UF-Malaysia Projek Harimau

Taman Negara (Malaysia) Field Study

Ecology and Population Status of Tigers in a Primary Rainforest of Peninsular Malaysia

Semi-annual programmatic report submitted to the Save the Tiger Fund

30 November 2001

Grantee: University of Florida
Project No: 98-093-061, 99-268-082 and 2000-0182-018
Reporting period: June – November 2001
Prepared by: Dr. Melvin Sunquist and Kae Kawanishi

Captured simultaneously from both sides of a trail on 11 August 2001

PROJECT PERSONNEL

Project Advisor	Dr. Melvin Sunquist Department of Wildlife Ecology and Conservation, University of Florida, USA
Principal Investigator	Kae Kawanishi Department of Wildlife Ecology and Conservation, University of Florida, USA
Malaysia Counterpart:	En. Sahir Othman Director, Division of Research and Conservation, Department of Wildlife and National Parks, Peninsular Malaysia (DWNP) En. Sivananthan Elagupillay, Head, Management Unit, DWNP En. Rahmat Topani Development Division, DWNP
Field Assistants:	Abd. Malek Sahak, DWNP Pahang Kamarizuan Kamarudzzaman, DWNP Taman Negara Pahang AhMad Zaharudin Abd. Hasim, DWNP Taman Negara Pahang Zamzuri bin Ishak, DWNP Taman Negara Kelantan Abu Zahrim Ismail, Project staff Hairul Azhar b. Harun, Project staff Abraham Mathew, Project staff Song Horng Neo @ Liang, Project staff Others, DWNP staff, volunteers, villagers, aborigines

EXECUTIVE SUMMARY

A large tract of contiguous forest in north-central Malaysia with a core protected forest, Taman Negara National Park (4,343 km^2), offers the best chance for long-term persistence of the tiger in Malaysia. Yet even in this Peninsular Malaysia's only National Park, ecological data on the tiger and its prey community are lacking. The primary goal of this project is thus to gather baseline ecological information on tiger and prey in Taman Negara, using sampling-based population estimation techniques with camera traps. The specific objectives are: 1) to develop and refine the sampling techniques necessary to estimate the density of tigers and abundance of prey species, 2) to estimate population size of the tiger and the prey biomass, 3) to investigate the tiger ecology in relation to the habitat integrity, and 4) to improve the local capacity in sampling techniques so that the monitoring of the tiger population in the park can be continued. The project primarily uses infrared camera-trapping systems to identify species and individual tigers.

In cooperation with the Department of Wildlife and National Parks Peninsular Malaysia (Perhilitan), the data collection started at Merapoh, Pahang, on the remote western side of Taman Negara in November 1998. The refinement of the sampling technique and data collection in Merapoh were completed in May 2000 and the field operation was transferred to the second sampling site, Kuala Terengan, near the park headquarters in Kuala Tahan, Pahang. In January 2001 the field operation was moved from the second site to the last sampling site, Kuala Koh, Kelantan, on the northern boarder of Taman Negara. The 34-month field study was completed in August 2001.

We are in the last phase (data analysis) of this 5-year project. During some 13,808 trap-nights we collected 4,536 wildlife photographs, among which 1.3% (n=61) were of tigers. The photographs documented 55 vertebrate species. Rare species such as dhole (*Cuon alpinus*) and storm's stork (*Ciconia stormi*) were documented for the first time from Taman Negara. Selected preliminary results are presented in this report.

Data analysis and drafting the dissertation will be the priority for the next 6 months. If time remains, a public presentation in Malaysia and a workshop for Perhilitan staff will be considered. Next year Kawanishi will briefly visit the USA to finalize the dissertation and publications and complete the requirement for Ph. D. at University of Florida. Kawanishi will then return to Malaysia to continue the collaboration with Perhilitan on tiger research and conservation in Malaysia.

PROGRESS AND ACCOMPLISHMENTS (June – November 2001)

The last grant proposal submitted to the Save the Tiger Fund on June 1 2001 included a progress report up to the date. Thus the period covered in this report is from 1 June to 30 November 2001. This period covered two phases of the project:

Phase II (June - August, 2001): Field work
Phase III (September – November, 2001): Initial Data Analysis

The 34-month fieldwork was completed at the end of August. Most of September was spent on data entry, maintenance of vehicles and camera-trap equipment, cleaning and vacating field stations, sending out thank-you letters. Data analysis began in October by first looking at scat samples. The progress is discussed in the chronological order below and some of the preliminary results are included at the end.

Wildlife Conservation Society tiger workshop in Thailand and Dr. Sunquist's visit to Malaysia

In June Kawanishi was invited to participate in the Wildlife Conservation Society Tiger Workshop in Thailand for 9 days. During this time, the fieldwork was carried out by the field crew without her supervision. All necessary data were collected in her absence. Following the workshop, the project advisor, Dr. Melvin Sunquist visited Malaysia for 9 days. Together we met with project partners (Perhilitan and WWF-Malaysia) to discuss the future plans for this project and for the collaborative research efforts for conservation of tigers in Malaysia. We then visited the field site. Dr. Sunquist met with the field crew and majority of the Perhilitan key personnel who had provided support to the project, and then inspected some of the camera-trap sites. Back in Kuala Lumpur we discussed the approach to the next phase of the project. He took 84 samples of suspected *Panthera* scats to the USA for a molecular analysis.

Renewal of the research pass

The Economic Planning Unit in the Prime Minister's Department Malaysia granted a renewal of the annual research pass to Kawanishi at the end of July.

Completion of the fieldwork

The 34-month field sampling effort was completed at the end of August. Our target was to expend comparable camera-trapping efforts at all three sample sites, with minimum of 4,000 trap nights at each site. This goal was met in August. The second field assistant's contract ended in July and he had to return to his permanent job. An appointment of a Perhilitan ranger, Mr. Malek Sahak, to the project as the main trakker/trekker also expired in August. The August fieldwork was thus partially supported by three additional volunteers.

September: wrapping-up month

All camera-trapping related data were entered into computer and photographs were organized in albums. The rest of data entry was done in November. We cleaned up and vacated the field stations. Basic furniture was moved backed to the first field station that was renovated with WWF-Netherlands funding in 1999. This building was originally a property of Perhilitan, and thus was returned back to Perhilitan with donation of the furniture for future researchers in

Taman Negara. The 4WD project vehicle on loan from WWF-Malaysia was returned. All the camera traps were cleaned. Working CamTrakker units were donated to Perhilitan Taman Negara and Perhilitan Pahang with a hope that the monitoring and research of wildlife in Taman Negara would be continued using the standardized method. Over 3 dozen members of Perhilitan staff, local villagers, and students were trained on the sampling technique under this project. All TrailMaster units were shipped back to University of Florida.

Scat Analysis

Subsamples of more than 100 suspected *Panthera* scats, including some collected on plantation roads outside Taman Negara, were washed and processed so that only hairs and bones remain. Hair samples from potential prey animals were collected from Perhilitan mini zoo in Pahang and Perhilitan museum in Kuala Lumpur to form a reference collection. About 90% of the 89 samples looked at so far have been identified to at least a genus level except for reptiles, birds, and mice. An arrangement is being made with the National Zoo, where a former field assistant works, to collect hairs of a black panther (*Panthera pardus*), dhole (*Cuon alpinus*), and a dusky langur (*Trachypithecus obscurus)* to complete the reference collection. The scat analysis, including the molecular analysis, should be completed within this year.

Publications and exposure

Two minor papers were submitted, accepted, and in press during this reporting period. These are:

- Kawanishi, K., M. Sunquist, and O. Sahir. In press. Malayan Tapir (*Tapirus indicus*), far from extinction in a Malaysian rainforest. Tapir Conservation (IUCN/SSC Tapir Specialist Group) 11.

- Kawanishi, K. In press. Standardized data management system for camera-trapping studies in Malaysia. J. Wildlife and Parks (Malaysia).

Requests for presentations were made by Japan International Cooperation Agency (JICA) - Malaysia Office, University Putra Malaysia, and Zoo Negara (National Zoo). Kawanishi took the first request and postponed the latter two until the completion of the data analysis next year. Copies of our project overview, published in *Cat News* (Kawanishi *et al.* 2001), plus updated information were translated into Japanese by volunteers and handed out to participants as supplementary information. The presentation took place in Kuala Lumpur on November 13 for about 40 delegates from JICA and Japanese Embassy.

In addition, the primary field assistant, Song Horng Neo-Liang, gave a presentation on the project in Mandarin at the Malaysia scout group annual assemblage. The audience was comprised of Chinese-Malaysian students with various age groups, ranging from grade school to senior high school.

Capacity building

A protocol written by Kawanishi, entitled *Standardized Data Management System for Camera-trapping Studies in Malaysia*, was accepted by Perhilitan and now is In Print for the next issue of *The Journal of Wildlife and Parks*. The implementation of the protocol will require a workshop and a manual written in Malay, and Kawanishi has been requested by Perhilitan to assist in these related activities. This will be realized next year when the dissertation is completed.

Together with the Director of Perhilitan Division of Management Information System, Kawanishi assisted in finalizing a grant proposal to the Environmental System Research Institute Conservation Program for upgrading Perhilitan's GIS application software. The software was to be used for the analysis of this study and for management of Perhilitan's national wildlife database. The Director, who has no full-time staff under him, however, became extremely busy, then in October he was transferred to the Perhilitan's parent Ministry. The MIS lost its only full-time staff, and is currently non-existence. This sub-activity is thus postponed indefinitely.

Various requests have been made by Perhilitan research officers to Kawanishi to assist them in analyzing existing data and in designing future research on various species. Due to time constraints, she could only attend to a few of the most pressing requests. She was also invited to give a mini-lecture on population sampling design at a Division of Research internal meeting where officers and directors discussed the annual research plans.

