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COMPARISION OF METHODS FOR DETECTING AND SURVEYING TROPICAL CARNIVORES

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The rapid rate of decline toward global extinction of mammals (Hoffmann et al., 2011), particularly carnivores, has alerted the conservation community toward accelerating efforts to fully understand species' distributions, population trends, threats, and conservation status. Specifically, the diversity and richness of Borneo's carnivores, along with the number and increasing intensity of threats to these species (Shepherd et al., 2011), highlights the importance of identifying techniques appropriate to specific conservation and research needs. As demonstrated in this supplemental issue, the range of techniques available to study tropical carnivores has progressed rapidly over the past several decades and have become as varied, and sometimes complex, as the species' themselves. Understanding which techniques to use in carnivore studies depends largely on programmatic goals and objectives, modified in part by study location and species' ecology. Herein, we synthesise the broad categories of techniques currently used to study tropical carnivores and provide insights into relative costs and efficacies of each.

Conducting interviews is a common technique in tropical regions for assessing distribution and sometimes trends of carnivores and other species. Mohd-Azlan et al. (2013) synthesised the utility of these surveys and the collected secondary data for estimating carnivore presence. The authors acknowledged the potential benefits of these survey including low relative costs and the ability to survey large areas rapidly. However, the authors also emphasised several potential shortcomings of this technique such as misidentification of species and possible language barriers between interviewers and local residents. The difficulty separating accurate from inaccurate interview data was noted. Although examples in the literature are limited, the efficacy of secondary surveys to estimate trends in abundance is also questionable. The authors emphasised the need for validation of secondary survey designs to estimate potential sources of error and reduce bias. One of the greatest current benefits of secondary surveys may be to develop dialogues with people in the conservation project area and to increase study acceptance and participation of local communities.

A number of non-invasive methods have been developed for carnivore detection and monitoring. Mathai et al. (2013) reviewed the use and application of line transects for tropical carnivores, a widely used technique for studying wildlife. The authors concluded that used alone, transect surveys as currently implemented are of limited value in studying tropical carnivores. The major reason for this assessment was that numbers of detections are typically too low for meaningful estimates of presence or abundance, a consequence of the secretive nature of carnivores and poor observation conditions due to typical dense vegetation and varied terrain. Those carnivore species for which adequate detections can be obtained for meaningful interest are often of low conservation priority. Mathai et al. (2013) also state that many of the metrics obtainable from transect surveys (e.g., encounter rates, diversity indices) may have ecological value but often limited conservation value. The authors do suggest however that transect surveys may serve as a useful complement to other techniques if sufficient resources are available. Particularly, they note the potential value of conducting transect surveys along roads or rivers to document species of high conservation value.

Camera trapping is one of the most rapidly expanding techniques in wildlife investigations; Sunarto et al. (2013) provided an overview of their application for surveying tropical carnivores. The authors outlined the various types of equipment available and provided detailed information on study design relative to target species, including logistical and operational considerations, frequency of data collection, and guidance on reducing errors and biases. Various methods

of analysing data obtained from cameras, ranging from general species inventory to complex spatial mark-recapture models to estimate abundance, were reviewed. In addition, other aspects of carnivore ecology such as behaviour and rates of movement can be obtained from studies employing camera traps. Images from camera trap studies can also be used as a powerful tool to raise public awareness of conservation issues. This synthesis concluded with future developments and applications to further our knowledge of tropical carnivores and their conservation.

As with camera trapping, the use of molecular tools to understand carnivore ecology to improve conservation has made considerable advances in recent years. Goossens & Salgado-Lynn (2013) describe the importance of using non-invasive techniques to obtain genetic samples, particularly for endangered species. Non-invasive genetic techniques for tropical carnivores are extremely challenging. For example, degradation of DNA in samples is of concern in all genetic studies, the climatic and logistical challenges typical of tropical environments magnifies this concern. The authors discuss the practicalities of collecting and preserving samples to minimise the loss of genetic material and maximise quality of samples for analyses. Conducting a pilot study to ensure efficacy and reliability of genetic material from samples is strongly encouraged before initiating full investigations. Similarly, the need to select loci (both type and numbers) appropriate to your study as well as minimise genotyping errors is crucial. Goossens & Salgado-Lynn (2013) conclude with an 11-step process that will improve the success of genetic-base studies of carnivores in tropical environments.

