularis*

Within their native home range in mainland Asia and western Indonesia, *M. fascicularis* has co-evolved with other species and is an integral part of the environment. Largely frugivorous, they are effective dispersers of seeds of both native plants and non-native weeds.

In terms of economic significance, *M. fascicularis* is an occasional food source for some indigenous forest dwelling peoples such as Dayaks in Kalimantan and other rural Indonesians (Mackie, *pers. comm*. 2003). We received no reports of Papuans using macaques as a food item.

Macaca fascicularis is also commonly used as a laboratory test animal in Western countries and thus has some monetary value. However, the availability of virus-free macaques bred in captivity (for example in Tinjil Island in Indonesia) has reduced the value of wild *M. fascicularis* trapped for the export trade. It should be noted that the revenues gained by these private companies are probably far less than the damage done to crops annually, not to mention unquantifiable negative impacts on biodiversity. Macaques in Papua are wild and located far from export centres, thus adding significantly to trapping and shipping costs.[12]

[12] IPCA is extremely dubious of any proposal for a biomedical macaque breeding operation in Papua. Ethical considerations about the use of monkeys as research animals aside, the possible presence of B-virus would pose a significant human health risk for workers and their families. It would also establish a commercial market value for macaques and thus provide a significant economic incentive to maintain or enhance macaque population levels in Papua. The actual economic, health, and biodiversity costs far outweigh any potential positive financial benefit of establishing commercial macaque farms for the pharmaceutical animal export trade.

8. Literature Review: Assessing *Macaca fascicularis* as an Exotic Invasive Species in Mauritius, Palau, and Hong Kong

By definition, *Macaca fascicularis* in Papua is an *exotic* (i.e. introduced or non-native) species. *Invasiveness*, on the other hand, is a term that indicates the degree to which a species has, or has the capacity to, spread widely and to thereby displace native species. Thus, determining whether or not Papua macaques are invasive was one of the goals of this study.

The degree of invasiveness cannot be reliably predicted in risk assessments of alien species. One factor has a consistently high correlation with invasiveness, however, namely whether or not the species in question has proven to be invasive elsewhere, especially where climate and habitat are similar to that of the location of the risk assessment (Simberloff, 1999).

While there is no substitute for the direct field study of the macaques in New Guinea itself, in assessing the risk of *Macaca fascicularis* becoming an invasive species in Papua, we also gained much insight from a comprehensive literature review of case studies, as well as by consulting with local experts in other areas where the species has been introduced.

Macaca fascicularis has been introduced to a number of locations by humans. At present, exotic *M. fascicularis* is only recorded in the wild from Mauritius, Angaur Island (Palau); and Hong Kong[13]. It is listed as one of world's worst 100 invasive species by the Invasive Species Specialist Group of the IUCN Species Survival Commission (Lowe *et al*. 2000).

8.1. Mauritius

Mauritius is a tropical island in the Indian Ocean located approximately 450 miles east of Madagascar. The total size of the island is approximately 2,040 km^2. As a result of anthropogenic conversion of 95% of its original forest habitat, augmented by numerous invasions of exotic weeds and vertebrates, many Mauritian species (including endemics) are now extinct. The island has lost 55% of its land birds (16 species in all), 11 species of which were endemic. It has also lost 8 species of reptile, all of which were endemic (Cheke, 1987). Many surviving endemic flora and fauna are still endangered and at risk of extinction. Of the 11 extant species of native Mauritian land-birds, 8 are endangered (all endemic to species or subspecies level) (Safford and Jones, 1998). In an attempt to save these species, conservation and ecological research organizations have expended much effort in understanding the causes behind species declines, ways to combat invasive species, and how to protect those native species that remain.

Macaca fascicularis was introduced to Mauritius 400 years ago, and because of its documented predatory behaviour has been widely recognized as a major contributing factor in many extinctions and in the continuing threat to endemic birds and vertebrates (Stafford, 1991; Jones,

[13] The closely related *Macaca mulatta* (Rhesus macaque) was introduced to Florida (USA) c. 1930, and there are now several separate populations of several hundred animals. They are noted to have "severely degraded the mangroves and other vegetation [at Racoon Key]…presumably to the detriment of nesting birds and…the endangered silver rice rat." (Layne, 1997).

1992; Carter, 2002). Quammen (1996) comments that Mauritian *Macaca fascicularis* are suspected to be a "much underestimated…contributing factor in the extinction of the dodo."[14]

The earliest recorded introduction of *M. fascicularis* outside of its native range was from Mauritius. The agents of macaque introduction(s) to the island were allegedly either Dutch (Cheke, 1987) or Portuguese sailors (Sussman and Tattersall, 1986) at the turn of the 16th century. The first definite record of *M. fascicularis* on Mauritius is a Dutch report dated 1606. Whomever brought the macaques is not relevant for the purposes of this study, but it is important for the fact that macaques have inhabited the island for approximately 400 years, and have long been regarded as a serious pest. Indeed, hordes of macaques raiding stocks and plantations have been the suggested cause for the abandonment of the Dutch colony in 1710 (Sussman and Tattersall, 1986).

As early as 1801, an observer on Mauritius, Mr. Grant, recognized that monkeys reduce bird numbers due to their great numbers predating bird eggs (cited in Cheke, 1997). Thompson also expressed concern in 1880 about macaques' damage to nests, eggs and seeds. Later, Gleadow in 1904 describes "whole forest aspects of the colony" being altered by macaques (*in* Sussman and Tattersall, 1986).

There is, however, some disagreement regarding the actual impact of *M. fascicularis* on the native Mauritian vertebrate fauna. Sussman and Tattersall (1986) state that the Mauritius macaques clearly prefer forest edge, degraded and secondary habitat to that of primary forest. They hypothesize that the rapid population increase of *M. fascicularis* and their rapid expansion into the forest interior *followed*, rather than *preceded*, forest disturbance and conversion to plantations brought about by the colonists during agricultural expansion. They also propose a hypothetical conclusion, namely, that whilst *M. fascicularis* is undoubtedly a nest predator and a destroyer of nests, they "doubt whether the monkeys ever played a predominating role in the extinctions of various indigenous bird species of Mauritius, or, more particularly, in reducing many that remain to near the point of extinction".[15]

In a later publication, however, Cheke (1987) presents anecdotal information from historical reports which show that the growth of monkey populations in Mauritius reached their peak ("of plague numbers, extreme damage") around the year 1700, only 100 years after their introduction. This is about 140 years before extensive native forest conversion to sugar cane plantations began. It remains unclear, however, whether in 1700 the "hordes" of macaques were distributed all over the island interior, thus directly contributing to the demise of endemic vertebrates, or were at high densities only around human settlements. As Cheke states, most of the island interior remained unexplored until later in that century.

[14] Quammen (1996), in a memorable turn of phase, notes that "*Macaca fascicularis* is capable of spreading…like a tribe of Visigoths".

[15] They comment further that "it…appears unlikely…that the allocation of scarce resources to control the monkey population of Mauritius would contribute substantially to conservation of what remains of the island's indigenous flora and fauna." (Sussman and Tattersall, 1986). To be sure, this is not exoneration of macaques' role in depredating native fauna. Rather, Sussman and Tattersall's observation is a cost-benefit statement, specific to a locale where *M. fascicularis* populations are already dense and widespread, of the relative benefits of a macaque control effort in mitigating losses versus other actions. In this latter respect, Mauritius is in a situation quite dissimilar to that of New Guinea today, where macaques are not yet widespread and where a control effort can be quite successful in eliminating negative impacts.

Cheke (1987) also suggests that monkeys are an "important additional burden on all the native birds", although there was, at that time, "little direct evidence" concerning persistent nest predation by macaques of three endangered bird species (*Falco punctatus* [Mauritius Kestrel], *Nesoenas mayeri* [Pink pigeon] and *Psittacule echo* [Echo parakeet]). Cheke points out that though endangered, these species remain extant and have thus coexisted with the macaques for 400 years. He does suggest, however, that macaques may have been responsible for the very rapid demise of the large parrot *Lophopsittacus mauritianus*, now extinct.

Since these studies were conducted in the 1980s, the role of *Macaca fascicularis* in egg and bird predation of endangered species has become clearer. Mungroo and Tezoo (1999) believe macaques to have been an important factor in the extinction of forest birds such as the Scops owl (*Scops commersoni*). Richard Gibson, Fauna Conservation Manager of the Mauritian Wildlife Fund describes macaques as a major pest, and states that the macaques' potential impact upon native birds, reptiles and amphibians is great. He has confirmed considerable predation damage to native birds, including eating of eggs and nestlings and "possibly the occasional adult bird… we regularly see pink pigeons with tail feathers missing – a sure sign of a monkey grab" (Richard Gibson, *pers. comm*.). This predatory behavior was also confirmed in Jones *et al.* (1992). Most recently, remote trigger cameras have provided definitive photographic documentation of macaque predation on bird nests (Carter and Bright, 2002). Richard Gibson also suspects opportunistic predation by macaques on endemic geckos (*Phelsuma* spp.), although there is as yet no direct evidence.

Bright and Carter (1999) state that in conjunction with habitat destruction, exotic mammals are responsible for the extinction of at least nine endemic species of Mauritian birds, and another six are currently under threat. Bright and Carter studied bird nest predation in an attempt to clarify which predators have the greatest impact on nesting success. In their use of baited surrogate nests they found that macaques and black rats (*Rattus rattus*) are the main predators of the Mauritius fody (*Foudia rubra*) nests; macaques thus dramatically affect survival rates of this species. Unlike Sussman and Tattersall (1986), they found that macaques are abundant in all forest types (including wet tropical forests), with the exception of exotic Japanese cedar plantations. Nest predation by macaques and rats was equally high in native forests, but macaque predation was lower in the plantations. There was a direct relationship between population density of macaques and levels of nest predation. Due to the macaque's lesser activity in cedar plantations, this habitat type can provide a refuge for some endemic Mauritius birds (Safford and Jones, 1998). Although black rats may represent a slightly greater threat to the fody than macaques, for local socio-religious reasons it is deemed undesirable to eradicate macaques on Mauritius (Bright and Carter, 1999).

Sussman and Tattersall estimated the macaque population on Mauritius to have been between 25,000–35,000 in their 1986 paper. The 2002 population of *M. fascicularis* on Mauritius is now estimated to be in the region of 60,000 (Gibson *pers. comm.*). This is a very high density for a small island, amounting to over 32 macaques per square kilometre (average for the entire island – including habitat unsuitable for macaques, developed areas, etc.)

A well documented additional impact of the high densities of macaques is the damage to Mauritius' rapidly vanishing native plants. As well as directly destroying native fruits, they are one of the primary dispersers of invasive plants fruits/seeds (Anon., no date; Richard Gibson, *pers. comm.*), and therefore a major factor in the overall modification of native Mauritian forest

environments. Mauritius has over 60 species of introduced noxious weeds (of the total ca. 1,700 species that have been introduced (MWF, 2002), so an additional mode of exotic seed dispersal by macaques is a significant cause for concern.

A symbiotic relationship between the Mauritius macaques and the exotic Strawberry Guava (*Psidium cattleianum*) is well documented by Cheke (1987) and Quammen (1996). *Psidium cattleianum*, spread by pigs and deer as well as macaques, has become extremely invasive in Mauritius. It forms homogenous stands in upland forests by outcompeting native flora and hindering its regeneration. The widespread nature and productivity of guava fruits has helped support high populations of macaques, which turn to native plants for their food supply outside of the guava fruiting season, thus imparting additional damage to native forest species (Cheke, 1987).

Macaques are also responsible for significant damage to sugar cane and other agricultural crops. They dig up sections of newly planted cane, eating the new shoots as well as ripe cane. Mauritius macaques are also attracted to cabbages, water melons, maize, potatoes, pumpkins, peppers, tomatoes and pineapples, sampling (and damaging) far more than is consumed. It is estimated that *M. fascicularis* creates economic losses of between US $1.5 – 3.0 million per year to farmers in Mauritius (Mungroo and Tezoo, 1999).

During the Workshop on the Restoration of Highly Degraded and Threatened Native Forests in Mauritius, held in September 1997, elimination of monkeys from forest habitats using a variety of methods was considered of the second highest priority – the first priority being elimination of pigs and deer (Wittenberg and Cock, 2001). No global approach to macaque control has been attempted in Mauritius, but problem populations are trapped from conservation forests and agricultural lands. The animals have become wary of these methods, trap shy, and difficult to control or manage (Mungroo and Tezoo, 1999). There is also a facility on Mauritius that breeds and exports *Macaca fascicularis* as pharmaceutical lab animals, though this is apparently unrelated to conservation-related control efforts (Anon, 2002b, Quammen, 1996).

8.2. Angaur, Palau

Located some 800 kilometers north of New Guinea, Angaur, also known as Ngeaur, is an isolated oceanic island in the Republic of Palau with a total terrestrial area of 8.4 km^2. Specific detailed information on the biodiversity of Angaur was not compiled for this report, but the Republic of Palau, as a whole supports some 1,000 endemic organisms, the majority of them terrestrial. These include about 200 endemic plants, (including 60 orchids), 300 terrestrial gastropods, 500 insects, 16 birds, 12 amphibians and reptiles, two freshwater fishes, and two species of bat (Anon, 2002). Angaur is noted for supporting the endangered IUCN listed *Megapodius laperouse senex*, an endemic bird subspecies from Palau.

The macaques of Angaur were apparently deliberately introduced during the German administration of the island (c. 1870 to 1914) (Poirier and Smith, 1974; Wheatley *et al*., 1999; Wheatley, 1999).[16] Japanese occupation began in 1914. Today, macaques are often caught and sold as pets to other islands in Palau, but to date apparently no wild macaque populations

[16] One study indicates that the population of macaques on Angaur could not have orginated from a single pair because of the relatively high degree of genetic variability among the population. This indicates that a continental area was the source of origin, and not the Philippines as some had previously suggested (Kawamoto, et. al. 1988.)

have yet established themselves in these other Palauan islands (Wheatley, 1999). Small oceanic islands such as Angaur – important centres of endemism – are prone to successful invasion from alien species that create ecological havoc. It is likely (though not yet reported) that the Angaur macaques prey on native birds, small vertebrates and eat / destroy native fruits.

The Office of Environmental Response and Coordination report (Anon, 2002) states that Palau hosts over 428 exotic species. According to a recent report by Space *et al. (2003),* Angaur is already host to at least 106 recorded alien plant species, 41 of which are described as of environmental concern. Many of these are included in the IUCN list of the World's 100 Worst Invasive Species (Lowe *et al*., 2000) and it is highly probable that some of these exotic plant species benefit from increased seed dispersal by the macaques. In an already-disturbed forest environment such as Angaur's (the result of heavy bombing in World War II), this would give invasive plants an additional competitive advantage over native flora and negatively affect native regeneration. Atkinson and Atkinson (2000) have noted that research on the role of exotic vertebrates in enhancing the spread of invasive plants on island ecosystems is urgently needed.

The role of macaques as crop raiders has been amply documented (Wheatley, 1999; Wheatley et al., 1999; Chalise, 2001; Hill, 1998). As opportunistic foragers, macaques feed not only on wild fruits, leaves, and animals but also take cultivated crops and fruits. Wheatley *et al.* (1999) notes that Angaur macaques are considered by local residents to be a major pest because of their garden raiding. The state government of Angaur describes the macaques as a "serious pest and a major threat to Angaur's agriculture…causing severe damage to Angaur's fruits and crops" (Anon, 2002). Antipathy among Angauran villagers towards macaques for damage to their crops has given rise to hunting of macaques by the local community, as well as an Angaur State Government-sponsored eradication programme established in June 2001. A report on this eradication effort notes that, "In this campaign over 500 monkeys were eliminated from the island. This has not completely solved the problem, so the question remains how to control this pest species in Palau" (Anon, 2002).

Because of the very small size of Angaur, the population of *M. fascicularis* on Angaur has been accurately estimated. Despite relatively little disturbance from humans from the time of their introduction to the early 1970s (Poirier and Smith, 1974), Farslow (*in* Wheatley *et al.,* 1999) reported that after only about 70 years on the island the macaque population had increased to 825–900 individuals in 1981. In the years that followed, macaque numbers declined due to an increase in hunting and capture. By 1994, the population was approximately 341–400 (Wheatley *et al.,* 1999; Wheatley, 1999). However, in the years that followed their numbers had increased again, resulting in the removal of over 500 individuals in the government's recent eradication programme. In summary, hunting and capture between the years of 1981 and 1994 clearly does appear to have been effective in depleting numbers of macaques. Equally impressive, however, was the macaque population's capacity for recovery, with an approximate 20% increase in only 7 years.

No ecological studies on the impact of *M. fascicularis* in Angaur have apparently been conducted. As of 2003, macaques presumably remain extant on Angaur, and it seems quite possible that they are having some discernable but as yet unquantified impact on the island's biodiversity, through predation/competition and/or enhanced seed dispersal of exotic plants.

8.3. Hong Kong

Macaca fascicularis (as well as *M. mulatta*) has been recorded as a pest in Kowloon, Hong Kong. Introduced during the 1950's or 1960's as escaped pets or released by a circus troop, the macaque populations have now grown to levels where they are disturbing visitors to local parks (Walker, 2002), including as Kam Shan, Lion Rock, Shing Mun Country Parks and Tai Po Kau Nature Reserve. Many of the problem populations are apparent *M. fascicularis* and *M. mulatta* hybrids. In 2002, the estimated total population was about 1,300 (Anon. 2003b), and some estimates put the annual population growth rate at 10% (Walker, 2002).

No information is available concerning the impacts of *M. fascicularis* on native environments in Hong Kong, which contains some of the last remnants of broadleaf coastal forests in southern China, as well as an endemic freshwater biota (Polhemus, pers comm., 2003). In 2002, the Hong Kong government, concerned with human health issues posed by macaques, began a trial population control program using Porcine Zona Pellucida, or PZP, immunovaccines that cause infertility in females (Anon, 2001b; Walker, 2002). It is unclear whether or not PZP immunovaccines are an effective contraceptive over the medium- to long-term, and the PZP-treated monkeys will be observed in the field for at least two years to determine efficacy. (Wong, 2002).

8.4. Positive impacts and uses of exotic *Macaca fascicularis*

In areas where *M. fascicularis* is an exotic species, no positive impacts to the environment (i.e., fulfilling an important ecological role that enhances native biodiversity) have been reported. In terms of biodiversity value, their role is instead quite clearly a negative one in their impact on native flora and fauna.

Economically, *Macaca fascicularis* does have commercial value. Mauritian *M. fascicularis* are trapped and sold to the pharmaceutical industry (Anon. 2002; Quammen 1996). Quammen (1996) reports that the retail value of wild *M. fascicularis* from Mauritius in U.S. biomedical research laboratories is approximately $1500 per individual. Matsubayashi *et al.* (1992) reports that Mauritian macaques are particularly clean with respect to viruses, and therefore may be of particular value as experimental animals in the assay of virus vaccines. Two companies presently operate in Mauritius trapping macaques from sensitive conservation forest areas and places where they have become a nuisance to agriculture (Mungroo and Tezoo, 1999).

Wheatley *et al*. (1999) reports that *M. fascicularis* from Angaur are often hunted and sold as pets. Hunters prefer to shoot mothers and sell the surviving infant for up to US$100. This provides an important source of income for hunters on an island where there are few opportunities for employment.

In Hong Kong, the macaques have become an attraction for visitors to parks, even though they have to put up with occasional harassment from aggressive animals. Macaques are considered of recreational value in Hong Kong, an area with high population and little wildlife (Anon, 1998).

9. The Distribution and Characteristics of *Macaca fascicularis* in Papua

9.1. Previous reports on Papua macaques

Prior to this study, all published information on the known and presumed distribution of Papua macaques was either compiled from secondary sources or based on anecdotal evidence. Few of these reports were publicly available but include:

- A report prepared by CI-PNG (Wilmot & Kamalasa, Ltd., 2001).
- An M.A. dissertation of Maria Mote, a student at UNCEN (Mote, 1999).
- A WWF-Sahul web-based report based on Mote's paper.
- A WWF-Sahul project proposal (Rindo-Rindo, 1999) which incorporates a map with (presumed) macaque localities in the Jayapura and border areas.
- Phil Shearman's report to TNC on invasive species in the Asia-Pacific region.

In 2000, WWF-Sahul staff led by Yopie Muskita carried out a field survey in the areas of Arso, Skoh, Wutung, and Holtekam (i.e. areas south of Abepura and towards the PNG border area) to determine macaque locations (Torobi *pers comm.*, 2002). Apparently no macaques other than captive pets were found in these areas; no written report for this activity was produced.

IPCA collected written reports as well as hearsay records and information passed on by informants through interviews with the staff at WWF, CI, BKSDA (Nature Conservation, Dept. of Forestry), BAPEDALDA (Environmental Impact Agency), and local NGOs that were members of the former Observers of Exotic Species in Irian Jaya Network (formed in 1997 after concern about exotic plant species, but which became dormant in 2000). Whenever possible, we tracked down and interviewed the initial informant. As an example, there was a hearsay report in 2000 of macaques in Mulia in the central highlands by Mr. Kornelius Oma, a reporter from Kompas newspaper. Mr. Oma claimed to have witnessed "hundreds" of individual macaques in the hills above Mulia. Though he published no articles on the subject, he passed on this information to Yopie Muskita at WWF, and this information subsequently spread anecdotally through the conservation community in Papua. IPCA traced this reporter, interviewed him, and made a site visit to Mulia to assess the report's accuracy.

9.2. Historical origins of *Macaca fascicularis* in Papua

The first unconfirmed report by a conservation organization of *Macaca fascicularis* in the Jayapura area was in the 1980s.[17] We posit that the earliest likely time for an introduction was with the arrival of the Dutch administration in the Hollandia (now Jayapura) area in 1910, but it is more likely to have occurred sometime between 1941 and the 1970s.

Several theories have been suggested for the origin of *Macaca fascicularis* in Papua and the vector for their introduction. These include:

- Japanese armed forces during World War II (c. 1942–1944).
- US and Allied forces during World War II (c. 1944–1946).

[17] Ronald Petocz, an American researcher who was the first WWF/IUCN Project Leader to open an office in Irian Jaya in 1980 writes: "I seem to remember going to Ormu in the Cyclops Mountains and the people there telling me that macaques were in the area. I can't remember the date as we did not deal with this in the Conservation Plan I did for [Irian Jaya]. Nevertheless this would have been before my departure from Irian in 1987" (Petocz, pers. comm. 2003).

- Dutch colonials or their staff (c. 1910–1942; 1946–1963).
- Official transmigrants resettled to Papua from Java and other parts of Indonesia (c. 1964–2000).
- Indonesian Armed Forces after Indonesia took control from the Dutch (c. 1964–present).
- Voluntary economic migrants from other parts of Indonesia (c. 1964– present).

There is abundant suitable habitat for macaques in Papua, yet their distribution to date remains restricted. From this circumstantial evidence we concur with Wilmot & Kamalasa, Ltd. (2001) and infer that it is likely that their introduction into Papua occurred in a single event and not many repeated introductions and subsequent escapes to the wild over a period of time. On the one hand, in our interviews with local communities in the Kotaraja / Vim area, informants consistently stated that the arrival of the macaques *pre-dated* the arrival of the Indonesian administration. On the other hand, since the Papua macaques are resident only in a relatively small area, it seems likely that the introduction occurred in the recent past. This is because the longer the interval between their arrival and the present, the further afield they are likely to have spread, especially since the fragmented forests they now inhabit were part of a continuously forested area not long ago.

We collected blood samples from four individual macaques for DNA analysis to determine from which specific island the Papua macaques originated. There are many sub-species of *Macaca fascicularis*, and the species as a whole possesses very high genetic variation, which results in a high degree of polymorphism and heterozygosity (Scheffrahn, de Ruiter, & van Hooff, 1996). Indeed, some primate taxonomists consider *M. fascicularis* to be more of a "species group" or superspecies than a discrete species *per se* (i.e., *M. fascicularis* is related in complex and as yet poorly understood ways to other species such as *M. mulatta, M. cyclopis, and M. fuscata*) (Hoelzer & Melnick, 1996). In short, the taxonomy of *Macaca fascicularis* is quite complicated. Obtaining a DNA sequence for the Papuan population would help determine their origin and provide a clue as to the original vector. Since neither DNA testing facilities nor a DNA database for macaques currently exists in Indonesia, and also due to the high degree of difficulty in obtaining an export permit for the blood samples, DNA sequencing results have not yet been carried out.

We present evidence below on the possible historical vectors of introduction. Many of these theories are purely speculative and/or anecdotal, and we are unable to document definitively how the macaques arrived in the province. Indeed, it may now be impossible to separate anecdote from evidence.

9.2.1. Pre-Colonial and Early Dutch Era (c. 3000 B.C. – 1940 A.D.)

Swadling (1996) presents the most comprehensive account of trade patterns linking New Guinea to the outside world.[18] It is theoretically possible, but highly unlikely, that *M. fascicularis* might have been introduced to the Jayapura area by pre-colonial era trade contacts. Archeological evidence suggests that the Hollandia (now Jayapura) area was linked to island Southeast Asia by small-scale trade in cloves, marsupials, obsidian, and bird of paradise skins for 2,000 and possibly as long as 5,000 years. Early traders working the northern New Guinea coast were probably from Seram and the Moluccas (i.e., areas without *M.*

[18] All historical information on pre-colonial and early Dutch periods is from Swadling (1996), while all analysis/evaluation of possible macaque introduction during this period is our own.

fascicularis), as well as some Chinese traders. During this time, contact was sporadic, and trade cycles waxed and waned over the centuries.

A Dutch garrison established in Humboldt (now Yos Sudarso) Bay in 1852 seems to have succeeded only in arousing local antagonism, and was short-lived. Bird of paradise skins – probably the trade item from New Guinea most in demand up until the 1930s – were not collected in the Jayapura area in great numbers until the 1880s. The first trading station (consisting of Chinese, Ternatian, and Tidorese traders) was established in the 1890s at Metu Debi Island in Humboldt Bay. Chinese traders seem to have played the main role, importing trade goods mostly from China and Japan (rice, textiles, metalware, fuel, and beads), and exporting bird of paradise skins (until prohibited in 1931), massoy and lawang bark, trepang, shell, and small quantities of coffee and cotton. Hollandia was established in 1909–10 to determine the boundary between Dutch and German New Guinea, but aside from a small Dutch administrative presence, some coconut plantations, and trade in copal, the area remained something of a backwater until World War 2.

In terms of the sporadic trade between Chinese and Moluccan traders and residents of the Jayapura area dating back to antiquity, macaques were never a trade item with any value whatsoever, nor would these traders have had the inclination or resources to carry macaques for their aesthetic value. Based on historical trade evidence alone, it is highly dubious that the Papuan macaques would date from this period. It is possible that early Dutch administrators or their Indonesian assistants might have brought with them macaques from western Indonesia as pets, but based on ecological evidence (i.e. lack of macaque spread) and lack of historical records, this is highly unlikely. Finally and perhaps most persuasively, all local residents interviewed for this study were adamant that macaques were introduced in the recent past – the earliest reported time being that of the Japanese military occupation in World War 2.

9.2.2. Japanese Military (1941 – 1944)

It is possible that macaques were introduced by Japanese Armed Forces during their occupation of the Jayapura (then Hollandia) and Sentani areas between 1942 and 1944. Based on the accounts of many informants interviewed for this study, there is sketchy and anecdotal evidence to suggest that they were the vector. Perhaps most relevant is that the idea of a Japanese origin for the Papua macaques is widely held by many local inhabitants, including Papuans. Heri Hamadi, a relative to one eyewitness, recounted that the macaques were introduced to the Vim hills by a Japanese ship which entered the shallow waters of Youtefa Bay to escape an attack by Allied forces. In this version of events, the soldiers, crew, and macaques escaped on foot into the hills after the ship grounded on the shore.

It is also possible that macaques were brought in by the Japanese prior to the Allied invasion. Other locally-held theories are that the Jayapura macaques were escapee “food testing guinea-pigs” for Japanese soldiers (John Maturbongs, 2002), or were intentionally introduced as wild game meat. We are unable to rule out either possibility. However, had macaques been brought as a food-testing animal, it seems likely that they would have been used for the same purpose in other parts of Japanese-occupied Papua, including the Sentani area, Wakde, Sarmi, Biak, Numfoor, Sansapor, Sorong, and Timika areas (not to mention Japanese-occupied areas on the north coast of what is now PNG), but this was evidently not the case.

It is interesting to note, however, that the Japanese were responsible for alien species introductions to New Guinea, at least one of which has become a notorious invasive pest: the giant African snail, *Achatina fulica*, which was brought in as a food source (Low, 1999).

9.2.3. U.S. Armed Forces (1944 – 1946)

One report has posited the U.S. army as the vector for the introduction of the "guinea-pig monkeys" to test the edibility of native fruits for American troops facing potential jungle/guerilla warfare (WWF Indonesia - Sahul, 2000). This seems unlikely, given that the U.S.-led New Guinea Campaign came from the east (i.e. from the Pacific Islands and PNG), which is outside the macaque's natural range.

There were established *M. fascicularis* populations inhabiting Angaur Island, Palau, Micronesia (some 800 km north of New Guinea) at the time of World War II. However, this island was liberated by the American Allied forces *after* the assault and occupation of the north coast of New Guinea. It is thought that U.S. troops were responsible for the introduction of the Brown Tree Snake (*Boiga irregularis*) from New Guinea to Guam, where they became an infamously destructive invasive species – so it is certainly true that such accidents are possible on the part of the U.S. military (Fritts and Rodda, 1995). It is thus possible that after Angaur was liberated, macaques were brought by cargo or personnel ship to Hollandia. Given that the war was ongoing and U.S. forces had a more pressing agenda at the time, and that (unlike New Guinea to Guam) the general path of troop and cargo movement was in the opposite direction, we still regard a U.S. military source as unlikely.

9.2.4. Post-War Dutch Colonists (1946 – 1963)

Our interviews revealed an anecdotal report of a possible vector. Mr. Matias Borotia, a member of the community from Arso Kota, previously lived in Abepura, where he knew a Dutch-Indonesian (a cook at the public works mess – now Departemen Pekerjaan Umum) who claimed to have owned a pair of macaques as pets in 1956–57. The origin of the macaques is not known but they were left in Abepura upon the cook's return home. This is a possible vector although as a second-hand anecdotal report, we were unable to collect any corroborative evidence.

Although we did not conduct any review of the Dutch colonial-era scientific literature (c. 1910–1963), to the best of our knowledge there are no official reports mentioning macaques in the Jayapura area from the Dutch era. Given the pressing political concerns after the war, however, documenting a few pet macaques – who may have subsequently been released either accidentally or deliberately – was probably not an immediate priority on the part of the Dutch administration or any visiting scientists. On the other hand, both Petocz (pers. comm. 2003) and Diamond (pers. comm., 2001) suggest that had macaques been present at that time, they would almost certainly have documented the fact.

9.2.5. Official Transmigrants (1963 – 1980s)

One commonly held belief on the origin of Papua macaques is that Transmigrants brought the monkeys into the area. This is also mentioned in certain literature (WWF Indonesia-Sahul, 1999; Shearman, 2001). The Indonesian Government's Transmigration programme established new villages in previously forested areas of the Outer Islands, including Papua, for the landless poor of densely populated regions such as Java and Bali. The first official Transmigrants (i.e. sponsored by the Government of Indonesia) arrived in what was then West Irian in 1964. Between 1964 and 1978 approximately 1500 families (roughly 7500 people) were settled in the

province under official sponsorship[19]. From 1978 until 1986, the transmigration program settled 100,000 persons in the province (Manning, 1989).

The Transmigration programme was initiated in the Arso area in 1985. The theory that Transmigrants were the primary vector for macaque introduction has emerged probably because the presence of macaques was first noted at approximately the same time as the start of the Arso settlement. However, we caution that this correlation is not proof. Indeed, after numerous interviews with Transmigrants in the Arso area, we are unable to substantiate this hypothesis. No Transmigrants that brought macaques into Papua were identified during this survey.