When the analysis is completed in 2002, a workshop for the Perhilitan staff will be conducted on data entry, management, and analysis technique. At that time Kawanishi will present the results of the study and make recommendations for tiger management in Taman Negara. Then, based on the outputs, we will plan the future direction for the tiger conservation in Malaysia. Kawanishi hopes to continue her collaboration with Perhilitan on the research and conservation of the tiger and its landscape in Malaysia.

Selected preliminary results

Table 1 summarizes the sampling efforts and camera-trapping results at the three sample sites. A trap night is a 24-hour period during which a camera trap was functional. A total of 13,808 trap nights were expended with 4,192, 4,830, and 4,786 trap nights at each of the three sites. Some 4,536 wildlife photographs were collected and 1.3% (n=61) of the total photographs were of tigers. A total of 16 individual tigers were captured in a total sampled area of approximately 600 km^2. The actual population estimates and effective trapping areas (thus densities) are yet to be computed. We are currently experimenting with different mark-recapture population estimation models and numbers of occasions for the computation of the population estimates.

A total of 55 vertebrate species, including 2 reptilian, 12 avian, and 41 mammalian species, were detected. The only medium to large terrestrial mammal known to occur in Taman Negara that was not camera-trapped in this study was the Sumatran rhinoceros (*Dicerorhinus sumatrensis*). We have records of tracks and feces of this critically endangered species, but the animals eluded camera traps. Figure 1 shows the cumulative number of species camera trapped at the three study sites. While the species curves for all vertebrate species appear to be still increasing, the species curves for mammals are reaching an asymptote somewhere between 30 and 35 species. This number would be increased only by chance captures of small mammals such as rodents. Therefore, if the sampling had continued, the species curves of vertebrate species might have increased more likely by non-mammalian species.

All photographs of sambar deer *Cervis unicolor* (n=320), barking deer *Muntiacus muntjac* (n=554), and tapir *Tapirus indicus* (n=539) were examined closely in an attempt to identify individuals based on sex, body markings, antlers, and scars. Individual identification was

possible only with sambar stags based on the antlers. There appear to be enough data that we might be able to derive a population estimate of the male sambar deer, using Program NOREMARK (White 1996).

Attempts were made to draw inference on relative abundance of large mammals based on camera-trap data. Relative Abundance Index (RAI) of species was calculated using:

$$RAI = \Sigma_{i=1} d_i X\ 100/\Sigma_{i=1} tn_i,$$

where i is a trap location, d is a detection and tn is a trap-night at ith location. To minimize the effect of activity level on number of photographs and to standardize the analytical procedure, we define 'detection', a unit of observation, as more than one photograph of a species per trap night per camera-trap location (see Kawanishi *et al.* 1999 for details). Figure 2 shows combined RAI of all three study sites. Among carnivores sun bear (*Helarctos malayanus*), Malay civets (*Viverra tangalunga*), and leopards appear to be most abundant. Among ungulates, barking deer, wild boar (*Sus scrofa*), and tapir appear to be most abundant. The RAI data require further examination on several accounts: 1) assumptions and limitations using RAI; 2) the site differences; 3) effects of group size; 4) sampling bias (e.g., trail related and passive vs. active infrared camera traps); 5) relation between RAI of human and human activity data collected separately during surveys; and 6) relation among absolute abundance estimates (for tigers and possibly sambar deer), the RAI based on camera-trapping data, and RAI based on track-counts data.

Other data such as of track counts, human disturbance, and camera-trapping performance have not been analyzed yet. This and the spatial analysis using GIS will be the priority for the next 6 months.

PLANNED ACTIVITES FOR THE NEXT 6 MONTHS

1. Complete data analysis.
2. Submission of a draft of the dissertation to committee members.
3. Public presentation at a local University and National Zoo.
4. Internal presentation at Perhilitan possibly followed by a workshop on the data entry, management, and analysis technique. The workshop should also include a discussion on the implementation of recommendations made in this study and what's needed to be done next to implement the national tiger conservation strategy.

Note: the timing of the activities 3 and 4 largely depend on completion of the activities 1 and 2.

ACKNOWLEDGEMENTS

Every aspect of the fieldwork is carried out in cooperation with Perhilitan and the project is supported and assisted by various Perhilitan personnel. Foremost, we are grateful for the generous support and consideration provided by the Director General, Mr. Musa Nordin, and the former Director General Mr. Mohd. Khan. We would also like to thank Mr. Sahir Othman, Sivananthan Elagupillay and Rahmat Topani of Perhilitan headquarters for the guidance and facilitative support, and Mr. Zainuddin B. Ab Shukor of Perhilitan Pahang, Mr. Hassan Kassim

of Perhilitan Kelantan, and Mr. Hasnan Yusop of Taman Negara for allowing us to work with their best rangers.

The financial support for this research has been provided by the Save the Tiger Fund (54%), a special project of the National Fish and Wildlife Foundation created in partnership with ExxonMobil Corporation, the World Wide Fund for Nature (WWF)-Japan (17%), WWF-UK (7%), WWF-Netherlands (3%), the Disney Wildlife Conservation Fund (7%), University of Florida (7%), and the 21st Century Tiger (3%). In addition, both the Wildlife Conservation Society and WWF-Malaysia loaned a 4-wheel drive vehicle, and Nitto Denko Electronics Sdn. Bhd. donated a second-hand sedan to the project.

REFERENCE

Kawanishi, K., A. M., Sahak, and M. Sunquist. 1999. Preliminary analysis on abundance of large mammals at Sungai Relau, Taman Negara. J. Wildlife and Parks (Malaysia) 17:62-82

Kawanishi, K., M. Sunquist, and O. Sahir. 2001. Tiger research in Taman Negara National Park, Malaysia. Cat News 34: 7-9.

White, G. C. 1996. Program NOREMARK software reference manual. Department of Fishery and Wildlife, Colorado State University. 30 pp.

Table 1. Summary of sampling efforts and results of camera-trapping studies in Taman Negara National Park, Malaysia 1999 – 2001.

Study area	Merapoh	Kuala Terengan	Kuala Koh	Total
Location (lat/long)	N4.60/E102.08	N4.53/E102.43	N4.80/E102.45	N/A
Approx. area with camera traps (km^2)	200	200	200	600
Camera-trapping period	4/99 – 5/00*	3/00 – 1/01	10/00 – 8/01	4/99 – 8/01
Days camera traps were operational	399	319	300	1018
Total trap-nights	4,192	4,830	4,786	13,808
No. trap locations	47	43	45	135
Trap-nights/day Mean ± SD	10.5 ± 7.7	15.1 ± 7.0	16.0 ± 10.0	13.6 ± 8.6
Trap-nights/trap Mean ± SD	89.2 ± 53.7	112.3 ± 55.3	106.4 ± 46.0	102.3 ± 52.2
No. wildlife photo	1,519	1,266	1,751	4,536
No. tiger photo	22 (1.4%)	14 (1.1%)	25 (1.4%)	61 (1.3%)
No. tiger capture**	12	11	15	38
No. individual tigers captured	5	5	6	16
No. trap- nights/tiger photo	191	345	191	226
No. trap- nights/tiger capture	350	439	319	363
Species richness (vertebrate spp.)	44	40	37	55
Species richness (mammalian spp.)	33	33	29	40
No. 100-m strips surveyed for track counts	119	291	308	718
Distance (km) walked for line transect	42	44	4	90

* The actual fieldwork started in November 1998. After several months of preparation for the first sampling, including surveying, recruiting the field crew, designing and testing the camera protective casings, and testing the camera traps with various specifications for the optimal setting, the actual camera trapping started in April 1999.

