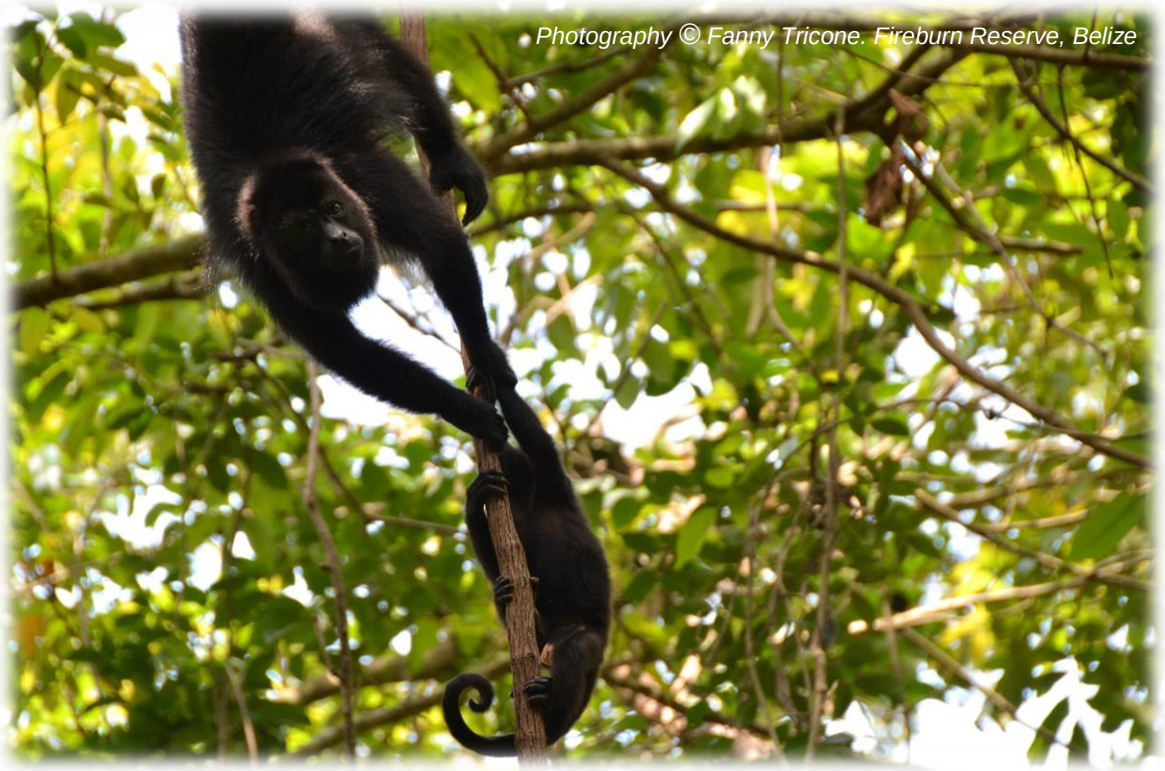
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Assessment of a Yucatan black howler monkey population reintroduction

Par : Fanny TRICONE


Photography © Fanny Tricone. Fireburn Reserve, Belize

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Synthèse en français du mémoire

Introduction

Les primates du néotropique sont menacés par la disparition des forêts tropicales et la chasse des animaux sauvages pour le trafic illégal des animaux de compagnies. La réintroduction d'espèces est une des mesures de lutte contre la perte de biodiversité et elle vise à rétablir des populations autosuffisantes et viables dans des milieux où les espèces ont disparu. Cependant, il a été montré que l'évaluation du succès des réintroductions n'était pas possible pour environ la moitié des projets, à cause d'un manque de suivis et d'évaluation après remise en liberté des animaux.

Alouatta pigra, ou Hurleur du Guatemala, est une espèce en voie d'extinction. Des projets de réintroductions ont été mis en place depuis les années 80 sur cette espèce de singes hurleurs. La répartition géographique de l'espèce s'étend de la péninsule du Yucatan au Mexique, au Belize et au Nord-est du Guatemala. Au Belize, Wildtracks détient le seul Centre de Réhabilitation de Primates du pays et participe à la réhabilitation d'anciens animaux de compagnie et au transfert d'individus sauvages pour les réintroduire et rétablir une population dans un site où l'espèce a disparu depuis environ 70 ans. Après chaque remise en liberté, un suivi de 3 mois est mis en place pour assurer la survie des individus en milieu sauvage. De Juin 2011 à Juin 2014, 28 singes hurleurs ont ainsi été relâchés. Après ces 4 années de remises en liberté, un projet de 6 mois a été mis en place en 2015 pour effectuer un bilan sur l'état actuel des individus relâchés et de leur réintroduction. Les but principaux de ce projet étaient de localiser le plus d'individus possible, de déterminer la composition des groupes et leur condition, ainsi que leur domaine vital actuel pour conduire une évaluation de la réintroduction de l'espèce à ce jour.

Dans cette optique, ce mémoire a été divisé en quatre parties. La première partie est une étude démographique établissant les caractéristiques de la population telles que la taille des troupes et leur composition, la densité de population et l'identification des individus. La seconde partie est une étude des domaines vitaux pour localiser les singes relâchés et évaluer la taille et l'utilisation de leur domaine vital. La troisième partie est une étude sur les ressources alimentaires, pour améliorer les connaissances sur les plantes nourricières présentes sur les lieux de remise en liberté et améliorer la recherche de nouveaux sites de lâcher. Finalement, la dernière partie est une étude du statut actuel des singes libérés selon des critères d'évaluation établis dans le rapport, ainsi qu'une étude statistique sur la survie.

Méthodes

Site d'étude et population étudiée

La réintroduction des singes pris en charge par le Centre de Réhabilitation s'effectue sur deux sites contigus, situés au Nord-Est du Belize, dans la région de Corozal : Fireburn Reserve et Kakantulix Archaeological Reserve. 20 singes réhabilités ont été relâchés à Fireburn Reserve et 8 singes transférés ont été relâchés à Kakantulix Archaeological Reserve. Le choix de séparer singes réhabilités et singes transférés a été fait pour permettre aux singes réhabilités d'apprendre à vivre en milieu sauvage sans pression par des individus sauvages expérimentés.

Localisation des troupes et future sites de remise en liberté

Les troupes et les individus ont été localisés en suivant leurs hurlements et en explorant les Réserves. La méthode d'exploration a été établie en analysant d'anciennes études faites sur la végétation présentes à Fireburn Reserve et ainsi définir des zones de recherche prioritaires (habitats propices à l'établissement de singes hurleurs). L'exploration a débutée dans ces zones prioritaires, en commençant par surveiller les sites de lâchers et les aires explorées par les troupes lors du suivi de trois mois effectué après remise en liberté.

Pendant l'exploration, les aires explorées ont été cataloguées en 3 types de zones en fonction de la présence ou non d'espèce nourricières, la connectivité et la hauteur de la canopée : « site potentiel de lâchers », « corridor potentiel » et « non favorable pour les lâchers ». Cela a permis de cartographier l'aire totale explorée au cours de l'étude pour aider à la localisation de nouveaux sites de lâchers pour les futures remises en liberté.

Identification des troupes et des individus

Chaque individu a été identifié par le nom, le sexe et l'âge. Chaque individu ayant une forme unique de pigmentation sur leurs parties génitales, l'identification des individus a été faite à l'aide de photographies faciales mais également à l'aide de photographies du postérieur des individus. La photographie faciale a permis l'identification par le nom des individus en comparant cette photographie avec des photographies des individus relâchés prises quand ils étaient encore présents au Centre de Réhabilitation. Une clef d'indentification a été mise en place pour aider à l'identification des individus et des troupes, présentant chaque individu par le nom, une photographie faciale et une photographie du postérieur.

Collection et analyse des données

Caractéristiques de la population

Chaque individu a été identifié par le sexe une classe d'âge : adulte, sub-adulte, juvénile ou nourrisson. L'âge des singes a été estimé grâce à l'âge hypothétique des singes à l'admission au Centre de Réhabilitation. Les densités de population ont été exprimées par individu au kilomètre carré.

Localisation GPS

La localisation des individus et des troupes, et l'analyse de leurs déplacements a été faite grâce à un GPS. Il a été relevé par points GPS où les singes se reposaient durant la journée, dormaient la nuit et hurlaient durant les suivis. Cela a été réalisé pour permettre la localisation de leurs sites préférés sur leur domaine vital et pour évaluer si les singes réhabilités étaient capables de défendre leur territoire grâce aux hurlements. Ces informations géographiques ont été traitées à l'aide de cartes sur ArcMap 10.1, et une méthode de polygones numérisés a été utilisée pour évaluer la taille des domaines vitaux.

Plantes nourricières

Les singes hurleurs sont connus pour être une espèce colonisatrice, capable d'adapter leur régime alimentaire lors de transfert dans de nouveaux habitats. Peu est connu sur le régime alimentaire de l'espèce dans le site de réintroduction utilisé par le Centre de Réhabilitation, l'espèce ayant disparu du site il y a environ 70 ans.

Les espèces alimentaires ont été identifiées à l'aide de photographies. Pour chaque espèce, il a été noté si les singes se nourrissaient des jeunes feuilles, des feuilles matures, des fruits, des fleurs ou des pétioles, et si ils s'en nourrissaient pendant plus ou moins de 5 minutes. Pour évaluer les variations de la disponibilité en fruit du site de réintroduction, le mois où les fruits d'une espèce ont été consommés a été relevé. De plus, le comptage du nombre de fois où une espèce a été enregistrée pour l'alimentation a été effectué pour déterminer les espèces consommées préférentiellement.

Critères d'évaluation

Des animaux réhabilités et élevés en captivité n'atteignent pas le même niveau de compétences que des animaux sauvages. Le programme du Centre de Réhabilitation devant permettre la survie des animaux une fois relâchés en milieu sauvage, il était important d'évaluer leurs comportements pour s'assurer qu'ils agissaient comme des animaux sauvages et planifier ou non des interventions. Pour évaluer le statut actuel des individus relâchés et de leur réintroduction, plusieurs critères ont été choisis :

- Trouvé : l'individu a été trouvé ou non lors de l'étude (ceci permet une estimation minimale du taux de survie).

- Réponse à la présence d'humains : l'individu ignore, s'énerve, est attiré par la présence d'être humain.
- Vu sur le sol : l'individu a été vu ou non sur le sol.
- En bonne santé : L'individu parait en bonne santé ou non (visuellement observé par la qualité de la fourrure et du poids).
- Reproduction : la présence de nouveaux nés ou des comportements reproducteurs ont été observés ou non.
- Cohésion à une troupe : l'individu appartient à une troupe ou non.
- Domaine vital établi : l'individu a établi un domaine vital ou non.

Etude de la survie

Une étude statistique a été faite sur la survie (trouvé, non trouvé) pour chercher si certains facteurs avaient une influence sur le fait de trouver ou non les individus après lâchers. Ces facteurs étaient :

- L'origine (sauvage ou animal de compagnie).
- Le sexe
- L'âge à l'admission au centre de réhabilitation
- L'âge à la remise en liberté
- Le degré d'humanisation au moment des lâchers
- Le temps réhabilité et le temps vu après lâchers dans le milieu sauvage.

La variable à expliquer est une variable binomiale. Un modèle linéaire généralisé de famille d'erreur la famille binomiale, et pour fonction de lien la fonction logit, a été choisi pour effectuer cette étude.

Résultats

Etude démographique des singes hurleurs relâchés

Caractérisation des troupes et de la population

24 singes ont été trouvés au cours de l'étude, dont 3 nouveaux nés. La population observée était constituée de 9 males, 12 femelles et 3 nouveaux nés. Cinq troupes ont montré une cohésion et l'établissement d'un domaine vital.

La densité moyenne de la population était 14,2 indiv/km². La densité de population était de 24,3 indiv/km² à Fireburn Reserve et de 4,2 indiv/km² à Kakantulix Archaeological Reserve. L'âge à la première naissance des femelles était d'environ 4,4 ans.

Identification des individus

L'identification des individus par le nom a été possible pour tous les individus trouvés lors de l'étude, et la clef d'identification a été réalisée pour tous ces individus ainsi que les individus présents au Centre de Réhabilitation au moment de l'étude, sauf pour les jeunes pour lesquels seuls des soigneurs spécifiques ont accès.

Evolution de la composition des troupes depuis remise en liberté

La comparaison de la constitution des troupes au moment des lâchers avec celle trouvée lors de l'étude a permis d'étudier l'évolution et la stabilité des troupes. Quatre troupes sont restées soudées (sans tenir compte des individus manquants et des nouveaux nés présents). Une nouvelle troupe a été déterminée, constituée de trois individus provenant de trois troupes initiales différentes. Cinq individus ont été observés sans troupe stable à Kakantulix Archaeological Reserve et interagissant entre eux ou avec des individus de troupes nouvellement relâchées en 2015.

Etude des domaines vitaux des singes hurleurs relâchés

Localisation des troupes et futurs sites de remise en liberté

Une aire d'environ 640 hectares a été explorée et cartographiée durant cette étude. Tous les singes trouvés ont été localisés dans des aires classifiées comme « site potentiel de lâchers ». Tous les individus ont été trouvés autour de leur site de lâchers, hormis Bonnie, une femelle qui a migré de Fireburn Reserve à Kakantulix Archaeological Reserve. La cartographie de l'aire explorée a été utilisée pour rechercher des sites de remises en liberté pour 2015.

Utilisation et tailles des domaines vitaux

Une étude des domaines vitaux a été réalisé sur les troupes et individus qui ont pu être suivis pour un minimum de trois jours. La taille des domaines vitaux étudiés variait de 2,6 à 11,6 hectares. Chaque domaine vital possédait un chevauchement d'en moyenne 18.6% de sa taille totale avec les domaines vitaux voisins.

Des hurlements ont été enregistrés pour toutes les troupes de singes réhabilités trouvés lors de l'étude. Ces hurlements ont eu lieu à la jonction entre deux domaines vitaux. Des arbres et des sites favoris des singes, utilisés pour se reposer et passer la nuit ont été cartographiés sur chacun des domaines vitaux.

Etude alimentaire des singes hurleurs relâchés

Un total de 32 espèces et de 14 familles de plantes alimentaires ont été identifiés au cours de ce projet. Les cinq mêmes espèces favorites ont été trouvées chez les singes étudiés pour se nourrir pendant plus ou moins de cinq minutes, ces espèces étant : *Cecropia peltata*, *Ficus sp.*,

Protium copal, *Leucaena leucocephala* et *Vitis tiliifolia.* Un minimum de trois différentes espèces de fruits consommées a été relevé par mois de Mars à Août.

Evaluation des remises en liberté

Durant ce projet, un total de six singes n'a pas été retrouvé et un autre individu avait été trouvé mort en 2014. 87,5% des singes sauvages transférés et 70% des singes réhabilités ont été retrouvés. Tous les singes retrouvés ont été évalués en bonne santé, et 34% ont montré des capacités de reproduction. 71% des singes appartenaient à une troupe stable, et 76% avaient établis un domaine vital. 86% des singes ont montré une réponse adaptée à la présence d'êtres humains et n'ont pas été vu sur le sol.

Pour l'étude statistique sur la survie, le nombre de données était trop faible pour calculer les coefficients du modèle linéaire généralisé. Une étude graphique des effets significatifs a alors été réalisée, montrant l'influence de l'origine (animal de compagnie ou sauvage) et du temps vu après lâchers dans le milieu sauvage (plus ou moins d'un an) sur la probabilité de trouver ou non l'individu.

Discussion

Analyse des résultats

Caractéristiques démographiques

La densité de population moyenne trouvée dans cette étude était similaire à celle référencée dans la littérature. La population observée a juste commencé à se reproduire. De ce fait, les densités de population observée devraient augmenter dans les années futures, ainsi que grâce aux nouvelles remises en liberté.

Cohésion des troupes

Les troupes trouvées étaient stables. Les problèmes d'instabilité rencontrés à Kakantulix Archaeological Reserve pourraient être attribués au fait que des individus, et non uniquement des troupes, ont été relâches sur ce site. Ces individus chercheraient à établir des troupes et interagiraient avec les femelles présentes sur le site. De nouveaux changements sont à prévoir avec les nouveaux lâchers et la recolonisation du milieu à venir.

A cause de ces changements de troupes et du fait que les visages des singes changent en grandissant, la clef d'identification devra être mise à jour régulièrement dans le futur.

Nouveaux sites de remise en liberté

Les aires les plus importantes qui ont été trouvées favorables aux lâchers étaient déjà habitées par des singes hurleurs. Pour trouver de nouveaux sites de remise en liberté, il est important de

vérifier que l'emplacement est suffisamment éloigné des troupes établies. De plus, les nouvelles remises en liberté ne doivent pas se faire dans des habitats saturés, pour ne pas compromettre la population déjà établie.

Dans ce rapport il a donc été conseillé de ne pas faire de nouveaux lâchers dans Fireburn Reserve du fait que toutes les aires classifiées comme « potentiel site de lâchers » étaient déjà occupés par des troupes, que la densité de population dans cette Réserve était élevée et que la population établie à cet endroit avait commencé à se reproduire. La densité de population à Kakantulix Archaeological Reserve était suffisamment basse pour permettre les lâchers de 2015, et il a été décidé d'y effectuer les nouvelles remises en liberté.

De nouvelles aires de remise en liberté devraient être recherchées pour les futurs lâchers car les sites de remises en liberté utilisés actuellement seront bientôt saturés.

Caractéristiques des domaines vitaux et utilisation

Une étude faite sur *Alouatta pigra* a montré que des troupes récemment transférées établissaient généralement leur domaine vital six mois après remise en liberté, et continuaient d'explorer leur habitat un an après remise en liberté. Les individus trouvés dans cette étude ont été relâchés au moins un an avant ce bilan. De ce fait, il a pu être montré que l'établissement des domaines vitaux pouvait prendre plus d'un an.

La taille moyenne des domaines vitaux pour l'espèce est de 9,2 hectares, ce qui est supérieur à ce qui a été trouvé dans cette étude. Or, la taille des domaines vitaux est inversement proportionnelle à l'abondance de nourriture et à la densité de population. La densité de population trouvée à Fireburn Reserve était supérieure à la densité moyenne de l'espèce et pourrait expliquer ce résultat. Grâce à l'identification des espèces nourricières, une étude sur l'abondance de ces espèces sur le domaine vital de chaque troupe pourrait être faite à l'avenir pour évaluer si la taille des domaines vitaux serait également corrélée avec l'abondance de nourriture.

Le recouvrement des domaines vitaux chez les singes hurleurs peut atteindre environ 30%. Ces connections entre domaines vitaux permettraient la reproduction d'individus de troupes différentes et donc le maintien d'une diversité génétique au sein de la population.

Chez les singes hurleurs, la défense des territoires est faite à l'aide de hurlements dissuasifs pour informer les adversaires du nombre de mâles adultes dans la troupe et éviter des combats couteux en énergie. A Fireburn Reserve, la stratégie semblait efficace, aucun combat n'ayant été observé. Cependant cela pourrait également être dû au fait qu'il n'y ait encore que peu de mâles adultes dans la Réserve.

L'étude sur les aires de repos a confirmé l'idée selon laquelle les singes hurleurs avaient des sites préférentiels pour se reposer et passer la nuit. La localisation de ces sites permettra une localisation plus aisée des troupes dans le futur.

Capacité nourricière des zones de remise en liberté

Alouatta pigra consomme en moyenne 23 espèces et 11 familles de plantes. La comparaison avec les résultats trouvés dans cette étude a montré que les singes se nourrissaient avec succès dans leur nouvel environnement et que cet environnement fournissait suffisamment de ressources pour leur survie.

L'espèce a été décrite comme étant aussi frugivore que possible et aussi folivore que nécessaire. De Mars à Août, l'étude sur les espèces nourricières fruitières a permis de montrer que le site de remise en liberté permettait aux singes de se fournir en fruits sans interruption durant cette période.

Cette étude soutient les efforts du Centre de Réhabilitation pour mettre davantage l'accent sur la production d'espèces locales présentes sur les sites de remise en liberté pour nourrir les singes réhabilités, en fournissant une identification des espèces nourricières favorites consommées par les singes sur les sites de réintroduction.

Evaluation du statut et de la réintroduction des singes relâchés

Tous les singes transférés, sauf un dont le squelette a été retrouvé avant ce bilan, étaient en vie un an au moins après remise en liberté. La survie à long terme des singes réhabilités était d'au moins 70%. En effet, ne pas trouver un individu ne signifie pas qu'il est mort. L'individu en question pourrait avoir migré dans des aires non surveillée ou pourrait ne pas avoir été localisé du fait des difficultés visuelles pour détecter un singe dans la canopée. Deux individus manquants ont cependant été identifiés à haut risque de décès. Une cause probable de décès serait une mort naturelle par prédation. La présence de prédateurs naturels des singes hurleurs a été mise en évidence par des pièges photos sur les Réserves au cours de ce projet.

95% des singes relâchés ont été estimés être sexuellement matures durant ce projet. D'autres individus que ceux trouvés lors de l'étude pourraient se reproduire avec succès, mais les nouveaux nés n'auraient pas été trouvés. En effet, la mortalité infantile chez les singes hurleurs peut atteindre environ 21-35%, et la plupart des femelles relâchées (ex-animal de compagnie) n'ont jamais vu d'autres femelles s'occuper de nouveaux nés. On pourrait donc s'attendre à ce que ce pourcentage soit plus élevé dans la population étudiée. De même, les singes relâchés ne savent probablement pas comment détecter des prédateurs et protéger leurs congénères.

Facteurs influençant la survie

Aucun des facteurs inhérent au Centre de Réhabilitation n'aurait une influence sur la survie des individus après remise en liberté. Si l'individu n'a pas été vu un an après remise en liberté, ses chances de ne pas être retrouvé par la suite seraient de 100%. Autrement, ses chances d'être trouvé seraient élevées, d'autant plus si l'individu était d'origine sauvage. Le fait que le singe ait été un animal de compagnie n'influence pas de façon significative la probabilité de survie.

Limites du projet

Comme le but principal de ce projet était de trouver le plus d'individus possible, le temps de terrain a été consacré en priorité à l'exploration des sites de remise en liberté. Par conséquent le temps passé à suivre chaque troupe et individu nécessiterait d'être augmenté pour avoir des résultats plus pertinents sur les domaines vitaux et l'alimentation.

L'utilisation des domaines vitaux dépend de la disponibilité en nourriture et donc varie de façon mensuelle. Par conséquent, les troupes n'utilisent pas tout leur domaine vital au même moment de l'année. De ce fait, les études sur les domaines vitaux et les espèces nourricières devraient être faites sur une année complète.

La connaissance sur les espèces nourricières utilisées au cours d'une année permettrait de trouver des sites de remise en liberté de bonne qualité, comme ils doivent fournir des ressources alimentaires à travers toutes les saisons.

Des échantillons de plantes ne pouvaient pas être collectés durant cette étude. La collecte d'échantillons aurait pu permettre d'identifier plus précisément les plantes consommées par les singes.

Les singes transférés n'ont pas pu être suivis pendant trois jours consécutifs. Du fait de leur réponse négative à notre présence, les singes n'ont pas pu être trouvés le jour suivant. De ce fait, l'étude du domaine vital des troupes n'a pas pu être effectuée sur les individus transférés.

L'étude statistique faite sur la survie nécessitait plus de données. Cette étude pourrait être refaite dans le futur, lorsque plus de singes auront été relâchés. De nouveaux effets significatifs pourraient alors apparaitre.