Transmigrants arrive in their new villages located in the middle of the forest with minimal luggage and only major essential items for eking out an agricultural living. Although food supplies are provided through the government scheme, they are minimal, and thus the luxury of pet monkeys is of very low priority upon departure from their home islands. Arrivals have also stated that they were subject to quarantine checks upon arrival (Sangadah, 2003).

The ability of poor Transmigrants to bring pet macaques with them upon their first arrival in Papua was certainly very limited. It is possible, however, that as these new arrivals began to enjoy greater economic prosperity in the years following their settlement in Papua, some may have traveled back to Java/Bali, returning to Papua with a pet macaque. Alternatively, the vector might have been Java-based relatives visiting family in Jayapura, and bringing a gift to remind them of the forest surroundings back home. While this is pure speculation, it does seem consistent with general economic and cultural conditions in the area. We regard a Transmigrant vector for macaque introduction as possible.

9.2.6. Indonesian Army / Police (1963 – 1980s)

Some police and army personnel are known to have brought macaques into Papua for sale in recent times but there is no evidence that the Indonesian Armed forces have deliberately introduced the monkeys as speculated by *Jubi* (Mirino and Ramandey, 2002). Even though macaques have been brought to Papua by these actors, it does not necessarily follow that the animals were released and were therefore the source animals. In addition, all local communities and informants in the Kotaraja / Vim area stated that the arrival of the macaques pre-dated the Indonesian administration. However, this can still be considered a possible source of the Papua macaques.

9.2.7. Voluntary (Economic) Migrants (1963 – 1980s)

A consultant report by Conservation International – PNG (Wilmot & Kamalasa, Ltd., 2001), concluded that the establishment of present wild populations of macaques was likely not as a result of deliberate importation and subsequent intentional or accidental release by either Transmigrants or economic migrants. This conclusion was apparently mainly based on personal communications with WWF-Jayapura staff rather than local informants. Their reasoning was that voluntary migrants (including people that were originally Transmigrants and returned to Papua after visits to their homelands) usually disperse throughout the entire region of Papua, and if this were the primary vector for introductions of macaques, one might expect several unrelated introductions and resulting separate macaque populations in various parts of the province. This is not the case.

[19] Specific figures for the Jayapura area were unavailable.

However, this fact in itself is not logical evidence that the Jayapura introduction was *not* the result of a Transmigrant/Voluntary Migrant vector. The fact that something occurs once does not logically require that it must therefore happen repeatedly. We therefore cannot rule out the possibility that economic migrants were the vector of introduction.

9.2.8. Conclusion

It is probably impossible to ascertain with certainty the source or date of introduction of *Macaca fascicularis* in Papua. What is most relevant is that an accidental or deliberate release did occur, and unless local understanding and institutional capacity to monitor and prevent other exotic species being imported to the province is enhanced, further introductions of macaques or other potentially invasive species are not merely possible, but likely over the medium- to long-term.

Not only may it be impossible to determine conclusively how and by what vector macaques arrived in Jayapura, but even if the facts were known for certain, they would also be of limited value. Assigning blame is not constructive. In the end, what parties were the original vector is relevant only to understanding how it occurred and what steps are therefore necessary to prevent future (re)introductions and/or releases. The essential point is how easy it is for a destructive alien species introduction to take place in Papua. The prevailing belief seems to be that all local species are “Indonesian” rather than from Java, Papua, Bali, Sulawesi, etc., and awareness of basic biogeography or concepts of endemic and/or alien species is quite poor. Certainly, there is very little local consciousness among local residents, military, or policymakers of the possible negative consequences that released or escaped exotic pets might have on local ecosystems. Given other pressing political and economic priorities, this is in some sense understandable but no less alarming to anyone concerned with the preservation of New Guinea’s biodiversity.

In various interviews IPCA received very credible reports that pet macaques do periodically slip past the Department of Animal Quarantine officers in Jayapura and Sentani (see Section 11.4). This does not prove that economic migrants, Transmigrants, police, or military were the original vector for the existing macaque troops, but it does raise the possibility. This practice is certainly cause for deep concern, and should be addressed as part of a solution to the macaque problem, if only to prevent future re-introductions.

9.3. Distribution and population assessment survey (DAPAS) methods

Following the initial literature review stage of this study, IPCA needed to establish an accurate assessment of the distribution of *Macaca fascicularis* in Papua, based on field surveys and interviews with local communities. This component included an estimate of macaque populations and combined with information on the characteristic behaviours of *M. fascicularis*, the degree of actual or potential invasiveness in Papua.

The Distribution and Population Assessment Surveys (DAPAS) were conducted through community interviews as well as direct field observation surveys over the 6 months from October 2002 – March 2003.

Based on the initial information received from reports and interviews, IPCA targeted an area consisting of the districts of Arso, Muara Tami, Skanto, Genyem, Lereh, Sentani, Cyclops

Mountains and other areas near Jayapura, as well as Vanimo (in PNG), Manokwari (in the Bird's Head), and Mulia (in the Central Highlands), for the DAPAS surveys. (See Figure 3; direct field surveys that were carried out in Mulia and Manokwari are off-map.)

Given the often cryptic nature of forest-dwelling macaques and the vast areas involved, community interviews are in many ways both a more feasible and a more reliable method for preliminary surveys. Local communities (and especially indigenous Papuans) are heavily dependant on the forest for resources, and also tend to farm the forest edges (preferred habitat for *Macaca fascicularis*), and so are consistently well-informed about the condition of their forests. Thus, local hunters and farmers who derive their livelihoods from the forest became among the most reliable and knowledgeable informants in this study as to the presence or absence of *Macaca fascicularis* in a particular area.

In order to elicit community understanding and support for the project, and to facilitate community interviews, IPCA produced leaflets describing the project as well as a small A3 poster identifying *Macaca fascicularis* and differences between macaques and native fauna with which it might become confused (See Figure 2). With the aid of these materials, extensive informal interviews were carried out with over 400 key informants from village and agricultural communities, traditional leaders, security forces and local government. All reports relating to positive IDs of *Macaca fascicularis* were followed up by tracking down and interviewing eyewitnesses.

In addition to village interviews with communities, direct observation surveys were carried out to verify the presence of macaques, and in particular to assess whether or not they had spread beyond their known range. In addition to time spent on interviews and field plot assessments, the IPCA team spent over 22 days (approximately 55 man-days) in the field surveying habitat preferred by macaques on the eastern edge of the Cyclops Mountains, the forests on the hills immediately south and east of Abepura, and areas south of Sentani Lake.



PERNAHKAH ANDA MELIHAT BINATANG INI DI PAPUA ?



Kenali Ciri-cirinya

- Warna bulunya abu-abu kecoklatan
- Ekornya panjang
- Memiliki jambul dan jenggot yang panjang
- Biasanya berkelompok 10-30+ ekor
- Makanan adalah bermacam-macam termasuk buah-buahan, daun, serangga, telur dan anak burung kepiting dll.

KERA EKOR PANJANG

Karena BUKAN BINATANG ASLI PAPUA dan sangat mengganggu petani kebun, bisa menularkan penyakit HerpesB, dan juga mengancam satwa-satwa asli Papua.





Kalau Anda lihat Kera Ekor Panjang ini dekat kampung Anda, tolong laporkan kepada Kepala Kampung / Desa. Terima kasih.

IPCA
Indo-Pacific Conservation Alliance

UNIVERSITAS CENDERAWASIH

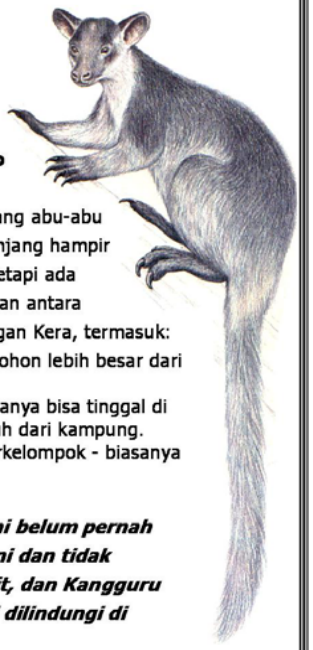


YPLHC

DEPARTEMEN KEHUTANAN BKSDA PAPUA

BAPEDALDA PROP

JANGAN BINGUNG !!



Kangguru Pohon Kelabu atau **Lao-lao** adalah binatang asli Papua. Warna bulu yang abu-abu dan ekornya yang panjang hampir sama dengan Kera. Tetapi ada lebih banyak perbedaan antara Kangguru pohon dengan Kera, termasuk:

- Tubuh Kangguru pohon lebih besar dari Kera.
- Kangguru pohon hanya bisa tinggal di hutan perawan jauh dari kampung.
- Hidupnya tidak berkelompok - biasanya sendiri.

Kangguru pohon ini belum pernah mengganggu petani dan tidak membawa penyakit, dan Kangguru pohon /Lao-lao ini dilindungi di Indonesia.

Figure 2: Poster used in community interviews by IPCA/UNCEN in 2002

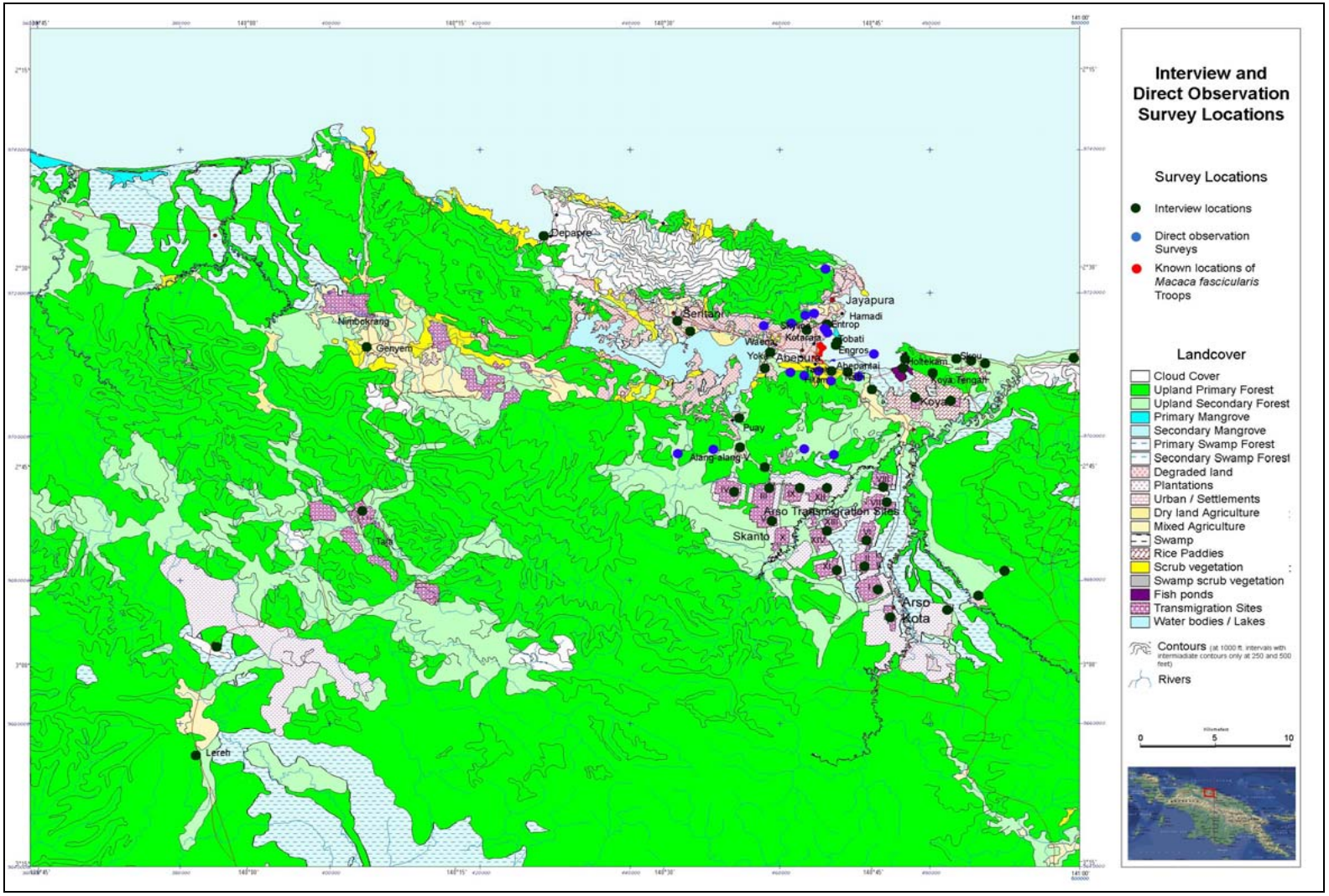


Figure 3: DAPAS and community interview locations for this study

9.4. Distribution and population assessment survey results

Of the more than 400 informants interviewed by IPCA, many were already familiar with *M. fascicularis*, having seen them around Kotaraja (south of Jayapura city) where they are regularly seen by even casual observers. These informants were consistently able to accurately describe their appearance and behaviour. Without exception, all informants confirmed that there were no wild widespread macaque breeding populations outside of the Kotaraja area. A detailed list of informants, their localities, and responses is listed in Appendix 2.

Based on direct field observation surveys and community interviews, IPCA has concluded that with a very high degree of probability all breeding populations of *M. fascicularis* are restricted to the immediate area around Jayapura at the time of writing. Despite repeated and extensive surveys and community interviews in the areas around Arso, the PNG border, Mulia, and Manokwari, IPCA found no evidence to suggest that macaque populations have spread beyond the Kotaraja area. We therefore also conclude that macaques have not yet entered the independent state of Papua New Guinea.[20] It is evident that *Macaca fascicularis* are not yet an invasive species in Papua, though they certainly have the potential to become invasive.

There are several reports of various macaque populations – anecdotal or otherwise – from Papua as well as Papua New Guinea which have appeared in literature / reports, local mass media. These unverified reports were probably sometimes accepted as factual, even through no real evidence was produced. In some cases, captive individuals (i.e. pets) or released individual pets were apparently taken as evidence of large macaque populations in an area. In others, reports of macaques might have been based on misidentifications of tree kangaroos. The lack of good data-gathering was likely a function of the difficulty of the terrain, lack of funding, and generally problematic nature of field surveys in remote areas of Papua. IPCA has completed investigation into all these cases, none of which have lead to any recording of new populations outside the Kotaraja area and environs.

IPCA investigated an isolated sighting of a single wild individual on the banks of the Tami River near Arso Kota in 2001, by Fery Tuames, a resident of Arso. No further sightings have been reported since the initial instance; in follow-up interviews Mr. Tuames reported to us that he is “100% confident” that there are no macaque populations in the area. We conclude that that the individual macaque witnessed by Mr. Tuames was probably an escaped pet from the nearby transmigration sites. Alternatively, it is also possible that the animal may have been confused with a tree kangaroo or forest wallaby.

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[20] Exotic species are dynamic, and macaques are a particularly cryptic species. Since it is impossible to demonstrate an absence (i.e. “prove a negative”), IPCA acknowledges that that there remains a remote chance (<5%) that *M. fascicularis* maybe present in the wild outside the areas described here. The IPCA macaque project team spent every effort to survey as large an area as possible and to interview as many people as possible, within the restricted timeframe and budget. Furthermore, we wish to point out one particular area that could conceivably prove to have an extant macaque population, though we made strenuous attempts to collect evidence there. Because of its difficult physical and logistical challenges, the swamp forest near Holtekam (east of Kotaraja) was under-studied by our team. This area is a long distance from the area with confirmed macaque populations, however. Furthermore, all local interviewees from villages between Kotaraja and Holtekam forest reported that there were no macaques there. Finally, in such a vast area, it is of course always possible that a small troop exists in the forested mixed lowland forest and karst terrain between Jayapura and PNG, though if so they remained undetected by both local communities and the IPCA team. All available evidence suggests that there are **no** macaques in these areas, but we cannot claim infallibility.

While our survey did not reveal any macaques being kept as pets in the Arso area, this is not necessarily conclusive (i.e. absence of evidence is not necessarily evidence of absence). So the possible sighting of a (presumably isolated) individual macaque does raise serious concerns. While we conclude that the Tami case is an isolated instance, the fact that an individual (pet?) macaque may have escaped from a transmigration area is cause for serious concern. Unlike the "forest islands" in more or less urbanized areas where macaques are currently located, many transmigration sites (including Arso) are adjacent to primary and secondary forests that stretch more or less unbroken for tens of thousands of hectares. If a future accidental or intentional escape or release involves more than one animal (i.e. male and female) or a gravid female, it could gravely complicate the situation and eventually result in the establishment of a robust macaque population in forests where they are much harder to access or detect. Clearly, village government and community education about the potential negative consequences of escapes/releases are essential to help minimize any such accidents.

We also carried out a site visit to Manokwari and Sorong to investigate reports of *M. fascicularis* populations in the area. Absolutely no evidence of wild troops was found. There are apparently no pet macaques in Arso. We did receive credible reports of at least one pet macaque in the Ransiki transmigration area (SP11), possibly at least one in Wasior (Wandammen Peninsula – Kepala Desa [?]), a breeding pair in Sentani (Batak doctor), and one in Taja (near Lereh) owned by a policeman. There are reports that the Brimob (police mobile brigade) barracks near Kotaraja has several pet macaques. Mr. Ruatakurei, a Papuan hunter from Serui and now based in Kotaraja, has apparently captured several wild macaques from the Jayapura area and sold them as pets.

A site visit was made to Vanimo in PNG in early July 2003 to ascertain the factuality of anecdotal reports of macaques in the border area and in the Bewani Mountains. We interviewed National Agriculture Quarantine Inspection Service (NAQIS) personnel about past surveys and patrols. NAQIS was already alert to the risk of *M. fascicularis* as a potential species that could cross the border, and they reported that when on patrol they specifically inquire with local communities if they have seen or heard reports of the species entering PNG (Petrus Aleti *pers comm.*, 2003). The latest operation (in conjunction with Australian Quarantine Inspection Service) was carried out in May 2003 along the border to the Bewani District. No reports of macaques were found during this routine patrol for introduced species. We also interviewed several personnel from the 2nd Pacific Islands Regiment. Based in Vanimo and frequently patrolling the border, the Regiment has never encountered *M. fascicularis* nor heard suspicious reports from communities (Julius Gilgil, *pers. comm.*, 2003). These findings correspond with the Wilmot & Kamalasa report (2001) and a WWF-Sahul survey that included Wutung village on the PNG – RI border (Torobi, *pers. comm.*, 2003) that found no evidence of macaques on the PNG side of the island.

Once we were able to accurately establish the actual range of macaque populations in Papua, additional surveys were carried out to determine accurate population numbers and to document macaque behaviour and estimate their ecological impact. (See Sections 10 and 11.)

10. Monitoring Extant *Macaca fascicularis* troops in Papua

In carrying out a risk assessment of an exotic species, IPCA has followed the principles described by the IUCN Global Invasive Species Programme (GISP) in Wittenberg, R. and M.J.W. Cock (Eds.), (2001). *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices*. We documented that *Macaca fascicularis* has established a sustained breeding population in the Kotaraja area, but has not yet become invasive and spread throughout forested regions of Papua. To determine whether or not the species has the potential to become invasive in the near or distant future, it was also necessary to assess the ecology of alien *Macaca fascicularis* in Papua, through monitoring both its behaviour and the specific characteristics and suitability of Papuan habitat.

10.1. Aims of monitoring

IPCA carried out detailed field surveys during five months from Dec 2002 – May 2003 in the known ranges of the macaques to:

1. Determine the exact population and home ranges of macaque troops;
2. Determine their sex ratio and age composition;
3. Determine the ecology of *Macaca fascicularis* in Papua, including principal food preferences, habitat preferences and other behaviours pertaining to ecological impact.

10.2. Methodology

Trails were cut throughout the forests in the home ranges of the Papua macaques in order facilitate direct observations. Team members started observations in the early morning (05.30–06.30) and surveyed these paths for several hours until the troop was lost, or became inactive. Information recorded included: all general behavioural activities, the number and sex (if possible) of the individuals sighted, food plants eaten and location.

Synchronised surveys involving biology student volunteers from the Faculty of Mathematics and Life Sciences, Cenderawasih University were also carried out to gain more accurate estimate of population, demography and sex. This method involved multiple teams surveying the same site from different directions / paths. The teams were in contact with one another via walkie-talkies. Team members recorded their observations, as well as the time, direction and distance of troops observed. In this way, results from several groups could be cross-referenced, allowing more efficient coverage of a larger area.

Demography analyses used the following age classes:

Adult:	Sexually mature.
Juvenile:	Immature but independent of mother (1 to about 4 years) characterised by being smaller than the adults, and often much more active and playful.
Infants:	Those carried by, or in close association with, the mother.

Sexual determination by identifying the presence or absence of penis or mammaries was attempted for adults and juveniles (if a clear view could be obtained), but was not attempted for infants.

10.3. Results

10.3.1. Extant *Macaca fascicularis* populations in Papua

Macaques were observed in 100 recorded sightings consisting of a total of 2,039 minutes observation time. IPCA documented six breeding *Macaca fascicularis* troops and several out-lying individuals in the Kotaraja area. Data for these troops are displayed in Table 1. The total number of wild macaque individuals in Papua was 62. A summary of the all observations is listed in Appendix 3, and their locations shown in Figure 4.

Troop	Location	Troop Size (No. of Individuals)	Geographic Coordinates	Elevation (m a.s.l)
Kapal	Eastern slopes of Meermokh hill	5	S 2°35.950' E 140°41.350' - S 2°36.110 E 140°41.500'	15 – 200
Vihara	Western slopes of Meermokh hill	14	S 2°36.050' E 140°41.090' - S 2°36.220' E 140°41.310'	35 – 185
Meer	Southern and western slopes of Meermokh hill	13	S 2°36.200' E 140°41.080' - S 2°36.240' E 140°41.550'	20 – 225
Mangga	Waymhoruk hill	12	S 2°36.330' E 140°41.250' - S 2°36.650' E 140°41.280'	50 – 90
Pantai	South end of Waymhoruk hill	5	S 2°36.650' E 140°41.210' - S 2°36.820'E 140°41.180'	30 – 60
Tanah Hitam	Tanah Hitam sago swamps	10	S 02°36.904' E 140°40.680' - S 02°36.959' E 140°40.979'	10 – 15

Table 1: Data for extant *Macaca fascicularis* populations in Papua

A single macaque individual is located in the Maunou and Tiaknou hills (E 140°41.300'; S 2°36.900'). Note that this is shown on Figure 4 but not noted in Table 1. The total suitable habitat available for this individual animal is in excess of 40 hectares.

Several residents of Entrop and Kelapa Dua reported a troop of macaques in the area (located between Jayapura and Abepura). Initial reports were that the troop consisted of "several" individuals. Extensive surveys of the area by IPCA yielded no positive sightings of these macaques. Some members of the community in Entrop stated that youths of the area used to shoot at the macaques which used trees close to human habitation. It is possible that members of the local community trapped what was a small troop, and thus no individuals now remain. However, as our field surveys were ending in late June 2003, Mr. Marcus Urobka from the Veterinary Clinic and Laboratory received a positive sighting of two individuals close to Kelapa Dua (S 2°34.720' E140°41.642'). This report still needs confirmation. The reported range was in the order of 15 hectares covering the agricultural / secondary forest south of Entrop and Kelapa Dua.

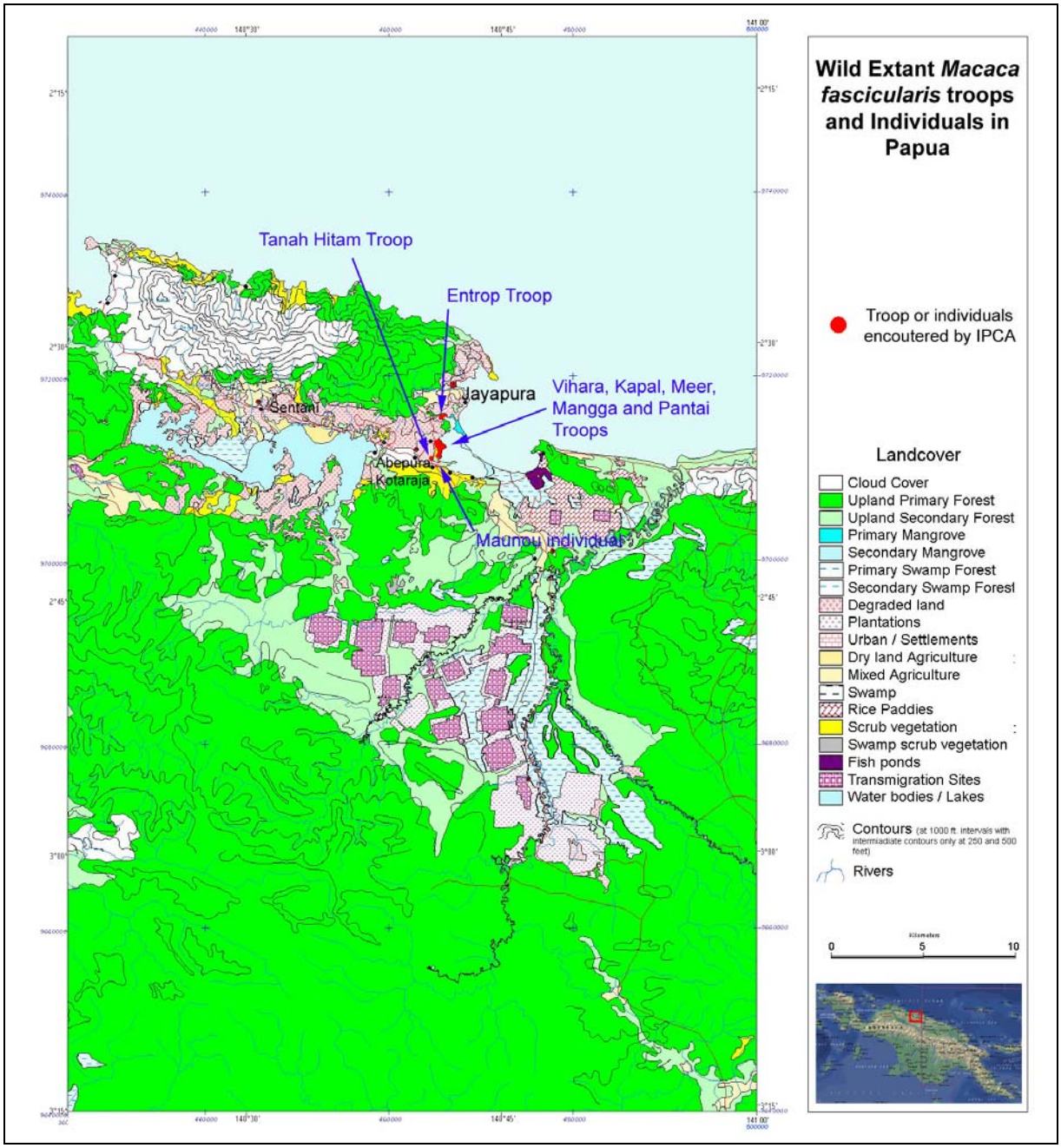


Figure 4: Map of Jayapura, Sentani and Arso areas showing the distribution of *Macaca fascicularis* in Papua, Indonesia

10.3.2. Physical characteristics of *M. fascicularis* in Papua

The physical characteristics of *Macaca fascicularis* in Papua do not differ from those described of the species in other parts of its native range. Fur colour: upperparts dark brown with light golden brown tips; underparts light grey; tail dark grey/brown; crest (when present)

and eyebrows tipped with black. Visible skin: black on feet and ears; muzzle light grayish pink; eyelids are often with prominent white markings and sometimes white spots on the ears (see plates).

Measurements taken from four captured specimens are displayed in Table 2.

	Troop	Head-body length (mm)	Tail length (mm)	Body weight (kg)	Upper Canine (mm)
Adult male	Mangga	490	590	7.5	23
Adult male	Mangga	480	610	6.0	18
Adult female	Tanah Hitam	410	500	5.0	6.5
Adult female	Tanah Hitam	400	510	5.0	7.0

Table 2: Measurements taken from four *Macaca fascicularis* individuals trapped from the wild at Kotaraja.

10.3.3. Habitat preference in Papua

Extant breeding troops of *M. fascicularis* were found in primary forest over limestone (with evidence of very light selective logging); secondary regrowth lowland forest over limestone; and freshwater swamp forest dominated by sago (*Metroxylon sagu*). In Papua, *M. fascicularis* **does not show a preference for secondary forests over primary forests**. Three troops are found in primary (or very lightly disturbed) forest, while three troops are in secondary or disturbed forest. One of the troops, Tanah Hitam, is found in very disturbed gardens and sago swamps that have heavy human activity. However, troops in primary forest did spend a large amount of time on the forest edge – which can be considered a more disturbed habitat – probably since many of their favoured foods grow more abundantly there.

The primary forests that we studied are dominated by *Pometia pinnata, Intsia bijuga, Ficus benjamina, Ficus drupacea, Celtis latifolia, Aglaia* sp. and members of the Sapindaceae and Sapotaceae. They have a fairly uniform canopy profile with an average height of about 25 metres, although almost pure stands of *Pometia pinnata* reach 35+ metres in deep soiled valleys / gullies. On the steep slopes, bare rock out-crops were common. Here several species of *Ficus* dominated. The understory varied drastically depending on substrate. Where rocks were exposed to the surface, the undergrowth was dense and tangled, with *Antiaropsis* sp. and lianas (*kawat besi*) dominant. In deeper soils where trees grew larger, the understory was sparse.

Secondary regrowth forests were very different in species composition. There were no limestone rocks exposed and the area appeared to have reverted from agricultural fields back to secondary forest. Soils were deep. The species composition is relatively diverse but dominated throughout by *Intsia bijuga* and *Pometia pinnata*. Few of the largest trees reach more than 50 cm diametre at breast height. *Cocos nucifera*, *Mangifera indica*, *Cupaniopsis* sp., *Terminalia archboldi*, and *Cerbera floribunda* were also frequent. Other fruiting trees such as *Artocarpus altilis* and *A. heterophylla* were also present. The understory was relatively sparse indicating mature regrowth. It was dominated by *Hibiscus tiliaceus*, *Macaranga* spp., *Pandanus* sp., and several species of small *Ficus*.

The sago swamps were almost pure stands of sago (*Metroxylon sagu*) with occasional *Octomeles sumatrana* and *Terminalia cattapa*. The swamps were surrounded by a) buildings and habitation and b) mixed fruit and vegetable fields (both in a managed and abandoned / fallow state) and several *Ipomoea aquatica* (kangkung) ponds.

10.3.4. Feeding preferences

10.3.4.1. Plant food resources

Table 3 shows the plant species that were either observed being eaten or showed clear signs that they had been eaten (i.e. primate teeth marks) by *M. fascicularis*. Although we documented the major "staples", this list cannot be considered complete. Many plants that may in fact be eaten may not have been in season during the survey, thereby skewing the sample. It is likely that *M. fascicularis* exploits a far greater diversity of species in its diet than those we recorded. As is shown in Table 3, *M. fascicularis* is predominantly frugivorous but also takes significant proportions of leaves, flowers and bark (as well as large insects). This omnivorous behaviour is consistent with the literature.

In the primary forest troops, *M. fascicularis* shows a heavy feeding preference for *Ficus* species (Moraceae) as well as *Halfordia papuana* (Rutaceae). Vihara, Kapal and Meer troops showed strong preference for the figs *F. benjamina* and *F. drupacea* when in season. These troops were regularly observed during the mornings in the same large fig trees, moving off only when all ripe figs had been consumed. The young shoots and (later in the season) fruit pods and seeds of Ironwood (*Intsia bijuga*) are another important staple of all *M. fascicularis* troops except Tanah Hitam. Matoa (*Pometia pinnata*) shoots were seen to be taken on a single occasion. This species was not in fruit during the surveys, but it is assumed that this edible and sweet fruit forms an important part of the macaque diet during the short fruiting season. Many other plants, including exotic species of the forest edge such as the weeds *Passiflora foetida*, *Piper aduncum* and *Pennisetum* sp. were observed to be taken but recorded only once.