** Tiger photos excluding duplicates of the same individual taken within 24 hours.

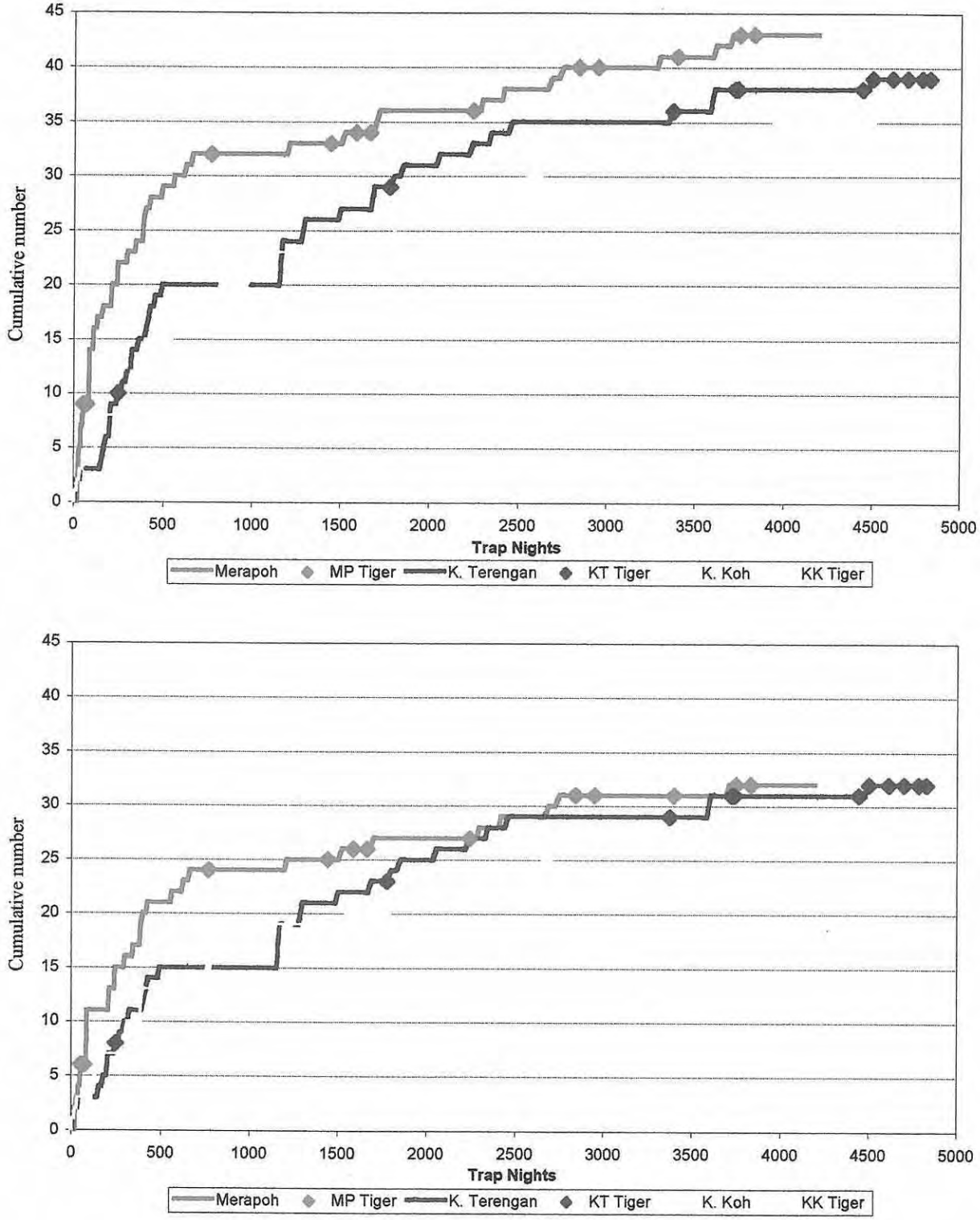

Figure 1. Cumulative number of vertebrate species (above) and mammalian species (below) photographically captured with camera traps as a function of 24-hr trap nights from April 1999 to August 2001 in Merapoh, Kuala Terengan, Kuala Koh, Taman Negara National Park, Malaysia. The filled diamonds indicate tiger captures, excluding duplicates of the same individuals captured within one trap night.

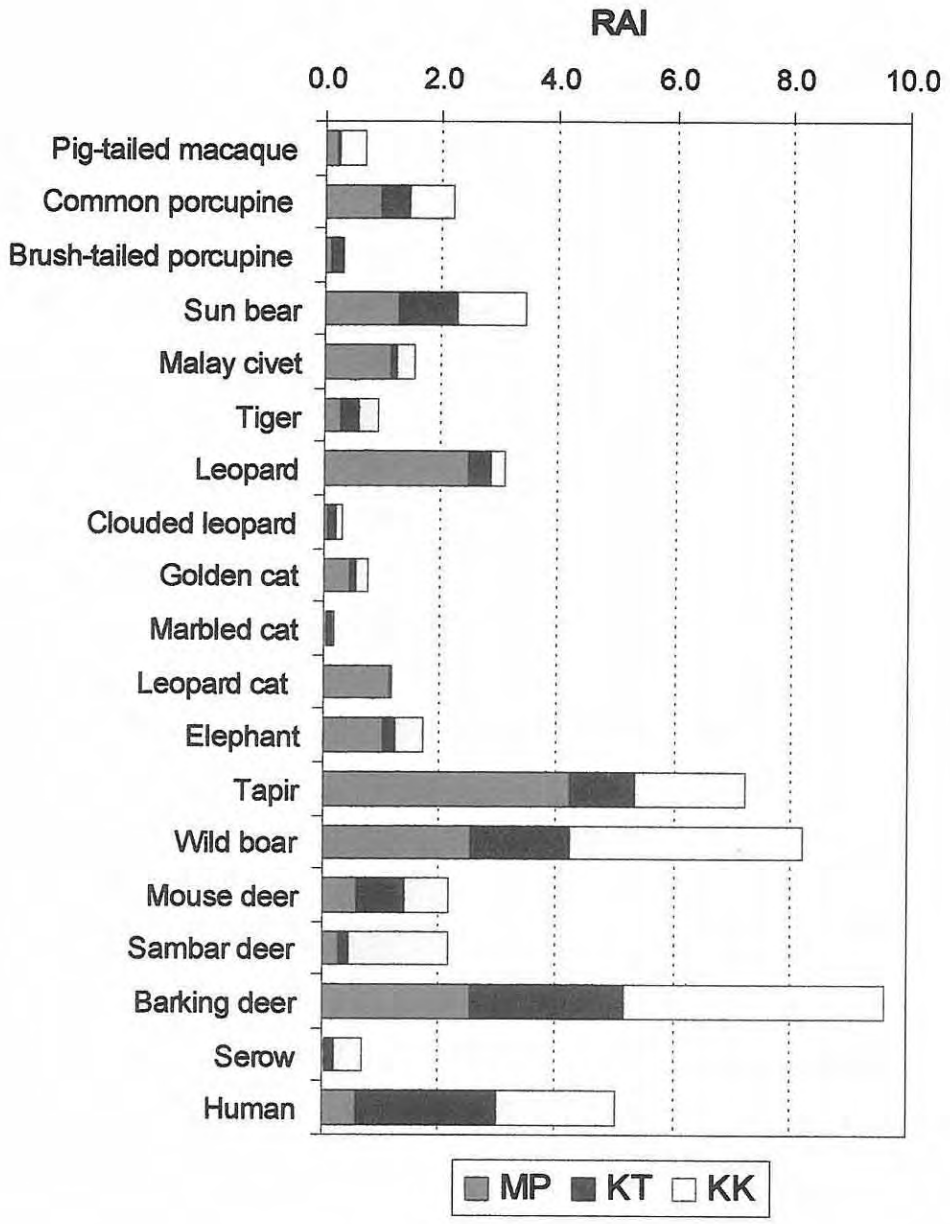

Figure 2. Combined Relative Abundance Indices (RAI) of medium to large terrestrial mammals photographically captured in the three study sites, Merapoh (MP), Kuala Terengan (KT), and Kuala Koh (KK) in Taman Negara National Park, Malaysia from April 1999 to August 2001. See text for computation of RAI.

serves as FINAL REPORT ORIGINAL

UF-Malaysia Projek Harimau

Taman Negara (Malaysia) Field Study

~ Ecology and Population Status of Tigers in a Primary Rainforest of Peninsular Malaysia ~

A proposal submitted to the Save the Tiger Fund by

Melvin E. Sunquist, Associate Professor

and

Kae Kawanishi, PhD Candidate

Department of Wildlife Ecology & Conservation
University of Florida
Gainesville, Florida 32611-0430
USA

Submitted on June 1, 2001

EXECUTIVE SUMMARY

Although the population status of the tiger remains uncertain throughout its range, Malaysia may support the largest population of the Indochinese tiger (*Panthera tigris corbetti*) left in the wild. A large tract of contiguous forest in north-central Malaysia with a core protected forest, Taman Negara National Park (4,343 km^2), offers the best chance for long-term persistence of the tiger in Malaysia. Yet even in this Peninsular Malaysia's only National Park, ecological data on tiger and prey communities are lacking. This study thus aims to provide the baseline ecological information on tigers from Taman Negara.

The knowledge of tiger ecology is needed in Malaysia as a foundation for development of a conservation strategy. Top carnivores are difficult to study, especially in rainforests where dense foliages hampers the observation, trapping, and radio tracking of such secretive, low-density mammals. It is thus critical to develop a system that will allow authorities and biologists to determine the current population status of the tiger and to launch a monitoring program of the tiger and its prey species in Malaysia.

This is the first intensive ecological study of the species in its pristine habitat of Malaysia and also the first long-term research conducted by a foreign institution in Taman Negara. The specific objectives are: 1) to develop and refine the sampling techniques necessary to estimate the density of tigers and abundance of their prey species, 2) to estimate population size of tigers and their prey biomass, 3) to investigate the distribution and abundance of tigers in relation to the habitat quality, including various topographic features, prey biomass, and both anthropogenic and natural disturbances, and 4) to train local students and government staff in application of sampling and data management/analysis techniques so that the monitoring of the tiger population can be continued.

The study uses mark-recapture estimation models based on photographic capture data collected from three sampling sites of 200 km^2 each to estimate population size of tigers in Taman Negara. In addition to the camera trapping, we also collect scats of tigers and leopards for a dietary analysis, conduct line-transect and track-count samplings to estimate the abundance of prey species, and survey human/natural disturbance in the park to assess the habitat integrity for tigers and prey. All of the above information will be incorporated into a spatial modeling of the predator-prey communities using GIS.

Every aspect of the fieldwork is being carried out in cooperation with Malaysia Department of Wildlife and National Parks (PERHILITAN) and the project is supported and assisted by various PERHILITAN personnel. Prior to the fieldwork, potential sampling areas in Taman Negara were suggested by PERHILITAN based on presence of tigers and logistical support. The fieldwork was started in one of the suggested areas in November 1998. After a reconnaissance and modification of the camera equipment were made, the first camera was put to test in April 1999. Camera trapping set-up specifications and the sampling technique have undergone various tests for refinement and improvement during the study. Sampling in the first study area was completed in May 2000. Sampling in the second study site was completed in January 2001, while the reconnaissance in the last study site began in October 2000. Our immediate goal is to achieve a comparative trapping effort (3,000 – 4,000 trap-nights) in the last study area and complete the data collection in August 2001. Then the final year of the project (September 2001 – August 2002) is for the data analysis and dissemination, for which we are requesting additional financial support from the Save the Tiger Fund.