Conclusion

Le but de ce projet était de faire un bilan sur l'état et la réintroduction de singes hurleurs pour évaluer le ré-établissement d'une population où l'espèce a disparu. Cela a été effectué en évaluant la survie, la reproduction, l'établissement des domaines vitaux, la cohésion des troupes, la réponse des singes à la présence d'humains, la présence des singes au sol et leur condition de santé visuelle, ainsi qu'en étudiant l'utilisation de leur domaine vital et la présence d'espèces nourricières sur les sites de remise en liberté.

En 2015, la population a pu être caractérisée et 75% des singes relâchés ont été trouvés en bonne santé, identifiés et localisés après au moins un an passé en milieu sauvage. Dans d'autres études, le taux de survie atteint seulement un maximum de 40%. Dans cette étude, 76% des singes relâchés avait établi un domaine vital et 71% appartenait à une troupe stable. Les singes réhabilités étaient capable de se nourrir et de défendre leur territoire comme des singes sauvages. De plus, 24% de la population a commencé à se reproduire avec succès, et 32 espèces alimentaires ont été identifiées au cours de l'étude.

Les difficultés pour trouver des singes dans la canopée, la migration d'individus vers des zones non surveillées et la prédation ont été les explications les plus probables pour la disparition des individus.

Il a été montré dans cette étude que les singes hurleurs semblent avoir des sites préférentiels pour passer la nuit et se reposer. Peu d'étude ont porté sur l'analyse spatiale de la distribution de ces sites. Ce rapport pourrait être un point de départ pour étudier ce sujet, comme cela a été réalisé avec les singes araignées.

L'étude statistique sur la survie a permis de montrer l'importance de faire des suivis sur plus d'un an pour évaluer correctement la survie des individus.

Le but des réintroductions étant de ré-établir une population viable et autosuffisante, leur évaluation devrait être effectuée jusqu'à la reproduction réussie de la descendance de la génération réintroduite. Par conséquent, des bilans futurs seront nécessaires pour évaluer les taux de reproduction de la population réintroduite. Chez les Gibbons, des projets de réintroduction ne relâchent des troupes qu'une fois qu'elles se reproduisent. Cette approche pourrait être abordée par le Centre de Réhabilitation pour améliorer la reproduction de la population réintroduite.

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1 INTRODUCTION

Neotropical primates are threatened by the loss of tropical forest due to human activities (Chapman & Peres, 2001) and hunting pressure for consumption or sale for the pet trade (Horwich, 1998). Conservation efforts for primates are discussed in the scientific literature, such as habitat conservation and protection against international primate trade (Konstant & Mittermeier, 1982,; Mittermeier et al., 1989). Species reintroduction is another measure to fight against the loss of biodiversity and it aims to re-establish a viable, self-sustainable population in the wild inside its indigenous range from which it has disappeared (IUCN/SSC, 2013,; Baker, 2002). Guidelines have been published to ensure that everything goes smoothly in reintroduction projects (IUCN/SSC, 2013,; Baker, 2002,; Armstrong & Seddon, 2008,; Beck et al., 2007)). Despite all these measures, a study assessing the results of 20 years of reintroduction projects showed that it wasn't possible to evaluate the success or the failure of around half of the projects (Fischer & Lindenmayer, 2000). Generally, this may be due to historical lack of monitoring in the projects, negligence in the implementation of the evaluation and monitoring after release and/or reluctance to report the failures (Sarrazin & Barbault, 1996,; Cheyne, 2009a). A study showed that only a third of rehabilitation centers assessed the success of releases (Guy et al., 2013). Assessments should include behavioural, demographic, and ecological studies and take into account other factors such as social changes (for example, group stability and intergroup interactions), health, reproductive behaviour and success and mortality (Baker, 2002).

Alouatta pigra, or Yucatan black howler monkey, is one of the 11 species of the genus *Alouatta* to be listed on the IUCN red list which catalogues and evaluates the status of threatened species. *Alouatta pigra* is endangered and ranges from the Yucatán Peninsula in Mexico, Belize and the Northern and central Guatemala (Marsh et al., 2008). Reintroduction projects have been conducted on this species since the 1980s (Horwich et al., 1993). Howler monkeys are folivorous, florivorous, and frugivorous, and the consumption of fruits represents around 38.5% of their diet (Dias & Rangel-Negrin, 2015). Therefore, the conservation of howler monkeys is essential for the forests as they are important seed dispersers (Arroyo-Rodriguez et al., 2015). In Belize, around a quarter of the national territory is under some form of conservation management, and the pet trade of this species is illegal. Wildtracks, a non-governmental organization, hosts the only Primate Rehabilitation Centre in Belize and participates in the rescue of injured monkeys in the wild, translocation and confiscation of illegal pets in partnership with the Forest Department of Belize. The rescued monkeys receive care and enter a rehabilitation programme to allow them to be released back into the wild.

Between June 2011 and May 2015, Wildtracks has released 28 howler monkeys. These included rehabilitated monkeys from the pet trade and also translocations of wild monkeys. A

post release monitoring period of 3 months has been applied to each released troop of rehabilitated howler monkeys, to ensure their survival in the wild. After four years of releases, Wildtracks decided to start a 6 month project to determine the current status of the released Yucatan black howler monkeys and of reintroduction into their former range to re-establish a viable sub-population. The main goals of this project were to locate as many of the released howler monkeys as possible, determine group composition, condition, and current territories in order to conduct evaluation of species re-introduction to date.

For that purpose this study was divided in four parts to conduct the assessment of the population reintroduction. The first part was a demographic study, analysing the characteristics of the population such as troop size and composition, population density and individual identification. The second part was a home range study to locate the released monkeys and evaluate the size and home range use of established monkeys. The third part was a feeding study to improve the knowledge of the feeding species used by the released monkeys and to improve the search for suitable release sites. And finally, the last part was an evaluation of the status of the released monkeys, including health condition, reproduction, troop cohesion and establishment, and a statistical study of survival.

2 METHODS

2.1 STUDY SITE AND STUDY POPULATION

Reintroduction and translocation of rehabilitated and wild monkeys occurred in two contiguous sites: the Fireburn Reserve and the proposed Kakantulix Archaeological Reserve. These sites are located on the Eastern shore of the Shipstern Lagoon, in the Corozal District of north-eastern Belize (Figure 1). These two release sites are within the historical range of *Alouatta pigra*, and are protected and free of historical threats, which is conducive to the establishment of a new population of black howler monkeys (Konstant & Mittermeier, 1982). Therefore, they fulfill the requirements of the reintroduction guidelines (IUCN/SSC, 2013,; Baker, 2002. Moreover, the Fireburn Reserve was studied in 2005 to ensure that there were suitable areas for howler monkey releases, in terms of food abundance and canopy structure (Fanigliulo, 2005).

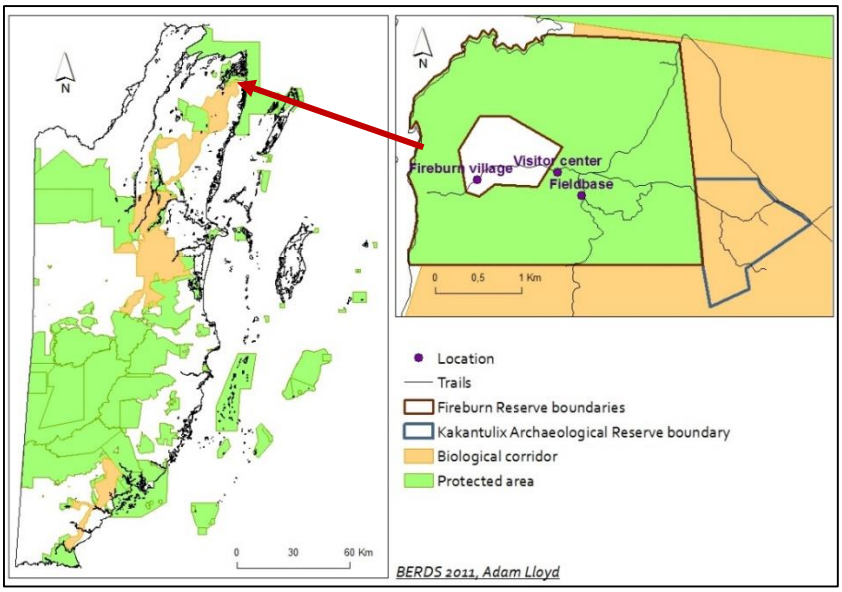


Figure 1: Protected areas and corridors of Belize, and location of the release sites

The study population is constituted by 21 howler monkeys, of which 12 were estimated sexually mature at release (Table 1 and 2, Appendix XII).

Rehabilitated monkeys were released into the Fireburn Reserve (Appendix X): a 736 hectare protected area that is part of the North-East Biological Corridor of Belize. The Reserve surrounds the Fireburn Community and is jointly managed by Wildtracks and the Community. To date, 20 rehabilitated howler monkeys (6 troops) have been released at the Fireburn Reserve since 2011 (Table1). These troops included both wild monkeys and those confiscated from homes and kept as pets through the illegal pet trade.

Table 1: List of the released rehabilitated howler monkeys

Name	Sex	Release date	Source	Sexually mature*
Agatha	F	May 10, 2011	Pet	
Bonnie	F	May 10, 2011	Pet	
Clyde	M	May 10, 2011	Pet	
Holly	F	May 10, 2011	Pet	
Dudley	M	June 15, 2012	Pet	X
Eden	F	June 15, 2012	Pet	
Igor	M	June 15, 2012	Pet	
Minnie	F	June 15, 2012	Pet	
Mo	F	June 15, 2012	Pet	
Nicky	M	June 13, 2013	Pet	
Willow	F	June 13, 2013	Pet	X
Hazel	F	June 13, 2013	Pet	X
Richie	F	June 14, 2013	Pet	
Fern	F	June 14, 2013	Pet	
Charlie	M	June 14, 2013	Pet	
Mia	F	June 14, 2013	Wild	
Sultan	M	June 16, 2014	Pet	X
Livvy	F	June 16, 2014	Wild	X
Kofi	F	June 16, 2014	Pet	X
Paz	M	June 16, 2014	Pet	

**At release*

Translocated monkeys were released adjacent to the Fireburn Reserve, in the proposed Kakantulix Archaeological Reserve (Appendix X). This site is currently undergoing the process of becoming included within Belize's protected area network (Walker, P. pers. comm.). In order to give the rehabilitated monkeys time and space to establish their territory and learn how to

defend it, the decision was made to not release rehabilitated monkeys and wild monkeys in the same location. To date, 8 translocated howler monkeys (2 troops and 2 individuals) have been released since 2011 (Table 2).

Table 2: List of the released translocated howler monkeys

Name	Sex	Release date	Source	Sexually mature*
Coco	M	March 29, 2014	Wild	X
Kong	M	March 29, 2014	Wild	X
Tower Hill male	M	August 07, 2014	Wild	X
Tower Hill female A	F	August 07, 2014	Wild	X
Tower Hill female B	M	August 07, 2014	Wild	
Tower Hill female C	F	August 07, 2014	Wild	
Barton Creek male	M	August 30, 2014	Wild	X
Barton Creek female	F	August 30, 2014	Wild	X

**At release*

2.2 LOCATION OF THE TROOPS AND FUTURE RELEASE SITES

From March 03 to August 06, 88 days were spent in the field surveying the primate population. Troops and/or individuals were located by one of two methods: tracking their howls and by exploring the reserves.

2.2.1 LOCATION BY THE HOWLS

Following previous methods of population survey on howler monkeys (Estrada et al., 2002,; Estrada et al., 2004,; Rosales Meda et al., 2008), when howls where heard, the troop was located on the map by triangulation, using a compass and a GPS. Detected troops were reached by utilising existing trails then exploring the forest.

2.2.2 LOCATION BY EXPLORATION

When new individuals could not be found, a new method of exploration was established. This method of exploration consisted of walking in zig-zag formations in unexplored areas. To ensure parallel transect lines, a GPS and compass were used to navigate an area consisting of approximately 60 meters between the two transects. During exploration, the biggest trees were checked attentively. The scent of fecal matter, leftovers from meals (i.e. fruit and/or vegetation), and noise in branches were actively sought out.

The exploration method was established in the Fireburn Reserve. A map of the vegetation and land use in the Fireburn Reserve (Maskell, 2000) was studied by M. Fanigliulo in 2005 (Appendix VI) to estimate the availability of possible release sights (Fanigliulo, 2005). Five habitats were kept, based on food abundance, size and canopy height: “dense cohune”, “lowland moist forest with cohune”, “medium sized lowland moist forest”, “secondary growth – pioneer species” and “shorter lowland moist forest” (Figure3). The results from the study by M. Fanigliulo were used to classify the suitability of the area for the howler monkey establishment and therefore define priorities for the exploration:

- Not suitable areas: habitats not kept due to low trees and no food (Fanigliulo, 2005).

- Potentially suitable areas: “shorter lowland moist forest” habitat, defined as a less suitable release site based on the low food abundance (Fanigliulo, 2005).
- Suitable: “dense cohune”, “lowland moist forest with cohune”, “medium sized lowland moist forest” and “secondary growth – pioneer species.

The small patches of habitat were integrated into the main classes of vegetation around them, and a new map was created.

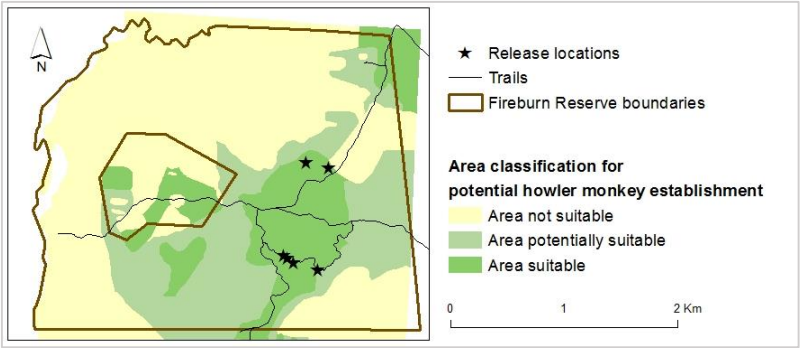


Figure 2: Classification for the exploration method in the Fireburn Reserve

The habitat suitability results were then used to define priorities of habitat exploration outside of the Fireburn Reserve.

The suitable habitat for the establishment of the monkeys, based on the map of vegetation and land use, was first checked. The location of the release cages and the location of the troops during their post-release monitoring were also used as a baseline to start the exploration of these areas.

2.2.3 NEW RELEASE SITES

One of the factors which can lead to failure or the success of reintroduction is the selection of release sites (Griffith *et al*., 1989,; Cheyne, 2006).

Howler monkeys rarely jump to negotiate discontinuities in the canopy ((Youlatos & Giollot, 2015). Therefore, it is important to check the connectivity of the canopy to find new release sites, mostly for rehabilitated monkeys whose climbing skills are not expected to be as good as for wild monkeys.

While using the exploration method to find new howler monkeys, data were recorded on the canopy height (>10m or <10m, assumed high enough to avoid predation), canopy connectivity, the presence of food species (*Ficus sp.* and *Brosimum alicastrum*, used by Wildtracks to find new release locations), and the reason of the turnaround between two transects. These data were used to create a map classifying the explored area:

- Potential release area: presence of food species, canopy height > 10m and good connectivity of the canopy.
- Potential corridor: canopy height enough, good connectivity of the canopy, absence of the feed tree species.
- Not suitable for release: no presence of the feeding species, canopy height < 10m.

And to explain the limits of the map:

- Vegetation not suitable past this limit: low areas, no presence of feed species.
- Not explored past the limit: lake of time, too far outside the Reserves boundaries.

2.3 IDENTIFICATION OF THE TROOPS AND INDIVIDUALS

The identification of the rehabilitated monkeys was done by both photos of faces and posteriors. The monkeys were identified by comparing photos of their faces with old photos of the individuals when they were staying at the Primate Rehabilitation Centre. Based on the observation that monkey faces can change a lot during maturation, and the difficulty of viewing their faces in the canopy, only the initial identification was conducted using facial photos and further identification was conducted using photos taken of their posteriors. After observing in the Primate Rehabilitation Centre that each monkey has a unique pink shape on their posterior (Horwich, 1983b), this method proved to be more practical as has been shown to be the case by spider monkey biologist (Denise, A. pers. com.). Photos of the faces and of the posteriors of the monkeys still present at the Primate Rehabilitation Centre were also collected to help with the identification of individuals for the future releases. The photos of the faces were taken from the front side and the photos of the rears were taken to show the continuity between anus, perineum and urogenital.

With the photos of both face and rear, an identification key was created to help the future studies. Photos were taken of the released monkeys found and the monkeys present at the Primate Rehabilitation Centre. The individuals were grouped by troops. The troops found at the Fireburn Reserve were named by the name of the alpha male. The current status of the individuals and their intake information were noted.

The intake information was classified as:

- Ex-pet: was originally kept as a pet (after capture from the wild). Rehabilitation needed.
- Wild: was injured and taken from the wild as an adult. Rehabilitation needed.
- Wild infant: was rescued from the wild (usually victim of an infanticidal attack) as an infant. Rehabilitation needed.
- Translocated: was removed from an unsuitable area. No rehabilitation needed (beyond quarantine and de-parasitizing).
- No intake: individual has not been at Wildtracks.

2.4 DATA COLLECTION

2.4.1 POPULATION CHARACTERISATION

Individuals were identified by sex and age class. Age was classified as either adult, subadult, juvenile or infant (Rumiz, 1990). Infants were not counted in reproductive troop size. The age of the monkeys was estimated based on the hypothetical age of the monkeys at intake in the Primate Rehabilitation Centre (Appendix XII). Gestation of howler monkeys lasting six

months (Van Belle & Bicca-Marques, 2015), and the age of the monkeys when they successfully reproduced were calculated. Population density was expressed as indiv/km² and was calculated in the potential release areas (cf. part 2.2.3) in Fireburn Reserve and in Kakantulix Archaeological Reserve.

2.4.2 GPS LOCATIONS

When a troop or an individual was located, the geographical location was recorded using a GPS. The troop or individual was followed for a minimum of three days when possible, to check on the establishment of their home range. This allowed for the collection of GPS locations, identifying range of home ranges through their travels, and the use of their home range by identifying areas where the individuals slept, rest and howled.

For the rehabilitated monkeys, howling areas were recorded to check their ability to defend their territory (Van Belle et al., 2014). When a male was howling at another male, both location and identification were recorded for the different troops.

Howler monkeys have preferred sleeping sites (Chivers, D.J., 1969,; Jardim, M.M.A., 1997). Therefore, the sleeping sites found during this study were recorded by GPS to more easily locate the troops in the future. These sites were defined when a troop was resting in the evening and found in the same location the next morning. The resting sites were defined when a troop was inactive for more than 30 minutes in the same tree.

2.4.3 FEEDING PLANTS

Alouatta pigra has been identified as a coloniser species, due to its dietary flexibility (Silver et al., 1998). Moreover, this species can add new species to its diet when translocated in a new habitat (Silver & Marsh, 2003). Howler monkeys disappeared around 70 years ago from the release sites used in this study. Little is known about the diet of the howlers in this area. Therefore, data was collected to identify the feed species used by the monkeys after release to help the search of new release locations in the future and assess the food richness of the release sites.

When tracking the monkeys, photos of the feed plants were taken for identification at a later date. The date and the part of the plant eaten: young leaves, mature leaves, fruits, flowers and petioles (Silver & Marsh, 2003) was also recorded. Two feeding behaviors were observed when tracking: “snacking” and “feeding”. Snacking consisted of the monkeys quickly moving and then stopping for less than five minutes to eat, whereas feeding consisted of the monkey stopping for more than five minutes to eat. The identification of feed species was used to improve the knowledge of the plants sought out by the foraging monkeys in their home range.

The feed plants were first identified by local assistants. Then, the photos of the plants remaining were sent to S. Brewer, plant ecologist, for identification.

As the availably of the fruits varies with the season, the months were noted to determine how the fruit consumption varied. It was assumed that browse would be available for the

duration of the study. Each species, and the number of times the monkeys ate each species, was recorded to estimate their browse preference. The time spent tracking each troop was similar as not to bias the results.

2.4.4 EVALUATION CRITERIA

Ex-pet individuals don't acquire the same level of skills and autonomy to survive in the wild after release as wild animals (Cheyne, 2009a). Therefore an evaluation of the status of the howler monkeys and of their reintroduction was conducted to assess their capacity to survive in the wild and to plan intervention if necessary. First it was evaluated whether the individual was found or not. This allowed an estimation of the survival rate. For the monkeys which were not found, information was collected about the last time that they had been seen in the wild by the trackers, and a risk assessment for mortality was conducted: low, medium or high; based on the skills of the individual at release.

Then for the individuals found, several criteria were chosen:

- **Seen attracted to people:** all of the monkeys released spent at least one month in the Primate Rehabilitation Centre for quarantine and health assessment and may be apt to approach people (Baker, 2002). Released monkeys should not interact with people anymore (Baker, 2002), therefore, it was checked if the individual showed positive interest in human presence or not. Curiosity leading to the individual going lower in trees to look at humans, or attempt at positive interaction with people (like play) was recorded. Negative interaction (like howls towards people, excretion of feces) was not counted as a sign of attraction.
- **Seen on the ground:** Wild howler monkeys should live in the canopy whilst they are known to descend to the ground to cross gaps between trees (Pozo-Montuy & Serio-Silva, 2008), they should generally avoid doing so because of increased risk of predation. During rehabilitation, monkeys are accustomed to being on or near the ground at the Primate Rehabilitation Centre because of the time spent in cages. It was important to make sure that when released, the monkeys stay in the canopy to avoid predation.
- **Healthy:** The health condition of the individuals was checked in case some monkeys needed to go back to the Centre.
    - Good condition: Dense and fluffy fur with good sheen, and good weight.
    - Poor condition: Fur and/or weight below optimal.
- **Reproduction:** Reproductive success was assessed by identifying presence of wild born baby monkeys as well as observation of mating behavior (Van Belle & Bicca-Marques, 2015,; Horwich, 1983a).
- **Troop cohesion:** As problems in troop cohesion can lead to high mortality rates and lack of breeding (Guy et al., 2012), it was checked if the individual belonged to a troop.

- **Established home range:** it was checked if the individual had established a home range since release.

2.5 DATA ANALYSIS

2.5.1 HOME RANGE STUDY

The location of the travels of each troop was studied using ArcMAP10.1. To calculate the home range of the troops, digitized polygons were used as described by Ostro et al. (1999b), to use the same method as previous studies done on *Alouatta pigra* (Fortes et al., 2015) and allow comparison of the results found in this study. Maps of the territories were made, showing where the troops were sleeping at night, resting and howling, whenever it occurred.

2.5.2 SURVIVAL STUDY

With the help of a study on the evaluation of the reintroduction of Gorillas (King et al., 2012), different factors which could influence the survival (Found/Not found) were defined. These factors are the explanatory variables and are qualitative variables, represented by categories:

- Source : Pet/Wild
- Sex : Male/Female
- Age at intake : Infant/Juvenile/Subadult/Adult
- Age at released: Infant/Juvenile/Subadult/Adult
- Degree of humanisation at release: Low/Medium/High
- Time rehabilitated: <1 year/1-2 years/>2 years
- Time seen after release in the wild: <1 year/>1 year

The variable that needs to be explained is a binomial variable: Found/Not found.

The influence of these factors was studied using a generalized linear model in the software R 3.1.1, with the error family being the binomial family, and with the link function the function logit.