Food supply for *M. fascicularis* in the secondary forest site showed marked seasonality for many species and hence the diet of *M. fascicularis* varied significantly between seasons. Most notably, mango (*Mangifera indica*) fruits at the start of the rainy season (November–December). During the study period, *Intsia bijuga*, *Pometia pinnata* and *Terminalia archboldiana* (which was occasionally encountered in the secondary site) produced new leaves, and *F. andenosperma* and one unidentified *Ficus* sp. were in fruit. During this time *M. fascicularis* has an abundance of food. Later in the season (February to April) the seed pods of *Intsia bijuga*, the seed of *Macaranga* spp., *Trichspermum* and *Cupanopsis* are available, and in July–September *Pometia pinnata* fruited. Whilst the later was not observed being taken by *M. fascicularis* it is reasonable to infer that they would certainly feed on this sweet fruit.

In addition, a year-round supply of readily available, nutritious food was available in the form of planted coconuts. There are over 150 trees in the secondary site that were used by *M. fascicularis*. Individuals were seen taking immature fruits over long time periods in coconut groves. The macaques rip open the coconut husk with their teeth, bite a small hole in the inner shell and scrap out the flesh with their hand. It is thought that coconuts also provide a

much-need source of water for Pantai and Mangga troops, as there are no rivers or other water sources in the immediate area. Pantai and Mangga troops did not have access to large fig trees such as in the primary sites. However, smaller stature species (*Ficus ampelas, F. variegata*) grow in the area, providing an almost year-round supply of figs for Pantai and Mangga troops. In addition two planted species of *Artocarpus* also provided a source of regular food. Pandan (*Pandanus* sp.) and pineapple (*Ananas comosus*) shoots were regularly taken year-round.

The Pantai and Mangga troops are in close proximity to large areas of agricultural fields. If the supply of food available in the forest was low (especially during the dry season when few species were in fruit), these troops would regularly raid crops adjacent to their home range. Troops were observed moving up to 300 metres from the forest edge through *Imperata cylindrica* grassland to reach fields. The most commonly taken crop was cassava (*Manihot esculenta*). Because of damage from macaque crop-raiding, other species such as bananas (*Musa spp.*), maize (*Zea mais*) and papaya (*Carica papaya*) are longer planted by farmers in the area.

The troop in the sago swamp at Tanah Hitam (approx. 3 km^2 in area) are specialised crop raiders. This is presumably because their sources of food within the swamps are extremely limited. Sago pith was eaten by macaques after being discarded by the local community to make sago flour. Farm crops are seasonally available although limited. Since sago forest is ecologically sterile for macaques, and reptiles – which are not a staple food anyway – are very rarely encountered (perhaps due to the very high density of macaques at Tanah Hitam), it is clear that this troop can only exist in this area due to anthropogenic (farming and sago processing) activities.

Table 3 shows the plants (leaves, fruits, seeds, etc.) that were observed to be consumed by macaques. The origin of each plant determination is noted on the table after the species name: all identifications by Herbarium Universitas Papua (UNIPA) except those marked # by the IPCA Macaque Project Team; * by IPCA Team using Wormsley (1978); ** IPCA team using Henty (1981); and *** by Wayne Takeuchi of the Arnold Arboretum, Harvard University.

Key to Table 3

Macaques Troops		Plant Parts Eaten		Frequency Eaten	
Vi	Vihara Troop	L	Leaves / shoots / buds	O	Often
M	Meer Troop	B	Bark	F	Frequently
Mg	Mangga Troop	Fl	Flowers	S	Seldom
P	Pantai Troop	Fl	Fruits	R	Rarely
K	Kapal Troop	R	Roots / tubers		
Ta	Tanah Hitam Troop	O	Other		

		Macaque Troop						Parts Eaten							
Family	**Species**	**Vi**	**M**	**Mg**	**P**	**K**	**Ta**	**L**	**B**	**Fl**	**Fr**	**R**	**O**	Frequency	Planted crops
Acanthaceae	*?*	✓						✓						S	
Anacardiaceae	*Mangifera indica* L. #			✓	✓	✓	✓	✓			F			C	*
Araceae	*Colocasia esculenta* (L.) Schott #						✓	✓						F	*
Bromeliaceae	*Ananas comosus* (L.) Merr. #			✓	✓		✓	✓			F			F	*
Caesalpiniodeae	*Intsia bijuga* (Colebr) O.Kuntze #	✓	✓	✓	✓	✓		✓			✓			C	
Caesalpiniodeae	*Maniltoa* sp.	✓	✓					✓						O	
Caricaceae	*Carica papaya* L. #			✓			✓				F			F	*
Combretaceae	*Terminalia archboldiana* Coode *			✓				✓						O	
Convolvulaceae	*Ipomoea batatas* (L.) Lam. #			✓			✓					✓		O	*
Cucurbitaceae	*Momordica charantia* L. #	✓	✓								✓			S	
Euphorbiaceae	*Macaranga quadriglandulosa* Warb.		✓								S			O	
Euphorbiaceae	*Macaranga tanarius* (L) Muell - Arg	✓	✓								S			O	
Euphorbiaceae	*Manihot esculenta* Crantz.			✓	✓		✓					✓		C	*
Flacourtiaceae	*Casearia sp.*					✓		✓						S	
Leguminosae	?	✓							✓					S	
Leguminosae	*?*	✓						✓						S	
Liliaceae	*Pleomele angustifolia* (Roxb) N.E.Brown		✓	✓	✓						F			S	
Loranthaceae	*Descaisnina hollrungii* (K.Schm.) Barlow **	✓								✓				S	
Malvaceae	*Hibiscus tiliaceus* L.		✓	✓	✓			✓						O	
Meliaceae	*Aglaia sp.*		✓						✓					O	
Monimiaceae	*Palmeria* sp.	✓								✓	✓			S	
Moraceae	*Antiaropsis sp.*	✓						✓						S	
Moraceae	*Artocarpus altilis* (Park.) Fosberg. #										✓			O	*
Moraceae	*Artocarpus heterophylla* Lam. #										✓			O	*
Moraceae	*Ficus adenosperma* Miq.			✓							✓			F	
Moraceae	*Ficus ampelas Burm.F*		✓	✓							✓			F	
Moraceae	*Ficus drupacea* Thumb.	✓									✓			C	
Moraceae	*Ficus mangiferifolia* Laut & K.Sch. (*Ficus pachystemon* Warb.)	✓	✓								✓			O	
Moraceae	*Ficus variegata* Bl.			✓	✓	✓					✓			C	
Moraceae	*Ficus virgata* Reinw. Ex Bl.		✓								✓			O	
Moraceae	*Ficus benjamina L.*	✓	✓			✓					✓			C	
Moraceae	*Ficus* sp. #	·		✓							✓			O	
Musaceae	*Musa* spp. #							✓			✓			F	*
Myristicaceae	*Myristica cimifera Rbr.*		✓					✓			?			S	
Palmae	*Cocos nucifera L.* #			✓	✓	✓					S			C	*
Palmae	*Metroxylon* sp. #						✓						✓	F	
Pandanaceae	*Pandanus (monticola)* #		✓	✓	✓	✓		✓			?			C	
Papilionoidae	*Vigna unguiculata* (L.) Walp. #										✓			F	
Passifloraceae	*Passiflora foetida* L. #	✓		✓	✓						S			O	
Piperaceae	*Piper aduncum* #							✓			?			S	
Poaceae	*Pennisetum sp.*	✓						✓						S	
Poaceae	*Zea mais L.* #	✓	✓	✓			✓				✓			F	*
Rubiaceae	*Guettarda speciosa* L.	✓									F			S	
Rubiaceae	*Randia* sp.		✓								✓			S	
Rubiaceae	*Timonius* sp.		✓								✓			S	
Rutaceae	*Halfordia papuana* Ltb.		✓								✓			C	
Rutaceae	*Lunasia amara* Blanco.	✓						✓						S	
Rutaceae	*Micromelum minutum* (Forst. F) Seem. (*Micromelum pubescens* Bl.)			✓	✓						F			S	
Sapindaceae	*Jagera javanica (Bl.) Kalkman subsp. Javanica* ***			✓							S			S	
Sapindaceae	*Pometia pinnata* J.R. & G.Forster #	✓	✓	✓	✓	✓		✓	✓		✓			C	
Sapindaceae	*Cupaniopsis sp.* ***			✓	✓				✓		F			O	
Sapotaceae	*??* ***		✓								F			F	
Tiliceae	*Trichospermum (=Althoffia) pleostigma (F.Muell)* Warb.			✓							S			O	
Ulmaceae	*Celtis latifolia* Planch.	✓	✓								F			F	
Vitaceae	*Cissus* (?)	✓						✓						S	

Table 3: Plant species observed to be eaten by *Macaca fascicularis* in Papua

10.3.4.2. Other sources of food

Macaques were observed catching and eating insects on a number of occasions. Though insects are not a large part of the macaque diet, they are caught and eaten on an opportunistic basis. The Tanah Hitam troop ate sago pith (after it was processed by the local residents) and piles of waste from the sago processing were searched for sago grubs (the larvae of the Capricorn Beetle (*Rhynchophorus ferrungineus or R. bilineatus*). These larvae are rich in protein and lipids (fats) not found in plant material.[21]

Mangga, Pantai and Meer troops were also observed taking white scale insects that proliferated in the Vim site (especially on mangoes and matoa). These insects are often tended by ants as they exude sugary liquids that they suck from the sap in leaves. Seasonally, macaques would spend large amounts of time examining leaves and licking or nibbling at the leaf surface. It is thought that macaques also favoured the sugary exudates from these insects.

Papua macaques were not observed eating bird eggs or hatchlings, but based on the documented evidence of this from Mauritius, we infer that Papuan macaques do indeed take these on an opportunistic basis. Reports from Mauritius also suggest that macaques may take small lizards, and so this may be the case in Papua as well. Further evidence for this assertion comes from our comparative plot-based studies of bird and lizard diversity and abundance inside and outside the macaques range (see Section 11 below for details).

It should be noted that the list in Table 3 is for the food preferences of the macaques specifically at Vim and Kotaraja. Had macaques been discovered in other locations, it is likely that a slightly different suite of species would have been recorded. However, many of the above recorded species, and especially those that were used frequently by *M. fascicularis* (such as *Intsia*, *Ficus*, *Pometia*), are common trees throughout the lowland primary and secondary regrowth forests of New Guinea. Therefore, by extrapolation from the feeding preference demonstrated by *M. fascicularis* at the Vim, Kotaraja, it is extremely likely that this species could support itself through most of the lowland forests of New Guinea.

The advantage of *Macaca fascicularis* to adapt to different food sources is reflected in the diverse nature of plants taken (Table 3). This is further shown by the variety of food plant parts eaten (leaves/shoots, bark, flowers, fruit/seeds and pith) as well as their appetite for agricultural crops and insects found on the forest edge and in sago forest. Finally, significant seasonal variation in diet was displayed by *M. fascicularis* in switching to different sources of food when they became available.

10.3.5. Home range and population density

Home range limits were plotted on a base map from sightings of *M. fascicularis,* from *which* the approximate distance and bearing from observation transects were recorded. Additional information was gained from frequent sighting off the observation transects and a thorough

[21] Sago grubs are a very important food source for forest-dwelling peoples throughout lowland New Guinea. Though it would be premature to state definitively, should macaques spread further on the island, it is conceivable that they could compete with humans for these food resources.

knowledge of the area. Table 4 displays a summary of home ranges and density for all six troops. The home ranges of the five main troops at Vim (Kotaraja) are plotted on a detailed map in Figure 5.

Troop	Troop Size (No. of Individuals)	Home Range (Ha)	Density (individuals per Ha)
Kapal	5	6.8	0.7
Vihara	14	10.8	1.3
Meer	13	21.7	0.6
Mangga	12	9.9	1.2
Pantai	5	5.6	0.9
Tanah Hitam (not shown in Fig. 5)	10	+- 3	3.3

Table 4: Troop size, Home Range size and Density of Macaque Troops in Papua.

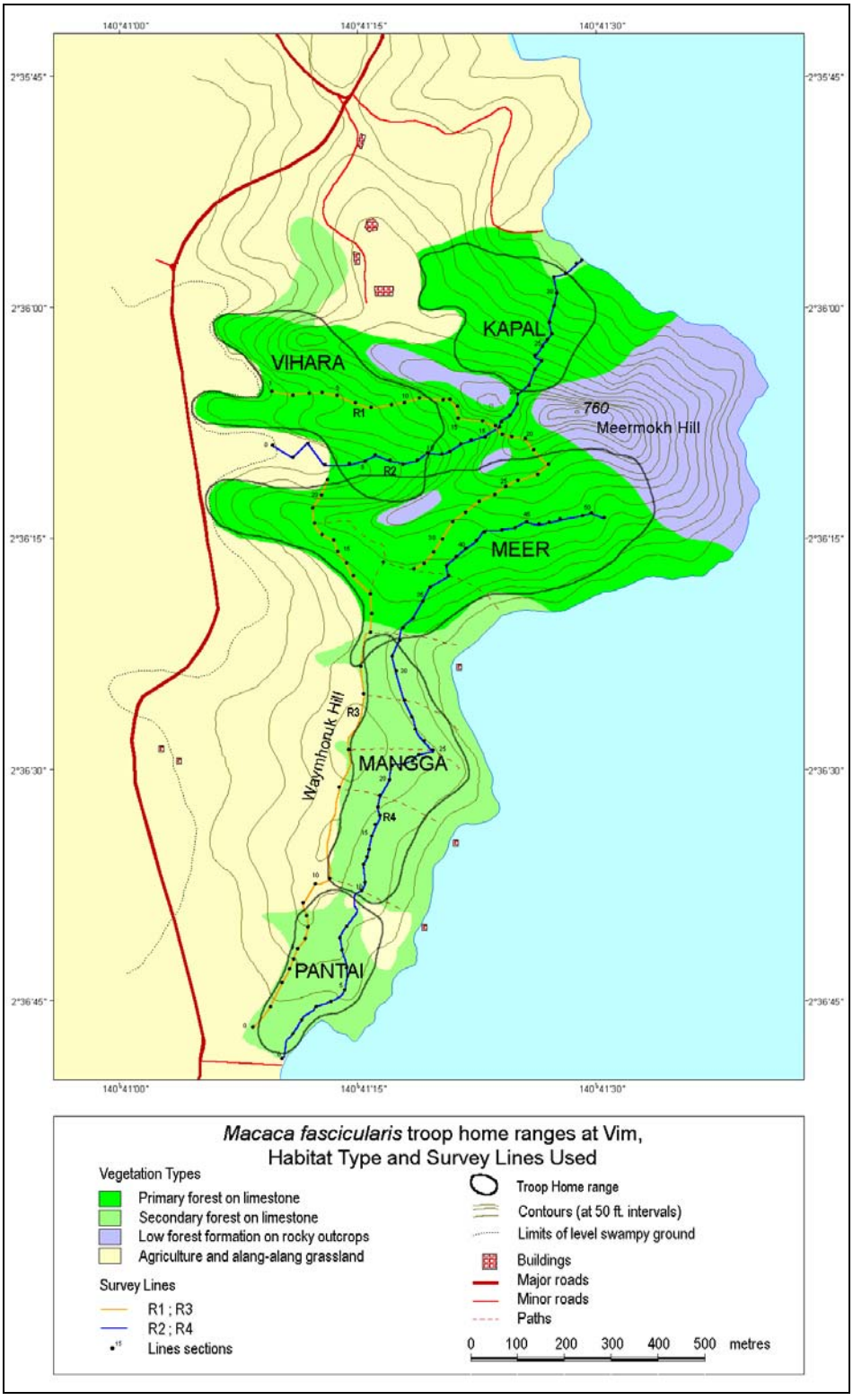


Figure 5: Home ranges of five *Macaca fascicularis* troops at Vim, Kotaraja.

The home ranges of Papua macaques are small (3 to 22 hectares) compared with those described in the literature (between 50 and 100 hectares) for *Macaca fascicularis* in their native range, which is also reflected in small group sizes.[22] This however reflects the small size of the troops. Despite the relatively small size of the ranges, their population densities are consistent with those described in the literature. The major exception is the Tanah Hitam troop, which because of the ample supply of garden crops allows for an artificially high density (but as a result are also reliant on crop-raiding for survival).

Small troop size may have been a reaction to disturbance and hunting, as suggested by Wheatley *et al.* (1999). Smaller troop sizes are harder to detect by humans than larger troops, and therefore there would be an introduced selective pressure towards smaller troops. In addition, the two single-male troops present in Papua may be due to the lack of predators (see Section 10.3.7).

10.3.6. Behaviour and troop structure

In the initial stages of the survey, troops were extremely difficult to observe, even with new paths cut within the forests of their home ranges. *Macaca fascicularis* troops in Papua (as elsewhere) are very wary of humans, and so gaining good observations at close range was generally difficulty throughout this project. Determination of populations, age class, and sex required repeated observations and cross-referencing of the overall dataset. Only two groups (Tanah Hitam and Mangga) became somewhat habituated to our presence after repeated contacts / observation by our team and baiting trials. Even so, habituation levels remained low.

10.3.6.1. Behaviour

Although predominantly arboreal, all Papuan troops spent significant amounts of time on the ground. Meer, Vihara, Mangga and Tanah Hitam troops were observed to rest closer to or on the ground during midday. The forest floor shows clear signs of pathways regularly used by *M. fascicularis* to move quickly through their home range. Macaques typically dropped to the ground when fleeing after spotting a human observer. Vihara, Tanah Hitam and Mangga troops were also seen feeding on the ground, either from natural food plants or bait that had our team had placed there. The macaques' willingness to feed and/or rest at or near the ground will allow significant advantages for the trapping of macaques in an eradication / control programme.

Other behaviours, such as social grooming, aggressiveness, vocalisation and mating are consistent with the literature on *Macaca fascicularis* within its native range.

[22] Troop sizes are determined through dynamic interactions between available forest size, food prevalence, and social relations between and within troops. We speculate that the reason for the relatively small troop size of Papua macaques is mainly influenced by the relatively limited availability of food resources, though it can be argued that social factors are as or more important.

10.3.6.2. Demography and sex ratios

Table 5 shows the population, sex and age structure of *M. fascicularis* in Papua.[23] As the age of adults in the literature is variable, as well as age structure for this survey being estimated from observations only, it is expected that slight errors in Papuan macaques' demography are inevitable and the following is only intended as a guide.

	Adults			Juveniles			Infants	
Troop	♂	♀	Total	♂	♀	Total	Total	Total no. of individuals
Kapal	1	2	**3**	?	?	**1**	**1**	**5**
Mangga	2	4	**6**	≥2	≥2	**5**	**2**	**13**
Meer	2	4	**6**	≥1	≥1	**4**	**2**	**12**
Pantai	1	2	**3**	?	?	**2**	**1**	**6**
Tanah Hitam	2	3	**5**	1	3	**4**	**1**	**10**
Vihara	2	4	**6**	1	3	**4**	**4**	**14**
Maunou (single individual)	1	-	**1**	-	-	**0**	**0**	**1**
Totals	11	19	**30**	(7)	(13)[24]	**20**	**11**	**61**

Table 5: Population, sex and age structure of *Macaca fascicularis* troops in Papua.

Adult sex ratios were more reliably determined than those of juveniles. Adult male: female ratios were 1:2 for five of the six troops; the remaining troop has a male: female ratio of 1:1.5. The average *adult* male: female sex ratio in Papua is 1:1.9. If we assume 1:1 male-female ratio amongst infants, the sex ratio for the entire Papuan population is 1:1.73. This is lower than those reported in the Poirer and Smith (1974) (see literature review), but may be explained where resource competition is low and there is reduced pressure on subadult males (Caldecott *et al.,* 1996).

10.3.6.3. Potential population increment

Ross (1992) has calculated the intrinsic rate of natural increase (r_m)[25] for *Macaca fascicularis* as 0.22. In other words, the natural reproduction rate for a population of one hundred *Macaca fascicularis* females is 22 infants per year. The figure has been calculated using an average age of first reproduction for females of 3.9 years, a between-birth interval of 1.1 years, and a maximum fertile age of 30 years old. Ross acknowledges that there are problems when using the intrinsic rate of natural increase to measure population growth; the equation assumes, for example, that offspring are 1:1 male-female.

[23] Adult females are defined as those bearing young, or thought of sufficient size to reproduce; for males: those seen to be sexually active with adult females, or of similar size. Juveniles are defined as those of a lesser size than individuals thought to be capable of reproduction, or those typically retaining close kinship ties with mothers. Infants were those being carried or closely tended by mothers. de Ruiter (1992) describes the age of adults as more than 5 years; 1-4 years for juveniles and <1 year for infants. Ross (1992) states the female mean age at first reproduction for *M. fascicularis* is 3.9 years.

[24] A hypothesized total number of male/females based on average adult male:female ratio of 1:1.9.

[25] The intrinsic rate of natural increase (rm) was calculated from Cole's (1954) equation where:

$$1 = e^{-rm} + be^{-rm(AR)} - be^{-rm(L+1)}$$

where b is the annual female birth rate (1.1 years), AR is the age at first reproduction (3.9 years), and L is the age of last reproduction (taken as 30 years in this case).

In using this equation to approximate future potential population growth, we must assume male: female pressure, using the average of 1:1.73 as found in the macaque populations in Papua, and apply it using the formula:

$$\text{Population } ♀_n = \sum ♀_{n-1} + (rm.\sum ♀_{n-1})/ 2$$

$$\text{Total Population}_n = \text{Population } ♀_n + \text{Population } ♀_n /1.73$$

This equation is based purely on the average reproduction rates of females, taking into account the natural death rate / limits of productive age of *M. fascicularis*. It does not factor in deaths due to disease or food competition. This equation and the figure derived from it should only be taken to illustrate the *theoretical* potential population growth based on documented studies of other *Macaca fascicularis* troops. We do not intend to assert that this is or will be the actual rate of population growth. Table 6 illustrates this hypothetical population growth using these formulae.

Year	Total Females (ad, juv, inf)	Potential New born	Female infants	Total No. of Males	Total Population
2003	38	8	4	22	60
2004	42	9	5	24	67
2005	47	10	5	27	74
2006	52	11	6	30	82
2007	58	13	6	33	91
2008	64	14	7	37	101
2009	71	16	8	41	112
2010	79	17	9	46	124
2020	224	49	25	129	354
2030	636	140	70	368	1004
2040	1806	397	199	1044	2850
2050	5128	1128	564	2964	8092

Table 6: Theoretical maximum potential population increment of macaques in Papua

The maximum potential increment (which does not include deaths caused through capture by man, or diseases) given an initial level of 38 female individuals[26] in 2003, produces another 8 individuals giving an adjusted total population of 67 in 2004. By 2010 the potential number of individuals could have reach 124, and by 2030 the number would have increased to over 1000. (N.B. This also assumes an ample unrestricted food supply through expansion of their range in Papua.)

These figures serve to illustrate the potential of *Macaca fascicularis* for rapid population growth given expanded range of habitat and other factors. If macaque populations experience protection from hunters and predators and find sufficient food resources, such as may happen if a population were to escape beyond the present range and into Papua's vast forest hinterland, it is conceivable that these figures may become operative. Given the right conditions (ample supply of food, access to new habitat, no hunting pressure), New Guinea could experience a population explosion of *Macaca fascicularis*.

[26] Assuming 1:1 ratio of male: female amongst infants.

It can be speculated that Papua macaques may still be in a lag phase of population growth. When introduced to a new location, alien species may reproduce at a slow rate for an indeterminate period of time while they adapt to the new environment, after which they enter a phase of rapid and exponential growth. This phenomenon is a common feature of biological invasions (Kowarik, 1995; Mack, 1985; Sakai et al., 2001). Many newly introduced species (especially plants, which are easier to track and thus well-documented) follow the population growth pattern shown in Figure 6.[27] The length of the theoretical lag phase varies, and may depend on (a) the species becoming adapted to local conditions and food resources, (b) establishing a viable population before reaching the point where it can expand rapidly, or (c) on a change in external conditions that allows the population to expand (ex. through expansion in the availability of preferred habitat).

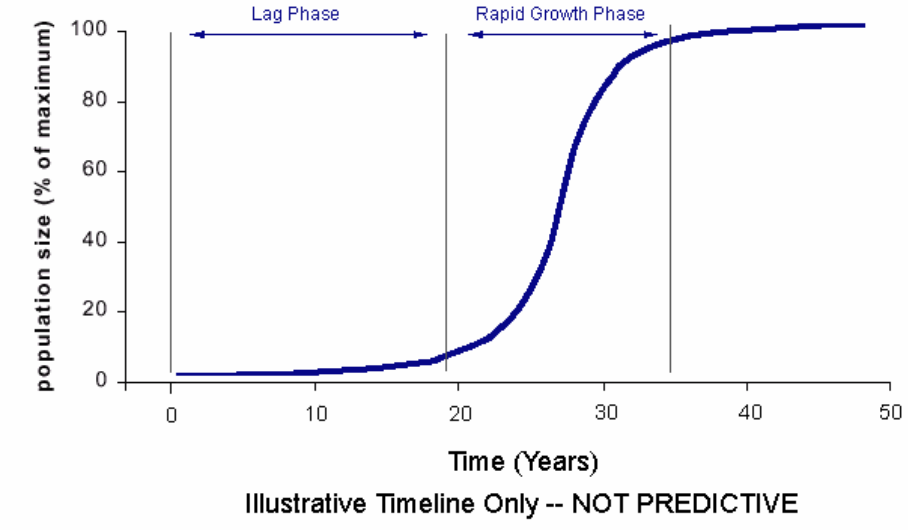


Figure 6: Timeline depicting theoretical population growth lag and rapid expansion phases; N.B. This is illustrative only

10.3.7. Predators and competitors

Except for humans and their hunting dogs, no large predators of *Macaca fascicularis* are documented in Papua. The only native species capable of preying on macaques are probably members of the family Boidae (boas and pythons), though various poisonous snakes may envenom *M. fascicularis*.

In areas we surveyed with macaques, native mammals were at a very low density and the evidence suggests that *M. fascicularis* poses a bigger competitive threat to these species than vice versa (see Section 11.2.4). We recorded large snakes (ex., *Morelia amethistina*) only from areas without *M. fascicularis*, which is suggestive of the same conclusion. The absence of such predators/competitors presents an ecological opportunity in the form of a

[27] Note that this figure is intended to be illustrative only. We do not suggest that this curve closely predicts the actual population growth of Papua macaques, only that the curve is generally accurate for many alien invasive species, and could eventuate for macaques in New Guinea, given the right conditions.

higher potential reproduction and survival rate in New Guinea than would occur in forests in the native range of *Macaca fascicularis*.

Hunting by humans is a significant threat to *M. fascicularis*. One hunter, Mr. Ruatakurei from Kotaraja, reported that he caught fourteen individuals within two years, which represents up to 20% of the total macaque population in Papua. It is possible that human hunting of these populations is the major factor that has limited their population expansion to date. Smaller troop sizes may be a reaction to such disturbance and hunting, as suggested by Wheatley *et al.* (1999). Smaller troop sizes are harder to detect by humans than larger troops, and therefore there would be an introduced selective pressure towards smaller troops. In addition, the two single-male troops present in Papua may be as a result of the lack of predators such as eagles or felids (van Schaik and van Noordwijk, 1983), since multi-male groups where males perform a greater defense and early warning role would be redundant.

11. Ecological Impact Study of *Macaca fascicularis* in Papua

Negative impacts from predation by exotics macaques on the Mauritian native fauna has been reported by Cheke (1987), Bright and Carter (1999), and Carter and Bright (2002). Birds suffer nest predation to eggs and hatchlings, and there is circumstantial and anecdotal evidence for attacks on adult birds. *Macaca fascicularis* has never been recorded preying upon small lizards, although this is suspected (Gibson *pers. comm*., 2002). Threats to native Papuan fauna through predation and competition from *Macaca fascicularis* have been hypothesized by conservationists but hitherto unproven.

11.1. Aims of ecological impact study

The project sought to gather information to measure the real or potential impacts of *Macaca fascicularis* on:

1. The native Papua environment, especially in respect to native species, due to macaques' alteration of habitat (such as dispersal of weed species, damage to native plants and seed stock);
2. Income and livelihoods of farmers caused by crop-raiding by macaques;
3. Human health.

11.2. Impact of *M. fascicularis* on the native environment and species

11.2.1. Experiment design and justification

To assess the impacts that *Macaca fascicularis* are having on the native species, a set of baseline biodiversity data for the area before the arrival of *Macaca fascicularis* would have been desirable. Unfortunately, however, to our knowledge no such study was ever conducted. In absence of these data, IPCA designed and carried out a plot-based comparison of sites. Paired sites with and without *M. fascicularis* were selected in both primary and secondary forests. Care was taken to choose sites that share a similar geology, topography, vegetation, climate and history of land use.

Ideally, replicate sites would have been chosen to show an array of possible impacts on biodiversity from the presence of macaques, and to make any statistical analysis more robust. However, as *M. fascicularis* only occurred in the one general location with secondary and primary forest (biodiversity surveys were not carried out in the outlying Tanah Hitam site as this was in disturbed sago forest, or with the single Maunou individual), this option was not available. The experimental design for measuring impact of *M. fascicularis* in two habitat types is illustrated in Figure 7 and represents the best possible design available for comparing possible impacts on biodiversity due to the presence of *M. fascicularis.*

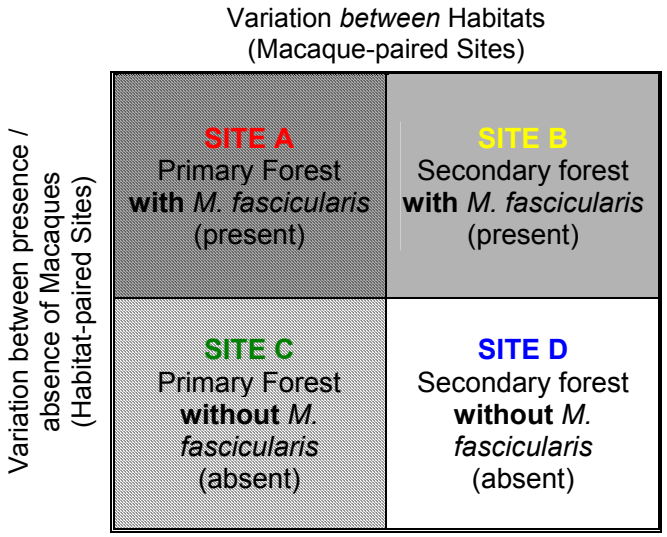


Figure 7: Experimental design for measuring impacts of *Macaca fascicularis*

Primary forest at Skyline (between S 2°35.022', E 140°41.439' and S 2°34.965', E 140°41.872') is inside the Youtefa Tourist Park (*Taman Wisata Youtefa*). This primary forest covers about 75 hectares, over limestone / karst, dominated by *Pometia pinnata*. It is located 1.5 kilometer north of Vim and is 0 – 150 metres above sea level. A secondary site was chosen at Nafri (between S 2°37.989', E 140°43,292' and S 2°38,034', E 140°43.807') was supported similar vegetation and topography as the site at Vim. Unfortunately, there was no similar vegetation site closer to Vim, however, this site was approximately four kilometres from the Vim sites and also located the shores of Youtefa Bay. A map of the locations is shown in Figure 8.