INTRODUCTION

The estimated number of tigers in Malaysia declined from 3,500 in the 1950s (Locke 1954) to 250 in the early 1980s (Khan et al. 1983). Although these "estimates" are largely intelligent guesses with no statistical precision, they clearly indicate a population decline. Protection of human life, livestock, and crops from wildlife is the responsibility of the Malaysia Department of Wildlife and National Parks (PERHILITAN). Any animals perceived as threats are killed by PERHILITAN or occasionally by locals, and in rare occasions relocated (Khan et al. 1983, Khan 1987). PERHILITAN's records indicate that between 1947 and 1985 at least 310 problem tigers were killed by the government alone (Khan 1987). In 1976 the tiger became a totally protected species under the Wildlife Protection Act, and the official removal of tigers in most part stopped. Instead, PERHILITAN has made numerous attempts, more frequently without avail, to capture the problem tigers and relocate them to zoos (pers. comm. Mr. Siva Elagupillay, Head of Research/Management Unit, PERHILITAN). Anyone found guilty of killing a tiger is liable to a penalty of up to RM15,000 (US$4,000) or up to five years imprisonment (Commissioner of Law Revision Malaysia 1994). These approaches have not been effective in resolving the conflict between locals and wildlife, but the number of tigers has reportedly doubled since early 1980s (Khan et al. 1983, Topani 1990).

The current population estimate of 600-650 in Malaysia was derived from pugmark surveys of mostly nuisance tigers conducted over a two-year period by various government personnel (Topani 1990, Samsudin and Elagupillay 1996). Although the number of tigers might have increased in response to the protected status, their prime habitats continue to disappear.

At the turn of this century primary rainforest covered over 90% of the Peninsular Malaysia (Collins et al. 1991). In 1957, when the nation proclaimed its independence, it was estimated that the amount of forested land had declined to 74% (Myers 1980). By 1985, less than half (47%) of the country was forested (Collins et al. 1991). The phenomena of habitat reduction and fragmentation are not unique to Malaysia but are widespread throughout the tigers' range. Like elsewhere in the world, protected areas in Malaysia form small isolates, and occur mostly in less productive hill to montane forests. Unlike Thailand, however, where tigers do not reside outside the protected areas (Rabinowitz 1993), tigers in Malaysia frequently inhabit agroforestry landscape outside the protected area (Johns 1983, Khan et al. 1983, Topani 1990). Prior to the Wildlife Conservation Society and PERHILITAN's rapid assessment study using camera-traps in 1997-1998, past research on tigers were livestock depredation related studies (Blanchard 1977, Elagupillay 1983). There is no information on tiger ecology available from protected areas, which cover 6.3% of Peninsular Malaysia (Collins et al. 1991).

The existing protected area system in Peninsular Malaysia relies heavily on its only national park, Taman Negara. Encompassing 4,343 km^2, the park accounts for 59% of the total protected area in Peninsular Malaysia, and is not only the largest park among 13 national parks in the nation (12 other parks are in Borneo), but also one of the largest in Southeast Asia. Largely due to its inaccessibility, the park, established in 1938, has remained intact and undisturbed for the most part.

Taman Negara is part of a large contiguous tract of forest that stretches from southern Thailand. Encompassing a total of 27,469 km^2, this large forest tract includes 7,135 km^2 of five protected areas (Dinerstein et al. 1997). Thus, by its size, Taman Negara represents the core protected area in this tiger conservation unit (TCU) and is likely to offer the best chance for persistence of the tiger population in Malaysia. Based on the following criteria: large block of habitat suitable for tigers and prey, with adequate core area; and low to moderate poaching pressure on tigers and prey, Dinerstein et al. (1997) designated this area as Level 1 Tiger Conservation Unit (TCU) in their global tiger conservation strategy. Level 1 TCU offers the highest probability of persistence of tiger populations over the long term. Ironically, however, there are no ecological data on tigers from any parts of this critical conservation area to support the significance of the TCU or accuracy of the broad-scale assessment made by Dinerstein et al. (1997). Thus, this study aims to provide the baseline ecological information on tigers from Taman Negara.

Under the Constitution of Malaysia, land is a state matter and the State Executive Committee of each state, not the Federal Government, is the highest decision-making body concerning land-use policy. Taman Negara represents the only piece of land in Peninsular Malaysia that comes under direct jurisdiction of the Federal Government (Nordin 1983). It is thus hoped that the future of the park is safe from large-scale commercial exploitations. However, under ever increasing development pressure, the landscape outside the park is rapidly changing from undisturbed forest reserve to selectively logged forest to large-scale agricultural plantation with settlements along roads that surround the park. These roads, including the currently constructed highway immediately north of Taman Negara, undoubtedly provide a better access to the park, which was once remote and secluded. Cumulative effects of such rapid environmental changes on the biodiversity inside a protected area is difficult to assess and mostly unknown, particularly when secretive low-density mammals such as top carnivores are the target species. Except for the Sumatran rhinoceros (*Dicerorhinus sumatrensis*), research on population status of large mammals had not been conducted in Taman Negara. The goals of this research are thus to 1) initiate a monitoring program of the tiger and its prey base in Taman Negara by first refining the monitoring technique, 2) estimate the current population size, and 3) train PERHILITAN staff and local students in application of the technique.

Much of the existing information on the ecology of tigers has been gathered by direct observations or radio telemetry in India, Nepal, and Russia (Schaller 1967, Seidensticker 1976a, McDougal 1977, Sunquist 1981, Smith et al. 1987, Karanth and Sunquist 1995, Miquelle et al. 1999). In addition to the inherent difficulty of observing these secretive, naturally low-density mammals, the nature of tropical evergreen forests hampers the direct observation, trapping, and radio tracking of the equatorial races Recent development of self-activating, remote-camera systems equipped with an infra-red sensor or a weight pad as a triggering mechanism has facilitated studies of secretive carnivores (Mace et al. 1990, Jones and Raphael 1991, Zielinski and Kucera 1995, Karanth 1995), rainforest mammals (Seydack 1984, Kawanishi 1995, van Schaik and Griffiths 1995) and tigers (Karanth and Nichols 1998, Laidlaw and Shaharuddin 1998, Franklin et al. 1999). This technique allows a wide array of terrestrial wildlife to be detected and monitored in a standardized manner over a large area with minimum

disturbance, bias, and effort (Bull et al. 1992, Griffiths and van Schaik 1993, Kawanishi 1995).

The camera-trapping technique combined with the capture-recapture models has been used to estimate the number of tigers in south India (Karanth 1995, Karanth and Nichols 1998) and grizzly bears (*Ursus arctos horribilis*) in North America (Mace et al. 1994). Since the accuracy of pug-mark surveys has long been questioned (Karanth 1987), this new technique is expected to produce more reliable population estimates of tigers throughout its range. Because the climax state of a mature tropical evergreen forest does not support a diversity of terrestrial herbivores (Eisenberg and Seidensticker 1976, Eisenberg 1980), tiger density in Taman Negara is expected to be much lower than densities recorded in India (Karanth and Nichols 1998). Therefore, a number of modifications to the sampling design and the analytical procedure need to be made to fit the local conditions in Malaysian rainforests.

As tiger density and home range size are positively correlated with density and biomass of large cervids (Sunquist 1981, Seidensticker 1986, Karanth and Sunquist 1995), a carrying capacity of tigers at a specific site can be derived from a careful assessment of prey base with a known estimate of the cropping rate of the prey biomass (Sunquist 1981). Furthermore, since the decline of the tiger's prey base would inevitably reduce tiger density in an area, monitoring the tiger's prey base is proposed as the single most important task that provide a barometric indication of the health of the tiger's ecosystem (Karanth and Stith 1999). However, an assessment of wildlife abundance is a challenging task for wildlife biologists. The difficulties are compounded in a tropical rainforest due to the nature of its dense vegetation, high organic decomposition rate, and secretive nature of many animals.

Visual line-transect surveys have been used to estimate the abundance of tiger prey in India (Karanth and Sunquist 1992) and in Nepal from the back of an elephant (Seidensticker 1976b). It also has been successfully applied to measure abundance of primates in forested habitat (Wilson and Johns 1982, Brockelman and Ali 1987). This sampling method is, however, recommended for highly visible animals inhabiting relatively open habitat (Lancia et al. 1994). Due to the nature of the vegetation in the park and the secretive nature of many animals, most of the assumptions (Burnham et al. 1980:14) and recommended sample size (n = 40) will be difficult to meet in the study sites.

When the chances of direct observation are limited, indirect signs of target animals (e.g., feces or tracks) can be counted to derive abundance indices. However, the rapid organic decomposition rate in a tropical rainforest poses another difficulty; except for elephant and gaur dung, pellets of most ungulates appear to be decomposing faster than they are detected. The effort required to search pellets exceeds the time available, and we abandon the idea of employing pellet count.

Excluding the distance traveled by boat, we cover over 60 km of the forest floor every month on foot. There are many areas in Taman Negara that provide ideal substrate for track surveys (e.g., clay-rich soil of lowland forests and sandy soil of river banks). Monthly track counts have been productive and less time consuming than the pellet count. The preliminary result has generated a relative abundance for each species in the first two study sites (Kawanishi *et al.* 1999 and in prep).

One of many advantages of the camera-trapping technique is that it is not taxon-specific. Kawanishi (1995) demonstrated the efficacy of the remote-camera system to monitor top carnivores and other secretive or rare rainforest mammals. Camera traps facilitate the study of the tiger's prey base in Taman Negara by providing a relative abundance index, distribution, species assemblage, and activity pattern. At this point of the study, with only four months of sampling remaining, it is unlikely that line-transect sampling will generate density estimates of prey species. We may be able to estimate the abundance of prey species by calibrating an absolute density estimate of tigers against cumulative relative abundance indices based on track-counts and photo-capture rates, then applying the calibration to the indices of the prey species. Alternatively, based on known densities and photo-capture rates of prey species from other studies, the photo-capture rates of the prey species in this study can be calibrated to estimate prey abundance (Carbone et al 2001).

Spatial analysis of the data will be achieved with GIS. Multivariate statistics and an ArcView/Spatial Analyst will be used to model landscape-level habitat use of tigers in the park.

Justification and Objectives

Malaysia needs a strategy for conservation of the tiger, its critical habitats, and its prey. A number of biologists are now attempting for the first time to scientifically study the ecology, distribution, and population status of tigers in Malaysia so that threats to the persistence of tiger populations in Malaysia can be identified and an action plan can be formulated.