3 RESULTS

3.1 DEMOGRAPHIC STUDY OF THE RELEASED HOWLER MONKEYS

Table 3: Time spent tracking each troop and individual during the study

Group	Name	Time tracking (h)
A	*Dudley*	35.2
B	*Charlie*	34.9
C	*Nicky*	32.1
D	*Clyde*	38.2
E	*Paz*	25.9
F	*Tower Hill*	6.4
G	*Barton Creek male*	2.7
H	*Kong*	12.5
I	*Barton Creek female*	4.08
J	*Bonnie*	7.27
H	*Coco*	0.5

During this study, an average of 33.3 hours were spent tracking each troop of the rehabilitated monkeys and of 9.5 hours for the translocated ones (Table 3). For the translocated monkeys, the average was calculated on Kong, Barton Creek male and Tower Hill's troop because Bonnie and Barton Creek female were tracked with either Kong or Barton Creek male, and Coco was not tracked.

3.1.1 POPULATION AND TROOP CHARACTERISTICS

Table 4: Howler monkeys detected during the study

		Adult		Subadult		Juvenile		Infant		
Troop	**Name**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Total**
A	*Dudley*	1	2					2		5
B	*Charlie*		2	1				1		4
C	*Nicky*	1	2							3
D	*Clyde*	1	2							3
F	*Tower Hill*	1	1				1			3
Solitary										
E	*Paz*			1						1
Individuals interacting										
G	*Kong*	1								1
H	*BC male*	1								1
I	*Bonnie*		1							1
J	*BC female*		1							1
K	*Coco*	1								1
	Total	7	11	2			1	3		24

BC = Barton Creek

24 monkeys have been found during this study (Table 4). The observed population consisted of 9 males, 12 females, and 3 infants. A, B, C, D and F were established in troops during the studies, but switches between the individuals G, H, I, and J have been seen.

The mean size of reproductive troops was 3. All the troops were unimale.

The population density was on average 14.2 indiv/km² and range from 4.2 indiv/km² at Kakantulix Archaeological Reserve to 24.3 indiv/km² at Fireburn Reserve.

Table 5: Estimations of ages for the infants (A) and the monkeys that reproduced (B)

A

	Estimate age of the infants
Minnie	3 months the 23/02/15
Mo	4 months the 23/02/15
Fern	2-2,5 months the 06/03/15

B

	Age at first birth	**Age at successful copulation**
Minnie	4.3-4.4 years	3.8-3.9 years
Mo	4.3-4.4 years	3.8-3.9 years
Dudley	-	5.4 years
Fern	4.4 years	4.0 years
Charlie	-	3.1-3.2 years

The age of the infants was evaluated by Paul Walker (Table 5 A), allowing the calculation of the age at first birth for the females and the age when the monkeys were sexually mature

by calculating when they copulated successfully (Table 5 B). The age at first birth for the females was found to be approximately 4.3-4.4 years. The females were found to be sexually mature at 3.8-3.9 and 4.0 years old, and the males at 3.1-3.2 and 5.4 years old. 20 of the 21 monkeys found in this study were estimated to be sexually mature in June 2015 (Appendix XII).

3.1.2 IDENTIFICATION OF THE INDIVIDUALS

All the individuals found were successfully identified. The identification key was created with the 24 monkeys found in the wild and the howler monkeys which were present at the Primate Rehabilitation Centre from March 2015 to May 2015, except for the infants in the Nursery Unit, where only dedicated carers have access (Figure 5 and Appendix XIV).



Figure 3: Abstracts from the identification key

3.1.3 EVOLUTION OF THE TROOPS' COMPOSITION SINCE RELEASE

Table 6: Troop composition before and after release

Released groups from 2011 to 2014			Groups found in 2015		
Group 1	**Group 4**	**Group 8**	**Group A**	**Group D**	**Group H**
Clyde	Charlie	Paz	Dudley	Clyde	Barton Creek male
Holly	Fern	Kofi	Mo	Mia	
Bonnie	Richie		?	Livvy	**Group I**
Agatha	Mia	**Group 9**	Mo's baby		Bonnie
		Tower Hill male	?'s baby	**Group E**	
Group 2	**Group 5**	Tower Hill female A		Paz	**Group J**
Dudley	Coco	Tower Hill female B	**Group B**		Barton Creek female
Igor		Tower Hill female C	Charlie	**Group F**	
Eden	**Group 6**		Fern	Tower Hill male	**Group K**
Mo	Kong	**Group 10**	Richie	Tower Hill female A	Coco
Minnie		Barton Breek male	Fern's baby	Tower Hill female C	
	Group 7	Barton Creek female			
Group 3	Sultan		**Group C**	**Group G**	
Nicky	livvy		Nicky	Kong	
Willow			Hazel		
Hazel			Willow		

The Table 5 shows the evolution of troop composition after release. Based on the released monkeys found, at the Fireburn Reserve only two females, Mia and Livvy, switched troops after release to create a new troop with the male Clyde. The Barton Creek monkeys were not found together during the study, showing that they separated after release. Only two troops were found with new monkeys. Group A had two male infants and group B had one male infant.

On May 3rd, Barton Creek male was found with Bonnie. On May 11th, Kong was found with Barton Creek female. On May 19th, the Tower Hill monkeys were found and entered into a fight with Kong who was alone. On July 10th, Barton Creek male was seen joining one of the new troops released in June 2015 (called the Teens), to mate with the females. The same day, Bonnie was seen alone, calling for the Barton Creek male. On July 14th and 15th, Kong was found with Bonnie. On August 6th, Coco was seen with Bonnie.

3.2 HOME RANGE STUDY OF THE RELEASED HOWLER MONKEYS

3.2.1 LOCATION OF THE TROOPS AND FUTURE RELEASE LOCATIONS

During this study, an area of 638 ha was explored to find the released howler monkeys (Figure 6).

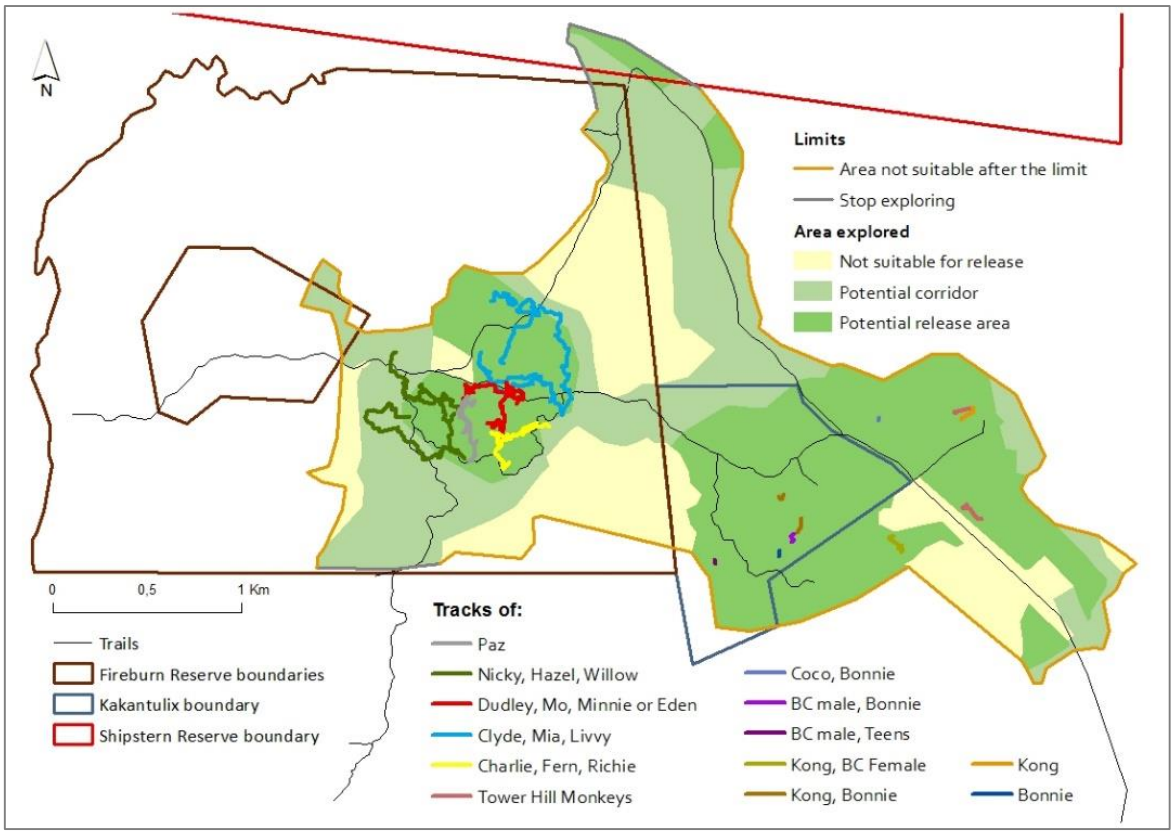


Figure 4: Map of the area explored

All the monkeys were found in the area classified as “potential release area”, which were defined as suitable for the monkey establishment. Only Nicky’s troop was found using a “potential corridor” area in his home range.

All the monkeys were found in the area they were released, except Bonnie, who moved from Fireburn Reserve to Kakantulix Archaeological Reserve.

The analysis of the area explored for new release sites was used for the releases of 2015 (Appendix VII).

3.2.2 HOME RANGE USES AND SIZE OF THE RELEASED MONKEYS

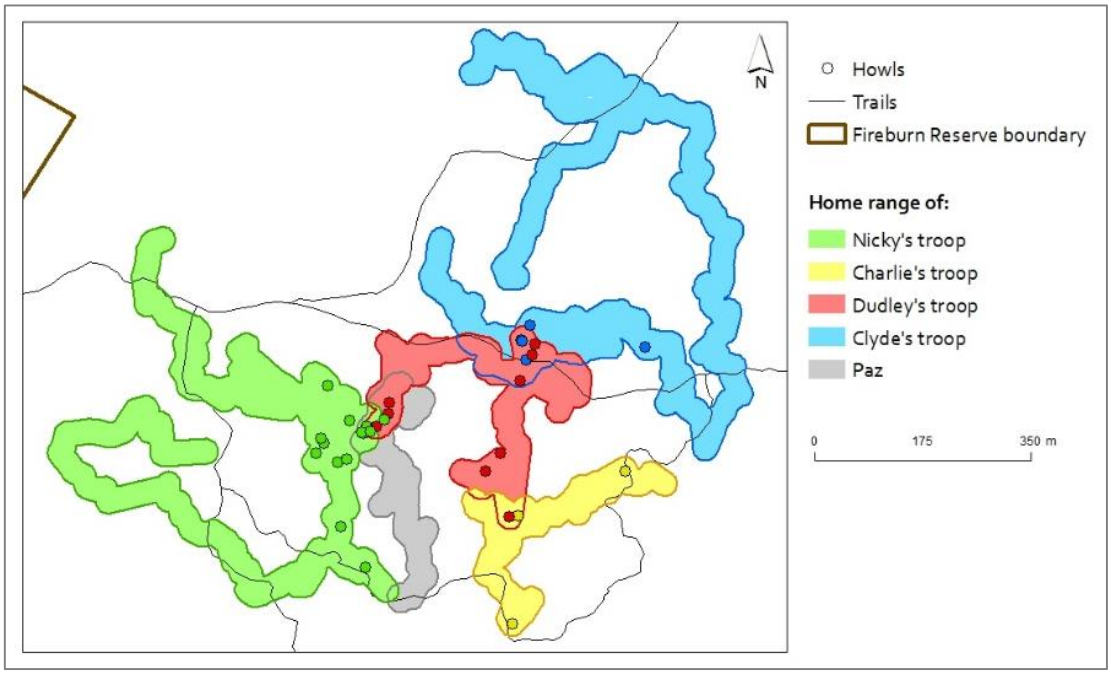


Figure 5: Home ranges and howls at Fireburn Reserve

This study was possible only on the troops and individuals that have been successfully tracked for a minimum of three days. Therefore, only the monkeys found at Fireburn Reserve were studied here.

Table 7: Home range size and overlaps

	Home range (ha)	Overlap (%)
Nicky's troop	9.7	3.0
Charlie's troop	3.0	8.6
Dudley's troop	4.5	37.4
Clyde's troop	11.6	8.0
Paz	2.6	36.1

In the Fireburn Reserve, the size of the home ranges of the troops found, using digitized polygons (Appendix V), ranged from 2.6 ha to 11.6 ha (Table 6), with an average of 6.3 ha. Each home range overlapped with other troops' home range. The average of the overlap was 18.6% and range from 3.0% to 37.4%.

At Fireburn Reserve, all the troops were recorded howling at another troop during this study, except for the individual Paz. The howls appeared to occur at the border of their home range and mostly at the proximity between two troops' territories (Figure 7). Non-aggressive chasing was seen between Dudley and Clyde for the use of a *Ficus* tree (see Fig tree on Figure 6).

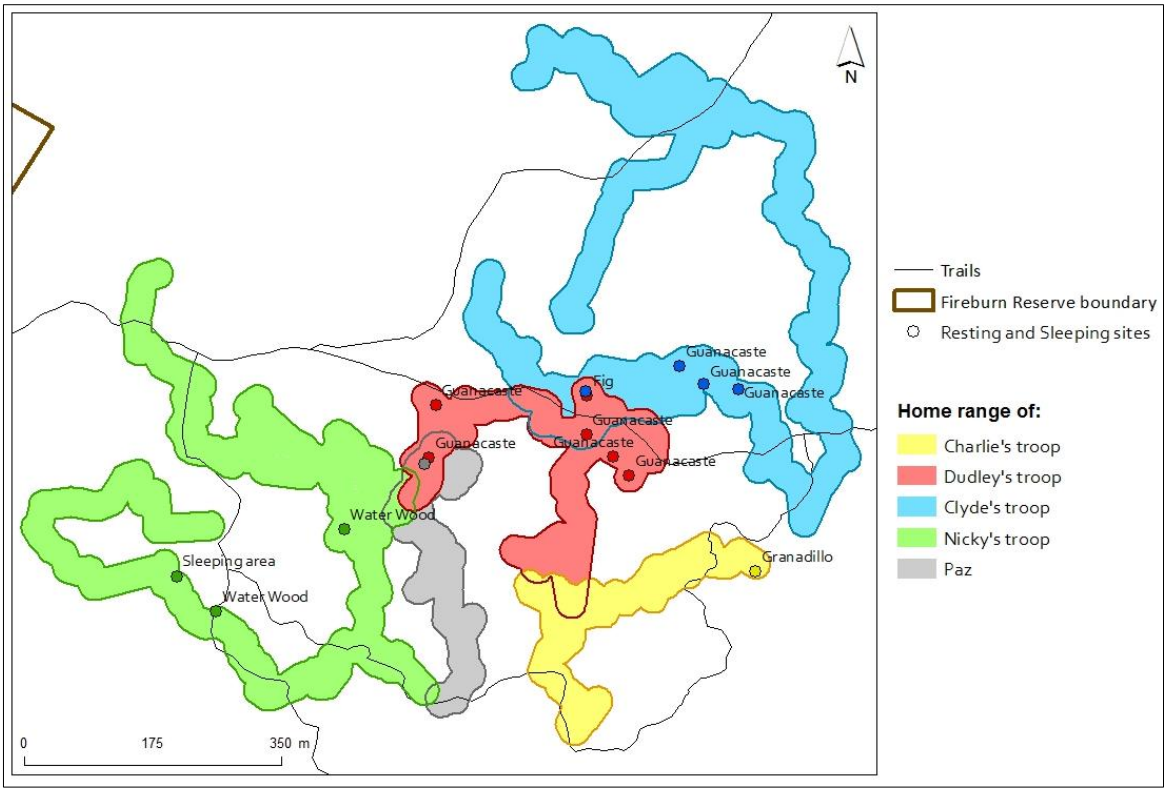


Figure 6: Map of the sleeping and resting sites

After the regular tracking of each troop and individual to find their home range establishment, the monkeys were found again several times in particular areas, sleeping and resting (Appendix IV). It appeared that the monkeys preferred the biggest trees on their home range. These trees and particular sites have been mapped in Figure 8. Paz and Dudley's troop were found using the same Guanacaste tree when the other one was absent. The same way, Clyde and Dudley shared the same Fig tree.

3.3 FEEDING STUDY OF THE RELEASED HOWLER MONKEYS

A total of 32 species and 14 families have been identified as feeding plants during this study (Table 6).

Table 8: List of the feeding plants identified

Family	*Genus*	*Species*	Common name	Type	Part eaten	Location
Anacardiaceae	*Metopium*	*brownei*	Black poisonwood	tree	FR	FBR
	Spondia	*radlkoferi*	Hogplum	tree	ML, FR, YL	FBR, K
Araceae	*Philodendron*	*radiatum*	Philodendron	epiphyte	YL, ML, PE	FBR, K
	Philodendron	*sp.*		epiphyte	ML	FBR, K
	Syngonium	*sp.*		epiphyte	ML	FBR, K
Burseraceae	*Bursera*	*simaruba*	Gumbalimbo	tree	YL	FBR, K
	Protium	*copal*	Copal	tree	ML, YL, FR	FBR, K
Cecropiaceae	*Cecropia*	*peltata*	Cecropia	tree	PE, ML, YL, FR	FBR, K
Fabaceae	*Enterolobium*	*cyclocarpum*	Guanacaste	tree	YL, ML	FBR, K
	Leucaena	*leucocephala*	Waterwood	tree	YL, ML	FBR, K
	Lonchocarpus	*sp.*		tree	ML	FBR
	Lysiloma	*latisiliquum*	Salam	tree	YL	FBR, K
	Swartzia	*cubensis*	Catalox	tree	YL	K
	Platymiscium	*dimorphandrum*	Granadillo	tree	YL	FBR
Loganiaceae	*Strychnos*	*sp.*	Chicoloro	vine	FR	FBR
Moraceae	*Brosimum*	*alicastrum*	Ramon	tree	YL, ML	FBR, K
	Ficus	*sp.*	Fig	tree	YL, ML, FR	FBR, K
	Trophis	*racemosa*	Red ramon	tree	FR, ML	FBR, K
	Trophis	*sp.*		tree	ML	FBR, K
Sapindaceae	*Cupania*	*belizensis*	Grande Betty	tree	ML, FR	FBR
	Matayba	*apelata*	Boy job	tree	ML	FBR
	Serjania	*sp.*		vine	ML	FBR
	Talisia	*oliviformis*	Wild wia (Guaya)	tree	FR	FBR
Sapotaceae	*Manilkara*	*zapota*	Sapote	tree	FR	FBR
	Pouteria	*reticulata*	Black maya	tree	FR	K
	Sideroxylon	*sp.*		tree	FR	K
Simaroubaceae	*Simarouba*	*glauca*	Negrito	tree	FR	FBR
Smilacaceae	*Smilax*	*sp.*		vine	FR, ML	FBR
Sterculiaceae	*Guazuma*	*ulmifolia*	Pixoy	tree	YL	FBR, K
Verbenaceae	*Petrea*	*volubilis*		vine	ML, FL	FBR
	Vitex	*gaumeri*	Yaxnik	tree	YL	FBR, K
Vitaceae	*Vitis*	*tiliifolia*	Water vine	vine	ML, YL	FBR, K

FBR= Fireburn Reserve, K= Kakantulix Archaeological Reserve*, ML= Mature Leaf, YL= Young Leaf, FR= Fruit, PE= Petiol*

From March to July 2015, a total of 162 records have been collected for browses, where 102 were identified as snacking behavior and 60 as feeding behavior. Regarding the number of records on each species for snacking, feeding and the total of records, the five favourite browses used by the howlers at Fireburn Reserve were the same: *Cecropia peltata*, *Ficus sp.*, *Protium copal*, *Leucaena leucocephala* and *Vitis tiliifolia* (Table 7).

Table 9: List of the browses eaten by the released monkeys

Family	*Genus*	*Species*	Common name	% Snack	% Feed	% Total
Anacardiaceae	*Spondia*	*radlkoferi*	Hogplum	5	5	10
Burseraceae	*Bursera*	*simaruba*	Gumbalimbo	2	2	4
	Protium	*copal*	Copal	6	10	16
Cecropiaceae	*Cecropia*	*peltata*	Cecropia	10	28	38
Fabaceae	*Enterolobium*	*cyclocarpum*	Guanacaste	2	2	4
	Leucaena	*leucocephala*	Waterwood	9	10	19
	Lonchocarpus	*sp.*		1	2	3
	Lysiloma	*latisiliquum*	Salam	4	2	6
	Platymiscium	*dimorphandrum*	Granadillo	1	2	3
Moraceae	*Brosimum*	*alicastrum*	Ramon	4	5	9
	Ficus	*sp.*	Fig	10	10	20
	Trophis	*sp.*		1		1
Sapindaceae	*Cupania*	*belizensis*	Grande Betty	3	2	5
	Matayba	*apelata*	Boy job		2	2
Sterculiaceae	*Guazuma*	*ulmifolia*	Pixoy	3	2	5
Verbenaceae	*Vitex*	*gaumeri*	Yaxnik	5	2	7
Sapindaceae	*Serjania*	*sp.*			3	3
Smilacaceae	*Smilax*	*sp.*		1		1
Verbenaceae	*Petrea*	*volubilis*		3		3
Vitaceae	*Vitis*	*tiliifolia*	Water vine	11	7	17
Araceae	*Philodendron*	*radiatum*	Philodendron	1		1
	Philodendron	*sp.*		0	2	2
	Syngonium	*sp.*		2		2
			Out of sigh	18	5	23
			Total	100	100	200

Fruit and flower consumption has been recorded from March to August 2015 (Table 8). During this period, the monkeys used fruits from at least three different species each month. This showed monthly overlaps in plant species used for fruit during that period at Fireburn Reserve.

Table 10: List of the fruits and flowers used each month of the feeding study by the released monkeys

		Family	*Genus*	*Species*	Common name	March	April	May	June	July	August
FRUIT	Tree	**Anacardiaceae**	*Metopium*	*brownei*	Black poisonwood					X	
			Spondia	*radlkoferi*	Hogplum				X	X	
		Burseraceae	*Protium*	*copal*	Copal			X			
		Cecropiaceae	*Cecropia*	*peltata*	Cecropia				X	X	X
		Moraceae	*Ficus*	*sp.*	Fig				X	X	
			Trophis	*racemosa*	Red ramon		X	X			
		Sapindaceae	*Cupania*	*belizensis*	Grande Betty			X			
			Talisia	*oliviformis*	Wild wia			X			
		Sapotaceae	*Manilkara*	*zapota*	Sapote	X	X				
			Pouteria	*reticulata*	black maya					X	X
			Sideroxylon	*sp.*							X
		Simaroubaceae	*Simarouba*	*glauca*	Negrito	X	X				
	Vine	**Loganiaceae**	*Strychnos*	*sp.*	Chicoloro	X					
		Smilacaceae	*Smilax*	*sp.*		X	X				
FLOWER	Tree	**Verbenaceae**	*Vitex*	*gaumeri*	Yaxnik		X				
	Vine	**Verbenaceae**	*Petrea*	*volubilis*		X	X	X			
					Number of species used each month	5	6	5	3	4	3

3.4 EVALUATION OF THE RELEASES

3.4.1 SURVIVAL AND STATUS OF THE RELEASED HOWLER MONKEYS

Table 11: Success and failure of the releases

	Total	%
Individuals found	21	75
Individuals not found	6	21
Individuals dead	1	4

During this study, six monkeys were not found, and one was recorded dead in 2014: the skeleton of the Tower Hill female B was found two months after release at the release site (Appendix XI).

75% of the released monkeys were found during the project (Table 9). 87.5% of the translocated monkeys and 70% of the rehabilitated ones were found. Table 10 gathered together the results from the monkey status study (Appendix VIII). All the monkeys found showed good fur and weight condition. 34% of the monkeys found showed reproducing capacities. 23% of them were successful as three infants were found from three different females and two different males. Another male successfully copulated with two females newly released in 2015, and another male showed an unsuccessful copulation with another female.