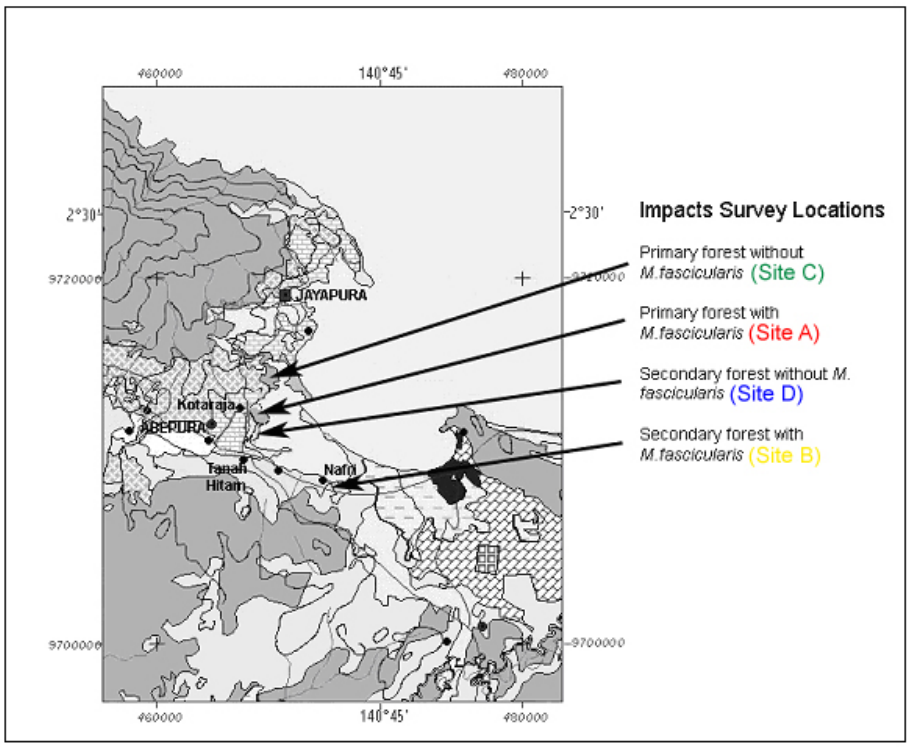


Figure 8: Map of locations for impact surveys

The impacts through predation by *Macaca fascicularis* on diversity of small lizards and birds has been the subject of other studies (and summarized in this paper; e.g. Carter and Bright, 2002, Gibson, 2002). We targeted these taxa for a comparison study on the effect of exotic *Macaca fascicularis* on native Papuan species. In addition to birds and lizards, large nocturnal mammals were surveyed, since they are reported to eat many of the same food species (Flannery, 1995) that we observed *Macaca fascicularis* to eat. Our hypothesis is that native New Guinea fauna may suffer stress through competition from macaques over food resources or suffer from direct predation.

11.2.2. Bird fauna surveys

11.2.2.1. Methodology

Birds were studied intensively as they are relatively easy to identify through vocalisations. Point census and adapted MacKinnon List (MacKinnon and Phillipps, 1993) methods were used by the IPCA team, assisted by UNCEN biology students. This method was used to quantitatively sample bird diversity wherein all bird species and their abundances were recorded within a 50m radius. Twenty replicate ten-minute point censuses were completed throughout Sites A, B, C, and D.

The MacKinnon list was used to qualitatively describe bird diversity. This methodology is useful in describing the relative "completeness" of a diversity sample, and has been used successfully by the first author to describe bird diversity in other parts of Indonesia. A list was made of all species discovered on site (including those already recorded by the point census). When a list of ten species had been reached, a new list was started.[28] A species could not be recorded more than once in any single list. A discovery curve was produced by plotting cumulative number of species encountered against the number of lists.

11.2.2.2. Results and conclusions

Results for the surveys are shown in Table 7.

	MacKinnon list method	Point Census method			
	No. of Bird Species recorded	No. of Species recorded	Mean no. of species	Mean no. of individuals	Shannon Diversity index
Primary with *M. fascicularis* (A)	**22**	**19**	**5.05**	**7.45**	**2.544**
Primary without *M. fascicularis* (C)	**33**	**27**	**6.55**	**11.06**	**2.720**
Secondary with *M. fascicularis* (B)	**26**	**22**	**4.85**	**7.13**	**2.545**
Secondary without *M. fascicularis* (D)	**36**	**31**	**7.35**	**14.33**	**2.819**

Table 7: Summary of results of bird surveys in primary and secondary forests with and without *Macaca fascicularis*

[28] Twenty species per list were used in the original methodology, but due to very low diversity in some sites, this number had to be reduced.

Higher numbers of bird species, as well as individuals, were recorded in sites without *M. fascicularis* in point censuses. Similarly, the bird species discovery curves are steeper and higher for sites without *M. fascicularis* (Figure 9), illustrating a higher diversity for sites where *M. fascicularis* is absent. Secondary sites were also more diverse than the paired primary sites.

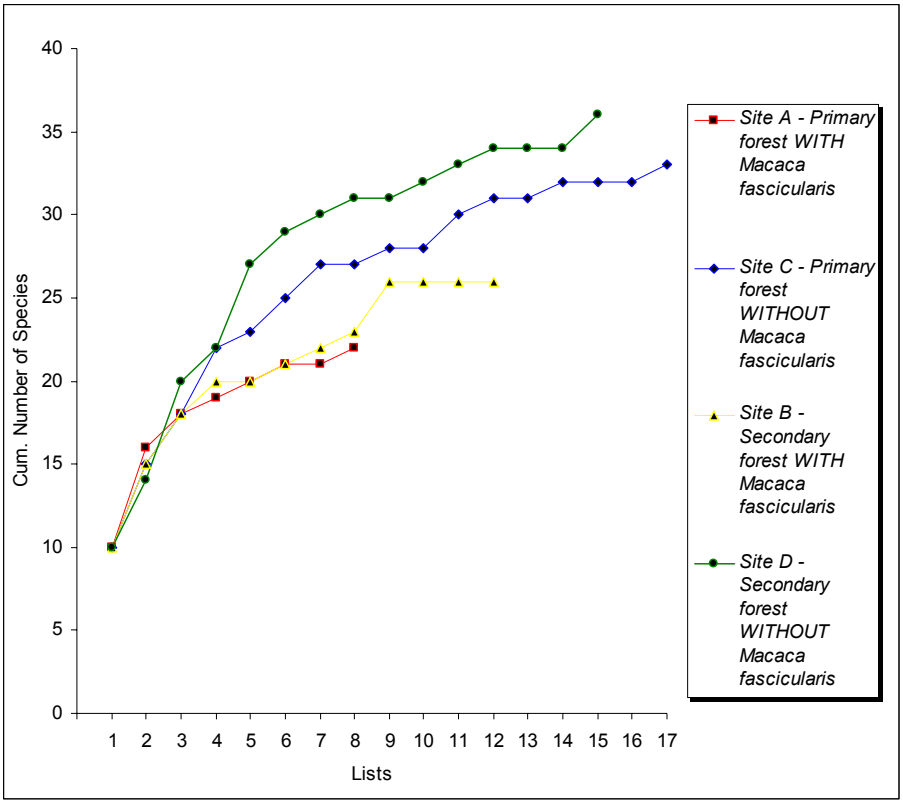


Figure 9: Bird species discovery curves generated from MacKinnon List method

Two-way Analysis of Variance (ANOVA)[29] was used to investigate the effect of the independent variables (viz., secondary or primary habitat; and presence/absence of *Macaca fascicularis*) on mean number of species and abundance recorded in twenty point census replicates. The results of the ANOVA are displayed in Table 8.

ANOVA
Diversity of birds in point census samples

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	
Habitat (Primary/Secondary)	1.8	1	1.8	0.45	0.51	Not significant
Presence of *M. fascicularis*	80	1	80	19.80	2.89 E-05	Highly Significant
Interaction	5	1	5	1.24	0.27	Not significant
Within	307	76	4.04			
Total	393.8	79				

ANOVA
Average abundance of birds in point census samples[30]

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	
Habitat (Primary/Secondary)	0.04	1	0.04	1.20	0.28	Not significant
Presence of *M. fascicularis*	1.13	1	1.13	31.64	2.94E-07	Highly Significant
Interaction	0.09	1	0.09	2.38	0.13	Not significant
Within	2.71	76	0.035			
Total	3.98	79				

Table 8: Results from ANOVA (Analysis of Variance) tests for bird fauna

The difference in average diversity (the number of bird species recorded) between the sites with *M. fascicularis* present and sites with *M. fascicularis* absent (i.e. difference between sites A & C and between B & D) is highly significant ($F_{1.76}$ = 19.804, P <0.001). The difference in average abundance (number of individuals recorded) between sites with *M. fascicularis* present and sites with *M. fascicularis* absent (i.e. between sites A & C and between B & D), is also highly significant ($F_{1.76}$ = 31,644, P <0.001). ***Thus, there is a statistically significant correlation between the presence of* M. fascicularis *and lower bird numbers and diversity.***

Differences in average number of species and individuals recorded in point censuses between habitats (with or without *M. fascicularis*) were not statistically significant. In other words, the variation in habitat (primary to secondary) between sites that (a) either supported, or (b) did not have *M. fascicularis*, did not have an effect on bird species diversity or their abundance. The interaction between habitats and the presence/absence of *M. fascicularis* showed no statistical significance for number of species and individuals, therefore there was no complex interaction effect between the independent variables.

Analysizing the data qualitatively, there are noticeably fewer species and lesser abundance of pigeon (Columbidae), parrots (Psittacidae), birds-of-paradise (Paradisaeidae) and frogmouths (Podarigidae) in sites with *M. fascicularis*. These species (many of which are endemic to New Guinea) may be more susceptible to any nest predation or competition for food resources inflicted by *M. fascicularis*. The design of our surveys did not allow us to test

[29] See for example: Wilson, R.S. (2001). *Geographic variation in thermal sensitivity of jumping performance in the frog Limnodynastes peronii*. The Journal of Experimental Biology 204, 4227-4236. Online at: http://jeb.biologists.org/cgi/content/full/204/24/4227#CHRISTIAN-AND-TRACY-1981

[30] Transformed values of number of individuals were used in the ANOVA as the variance was larger than the mean.

this hypothesis. It is suggestive that we were unable to locate any bird nests at all within *M. fascicularis'* home ranges (even though more survey time was spent in those areas), while several nests were recorded in the comparison sites.

11.2.3. Reptile fauna surveys

11.2.3.1. Methodology

Assisted by a team of UNCEN students, IPCA set up twelve standard 5 x 5 metre litter plots were established randomly along observation trails in each of the four sites to capture small reptiles. Five to eight people carefully searched the forest floor litter starting from the edges of the plot slowly moving towards the centre. Species were given an individual number and described. Most species in the samples were identified to genus, and those of the genus *Emoia* were identified further to species level. A summary of these results is shown in Table 9. Detailed results of the litter plot sampling are given in Appendix 6.

	Litter Plots (total 12, 5 x 5metres)				
	Total no. of Reptile Species recorded	Mean no. of species (per plot)	Total no. of individuals recorded	Mean no. of individuals Per plot)	Shannon Diversity index
Primary with *M. fascicularis* (A)	**2**	**0.25**	**3**	**0.25**	**0.637**
Primary without *M. fascicularis* (B)	**13**	**2.58**	**41**	**3.41**	**2.206**
Secondary with *M. fascicularis* (C)	**3**	**0.25**	**3**	**0.25**	**1.099**
Secondary without *M. fascicularis* (D)	**8**	**1.92**	**37**	**3.08**	**1.949**

Table 9: Diversity and abundance of reptile species found in 12 litter plots in four sites

11.2.3.2. Results and conclusions

The difference between sites with without *M. fascicularis* was dramatic for lizards, both in terms of abundance and species diversity. Many more species and individuals were found in the sites without *M. fascicularis*. The primary forest site without *M. fascicularis* (Site A) was the richest site.

A two-way Analysis of Variance (ANOVA) was used to investigate the effect of the independent variables (viz., secondary or primary habitat; and presence/absence of *Macaca fascicularis*) on mean number of species and abundance recorded in twelve point census replicates. The results of the ANOVA are displayed in Table 10.

ANOVA
Diversity of lizards in 12 litter plot samples

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	
Habitat (Primary/Secondary)	1.33	1	1,33	0.94	0.337	Not significant
Presence of *M. fascicularis*	48.0	1	48	33.88	6.18E-07	Highly Significant
Interaction	1.33	1	1,33	0.94	0.337	Not significant
Within	62.33	44	1,42			
Total	113	47				

ANOVA
Abundance of lizards in 12 litter plot samples

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	
Habitat (Primary/Secondary)	0.33	1	0.333	0.099	0.75	Not significant
Presence of *M. fascicularis*	108	1	108	32.035	1.06 E-06	Highly Significant
Interaction	0.33	1	0.333	0.099	0.75	Not significant
Within	148.33	44	3.371			
Total	257	47				

Table 10: Two-way Analysis of Variance (ANOVA) for reptile samples in four sites

Similarly to the bird fauna surveys, the difference in average diversity (the number of lizard species recorded) and average abundance (number of individuals recorded) between the sites with *M. fascicularis* present and sites with *M. fascicularis* absent (i.e. difference between sites A and C and between B and D) is statistically significant ($F_{1.44}$ = 33.88, P << 0.001 and $F_{1.44}$ = 32.035, P<< 0.001). ***The presence of* M. fascicularis *exhibited a highly significant negative effect on numbers and diversity of lizards*.**

Differences in average number of species and individuals of lizards recorded in litter plots between habitats with or without *M. fascicularis* (i.e. difference between sites A and B and between C and D) were not statistically significant. In other words, the variation in habitat (primary to secondary) between paired sites that either (a) supported or (b) did not support *M. fascicularis*, did not have an effect on bird species diversity or their abundance. The interaction between habitats and the presence/absence of *M. fascicularis* showed no statistical significance for number of species and individuals, therefore there was no complex interaction effect between the independent variables.

11.2.4. Mammal and large reptile fauna surveys

11.2.4.1. Methodology

Each of the four sites A, B, C, and D was surveyed by the IPCA project team and UNCEN students. Three teams composed of two to four members used flashlights to survey along paths between the hours of 20:00 and 02:30. Each of the sites was surveyed with approximately the same time and effort.

All animals encountered were described as accurately as possible by the observer. These observations were recorded and identifications made by reference to standard New Guinea mammal and reptile books (Flannery, 1995 and O'Shea, 1996). Sampling mammals and

larger reptiles using this method was relatively unproductive and low numbers of species and individuals were recorded in all sites. Due to the onerous time and manpower demands of this type of survey, only a single night was spent in each of the sites.

11.2.4.2. Results and conclusions

The results are displayed in Table 11. Small, but potentially ecologically significant differences between sites were noted. No larger arboreal mammals were found in the secondary site where *M. fascicularis* was present (Site B). Visibility was the best at this site yet only the small nectar feeding *Petaurus breviceps* was found. The large slow moving Common Spotted Cuscus (*Spilocuscus maculatus*) was found in both sites without *M. fascicularis* (i.e. C & D), whereas the Northern Common Cuscus (*Phalanger orientalis orientalis*) was observed in the primary site with *M. fascicularis* (Site A) where *Pometia pinnata* (a food plant) is dominant.

Only one species of large snake was recorded, *Morelia amethistina amethistina* and only in sites without *M. fascicularis* (Sites C & D). Smaller ground-dwelling and arboreal snakes were recorded from sites that supported *M. fascicularis*.

Though there is still insufficient census data to draw proper conclusions, the data that we collected do support the hypothesis that *M. fascicularis* negatively impact large mammals (especially Phalangeridae[31]) and reptiles, through increased competition over food resources. Increased competition on these mammals may reduce successful reproduction and therefore reduce food supplies for larger predators such as *Morelia amethistina*.

	Species	English Name	Primary forest with *M.fascicularis* Site A	Primary forest without M.*fascicularis* Site C	Secondary forest with *M.fascicularis* Site B	Secondary forest without *M.fascicularis* Site D
MAMMALS						
Dasyuridae	*Murexia longicauda*	Short-furred Dasyure	1 (?)			
Peroryctidae	*Echymipera kalubu*	Common Echyimpera	2 (?)		3	3
	Echymipera (clara ?)	Clara's Echymipera				1
	Sp.	Unidentified Peroryctid		1		
Phalangeridae	*Phalanger orientalis orientalis*	Northern Common Cuscus	1			
	Spilocuscus maculatus	Spotted Cuscus		1		1
Petauridae	*Petaurus breviceps*	Sugar Glider			1	
Muridae	*Pogonomys* (*loriae ?*)	(Large) Tree-mouse		1		
	Sp.	Other unidentified Murid		1		
REPTILES						
Pygopodidae	*Lialis jicari*	New-Guinea Snake-Lizard			1	
Boidae	*Morelia amethistina amethistina*	Amethystine Python		1		1
Colubridae	*Stegonotus sp.*	Ground Snake	1			
	Dendrolaphis sp.	Treesnake		1		

Table 11: Mammal and large reptile records from night surveys

[31] No Macropodidae were found in the area, as they were probably hunted out long ago; no conclusions can therefore be drawn for that family.

11.2.5. Alteration of habitat by *Macaca fascicularis*

Macaca fascicularis has been recorded in other locations to have direct and indirect impacts on the environment by damaging native plants and by spreading seeds of native and non-native plant species. Over the medium- to long-term, this can result in major alterations to forest habitats, such as has been the case in Mauritius.

Today there are an ever-increasing number of exotic plants that are spreading throughout Papua. Weedy species in general usually exploit the forest edge and disturbed habitats which are also preferred habitat for macaques. If the range of *M. fascicularis* increases, macaques may indeed play an important role in the spread of exotic weeds and alteration of habitats in Papua in the future. IPCA recorded an exotic plant species, *Passiflora suberosa*[32] in areas very close to the home ranges of *M. fascicularis* troops in Papua. Although further confirmation is needed, it is thus possible that Papua macaques may enhance the wider spread of this potentially "habitat-altering" plant if *M. fascicularis*' range coincides with that of *P. suberosa* in the future. *Macaca fascicularis* eats the fruits of exotic plants such as *Passiflora feotida*, and may spread these species to gaps within the forest interior.

In Papua, we recorded *M. fascicularis* eating and destroying the large seeds of *Intsia bijuga*, a commercially and culturally valuable hardwood timber species. However, the regeneration of this species is still good with many seedlings in the understory. Smaller seeds of figs, *Halfordia papuana, Celtis latifolia* etc. are spread in faeces but no one of these native trees totally dominates the forest stand.

At present low levels, *M. fascicularis* probably does not significantly alter the floral ecology and composition of forest tree species by damaging native seed stock or improving seed dispersal of certain species (including exotics), although more research is needed on this subject.

11.3. Economic impacts of *M. fascicularis* in Papua

The impact of main concern to farmers in regard to *M. fascicularis* is crop raiding. A summary follows describing and assessing losses sustained by farmers with fields adjacent to macaque troops in Papua.

11.3.1. Cassava (*Manihot esculenta*)

A large proportion of the cassava crop in the Jayapura area is grown for the leaves which are eaten as a vegetable, and often constitutes a main source of income for farmers. If the leaves are harvested (i.e. by macaques), the cassava roots do not develop well, and the product cannot be sold at market. When macaques uproot these plants they are rewarded with small roots, and therefore they tend to uproot even more plants until satisfied.

[32] *Passiflora suberosa* has only been recorded at one site in Papua, less than 500 metres away from the nearest macaque population. At this site, *P. suberosa* forms dense creeping and climbing mats, smothering vegetation. Although most vigorous in disturbed sites and forest edge, is has been found in primary forest.

A single farmer adjacent to the Mangga and Pantai troops estimated a personal monthly loss of Rp.100,000 (approx. USD $11.90) per month due to crop raiding. This informant reported that he repeatedly has to spend extra time re-planting cassava plants that have been ripped out of the ground by macaques. We observed that in some instances, up to 5% of a given crop was uprooted in a single field in a single raid by macaques. Crop losses do not seem to be evenly spread through the year, and the greatest losses are inflicted during the dry season (April to August) when the macaque's natural food resources are low. At these times, farmers adjacent to macaque areas are often extremely hard hit. The total loss for all four households of farmers is estimated at approximately Rp.4,000,000 (approx. USD $475, or $125 per household) per year.

11.3.2. Coconut (*Cocos nucifera*)

IPCA recorded 162 mature coconut trees that were harvested by the Mangga and Pantai macaque troops. Due to massive crop-raiding by macaques in which the animals took the nut before they were of marketable size / maturity, local communities stopped harvesting coconuts long ago. The local market price of a coconut is about Rp. 500, and a single mature tree can produce an average of 250 coconuts per year[33]. We conservatively estimate a total cash loss for the immediate area of Rp. 20,250,000 (approx. USD $2,420) per year to (would-be) local coconut harvesters. This represents a very significant loss of income to poor villagers.

11.3.3. String Beans (*Vigna unguiculata*)

There were several reports from farmers of the total failure of their crop due to *M. fascicularis* crop raids. Macaques tended to strip the beans just days before the farmers had planned to harvest them. Estimated losses were between Rp.100,000 – Rp.250,000 (approx. USD $11.90 to $30.00) per farmer depending on the size of their fields. This does not include the opportunity cost of time wasted in clearing, planting and tending the crops during the two months prior to the would-be harvest. Now the crop is guarded closely before harvest to ensure that the fields are not raided.

11.3.4. Mangos (*Mangifera indica*)

The year 2002 was an especially good year for mangos. We estimate that up to 2 metric tonnes of mangos were consumed or damaged (partially eaten or picked before being ripe) by Mangga and Pantai troops during the months of the November and December fruiting season. Indeed, judging from our examination of macaque faeces and the proximity of the troops to the mango groves within their home range, it is not unreasonable to conclude that the diet of these troops in these months was almost totally comprised of mangos. With a market price at the time of Rp. 2,500 per kilo, we estimate that macaques resulted in the loss of a potential Rp. 5,000,000 (approx. USD $597) for the local community.

11.3.5. Other Crops

Other crops were also commonly raided, especially fruit (papaya, bananas) around Tanah Hitam troop. This has affected many local residents, although because most of these crops are grown for household consumption, it probably causes little in the way of loss of potential household income. It is unlikely that individual households replaced these crops with bought

[33] Average annual harvest stated by coconut sellers at Skyline on the Abepura–Jayapura road. Older trees can produce up to 500 coconuts a year.

goods. However, the negative impact on the nutrition of poor farmers and their families probably constitutes a very real, if unquantifiable, loss to rural livelihoods.

11.3.6. Economic Losses

A rough estimate of the total damage to the rural economy from macaque crop-raiding of cassava, coconuts, string beans, mangos, and other crops in the Kotaraja area is therefore on the order of Rp. 30,000,000 per year (approx. USD $3,500 / year). This represents a significant economic loss to poor farmers, and an additional challenge with which they have to cope. All the farmers interviewed by IPCA agreed that the removal of the macaques would have a significant positive benefit to their livelihoods.

It is also important to note that these figures are for a relatively very small area affected by macaques (probably less than 100 hectares of farmed land). Should macaque populations somehow become widespread throughout New Guinea, it is not hard to extrapolate from these figures to calculate the potential for economic damage to Papua and PNG's rural economies. Already among the poorest economies in the world, the added losses from macaque damage would likely bring additional difficulties in adequately feeding an expanding human population in these areas.

11.4. Public and Animal Health Concerns and Potential Impacts

M. fascicularis is the carrier of a number of diseases that can potentially spread to humans (Brown, 1997; Baskin, 1999). Judging from the proliferation of scientific articles on the subject, of highest concern to the scientific and health communities is the threat of rabies and B-virus (*Herpesvirus simiae*).

It was unknown until the present survey whether or not *Macaca fascicularis* populations in Papua harbour disease. IPCA captured and autopsied four individuals after humane lethal injections by the Livestock Clinic and Laboratory in Jayapura; brain tissue was sent to Animal Clinic and Laboratory, Maros, Sulawesi Selatan for further investigation. The test results showed that the four individual *M. fascicularis* samples were rabies-free. Pathological tests on brain tissue were negative and showed healthy, normal tissue free from past diseases. Poxvirus was negative for all individuals. B-virus, hepatitis and other viruses could not be tested using these samples.

Blood serum was also collected from the four animals to test for viral infection and viral antibodies to past infections. Unfortunately, we found that no facilities currently exist within Indonesia that can test for specific zoonotic viruses that are pathogenic in humans such as B-virus, hepatitis, and other human pathogens commonly found in macaques (c.f. Brown [1997), Baskin [1999], mentioned in Matsubayashi *et al.* [1992]). The blood material (1ml of blood in 1ml of alcohol) is currently being stored in the first author's refrigerator in Surabaya. Permission from the Government of Indonesia is still needed to export this material for testing. Given the intricacies of Indonesian bureaucracy, such permission is difficult to obtain, and the assistance of Indonesian researchers is requested.

IPCA had several discussions with the Department for Animal Quarantine (DAQ) in Papua. The staff there were already aware of the potential human health issues posed by exotic macaques in the province. Papua is officially a "rabies free" area, although the disease is

present at low levels in other parts of the Indonesian archipelago. The Department of Animal Quarantine (DAQ) is aware of the potential rabies threat (though not necessarily B-virus) posed by *Macaca fascicularis*, and on this basis importation of the species is banned. They have adopted a precautionary approach in terms of macaques' risk to public health, and the DAQ policy is that no macaques are allowed to be brought into Papua.

Given the extreme virulence of B-virus in particular, a precautionary approach should be applied. Unless proven otherwise, it should be assumed that zoonotic viruses endemic to *M. fascicularis* are present in Papuan populations. It should also be assumed that they do pose a potential heath threat to humans and livestock, though the risk is probably vanishingly small to anyone except those in direct contact with animals. There is a viral transmission risk from Papuan macaques to hunters, since their potential exposure to bites or blood material is high. Due to the relatively small number of individual macaques currently present in Papua and their general isolation from human communities and livestock (except, notably, those macaques at Tanah Hitam), the risk of incidental viral spread from macaques to humans is probably very small.

If a population control program for Papuan macaques is undertaken at some time in the future, any effort that involves handling live, anaesthetized, or dead macaques must involve special precautions (gloves, body protection, glasses, etc.) to protect against transmission of disease through bites, scratches, or splashes. A supply of antiviral medication (acyclovir or valacyclovir) will be required for anyone requiring post-exposure prophylaxis.



Plates 1-8 : (Clock-wise from top left).
1 : Dominant (alpha) adult male in Tanah Hitam Troop.
2 : Infant from Tanah Hitam Troop.
3 : Adult female from Tanah Hitam Troop.
4 : Two juveniles from Tanah Hitam Troop.
5 and 6 : Adult male feeding in ***Ficus benjamina***, from Vihara troop.
7 : Dominant (alpha) adult male from Mangga Troop.
8 : Adult female from Mangga Troop.

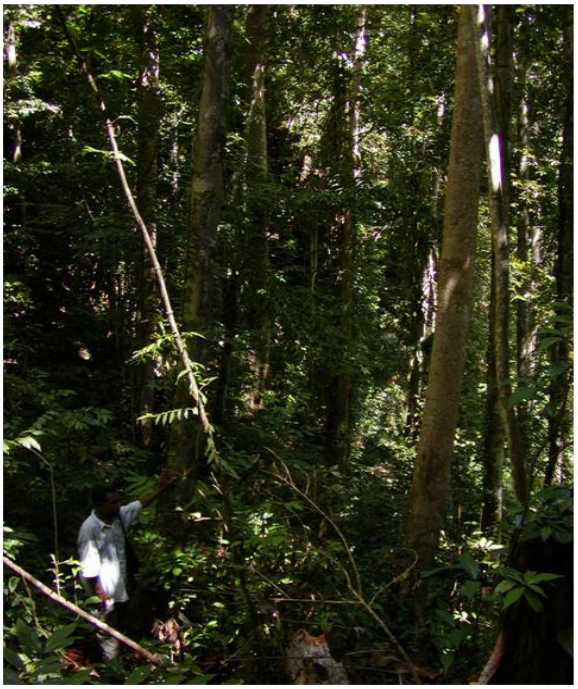


Plate 9 : Primary forest with Meer Troop home range.



Plate 10 : Coconuts eaten by macaques (Mangga Troop).



Plate 11 : Damaged / half-eaten Mangoes and Pineapple shoots littering the forest floor.



Plate 12 : Macaque Impact Survey work. (left Reptile litter plots in progress and (right compilation of result from night survey teams.



Plate 13 : (right) Common Spotted Cuscus (***Spilocuscus maculata***) recrded during night surveys.

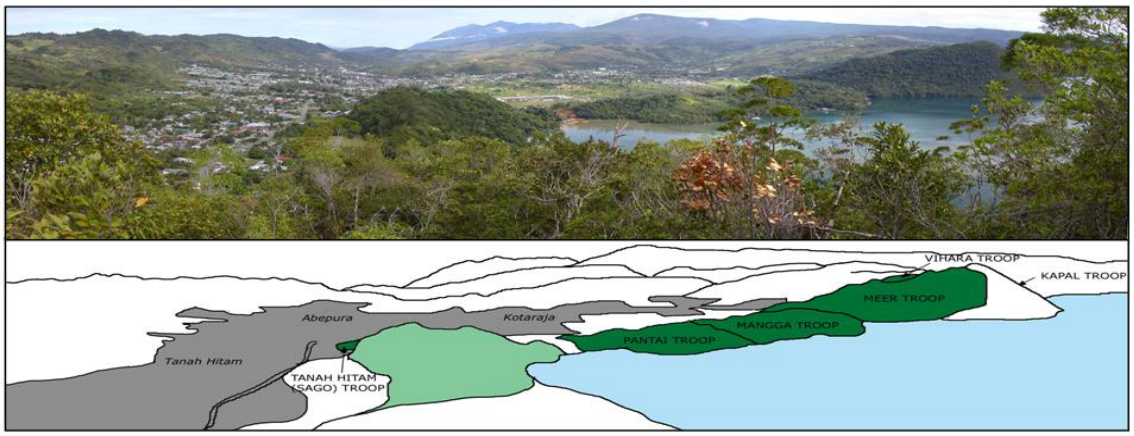


Plate 14 : Panoramic views of Troops home ranges and the towns of Tanah Hitam, Abepura and Kotaraja.

12. Detection, prevention, and quarantine issues related to Papua macaques

12.1. Prevention

Although it is too late for prevention of *M. fascicularis* introductions in the Jayapura region, prevention of introduction to other parts of Papua is important to stop additional establishment of populations in the wild. It is important to analyse the possible pathways of introduction of macaques into Papua, to prevent further introductions in the future.

This inadequacy of quarantine and detection capacity is all-the-more critical since Papua is the gateway to Australasia and the Pacific from Asia and visa versa. It is not a stretch to suggest that Papua the most likely pathway for exotic species of Asian origin to be introduced to PNG, and ultimately Australia and the Pacific islands. The prevention of alien species becoming established and invasive in Papua is therefore of strategic importance not merely to the biodiversity of Australia, Papua New Guinea and other Pacific Rim countries, but to the economies of those nations as well. Of course, it is also quite possible for the flow of introduced species (and diseases) to come from the east into Indonesia and quarantine service inspections of imports from PNG are also lacking.

12.2. Potential for future introductions

This survey clearly showed that economic migrants (as well as individuals from the police and military) do carry alien species to Papua, including macaques, for sale upon arrival or to keep as pets. This processes continues relatively unchecked due to the migrants' persistence and ingenuity for bringing economically valuable exotic species into (and exporting endemic species out of) Papua.

IPCA had several discussions with the Department for Animal Quarantine (DAQ; part of the Ministry of Agriculture) in Papua, and they indicated that they were already aware of the potential human health issues posed by exotic macaques in the province. Their policy is that no macaques are allowed to be brought into Papua. The DAQ is authorized to screen for all animals that are potential vectors of this disease (including *M. fascicularis*) at points of entry into Papua (seaports and airports) by visual searches of suspect cargo. When suspect cargo are detected they are to be either destroyed or returned (Elias Inte, pers. comm., 2003.) IPCA made requests to the DAQ office for a copy of the written regulations or policy with regards to importation of macaques to Papua, but it was never provided, perhaps because it is an unwritten policy.

However, the quarantine mechanism in Papua is prone to serious breaches, since the financial and manpower capacity of the DAQ is low and the number of ports and volume of cargo is high. Though no instances of *M. fascicularis* have been officially reported in recent years (Elias Inte, pers comm., 2003), IPCA heard credible reports from local community leaders that individual pet macaques still occasionally arrive in Papua unnoticed by government authorities. Indeed, DAQ reported to IPCA that macaques probably do slip through ports and airports undetected (Inte, pers comm., 2003). Clearly, to prevent exacerbation (i.e. macaque dispersal through a "range jump") or repetition of the problem,

DAQ needs greater funding and training in order to have a merely adequate capacity to inspect cargo.