Tropical carnivores often occur at low densities; consequently, non-invasive and secondary survey approaches may be unsuitable in some circumstances to achieve research or monitoring objectives. McCarthy et al. (2013) summarised approaches used for live capture of tropical carnivores. The authors stressed the importance of clearly identifying study goals to ensure live trapping is an appropriate technique and that adequate numbers of carnivores are captured for meaningful inference. Basic understanding of carnivore species ecology including temporal variation in activity, movement patterns and habitat use will markedly improve capture success. In addition, selection of trap types will vary markedly depending on species studies, as will use of effective baits and lures. The importance of trap placement to maximise detection by target species was emphasised. Investigator recognition of limitations and biases are considered key to successful live trapping efforts in tropical forests. Importantly, the authors emphasised the need for humane treatment of captured animals, particularly time held captive, and means of reducing animal stress and injury during capture and handling procedures.

Radiotelemetry has become one of the most useful techniques in wildlife conservation because of its ability to obtain animal location and other data remotely. However, use of radiotelemetry techniques to improve our understanding of tropical carnivores has been limited. Belant et al. (2013) provide an overview of various techniques and data analyses suitable for carnivores in the tropics. Because of dense vegetation and remoteness of many tropical study sites, use of more traditional very high frequency radio transmitters may not be suitable because of our inability to obtain adequate numbers of locations/animal. In these situations, more recent global positioning and satellite tracking systems offer additional potential to address aspects of resource use, spatial ecology, and survival of carnivores. The authors stressed the importance of establishing clear study objectives to not only ensure field efforts (e.g., number of animals monitored, frequency of monitoring) are adequate but also to ensure that radiotelemetry is an appropriate technique. The authors consider newer approaches to data analyses that incorporate modern statistical methods and philosophies, including mechanistic approaches will likely be of greatest value for improving our understanding of tropical carnivore ecology.

Knowledge of species' distributions and factors that influence their distributions is fundamental to wildlife conservation and management. Data derived from many of the techniques discussed in this supplement can be used to model species distribution. Kanagaraj et al. (2013) provide an overview of several established techniques available to model species distributions and their application to tropical carnivore conservation. The authors also discuss potential data biases (e.g., spatial autocorrelation, mulitcollinearity) that may be inherent to species presence data and provide recommendations for reducing them. Overall, there are numerous important benefits to using species distribution models (SDM) which include understanding effects of land use change on carnivores, species interactions, and variation in habitat use within and among carnivore species. A primary benefit for developing SDMs is to understand species-habitat relationships that can then be used to estimate carnivore responses to natural perturbations of habitat or anthropogenic activities. This knowledge in turn can be used to develop more effective management plans to improve conservation of tropical carnivores.

Absolute suitability of research techniques for studying tropical carnivores varies markedly depending on research questions (Table 1). Virtually all techniques can be employed for estimating presence or absence of carnivores whereas comparatively few are suitable for estimating diet, gene flow, or pathogens. Similarly, the relative suitability of techniques to address a given research question will also vary widely. For example, camera trapping is highly suitable for estimating occupancy of a species, whereas live trapping and radio telemetry are of medium suitability and secondary information is not suitable. Also, species distribution models and radiotelemetry are highly suitable for estimating resource selection whereas molecular techniques are considered of low suitability.

Equally diverse are the relative efforts and sample sizes necessary to meet study objectives when studying tropical carnivores (Table 2). For example, equipment costs to conduct secondary information surveys, transect surveys, and species distribution models are comparatively low, requiring either recording equipment (audio or video), maps

Table 1. Relative efficacy of monitoring and survey techniques to address research questions of tropical carnivores (NS = not suitable).

Research Question	Research Technique (Reference)						
	Secondary information (Mohd. Azlan et al., 2013)	Transect survey (Mathai et al., 2013)	Camera trapping (Sunarto et al., 2013)	Molecular techniques (Goossens & Salgado, 2013)	Live trapping (Gitzen et al., 2013)	Telemetry (Gitzen et al., 2013)	SDM[1] (Kanagaraj et al., 2013)
Presence	Low	Medium	High	Medium	Medium	NS	Medium
Absence	NS	Low	Medium	Low	Low	NS	Medium
Occupancy	NS	Medium	High	Low	Medium	NS	Medium
Abundance/Density	NS	Low	Medium	Low	Medium	Medium	Low
Resource selection	NS	Medium	Medium	Low	Medium	High	High
Activity	NS	Low	Medium	NS	Low	High	NS
Diet[2]	NS	NS	NS	Medium	Low	Low	NS
Movement	NS	NS	Low	Low	Low	High	Medium
Gene flow	NS	NS	NS	High	NS	Low	Low
Distribution	Low	Low	High	Low	Medium	Low	High
Species richness	Low	Medium	High	High	Low	NS	Medium
Species interaction	NS	Low	Medium	Low	Low	Medium	Medium
Pathogens	NS	NS	NS	Low	Medium	Low	Medium

[1]SDM = Species Distribution Modelling in a predictive framework
[2]Stable isotopes analysis can also be applied

Table 2. Comparative effort and sample sizes (N) necessary for studying tropical carnivores.