Our study is part of a collaborative research effort by Department of Wildlife and National Parks of Malaysia (PERHILITAN), Wildlife Conservation Society (WCS), World Wide Fund for Nature-Malaysia (WWFM), and the University of Florida (UF). The ultimate goal of the collaborative research is to define the geographical extent of tiger populations in Malaysia in relation to landscape characteristics and to assess the landscape linkage by identifying potential or existing corridors. This information will allow identification of critical habitats where changing land-use patterns may result in further habitat fragmentation and reduction in population size. The outputs will be used to 1) define land-use strategies that are compatible with tiger conservation, 2) estimate the tiger population size, 3) forecast changes in tiger distribution, and 4) devise an ecosystem- and landscape-scale tiger conservation strategy.

Tiger experts anticipate that this project will generate one of the most reliable estimates of the tiger density from primary lowland rainforests. By filling a major gap in our current understanding of tiger ecology, the result will have major implications for the global tiger conservation. With this ambitious goal, the project has received much generous financial support from the Save the Tiger Fund (55%), a special project of the National Fish and Wildlife Foundation created in partnership with ExxonMobil Corporation, the World Wide Fund for Nature (WWF)-Japan (18%), WWF-UK (7%), the Disney Wildlife Conservation Fund (7%), University of Florida (7%), WWF-Netherlands (3%), and the 21st Century Tiger (3%). The Wildlife Conservation Society and WWF-Malaysia loaned a 4-wheel drive vehicle to the project, and Nitto Denko Electronics Sdn. Bhd. donated a second-hand sedan to the project.

The specific objectives of the UF project in the protected primary rainforest of Taman Negara are:

1) To develop and refine the sampling techniques necessary to estimate the density of tigers and abundance of their prey species in the rainforest of Malaysia.
2) To estimate population size of tigers and prey biomass.
3) To determine the tigers' habitat use.
4) To train local students and government staff in application of sampling and data analysis techniques so that the monitoring of the tiger in the park can be continued and tiger densities outside the park can be estimated using the same protocol.

STUDY AREA

Taman Negara (4°10' - 4°56'N, 102°00' - 103°00'E) is located in the north-central peninsula where three states, Trengganu, Kelantan, and Pahan adjoin. The altitude ranges from 70 m to 2,191 m ASL at the peak of Mt. Tahan. Malaysia has a tropical climate with hot and humid conditions year-round and little seasonal variation. Taman Negara receives approximately 250 cm precipitation annually (Dale 1959). The forest type is broadly classified as a tropical evergreen moist forest, which ranges from lowland humid tropical forest to montane oak (Fagaceae) and ericaceous forests (Weber 1972, Whitmore 1984). Breeding populations of all the endangered terrestrial mammalian species in Peninsular Malaysia along with almost all the resident avifauna except for mangrove and coastal species are found in the park (Marshall 1973, Hurst 1990).

The road density in the park is <0.5 km/100 km^2, representing one of the lowest in the world. This low density of roads provides protection for wildlife and a logistical challenge for field biologists. The overall trail system is also limited in the park except for those near the park headquarters and ones leading to the peak of Mt. Tahan. These logistic difficulties has resulted in fewer field studies in Taman Negara than in other smaller and more accessible reserves in Malaysia (Marshall 1973). As a result, this is the first intensive ecological research being conducted by a foreign institution in Taman Negara.

Because it is a national park, public access is considered important. The number of visitors has been increasing every year. In 1996 approximately 55,000 people visited the park. There are four facilities in the park, at Kuala Tahan and Merapoh in the state of Pahan, Kuala Koh in Kelantan, and Tanjung Mentong in Terengganu. Kuala Tahan, the park headquarters, is by far the most popular site, visited by 85% of the total visitors (PERHILITAN 1997).

Taman Negara is home to approximately 400 aborigines (Orang Asli). They are traditionally nomadic hunters/gatherers who use blowpipes and poisoned arrows to hunt In recent years, however, their lifestyle has undergone rapid changes due to interactions with other cultural types (mainly with Malays and Westerners) and regulations placed upon them by PERHILITAN. Currently about 150 of these 400 live as complete nomads in the park (van der Schot 1990).

Based on available information and resources, we decided to sample three sites of 200 km^2 each (Figure 1). The specific sampling locations were selected in consultation with Malaysia Department of Wildlife and National Park (PERHILITAN) based on prior knowledge of tiger presence and availability of logistical support (e.g., accessibility, manpower, field station, and drainages for transportation).

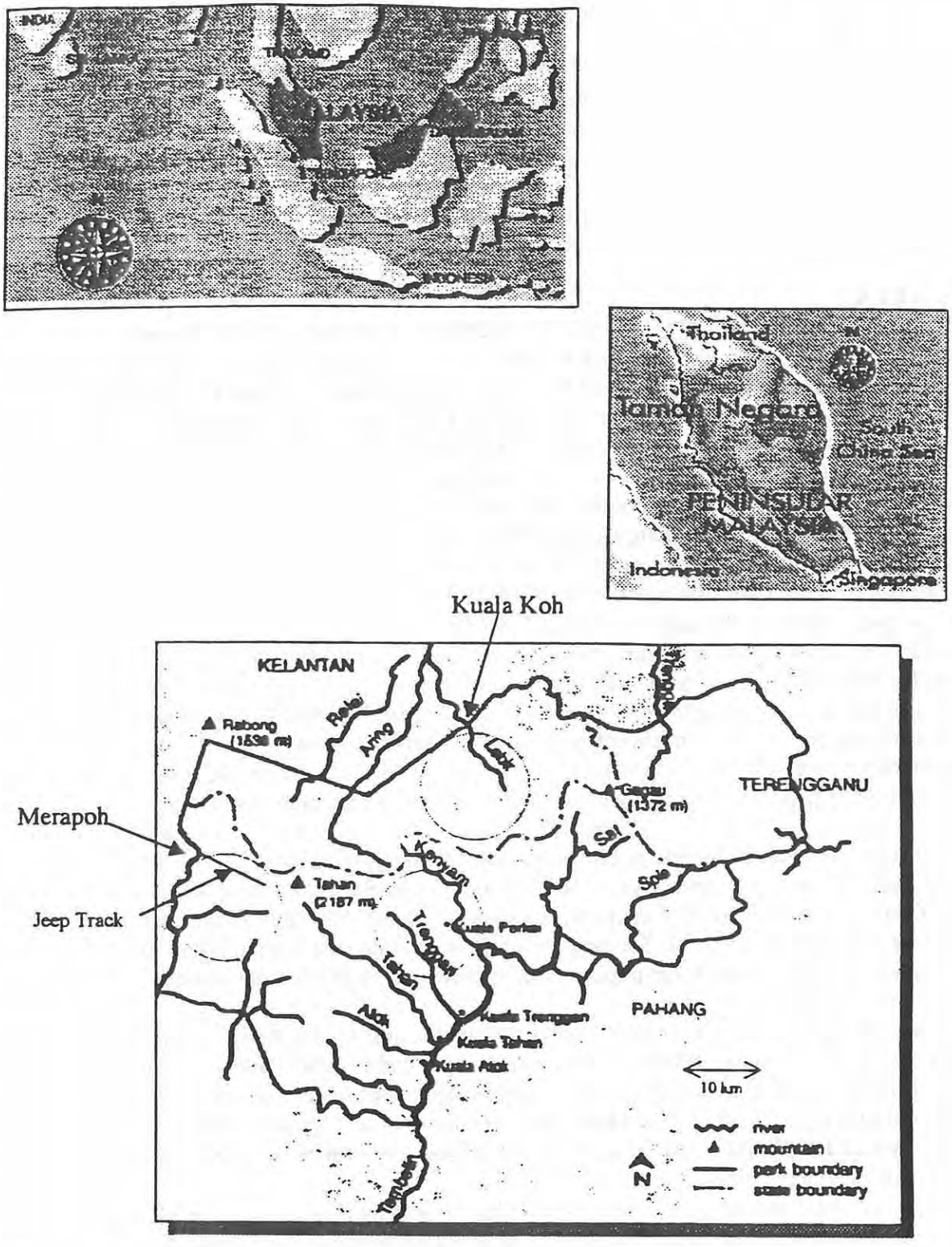

Figure 1. Location of Taman Negara National Park in Malaysia. The dotted circles indicate approximate locations of the sampling areas.

METHODOLOGY

The priority of the field operation has been camera-trapping. Whenever time allows, the line-transect sampling, track counts, and search for tiger scats are conducted.

Camera-trapping

Tigers' individually unique stripe patterns can be used to "mark" each animal "captured" or detected by camera traps. Because the stripe pattern is asymmetrical, both flanks have to be photographed for individual identification. This was initially to be achieved by using TrailMaster infrared sensor (TM1500; Goodson & Associates, Inc., Lenexa, Kansas, 66215 USA), which is activated by an animal breaking the beam and triggering the two cameras (TM35-1). One camera is set on each side of the trail and each is focused on the trail. The trigger system, which receives a signal from a sensor and triggers the two cameras simultaneously, is the only component that is not waterproof. Due to numerous false triggers caused by moisture getting into the electrical circuit, the project has abandoned the use of the trigger system. Instead, two camera traps are occasionally set up on the both sides of a high-traffic game trail.

Despite various tests and modifications, the trapping performance and reliability of the TrailMaster system has been low. To improve the trapping success rate, the Save the Tiger Fund generously contributed 33 CamTrakker units (passive infrared camera traps) to the project at the end of 1999. We started to use the CamTrakker units in addition to TrailMaster in February2000, and the results have been remarkable. These additional camera-traps have enabled us to start sampling in the new study site while some cameras are still collecting data in the previous study site, and to have more dual camera set-up sites (two camera traps set on each side of a game trail). CamTrakker cameras are also much easier to use. The appropriate use of TrailMaster requires training and substantial practice (Rice *et al.* 1995). For training purposes, bi-lingual guidelines for the use of TrailMaster have been prepared and distributed to project staff.