In our discussions with officials in Vanimo, the National Agricultural Quarantine Inspection Service of Papua New Guinea (NAQIS) indicated that they are alert to the potential for *M. fascicularis* to cross the border into PNG, either through human-assisted transport, or by expansion of its range in Papua. Though the latter is very unlikely in the short to mid-term through natural spread, it could more easily happen through a range jump if pet macaques were brought to a new settlement and released/escaped. NAQIS routinely checks all baggage of persons coming into PNG from Indonesia, as well as through patrol checks to border communities. IPCA interviewed staff at the NAQIS in Vanimo, and to date there are no reports of *M. fascicularis* in the border areas of PNG.

12.3. Institutional capacity enhancements required

Animal quarantine services in Papua are minimal and thus largely ineffective to the possibility of macaques (as well as other exotic animals, plants, pests and diseases) being carried in by humans from western Indonesia. In short, given inadequate manpower, weak institutional capacity, and the numerous ports of entry and human arrivals in Papua, it is clear that DAQ is not an effective institution. This is not a criticism of DAQ, but rather simply recognition that their sincere efforts are limited by lack of capacity and funding, and by the sheer scale of the endeavor.

The inadequacy of quarantine and detection capacity in Papua has have been identified by AusAid and the *AusAid Irian Jaya Quarantine Animal and Plant Health Support Project* is attempting to improve the situation. We quote information concerning this important project directly from Shearman (2001):

> A major AusAid project is planned for commencement in 2002. It will be implemented by Biosecurity Australia and the Northern Australia Quarantine Strategy (NAQS) of the Australian Quarantine and Inspection Service (AQIS) in partnership with the Indonesian Centre of Agricultural Quarantine (CAQ – which consists of two departments -- Animal and Plant Quarantine). The project will be largely funded by the Australian Government Sector Linkages Program of AusAID. Its primary aim is to increase the level of protection for agricultural enterprise in Irian Jaya and in so doing, reduce the risk of pest incursion into Papua New Guinea and Australia. Specific components include:
>
> - Quarantine support by provision of public awareness materials and presentations at sites in Papua and, if deemed worthwhile, outside Papua at sites like Ujung Pandang (Makassar) airport.
> - Assistance to CAQ in Papua with advice on Provincial quarantine legislation.
> - Enhancement of CAQ capability within Papua on aspects of plant health and quarantine.
> - Animal and plant health surveys in Papua to further define the health status of the Province.

- Training for veterinarians in Papua in planning emergency animal disease management.

The component aimed at improving Provincial legislation is seen to be particularly important, given that CAQ does not currently have the jurisdiction to carry out proper assessments. If successful, the expected benefits of legislative change are to increase powers of quarantine inspectors to inspect sea-craft of all types, preferably before docking, and aircraft. The legislation should also require vessels to report their intended arrival, enabling inspection to take place off-shore. Contact: Tim Buick, Senior Veterinary Officer, Biosecurity Australia. Phone (02) 6272 4920; Fax (02) 6272 3399, E-mail: Tim.Buick@affa.gov.au

We have no additional details on this program[34] or its current status, but clearly the endeavor is an extremely important one worthy of continued support from the donor, conservation, and scientific communities.

12.4. Policy-level changes needed

DAQ also requires enhanced authority to properly regulate the import of species such as *Macaca fascicularis*, which is a policy-level objective best pursued at the Jakarta and Jayapura provincial government levels. As long as animals are disease-free, many potentially invasive exotic species are legally permitted to be brought into Papua from Java, Sumatra and Sulawesi.[35] Since they are legally categorized merely as an "Indonesian species", individual macaques that are certified to be free of rabies are theoretically allowed to be brought into Papua (Inte, pers comm., 2003).

Apart from official concern over possible spread of diseases that attack economic crops, there is no legislation to differentiate between native species from the three bioregions within Indonesia (Sundaland, Wallacea and Sahul [New Guinea]). The notion among policymakers, law enforcers, and other stakeholders that macaques are simply an "Indonesian species" – and thus acceptable anywhere in Indonesian territory – is a dangerous but widespread misconception, and one that could lead to an exacerbated macaque problem and/or other serious invasive species problems in the future, in Papua or elsewhere.

It is increasingly recognized that the threat to biodiversity posed by invasive species is second only to direct habitat destruction, and so not to enhance understanding of these issues would be a serious mistake. Given other major political and economic issues in Indonesia today, putting this issue on the policy "radar screen" will require real commitment and finesse. Clarification of the official government policy regarding the transport of species around the archipelago that – at the very least – recognizes and differentiates between the

[34] The relationship of the Centre for Animal Quarantine and the Department of Animal Quarantine is unclear, though presumably they are linked (? if not synonymous).

[35] Other serious invasive pests already established in Papua include fishes such as Striped Snakehead (*Channa striata*; a notorious predatory fish brought in by transmigrants from Sulawesi as a food item and now found in abundance in Sentani, Timika, Waigeo, and other locations), Climbing Perch (*Anabas testudineus*; now found along the south coast from Timika to the Morehead River in PNG), Tilapia (*Oreochromis mossambica*; now abundant in various locations in Papua and PNG), and Walking Catfish (*Clarias batrachus*; now in Vogelkop, Sentani, and Timika). See Allen, G.R. et al., 2000.

three major biogeographic realms found in Indonesia is urgently needed. New regulations restricting the transport of species from one area to another are required. Although effective legal enforcement of any such new regulations is unlikely anytime in the near future, the authority thus provided by such legal recognition would be of great benefit in itself to conservation organizations.

We urge conservation organizations – particularly WWF, CI, and TNC, which have uniquely strong access to policymakers – to prioritize alien and invasive species issues in their programmes in Indonesia. We are less familiar with the institutional capacity and level of policymakers' understanding of invasive species issues on the PNG side of the island, though similar efforts among political leaders and bureaucratic officials would certainly be highly beneficial.

13. Baiting and Trapping Trials

13.1. Baiting

As described below in Sections 15.2 – 15.3, Eradication and / or Control will require the removal of individual macaques from the area. Containment may require the removal of rogue individuals that have spread outside the set limits of a particular area. As macaques generally are difficult to catch alive (a fact verified by local Papuans and hunters), IPCA designed and carried out baiting and trapping trials to ascertain the level of difficulty that would be involved in a future control strategy for Papua macaques.

Baiting trials were carried out throughout the month of February 2003 with Mangga troop, since this troop seemed to be the most sensitive to human activity and the quickest to flee after human detection. A feeding station was set up in a location nearby to where the troop was frequently encountered in the afternoons. The station was baited with ripe bananas and maize tied firmly to branches. After three days the troop was accustomed to taking the food. A hierarchy or "pecking order' was clearly visible, with the adult males approaching the bait first, followed by females and their young, and lastly by other males and juveniles. Maize was usually taken in preference to bananas. If food was sufficiently supplied, most or all individuals at the feeding station received some food. After nine days the macaques were sufficiently habituated to allow IPCA/UNCEN team members to openly approach the feeding station to within 30 metres and take photographs. The macaques also became accustomed to waiting for our staff to set up the feeding station. Importantly, however, baiting suddenly became ineffective when supplies of naturally supplied foods improved (i.e., the seed pods of *Intsia bijuga*, the seed of *Macaranga* spp., *Trichspermum* and *Cupanopsis* are available beginning in February/March). Thus if baiting methods are employed for whatever reason, team members will have to take into account the other naturally occurring foods available to troops at that time of year.

13.2. Trapping

Trapping trials were carried out in Mangga and Tanah Hitam troops during June 2003. These troops were chosen for ease of access when carrying the traps. Three Tomahawk double-door type traps (40 x 40 x 100 cm) were constructed by a local welder (Figure 10) as described in De Ruiter (1992). Due to the unique nature of this request and the lack of suitable materials needed, the traps took longer than expected to construct. Because this occurred at the end of the fieldwork phase of the research, only two-week trials were possible.



Figure 10: Steel spring-loaded double-door, Tomahawk-type trap. The rear part of the trap is covered in fine wire mesh to prevent macaques stealing the bait without entering the trap.

Bait consisted of maize tied to fishing line which was attached to the catch of the spring loaded doors. After De Ruiter (1992) the traps were set in position on wooden platforms made from poles and set two metres off the ground. This was done 2 – 4 days after baiting at the feeding stations. The trapping station could be observed from the edge of the forest, approximately 30m away. The traps were then set in a fixed open position until such time as the macaques were clearly confident at approaching and entering the trap to be rewarded, which took approximately 1 – 3 days. The traps were then primed and observed continuously by a team member from a hidden location. Traps sometimes failed to trigger after bait had been taken, or were set off prematurely by macaques sitting on them.

The success rate of the traps (number of individuals caught / number of times primed x 100) was 40%, with the team successfully trapping four individuals (see Figure 11). It was not possible to determine with certainty whether the remaining macaques became trap-wary because of the fate of other troop members. However, in both locations a single individual was caught on the first day and another individual on the following day. More individuals would have been caught if (a) the traps themselves had not been used as a holding cage and (b) if one of the traps was better constructed (viz, the door failed to close cleanly).



Figure 11: Successful capture of adult male from Mangga troop

13.3. Summary and conclusions

- Live trapping of *Macaca fascicularis* is a valuable tool for risk management.
- Baiting can condition macaques troops to humans and is essential as a precursor to trapping or other management options.
- The success of baiting macaques is aided by the macaque's tendency to regularly come close to the ground and heavily use several locations for resting and playing. These locations could easily be identified from the clean forest floor and number of tracks entering / leaving the location.
- The traps are simple to use by trained personnel.
- A high capture rate can be achieved with good quality traps.
- For optimal results, trapping / baiting should be carried out when natural food resources are limited. This will require monitoring since fruiting will vary from year to year; generally, however, food resources start to become scarce during the dry season (April – July). The wet / fruiting season (November – February) should be avoided as it will be less successful.

14. Stakeholder Outreach

14.1. NGOs and Government

IPCA and UNCEN hosted a seminar in Jayapura in March 2003 to discuss preliminary findings. This meeting was attended by village representatives, NGOs, government officials, and UNIPA and UNCEN faculty and students (See Appendix 7 for list of participants). We used this seminar both to describe and socialize our preliminary findings, and to gauge community and NGO support for eradication/control efforts in the future. Given the diversity of reactions to our suggestion that eradication is the most appropriate and effective strategy to address a potentially serious problem, an eradication strategy should only be carried out after support is secured from the main stakeholders (viz., landowners and the government), and an understanding reached within the NGO community. During the seminar, few stakeholders were prepared to support eradication without "100% proof" of the effects of *M. fascicularis* on native fauna and economy. (This workshop was held before any conclusions could be drawn from the surveys.) Local dissemination and socialization of the findings in this paper is therefore essential.

Finally, there was strong consensus among seminar participants that the Jaringan Pemerhati Spesies Eksotik Invasive (JPSEI) be re-vitalised. Bapedalda are to be the sponsor and may fund a secretariat and get an SK Gub. Bapedaldas also expressed an interest in building a database for invasive exotics in the province. JPSEI will decide on priorities and actions to take - thus eliminating the need for additional workshops with undefined agendas and outputs.

The workshop did secure strong support for control and containment strategies to be implemented immediately, and the need for more monitoring of *M. fascicularis* populations, whilst the awareness campaigns are being carried out. There was agreement that the population should be reduced to "safe levels", and for the capture of individuals that spread outside the present geographical distribution.

14.2. Local communities

The seminar also raised the importance of deciding final methodology and strategies (eradication, control etc. and what specific methods would be used) after consulting with stakeholders, and after a period of public awareness and feedback campaigns.

It is difficult to overstate the importance of involving local communities in an awareness effort and other activities. Indeed, without the support of local stakeholders, it will be difficult or impossible to undertake a macaque population control effort in Papua. In addition, there are several complex social issues surrounding landowners of the forests where macaques are currently present, including the presence of squatters from Sorong on lands claimed by the Tobati and other clans. It will be essential to handle these issues with sensitivity, respect, and skill. Though such efforts may be considered tedious, difficult, and time-consuming, they are essential. We have laid a strong foundation to secure the support of local communities and landowners, and though work remains to be done on this front, a well-designed and managed follow-on control campaign can successfully engage these stakeholders and win their support.

15. Risk Management Options for Papua Macaques

15.1. Containment

Containment of a species is the restriction of its distribution or spread, and the confinement to a specified geographic range. Thus *the emphasis of Containment is on the limitation of geographical spread of alien species, not necessarily the population levels within that geographic area.*

While Control and Containment are different strategies, they are not necessarily mutually exclusive. Because *M. fascicularis* is a social species, a reduction in the number of troops and troop size will have a corresponding effect in reducing the size of the home range.

As long as wild breeding populations of alien species remain in an area, they retain the potential to reproduce and invade other areas. Rigorous and continual monitoring and early detection capacity are therefore essential to detect if new populations spread beyond the margins of the containment area, or jump to form totally new populations outside the determined geographic range.

Containment should be considered an option only if the ecological and economic damage that the alien species inflicts within the determined geographical range can be tolerated / accepted (i.e. if the area is no longer of special value for conservation) and if there is an acceptably low risk that the species will escape the containment area and become invasive. When these criteria are met and containment strategies implemented, the target species may have extensive impact in the restricted area, but other areas outside the alien species' range are (at least temporarily) safeguarded.

The **advantages** of Containment in the case of *Macaca fascicularis* in Papua include:

- Containment of macaques to a particular area can be implemented quickly as an emergency strategy. This allows time to plan, secure funding to implement a broad-scale Eradication or Control strategy, and to provide some measure of protection to other areas from being invaded in the interim.

The **disadvantages** of Containment include:

- The existence of gaps in barriers between the macaques' present range and other suitable habitat (*alang-alang* grassland and rivers do not constrain the movement of *Macaca fascicularis*) means that Containment alone is not a viable long-term strategy since it carries the risk of further spread.
- Continual vigilance and monitoring is required over an indefinite time horizon, and involving significant manpower.
- Given the continual possibility of spread and/or escapees, the program must have the capacity to initiate immediate control and/or eradication measures. This requires funding and training for such a program must already be in place for immediate implementation.
- Should Containment fail and eradication measures be necessary, all the costs and potential disadvantages of Eradication will apply (see Section 15.3).

- There is a current lack of adequate human resources for the effective long-term management of such an area; this will require both an up-front and periodic re-investment in technical training of staff, as well as overhead costs for the implementing organization in carrying out financial oversight, bookkeeping etc.

Table 12 examines in greater detail the advantages and disadvantages of the various available Containment options.

15.1.1. Evaluation of Containment options

Because of the potential ecological and economic impact of macaque spread outside a containment area, and the far higher difficulty and costs (including eradication of escaped individuals) should that eventuate, Containment alone is risky. However, as an interim measure, Containment does help mitigate the chances of macaque spread before more effective measures can be implemented.

15.1.1.1. Containment within existing forest island

Since the existence of gaps in barriers between the macaques' present range and other suitable habitat, as well as the fact that alang-alang grassland presents no barrier whatsoever to the movement of the animals, this strategy alone is entirely inadequate as a long-term solution. Indeed, to be effective, Containment would require not only continued vigilance lasting indefinitely (perhaps decades or longer), but it would also necessarily involve eradication of potential escapees – and thus bringing along all the costs and disadvantages associated with that strategy.

On the other hand, as a short-term, stop-gap approach that includes monitoring of the macaques to ensure they do not spread, Containment allows time to secure funding and to plan a longer-term population control strategy and programme.

15.1.1.2. Physical containment / monkey forest park

Some local entrepreneurs and government officials in Jayapura have expressed interest in capitalizing on the presence of exotic macaques to establish a private macaque zoo/forest to generate economic revenue. This would involve relocating the animals to some undetermined site, either a forest island, fenced-in pen, or some combination thereof. Their hope is that this "monkey forest" would attract local and foreign tourists and provide a stream of revenue.

Such a scheme will require a very large financial outlay to construct facilities. Combined with the current lack of foreign tourists (not to mention that those foreign tourists who do visit Papua have little interest in seeing macaques – something they can more easily do in Java, Bali, or other more easily accessible locations), this idea seems is almost certainly non-viable as a business. Moreover, it would increase the risk of human exposure to B-virus. A recent CDC study concluded that nearly half of the workers at the monkey forest area in Sangeh, Bali were exposed to B-virus through bites and scratches (Engel, 2002).

Table 12: Advantages and disadvantages of available Containment options

Method	Advantages	Disadvantages	Costs
Containment within existing forest island.	• The *Macaca fascicularis* populations are relatively confined in a forest island surrounded by ever increasing development, which harbours most all of their food needs. • As an interim strategy this method can be implemented quickly (as an emergency strategy) and allows time to plan, secure funding and implement a broad-scale eradication or control strategy, and protecting other areas from being invaded in the interim.	• The strategy is uncertain to succeed as there are many variables involved concerning invasiveness of *Macaca fascicularis*. As long as populations remain low and food availability remains high, the species is not likely to spread. However, this situation is not guaranteed, and new troops can easily travel unforested areas to new habitat. Given the potential ecological and economic impact of spread, the risk that *M. fascicularis* will increase its range within Papua is unacceptably high. • Gaps in barriers between present range and other suitable habitat do exist. *Alang-alang* grassland and rivers afford little to contain *Macaca fascicularis*. • Continuous vigilance and monitoring is required (involving manpower and technical / training resources) and must be coupled with immediately available funding for *ad hoc* control / eradication strategies if required. • Lack of human resources for the effective management of such an area. • Trapping and relocation back into the containment area may be required. • Potential escapes will require control measures. • Human disturbance (hunting, agriculture) within the area will have to be reduced in order leave sufficient habitat and food resources for *Macaca fascicularis* troops to stay in the determined geographical range. • Continued disturbance to native species and economic losses to farmers' crops will have to be tolerated.	• Costs involved include monitoring expenses (dedicated staff time), in-place funding for any immediate control measures that may be necessary should the population show signs of spread beyond the containment area.
Physical containment (fences / walls)	• Creation of a *monkey forest* sanctuary to provide source of revenue.	• Large financial investment needed. • Revenues from a "monkey forest" are likely to be minimal at best, since both local and tourist interest is quite marginal. • Lack of human resources for the effective management of such an area. • High disturbance during construction may displace the *Macaca fascicularis* populations, necessitating trapping and relocation back into the reserve / sanctuary. • Intensification of impact from *Macaca fascicularis* on any native species and native forest due to potentially high densities within sanctuary. • Potential escapes will require control measures.	• Suggested by some individuals. This is a rather far-fetched idea that is not in-line with any conservation objectives or management of alien species. It is also almost certainly economically non-viable. • Higher risk of human exposure to B-virus and other macaque-borne diseases.

15.2. Control Management Options

Control strategies of alien invasive species aim to reduce and restrict the population abundance and density to a certain level (or threshold) where the impacts to biodiversity and damage to the economy are thought to be acceptable. *The emphasis of Control is on the population level within a given area*.

Generally in the case of alien invasive species problems, Control is regarded as the priority management option **only if** eradication is no longer possible due to scale, expense, or other constraints (ex., if there are major social/political objections to eradication programmes).

Another problem often confronted is what constitutes an "acceptable threshold" level. In the case of *Macaca fascicularis* this may be at a level where they will not spread further to new areas due to in-species competition pressure.

The **advantages** of Control include:

- Costs may be less in the short-term (although this is not necessarily the case if PZP vaccination requires trapping and annual re-vaccination, or in the case of surgical sterilization [SS] which has high up-front costs). Since population numbers are still relatively low, a control program can be implemented in a relatively short time.
- More limited potential of local and international objections.
- The existing *M. fascicularis* population in Papua occurs in a natural forest "island" surrounded by mostly urban and agricultural areas which hence present somewhat of a barrier to the further spread of *Macaca fascicularis* (albeit an ultimately deficient one over the medium- to long-term), and would thus make control and containment easier.

Disadvantages include:

- A Control programme will require long-term commitment and funding for implementation (including monitoring) of the population, as long as a breeding population exists, to prevent the species becoming invasive.
- Control options (ex. PZP treatment, which must be repeated on an annual basis) will require a long-term program, with costs occurring over many years. These costs will ultimately be higher than that of an Eradication programme. SS is the exception to the rule of higher long-term costs; this option has a high up-front but one-time cost structure.
- Given the continual possibility of spread and/or escapees, a Control programme must possess the capacity to initiate immediate Eradication measures. This requires funding and training for such a program must already be in place for immediate implementation.
- Should Eradication measures be necessary, all the costs and potential disadvantages of Eradication will apply (see Section 15.3).
- There is a current lack of adequate human resources for the effective long-term population control and management of such an area; this will require both an up-front and periodic re-investment in technical training of staff, as well as overhead costs for the implementing organization in carrying out financial oversight, bookkeeping etc.
- Relative to a one-time Eradication effort, a longer-term Control program would result in many and repeated impacts on a larger number of animals.

- The viability of a long-term Control programme is susceptible to funding availability, political stability, a change in political will or social values of the benefits of keeping *Macaca fascicularis*.

Table 13 examines in greater detail the advantages and disadvantages of the various available Control options for Jayapura macaques.

15.2.1. Evaluation of Control options

15.2.1.1. Porcine Zona Pellucida (PZP) immunocontraception vaccine

Particular note needs to be made of PZP since many in the international biodiversity conservation community are unfamiliar with the technique. PZP is a vaccine that produces an immune response in mammals that prevents conception.[36] It is a promising form of contraception because: (1) it prevents pregnancy in most treated female animals; (2) it can be delivered remotely by small darts; (3) contraceptive effects are reversible; (4) it is effective in most or all mammal species; (5) it has no major health side-effects; (6) it has no effect on social behaviours; and (7) it does not enter into the food chain (PZPinfo.org, 2003).

PZP is well-tested for mammal population control, but requires different dosages, booster timing, and techniques for each mammal group, and its usage in wild (as opposed to captive) macaques is not well-understood.[37] Kirkpatrick (2001) states, "…the mere availability of a good physiological immunocontraceptive does not insure its effective application to wildlife. It is a large leap from inoculating a deer in a pen to inoculating a wild free-roaming deer; it's yet another leap from administering the vaccine in the field to controlling a wildlife population."

To our knowledge, the only use of PZP in controlling wild macaque populations is that pioneered by the Hong Kong Government beginning in 2002.[38] It has been proposed for possible macaque (*M. sylvanus*) population control efforts in Puerto Rico and Gibraltar (Anon. 2002c).

Given the difficulty of terrain, density of vegetation, and the cryptic nature of Papua macaques, successful immunization through darting[39] will be difficult at best, further

[36] Use of PZP in females allows continued normal menstrual cycles and ovulation, but prevents conception. When the vaccine is injected, it stimulates production of antibodies that attach to the sperm receptor cells on the ovum, distorting their shape and thereby blocking fertilization. Because PZP alone is not sufficient to provoke a sufficient immune response, the vaccine is delivered along with an adjuvant which acts as a general immunostimulant.

[37] Dr. Irwin Liu, the leading researcher on PZP, states, "I don't believe that there is a 'foolproof' PZP vaccine that is available for commercial use and one that guarantees [infertility for macaques]." Irwin Liu, personal communication, 17 November 2003.

[38] The Hong Kong Agriculture, Fisheries, and Conservation Department report (Anon. 2003b) states: "The feasibility of implementing population control for wild monkeys by contraceptive treatment was explored by field trials which commenced in early 2002. The captured monkeys were lightly anaesthetised by injection, treated with contraceptive agent, ear-notched and microchipped for identification, vaccinated against rabies and then released back to their social group on the same day. The treated monkeys will be observed in the field for at least two years. Field trial results will be used in planning a large-scale contraception programme for the wild monkeys in the long run."

[39] Successful immunization with PZP requires either hand injection or darting into the rump or hip muscle of the target animal; because of the high viscosity of the vaccine, a large needle and quick injection is required. Darting requires the use of Pneu-Dart capture guns or other commercial dart guns. Darts are disposable, and can be easily retrieved.

compounded by the uncertainty of whether a given female has already been vaccinated (alleviated somewhat by special marker darts which leave a dye mark on the animal). Adminstration of the vaccine will be easier if traps are used, but (a) this creates more stress on the animals and (b) presents the problem of trap-shyness and thus less than 100% application of all females.

PZP is not 100% effective. When administered properly, it prevents pregnancy an average of 90% of the time in treated animals (PZPinfo.org, 2003). In addition, the long-term efficacy of PZP in preventing conception in macaques in particular is uncertain (Wong, 2002). Use of PZP may be effective in preventing pregnancy for only 5 years in females (Walker, 2000).[40]

To eliminate any potential risk of macaque spread and the biodiversity implications thereof, a PZP-based population control programme would **require a goal of zero reproduction through 100% immunization of female macaques.** This in turn would require a long-term commitment to achieve this result. Macaques have a reproductive lifespan of approximately 28 years, and it is possible that use of PZP may actually increase the longevity among treated animals (PZPinfo.org, 2003), thus potentially prolonging the necessary duration of a PZP campaign.

Use of PZP in an immunocontraceptive population control strategy for Papua macaques would therefore require two doses in year one, and every 8–12 months thereafter for the productive life of female macaques (i.e., approx. 26 years; 3.9 years being the age of first oestrus, and menopause starting at approximately age 30). A PZP program would hence need to be designed and funded with an assumed project span of +/- 26 years, though it is possible that a more efficacious immunocontraceptive regime (i.e. sterilization) may be available before that time. Such a long project life would thus require secure funding and substantial level of commitment among stakeholders in order to ensure that the population control regime is effective in preventing macaque spread. This certainly would entail higher project costs.

A PZP strategy will also entail very significant labor and training expenses. In addition, given the political context in Papua today, permission to possess dart guns could be problematic. Because government authorities are unfamiliar with such weapons, they may be confused with a lethal weapon.

15.2.1.2. Surgical sterilization of male macaques

To be effective, the surgical sterilization (SS; i.e. male vasectomization) strategy would have to successfully target 100% of male wild macaques. To ensure total prevention of macaque

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It is possible to deliver the PZP dose in food, but this is explicitly NOT recommended since non-target species may inadvertently eat the food. Food-based delivery must therefore be species-specific; given the difficulties in doing so, PZP has never been food-administered in the field in any species.

[40] On the other hand, there is some indication that long-term use of newer recombinant forms of PZP in macaques may lead to sterility rather than merely contraception (Liu, pers. comm. 2003). This would be advantageous for a Control programme in Papua, but for how long and how repeatedly the vaccine would have to be applied before sterility is achieved is unclear – probably at requiring at 6 to 7 injections over at least five years (Liu, 2003). More important is the fact that recombinantPZP is currently experimental and not available commercially.

spread or population jumps, SS would also need to target male pet macaques, which would hence necessitate additional surgical procedures in other towns and cities where pets are present. There are captive pet macaques in the Jayapura area as well as in at least two other sites, Manokwari and Wasior. It is highly likely that there are several other sites with pet macaques as well. Determining where these pets are and obtaining the owner's permission may prove to be a matter of some difficulty.

Because SS involves extensive handling of wild captured macaques that are likely to be quite angry until sedated, this method carries a high risk of potential exposure of programme staff to B-virus and other diseases. This fact will necessitate the use of protective gear that is difficult to wear in hot, humid, dirty forest environment. There is an almost total lack of suitable veterinary facilities in Jayapura area, and thus the surgery would probably have to take place in difficult field conditions. In addition, it should be noted that this method would create considerable stress on the animals, and some mortalities (including post-op infection) should be expected.

Surgical sterilization of males (i.e. vasectomization) will involve a substantial up-front cost since veterinary surgeons who are qualified to perform this procedure are in very short supply in Indonesia (and completely absent in Papua). SS will thus require surgeons from Europe, Australia, or the U.S., which is likely to be cost-prohibitive. Such a program may require 6 months or longer to capture 100% of wild male macaques and 100% of male pets. To reduce costs, it may be possible to obtain veterinary volunteers to perform the surgery, though this option would require the assistance of primate welfare groups to identify and recruit the surgeons.

Two clear advantages of SS relative to PZP are: (a) although the costs are substantial, they are one-time only; and (b) it would be effective as a shorter-duration program.

15.2.1.3. Shooting / trapping / poisoning

These methods can also be applied either as part of a Control or Eradication strategy and are discussed in detail in Section 15.3.

Table 13: Advantages and disadvantages of available Control options

Method	Advantages	Disadvantages	Costs
Shooting / hunting, Trapping (Mechanical control) or Poisoning (Chemical control)	• All the advantages of eradication apply (see Table 14). • Compared to the equivalent eradication method, there is an added advantage, in that these control activities are *less intensely implemented* and thus the reduction of the target population to a certain threshold level is more quickly and easily reached.	• All of the disadvantages applicable to Trapping, Hunting, Poisoning also apply (see Table 14). • Trap shyness and / or a change in behaviour due to an increased sensitivity to hunting is likely and *may happen before the acceptable population level is reached.* • Diminishing marginal returns.	• Relatively "cost-effective" in the short-term. However, will be more costly in long-term, after *x* number of replications of population control have bee carried out.
Population control with the use of Porcine Zona Pellucida, or PZP immunovaccines sterilization (Anon, 2001b) and release back to wild (as pioneered with Hong Kong macaques beginning 2002).	• No animals are destroyed using this method of control; thus, probably the most acceptable to animal rights groups – thus avoids disagreement. • If 100% female sterility is achieved, this will result in the long-term eradication of the population due to negative population growth rates.	• Relatively unknown and untested method of population control. • Sterilization method appears not be 100% effective; fertility is likely regained in females after 5 years (Anon, 1998, Walker, 2000; Wong, 2002); and NO sterilization in males at all. • Requires re-application of PZP every five years (?) for up to 30+ years, imposing higher costs and possible neglect of project over long-term. • Requires 100% capture of all female individuals through trapping (as in eradication). Hence, all of the disadvantages applicable to "Trapping Eradication" also apply.	• Expensive. Though only females need be trapped and sterilized, PZP is only effective +/- 5 years; thus requires long-term program. More expensive than some eradication programmes, since 100% trapping is a pre-requisite. • Additional costs of immunovaccines (approx. $20 + shipping, per dose) • Additional labor costs for long-term monitoring to measure effectiveness. • Re-administration of PZP doses for up to 30+ years (?), imposes substantial additional labor and dosage costs.
Population control with the use of surgical sterilization (vasectomization) of males (and releasing back to wild).	• Internationally politically and socially acceptable to animal rights groups – thus avoids disagreement. • If 100% sterility is attained in males, this will result in the long-term eradication due to negative population growth rates.	• Requires 100% capture of all males, hence, all of the disadvantages applicable to "Trapping Eradication" also apply. • Causes considerable stress on animals. • Requires facilities and veterinary personnel for sterilization surgery and post-surgical recovery before release – currently unavailable in Papua. • Additional risk of possible exposure to zoonotic disease amongst handlers	• Most expensive management option in the short term. • May be cheaper than other long-term chemical or mechanical control methods that require multi-decade commitment. (ex. PZP)

15.3. Eradication

Eradication is the total removal of a species from a particular area. This involves one of the following: (1) destruction of all individual animals on-site, (2) trapping all animals for destruction off-site, or (3) trapping all individuals and exporting them back to their native range or some other site where they are not an ecological risk. The "precautionary principle" of alien invasive species management strategy advocates total eradication where possible (Wittenberg and Cock, 2001).

Eradication programmes are effective **only if all individuals are removed** within the time-frame set for the programme. This can present considerable costs and additional logistical complication factors, especially for cryptic or human-wary species. However, not all methods are the same in this regard; some, such as trapping with relocation, may involve higher costs than other techniques.

In regards to Papua macaques, there are a number of factors that are advantageous for an eradication programme:

- Population numbers are still relatively low.
- The current macaque populations occur only within a relatively small forest area which is isolated by agricultural and urban development from other suitable habitats (i.e. a forest island).
- The species may still be in the "lag phase" of colonization and not adapted to their full (reproductive and survival) potential in the Papuan environment.
- There is strong local support for the control of *Macaca fascicularis* populations.
- Given the political context in Papua today, short-term and targeted programmes are likely to be more effective than long-term, costlier ones.