71% of the monkeys found belonged to a troop, and 76% of them had an established home range.

14% of the monkeys showed a positive response to people and were seen on the ground. These monkeys were from the same troop: Dudley's troop. This troop was seen on the ground on April 19th, to feed on Piper, and on May 13th to play on the ground and to interact with people. The two infants in the troops showed no fear but curiosity towards people.

Table 12: Evaluation table of the status of the released howler monkeys and of their reintroduction

Evaluation criteria	Total	%
Healthy	21	100
Reproduction: infant	5	24
Reproduction: mating behavior	2	10
Seen on the ground	3	14
Seen attracted to people	3	14
Troop cohesion	15	71
Established home range	16	76

Table 11 showed the results of the enquiry about the individuals not found. Holly was not found after release and Sultan and Kofi were identified at medium risk after release.

Table 13: Risk assessment of the individuals not found

Individuals not found	Lastly seen	Risk assessment
Agatha	Seen with Clyde in late 2012	L
Holly	Left the troop after release	L
Igor	Seen with Dudley in 2014	L
Eden	Seen with Dudley in 2014	L
Sultan	Seen alone in 2014	M
Kofi	Seen with Paz in August 2014	M

3.4.2 INFLUENCE OF DIFFERENT FACTORS ON SURVIVAL

The model failed to calculate the significance of the coefficients (Appendix I) because the number of data was too small. Therefore, a graphic analysis of the significant effects (Source and Released) was done to analyse their meaning (Figure 7).

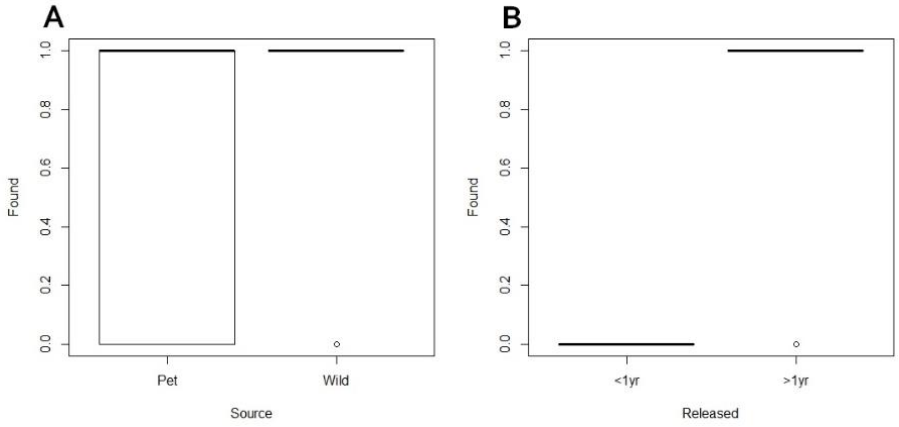


Figure 7: Graphics of the influence of Source (A) and Released (B) on the survival

If the individual was seen in the wild <1 year after release, the individual won't be found later

If the individual was seen in the wild >1 year after release, the individual will be found in most cases (only not found for one individual).

If the individual is a pet, it may be found in most cases but it is not significant

If the individual is wild, it will be found in most cases (only not found for an individual).

4 DISCUSSION

4.1 ANALYSIS OF THE RESULTS

4.1.1 DEMOGRAPHIC CHARACTERISTICS

The population density was similar to the ones found in previous studies on *Alouatta pigra* for troops of around 7.1 individuals (Van Belle & Estrada, 2006,; Pozo-Montuy et al., 2008,; Estrada et al., 2004). Nevertheless, this density was for troops which had a mean troop size at 3 whereas in the wild, the mean troop size for *Alouatta pigra* varies from 5.9 to 8.7 individuals (Fortes et al., 2015,; Estrada et al., 2004). The population studied just started reproducing as they reach sexual maturity (Appendix XII). The population density at Kakantulix Archaeological Reserve will increase due to the future releases and births. In 2015, 10 new howler monkeys were released in the area and may interact with the monkeys studied in this project (as seen already with the Barton Creek male who joined one of the newly released troops in July 10th).

The age at first birth was recorded around 3.5 years old in *Alouatta paliatta* (Glander. 1980) and 4-5 years for *Alouatta caraya* (Rumiz, 1990). The ages found in this study corresponded to the ones recorded for *A. caraya*. Sexual maturity was estimated to be 3 years old for the females and 3.5 years old for males in a study done on *A. palliata* (Glander. 1980). The individual Charlie was found to be sexually mature before 3.5 years old. This could be explained by the difficulties that occurred for the estimation of ages at intake (developmental retardation by malnutrition). His estimated age was his minimum age. His real age at intake could have been up to 3 years old.

4.1.2 TROOP COHESION AFTER RELEASE

In primates, social interactions in troops are important for survival. Foraging, climbing and territory defense skills for example are learnt in wild populations by living within a troop in the wild. Therefore, monkeys raised in captivity or rehabilitated monkeys don't acquire the same level of competences (Russon, 2009). Troop cohesion is important for the survival of the monkeys after release (Guy et al., 2014). The rehabilitation programme at the Primate Rehabilitation Centre ensures the formation of bounded troops before release (Appendix III).

The troops' composition observed during this project was stable. All of the troops of rehabilitated monkeys found in the wild still consisted of individuals from the same released troops, except for Paz who was found alone, and Clyde's troop: Clyde, Mia and Livvy. The

constitution of Clyde's troop could be explained by the fact that the females released with Clyde and the male released with Livvy were missing. Mia was a wild monkey, and it has been reported that she wasn't bonded strongly with her released troop. This female probably joined Clyde when he was an individual. Then Clyde was seen chasing the male, Sultan, released with Livvy to catch her not long after their release. These results showed that releasing new monkeys in inhabited areas may influence troop composition. Nevertheless, shifts between individuals from different troops exist in the wild (Ostro et al., 2001) and some of the new born monkeys will join other troops or create new troops in the future (Glander, 1980).

The releases at Kakantulix Archaeological Reserve only started in March 2014, and new releases of troops occurred in 2015. It has been shown during this project that the composition of the troops in this area was still not stable except for the Tower Hill monkeys. This could be explained by the releases of individuals in 2014, instead of bounded troops. Since translocated monkeys don't need rehabilitation as they already know how to survive in the wild, individuals were released by the Primate Rehabilitation Centre at Kakantulix Archaeological Reserve. These individuals may try to establish a troop with the monkeys released in the area and this could explain the relative instability in the troops' composition. Other troop composition changes will likely happen in the future with the new releases and the recolonization of the release area.

Because of these changes, the ongoing release of rehabilitated and translocated monkeys, and the fact that monkey faces change through growth up, the *Identification key of Yucatan black howler monkeys* (Appendix XIV) of the Primate Rehabilitation Centre of Belize will have to be updated, and the new howlers will have to be added to the key.

4.1.3 NEW RELEASE LOCATION

The biggest areas most suitable for new release locations found in this study were inhabited by released howlers. To find release sites, it is important to check that the location chosen is far enough from established troops. A study about translocation of howler monkeys showed that releasing the troops in uninhabited areas or over 1 km from other troops reduced stress and maintained troop cohesion (Horwich et al., 2002). Moreover, new releases should be done in unsaturated habitat (Kleiman et al., 1994) to not jeopardize the established population.

Unless additional areas of prime habitat are found, new releases shouldn't be done in the Fireburn Reserve due to the highest population density found to date, that will grow in the future because of reproduction. The reproduction of the released howlers has successfully started at Fireburn Reserve. Moreover, there may no longer be free suitable habitat for safe releases in the Reserve. The releases done in 2014 in the area already led to fights between the newly released monkeys and previously released troops.

The population density at Kakantulix Archaeological Reserve was still low enough to allow new releases in 2015 in the area, and the release sites were chosen to be as far as possible

from established troops (Tower Hill monkeys), from wild individuals located at the moment, and from the other released troops (Appendix VII).

New areas around Kakantulix Archaeological Reserve and Fireburn Reserve should be searched for future releases due to the lack of free space in prime habitat which will occur in the future with the establishment of the troops and the growth of the population.

The mapping of the area explored showed that the potential release sites found were connected by potential corridors, allowing the migration of individuals from one site to another.

4.1.4 HOME RANGE CHARACTERISTICS AND USES

The establishment of the territories depends on the availability of food resources (Ostro et al., 2000). The feeding species identified have been found in both Fireburn Reserve and Kakantulix Archaeological Reserve. At Fireburn Reserve, the territories of the monkeys were established. At Kakantulix Archaeological Reserve, as previously seen, the individuals were still switching troops and so they had not established a home range yet. Therefore, the home range study only occurred at Fireburn Reserve with rehabilitated monkeys. A study on *Alouatta pigra* showed that troops recently translocated generally establish their home range six months after release, and that they keep exploring the area one year after release (Ostro et al., 1999a). Therefore, in this study it has been shown that the establishment of home range can take more than one year after release.

An assessment on *Alouatta pigra* surveys showed that the home range size average for the species was 9.2 (+-6.4) ha, which was higher than the average found during this project. The size of home range is negatively correlated with the food abundance and population density (Fortes et al., 2015). The population density found at Fireburn Reserve was higher than the average for the species (see part 4.1.1), and could explain this result. With the identification of the feeding species, further studies could be done to evaluate if the home range size variability found in this project between troops could also be correlated with food abundance.

Overlap between territories is common in howler monkeys and can reach 30% +/-22% (Fortes et al., 2015). These connections between territories allow reproduction between individuals from different troops. This has been reported in *Alouatta pigra* despite the presence of territory defense (Horwich, 1983a). Infidelity between individuals from different troops and the migration of growing adults would allow maintenance of genetic diversity within a population.

In howler monkeys, territory defense is done with dissuasive howls to inform the opponents of the number of adult males in the troop and to avoid energetically expensive chasing and fights (Chiarello, 1995). The strategy has proven efficient at Fireburn Reserve, as no fights were recorded during the project, but it could also be because there were only a few fully mature males in the area. Fights are expected in the future when the male infants will reach maturity.

The study of the sleeping and resting sites confirms the idea that howler monkeys have preferred sleeping sites (Chivers, 1969,; Jardim, 1997). The identification of the key trees and sleeping sites for the released howlers will help the future research projects to find the troops.

4.1.5 FEEDING CAPACITY OF THE RELEASE SITES

An assessment on the diet of *Alouatta pigra* showed that this species consumes an average of 23 (2 to 74) species and 10.6 (1 to 21) families (Dias & Rangel-Negrin, 2015). The results found during this assessment were higher than this average. This showed that the released monkeys successfully forage in their new environment, and that the release sites provide enough diversity of plant species for feeding to ensure their survival.

Alouatta pigra has been described as frugivorous as possible and as folivorous as necessary (Silver et al., 1998). The intermonth overlaps found from March to August for the plants used for fruits showed that at Fireburn Reserve, the areas used by the monkeys allow them to feed on fruits constantly during that period.

Four of the five favourite browse species have been used to date at the rehabilitation centre (Appendix IX). The last one, *Vitis tiliifolia,* can't be grown on a sufficient scale at the Primate Rehabilitation Centre. Three plants used as browse at the Primate Rehabilitation Centre do not occur at the release site. Moreover, Dudley's troop was seen on the ground to feed on Piper, shrub (< 2m), used at the rehabilitation center. This study supports the efforts at the Rehabilitation Centre to place more focus on the production of local browse species, and to reduce, or avoid, use of Piper – so as to decrease the risk of monkeys descending to or near the ground.

4.1.6 EVALUATION OF THE STATUS AND THE REINTRODUCTION OF THE RELEASED MONKEYS

All the translocated monkeys, except one whose the skeleton was found, were still alive one year after release. The long-term survival of the rehabilitated monkeys was at least 70%, because 30% of the monkeys haven't been found - but absence of sightings to date does not indicate death: the individuals may simply have moved into areas not yet surveyed. As Holly has not been seen for four years and as Sultan and Kofi are assessed as at medium risk, these three individuals are at risk of being dead. Nevertheless, this study showed that released monkeys can move far from their release site. Indeed, Bonnie disappeared 8 months after release, was expected to be dead but was finally found 3.5 years later in 2015 during this project because she had moved to Kakantulix Archaeological Reserve. Fireburn Reserve has shown its capacity to provide food for the survival of the released monkeys (see part 4.1.5) and the Primate Rehabilitation Centre makes sure that the released monkeys have no diseases at release and that they forage properly after release. Therefore one possible reason of the disappearance of the released monkeys is natural death by predation. The presence of Felids, predators of howler monkeys (Cristobal-Azkarate et al., 2015), in the release sites have been demonstrated by camera trapping (Appendix XIII). Therefore, the monkeys not found

could have been killed. Predation can't be avoided and is a cause of failure in reintroduction and translocation projects (Griffin et al., 2000, Cheyne, 2009b).

The sexual maturity for howler monkeys should be approximately 3 years and 3.5 years for females and males, respectively (Glander, 1980). Calculation on the hypothetical age of the released monkeys (Appendix XII) informed that 95% of the monkeys found should be sexually mature. Three wild-born infants were observed during this study. Some other individuals may have been reproducing successfully already but infants were not found. Moreover, it is possible that other infants have been born but not survived. Infant mortality in the genus *Alouatta* is reported to be 21-35% and infanticide is the most easily identified cause of death (Pavé et al., 2012,; Knopff et al., 2004). Nevertheless, as no fights have been noticed at Fireburn Reserve, infanticidal attacks are unlikely at this stage of re-colonization. The dropping of the infants might be more likely to happen, as rehabilitated monkeys never had older females around them to learn how to take care of an infant. Furthermore, the survival of the infant can be improved by maternal watchfulness for predation (Treves et al., 2003), but this skill may be not present for the rehabilitated monkeys that may not know how to detect predators as effectively as their fully wild counterparts.

A protocol should be set up for Dudley's troop as they were seen on the ground and were attracted to people. Methods to scare the troop from people should be set up, and awareness of the Fireburn Community must be dispensed to ensure its success.

4.1.7 FACTORS INFLUENCING SURVIVAL

None of the factors inherent to the rehabilitation process had an influence on survival. Only the time seen in the wild after release and the source of the individual seemed to have an influence.

If the individual has not been seen one year after release, there would be a 100% chance not to find it in future researches. Otherwise, there would be a good chance that the individual will be found. If the individual is wild, it would be more likely to be found. The source Pet does not significantly influence the probability of being found or not.

4.2 LIMITS OF THE PROJECT

Research undertaken by the Primate Rehabilitation Center (Linton, 2013,; Feeney, 2011,; Denton, 2012) have focused primarily on initial home range establishment, food resource use, and the primary drivers of initial home range development. As the main goal of this project was to find as many monkeys as possible, priority was given to the exploration section of the methods. Therefore, the time spent tracking each troop and individuals would need to be increased to have more relevant data on the longer-term home range and feeding studies.

The home range use of howler monkeys depends on food availability and varies monthly. Therefore they don't use all their home range at the same time of the year (Ostro et al., 1999). Moreover, Ostro et al. (1999) showed that released monkeys keep exploring their release site

one year after release to establish their home range. Therefore, the home range study would need to be done over a longer period to have better knowledge of their home range throughout the year. Also the latest released monkeys might change their home range location in the future.

For the same reason, the feeding study would need to be done for at least one year, to evaluate the variation of food availability and uses by month. The knowledge of the fruits used by howlers for over one year would help to find good release locations as they need to provide food resources through all the seasons (Baker, 2002). The record of the fruit species used each month could determine whether the area allows monthly overlap in plant species used for fruit.

Samples of plants couldn't be collected during this study to identify more precisely some of the feeding plants. Collection would be suggested during further research.

No scientific evidence has shown that the pink pigmentation on the rear of *Alouatta pigra* doesn't change during growth, although file photos demonstrate that any changes are small. A study using photography should be done with the infants at the Primate Rehabilitation Centre to see the evolution of their shape through the different stages of the rehabilitation process.

The translocated monkeys couldn't be tracked for three consecutive days, due to difficulties to find them in an area with low density (4.2 indiv/km²), and their response to our presence. Tracking them upset the troops and the next day, the monkeys couldn't be found in the area we left them in the previous evening. This could be also due to the fact that the translocated monkeys didn't have an established home range yet, and didn't have favourite locations that would have allowed to locate them more easily.

The survival study needs to be done with more individuals. Only 28 monkeys were studied in this project which didn't provide enough data to estimate properly the influence of the studied factors on the survival. New significant effects could appear in the future if the analysis was done with the new released monkeys.

5 CONCLUSION

The goal of this project was to conduct an assessment of the status and the reintroduction of released howler monkeys to evaluate the re-establishment of a population in an area where the species had disappeared. This has been accomplished by evaluating survival, reproduction, home range establishment, troop cohesion, response to people, presence on the ground and health condition, and by studying their home range uses and the feed species present at the release sites.

In 2015, 75% of the released monkeys were found healthy, identified and located thanks to this study – demonstrating a high level of long-term survival. In other projects that assess the releases of rehabilitated monkeys, survival reached only a maximum of 40% after 12 months

(Guy et al., 2015). For the survival criteria, we can conclude that the releases evaluated in this project were successful.

It was found that only one troop of released monkeys will need future intervention from the Primate Rehabilitation Centre to ensure that it avoids the ground and doesn't interact with people. This assessment has helped to show that in 2015, 76% of the released monkeys have established a home range, and 71% have stable troops. Rehabilitated monkeys were able to defend their territory and to forage as wild monkeys. Moreover, 24% of the population has started reproducing successfully and 32 species of feeding plants have been identified in the release location. The information collected on the feeding species in the release areas will help to locate new release sites, especially with the use of the five favourite browses found to define an area suitable for releases in terms of food presence.

A skeleton was found prior to this study and was the only proof of death found for one of the missing released monkeys. The difficulties of finding monkeys in the canopy, their potential migration to other areas and predation were the most likely explanations for the other disappearances. Training to avoid predation is often missing in rehabilitation programs (Guy et al., 2013) and leads to the failure of reintroduction (Griffin et al., 2000, Cheyne, 2009b). No predation training is provided at the Primate Rehabilitation Centre (Appendix III) as no suitable and appropriate technique has been identified. Training techniques have been studied but their effectiveness is not certain and they can lead to inappropriate responses (Griffin et al., 2000). This assessment demonstrates than even without predation training, releases can be successful.

This project has shown that howler monkeys seem to have favourite trees in their home range. As only few studies have quantitatively analyzed the spatial distribution of sleeping sites for howler monkeys (Fortes et al., 2015). This report could be a baseline to start an analysis with the re-established population studied, as it has been done on Spider monkeys (Gonzalez-Zamora et al., 2012,; Chapman, 1989).

The study of survival showed that the source of the monkey (pet or wild) and the time seen in the wild after release during the post release monitoring (more or less than 1 year) are two factors that influence survival. This showed the importance of doing post-release monitoring for more than 1 year to predict the survival of the released monkeys.

With the goal of reintroduction being the re-establishment of a viable and self-sustainable population, the evaluation should be done at least until the successful reproduction of the offspring of the release generation occurs (Seddon, 1999). The released population reached sexual maturity. Therefore, further assessment should be done to evaluate the reintroduction success of the re-established population by evaluating reproduction rates (King et al., 2012). Gibbon reintroduction projects have only released troops which are copulating (Cheyne,

2009a,; Osterberg et al., 2015). This approach could be applied at the Primate Rehabilitation Centre to improve the successful reproduction of the re-establish population.

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Appendices



Photography © Fanny Tricone. Wildtracks Belize

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APPENDIX I: GENERALIZED LINEAR MODEL DONE IN R TO STUDY THE SURVIVAL

Table: Table used to do the generalized linear model

Found	Sex	Source	AgeI	AgeR	Rehab	Released	Hum
0	F	Pet	J	J	<1yr	>1yr	M
1	F	Pet	J	J	<1yr	>1yr	M
1	M	Pet	I	J	<1yr	>1yr	M
0	F	Pet	J	J	<1yr	<1yr	L
0	M	Pet	J	J	<1yr	<1yr	H
1	M	Pet	J	J	1-2yrs	>1yr	H
0	F	Pet	J	J	1-2yrs	>1yr	M
0	M	Pet	J	J	1-2yrs	>1yr	M
1	F	Pet	I	J	>2yrs	>1yr	M
1	F	Pet	I	J	>2yrs	>1yr	M
1	M	Pet	I	J	1-2yrs	>1yr	M
1	F	Pet	SA	SA	<1yr	>1yr	L
1	F	Pet	SA	SA	<1yr	>1yr	L
1	F	Pet	J	J	<1yr	>1yr	M
1	F	Pet	J	J	<1yr	>1yr	L
1	M	Pet	J	J	<1yr	>1yr	M
1	F	Wild	A	A	<1yr	>1yr	L
0	M	Pet	I	J	>2yrs	<1yr	H
0	M	Pet	I	J	>2yrs	<1yr	H
1	F	Wild	I	SA	>2yrs	>1yr	H
0	F	Pet	J	A	>2yrs	<1yr	M
0	M	Pet	I	J	1-2yrs	<1yr	M
1	M	Pet	I	J	>2yr	>1yr	M
1	M	Wild	SA	SA	1-2yrs	>1yr	L
1	M	Wild	A	A	1-2yrs	>1yr	L
1	M	Wild	A	A	<1yr	>1yr	L
1	F	Wild	A	A	<1yr	>1yr	L
0	F	Wild	J	J	<1yr	<1yr	L
1	F	Wild	J	J	<1yr	>1yr	M
1	M	Wild	A	A	<1yr	>1yr	L
1	F	Wild	A	A	<1yr	>1yr	L

AgeI= Age at Intake, AgeR= Age at release

Released= Time seen in the wild after release

Hum= Degree of humanisation at release

L=Low, M=Medium, H=High

Rehab= Time spent in rehabilitation

I=Infant, J=Juvenile, SA= Subadult, A=Adult

The Table presents the variables studied in the generalized linear model. The explanatory variables are qualitative variables, represented by categories: Sex, Source, AgeI, AgeR, Rehab, Released, and Hum.

The age classification used was one established for *Alouatta caraya* (Rumiz, 1990):

- Infant: up to 1 year old.
- Juvenile: 1 year to 3 years in females and 1 year to 4 years in males.
- Subadult: 3 to 4-5 years for females and 4 to 5 years for males.
- Adult: females after the first birth, about 4-5 years and males after 5 years.

The variable which needs to be explained is a binomial variable: Found (0 or 1).

This model have been studied in R 3.1.1 with the script presented in Figure 1.