Because tiger densities in tropical forests are lower than those in more temperate forests or grasslands due to the lower ungulate biomass in the former biome (Eisenberg and Seidensticker 1976, Eisenberg 1980), a sampling area of less than 100 km^2 will not produce a meaningful population estimate with statistical confidence intervals (e.g., 2.5 $\pm$ 2 tigers/100 km^2). Thus, an area of approximately 200 km^2 was selected as a sampling area based on logistics (trails, road, hydrology). First, prior knowledge of salt lick sites, active game trails, locations of caves was sought out from Taman Negara staff, Orang Asli, villagers, and the literature. Following surveys for secondary sign of tigers and prey species in suggested areas, camera traps are strategically deployed to maximize the capture probability of tigers. Due to the lack of a road system, we have to carry the equipment and hike to each trap site. Whenever possible, we use the existing river system to transport the equipment and the field staff. The distance we can travel by boat changes monthly, depending on water levels that can fluctuate daily. A caution is taken so that there is no large gap (area without traps) in the sampling area where any tiger may have a zero capture probability. Assuming that the tiger home rage in tropical forests to be 50 – 100 km^2, in order to have four traps in a home range (Otis et al. 1978), the recommended trap intervals are 5.7 to 8.0 km or 2.0 to 2.8 km for the best result. In most cases, traps are

spaced 2-4 km apart, but this depends largely on topography and logistics. Multiple traps are often set near "hotspots" such as salt licks or major game trails along waterways..

Karanth and Nichols (1998) define a sampling occasion as 4-6 consecutive trap-nights. Because of the low capture probability of tigers in this study (Table 1), the sampling intensity had to be increased. Furthermore, unlike the study sites in India, Taman Negara lacks an extensive road or trail system, thus navigation and transporting the equipment in the park have been the major logistical constrain. For these reasons, the camera traps are checked monthly, not daily, and one sampling occasion consists of about 4 weeks. Thus a trapping period of 10 sampling occasions spans over 10 months.

Table 1. Comparison of summary statistics for capture-recapture data on tigers collected with camera traps between this study in Taman Negara, Malaysia and a study (Karanth and Nichols 1998) in Pench National Park in India.

Location (size)	Vegetation type	Sampling period	No. occasions	Area with camera-traps (km^2)	Efforts (trap-nights)	Total no. individuals caught, M_{t+1}	Total no. captures n	No. trap-nights per capture
Taman Negara Malaysia (4343 km^2)	Tropical rain forest	4/99 – 5/00	12	200	4,167	5	11	379
Pench NP India (290 km^2)	Tropical deciduous teak forest	3/95 – 6/95	16	49	788	5	21	38

Upon arriving at a camera-trap location, we replace the old camera-trap with a new unit, in which fresh batteries and a film are installed, reset the camera-trap, conduct a test shot, then leave the new trap for another month. We only move the camera-trap to a different location if the results are poor (< 3photos/months). Film and batteries are removed in the field station or base camp. Film is processed locally and all data (negatives, prints, date and time of events, trapping performance, number of trap nights) are logged and recorded on a project laptop monthly. The camera-traps brought back from the field are cleaned and tested in the field station monthly and defective units are send back to manufacturers in the USA about twice a year. This data management and equipment maintenance process usually takes 4-6 days depending on the number of film and camera-traps.

In addition to the photographic data, any signs of tigers, including tracks, scats, scrapes, tree scratching, vocalizations, scent marking, and kills are recorded to assess the presence of tigers. Also, any evidence of human activities (legal or illegal) and natural disturbances are surveyed to assess the habitat integrity for the tigers and preys. All the above spatial data, in addition to a land-use map outside the park, will be incorporated into the GIS database of Taman Negara in PERHILITAN's GIS lab. Scats of tigers and leopards (max. diameter >20mm) are collected, weighted, measured and stored for later dietary analysis.

To assess prey abundance, a number of different sampling approaches have been tested. We have abandoned the pellet counts and are conducting line-transect sampling

and track counts whenever possible. To test the feasibility of line-transect, we walked several predetermined transects of 1-3 km each. For each detection, the sighting distance and sighting angle were obtained using a range finder and compass; these metrics were used to calculate a perpendicular distance from the transect. A total of 90 km of transects have been walked to date. Primates are relatively easily detected (n=34), whereas sightings of the ungulate species are limited to mouse deer (n=2), barking deer (n=1), wild boar (n=1), and sambar deer (n=1).

We randomly survey tracks of animals along 100-m stretches of trail. Then we count the number of stretches containing each species to obtain an index for the species. These indices will be compared with relative abundance indices based on the photographic data (Kawanishi *et al.* 1999) within and among sampling sites.

Data analysis

The capture history data will be first analyzed using program CAPTURE software (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991). Application of this closed population model to estimate a tiger population using photographic data has been refined (Karanth and Nichols 1998). It is the most versatile set of models that can account for heterogeneous capture probability due to individual, behavioral, or temporal variations (pers comm Dr James Nichols). CAPTURE uses a discriminant function model selection algorithm to provide an objective criterion for selecting the best fit model. Then the population size (N) and standard error of the population size ($SE(N)$) will be estimated for the most appropriate model (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991) CAPTURE also computes a closure test statistic. If it detects a violation of the population closure assumption, then data will be analyzed using an open population model, Jolly-Seber estimator (Seber 1982).

Direct observation data from line transects will be analyzed using program TRANSECT (Burnham et al 1980) to fit the Fourier series model to estimate prey abundance. It is a robust and good general-purpose estimator that is highly recommended by Burnham et al (1980) If the line transect technique fails to produce satisfactory results, relative abundance indices will be calculated based on number of tracks groups per unit distance sampled Calculating the relative abundance index based on the photographic data will follow the procedure described in Kawanishi (1995)

After the results of tiger and prey density estimates and indices of human/natural disturbances are incorporated into the GIS database, multivariate statistics and ArcView/Spatial Analyst will be used to model landscape-level habitat use of tigers in the park.

Hair samples of possible prey species will be collected from PERHILITAN museum specimen and also live animals from Zoo Meleka, which is administered and managed by PEHILITAN. The dietary analysis will take place in PERHILITAN mammal lab. In addition, selected samples will be sent back to the USA for a molecular analysis to determine the hosts.

Towards the end of the year 2001, preliminary results will be presented at a workshop in Kuala Lumpur, Malaysia. Expected participants at the workshop include the project staff, PERHILITAN staff, local university faculty members who can encourage field studies for wildlife conservation in the university curriculum, local university

students who are interested in future monitoring of tiger populations and prey abundance, and representatives from WWFM, WCS, and other pertinent NGOs.

Detailed methodology for data management/analysis will be presented for interested parties, particularly PERHILITAN staff and students, as a final stage of the capacity-building component of the project. It is anticipated that PERHILITAN Taman Negara will continue monitoring tiger population in the park and the Tiger Unit in PERHILITAN headquarters in KL will initiate a similar ecological study in critical habitats outside Taman Negara. We will assist them in these efforts in whatever way we can.

The dissertation will be drafted with close contacts with the Project Advisor, supervisory committee members, statisticians, and GIS specialists at UF. Kawanishi will be at UF for the last few months of writing. The dissertation will be defended and manuscripts for publication will be prepared by August 2002. Kawanishi will then return to Malaysia to continue her involvement in research related to the conservation of the tiger and its habitat.

TIMETABLE

Overall project period of the this study, January 1998 – August 2002, is divided into three main phases as follows:

Phase I (January – November 1998): Preparation

- Proposal development and acquisition of funding and research permit.
- Completion of the course work and qualify examination for a PhD at University of Florida.
- Equipment purchase.
- Building partnership with PERHILITAN, WWFM, and WCS.
- Recruitment of project staff.

Phase II (November 1998 – August 2001): Fieldwork

1. November 1998 – April 1999

- Establishing a field station and field crew in the first study site.
- Participating in a Tiger Workshop in India (WCS-India) and Tiger Symposium in Japan (WWF-Japan).
- Designing and building protective casings for cameras.
- Preliminary survey.
- Acquisition of a project vehicle and boats.
- Recruitment of project staff.

2. April 1999 – May 2000 (Sampling in the first study site)

- Testing and modification of camera casings.
- Refinement and improvement of camera-trapping technique.
- Preparation of bi-lingual guideline for camera-trapping.
- Gradual expansion of the sampling area from 40 km^2 to 200 km^2.
- Data collection (camera-trapping, line-transect, track counts, scat collection, and assessment of human disturbance).
- Acquisition of additional funding.

- Continuous recruitment and training of project staff and PERHILITAN rangers.

3. March 2000 – January 2001 (Sampling in the second study site)
- Establishing a logistical support and field crew in the second study site.
- Preliminary survey followed by data collection (camera-trapping, line-transect, track counts, scat collection, and human disturbance).
- Acquisition of additional funding.
- Continuous recruitment and training of project staff and PERHILITAN rangers.
- Slide presentations at a local university and in Taman Negara.
- Submission of a manuscript on preliminary results for a publication in the *Journal of Wildlife and Parks* (PERHILITAN).

4. October 2000 – August 2001 (Sampling in the third study site)
- Establishing a logistical support and field crew in the third study site.
- Preliminary survey followed by data collection (camera-trapping, line-transect, track counts, scat collection, and human disturbance).
- Continuous recruitment and training of project staff and PERHILITAN rangers.
- Acquisition of additional funding.
- Participation in the WCS tiger workshop in Thailand.
- Completion of the data collection.