However, the disadvantages of Eradication for *Macaca fascicularis* include:

- Higher short-term costs.
- Requirement for secure funding before activities are initiated (in order to prevent fruitless half-measures).
- Requires full commitment from implementing organization and their partner institutions.
- Subject to criticism from uninformed groups.

Table 14 examines in detail the advantages and disadvantages of the available of available Eradication options for Jayapura macaques.

15.3.1. Evaluation of eradication options

15.3.1.1. Hunting

While hunting using dedicated teams is a simple option, there are several significant disadvantages. First, permission to possess and use firearms or bowstrings in Papua is highly problematic. Given macaques' increasing wariness of humans that is sure to result from increased hunting, the problem of diminishing returns is likely to be a major obstacle. Moreover, such hunting pressure could induce macaques to flee their current range and colonize new forest areas – surely a worst possible outcome.

15.3.1.2. Bounty-based hunting

This option avoids some of the disadvantages of team hunting, but presents yet other significant problems. First, assigning any monetary value whatsoever to live or dead macaques introduces an economic incentive to local people for their continued presence in the province. That is to say, if local communities begin to see macaques as economically valuable because an organization is willing to pay for their capture, then over time it is likely that some will seek to perpetuate or even *enhance* macaque populations for their personal gain. Indeed, some may even seek to import additional macaques from Sulawesi, Bali, etc. to obtain rewards.

On the other hand, these problems may be avoided if the duration of the bounty period is very limited in duration (2–3 months maximum) AND clearly understood by all participants and local communities as being limited in time. This understanding is absolutely essential.

If macaques were somehow ever to become truly wide-spread in New Guinea (surely the worst possible outcome), community-based bounty-hunting may be the best option, since the scale and scope of the problem would by then be not amenable to other more focused options involving trapping or poisoning.

15.3.1.3. Trapping

See Section 13 for general evaluation of trapping as risk management method. In general, this is a feasible option given the relatively small size of current macaque populations in Papua. The major disadvantages are diminishing returns due to trap-shyness, the time-consuming nature required for habituation, stress on captured individuals, and high potential risk of B-virus and other disease exposure to team members. In Mauritius, macaques have become highly trap-shy and thus difficult to control in the absence of other options there. This suggests that trapping must be carried out relatively quickly and with intensity before macaques can become wary.

15.3.1.4. Trapping with euthanization

This method has significant advantages, including its relative simplicity and effectiveness. Given the need for training of team members, drug availability, and logistical complexity, it is more expensive than some other methods, but ultimately involving medium-level costs.

The main disadvantage of euthanization is the potential objection from international primate welfare groups.

15.3.1.5. Trapping with subsequent relocation

This method would involve trapping all macaques in Papua and relocating them to other areas of Indonesia where the species is native. There are several disadvantages to this method. First, we were not able to complete DNA tests on the Papua macaques, and so their origin site is unknown. Given the highly heterozygosity of *M. fascicularis*, sending them to a site that is technically their “native range” yet where existing populations of the species are genetically different can potentially be considered a form of genetic “pollution”. Second, conservation biologists also object to the possibility that Papuan macaques may harbor

lethal diseases that were acquired in New Guinea that would then be introduced to *M. fascicularis* populations in their home range.

Finally, relocating macaques to any off-island site would be quite expensive and logistically difficult. One primate welfare groups has suggested use of a snow monkey sanctuary in Texas[41] to house relocated Papua macaques. While this offer is appreciated, the extremely high cost and logistical difficulty (including the difficulty of obtaining export permission from Indonesia) is highly prohibitive. Compared with other eradication methods, trapping with relocation would likely increase costs by a factor of 2 or 3, while relocation to the U.S. would increase costs by an estimated 8 or 9 times. Additional costs would include additional staff time to handle complicated logistics, obtaining permissions, added costs of captivity and transportation in humane conditions, etc.

In short, given the extremely tight funding in international biodiversity conservation organizations today, trapping with relocation to other parts of Indonesia or abroad would likely be an option only if primate welfare groups are willing to find the additional funding required to carry out such a strategy. This would involve a substantial commitment on the part of such organization(s), and may prove difficult given the pressing need for swift implementation of a strategy to tackle the Papua macaque problem. We still believe, however, that conservation organizations should be open to this option if these conditions can be met in a spirit of cooperation.

15.3.1.6. Poisoning

This is a relatively simple and possibly the quickest and most cost-effective technique. There are effective toxins (ex. Brodifacoum) that target mammals only. Potential collateral damage to native mammal species can be minimized with use of specially designed bait traps that can be opened only by animals with opposable thumbs. Since marsupial mammals have no opposable digits, this would limit bait availability to primates. Baits can be placed in trees or otherwise well away from human-visited sites, and thus only be available to macaques. Such bait traps have been used with success in areas of New Zealand.

There are two main disadvantages to use of poison to eradicate Papua macaques. First is the potential objection from international primate welfare groups. Second, fallen macaque carcasses may be inadvertently eaten by local hunting dogs. Since dogs are a highly valued possession to communities and hunters, the death of prized hunting dogs would create resentment and severely undermine the program. There are two possible solutions: either dispensing muzzles to hunters for their dogs (though how widely they would be used is highly dubious) or setting up a program to compensate hunters whenever dogs are accidentally killed through poison ingestion.

[41] Their website describes the facilities as follows: “API's Primate Sanctuary is a 186-acre free-range primate rescue facility located near Dilley, Texas (70 miles south of San Antonio), and provides refuge for a variety of primates, including 275 snow monkeys, 20 vervets, and 29 baboons.” See http://www.snowmonkey.org

Table 14: Advantages and disadvantages of available Eradication options

Method	Advantages	Disadvantages	Costs
Hunting	• Simple technique: gun and/or bowstring.	• High risk of injury and suffering to macaques wounded but not killed. • Slow method, as troop will move rapidly and attempt escape after a single shot. • Increased wariness of humans resulting in diminishing marginal returns per level of effort. • Requires path maintenance through *M. fascicularis* territory. • Rarely does hunting totally eradicate an entire population (except on islands where quarry cannot easily hide). • Possible that large number of hunters will be needed. • Restrictions on gun ownership/usage in Papua will require special permission from TNI (Indonesian military) and Police	• Expensive. Large numbers of individuals can be eradicated in the initial stages BUT time needed and costs increases exponentially as animals are harder and harder to shoot (i.e., increasingly high marginal costs and decreasingly lower returns).
Bounty-based Hunting	• Incentives provided for local people to become involved in the programme and raising awareness of introduced / invasive species. • Local communities are adept at hunting and will require no additional equipment beyond their traditional hunting gear.	• Control and coordination of the programme will be difficult. • High risk of injury and suffering to those macaques wounded but not killed. • Whilst early returns for elimination of macaques by local communities are likely to be good, willingness to participate will quickly reduce as quarry is harder and harder to find. • Increased compensation required to maintain momentum. • Unless bounty period is clearly understood to be of short duration, this method will introduce a market incentive to maintain macaque presence in the province and/or incentivize bringing in additional macaques from outside Papua for cash reward. (Note trade-off between this strategy & increasing difficulty as macaques become harder to hunt.) • Rarely does hunting totally eradicate an entire population (except on islands where quarry cannot easily hide). • Animals become increasingly hunter-shy, change behaviour to avoid being shot and may even move unnoticed to new locations outside present range. This is an unacceptable risk.	• Relatively small and finite costs required, but must be calculated accurately in order to appeal to local hunters. until all individuals have been hunted.
Trapping (General)	• Techniques / expertise available • Physical Removal from the site. • Can be carried out by a small team. • Potentially more efficient than shooting	• Animals become trap shy and wary of trappers. • A variety of trapping techniques / designs are needed to fully eradicate a population. • Continuall habituation needed, thus costly in terms of time. • Training by experts with experience in trapping *Macaca fascicularis* will be needed. • Poses significant potential health risk to personnel from macaque bites/scratches & potential exposure to disease. • Stress to macaques	• Trapping in itself is not necessary an expensive option (the cost will be incurred post-trapping).

Trapping with Subsequent Relocation	• Considered more acceptable by animal rights advocates since it is regarded as more humane than euthanization.	• Time and permits needed for quarantine/ export (from non-native site) and import (to native range site) of live macaques. • Risk of escape during confinement period. • Requires determination of suitable site for relocation within their native range. • Requires DNA analysis to determine source area from which the Papua macaques originated. • Requires quarantine in relocation site to ensure new diseases are not introduced to established populations. • Considerable stress on animals during trapping, confinement, shipping, and adaptation to new habitat.	• Probably the most expensive option. This includes substantial additional (compared to other methods) for DNA analysis, site suitability check, quarantine / health checks, housing facilities in Papua and the recipient location, as well as the transportation of live animals.
Trapping with Subsequent Euthanization	• Methods for euthanization (ex. barbiturates) can be applied to quickly reducing stress and suffering of the macaques.	• Trained personnel with sufficient supplies of drugs will be required to be 'on-call' throughout the programme. • Increased risk of exposure to possible B-virus etc. for handlers; requires use of protective clothing, glasses, etc.	• Medium-level costs
Bait Poisoning	• *M. fascicularis* can be habituated to eating food provided. • Poisons that target only mammals (ex. Brodifacoum[42]) & bait stations that allow only macaque access are available. • No need for long-term staff in carrying out the programme. • Potentially the quickest management option for eradication (after habituation period). • Easily repeatable.	• Potential collateral damage to native species through high quantities of toxins used in bait. • Pollution from carcasses, and high potential for accidental poisoning of local hunting dogs that eat fallen carcasses (thereby reducing local support and requiring compensation)	• Cheapest overall eradication option.

[42] Brodifacoum is a bromylated hydroxycoumarin derivative; an indirect anti-coagulant; and an effective stomach poison which inhibits prothombin formation and induces capillary damage. To be effective it usually requires only a single ingestion of a bait formation in one feeding to produce a kill. It is extremely toxic to a broad spectrum of rodents and other small mammals but due to its low bait concentration and its delayed effect it is considered to be only of low acute toxicity hazard to humans. Brodifacoum is not toxic to plants (Anon., 2003).

16. Key Conclusions and Recommendations

16.1 Conclusions

- Populations of introduced *Macaca fascicularis* in Papua are currently limited to a relatively small area in the immediate Jayapura/Kotaraja area. There are approximately 60 individual macaques, in six different troops and possibly a few isolated individual males. There is no evidence of wild macaque populations in other areas of Papua or PNG with the possible exception of one or two isolated individual males to the southeast of Jayapura, and which appear to pose little risk of spread in and of themselves.

- There are also probably pet macaques in several cities and towns in Papua. This is cause for serious concern given the possibility of accidental escape or release of a male/female pair or a gravid female.

- *Macaca fascicularis* has a high potential to become an invasive pest in New Guinea. The species meets several key criteria for invasiveness: ecological generalism, vacant ecological niches in New Guinea, lack of predators, and preference for disturbed habitat. The observed feeding behaviours of macaques in Papua are consistent with those in their native range, and thus it is almost certain that the species can easily survive in other areas of New Guinea.

- Given current fragmented forest habitat, low population and an ample supply of food, and ongoing periodic human hunting of individual macaques, the immediate probability of macaque colonization of new forest areas is low but not impossible. Macaques can easily cross grassland and agricultural areas, and so there is no physical or ecological barrier to macaque movement out of their current forest "islands" to the greater forest hinterland. Combined with ongoing agricultural and logging-related forest disturbance in the area, colonization of other areas is not simply possible but probably likely over the medium- to long-term. Macaques are extremely agile and the species has the potential to cross the central mountain range into the southern half of the island.

- Given the right conditions such as ample supply of food, access to new habitat, and lack of hunting pressure, macaque populations in Papua have the potential to expand rapidly. Hunting by humans is probably a major factor currently limiting the growth of *M. fascicularis* populations.

- Papua macaques were not directly observed eating bird eggs or hatchlings, but based on the documented evidence of this from Mauritius, we infer that Papua macaques also engage in this behaviour. Many of the preferred fruits eaten by macaques are common trees throughout lowland New Guinea, and so it is extremely likely that the species can exist thoughout the lowlands.

- The results of our plot-based study provide strong evidence that macaques have a negative impact on the native flora and fauna. We documented that bird and small reptile diversity and abundances are lower in forest areas with *M. fascicularis* than similar habitat without macaques. The evidence is also suggestive that there is a similar negative effect of macaques on large mammals and reptile diversity and numbers.

- Macaques probably have direct and indirect negative impacts on native flora, especially by enhancing the spread of invasive plants such as *Passiflora suberosa* and others. Though macaques are strongly suspected to play such a role in Mauritius, Palau and other areas where they are exotics, further research is needed to confirm this hypothesis.

- Papua macaques are crop raiders and cause significant economic losses to rural farmers in the Jayapura area. If the range and population of macaques increases in New Guinea, far more widespread and serious cash income losses are certain to negatively impact the regional economy.

- Because their total population is still small and in a limited area, a successful population control campaign for Papua macaques is quite feasible.

16.2 Recommendations

- Since the ecological, health, and economic consequences of an expansion of *M. fascicularis* into the forest hinterland would be potentially quite serious, and because the possibility of escape from their present forest islands is a persistent danger, we strongly recommend that a concerted population control (containment/control/eradication) program and community awareness effort become an immediate priority. The threats from the exotic *M. fascicularis* cannot be totally eliminated until either all individuals are sterile or all populations are eradicated. Priority action is needed for the Tanah Hitam troop in particular.

- The probability of pet macaques in other towns in Papua is cause for serious concern. An accidental release or escape would gravely complicate the current situation and make a population control effort far more difficult and costly. Therefore, any such program must also address this issue directly, possibly persuading owners to submit the animals for surgical or chemical sterilization should the situation warrant.

- There is a demonstrated need for a environmental education effort in parallel with a control program that will socialize the results of this report and strengthen local support for population control measures. Any programme should be implemented only after support from stakeholders and the community is secured.

- A decision on which strategy – Containment, Control, or Eradication – should be employed first requires consensus among conservation organizations, government agencies, and other stakeholders. This will necessarily take into account likely funding sources and levels, and logistical and other constraints to implementation of such a program. It should also be recognized that whatever strategy is taken must be based on consensus with local community, without whose support any strategy will be ineffective.

- Given both the prevalence of B-virus in wild macaques elsewhere and the extreme pathogenicity of the disease in humans, a precautionary approach should be applied for anyone in contact with Papua macaques. Unless proven otherwise, it should be assumed that the virus is present in populations of *M. fascicularis* in Papua. Though the risk of incidental viral spread from macaques to humans is probably very small, any population control program for *M. fascicularis* must require the use of special precautions (gloves, body

protection, glasses, etc.) to protect against transmission of disease through bites, scratches, or splashes, and a supply of antiviral medication should be available to workers requiring post-exposure prophylaxis.

- Despite the best efforts of the Department of Animal Quarantine in Jayapura and Sentani, imported macaques do slip through the screening process from time to time. This is cause for deep concern. Enhancing the institutional capacity and authority of government agencies in Papua and PNG to detect and destroy imported alien species is an urgent priority. AusAid's project on *Irian Jaya Quarantine Animal and Plant Health Support Project* is of vital importance and should be strongly supported and/or expanded.

- Clarification of the official government policy regarding the transport of species around the archipelago that – at the very least – recognizes and differentiates between the three major biogeographic realms found in Indonesia is urgently needed. New regulations restricting the transport of species from one area to another are also essential.

- Conservation organizations – particularly WWF, CI, and TNC, which have greater access to policymakers – are urged to prioritize alien and invasive species issues in their programmes in Indonesia. Specifically, we recommend that these groups enhance lobbying efforts with Indonesian decision-makers for (1) clarification of the official government policy regarding the transport of species within and around Indonesia in a way that differentiates between the three major biogeographic realms found in Indonesia; and (2) the need for new regulations restricting the transport of species from one area to another; and (3) granting DAQ or similar agency with enhanced authority to properly regulate the importation of species such as *Macaca fascicularis*. All of these measures are among the policy changes that are urgently needed to prevent future serious invasive species problems in the country, and that of *M. fascicularis* in particular. It will be important to press this agenda at both the Jakarta and Jayapura provincial government levels in order to maximize the chances for enhanced policymaker understanding and implementation. Although effective legal enforcement of any such new regulations is unlikely anytime in the near future, the legitimacy that would be provided by such legal recognition would be of great benefit in itself to conservation organizations.

Appendices

Appendix 1 - Terminology Used In This Report

Terminology applied in this report follows Miller (2000) for invasive species.

alien = non-indigenous = exotic: occurring outside of natural range and dispersal potential (includes both introduced and immigrant).

introduced: often used for aliens in general, but best restricted to purposefully introduced species (as in biological control introductions).

invasive: a species which is an agent of ecosystem change, especially when threatening biological diversity; usually but not always an alien species.

endemic = precinctive: restricted to the region and not found elsewhere (although used in the sense of indigenous by the medical and veterinary community).

indigenous = native: occurring naturally in the region but not endemic.

In addition, we must clarify the use of the terms “home range” and “native range”, as special conditions apply with respect to *Macaca fascicularis*.

home range: the area used frequently by a troop of long-tailed macaques. The species is territorial and behaviourally restricts itself to a particularly “range”. However, the home range is not fixed and depends on group size and food availability. Troops may move to find new home ranges if the need arises.

native range: the geographical area of an indigenous species – in the case of *Macaca fascicularis* this area extends from southeast Asian to the Philippines, western Indonesia and Timor. Papua is outside the native range of *Macaca fascicularis*.

Appendix 2 - Community Interview Data

Key / Contact person	No. of In-former	Location	Job	Information given
Herri Hamadi	1	Kampung Skou Mabo Kec. Muara Tami	Petani	Ia pernah melihat kera ekor panjang di pelihara oleh masyarakat di Kampung Tobati pada beberapa tahun yang lalu, kera-kera tersebut di tangkap di daerah Vim Kotaraja, tetapi selama ia berada/tinggal di Kampung Skou Mabo ia tidak pernah melihat kera ekor panjang.
Ondoafi Skou Mabo (bersama 7 ornag masyarakat)	7	Kampung Skou Mabo Kec. Muara Tami	Petani	Di Kampung Skou Mabo tidak pernah melihat kera/ tidak ada kera ekor panjang.
Idris Dan KAPOLSEK Skou	2	Kampung Skou Mabo Kec. Muara Tami	DANDRAMIL dan POLSEK	Selama mereka bertugas 17 tahun di Kampung Skou Mabo dan mereka juga sering berburu di hutan, tetapi tidak pernah melihat kera ekor panjang di sana, hanya yang dijumpai yaitu Kanguru Pohon.
Ondoafi Skou Sae Kpl kampung S. Sae	5	Kampung Skou Sae Kec. Muara Tami	Petani	Tidak pernah melihat kera ekor panjang di Kampung Skou Sae selama ini.
Kpl kampung S. Sae	3	Kampung Skou Sae Kec. Muara Tami	Petani	Tidak pernah melihat kera ekor panjang di Kampung skou Sae selama ini.
Ondoafi Skou Yambe	5	Kampung Skou Yambe Kec. Muara Tami	Petani	Di Kampung Skou Yambe belum pernah di jumpai kera ekor panjang.
Kpl Kampung S.Yambe	5	Kampung Skou Yambe Kec. Muara Tami	Petani	Di Kampung Skou Yambe masyarakat belum pernah melihat kera ekor panjang selama ini dan memang tidak ada kera di Kampung Skou Yambe.
Philipus Ketua LMA	4	Arso V Kec. Skanto	Petani/Berburu	Daerah Arso V sebelum di buka menjadi pemukiman penduduk transmigrasi hingga sekarang belum pernah di temukan kera ekor panjang di daerah tersebut, hanya yang di temukan Kanguru Pohon, Kus-kus, Rusa dan Babi Hutan. Ada juga jenis-jenis eksotik lain yang masuk di daerah Arso V yang sebelumnya tidak ada di daerah ini tetapi sekarang sudah ada seperti; ikan gabus toraja (gastor), keong emas, dan beluntas hutan.
Jemmy (Ondoafi)	1	Desa Skanto Kec. Skanto	Petani	Di daerah Skanto belum pernah ada kera yang dilihat oleh masyarakat, karena selama masyarakat berburu di hutan Skanto hingga Kampung Taja belum pernah mereka temukan kera ekor panjang, yang sering mereka temukan yaitu Kanguru Pohon, Babi Hutan dan Rusa. Jenis-jenis eksotik yang masuk ke daerah Skanto yaitu ikan gabus toraja (gastor) yang telah menghabisi jenis-jenis ikan asli Skanto serta beberapa jenis gulma / pohon invasif.
Demianus Marasian	1	Arso III / daerah suku Wanyambe Alang-alang V Kec. Skanto	Ondoafi suku Wanyambe	Di daerah arso III / alang-alang V, khususnya daerah suku Wanyambe hingga kilo IX belum pernah ditemukan kera ekor panjang.
Agus Merasi	3	Arso IX Kec. Skanto	Buat perahu	Ia tinggal di Arso IX selama 5 tahun dan pekerjaannya ialah buat perahu di hutan dan sampai saat ini belum pernah melihat kera ekor panjang di daerah arso IX, yang pernah dilihat/ditemukan yaitu buaya darat.
Suraji	9	Arso IX Kec. Skanto	Petani / Berburu	Selama berada di Arso III dan pindah ke Arso IX belum pernah melihat kera ekor panjang.
Bubun		Arso IX Kec. Skanto	Petani / Berburu	Selama ia berada di Arso IX sejak tahun 1985/17 tahun lamanya tidak pernah melihat kera ekor panjang.
Ibrahim Hanuebi (kepala suku)	7	Kampung Nafri	Petani / Berburu	Di hutan sekitar kampung Nafri selama ia berburu belum pernah melihat kera ekor

				panjang, yang sering di dapatkan di hutan kampung Nafri adalah Kanguru Pohon, dan Kus-kus pohon. Pernah melihat kera ekor panjang tetapi di daerah Vim / jalan baru, dan pernah ada masyarakat yang memelihara kera ekor panjang tetapi sudah di kembalikan ke habitatnya di Vim Kotaraja.
Teddy L. Neharabia (Kepala Kampung	1	Kampung Nafri	Petani	Di daerah kampung Nafri belum pernah masyarakat menjumpai kera ekor panjang, yang sering mereka lihat di daerah sekitar Vim Kotaraja sampai ke pasar baru.
Rode Olua	6	Kampung Yoka	Petani	Tidak pernah melihat kera ekor panjang di Yoka.
Nikson Howay	8	Kampung Yoka	Berburu	Hutan daerah sekitar Kampung Yoka sampai ke kampung Puai belum pernah di jumpai kera ekor panjang, yang sering di jumpai adalah kanguru pohon, dan kus-kus.
Billy Lolo	7	Kampung Yoka	Berburu	Di kampung Yoka dan Puai sampai ke daerah sekitar Arso IV belum pernah ditemukan kera ekor panjang, karena kami sering berburu dan bermalam di hutan.
Naas Suklayo	7	Abepantai Kec. Abepura	Berburu	Selama berada di Abepantai dan kehidupannya berburu di hutan namun sampai saat ini belum pernah temukan / lihat kera ekor panjang di daerah sekitar Abepantai, yang sering di temukan yaitu kanguru, babi hutan dan kus-kus. Pernah melihat kera ekor panjang tetapi itu di daerah Vim Kotaraja saja
Agus Gumigi (RT IV Abepantai)	4	Abepantai Kec. Abepura	Petani	Ø Kehidupan kami disini berkrbun dan berburu, namun hingga saat ini kami belum pernah / tidak pernah melihat kera ekor panjang di daerah Abepantai, yang sering kami lihat dan sering masyarakat memberitahukan bahwa kera ekor panjang itu ada di daerah sekitar Vim Kotaraja.
Samsudin Basan (RW Kampung Buton)	7	Kel. Entrop Kampung Buton Skaylan	Petani	Ø Kami berada di Kampung Buton Skaylan sejak tahun 1974 dan kehidupan masyarakat kami sebagian petani namun hingga saat ini kami belum pernah melihat kera ekor panjang di daerah sini, pernah kami lihat tetapi itu di daerah Vim Kotaraja.
Yorry Towolom	1	Kel. Vim Kotaraja / Skaylan Kec. Abepura	Petani	Di daerah Skaylan ini belum pernah kami lihat kera ekor panjang. Kami sering melihat kera ekor panjang di daerah sekitar Vihara sampai ke daerah sekitar pasar baru. Kami berkebun di daerah sekitar Vihara dan hasil kebun kami selalu di makan oleh kera ekor panjang.
Darifen Jigibalom	1	Kel. Vim Kotaraja / Skaylan Kec. Abepura	Petani	Di daerah Skaylan ini tidak pernah kami melihat kera ekor panjang. Pernah ada masyarakat yang pelihara kera ekor dan terlepas di hutan sekitar Skaylan namun karena hutannya tidak terlalu banyak pohon-pohon sehingga kera tersebut di tangkap dan dikembalikan ke daerah sekitar Vihara.
Panus Kogoya	3	Kel. Vim Kotaraja / Skaylan Kec. Abepura	Petani / Berburu (Pensiunan Polisi)	Di daerah Skaylan ini tidak pernah kami melihat kera ekor panjang. Kalau di daerah sekitar Vihara itu ada kera ekor panjang dan pada tahun 1993 saya berkebun di sana dan hasil kebun saya selalu di makan oleh kera ini dan saya mencoba untuk menghitung jumlahnya kira-kira ada sekitar 100 ekor. Sekarang saya berkebun pada dua lokasi yaitu pada daerah di bawah Vihara dan di atas Vihara dan hasil kebun yang sering di makan oleh kera ekor panjang yaitu kebun yang di atas Vihara sedangkan yang dibawahnya tidak, dan pada empat bulan yang lalu saya mencoba untuk menghitungnya lagi kira-kira ada sekitar 30 ekor kera ekor panjang yang masih ada di sana.
Bambang	1	Padang Bulan Sosisal Perumnas IV Kec. Abepura	Ojek	Selama saya berada di daerah ini belum pernah saya melihat kera ekor panjang. Saya tinggal di daerah ini sudah 20 tahun dan saya sering main di hutan sekitar padang bulan tapi hingga saat ini belum pernah saya lihat kera, yang pernah saya lihat yaitu di daerah Kehiran Sentani.
Sek. Kampung Tobati	3	Kampung Tobati	Nelayan	Daerah ini belum pernah kami melihat kera ekor panjang, yang sering di ceritakan

				oleh masyarakat bahwa kera itu ada di daerah Vim Kotaraja sekitar Vihara.
Zet Haay	2	Kampung Tobati	Nelayan	Kera ekor panjang berada di daerah Vim Kotaraja yang di bawah oleh Tentara Jepang pada waktu perang dunia II, pada tahun 70an saya dan pernah saya lihat kera ekor panjang di sana hinggga saat ini. Tetapi kalau di daerah sekitar hutan bakau Tobati tidak pernah kami lihat.
Piet Ireuw	2	Kampung Tobati	Ketua Majelis Jemaat Tobati	Ø Kera ekor panjang masuk ke daerah Papua khususnya Jayapura yaitu pada daerah Vim Kotaraja pada perang dunia II yang di bawah oleh tentara Jepang sekitar tahun 1944 dan sampai sekarang masih ada di sana. Sedangkan pada daerah kampung Tobati tidak pernah kami lihar di sini.
Daniel Haay	1	Kampung Tobati	Petani	Dari kecil saya suka ikut ayah saya untuk berkebun di daerah Vim Kotaraja itu kera ekor panjang ini belum ada, nanti sejak perang dunia II baru kera itu ada di daera Vim Kotaraja.
Marsamel Yoom	4	Kampung Kehiran Sentani	Petani	Di daerah Kehiran pernah kami melihat kera ekor panjang 1 ekor yang berkeliaran di sekitar halaman rumah kami, namun ia sudah mati akibat kena strom.
Bapak Ruatakurei	1	Kompleks Pasar Baru Tanah hitam Kec. Abepura	Petani	Daerah sekitar jalan baru ini memang masih banyak kera ekor panjang, saya sering membuat jerat untuk menangkap kera tersebut. Pada tahun 1992 kera ini suka masuk ke rumah tapi sekarang karena sudah ada pembangunan pasar baru dan pembuatan jalan sehingga kera-kera ini lari ke hutan sekitar Vihara. Ø Di sini kera ekor panjang ada 4 kelompok 3 kelompok ada di daerah sekitar Vihara dan 1 kelompok lagi ada di sekitar SD Enggros Tanah Hitam.
Staf Desa Koya Barat	3	Desa Koya Barat Kec. Muara Tami	Staf Desa	Daerah Desa Koya Barat hingga saat ini kami belum pernah melihat kera ekor panjang, dan belum pernah ada informasi dari masyarakat tentang adanya kera ekor panjang di daerah sini.
Kepala Desa Houltekamp	1	Desa Houltekamp Kec. Muara Tami	Kepala Desa	Belum pernah melihat kera ekor panjang di daerah ini.
Sek.Desa Koya Koso	1	Desa Koya Koso	Sekertaris Desa	Saya juga sering masuk hutan di daerah sekitar sini, tapi saya belum pernah melihat kera ekor panjang di sini.
RT. Koya Koso	3	Desa Koya Koso	Petani	Pekerjaan kami setiap hari di hutan untuk mencari kayu, namun hingga saat ini kami belum pernah melihat kera ekor panjang di daerah sekitar kami tinggal.
Pos TNI-AD Yonif 132 Kilo IX	6	Desa Koya Koso	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Polsek Skanto	6	Arso V Kec. Skanto	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Pos TNI-AD Yonif 132 Arso III	3	Arso III Kec. Skanto	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Pos TNI-AD Yonif 132 Arso IV	5	Arso IV Kec. Skanto	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Pos TNI-AD Yonif 132 Arso V	5	Arso V Kec. Skanto	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Pos TNI-AD Yonif 132 Arso XII	3	Arso XII Kec. Skanto	Keamanan	Belum pernah melihat kera ekor panjang di daerah ini.
Yohanis Sita	15	Desa Soskotek Kec. Kaure Lereh	Kepala Kampung	Di daerah kami ini belum pernah kami melihat kera ekor panjang. Yang pernah kami lihat yaitu di SP I Taja tetapi di pelihara sedangkan yang liar di hutan kami belum pernah melihat. Sedangkan jenis eksotik lainnya yang masuk di daerah kami ini adalah Gabus Toraja tahun 2000 dan ia sudah menghilangkan dua jenis ikan asli Lereh.
Markus She	2	Desa Soskotek Kec. Kaure Lereh	Petani / berburu	Kera ekor panjang di daerah kami tidak ada dan kami sering berburu di hutan tidak pernah kami lihat, yang pernah kami lihat dan dapat yaitu kanguru pohon dan kus-kus. Eksotik lainnya yaitu Gabus Toraja masuk di daerah kami sekitar tahun 2000.
Paulus Kasu	2	Desa Soskotek Kec. Kaure Lereh	Petani / berburu	Kera ekor panjang tidak ada di daerah kami dan kami belum pernah melihat binatang itu di hutan sekitar Lereh sampai Taja. Jenis eksotik lain yang ada di