APPENDIX I: GENERALIZED LINEAR MODEL

```
> summary(data)
     Found        Sex     Source   AgeI    AgeR       Rehab    Released  Hum
 Min.   :0.0000   F:17   Pet :21   A : 6   A : 7   <1yr  :17   <1yr: 7   H: 5
 1st Qu.:0.0000   M:14   Wild:10   I : 9   J :20   >2yr  : 1   >1yr:24   L:12
 Median :1.0000                    J :13   SA: 4   >2yrs : 6             M:14
 Mean   :0.6774                    SA: 3           1-2yrs: 7
 3rd Qu.:1.0000
 Max.   :1.0000
> res<-glm(formula=Found~(Sex+Source+AgeI+AgeR+Rehab+Released+Hum)^2,family=binomial(link=logit))
Messages d'avis :
1: glm.fit: l'algorithme n'a pas convergé
2: glm.fit: des probabilités ont été ajustées numériquement à 0 ou 1
> anova(res,test="Chi")
Analysis of Deviance Table

Model: binomial, link: logit

Response: Found

Terms added sequentially (first to last)


               Df Deviance Resid. Df Resid. Dev Pr(>Chi)
NULL                              30      38.99
Sex             1    0.139        29      38.85  0.70901
Source          1    3.728        28      35.12  0.05350 .
AgeI            3    6.433        25      28.68  0.09234 .
AgeR            2    2.068        23      26.62  0.35552
Rehab           3    2.440        20      24.18  0.48617
Released        1   16.905        19       7.27 3.93e-05 ***
Hum             2    3.452        17       3.82  0.17798
Sex:Source      1    0.000        16       3.82  0.99997
Sex:AgeI        2    0.000        14       3.82  1.00000
Sex:AgeR        0    0.000        14       3.82
Sex:Rehab       1    0.000        13       3.82  0.99997
Sex:Released    1    0.000        12       3.82  0.99998
Sex:Hum         0    0.000        12       3.82
Source:AgeI     0    0.000        12       3.82
Source:AgeR     0    0.000        12       3.82
Source:Rehab    1    0.000        11       3.82  0.99996
Source:Released 1    0.000        10       3.82  0.99998
Source:Hum      0    0.000        10       3.82
AgeI:AgeR       0    0.000        10       3.82
AgeI:Rehab      3    0.000         7     504.61  1.00000
AgeI:Released  -1  288.349         8     216.26
AgeI:Hum        0    0.000         8     216.26
AgeR:Rehab      0    0.000         8     216.26
AgeR:Released   0    0.000         8     216.26
AgeR:Hum        0    0.000         8     216.26
Rehab:Released  0    0.000         8     216.26
Rehab:Hum       0    0.000         8     216.26
Released:Hum    0    0.000         8     216.26
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Il y a eu 30 avis (utilisez warnings() pour les visionner)
> # After subsequent removal of non-significant interactions, and then of non-significant effects #
> res<-glm(formula=Found~Source+Released,family=binomial(link=logit))
Message d'avis :
glm.fit: des probabilités ont été ajustées numériquement à 0 ou 1
> anova(res,test="Chi")
Analysis of Deviance Table

Model: binomial, link: logit

Response: Found

Terms added sequentially (first to last)


         Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                      30     38.986
Source    1   3.8018        29     35.184    0.0512 .
Released  1  20.1717        28     15.012 7.079e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 1: Script of the generalized model analysis in R

The model failed to calculate the significance of all the coefficients (Pr(>Chi) in Figure 1) because the number of data was too small. Therefore, a graphic analysis of the significant effects (Source and Released) was done to analyse their meaning (Figure 2), using the functions plot(Found~Source) and plot(Found~Released).

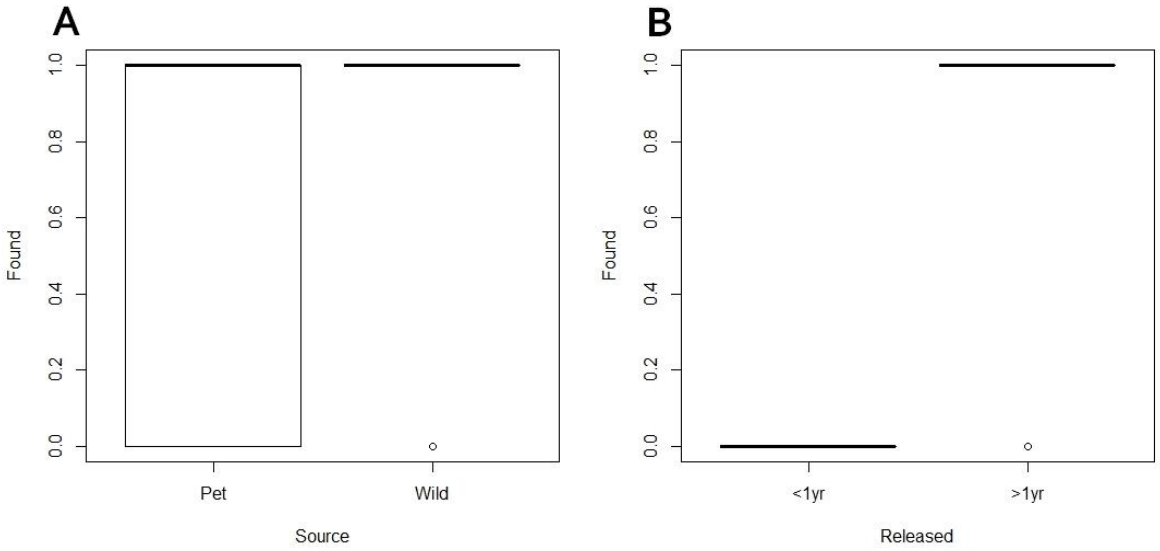


Figure 2: Graphics of the influence of Source (A) and Released (B) on the survival

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APPENDIX II: CRITERIA FOR REINTRODUCTION AT THE PRIMATE REHABILITATION CENTER OF BELIZE

Table: Analysis of the criteria for reintroduction for the Primate Rehabilitation Centre of Belize

Criteria for reintroduction	Primate Rehabilitation Centre	Notes
Condition of species		
Need to augment wild population	Yes	*Endangered species, re-establishing a sub population in the former range*
Available stock	Yes	*Confiscation from the pet trade*
No jeopardy to wild population	Yes	*No wild population at the release site*
Environmental conditions		
Causes of decline removed	Yes	*No more hunting*