<u>Phase III (September 2001 – August 2002): Data analysis and dissemination</u>
- Data analysis
- Presentation of preliminary results at PERHILITAN and/or a local university.
- Workshop for the PERHILITAN staff.
- Collaboration with PERHILITAN on upgrading and updating GIS system and database.
- Writing and submission of the dissertation.
- Defense and completion of a Ph.D. at University of Florida.
- Preparation of manuscripts for publication.
- Collaboration with project partners (PERHILITAN, WCS, and WWF-Malaysia) on the national tiger conservation strategy

PROGRESS

Summary of the sampling schedule, efforts and results

Study area	Area with camera traps (km^2)	Camera-trapping period	Total trap-nights	No. wildlife photo	No. tiger photo	No. trap-nights/ tiger photo	No. 100-m strips surveyed for track counts	Distance (km) walked for line transect
1. Merapoh	200	4/99 – 5/00*	4192	1519	22	191	119	42
2. Kuala Terengan	200	3/00 – 1/'01	4362	1264	14	312	222	44
3. Kuala Koh**	200	10/00 – 8/01	1640	412	1	1640	153	4

* The actual fieldwork started in November 1998. After several months of establishing the first study site, surveying, recruiting the field crew, designing and testing the camera protective casings, and testing the camera traps with various specifications for the optimal setting, the actual camera trapping started in April 1999

** The current sampling site.

Progress to date (January - May, 2001)

In the progress report submitted in January 2001, the following activities were proposed for the period of January – June 2001.

1. Secure the necessary funding to continue and complete the fieldwork.
2. Complete the sampling in the second study site and close the field station.
3. Continue sampling in the final study site.

With a major budget cut from a donor this year, the project experienced some difficulty in completing the sampling as designed. This problem was alleviated by funding support from 21st Century Tiger. We have also received additional funding from the Save the Tiger Fund, which will allow us to complete the sampling and support part of the data analysis process. We appreciate the continuous support from the Save the Tiger Fund and the new initiative by the 21st Century Tiger. We also thank Dr. Ullas Karanth of the Wildlife Conservation Society – India, for his technical advice and for his involvement in securing financial support for the continuation of project activities

Field work began on the final study site in October 2000 even though half of the field crew and equipment were still being used at the second study site. We closed all the traps in the second study site in January 2001, and then were able to put all resources into the final study site from February 2001. We now have 40 trap locations in the 200-km^2 sampling area. In order to achieve comparative sampling efforts in all three sites, the completion date of the data collection has been postponed from July to August. We hope to achieve a minimum of 3,000 total trap-nights in the final site by the end of August

Tigers in the rainforest continue to be elusive. After 6 months of sampling, a camera trap at the park border finally captured one tiger. Camera traps set up near fresh tiger tracks and even at a kill have failed to produce any tiger pictures. We now know some areas frequented by tigers, but the tiger tracks are recorded on different trails or locations in the area every month. This makes it difficult to camera trap these individual animals. Nonetheless, we will be concentrating the trap efforts in such hot spots by putting out multiple cameras. So far we have collected 79 suspected *Panthera* scats. Selected samples will be sent to the USA for molecular analysis this year.

Other accomplishments and works in progress

The first publication out of this research, *Preliminary analysis on abundance of large mammals at Sungai Relau, Taman Negara,* was published in the PERHILITAN journal, *Journal of Wildlife and Parks*. Another minor publication has been accepted by the *Cat News* this year. We will be submitting a few more publications currently in preparation in the next few months (see below for details).

A protocol, *Standardized Data Management System for Camera-trapping Studies in Malaysia*, is currently being reviewed by the authority on camera-trapping tigers, Dr. Ullas Karanth of Wildlife Conservation Society-India. A final draft will be re-submitted to PERHILITAN for consideration. The general concept presented in the initial proposal was well received by the Directors of Research Division and Management Information System (MIS) last year.

With the Director of MIS, we are putting together a grant proposal to the Environmental System Research Institute Conservation Program for upgrading PERHILITAN's GIS application software. The software will be used for the analysis of this study and for management of PERHILITAN's national wildlife database.

Kawanishi has been asked by PERHILITAN officials to give seminars on the wildlife population study, basic biostatistics, research design, and data management techniques. Selected topics will be presented at the proposed workshop for PERHILITAN later this year. Short seminars will be considered for research officers if time permits. Kawanishi has also been requested to attend the annual meeting for the Taman Negara Advisory Committee to present the overview and significance of this research. This will be realized in the next few months.

EXPOSURES TO DATE

Publications:

- Kawanishi, K., A. M., Sahak, and M. Sunquist. 1999. Preliminary analysis on abundance of large mammals at Sungai Relau, Taman Negara. J. Wildlife and Parks (Malaysia) 17: 62-82.

- Carbone, C., S. Christie, K. Conforti, T. Coulson, N. Franklin, J. R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D. W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D. J.

L. Smith, M. Sunquist, R. Tilson, and W. N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. Animal Conservation 4: 75-79.

- Kawanishi, K., M. Sunquist, and O. Sahir. In press. International collaboration on tiger research in Taman Negara National Park, Malaysia. Cat News.

- Kawanishi, K. In prep. Standardized data management system for camera-trapping studies in Malaysia. J. Wildlife and Parks (Malaysia).

- Kawanishi, K. and M. Sunquist. In prep. Preliminary analysis of abundance of large mammals in Taman Negara.

- Kawanishi, K., M. Sunquist, and Y. Husnan. In prep. Taman Negara, preserving Malaysia's Wildlife. Malayan Nature Journal.

Others:

- Public presentations in Osaka and Tokyo, Japan in 1998, and at a local University in Kuala Lumpur, Malaysia and at Kuala Tahan, Taman Negara in 2000.
- Special featured in *the Star*, an English newspaper in Malaysia, in 1999 and 2001.
- Featured in Japanese newspapers, *Tokyo* (1998), *Yomiuri* (1998), *Chunichi* (1999)
- Special featured in the WWF-Japan newsletter, *Toranomori ('Tiger's Forest') Press*, in 1999
- Special featured in a book, *Escape to the Great Outdoor of West Malaysia* by W. M. Bourke (2000), published by High Adventure Publishing, Malaysia.
- Featured in the PERHILITAN's newsletter, *Bulletin Perhilitan* in 2000
- Project photographs exhibited in 1)Taman Negara Information Counter in Kuala Tahan and interpretive room in Merapoh by PERHILITAN, 2) a public exhibition in Pahang by PERHILITAN in 1999, and 3) a tiger exhibition in Japan by the Japan Wildlife Conservation Society in 1999

PLANNED ACTIVITIES FOR THIS GRANT PERIOD (August '01 – August '02)

Phase II (August, 2001)

- Renewal of the annual research pass and visa with Malaysian government.
- Completion of the data collection.
- Meeting with project partners and the project advisor, Dr. Melvin Sunquist, to discuss the progress and future plans for this project and for the collaborative research efforts for tigers in Malaysia.
- Interview with Taman Negara superintendents from the past and retired PERHILITAN rangers to gather information on past status of wildlife within the park

Phase III (September, 2001 – August, 2002)

A. Data Analysis

- Performance of the camera-trapping technique in detecting Malaysia's wildlife

- Population estimates of tigers in Taman Negara in the mark-recapture framework.
- Dietary analysis using specimen from PERHILITAN museum and the Melaka Zoo. Selected samples will be sent to the USA for molecular analysis.
- Estimate of prey abundance based on line-transect, track counts, capture rates, and literatures.
- Habitat integrity analysis based on abundance, distribution, and activity patterns of prey, human disturbance, and land-use patterns outside the park.
- Spatial analysis and modeling of the tiger-prey-human community using GIS.

B. Dissemination

- Preparation and submission of dissertation and manuscripts for publication.
- Public presentation at a local University and internal presentation at PERHILITAN.
- Final reports submitted to all donor agencies and copies of dissertation submitted to the project partners and local government.

C. Capacity Building

- Finalizing a protocol, *Standardized Data Management System for Camera-trapping Studies in Malaysia*, with Divisions of Research and Management Information System (MIS) of PERHILITAN.
- Collaboration with PERHILITAN MIS for upgrading existing GIS system.
- Collaboration with PERHILITAN MIS for updating the Taman Negara digital database.
- Workshop for the PERHILITAN staff on the data entry, management, analysis technique and tiger management in Taman Negara.
- Assess the feasibility of, and seek support for, the continuation of the tiger research and population monitoring program in Taman Negara; provide guidance and proposal if necessary.

BUDGET (January '02 – August '02)

OPS **$12,500**
Kae Kawanishi (January '02 – August '02)
0.50 FTE Assistantship at University of Florida

Operating Expenses **$3,000**
Kae Kawanishi:
Fee waver for the same period as above ($750)

Airfare (Kuala Lumpur, Malaysia – Gainesville, FL, USA): 2,250

Total budget $15,500

Total Requested from STF **$15,500**

BUDGET JUSTIFICATION

OPS (Personal Services)
Kawanishi: Funding to support an assistantship to complete the data analysis, writeup and dissemination of results is requested. The standard biweekly rate of pay for a half-time PhD assistantship at University of Florida is currently $760. As per Kawanishi's appointment as a graduate research assistant, she is required to register for research credits. Fee waver cost associated with the research credits is included in the operating expenses below.

Operating Expenses
Kawanishi:
Fee waver – Fee waver for research credits at University of Florida @ $45 per pay period

Air fare – One round-trip airfare at economy class from Kuala Lumpur, Malaysia to Gainesville, FL, USA.

LITERATURE CITED

Blanchard, R, F. 1977. Unpublished report. Preliminary analysis of tiger mortality and livestock depredation in Trengganu and Kelantan, West Malaysia. Malaysia Department of Wildlife and National Parks, Kuala Lumpur, Malaysia.

Bourke, W. M. 2000. Escape to the great outdoor of West Malaysia. High Adventure Publishing, Kuala Lumpur, Malaysia.

Brockelman, W. Y., and R. Ali. 1987. Methods of surveying and sampling forest primate populations. Pages 23-62 *in* Primate conservation in the tropical rain forest. C. W. Marsh, and R. A. Mittermeier, eds. Alan R. Liss, Inc. New York, New York.