Consideration	**Research Technique (Reference)**						
	Secondary information (Mohd. Azlan et al., 2013)	Transect survey (Mathai et al., 2013)	Camera trapping (Sunarto et al., 2013)	Molecular techniques (Goossens & Salgado, 2013)	Live trapping (McCarthy et al., 2013)	Telemetry (Gitzen et al., 2013)	SDM[1] (Kanagaraj et al., 2013)
Equipment costs	Low	Low	High	High	Medium	High	Low
Personnel	Low	Medium	Low	Medium	High	High	Medium
Training	Medium[1]	Medium	Medium	High	High	Medium	High
Expected N	Medium	Medium	High	Medium	Low	Low	High
Required N	variable[2]	> 50	> 100	> 30	> 20	> 20	> 50

[1] Guidelines for standardised interview surveys are needed
[2] Specific sample size required is dependent on research question

and global positioning system units, or a computer system with geographic information system capabilities, respectively. Required sample sizes provided to achieve study objectives are estimates only; actual samples needed must be determined separately for each research or conservation project. Power analyses, stratification of study areas, and desired area of inference are examples of considerations that may be useful when estimating necessary sample sizes. We emphasise that personnel training needs were always considered moderate to high, as well-trained personnel are fundamental to the successful conduct of any tropical carnivore project.

The design and conduct of studies to detect and survey tropical carnivore studies can be challenging; their low densities, largely nocturnal activity, and secretive nature compared to many other species groups makes the conduct of effective surveys difficult. These challenges are exacerbated when considering the remoteness of many areas in which these species occur. The appropriate selection and implementation of survey techniques to achieve programmatic success is critical and must match the goals of a given study as identified by specific objectives. The synthetic review of the most important techniques to study tropical carnivores that are contained within this supplemental issue can serve as the foundation from which to select the technique most suited to achieving stated goals.

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See foreword of this supplementary issue.

LITERATURE CITED

Belant, J. L. & A. Wilting, 2013. Foreword – Methods for detecting and surveying tropical carnivores. *Raffles Bulletin of Zoology*, Supplement **28**: i–iii.

Gitzen, R. A., J. L. Belant, J. J. Millspaugh, S. T. Wong, A. J. Hearn & J. Ross, 2013. Effective use of radiotelemetry for studying tropical carnivores. *Raffles Bulletin of Zoology*, Supplement **28**: 67–83.

Goossens, B. & M. Salgado-Lynn, 2013. Advances and difficulties of molecular tools for carnivore conservation in the tropics: A guideline. *Raffles Bulletin of Zoology*, Supplement **28**: 43–53.

Hoffmann, M., J. L. Belant, J. S. Chanson, N. A. Cox, J. Lamoreux, A. S. L. Rodrigues, J. Schipper, and S. N. Stuart, 2011. The changing fates of the world's mammals. *Philosophical Transactions of the Royal Society B*, **366**: 2598–2610.

Karnagaraj, R., T. Wiegand, A. Mohamed & S. Kramer-Schadt, 2013. Using landscape modeling to map the road towards carnivore conservation in the tropics. *Raffles Bulletin of Zoology*, Supplement **28**: 85–107.

Mathai, J., D. Jathanna & J. W. Duckworth, 2013. How useful are transect surveys for studying carnivores in the tropical rainforests of Borneo? *Raffles Bulletin of Zoology*, Supplement **28**: 9–20.

McCarthy, J. L., J. L. Belant, C. Breitenmoser-Würsten, A. J. Hearn & J. Ross, 2013. Live trapping carnivores in tropical forests: Tools and techniques to maximize efficacy. *Raffles Bulletin of Zoology*, Supplement **28**: 55–66.

Mohd-Azlan, J., J. L. Belant & E. Meijaard, 2013. Using secondary survey information to study carnivores in Borneo. *Raffles Bulletin of Zoology*, Supplement **28**: 1–8.

Shepherd, C. R., J. L. Belant, C. Breitenmoser-Würsten, N. Duplaix, L. N. Ambu & A. Wilting, 2011. Conservation challenges and opportunities for Borneo's carnivores. *TRAFFIC Bulletin*, **23**: 89–91.

Sunarto, R. Sollmann, A. Mohamed & M. J. Kelly, 2013. Camera trapping for the study and conservation of tropical carnivores. *Raffles Bulletin of Zoology*, Supplement **28**: 21–42.