Sufficient protected habitat	Yes	*Protected Area*
Unsaturated habitat	Yes	
Biopolitical conditions		
No negative impact for locals	Yes	
Community support exists	Yes	*Fireburn Reserve in parternship with the Fireburn community*
GOs/NGOs supportive/involved	Yes	*Wildtracks, government forest department*
Conformity with all laws/regulations	Yes	
Biological and other resources		
Reintroduction technology known/in development	Yes	
Knowledge of species' biology	Yes	
Sufficient resources exist for programme	Yes	
Recommended reintroduction/translocation?	Yes	*Second translocated program in Belize*

Source of the Table: *Kleiman D. G., Stanley Price M. R. and Beck B. B. (1994). Criteria for reintroduction. In: Creative Conservation: interactive management of wild and captive animals. Olney, P. J. S., Mace, G. M. and Feistner, A. T. C., eds., London: Chapman and Hall, pp.287-303.*

APPENDIX III: ASSESSMENT OF THE REHABILITATION PROGRAM DONE AT THE PRIMATE REHABILITATION CENTER OF BELIZE

Table: Analysis of the different stage of rehabilitation done by The Primate Rehabilitation Centre of Belize

Stage of rehabilitation	Primate rehabilitation Center
Arrival	
History collection	X
Quarantine	X
Medical assessment	X
Behavioural assessment	X
Genetics	X
Group formation	
Behaviour	X
Compatibility	X
Wild group size and composition	X
Training and preparation	
Assess release suitability	X
Conspecific re-socialisation	X
Limit human contact	X
Predator awareness training	
Natural food	
Natural enclosures	X
Environmental enrichment	X
Pre-release assessment	
Release site	X
Observe behavior and identify problems	X
Health/disease screening	
Pre-release	
Acclimatisation to the release site	X
Natural food in the pre-release enclosure	
Food provided in a way to develop foraging skills	
Further limit human contact	X
Release	
Soft release	X
Transport plan	X
Post-release	
Long term monitoring (>1 Xear)	X
Periodic assessment of success criteria	

Source of the table: *Guy A. J., Curnoe D. and Banks B. (2014). Welfare based primate rehabilitation as a potential conservation strategy: does it measure up? Primates, 55, pp.139–147.*

APPENDIX IV: MAP OF THE RESTING AND SLEEPING AREAS RECORDED AT FIREBURN RESERVE

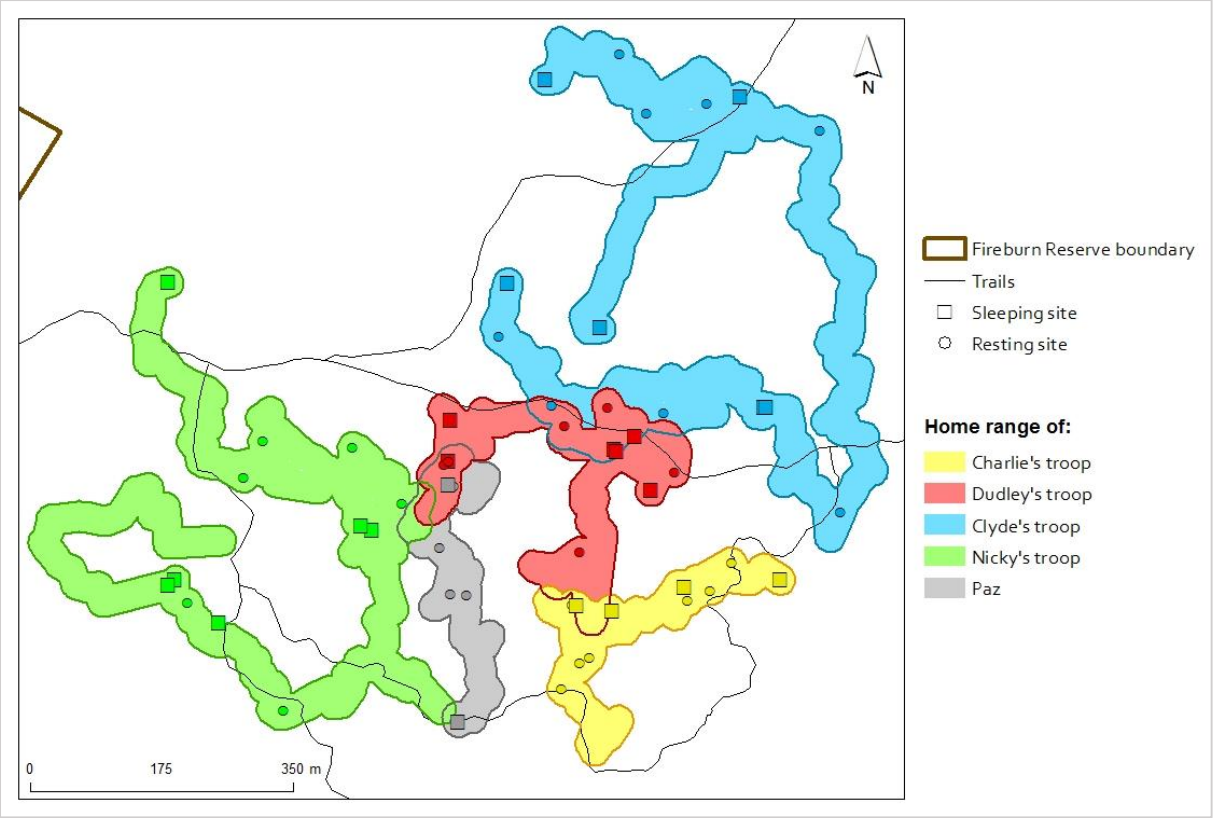


Figure: Map of the resting and sleeping areas

This map shows all the resting and sleeping sites recorded while tracking the monkeys at Fireburn Reserve.

APPENDIX V: DIGITIZED POLYGON METHOD

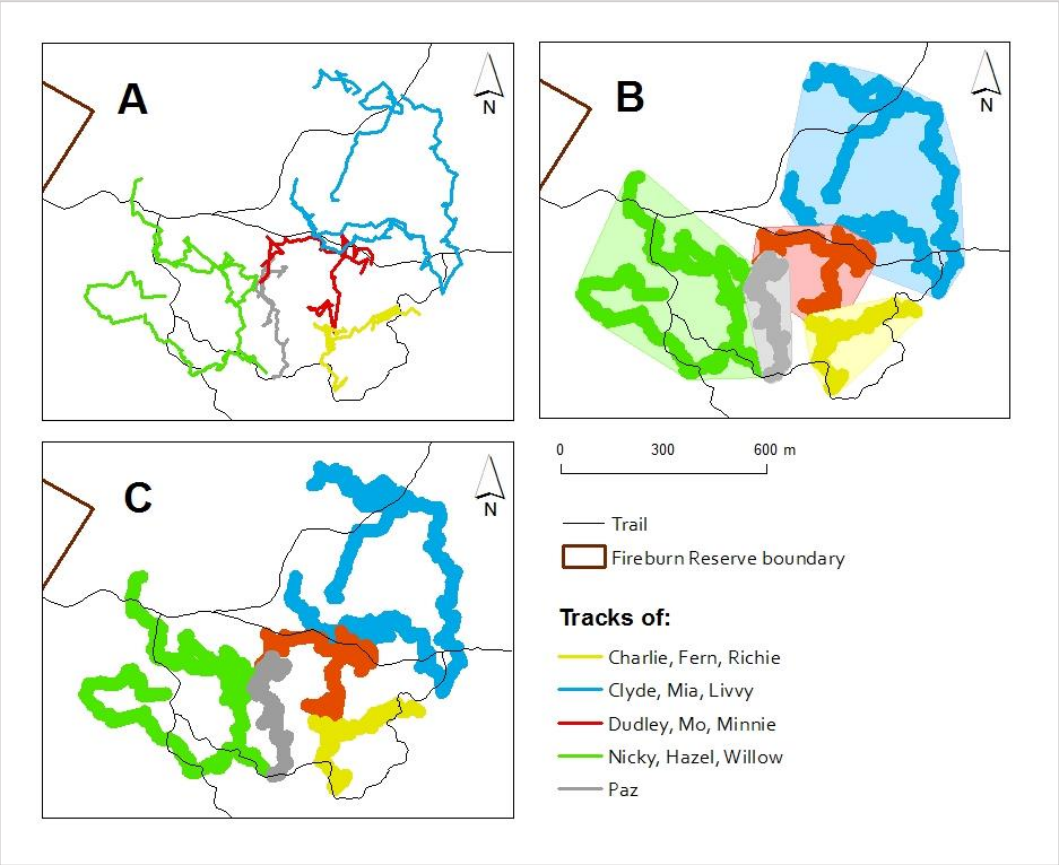


Figure: Maps of the creation of digitized polygons

The Figure shows the different steps for the creation of home ranges using digitized polygons:

- Figure 1A shows all day-range paths.
- Figure 1B, all day-range paths have been widened to 20 m, and a minimum convex polygon placed over the resulting polygon.
- Figure 1C shows the digitized polygon after lacunae of <l% of the minimum convex polygon have been incorporated into the polygon.

Bibliography:

Ostro L. E. T., Young T. P., Silver S. C., Koontz F. W. (1999). A Geographic Information System Method for Estimating Home Range Size. The Journal of Wildlife Management, Vol. 63, No. 2. (Apr., 1999), pp. 748-755.

APPENDIX VI: MAPS OF THE VEGETATION AT FIREBURN RESERVE

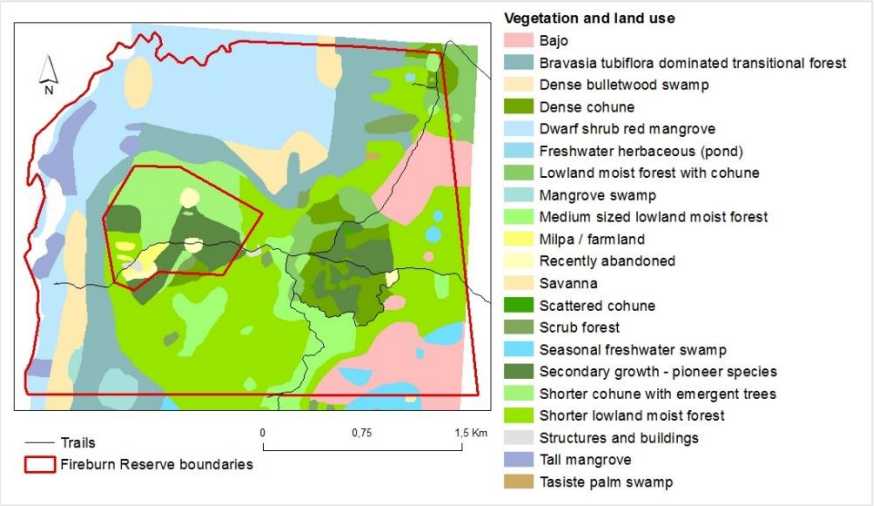


Figure 1: Map of the vegetation and land use established by L. Maskell in 2000

A map of the vegetation and land use at Fireburn Reserve has been studied by M. Flanigliulo in 2005 (Figure 1). Her study kept five of the vegetation types as suitable for the release of the howler monkeys (Figure 2).

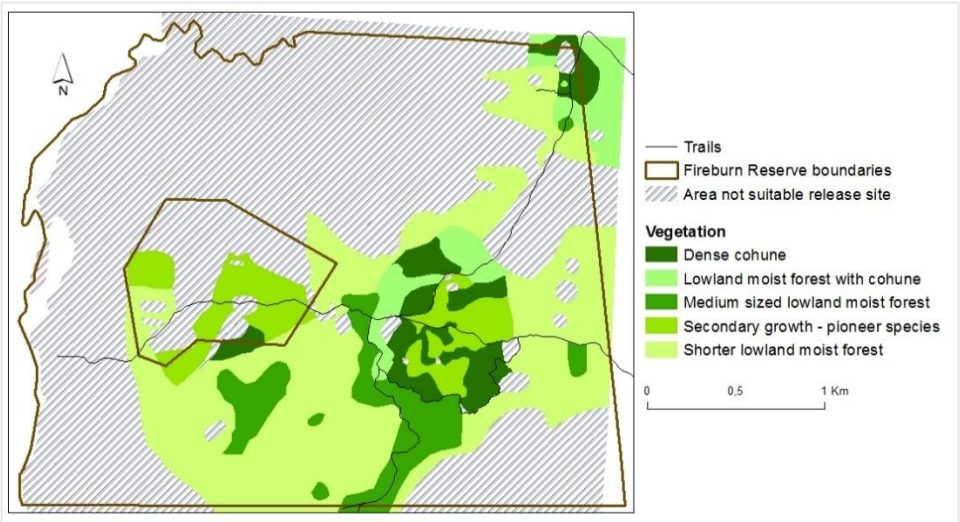


Figure 2: Map of the vegetation kept by M. Fanigliulo

Bibliography:

Maskell L. (2000). The plants of Fireburn Reserve, Corozal District, Northeast Belize. Report for Wildtracks. Belize.

Fanigliulo M. (2005). Suitability of the Fireburn Reserve as a Release Site for Black Howler Monkeys. University of Applied Sciences, Bremen.

APPENDIX VII: NEW RELEASE LOCATION IN 2015

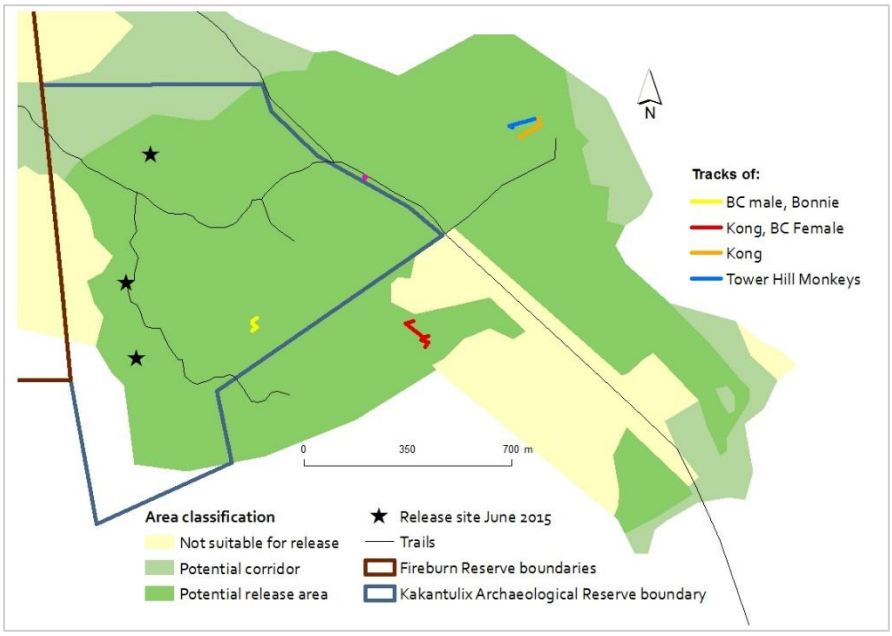


Figure 1: Map of the location of the releases in June 2015

In June 2015, three troops of rehabilitated monkeys were released at Kakantulix Archaeological Reserve (Figure 1).

The released sites were chosen to be:

- Within the potential release area.