				daerah kami yaitu pohon korek-korek hutan buahnya seperti sirih, semut merah kecil kepala besar yang suka membunuh anjing daerah yang diserangnya adalah mata dan airnya di keluarkan, serta hidupnya di tempat yang kering
Yahya She	3	Desa Soskotek Kec. Kaure Lereh	Ondoafi kampung Soar	Di sini kami belum pernah melihat kera ekor panjang yang pernah kami lihat di hutan kami yaitu kanguru pohon, kus-kus, babi hutan sedangkan untuk kera ekor panjang tidak perna kami lihat.
Dominggus She	2	Komp.Perusahan Kelapa Sawit Kec. Kaure Lereh	Karyawan Kelapa Sawit	Saya sebagai sopir tengki minyak kelapa sawit dan juga saya orang asli Lereh selama ini saya tidak pernah melihat kera ekor panjang di daerah kami ini dan perjalanan saya sampai ke Demta untuk mengantar minyak namun di tengah hutan ini kami belum pernah melihat binatang tersebut. Di komp.perusahaan ini ada salah satu karyawan yang memelihara kera ekor panjang yang di beli dari lokasi SP I.
Laurens Auri	8	Desa Lapua Kec. Kaure Lereh	Petani	Tidak pernah kami melihat kera ekor panjang di Lereh dari dulu hingga saat ini yang sering kami temukan di hutan waktu kami berburu yaitu kanguru pohon, kus-kus, kasuari dan babi hutan. Jenis eksotik yang ada di Lereh/baru masuk yaitu gabus toraja dan keong mas.
Metusalak Yamle	2	Desa Soskotek Kec. Kaure Lereh	Ondoafi	Di daerah ini kami belum pernah melihat monyet, di hutan Cuma yang sering kami dapatkan di hutan pada waktu kami berburu yaitu kanguru pohon, kus-kus, kasuari dan babi.
Suprapto	2	SP I Taja Kec. Kaure Lereh	TNI-AD (KODIM 1709)	Daerah ini tidak ada kera ekor panjang di hutan, dan saya pernah membawa satu ekor kera ekor panjang dari Jawa dan pelihara di sini, Cuma sekarang saya sudah menjualnya kepada salah seorang warga di kompleks perusahaan kelapa sawit.
Bapak Kogoya	2	Alang-alang V Arso III Kec. Skanto	Petani	Selama saya berada di sini saya belum pernah melihat kera ekor panjang di daerah sekitar sini, saya pernah bekerja di perusahaan Hanurata dan kami sering ke hutan untuk mencari kayu untuk diambil namun saya tidak pernah melihat kera ekor panjang.
Robi Suebu	3	Kampung Hawai Sentani	Karyawan Hotel Sentani Indah	Daerah Hawai Sentani tidak pernah kami melihat kera ekor panjang yang berkeliaran di hutan, pernah ada yang pelihara di daerah sini namun itu hanya satu ekor saja dan sudah di tembak mati sekitar dua tahun yang lalu.
Abraham Nahabial	1	Kampung Hawai Sentani	Pelajar SMU	Saya suka berjalan di daerah sekitar Hawai hingga ke kampung Yabaso namun saya belum pernah melihat kera ekor panjang di sini.
Surya Jaya	2	Asrama Koramil Sentani	Mahasiswa ISTP	Daerah ini dari kecil saya suka bermain dengan teman-teman ke hutan hingga saat ini namun kami belum pernah melihat kera di daerah ini, yang pernah kami lihat yaitu yang dipelihara oleh Dokter Manangsang.
Maikel Rumkorem	1	Koramil Tanah Hitam Abepura Kec. Abepura	Mahasiswa ISTP	Kera disini banyak yaitu sekitar 10 ekor, saya senang melihat karena kera jarang dilihat di Papua dan mereka tidak mengaggu kami manusia/mengejar kami yang sering ia makan yaitu hasil kebun seperti pisang dan pepaya yang ia suka makan.
Ibu Nerahabia	1	Tanah Hitam abepura Kec. Abepura	Petani	Saya pernah dengar cerita bahwa kera ini di bawah oleh orang lewat kapal dan ditinggalkan di gunung Vim, saya juga pernah dengar cerita bahwa kera ini jahat tetapi saya sendiri belum tahu kera itu yang bagaimana dan sejak saya tinggal di daerah ini baru saya lihat kera-kera ini mulanya mereka hanya berjumlah 9 ekor dan sekarang mereka sudah berkembang biak sekitar 13-17 ekor, saya sendiri tidak tahu akibat/ancaman yang di bawah oleh binatang ini maka saya sering memberikan makan kepada mereka selain itu juga mereka sering mencuri tanaman/hasil kebun saya seperti pepaya, singkong dan sayur gedi, jadi kalau sekarang atau kemudian nanti kera-kera ini mau dipindahkan saya tidak merasa keberatan karena binatang ini bukan binatang asli Papua dan suka mengancan

				lahan perkebunan saya serta jenis-jenis asli Papua.
Kel. Afaar	3	Skaylan Kel. Entrop Kec. Japsel	Pensiunan PNS	Kami tinggal di daerah ini sudah 20 tahun hingga saat ini kami belum pernah melihat kera di sekitar sini, yang kami tahu yaitu di belakang Vihara sampai ke sekitar pasar baru.
Yanni	5	Arso I	Sekertaris Desa	Selama kami tinggal disini mulai dari lokasi ini di buka hingga sekarang ini kami belum pernah melihat kera ekor panjang di hutan sini.
Kepala Desa Arso I	1	Arso I	Kepala Desa	Selama ini kami belum pernah melihat kera ekor panjang di daerah Arso I, masyarakat juga tidak pernah melihat binatang tersebut sebab kalau mereka lihat pasti mereka sudah ceritakan kepada kami. Pernah ada salah seorang masyarakat Wamena namanya Lukas Wenda pada tahun 2001 pernah menjerat seekor binatang seperti kera, tapi binatang ini besar sekali sehingga langsung di bunuh. Kera ini bukan binatang asli Papua jadi saya harap kalau ditemukan tolong dikembalikan saja ke daerah aslinya atau tidak di bunuh saja.
Katamin	3	Arso I	Petani / Berburu	Saya tinggal di Arso I ini sejak mulainya di buka transmigrasi yaitu pada tahun 1984 dan kehidupan saya lewat hasil pertanian dan juga saya sering berburu babi namun hingga saat ini saya belum pernah melihat kera ekor panjang di sini yang saya tahu bahwa kera ini hanya ada di Jawa.
Dadi	1	Arso I	Petani	Selama saya berada di Arso I sekitar 17 tahun hingga saat ini saya belum pernah melihat kera ekor panjang di daerah ini, yang saya tahu hanya di Jawa saja.
Bapak Iwanggin	1	Arso XIV	Karyawan Perusahaan Kayu	Tidak pernah kami lihat kera di daerah sini dan kami juga punya karyawan yang sering survey ke hutan namun hingga saat ini tidak pernah mereka temukan kera di hutan sini. Saya pernah lihat kera ini di belakang STM Kotaraja dan saya juga pernah tangkap 1 ekor untuk saya pelihara tetapi ia sudah mati.
Stevanus Mau	2	Arso XIV	Kepala Suku	Lokasi kami ini tidak pernah kami temukan kera ekor panjang di daerah kami ini karena saya sendiri suka berburu tetapi hingga saat ini saya belum pernah melihat kera ini di hutan.
Ibu Kogoya	3	Arso XIV	Petani	Kami tidak pernah melihat kera ekor panjang di sini selama ini dan bapak tiap hari berburu di hutan tetapi yang sering bapak dapat dihutan yaitu babi, kanguru dan kus-kus sedangkan untuk kera ini belum pernah.
Kepala Desa Arso XIV	2	Arso XIV	Petani / Berburu	Saya tinggal di sini sudah 5 tahun dan saya juga sering berburu ke hutan tapi saya belum pernah melihat kera ekor panjang di sini.
Paulus Kaso	4	Arso X	Petani	Sudah 20 tahun kami tinggal di sini dan juga kami sering ke hutan tetapi tidak pernah kami melihat kera ekor panjang, kalau di daerah saya di Timor memang ada tapi kalau disini tidak ada.
Nurdin	2	Arso X	Pedagang	Kami tinggal di sini sudah 5 tahun tetapi hingga saat ini kami belum pernah melihat kera ekor panjang dan juga tidak pernah kami mendengar informasi dari masyarakat tentang adanya kera di daerah ini.
Bapak Ngguai	1	Arso X	Petani / berburu	Saya orang asli arso dan kehidupan saya yaitu bertani dan berburu tetapi hingga saat ini saya belum pernah melihat kera di daerah kami ini.
Kepala Desa Arso X	2	Arso X	Petani	Saya berada di Arso X ini sudah 10 tahun hingga saat ini tetapi saya belum pernah melihat kera ekor panjang dan juga hingga saat ini belum ada informasi dari masyarakat / warga tentang kera ekor panjang di sini.
Moko	2	Arso VIII	Petani	Saya tinggal di Arso VIII ini sudah 10 tahun hingga saat ini, tetapi saya belum pernah melihat kera ekor panjang di sini.
Ibu Raubaba	1	Arso VIII	Petani	Belum pernah melihat kera ekor panjang di daerah ini.
Bapak Wenda	6	Arso VIII	Petani / berburu	Belum pernah kami melihat kera ekor panjang di daerah ini.

Kepala Desa Arso VII	1	Arso VII	Kepala Desa	Sudah 17 tahun saya tinggal disini tetapi saya belum pernah melihat kera ekor panjang di sini.
Ibu Oky Furima	2	Arso VII	Tukang Senso Kayu	Bapak selama ini di hutan untuk mengambil kayu, tetapi hingga saat ini ia belum pernah mendapatkan / melihat kera di hutan.
John Sineri	3	Arso VII	Pensiunan Polri	Di daerah ini belum pernah kami melihat / temukan kera ekor panjang, yang pernah saya lihat yaitu di daerah Nimbokrang satu ekor yang di pelihara oleh masyarakat saya langsung ambil kera itu ke Genyem dan saya langsung menembaknya hingga ia mati.
Harun	1	Arso VI	Sekertaris Desa	Belum pernah kami melihat kera ekor panjang di daerah ini.
Hendrik Asso	1	Arso VI	Kepala Desa	Saya tinggal di daerah arso mulai dari arso XIV, X, XI, VIII, VII, VI, I, II, dan Arso Swakarsa, pada waktu itu daerah ini sangat rawan sekali, namun hingga saat ini belum pernah kami melihat kera ekor panjang di daerah arso seluruhnya.
Matias Borotia	1	Arso Kota	Petani	Di daerah tidak pernah kami melihat kera ekor panjang, kalau daerah Vim Kotaraja itu ada dan ceritanya begini, waktu dulu sekitar tahun 1956 / 1957 ada orang Indo-Belanda ia koki RWD / sekarang disebut DPU dia yang memelihara 1 pasang kera ekor panjang tersebut, dia pulang ke daerahnya kera itu di tinggalkan di Abepura
Alex Lambe	7	Arso Kota	Petani	Tidak pernah melihat kera ekor panjang di daerah ini.
Agus Burupkay	1	Arso Kota	Petani	Tidak pernah melihat kera ekor panjang di daerah ini.
Roby	2	Arso Kota	Berburu	Tidak pernah melihat kera ekor panjang di daerah ini.
Ferry Kuames	3	Arso Kota	Staf Kecamatan Arso	Sekitar 2 atau 3 tahun yang lalu pernah ada masyarakat arso kota yang berburu dan melihat kera ekor panjang 1 ekor sedang bermain-main di hutan pinggiran sungai tami, namun hingga saat kera yang pernah dilihat itu sudah tidak nampak lagi di hutan yang pernah mereka jumpai.
Lili Suzali	4	Arso I	Petani	Tidak pernah kami melihat kera di daerah ini,Cuma sekarang baru ada yang saya pelihara ini saya bawah dari Jawa Barat.
Hengki Kalembulu	4	Kampung Puay	Karyawan Hanurata	Saya pernah mendengar cerita dari salah seorang bapak di kampung Bengueng bahwa ia berburu dan pernah melihat kera ekor panjang 1 ekor.
Yusak Doyapo	4	Kampung Puay	Berburu	Belum pernah kami melihat kera ekor panjang di daerah ini, sebab saya selalu berburu dan hingga saat ini belum pernah kami jumpai kera di sini.
Yosep Awaitouw	1	Kampung Yeikiwa	Berburu	Belum pernah kami melihat kera ekor panjang di sini.
Jonas Yoisan	2	Kel. Entrop	Petani	Di daerah ini sering kami lihat, dan juga ia suka mengganggu tanaman kami, susah sekali mengatasinya sebab hasil kebun kami seperti jangung belum kami penen ia sudah lebih duluan memanennya, istilahnya kita hanya menanam untuk binatang itu saja.
Lukas Wel	3	Kel. Entrop	Petani	Banyak kera ekor panjang di sini dan kami sering melihatnya bermain kalau pagi dan sore. Tanya saja sama anak-anak mereka juga tahu bahwa kera ada di sini.
Deky Ramandey	1	Kel. Entrop Belakang Terminal	Petani	Sering kami melihat kera ekor panjang di sini, tetapi sekarang sudah agak jarang kami melihatnya lagi sebab pohon tempat ia suka bermain sudah di bakar sehingga sekarang ini jarang kami melihatnya lagi.
Perry Wonda & Yoter Wonda	8	Kampung Wondeng Gobak Distrik Mulia Kab. Puncak Jaya	Petani	Kami tidak pernah melihat kera di Mulia.
Geine Wonda	19	Kampung Inginikime	Aparat desa & petani	Kami tidak pernah melihat kera disini
Penore Wonda & Minus Tabuni	5	Kampung Uringgame	Bekas GPK & Petani	Tidak pernah kami melihat kera di sini dan saya sendiri sering berkeliaran di hutan sini tapi tidak pernah saya melihat kera.

Alex Enemoe & Yanuas Enemoe	3	Kampung Kolarimbanak	Petani	Di sini tidak ada/tidak pernah kami lihat.
Niko Telengen	7	Kampung Wuyuneri	Petani	Tidak ada kera di sini karena kami belum pernah melihatnya.
Frans Pigome	1	Kampung Wuyuneri	TU SMU Neg.I. Mulia	Tidak pernah kami melihatnya.
Konday Manggaprouw	1	Kampung Wuyuneri	Guru SMU Neg.I.Mulia	Tidak ada kera di sini.
Yeheskiel Tenoy	1	Kampung Wuyuneri	Kepala Sekolah SMU Neg. I Mulia	Selama saya pindah dan bertugas di Mulia tidak pernah saya melihat kera di sekitar sekolah kami, dan saya sendiri sering kehutan di sekitar depan dan belakang sekolah namun hingga saat belum pernah saya melihat kera.
Pison & Gum	2	Kampung Wuyuneri	Penjaga sekolah	Kami belum pernah melihat kera disini, kami orang asli disini sebagai penjaga sekolah kami juga sering kehutan tapi tidak pernah kami melihat kera disini.
Enos Inumbi	6	Kampung Wuyukwi	Kepala Desa	Selama ini tidak ada kera yang kami lihat di Mulia, mulai dari saya kecil hingga saat ini kami belum pernah melihat kera itu disini. Pernah ada salah seorang Misionaris di Kec. Ilaga yang memelihara 1 ekor tapi sejak ia pindah ia mengambilnya.
Bapak Enembi	2	Kampung Tuwogi	Petani	Kera tidak ada disini.
Erikit Enembi	2	Kampung Tuwogi	Petani Nanas	Tidak ada kera disini/tidak pernah kami melihat kera disini.
Yupinus Wonda	1	Kampung Wuyukwi	Pelajar SLTP	Tidak ada kera di Mulai dan di Kecamatan-kecamatan sekitar sini, kami hanya pernah melihat kera di televisi saja.
Genius Wonda	1	Kampung Wuyukwi	Pelajar SLTP	Tidak ada kera disini sebab kami tidak pernah melihatnya.
Agus Raunsai	2	Kompleks SLTP Mulia	Guru SLTP Mulia	Selama saya berada dan mengajar di sini tidak pernah saya melihat kera di sini dan juga kalau ada sesuatu yang baru/hal-hal yang aneh sering siswa-siswaku menyampaikan kepadaku tapi hingga saat ini belum pernah kami mendengar bahwa ada kera di Mulia.
Bapak Kipuw	1	Jl. Borobudur Manokwari	Peg. Kec.Wasior	Saya sudah bertugas di Manokwari selama 30 tahun hingga saat ini tapi saya belum pernah mendengar bahwa ada kera di sini.
Yonas Tanati	3	Asrama Tingkat Blok II	Mahasiswa UNIPA	Saya pada waktu itu KKN di Kec. Ransiki tapi tidak ada kera di sana.
Viktor Taime	2	Asrama Tingkat Blok II	Mahasiswa UNIPA	Saya pernah KKL Sp 11 dan saya melihat ada masyarakat asli Manokwari yang memelihara kera ekor panjang 1 ekor.
Bertho Brabar	5	Desa Sabri Ransiki	Petani	Kami dari kecil tinggal di Ransiki hingga saat ini tapi belum pernah kami melihat kera di hutan Ransiki.
Rudy Wondiwoy	3	Jl. Trikora Wosi-Taman Ria	Kepala Kantor WWF Wilayah IV	Tidak ada kera di Manokwari sedangkan jenis eksotik lainnya yang ada di sini yaitu *Bufo Melanouticus* yang sudah ada di sini.
Susana A. Burdam	3	Jl.Ciliwung 01 Sanggeng	Manager Keuangan (YALHIMO)	Selama ini kami belum pernah melihat kera ekor panjang di daerah Manokwari.
Iswandhie Hasan	4	Jl. Trikora 56 Wosi	(PERDU) Finance	Selam survey kami di belum pernah kami melihat dan mendengar bahwa ada kera di Manokwari.
KDSA	3	Jl. Trikora Wosi	BKSDA II	Tidak ada kera di Manokwari hingga saat ini sedangkan kalau yang berani mengambil jenis eksotik dan kalau di ketahui oleh Karantina maka akan di musnahkan.
D. Waromi	3	Kampung Baru Sorong	Karyawan Perusahaan Minyak	Saya bekerja di perusahaan ini sudah hampir 8 tahun dan kami sering di hutan sekitar sele tapi tidak pernah kami melihat kera.
E. Fonataba	1	Kampung Baru Sorong	Pengawas	Saya sudah bekerja di perusahaan ini hingga saat ini, dan tugas saya sebagai

			Perusahaan Minyak	pengawas survey tetapi hingga saat ini kami belum pernah menemukan kera di daerah ini.
Adi Suprapto	8	Pos Penjagaan Wambes	Anggota keamanan/TNI	Sejak kami bertugas di pos Wambes, kami tidak pernah melihat kera ekor panjang, kecuali di Kotaraja dan Pulau Jawa
Bapak Timur Wenda	3	Kampung Wambes	Petani	Kami tidak pernah melihat kera ekor panjang di sini, Cuma yang sering kita lihat hanya Kanguru pohon/lao-lao.
Yosep Hamhabal	2	Wambes Kampung Kecil	Petani	Kami tinggal dari dulu atau sejak moyang kami hingga sekarang tidak pernah kami melihat binatang ini/ kera, yang kami lihat adalah kanguru/lao-lao.
Alex Kimber	1	Wambes Kampung Kecil	Petani	Kami tidak pernah melihat hewan ini disini.
Mekki Butih	1	Wambes Kampung Kecil	Petani	Sangat aneh sekali, sebab kami baru melihat hewan ini di gambar dan tidak pernah kami melihatnya di hutan sini
Petrus Mesas	1	Wambes Kampung Kecil	Petani dan Berburu	Hewan ini/kera ekor panjang ini tidak ada disini, kami sering berburu ke hutan dan bermalam di hutan tapi tidak pernah kami melihat/temukan binatang ini.
Dominikus Mesas	1	Wambes Kampung Kecil	Petani dan Berburu	Kami jamin bahwa 100% binatang itu tidak ada disini, karena kami sering berburu di hutan dan tidak pernah kami melihatnya.
Zulfikar	6	Pos Penjagaan Ujung Karang Lembah Bewani	Anggota keamanan/TNI	Kami sudah bertugas satu tahun disini kami tidak pernah melihat hewan ini, yang sering kami jumpai yaitu kanguru/lao-lao dan kus-kus.
Yance Bewangkir	2	Kampung Kriku lembah Bewani	Petani dan Berburu	Dari dulu kami tinggal disini hingga saat ini dan kami setiap hari berburu di hutan tapi kami tidak pernah melihat kera di sekitar daerah ini, hanya yang sering kami lihat adalah kanguru.
Deminus Enef	1	Dusun Kriku dan Yetti	Ondoafi dusun Kriku dan Yetti	Kami tinggal dari dulu sampai sekarang tidak pernah kami melihat hewan itu disekitar sini, dan apabila ada masyarakat yang melihatnnya pasti mereka sampaikan kepada saya karena hewan baru atau aneh.
Marthina Bewangker	1	Kampung Yetti lembah Bewani	Petani	Hewan atau binatang itu/kera ekor panjang ini tidak ada disini.
Julius Gilgil	5	Vanimo, PNG	2nd Pacific Islands Regiment, Warrant Officer	Sering patroli di daerah perbatasan PNG – RI. Pada tahun 1999 dilaksanakan joint-operation di daerah Yetti / Bewani sampai Wutung. Sudah tanya mengenai kera kepada masyarakat dan tidak ada laporan maupun observasi langsund di hutan.
Robert Babia	4	Vanimo / Wewak	Vanilla buyer	Sering jalan ke kampung untuk mencari vanili. Tidak pernah dengar tentang kera.
Francis K. Oken and Petrus Aleti	2	Vanimo	National Agricultural Quarantine and Inspecition Authority of PNG	NAQIA selalu mengawasi masalah kera ini di daerah PNG – RI sejak diangkat oleh lembaga-lembaga pelestarian International. Mereka belum pernah ketemu informasi maupun individu kera selama pengawasan tersebut. Pada bulan mei 2003 NAQIA kerjasama AQIA (Australi) berjalan operasi ke Bewani district, dan bertanya masyarakat khususnya tentang keberadaan kera. Tidak ada laporan sama sekali.

Appendix 3 - Observations of *Macaca fascicularis* at Vim / Kotaraja

Date	Time surveying	Time of observation	Total time observing *M.fascicularis*	Troop	Trail No.	Section	Notes
12/12/02	14.00 - 16.00	14.20	2	Mangga	-	-	Initial surveys to design trails. 6 individuals observed raiding cassava
15/12/02	06.00 - 12.15	06.00	2	Mangga	R4	30	In *Terminalia arch (SN 7)* eating young leaves (∑;♀♂; ad/juv/inf ?) - several individuals. Note group extremely sensative to observer.
		07.20	6	Meer	R3	T5	Group <5 indivs moving to n. (inc ad♂, 2 juv, 2 indivs heard)
		09.00	3	Mangga	R3	25	Group (∑;♀♂; ad/juv/inf ?) moving to s. Straggler juv ♂ following group.
16/12/02	06.30-12.00	06.40; 09.10; 10.00	35	Mangga	R4	w. of 21 - 31	Group moving n. - followed along R4, 21-31, occasional contacts and sightings - turned w. then s. juv seen eating seeds from *SN 1*
	16.00-18.00	16.45	1	Meer	R4	33	2 indivs moving n.
		17.30-	20	Mangga	R3	e of T1-T2	Group (∑;♀♂; ad/juv/inf ?) but incl. α♂, 2 juv, moving s. through low trees and seen raiding cassava. Settling in *Intsia* roost tree
17/12/02	06.00 - 11.00	06.10	2	Mangga	R4	22-23	4 indivs moving on ground
		10.00	1	Mangga	R3	e. of T3	♀ with inf. In coconut
18/12/02	15.00 - 18.00	17.30	22	Mangga	R4	w. of 29 (T4)	2 juv.♀ in roost tree (*Ficus* sp.)
19/12/02	06.00 - 12.00	06.45	17	Mangga	R3	T3 / T4	ad.♀ and 2 juv in *Term arch* (new leaves) *SN 7*
21/12/02	05.00 - 11.30	05.00	2	Mangga	R3	T4	Eating *Hibiscus (SN 6)* several indivs - soon lost contact
23/12/02	07.00 - 12.00	07.00	20	Mangga	R3	e. of T3	(obs. from T2) ad.♀ and 1 juv in Euphorbiaceae *(SN 3)*. Rest of group dispersed in mangoes and between T3 and T4. Also 2 indivs in *SN 7 (Terminalia*)
		08.20	10	Mangga	R4	31-10	Group persued to section 10. They regrouped in the fruiting mangoes at T2. Unripe fruit tasted on the stalk left alone - inc. 2 ad ♀♂ with 4 juv.
		09.30	25	Mangga	R3	T2 / T3	3 juv (♀♂ ?) seen feed ing in Ficus sp. *(SN 3*). Several indivs (∑ unknown) taking flowers of Meliaceae. Ad ♂ with inf. In mango. ad♂ also in adjacent mango
26/12/02	15.00 - 17.30	15.10	10	Mangga	R3 / R4	19 - 31	4 indivs (inc ad ♀ with inf. + 2 juv.) moving n.
27/12/02	06.00 - 11.00	06.30	5	Mangga	R4	24	Group split with 4 indivs (inc ad ♀ with inf. + 2 juv.) moving n. Remained of group to s.
		10.28	17	Mangga	R3	T2	Juv. Seen eating seed of Euphorbiaceae *(SN 3)*. 2 other juveniles in Matoa / mango
28/12/02	08.00 - 12.00	-	-	Entrop	-	-	No sighting
29/12/02	14.00 - 17.30	-	-	Entrop	-	-	No sighting
31/12/02	10.30 - 14.30	-	-	Kapal	R1	21	No sighting. Heard group near summit
02/01/03	14.30 - 18.10	14.30		Mangga			Group of 8 indivs seen (inc 2 sentries - juvs), Group eating cassava, *Intsia (SN 4)*and mangoes
		16.50	70	Meer	R3	Road	Group of 9 indivs (possible 10 as ♀ with inf.) feeding in fruiting *F.benjamina* on forest edge of s.ridge *(SN 12)* and also in fruiting *Ficus* sp. *(SN 11)*
03/01/03	16.30 - 18.30	17.45	5	Meer	-		Meer Group seen moving towards figs tree as of 02/01/03, observer cut up through ridge and intercepted group in fig tree, vocalising. 10 + obs.
04/01/03	14.00 - 18.00	14.10	20	Mangga	R3	T2	9 individuals obs (inc 1 inf.) eating *Intsia* and *Pandanus*
		17.20	40	Meer		Road	12 individuals obs. (inc 2 inf.) eating and moving between *Ficus* spp and Meliaceae *(SN 15)* - roost tree
		17.20	40	Vihara		Road	8 indivs obs (no inf.) on adjacent rocky ridge to n.
05/01/03	06.00 - 12.00	06.05	25	Meer	R2	Road - 3	Group already split remaining 3 indivs (♀♂?) - social activities. Moved to s. and e. towards R3 / T6 (south slope of Meer).
		06.10	140	Vihara	R2	Road - 5	Group moved slowly e. At least 6 indivs obs. Inc ad.♂ + ad.♀ with inf. Much social activities. Eating confined to *Intsia* and bark of liana *SN 25*, generally inactive. Resting on large fig on middle ridge.

07/01/03	05.00 - 08.30	05.15	180	Vihara		Road	5 indivs obs eating from large fig *(SN 21 &27)* and *Intsia.* Resting in large dead tree with strangling fig *(SN12)*
				Meer		Road	12 indivs obs (with 1 addition heard - leaves moving) ♀♂ unknown. Very active and spread out feeding on *SN 11-15* 150m from view-point.
09/01/03	06.00 - 10.00	06.05	135	Vihara		Road	14 indivs obs. 2 ad ♂; 4 ad ♀♀; 1 juv ♂; 3 juv ♀♀; inf 4 (with ♀♀). Eating *SN 26, 27, Intsia* and *32*
18/01/03	06.00 - 11.00	06.35	25	Meer		Road	7 indivs obs eating figs on s. ridge
		07.25	8	Vihara		Road	1 ad ♀ obs branch bouncing, no other indivs obs
		08.00					3 indivs of Meer troop seen moving e. feeding on figs, *Intsia* + flower and fruit of tree on ridge (unknown species)
23/01/03	06.30 - 12.00	-	0	Meer	R2	-	
25/01/03	07.00 - 13.30	-	0	Entrop	-	-	
27/01/03	07.30 - 14.00	-	0	Meer / Vihara	R2	Road	
28/01/03	06.00 - 12.30	?	14	Mangga	R4	32	6 indivs (♀♂; ad/juv/inf ?)
29/01/03	06.30 - 14.00	?	20	Meer	R2	0 - 20	4 indivs (♀♂; ad/juv/inf ?)
30/01/03	07.00 - 13.30	?	12	Mangga	R4	29	3 indivs (♀♂; ad/juv/inf ?) - eating *Intsia*
30/01/03		?	15	Mangga	R4	33	2 indivs (♀♂; ad/juv/inf ?) - moving s.
31/01/03	06.30 - 12.30	-	0	Meer / Vihara	R2	0 - 20	-
04/02/03	06.30 - 12.00	?	30	Meer	R2	Road - 5	4 individuals (♀♂; ad/juv/inf ?) - moving e. then s.
15/02/03	06.00 - 10.00	-	0	Kapal	R2	34 - 1	No sightings
22/02/03	08.00 - 10.00	09.10	35	Mangga	R3	T1	Group feeding at station (estimated that there were 8 indivs.
24/02/03	07.00 - 11.00	-	0	Entrop	-	-	No sightings
25/02/03	06.30 - 11.30	-	0	Entrop	-	-	No sightings
26/02/03		-	0	Entrop	-	-	No sightings
27/02/03		-	0	Entrop	-	-	No sightings
28/02/03	07.00 - 11.00	09.00	35	Mangga	R3	FS	Group at feeding station (inc 2 ad ♂; 2 ad ♀; 2 juv.)
01/03/03	07.00 - 12.30	10.30	30	Mangga	R3	FS	Group at feeding station (♀♂; ad/juv/inf ?)
02/03/03	07.00 - 09.30	08.00	90	Tanah Hitam	-	house	Group of 9 indivs in sago: (inc 1 ad ♂; 1 ad ♀; 4 juv (♂♀?); 1 inf)
03/03/03	07.00 - 11.00	07.15	15	Meer	R2	Road	3 indivs in fig farthest from road (♀♂; ad/juv/inf ?)
				Vihara		Road	∑; ♀♂; ad/juv/inf ?
04/03/03	07.00 - 10.00	07.30	45	Vihara	R2	Road to 3	To n. of 3 - 100m on middle ridge in usual fig resting place. See eating from fig and adj trees *(SN 21-24).* 5 indivs obs (inc. ad♂, 1 ♀, 3 juvs)
06/03/03	06.00 - 08.30	06.00	150	Vihara	R2	Road to 3	To n. of 3 - 100m on middle ridge in usual fig resting place. See eating from fig and adj trees (SN 21-24). 9 indivs obs (inc. 1ad♂, 2ad♀, 4 juvs, 2 inf)
07/03/03	06.30 - 12.00	07.00	75	Vihara	R2	3	6 indivs obs in Fig (♀♂; ad/juv/inf ?)
		11.00	5	Vihara	-	On central ridge from R2 10	Collected SN 21-25. Vihara troop spending much time on the forest floor. 1 ad ♂ (α) seen very close, many others heard. Moved off to n.
29/03/03	06.30-10.30		10	Meer	R1	25	6 indivs, 4 adults + 2 juveniles. In Intsia moved off to the west
29/03/03	06.30-10.30	07.70	5	Meer	R2	10	Single indiv from MEER. Eating SN 43
		06.30	25	Vihara	R2	0	11 indivs in fig (♀♂ ?) (VIHARA)
29/03/03	06.30-10.30	07.10	3	Pantai	R3	3	3 indivs in mango eating insects on leaves. (PANTAI)
		07.30	5	Pantai	R3	4	2 indivs moved east. (PANTAI)
		08.10	2	Meer	R3	12	6 indivs eating Intsia leaves (MEER) moved off to east.
29/03/03	06.30-10.30	07.08	2	Pantai	R4	5-6	2 indivs (PANTAI) (♀♂ ?)
		07.21	2	Pantai	R4	8	1♀ (h+) (PANTAI) in Intsia