Bull, E. L., R. S. Holthausen, and L. R. Bright. 1992. Comparison of 3 techniques to monitor marten. Wildl. Soc. Bull. 20: 406-410.

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildl. Monogr. 72: 1-202.

Carbone, C., S. Christie, K. Conforti, T. Coulson, N. Franklin, J. R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D. W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D. J. L. Smith, M. Sunquist, R. Tilson, and W. N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. Animal Conservation 4: 75-79.

Collins, N. M., J. A. Sayer, and T. C. Whitmore. 1991. The conservation atlas of tropical forests: Asia and Pacific. MacMillan Press, London.

Commissioner of Law Revision Malaysia. 1994. Laws of Malaysia Act 76, Protection of Wildlife Act 1972 (reprints). Kuala Lampur, Malaysia.

Dale, W. L. 1959. The rainfall of Malaya, Part I. J. Trop. Geogr. 13: 23-37.

Dinerstein, E., E. Wikramanayake, J. Robinson, U. Karanth, A. Rabinowitz, D. Olson, T. Mathew, P. Hedao, M. Connor, G. Hemley, and D. Bolze. 1997. A framework for identifying high priority areas and actions for the conservation of tigers in the wild. World Wildlife Fund-US, Washington, D. C.

Eisenberg, J. F., and Seidensticker, J. 1976. Ungulates in southern Asia: a consideration of biomass estimates for selected habitats. Biol. Cons. 10:293-308.

———. 1980. The density and biomass of tropical mammals. Pages 35-55 *in* Conservation biology: an evolutionary-ecological perspective. M. E. Soule, and B. A. Wilcox, eds. Sinauer Associates, Inc. Sunderland, Massachusetts.

Elagupillay, S. T. 1983. Livestock depredation problem by tigers in cattle farms. J. Wildl. Parks (Malaysia) 2:136-144.

Franklin, N., Bastoni, Sriyanto, D. Siswomartono, J. Manansang, and R. Tilson. 1999. Last of the Indonesian tigers: a cause for optimism. Pages 130 – 147 *in* J. Seidensticker, S. Christie, and P. Jackson, eds. Riding the Tiger: tiger conservation in human-dominated landscapes. Cambridge University Press, Cambridge, UK.

Griffiths, M. , and C. P. van Schaik. 1993. The impact of human traffic on the abundance and activity periods of Sumatran rain forest wildlife. Cons. Biol. 7: 623-626.

Hurst, P. 1990. Rainforest politics: ecological destruction in South-east Asia. Zed Books, Ltd., New Jersey.

Johns, A. 1983. Wildlife can live with logging. New Scientist 99: 206-211

Jones, L. L. C., and M. G. Raphael. 1991. Ecology and management of martens in fragmented habitats of the Pacific Northwest. Progress Report,. Pacific Northwest Research Station, Olympia, Washington.

Karanth, K. U. 1987. Tigers in India: a critical review of field censuses. Pages 118-133 *in* Tigers of the world. R. L. Tilson and U. S. Seal, eds. Noyes Publications, Park Ridge, New Jersey.

———. 1995. Estimating tiger *Panthera tigris* populations from camera-trapping data using capture-recapture models. Biol. Conserv. 71: 333-338

———, and B. Stith. 1999. Prey density as a critical determinant of tiger population viability. *in* Riding the tiger: meeting the needs of wildlife and people in Asia. J Seidensticker, S. Christie, and P. Jackson, eds. Cambridge Univ. Press, London

———, and J. D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79(8). 2852-2862

———, and M. E. Sunquist. 1992. Population structure, density and biomass of large herbivores in the tropical forests of Nagarahole National Park, India J. Trop. Ecol 8 21-35.

———, and ———. 1995. Prey selection by tiger, leopard, and dhole in tropical forests J. Animal Ecol. 8: 21-35.

Kawanishi, K. 1995. Camera monitoring of human impacts on rain forest wildlife in Tikal National Park, Guatemala. M.S. Thesis, Frostburg State University, Frostburg, Maryland

———, A. M., Sahak, and M. Sunquist. 1999. Preliminary analysis on abundance of large mammals at Sungai Relau, Taman Negara. J. Wildlife and Parks (Malaysia) 17: 62-82

Khan, M. K. M., S. T. Elagupillay, and Z. Zainal. 1983. Species conservation priorities in the tropical rain forests of Peninsular Malaysia. Malayan Naturalist 36: 2-8.

———. 1987. Tiger in Malaysia: prospects for the future. Pages 75-84 *in* Tigers of the world. R. C. Tilson, and U. S. Seal, eds. Noyes Publications, Park Ridge, New Jersey.

Laidlaw, R., and W. N. Wan Shaharuddin. 1998. Activities patterns of the Indochinese tiger (Panthera tigris corbetti) and prey species in Peninsular Malaysia. J. Wildl. Parks (Malaysia) 16: 85-96

Lancia, R. A., J. D. Nichols, and K. N. Pollock. 1994. Estimation of animals in wildlife populations. Pages 215 -253 *in* Research and management techniques for wildlife and habitats. T. A. Bookhout, ed. The Wildlife Society, Bethesda, Maryland.

Locke, A. 1954. The tigers of Trengganu. Published 1993; Monograph 23, Branch of the Royal Asiatic Society, Kuala Lumpur, Malaysia.

Marshall, A. G. 1973. Conservation in west Malaysia: the potential for international cooperation. Biol. Conserv. 5: 133-140.

Mace, R. D., T Manley, and K. Aune. 1990. Use of systematically deployed remote cameras to monitor grizzly bears. 1989 report. Montana Fish, Wildlife, and Parks. Kalispell. Montana.

———, ———, ———, and S. C. Minta. 1994. Estimating grizzly bear population size using camera sightings. Wildl. Soc. Bull. 22: 74-83.

McDougal, C. 1977. The face of tiger. Rivington Press, London.

Miquelle, D. G., E. N. Smirnov, T. W. Merrill, A. E. Myslenkov, H. B. Quigley. M G. Hornocker, and B. Schleyer 1999. Pages 71 – 99 *in* J. Seidensticker, S. Christie, and P Jackson, eds. Riding the Tiger, tiger conservation in human-dominated landscapes. Cambridge University Press, Cambridge, UK.

Myers, N. 1980. Conservation of tropical moist forests. National Academy of Science, Washington, D. C.

Nordin, M. B. 1983. Management of wildlife reserves in Peninsualr Malaysia. J. Wildl. Parks (Malaysia) 2: 106-118.

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978 Statistical inference from capture data on closed animal populations. Wildl. Monogr. 62: 1-35.

PERHILITAN. 1997. Laporan Taman Negara 1996. Unpublished report. PERHILITAN, Kuala Lumpur, Malaysia.

Rabinowitz, A. 1993. Estimating the Indochinese tiger *Panthera tigris corbetti* population in Thailand. Biol. Conserv. 65: 213-217

Rexstad, E., and K. P. Burnham. 1991. Use's guide for interactive program CAPTURE abundance estimation of closed animal populations. Colorado State University, Fort Collins, Colorado.

Rice, C. G., T. E. Kucera, and R. H. Barrett. 1995. Trailmaster_ camera system: Wildl. Soc. Bull. 23: 110-113.

Samsudin, A. R., and S. Elagupillay. 1996. A review of the protection of the tiger in Peninsular Malaysia. Proceedings of the second international conference and GIS workshop to assess the status of tigers, 24-31 January 1996, Thailand.

Schaller, G. B. 1967. The deer and the tigers: a study of wildlife in India. University of Chicago Press, Chicago.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second ed. Macmillian Publi. Co. Inc., New York, New York.

Seidensticker, J. 1976a. On the ecological separation between tigers and leopards. Biotropica 8: 225-234.

———. 1976b. Ungulate populations in Chitawan Vally, Nepal. Biol. Conserv. 10 183-210.

———. 1986. Large carnivores and the consequences of habitat insularization: ecology and conservation of tigers in Indonesia and Bangladesh. Pages 1-41 *in* Cats of the world: biology, conservation, and management. S. D. Miller, and D. D. Everett, eds. National Wildlife Federation, Washington, D. C.

Seydack, A. H. W. 1984. Application of a photo-recording device in the census of large rain-forest mammals. South African J Wildl. Res. 14: 10-14.

Smith, J. L. D., C. McDougal, and M. E. Sunquist. 1987. Female land tenure system in tigers. Pages 97-109 *in* Tigers of the world. R. C. Tilson, and U S Seal, eds. Noyes Publications, Park Ridge, New Jersey.

Sunquist, M. E. 1981. The social organization of tigers *Panthera tigris* in Royal Chitawan National Park, Nepal. Smithson. Contrib. Zool. 336:1-98.

Topani, R. 1990. Status and distribution of tiger in Peninsular Malaysia. J. Wildl. Parks (Malaysia) 9: 71-102.

van der Schot, W. E. M. 1990. Aborigines in Taman Negara: the impact of a hunters, gatherers, community on a lowland rainforest ecosystem. J. Wildl. Parks (Malaysia) 10:172-183.

van Schaik, C. P., and M. Griffiths. 1995. Activity periods of Indonesian rain forest mammals. Biotropica 28: 105-112.

Weber, B. E. 1972. A parks system for west Malaysia. Oryx 11: 461-9.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture removal methods for sampling closed population. Los Almos National Laboratory Publication LA-8787-NERP. Los Alamos. New Mexico.

Whitmore, T. C. 1984. Tropical rain forests of the Far East. 2nd ed. Clarendon Press, Oxford, London.

Wilson, W. L., and A. D. Johns. 1982. Diversity and abundance of selected animal species in undisturbed forest, selectively logged forest and plantations in east Kalimantan, Indonesia. Biol. Conserv. 24: 205-218.

Zielinski, W. J., and T. E. Kucera. 1995. American marten, fisher, lynx, and wolverines: survey methods for their detection. USDA Forest Service, General Technical Report PSW-GTR-157. Albany, California.