- As far as possible from the translocated monkeys located at that moment.
- At least 300m from another release site.

Using the same method, in August 2015, a release location for a troop of two monkeys that will be released in September 2015 was found at Kakantulix Archaeological Reserve (Figure 2)

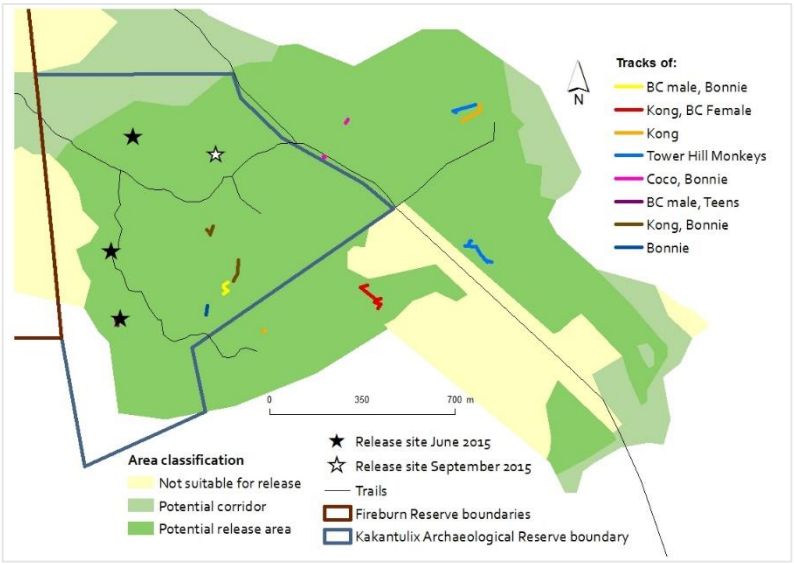


Figure 2: Map of the location of the release site for September 2015

APPENDIX VIII: TABLE OF THE EVALUATION OF THE STATUS OF THE RELEASED HOWLER MONKEYS

Table: Evaluation form of the released monkeys

Name	Found	Healthy	Reproduction		Seen attracted to people	Seen on the ground	Troop cohesion	Established home range	Previous update
			Infant	Mating behavior					
Agatha									Seen with Clyde in late 2012
Bonnie	✓	✓							Disappeared 8 months after release
Clyde	✓	✓					✓	✓	
Holly									Left the troop after release. Never seen after
Dudley	✓	✓	✓		✓	✓	✓	✓	
Eden									Seen with Dudley in August 2014
Igor									
Minnie	✓	✓	✓		✓	✓	✓	✓	
Mo	✓	✓	✓		✓	✓	✓	✓	
Nicky	✓	✓					✓	✓	
Willow	✓	✓					✓	✓	
Hazel	✓	✓					✓	✓	
Richie	✓	✓					✓	✓	
Fern	✓	✓	✓				✓	✓	
Charlie	✓	✓	✓				✓	✓	
Mia	✓	✓					✓	✓	
Coco	✓	✓							
Kong	✓	✓		✓					
Sultan									Seen alone in 2014
Livvy	✓	✓					✓	✓	
Kofi									Seen with Paz in August 2014
Paz	✓	✓						✓	
TH male	✓	✓					✓	✓	
TH female A	✓	✓					✓	✓	
TH female B									Found dead in 2014
TH female C	✓	✓					✓	✓	
BC male	✓	✓		✓					
BC female	✓	✓							
Total	**21**	**21**	**5**	**2**	**3**	**3**	**15**	**16**	

TH= Tower Hill, BC= Barton Creek

APPENDIX IX: LIST OF THE BROWSES USED AT WILDTRACKS

Table: List of the plants used at the Primate Rehabilitation Centre for browses

Family	Genus	species	Local name
Burseraceae	*Bursera*	*simaruba*	Gumbolimbo
Urticaceae	*Cecropia*	*peltata*	Cecropia
Moraceae	*Ficus*	*spp.*	Fig
Moraceae	*Brosimum*	*alicastrum*	Ramon
			Monkey vine
			Piper
Bambuseae			Bamboo
			Prickly Bush
			Hulub
			Bribri
Fabaceae			Water Wood

APPENDIX X: RELEASE LOCATIONS 2011 - 2014

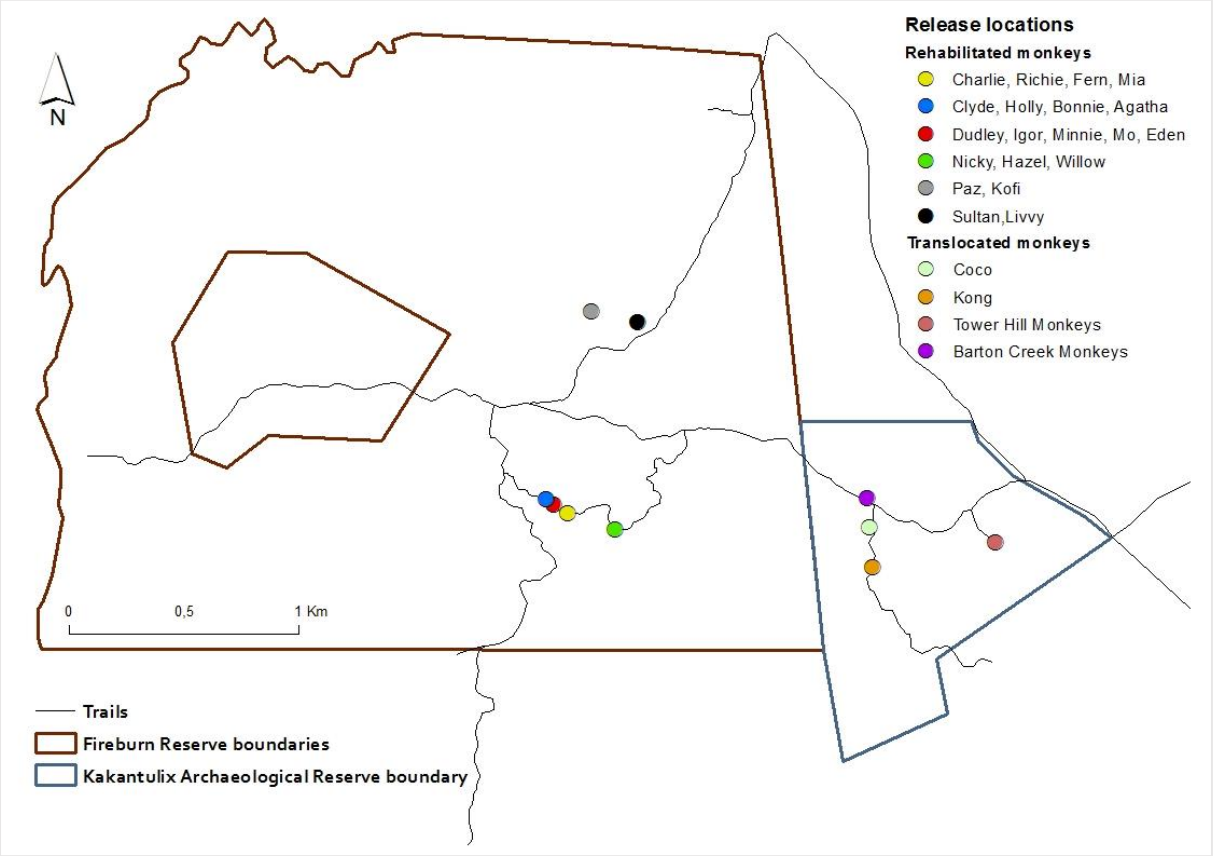


Figure: Map of the release sites from 2011 to 2014

Since 2011, 10 releases have been done by the Primate Rehabilitation Centre of Belize. Rehabilitated monkeys have been released in the Fireburn Reserve and translocated monkeys have been released in Kakantulix Archaeological Reserve (Figure).

APPENDIX XI: SKELETON FOUND AT KAKANTULIX IN 2014



Figure: Skeleton found at the Tower Hill release location in 2014. Photography © Rudy Castellanos. Belize

Analysed by: Paul Walker
Date found: Mid-September 2014
Location: Kakantulix Archaeological Reserve, next to the Tower Hill's release location
Cause of death: Fall
Pieces missing: Hyoid bone, one finger
Size: Juvenile monkey
Sex: Based of the size and form of the scale, female
Identification: Tower Hill older juvenile female

APPENDIX XII: HYPOTHETICAL AGES OF THE RELEASED HOWLER MONKEYS

Table: Hypothetical ages of the released monkeys based on the estimated age at intake

Name	Age at intake	Age at last release	Sexually mature at release	Age in June 2015	Sexually mature in June 2015
Agatha	18 months	23 months		6 years	X
Bonnie	18 months	23 months		6 years	X
Clyde	16 months	21 months		5.8 years	X
Holly	>2 years	> 2 years		>5 years	X
Dudley	≈ 2 years	3.5 years	X	6.5 years	X
Eden	16 months	2.8 years		5.8 years	X
Igor	16 months	2.8 years		5.8 years	X
Minnie	6-7 months	23-24 months		4.9-5 years	X
Mo	7-8 months	24-25 months		5-5.1 years	X
Nicky	5-6 months	3 years		5 years	X
Willow	adult (young)	adult (young)	X	adult	X
Hazel	adult (young)	adult (young)	X	adult	X
Richie	15-16 months	2.3 years		4.3 years	X
Fern	≈2 years	2.8 years		4.8 yers	X
Charlie	18 months	2 years		4 years	X
Mia	adult	adult		adult	X
Sultan	2.5 months	3.5 years	X	4.5 years	X
Livvy	9-10 months	3.6 years	X	4.8 years	X
Kofi	18 months	5 years	X	>5 years	X
Paz	10months	3.3 years		4.2 years	X
Coco	4-4.5 years	4.5-5 years	X	>5 years	X
Kong	5 years	5 years	X	>5 years	X
TH male	≥ 5 years	≥ 5 years	X	>5 years	X
TH female A	≥ 5 years	≥ 5 years	X	>5 years	X
TH female B	2-2.5 years	2-3 years		3-4 years	X
TH female C	14-15 months	16-17 months		2.4 years	
BC male	adult	adult	X	adult	X
BC female	adult	adult	X	adult	X

BC = Barton Creek, TH = Tower Hill

The sexual maturity was estimated using the one recorded for *Alouatta palliata* (Glander. 1980):