		07.24	3	Pantai	R4	9	3 (inc. 1♂) in low trees / bamboo (PANTAI) - same indivs as earlier obs
		07.50	2	Mangga	R4	26	4 indivs (3 ads + 1 juv) (MANGGA) - in mangoes
		07.59	3	Mangga	R4	30	3 indivs (1 ad. And 2 juv.) (MANGGA)
		08.18	3	Meer	R4	39	2 inivs (MEER)
02/04/03	06.30 - 11.00	07.20	15	Pantai	R4	5	3 indivs (♀♂ ?) moving towards the beach
		08.05	30	Mangga	R4	26	10 indivs seen (♀♂?) eating Hibiscus and Intsia shoots
02/04/03	06.30 - 11.00	10.30	20	Meer	R1	31	7+ (MEER) moving east
04/04/03	06.15 - 11.00	07.15	5	Kapal	R2	23	5 indivs. - 1 α♂; 1 ad ♀ carrying inf; 1 ad(♂♀?); 1 juv (♂♀?)
		09.15	3	Meer	R1	n. of 25-26 on ridge	8 indivs seen (heard for longer). Moved of to n and w.
04/04/03	05.30-10.00	?	12	Mangga	R4	10	4 ad and 2 juv, eating in Intsia. (MANGGA)
		?	17	Mangga	R4	13	2 ad (?) + 3 juveniles moving north
04/04/03	05.30-10.00	06.15	60	Vihara	-	middle ridge from road	8 indivs - 4 ad.♀ and 4 inf. in *F. benjamina*, moving north
05/04/03	6.30 -9.30	06.45	2	Vihara	R1	1	4 individs moving north
			30	Vihara	R1	5	2 ad ♂, 2 ad ♀, 1 juv., 1 inf. Eating fig and Intsia. Move N
			45	Vihara	R1	5-6	1 juv moving north.
05/04/03	06.30 - 10.00	09.10	25	Meer	R1	22	5 indivs (1 α♂; 2 ad ♀; 1 juv (♂♀?); 1 inf (♂♀?)
05/04/03	6.30-10.00	?	3	Mangga	R4	13	6 individuals sighted inc. 2 ad ♂; 1 ad ♀; 1 juv ♀; 2 juv (♀♂?)
		?	2	Mangga	R4	14	2 juv ♂
		?	2	Meer	R4	33	2 ad ♂; 1 ad ♀. Traversing ground using cut paths.
		?	2	Meer	R4	36	1 ad ♂; 1 juv ♂; 1 ad ♀
05/04/03	6.30-09.30	?	68	Vihara	R2	3	6 individuals sighted inc. 2 ad ♂; 2 juv (♂♀?) plus 2 inf / juv. (♂♀?). Moving n.
06/04/03	06.00 - 08.00	~07.00	10	Mangga	R4	13	13 indivs (inc. 1 ad ♀ pregnant; 1 ad ♂; 3 juv (♀♂?); 1 inf.; + 8 others (ad/juv/♀♂?)
06/04/03	06.00 - 08.00	07.15	4	Pantai	R3	9	4 indivs (inc 3 ad (♀♂?); 1 juv (♀♂?)). Raiding cassava
08/04/03	06.00 - 08.30	06.15	3	Pantai	R4	6	5 indivs (1 ad ♂ ; 1 ad ♀; 1 juv) + (1 ad ♀; 1 juv). Eating Meliaceae
		06.45	3	Mangga	R4	14	8 individuals seen (others heard), 6 in Intsia + 2 ad ♂. 2-3 indivs in each sub-group - dispersed of large area
09/04/03	09.30 - 12.45	09.45	5	Mangga	R4	T2	Observed 2 ad ♀ with juveniles (2). Specimen collecting disturbed group.
13/04/03	06.00 - 08.30	07.40	14	Kapal	R2	28	4 indivs heard / seen briefly. Followed group to e. then s. for 1/4 hr
		09.00	3	Meer	R2	11	5 indivs seen inc 2 ad ♀; 1 ad ♂; 2 juv (♂♀?).
20/04/03	07.00 - 08.30	-	80	Tanah Hitam	-	-	10 indivs. (2 ad ♂; 3 ad ♀; 4 juv (1♂, 3♀); 1 inf)
22/04/03	07.10 - 08.40	08.25	9	Mangga	R4	T3	10 indiv seen - all traversing along ground. (inc. 3 juvs, 6 ad)
24/04/03	06.10 - 09.15	-	8	Pantai	R3	7 - 8	6 indivs (1 ad ♂; 2 ad ♀; 2 juv (♂♀?); 1 juv)
04/05/03	1700 - 17.30	17.10	20	Meer	road		9 indivs (3 ad ♂; 3 ad ♀ (inc. 1 Pr+); 3 juv (♂♀?)
11/05/03	17.00 - 18.00	17.30	15	Meer	road		11 indivs; 2ad♂; 4 ad♀; 3 juvs;2 inf)

Appendix 4 - Bird Species Recorded in Four Study Locations Using MacKinnon List Method

	Primary forest WITH *Macaca fascicularis*								
		1	2	3	4	5	6	7	8
1	*Cracticus gouyi*	✓	✓	✓	✓	✓	✓	✓	✓
2	*Philemon buceroides*	✓	✓	✓	✓	✓	✓	✓	✓
3	*Meliphaga sp*	✓	✓	✓		✓	✓	✓	
4	*Ptilinopus iozonus*	✓							
5	*Centropus menbeki*	✓		✓					✓
6	*Dicrurus bracteatus*	✓			✓	✓		✓	✓
7	*Pitohui dicrous*	✓	✓	✓			✓	✓	✓
8	*Cacomantis variolosus*	✓			✓		✓		
9	*Nectarina jugularis*	✓			✓	✓	✓	✓	
10	*Dacelo gaudichaud*	✓							
11	*Trichoglossus haemotodus*		✓						
12	*Micropsitta pusio*		✓		✓			✓	
13	*Manucodia atra*		✓	✓	✓	✓	✓	✓	✓
14	*Myiagra alecto*		✓		✓		✓		✓
15	*Rhipidura rufiventris*		✓	✓		✓	✓	✓	✓
16	*Nectarina aspasia*		✓	✓		✓			✓
17	*Haliastur indus*			✓					
18	*Dicaeum pectorale*			✓	✓	✓		✓	
19	*Crateroscelis murina*				✓				
20	*Ptilinopus coronatus*					✓			
21	*Pycnopygius ixoides*						✓		
22	*Cyclopsitta diophthalma*								✓
	Cumulative Total Species	10	16	18	19	20	21	21	22

	Primary forest WITHOUT *Macaca fascicularis*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	*Philemon buceroides*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	*Melipahga sp*	✓		✓		✓		✓	✓		✓	✓	✓	✓		✓		
3	*Mino dumontii*	✓																
4	*Cracticus gouyi*	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓
5	*Cracticus cassicus*	✓			✓	✓			✓				✓		✓			
6	*Nectarina aspasia*	✓	✓				✓		✓		✓	✓			✓		✓	
7	*Dicrurus bracteatus*	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	*Paradisaea minor*	✓		✓		✓	✓		✓	✓		✓	✓				✓	✓
9	*Cacomantis variolosus*	✓	✓			✓				✓			✓		✓		✓	✓
10	*Rhipidura rufiventris*	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓		✓	
11	*Nectarina jugularis*		✓						✓		✓					✓		✓
12	*Haliastur indus*		✓	✓	✓		✓	✓					✓					
13	*Eclectus roratus*		✓															
14	*Toxorhamphus novaeguineae*		✓									✓						
15	*Manucodia atra*		✓				✓	✓		✓	✓	✓		✓		✓	✓	✓
16	*Corvus orru*			✓				✓										
17	*Micropsitta pusio*			✓							✓			✓	✓	✓		✓
18	*Ptilonopus aurantiifrons*			✓		✓		✓		✓								
19	*Pitohui dicrous*				✓			✓	✓							✓		✓
20	*Dicaeum pectorale*				✓				✓		✓				✓			
21	*Podargus papuensis*				✓													
22	*Chalcophaps stephani*				✓									✓				
23	*Dacelo gauchichaud*					✓												
24	*Coracina melaena*						✓	✓								✓		
25	*Alisterus chloropterus*						✓			✓							✓	
26	*Duclua rufigaster*							✓										
27	*Geoffroyus geoffroyi*							✓				✓					✓	
28	*Macropygia nigirostris*									✓								
29	*Gerygone chloronotus*											✓		✓				
30	*Melilestes megarhynchus*											✓						
31	*Myiagra alecto*												✓					
32	*Aviceda subcristata*														✓	✓		
33	*Centropus menbeki*																	✓
	Cumulative Total Species	10	15	18	22	23	25	27	27	28	28	30	31	31	32	32	32	33

	Secondary forest WITH *Macaca fascicularis*												
		1	2	3	4	5	6	7	8	9	10	11	12
1	*Malurus cyanocephalus*	✓			✓	✓			✓		✓		✓
2	*Meliphaga sp*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	*Nectarina jugularis*	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓
4	*Corvus orru*	✓						✓		✓			
5	*Cracticus gouyi*	✓	✓	✓			✓				✓	✓	✓
6	*Ptilinopus iozonus*	✓	✓									✓	
7	*Philemon buceroides*	✓	✓	✓	✓		✓		✓			✓	✓
8	*Manucodia atra*	✓		✓	✓	✓							
9	*Ptilonopus coronatus*	✓	✓										
10	*Nectarina aspasia*	✓			✓	✓	✓	✓	✓	✓	✓	✓	
11	*Myiagra alecto*		✓		✓	✓	✓	✓	✓				
12	*Accipter sp.*		✓										
13	*Pitohui dicrous*		✓	✓	✓	✓		✓	✓	✓	✓	✓	
14	*Centropus menbeki*		✓	✓	✓					✓			✓
15	*Haliatstur indus*		✓				✓	✓					✓
16	*Dacelo gaudichaud*			✓			✓					✓	
17	*Rhipidura leucothorax*			✓	✓	✓							
18	*Rhipidura rufiventris*			✓			✓	✓	✓		✓	✓	
19	*Glycichaera fallax*					✓							
20	*Dicrurus bracteatus*					✓	✓	✓	✓	✓	✓		✓
21	*Corvus tristis*						✓						
22	*Pitohui kirhocephalus*							✓		✓	✓		
23	*Halcyon sancta*								✓				
24	*Gerygone sp.*									✓		✓	
25	*Dicaeum pectorale*									✓	✓		✓
26	*Rhipidura leucaphrys*									✓			
	Cumulative Total Species	10	15	18	20	20	21	22	23	26	26	26	26

	Secondary forest WITHOUT *Macaca fascicularis*															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	*Philemon buceroides*	✓	✓	✓		✓	✓			✓	✓			✓	✓	✓
2	*Corvus orru*	✓		✓							✓			✓		✓
3	*Nectarina aspasia*	✓			✓	✓	✓	✓		✓		✓		✓	✓	
4	*Nectarina jugularis*	✓	✓		✓		✓	✓	✓	✓				✓	✓	
5	*Centropus menbeki*	✓					✓						✓			
6	*Cracticus gouyi*	✓			✓		✓	✓			✓	✓		✓		
7	*Cacomantis variolosus*	✓	✓				✓	✓			✓				✓	
8	*Pitohui dicrous*	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
9	*Rhipidura rufiventris*	✓	✓	✓	✓	✓	✓			✓					✓	✓
10	*Haliastur indus*	✓	✓					✓	✓							
11	*Rhipidura leucothorax*		✓						✓	✓	✓			✓	✓	
12	*Podargus papuensis*		✓		✓				✓					✓		
13	*Ptilinopus sp.*		✓							✓						
14	*Meliphaga sp*		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓
15	*Myiagra alecto*			✓				✓		✓				✓	✓	✓
16	*Pitohui kirhocephalus*			✓												✓
17	*Ptilinopus iozonus*			✓	✓						✓	✓	✓		✓	
18	*Malurus cyanocephalus*			✓	✓											
19	*Manucodia atra*			✓					✓			✓	✓		✓	
20	*Micropsitta pusio*			✓		✓			✓	✓		✓				
21	*Dicrurus bracteatus*				✓				✓			✓				✓
22	*Ducula sp.*				✓							✓				
23	*Corvus tristis*					✓										
24	*Trichloglossus haematodus*					✓										
25	*Cyclopspitta diopthalma*					✓							✓			
26	*Diceaum pectorale*					✓							✓			
27	*Eurystomus orientalis*					✓		✓					✓			
28	*Dacelo gauchichaud*						✓				✓					
29	*Rhipdura leucophrys*						✓									
30	*Myzomela nigrita*							✓								
31	*Cracticus cassicus*								✓							
32	*Coracina melaena*										✓		✓			
33	*Megapodius freycinet*											✓				

34	*Ptilinopus superbus*												✓			
35	*Amaurornis olivaceus*														✓	
36	*Arses telescophthalmus*														✓	
	Cumulative Total Species	10	14	20	22	27	29	30	31	31	32	33	34	34	34	36

Appendix 5 - Quantitative Bird Samples (Spot Observations) to Measure Diversity

Primary Forest with *Macaca fascicularis*

	Bird Species	Spot Observation 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		P_i	P_i^2	$P_i ln[P_i]$		
1	*Philemon buceroides*	2	4	2				2	3	3	1		1		1	1	1	2	1	2	3	29	0,173	0,030	-0,303	**Simpson's D**	**10,323**
2	*Meliphaga sp.*	2			1	1		1	2	2	2	2	1				1	2	4	1		22	0,131	0,017	-0,266	**Simpson's E**	**0,543**
3	*Cracticus gouyi*	1	2	1		2	2		2			1	2		1			1	3		1	19	0,113	0,013	-0,246	**Shannon's H**	**2,544**
4	*Dicrurus bracteatus*	1		1				2	1		1				2	2		3	2	2	2	19	0,113	0,013	-0,246	**Shannon's E**	**0,864**
5	*Centropus menbeki*	1																				1	0,006	0,000	-0,030		
6	*Ptilonopus iozonus*	7																				7	0,042	0,002	-0,132		
7	*Cacomantis variolosus*		1												1			1				3	0,018	0,000	-0,072		
8	*Pitohui dicrous*			4		1		4				2	1	2					1		2	17	0,101	0,010	-0,232		
9	*Nectarina aspasia*				1			1		1		2	2				1			1	1	10	0,060	0,004	-0,168		
10	*Dacelo glaudichaud*				1																	1	0,006	0,000	-0,030		
11	*Nectarina jugularis*					2										1		1	1			5	0,030	0,001	-0,105		
12	*Rhipidura rufiventris*							2			1							1		1	1	6	0,036	0,001	-0,119		
13	*Myiagra alecto*							1	2					2		1						6	0,036	0,001	-0,119		
14	*Manucodia atra*								1	1			1						1	2	2	8	0,048	0,002	-0,145		
15	*Malurus cyanocephalus*										1											1	0,006	0,000	-0,030		
16	*Dicaeum pectorale*												2			3	1			1		7	0,042	0,002	-0,132		
17	*Craterosceli murina*														1							1	0,006	0,000	-0,030		
18	*Micropsitta pusio*														2				3			5	0,030	0,001	-0,105		
19	*Cyclopsitta diopthalma*																				1	1	0,006	0,000	-0,030		
	Abundance	14	7	8	3	6	2	13	11	7	6	7	10	4	8	8	4	11	16	10	13	168	1,000	0,097	-2,544		

Primary Forest WITHOUT *Macaca fascicularis*

	Bird Species	Spot Observation 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		P_i	P_i^2	$P_i ln[P_i]$		
1	*Philemon buceroides*	1	2	2	3	2	3	2	2	2	2	4	4	3	3	3	2	2	3		2	47	0,191	0,037	-0,316	**Simpson's D**	**10,999**
2	*Melipahga sp*	2	1		1		3	3	2	2	2	2	2		3	1						24	0,098	0,010	-0,227	**Simpson's E**	**0,407**
3	*Mino dumontii*	1																				1	0,004	0,000	-0,022	**Shannon's H**	**2,720**
4	*Cracticus gouyi*		1	2	2	2	2	2	1		2	2	2	3	2	1			2	2	2	30	0,122	0,015	-0,257	**Shannon's E**	**0,825**
5	*Dicrurus bracteatus*		1				1		1		2	2		2	1	1	1	1	2	2	2	19	0,077	0,006	-0,198		
6	*Paradisaea minor*		1		1				1			2		1	1	1						8	0,033	0,001	-0,111		
7	*Haliastur indus*			1						2												3	0,012	0,000	-0,054		
8	*Nectarina jugularis*			1							3	1			2						2	9	0,037	0,001	-0,121		
9	*Corvus orru*				2					1												3	0,012	0,000	-0,054		
10	*Micropsitta pusio*				4							3	5					4	3	3	4	26	0,106	0,011	-0,238		
11	*Pitohui dicrous*					2				1												3	0,012	0,000	-0,054		
12	*Dicaeum pectorale*							1			2				2					1		6	0,024	0,001	-0,091		
13	*Rhipidura rufiventris*							1					1	3	1		2	1		1		10	0,041	0,002	-0,130		
14	*Ptilonopus aurantiifrons*								1	9				1	1							12	0,049	0,002	-0,147		
15	*Dacelo gaudichaud*								1									1				2	0,008	0,000	-0,039		
16	*Manucodia atra*									2			1	1	1	2				1		8	0,033	0,001	-0,111		
17	*Duclua rufigaster*									1												1	0,004	0,000	-0,022		
18	*Nectarina aspasia*										1	2	1		4	2	1				2	13	0,053	0,003	-0,155		
19	*Cracticus cassicus*										4								4			8	0,033	0,001	-0,111		
20	*Alisterus chloropterus*												1	1	1							3	0,012	0,000	-0,054		
21	*Cacomantis variolosus*													1						1		2	0,008	0,000	-0,039		
22	*Macropygia nigirostris*													1								1	0,004	0,000	-0,022		
23	*Toxorhamphus novaeguineae*															1						1	0,004	0,000	-0,022		
24	*Geoffroyus geoffroyi*															1						1	0,004	0,000	-0,022		
25	*Melilestes megarhynchus*															1						1	0,004	0,000	-0,022		
26	*Gerygone chloronotus*																	2				2	0,008	0,000	-0,039		
27	*Aviceda subcristata*																		1	1		2	0,008	0,000	-0,039		
	Abundance	4	6	6	13	6	9	9	9	20	18	18	17	17	22	14	6	11	15	12	14	246	1,000	0,091	-2,720		

Secondary Forest with *Macaca fascicularis*

	Bird Species	Spot Observation 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		P_i	P_i^2	$P_i \ln[P_i]$		
1	*Nectarina jugularis*	1		1	2	2	2	1			1				1	1		1	2		1	16	0,105	0,011	-0,237	**Simpson's D**	**8,699**
2	*Meliphaga sp.*	3	2	3	2	2	2	1	3	2	2		1	1	1	2		2	1	3	3	36	0,237	0,056	-0,341	**Simpson's E**	**0,395**
3	*Corvus orru*		1																			1	0,007	0,000	-0,033	**Shannon's H**	**2,545**
4	*Ptilonopus iozonus*			1													1	1				3	0,020	0,000	-0,077	**Shannon's E**	**0,823**
5	*Pitohui dicrous*				1	4				2	4			3	3	2	2			2	2	25	0,164	0,027	-0,297		
6	*Myiagra alecto*				1	1						2										4	0,026	0,001	-0,096		
7	*Philemon buceroides*				1			1					1							1		4	0,026	0,001	-0,096		
8	*Nectarina aspasia*					2	3		1								1		4	1	1	13	0,086	0,007	-0,210		
9	*Glycichaera fallax*					1																1	0,007	0,000	-0,033		
10	*Rhipidura leucothorax*						1								1						1	3	0,020	0,000	-0,077		
11	*Manucodia atra*						1													1		2	0,013	0,000	-0,057		
12	*Malurus cyanocephalus*						1					4				3						8	0,053	0,003	-0,155		
13	*Dicrurus bracteatus*							1	1	1	1	2	1			1				1		9	0,059	0,004	-0,167		
14	*Haliastur indus*								1	1										1		3	0,020	0,000	-0,077		
15	*Dacelo glaudichaud*								2										1			3	0,020	0,000	-0,077		
16	*Rhipidura rufriventris*								1		1		1				1					4	0,026	0,001	-0,096		
17	*Pitohui kirhocephalus*									1				2	2	2						7	0,046	0,002	-0,142		
18	*Halcyon sancta*												1									1	0,007	0,000	-0,033		
19	*Rhipidura leucophrys*													1								1	0,007	0,000	-0,033		
20	*Gerygone sp*													1				2	1			4	0,026	0,001	-0,096		
21	*Dicaeum pectorale*													1							1	2	0,013	0,000	-0,057		
22	*Cracticus gouyi*																1			1		2	0,013	0,000	-0,057		
	Abundance	4	3	5	7	12	10	4	9	7	9	8	5	9	8	11	6	6	9	11	9	152					

Secondary Forest WITHOUT *Macaca fascicularis*

	Bird Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		P_i	P_i^2	$P_i \ln[P_i]$		
1	*Philemon buceroides*	4	2	2			2	2	2	3		4	5	3	2	4		3		4		42	0,141	0,020	-0,276	**Simpson's D**	**12,202**
2	*Corvus orru*	3		2			1						1					5	1		1	14	0,047	0,002	-0,144	**Simpson's E**	**0,394**
3	*Nectarina aspasia*	1	2	2	2	1	1	2	2	2		2	2		2	1	3		2	2		29	0,097	0,009	-0,227	**Shannon's H**	**2,819**
4	*Nectarina jugularis*	1	1						2	2			2				1	2	2	2		15	0,050	0,003	-0,150	**Shannon's E**	**0,821**
5	*Centropus menbeki*	3							2													5	0,017	0,000	-0,069		
6	*Cracticus gouyi*	2					2		2	2			1	1	2			2	1			15	0,050	0,003	-0,150		
7	*Rhipidura leucothorax*		1				2		3				1	1					2	1		11	0,037	0,001	-0,122		
8	*Pitohui dicrous*		2		4				3	5	3		9	4	1		4		3	1	3	42	0,141	0,020	-0,276		
9	*Meliphaga sp*		1		2		1	1		4	2	1	2		1			3	1	4	2	25	0,084	0,007	-0,208		
10	*Podargus papuensis*		1				1				1								1			4	0,013	0,000	-0,058		
11	*Myiagra alecto*			1							2	2						2		2	2	11	0,037	0,001	-0,122		
12	*Pitohui kirhocephalus*			3																		3	0,010	0,000	-0,046		
13	*Ptilonopus sp*			1									1									2	0,007	0,000	-0,034		
14	*Rhipidura rufiventris*			1						1		1								2		5	0,017	0,000	-0,069		
15	*Micropsitta pusio*				10	6	4				5	3			5	1						34	0,114	0,013	-0,248		
16	*Manucodia atra*					1	1				1				1	1	1			1		7	0,023	0,001	-0,088		
17	*Malurus cyanocephalus*					2																2	0,007	0,000	-0,034		
18	*Dicaeum pectorale*						1															1	0,003	0,000	-0,019		
19	*Cyclopsitta diopthalma*							1														1	0,003	0,000	-0,019		
20	*Trichoglossus haematodus*							2														2	0,007	0,000	-0,034		
21	*Corvus tristis*							3														3	0,010	0,000	-0,046		
22	*Dacelo gaudichaud*								1				1	1								3	0,010	0,000	-0,046		
23	*Cacomantis variolosus*								1		1			1			1			1		5	0,017	0,000	-0,069		
24	*Arses telescopthalmus*								2		2										2	6	0,020	0,000	-0,079		
25	*Cracticus cassicus*										1											1	0,003	0,000	-0,019		
26	*Haliastur indus*										1											1	0,003	0,000	-0,019		
27	*Rhipidura leucophrys*												1									1	0,003	0,000	-0,019		
28	*Ptilinopus superbus*													1		1	1					3	0,010	0,000	-0,046		
29	*Megapodius freycinet*														1							1	0,003	0,000	-0,019		
30	*Dicrurus bracteatus*															1	1				1	3	0,010	0,000	-0,046		
31	*Amaurornis olivaceus*																				1	1	0,003	0,000	-0,019		
	Abundance	14	10	12	18	10	16	11	20	19	19	13	26	12	15	9	12	17	13	20	12	298					

Appendix 6 - Quantitative Lizard Samples (Litter Plots) to Measure Diversity

Primary Forest without *M. fascicularis* (Skyline)

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*		P_i	P_i^2	$P_i ln[P_i]$		
Sp.1	*Emoia caeruleocauda*	1										1		**2**	0,049	0,002	-0,147	**No. Species**	**13**
Sp.2	*Emoia vercunda*	3				1			1	1		1		**7**	0,171	0,029	-0,302	**Simpson's D**	**7,277**
Sp.3	*Sp.??*	1												**1**	0,024	0,001	-0,091	**Shannon's H**	**2,206**
Sp.4	*Gehyra* sp.	1									1			**2**	0,049	0,002	-0,147		
Sp.5	*Nactus* sp1	2						2		1	3			**8**	0,195	0,038	-0,319		
Sp.6	*Spinomorphus sp.*			3				1	2	1		1		**8**	0,195	0,038	-0,319		
Sp.7	*Emioa maxima*			1	2	1			1		1			**6**	0,146	0,021	-0,281		
Sp.9	*Emoia* (cf. *battersbyi*)				1									**1**	0,024	0,001	-0,091		
Sp.13	*Emoia sp??*						1							**1**	0,024	0,001	-0,091		
Sp.14	*Glaphyromorphus* sp.						1				1			**2**	0,049	0,002	-0,147		
Sp.15	*Nactus* sp2										1			**1**	0,024	0,001	-0,091		
Sp.16	*Eugongylus* sp.											1		**1**	0,024	0,001	-0,091		
Sp.17	*Emoia* sp. ???											1		**1**	0,024	0,001	-0,091		
		8	0	4	3	2	2	3	4	3	7	5	0	**41**	1,000	0,137	-2,206		

Primary Forest with *M. fascicularis* (Vim)

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*		P_i	P_i^2	$P_i ln[P_i]$		
Sp.17	*Emoia* sp. ???										1			**1**	0,333	0,111	-0,366	**No. Species**	2
Sp.5	*Nactus* sp1	1					1							**2**	0,667	0,444	-0,270	**Simpson's D**	1,800
		1	0	0	0	0	1	0	0	0	1	0	0	**3**	1,000	0,556	-0,637	**Shannon's H**	0,637

Secondary Forest without *M. fascicularis* (Nafri)

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*		P_i	P_i^2	$P_i ln[P_i]$		
Sp.1	*Emoia caeruleocauda*		1								5	2		**8**	0,216	0,047	-0,331	**No. Species**	8
Sp.2	*Emoia vercunda*		1	1	3									**5**	0,135	0,018	-0,270	**Simpson's D**	6,427
Sp.5	*Nactus* sp1		1	1	2								1	**5**	0,135	0,018	-0,270	**Shannon's H**	1,949
Sp.6	*Spinomorphus sp.*				2		2							**4**	0,108	0,012	-0,240		
Sp.14	*Glaphyromorphus* sp.		1	1									1	**3**	0,081	0,007	-0,204		
Sp.20	*Sp. ??*								1	3	2		2	**8**	0,216	0,047	-0,331		
Sp.21	*Sp. ??*									1	1	1		**3**	0,081	0,007	-0,204		
Sp.22	*Lamprolephis smaragdina*												1	**1**	0,027	0,001	-0,098		
		0	4	3	7	0	2	0	1	4	8	3	5	**37**	1,000	0,156	-1,949		

Secondary Forest with *M. fascicularis* (Vim)

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*		P_i	P_i^2	$P_i ln[P_i]$		
Sp.14	*Glaphyromorphus* sp.	1												**1**	0,333	0,111	-0,366	**No. Species**	3
Sp.23	*??*				1									**1**	0,333	0,111	-0,366	**Simpson's D**	3,000
sp.24	*??*					1								**1**	0,333	0,111	-0,366	**Shannon's H**	1,099
		1	0	0	1	1	0	0	0	0	0	0	0	**3**	1,000	0,333	-1,099		

Appendix 7: List of Participants in IPCA/UNCEN-sponsored Seminar on Risks of Papuan Macaques and Other Invasive Species, held 18 March 2003 in Jayapura

No.	Name	Organization/Affiliation
1	H. R. Hamadi	Village Head, Tobati Enggros
2	Spenyel Sanyi	Youth leader, Enggros village
3	Adrian Hamadi	Village member
4	Magdalena M. R.	Village member
5	Gemius Wanimbo	Village member
6	Lorens Wenda	Village member
7	Orgenes Sesa	Village member
8	Agustinus Duwit	Village member
9	Dikson B.	YALI – PB
10	Nanang H. M.	BKSDA Papua I
11	Roy R.	WWF
12	N. J. Tangkepayung	WWF
13	John Maturbongs	WWF
14	Marthina Wonatorey	NRM
15	Gustavo M.	PERC
16	Dani Rumainum	PERC
17	Sherly Korwa	WALHI Papua
18	Yohana Mandowen	Pt. PPMA Papua
19	Johni Sanyi	Village member
20	Muh. Farid	CI Papua
21	Burhan Tjaturadi	CI Papua
22	Yance	CI Papua
23	Djemi M.	LPPM Papua
24	Jack A.	LPPM Papua
25	Agust W.	Dinas Kehutanan Prop. Papua
26	Candra N.	Dinas Kehutanan Prop. Papua
27	Drh. I. B. Soma W.	Karantina Hewan
28	Drh. Elias Inthe	Karantina Hewan
29	Lasmaida Goldaris	Bapedalda Provinsi
30	Baswi Siahaan	Bapedalda Privinsi
31	James Simanjuntak, S.Pd.	Bapedalda Provinsi
32	Riwan Triono, S.Hut.	Bapedalda Provinsi
33	Rendra Allan, S.E.	Bapedalda Provinsi
34	Ketty Kailola	Bapedalda Kota
35	Agustinus T. Ondi, S.Hut.	Bapedalda Kota
36	Yan Yunaki	UNIPA Faculty
37	Jean Banundi	Mapala
38	Dra. Verena Agustini, M.Sc.	UNCEN Faculty (FMIPA)
39	Dra. Rosye H. R. Tandung, M.Sc., Ph.D.	UNCEN Faculty (FMIPA)
40	Drs. Maklon Warpur, M.Si.	UNCEN Faculty (FMIPA)

41	Drs. Basa T. Rumahorbo, M.Si.	UNCEN Faculty (FMIPA)
42	Puguh Sujarta, S.Si., M.Si.	UNCEN Faculty (FMIPA)
43	Dra. Suriani Br. Surbakti, M.Si.	UNCEN Faculty (FMIPA)
44	Dra. Supeni Sufaati, M.Sc.	UNCEN Faculty (FMIPA)
45	Supiyanto, S.Si.	UNCEN Faculty (FMIPA)
46	Drs. Z. A. Wasaraka	UNCEN Faculty (PMIPA)
47	Drs. A. Renyoet, M.Si.	UNCEN Faculty (PMIPA)
48	Drs. Johan Kawatu, M.Si.	UNCEN Faculty (PMIPA)
49	Dra. R. E. Rehiara, M.Si.	UNCEN Faculty (PMIPA)
50	Drs. Marthin Kirenius, M.Sed.	UNCEN Faculty (PMIPA)
51	Dirk Y. P. Runtuboi, S.Pd., M.Kes.	UNCEN Faculty (FMIPA)
52	Maikel Simbiak, S.Pd.	UNCEN Faculty (PMIPA)
53	Yuvenalis A. Ledang	YPLHC
54	Wiwik S. W.	Teacher
55	Hengky L. Wambrauw	Student, PMIPA
56	Sekarmaji	Student, PMIPA
57	Kores Seh	Student, PMIPA
58	Hendrik Buiney	Student, PMIPA
59	Erlani F. Rahareng	Student, FMIPA
60	Rawati Panjaitan	Student, FMIPA
61	Listyo Rahayu	Student, FMIPA
62	Herlina Menufandu	Student, FMIPA
63	Evi L. Warikar	Student, FMIPA
64	John Dominggus Kalor	Student, FMIPA
65	Ir. Michael A.E. Mantiri, M.Si.	Bapedalda Provinsi
66	Pieter Tarobi	IPCA - Macaque Project
67	Ninil R Kemp	IPCA - Macaque Project
68	Neville Kemp	IPCA – Macaque Project

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