- Male: 3.5 years.
- Female: 3 years.

Bibliography:

Glander K. E. (1980). Reproduction and population growth in free-ranging mantled howling monkeys. American Journal of Physical Anthropology, 53, pp.25-36.

APPENDIX XIII: CAMERA TRAPPING AND PREDATORS

The presence of Felids at Fireburn Reserve and Kakantulix Archaeological Reserve was shown using camera traps, between May 2015 and July 2015. The identification of the Felids was done by Michael Starkey.

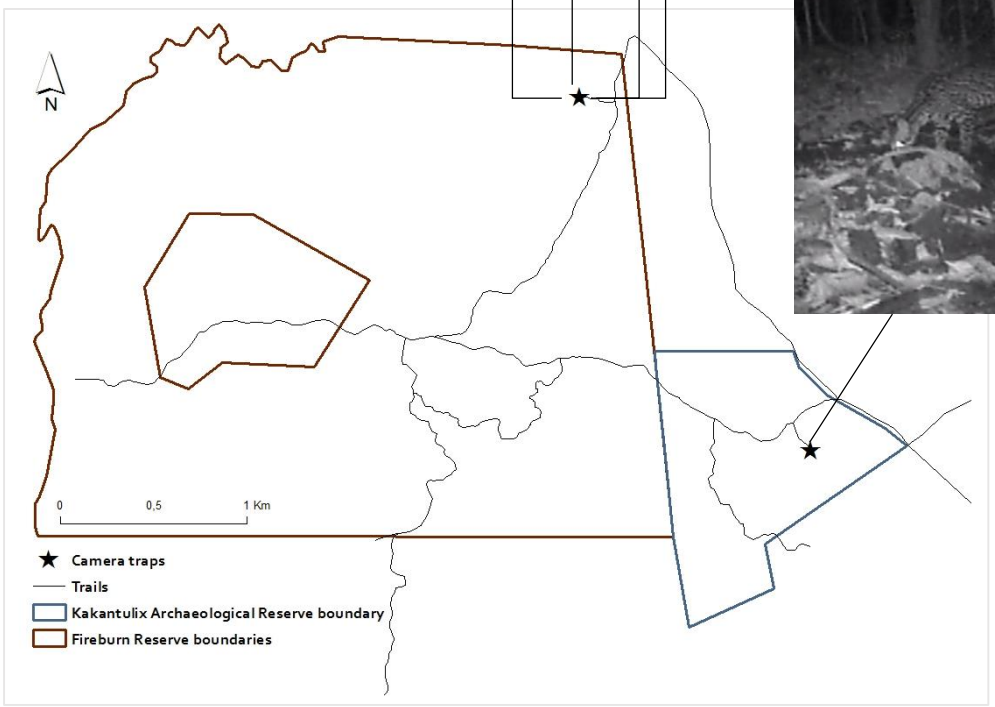












APPENDIX XIV: IDENTIFICATION KEY

Identification key of Yucatan black howler monkeys

-

Primate Rehabilitation Center, Belize



Edited in August 2015

Fanny Tricone

Wildtracks
Conservation, Education and Research

AGRO CAMPUS OUEST

Spécialité Génie de l'Environnement

Option Préservation et Aménagement des Milieux - Ecologie Quantitative

User's information

1

The released monkeys which have not been found in the wild or recorded dead are not included in this identification key:

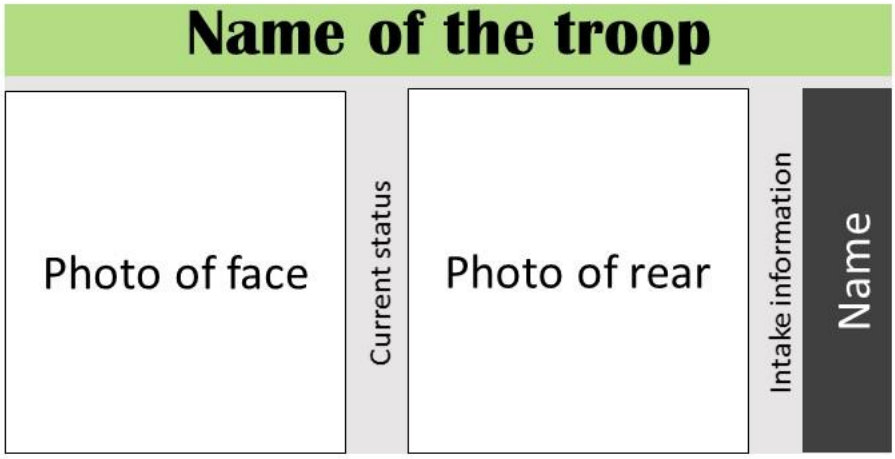
- Sultan
- Kofi
- Igor
- Eden
- Agatha
- Holly
- Tower Hill female B

The copyright of the photographies is *Fanny Tricone*, unless other mention added.

How to use the key

2

- Key structure

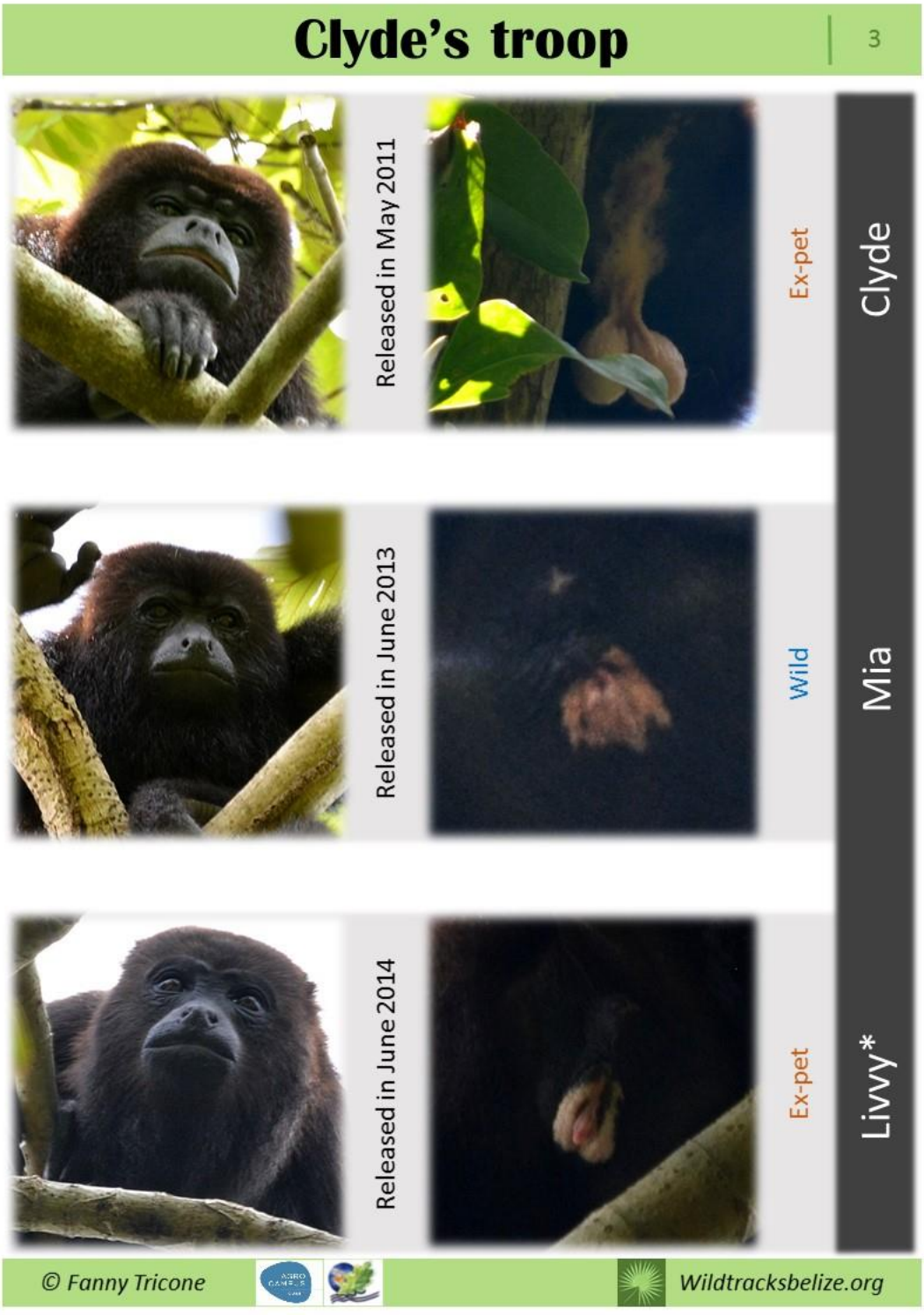


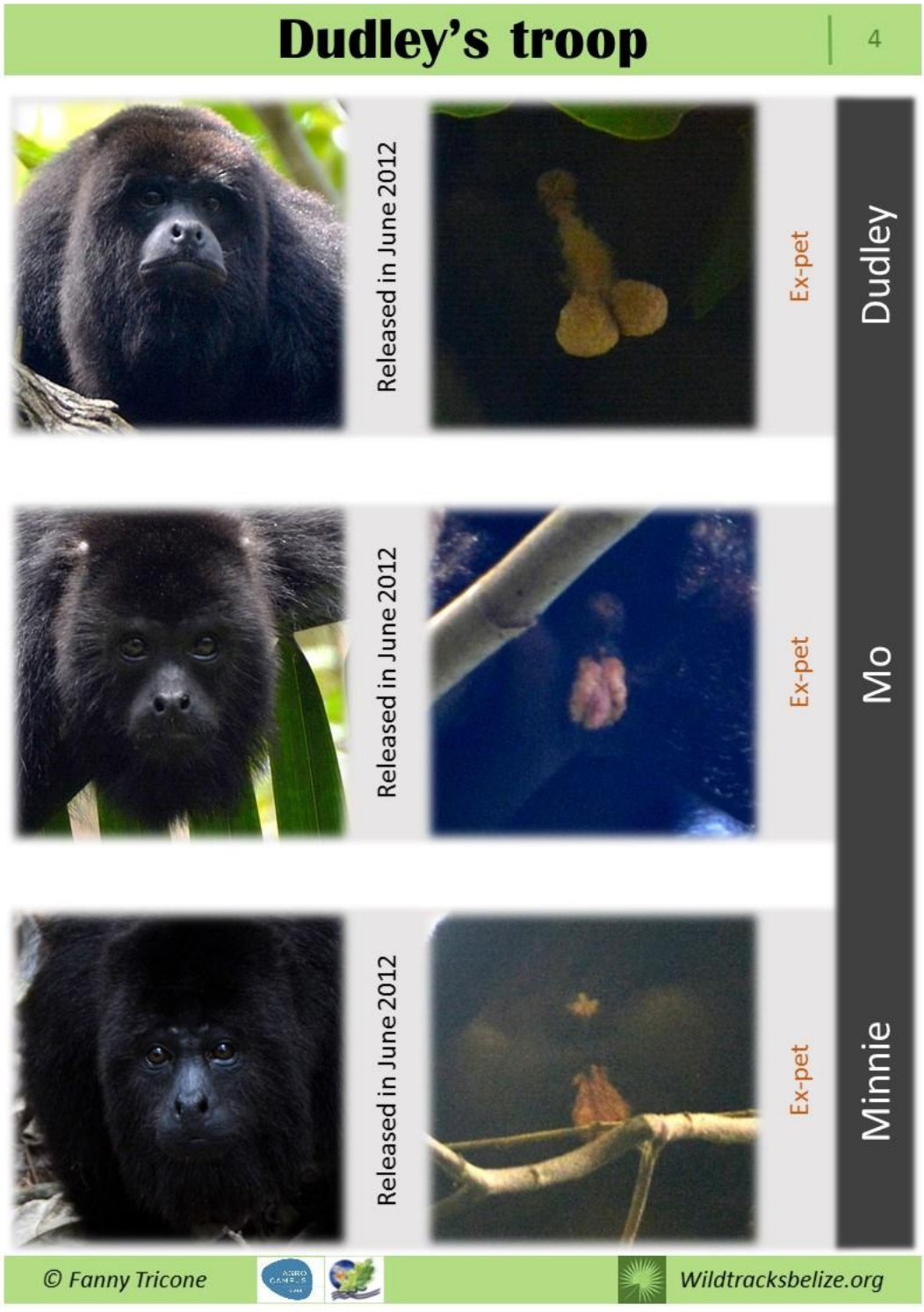
- Keywords

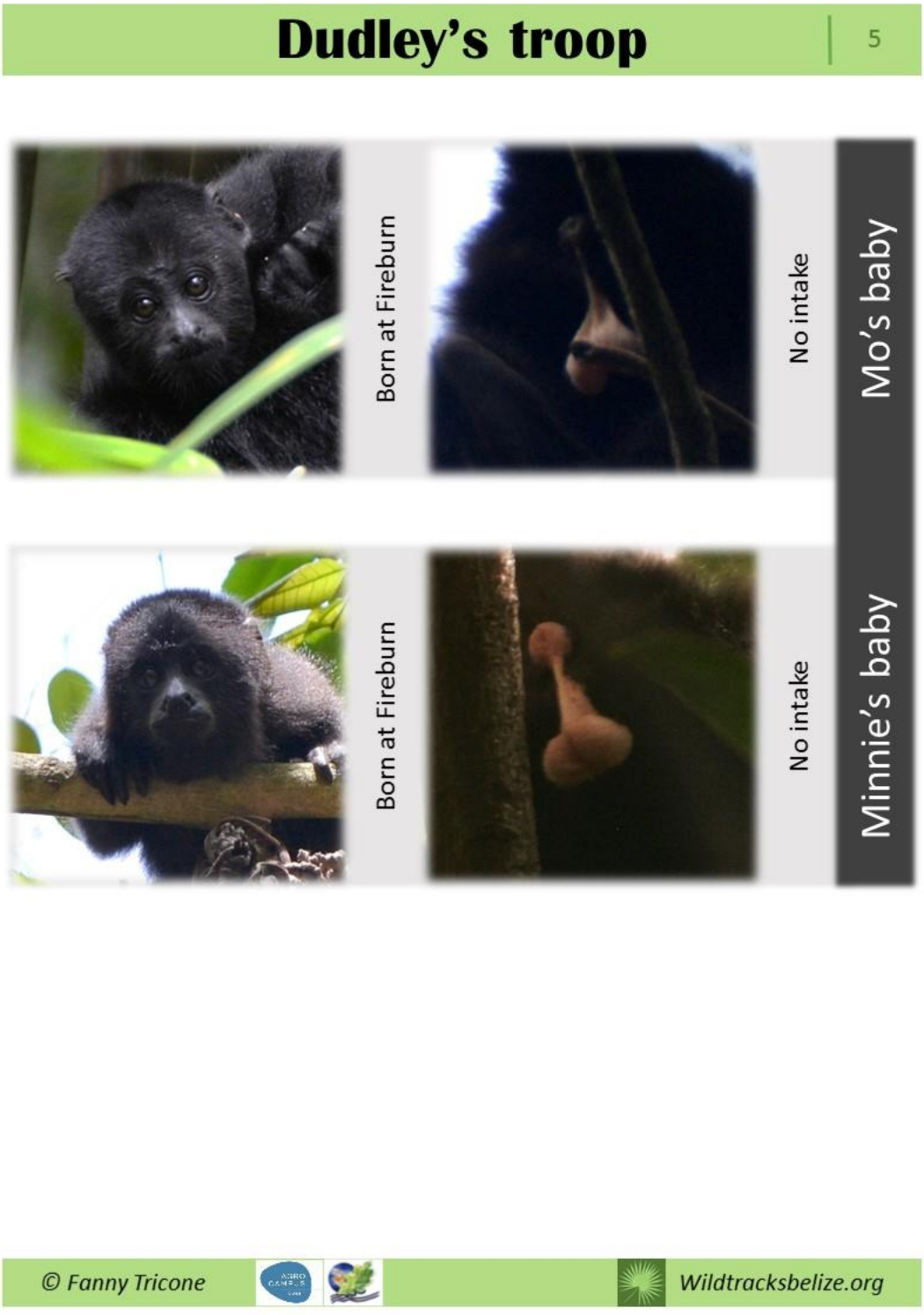
- **Ex-pet:** Was originally kept as a pet (after capture from the wild). Rehabilitation needed.
- **Wild:** Was injured and taken from the wild as an adult. Rehabilitation needed.
- **Wild infant:** Was taken from the wild (usually victim of an infanticidal attack) as an infant. Rehabilitation needed.
- **Translocated:** Was removed from an unsuitable area. No rehabilitation needed (beyond quarantine and de-parasitizing).
- **No intake:** Individuals has not been at Wildtracks.
- **PRC:** Primate Rehabilitation Centre
- ** Has broken left hand*

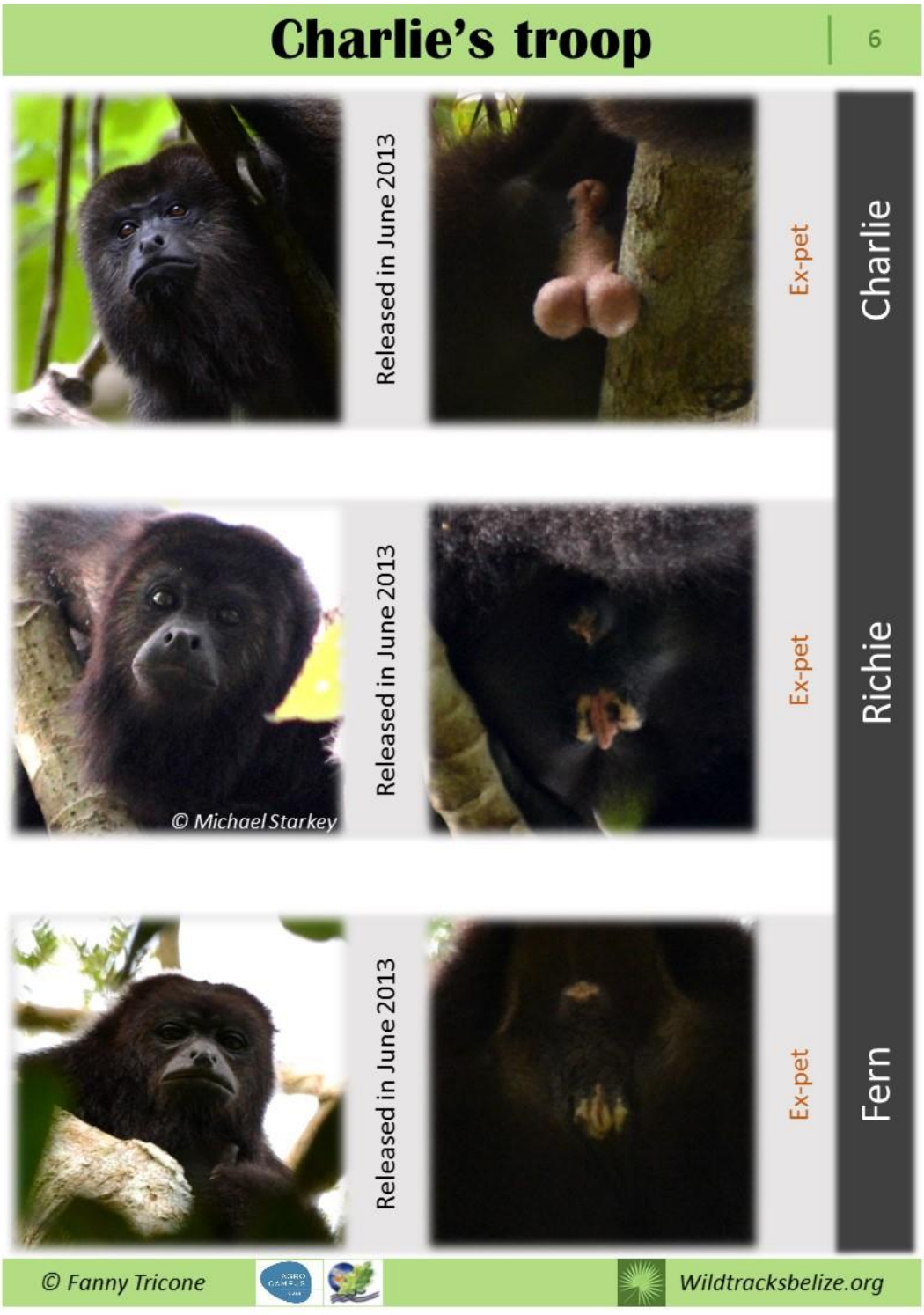
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Clyde's troop
3
Clyde
Ex-pet
Released in May 2011
Mia
Wild
Released in June 2013
Livvy*
Ex-pet
Released in June 2014
© Fanny Tricone
Wildtracksbelize.org


Dudley's troop
4
Dudley
Released in June 2012
Ex-pet
Mo
Released in June 2012
Ex-pet
Minnie
Released in June 2012
Ex-pet
© Fanny Tricone
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Dudley's troop
5
Born at Fireburn
No intake
Mo's baby
Born at Fireburn
No intake
Minnie's baby
© Fanny Tricone
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Charlie's troop
6
Released in June 2013
Ex-pet
Charlie
Released in June 2013
Ex-pet
Richie
© Michael Starkey
Released in June 2013
Ex-pet
Fern
© Fanny Tricone
Wildtracksbelize.org

Charlie's troop

7



Born at Fireburn

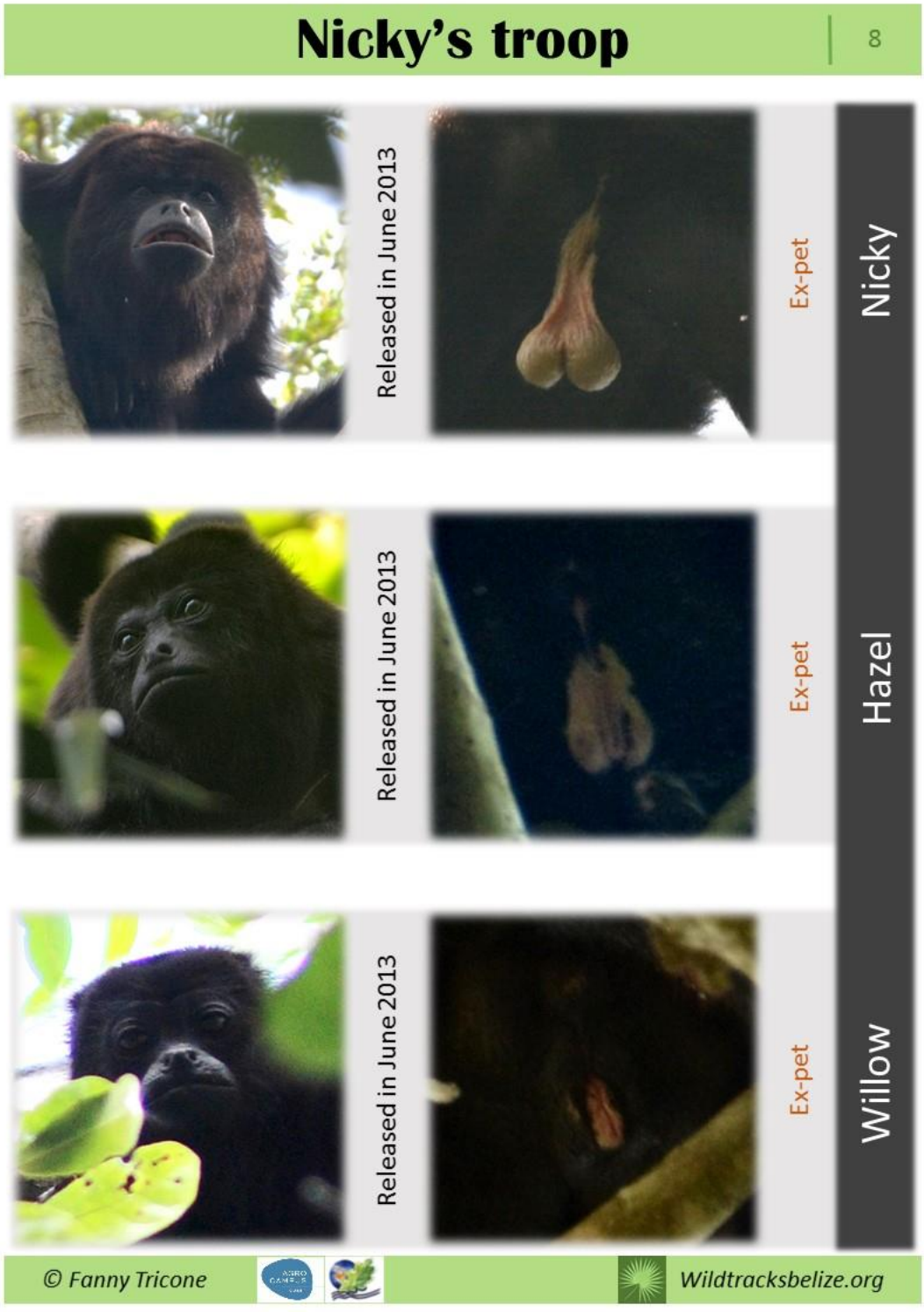


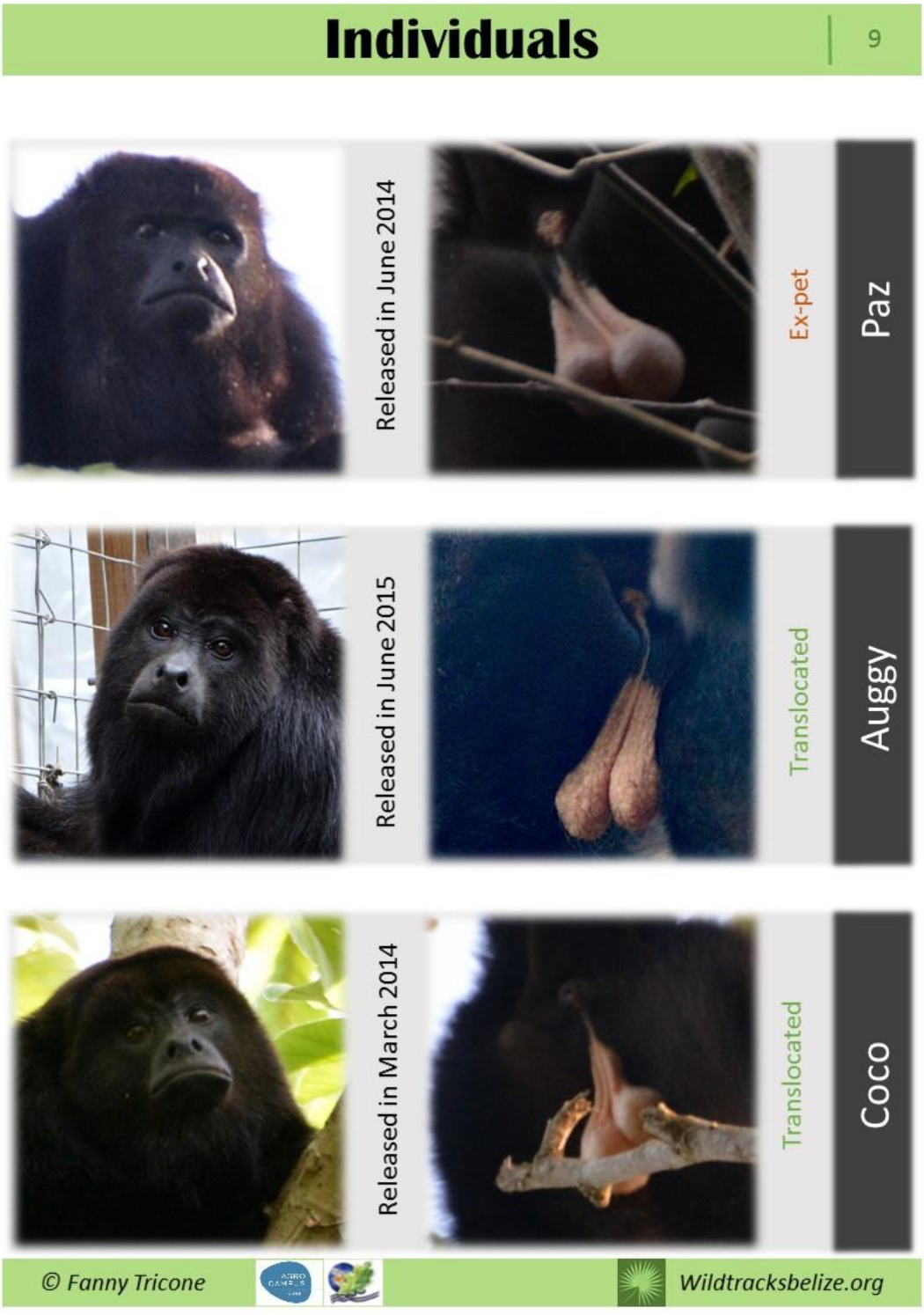
No intake

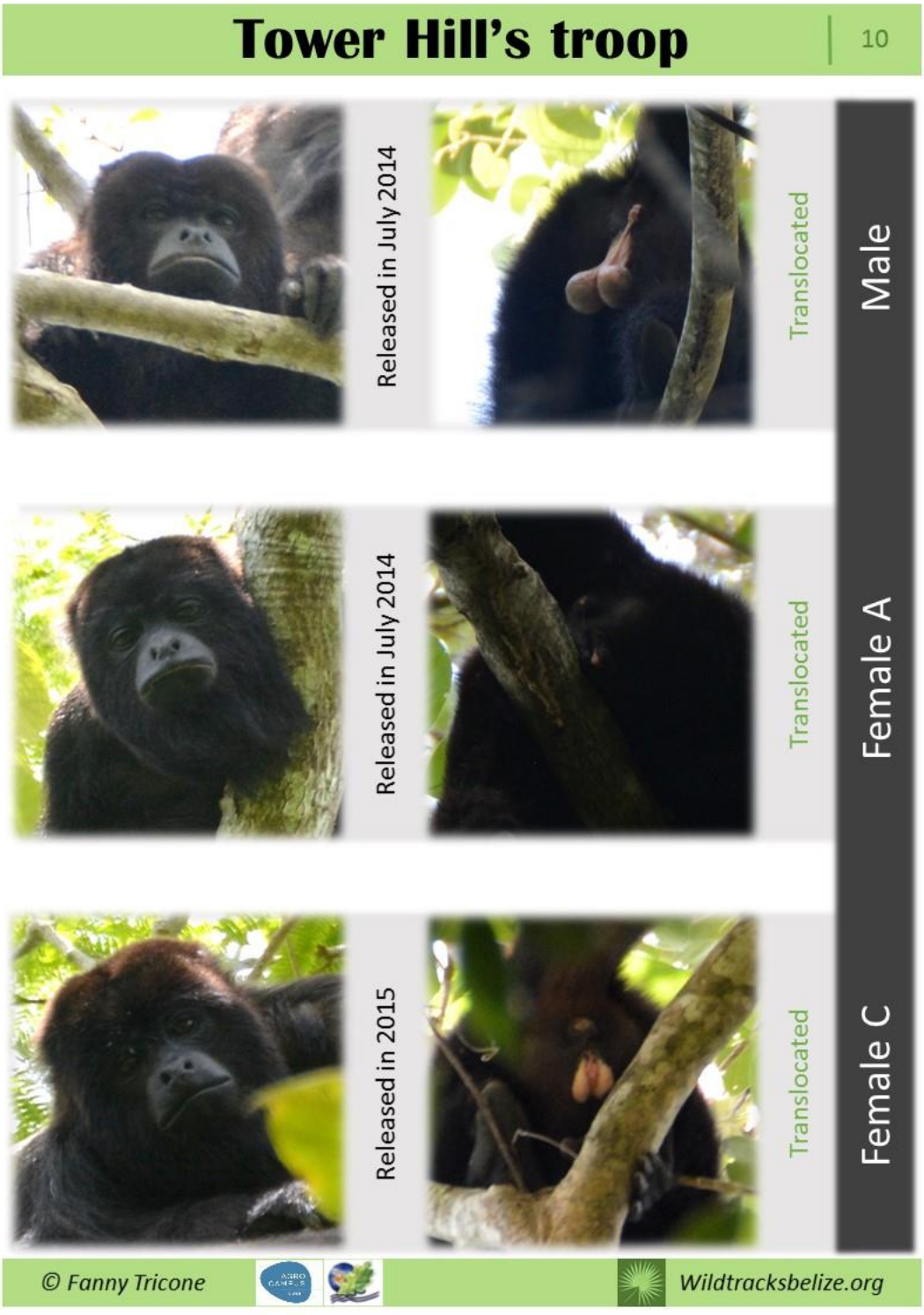
Fern's baby

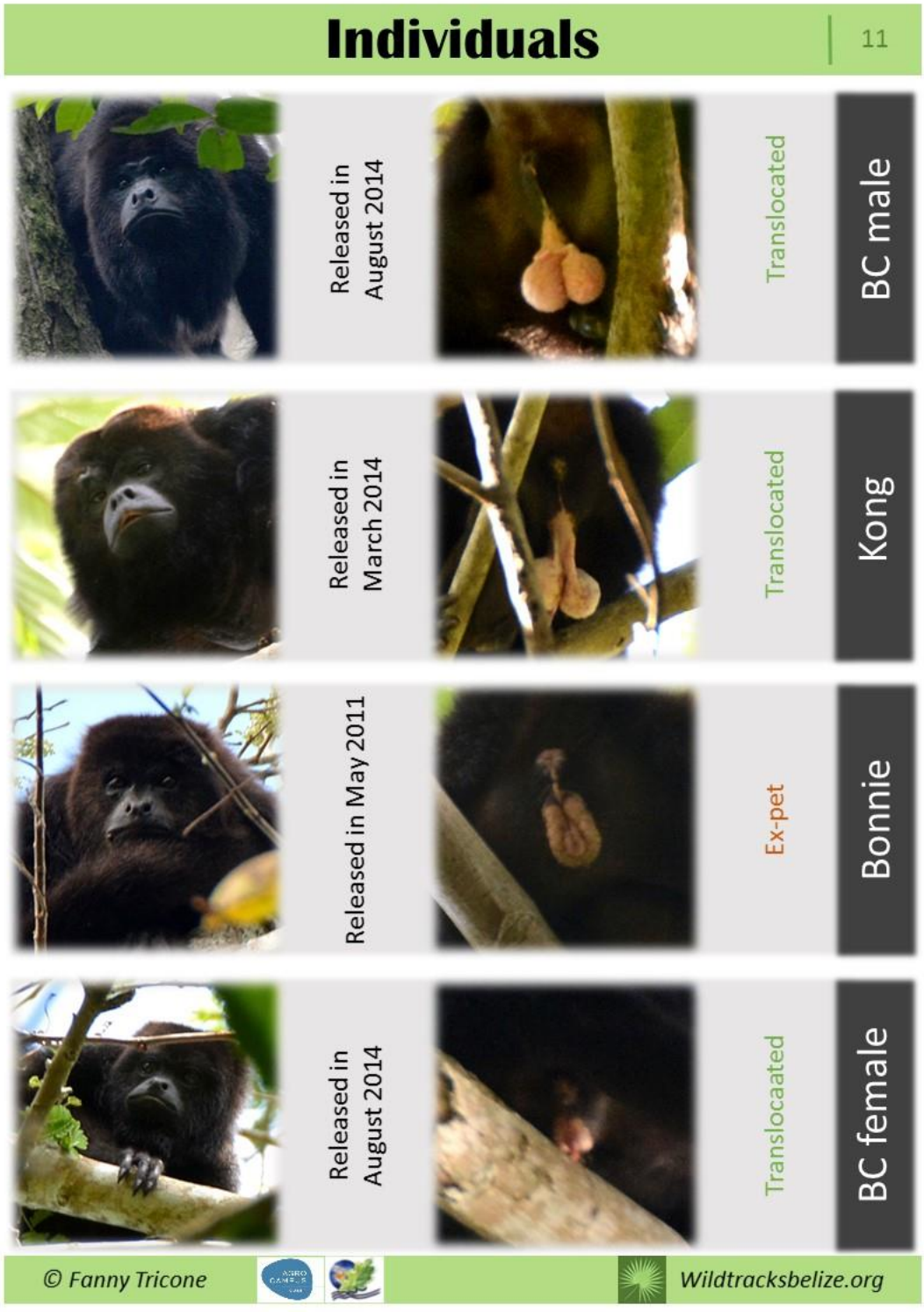
© Fanny Tricone

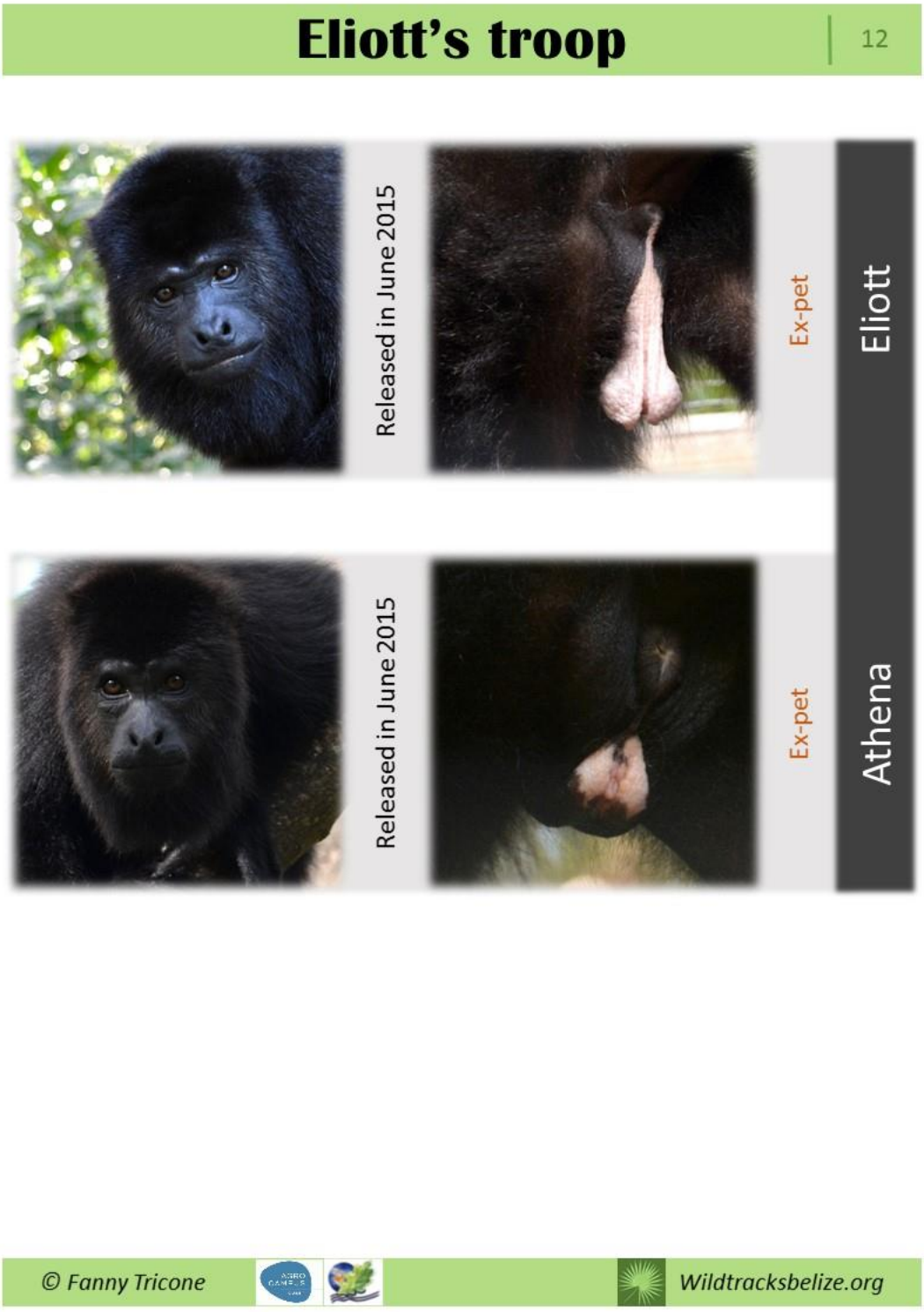
Wildtracksbelize.org

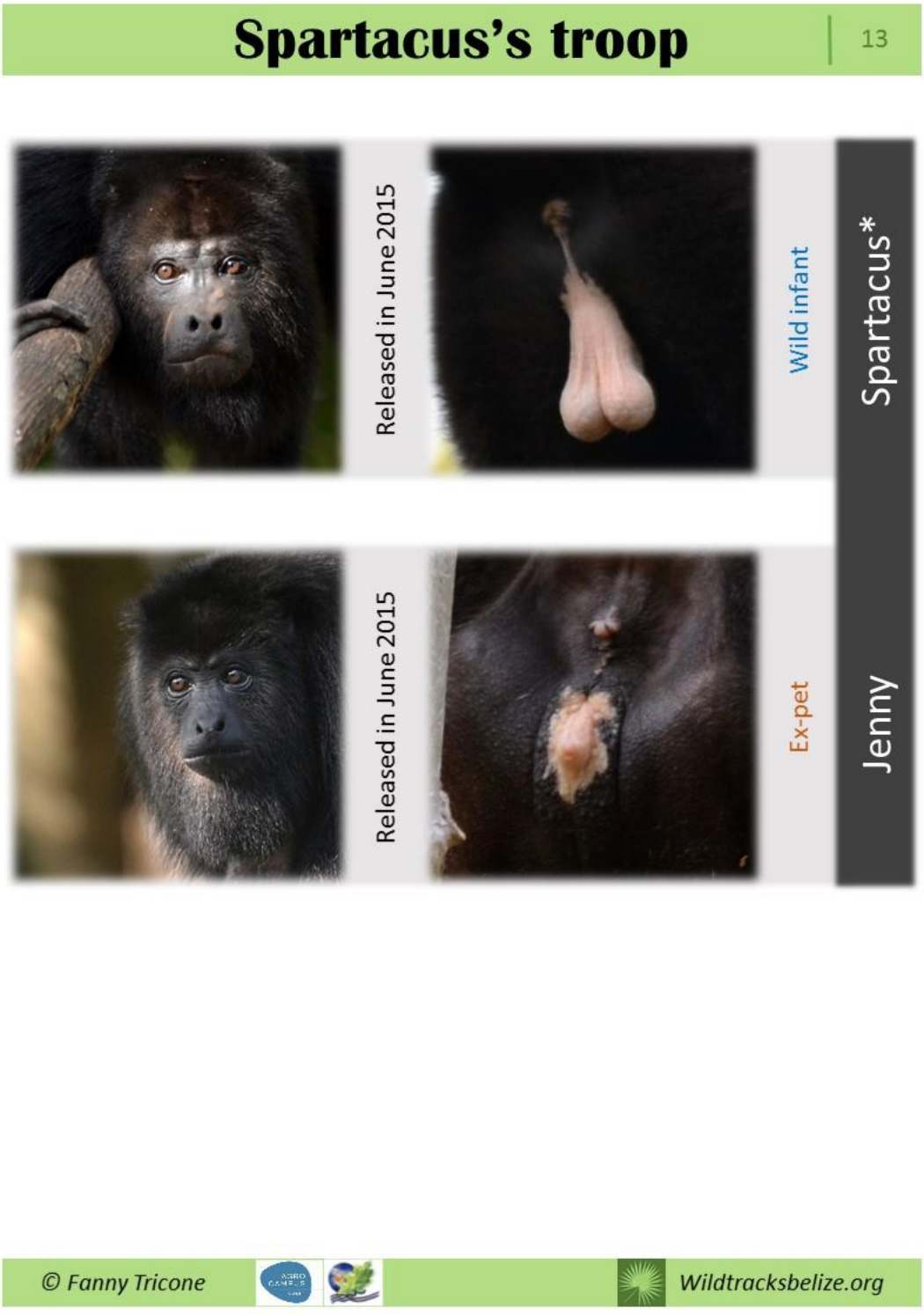

Nicky's troop
8
Nicky
Ex-pet
Released in June 2013
Hazel
Ex-pet
Released in June 2013
Willow
Ex-pet
Released in June 2013
© Fanny Tricone
Wildtracksbelize.org

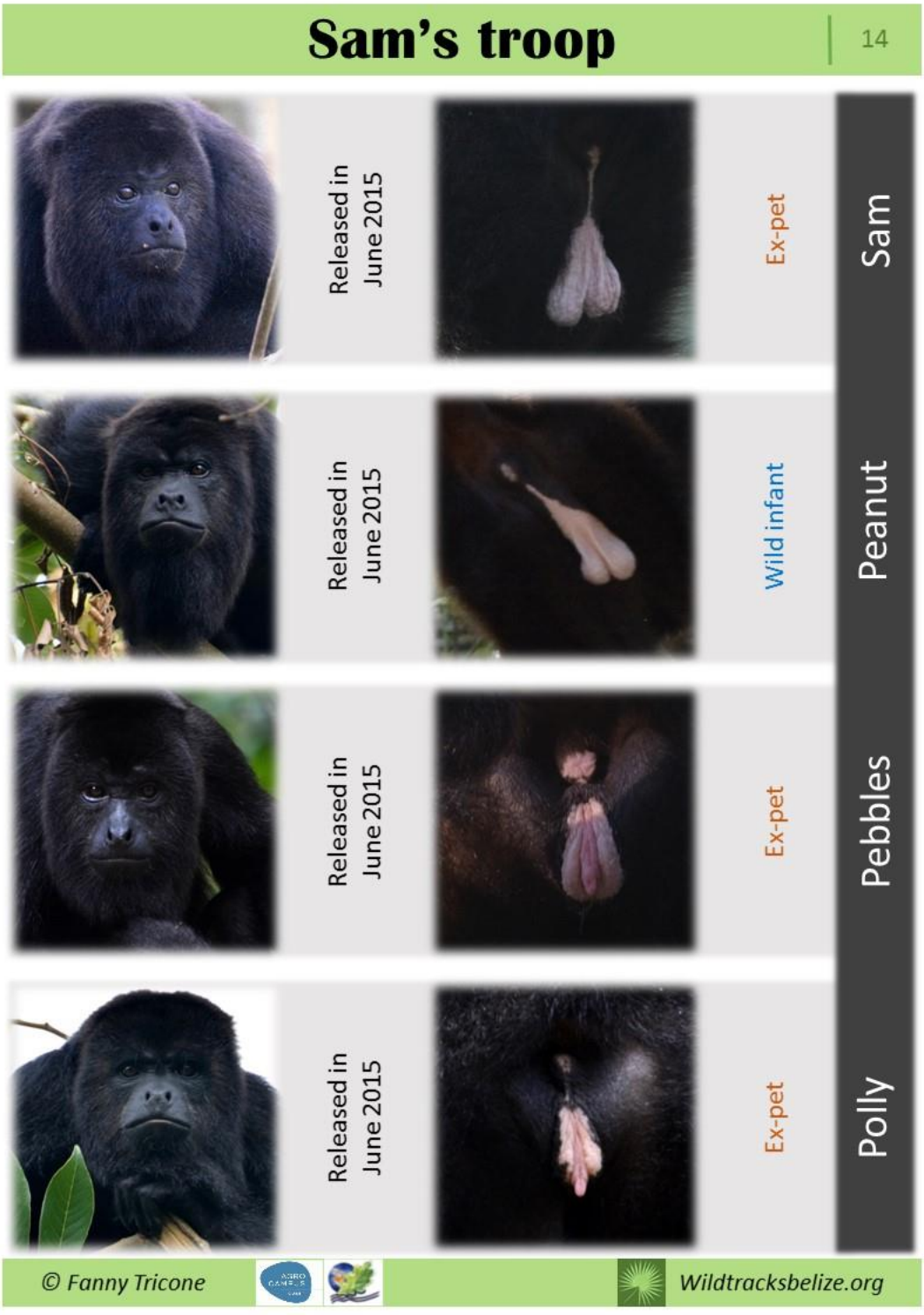

Individuals
9
Paz
Ex-pet
Released in June 2014
Auggy
Translocated
Released in June 2015
Coco
Translocated
Released in March 2014
© Fanny Tricone
Wildtracksbelize.org

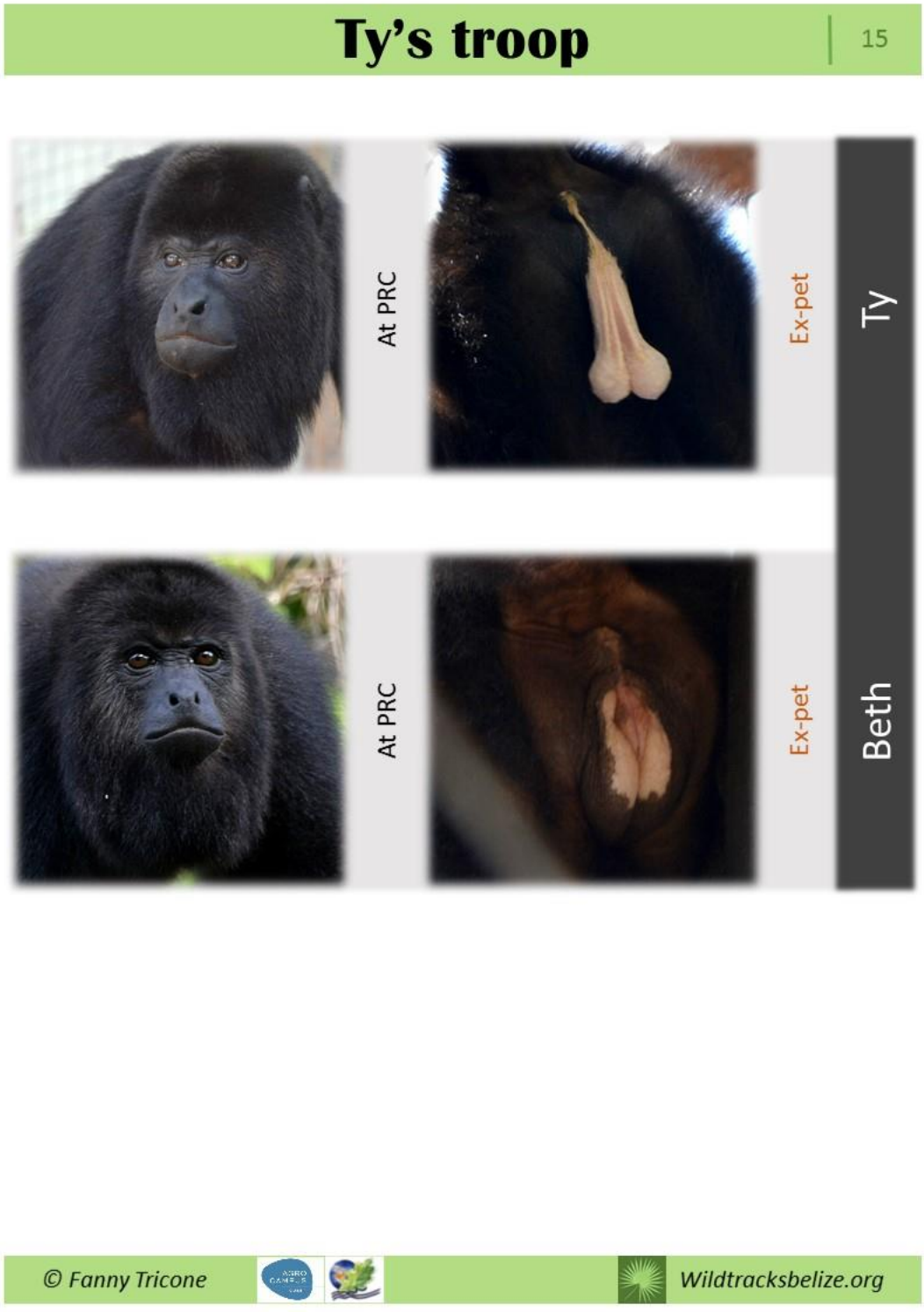

Tower Hill's troop
10
Released in July 2014
Translocated
Male
Released in July 2014
Translocated
Female A
Released in 2015
Translocated
Female C
© Fanny Tricone
Wildtracksbelize.org

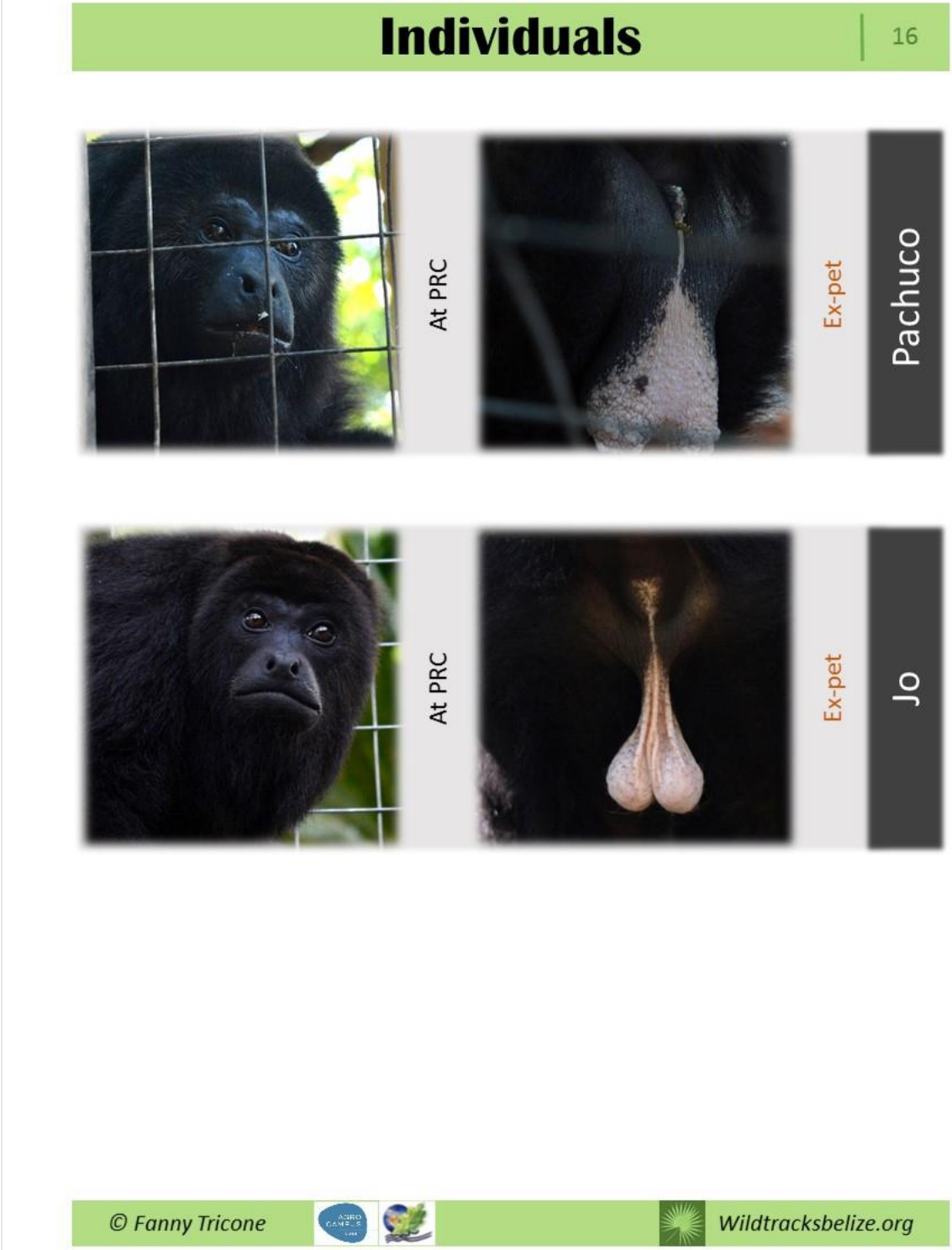

Individuals
11
Released in August 2014
Translocated
BC male
Released in March 2014
Translocated
Kong
Released in May 2011
Ex-pet
Bonnie
Released in August 2014
Translocaated
BC female
© Fanny Tricone
Wildtracksbelize.org

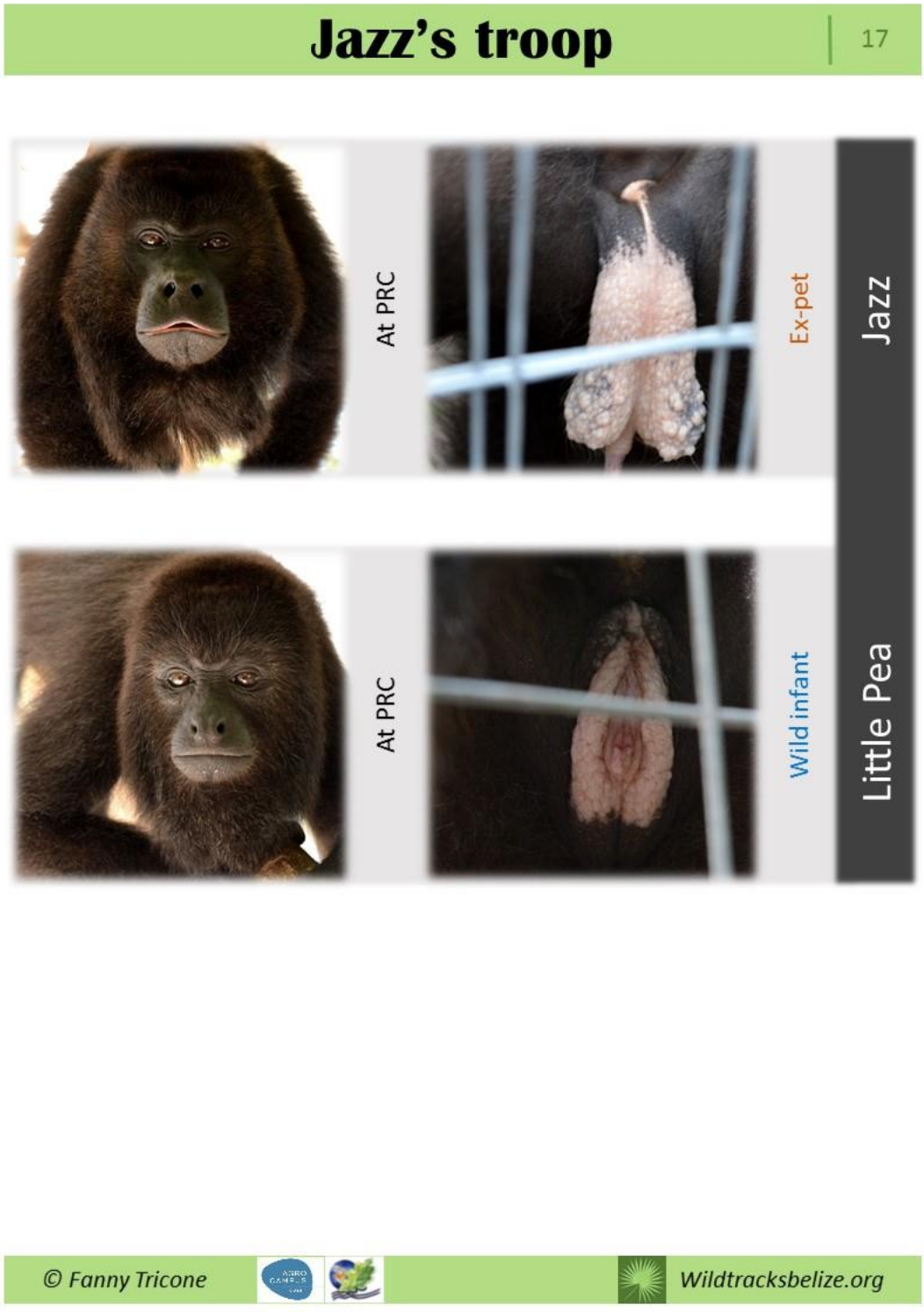

Eliott's troop
12
Eliott
Ex-pet
Released in June 2015
Athena
Ex-pet
Released in June 2015
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Wildtracksbelize.org

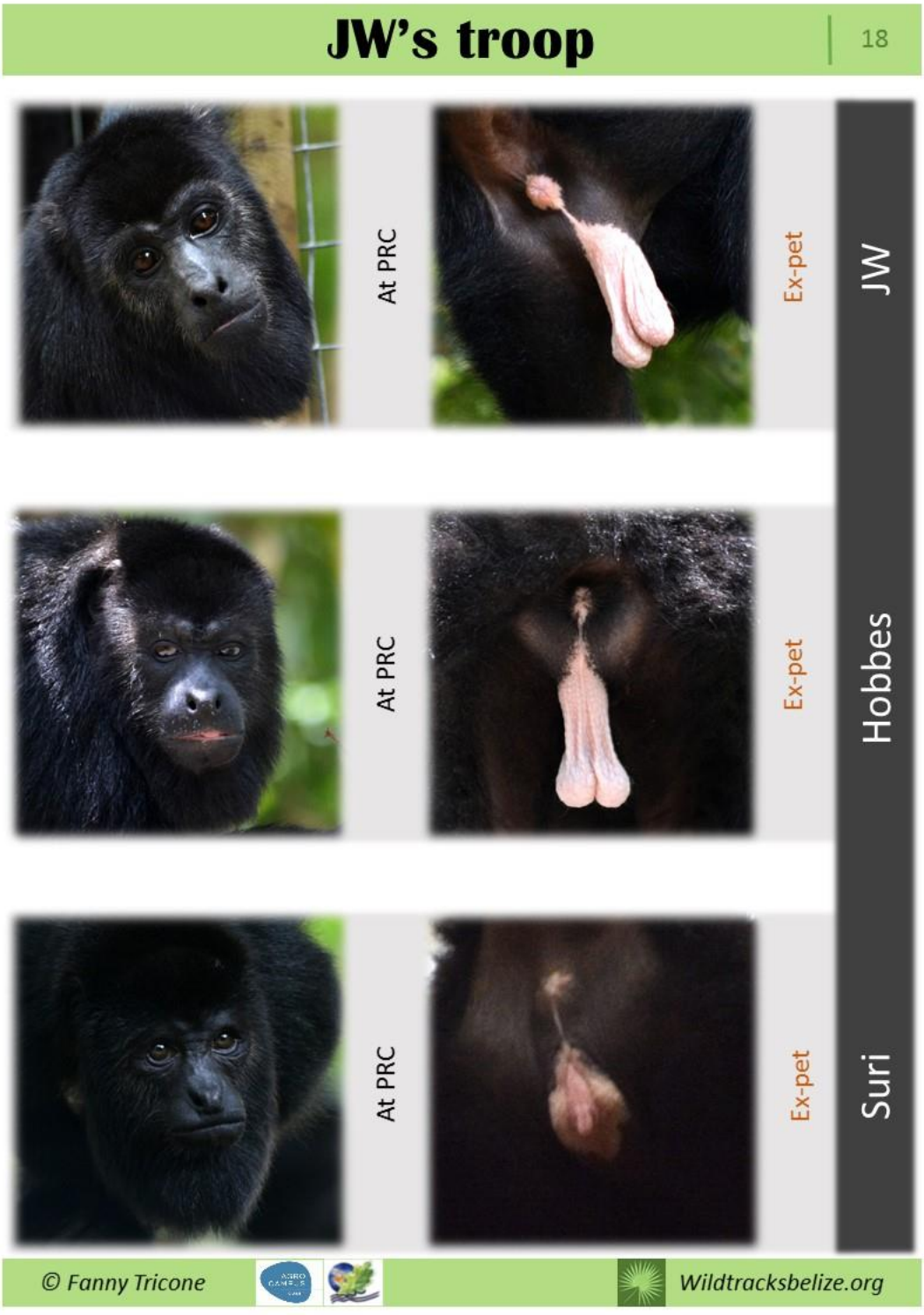

Spartacus's troop
13
Released in June 2015
Wild infant
Spartacus*
Released in June 2015
Ex-pet
Jenny
© Fanny Tricone
Wildtracksbelize.org

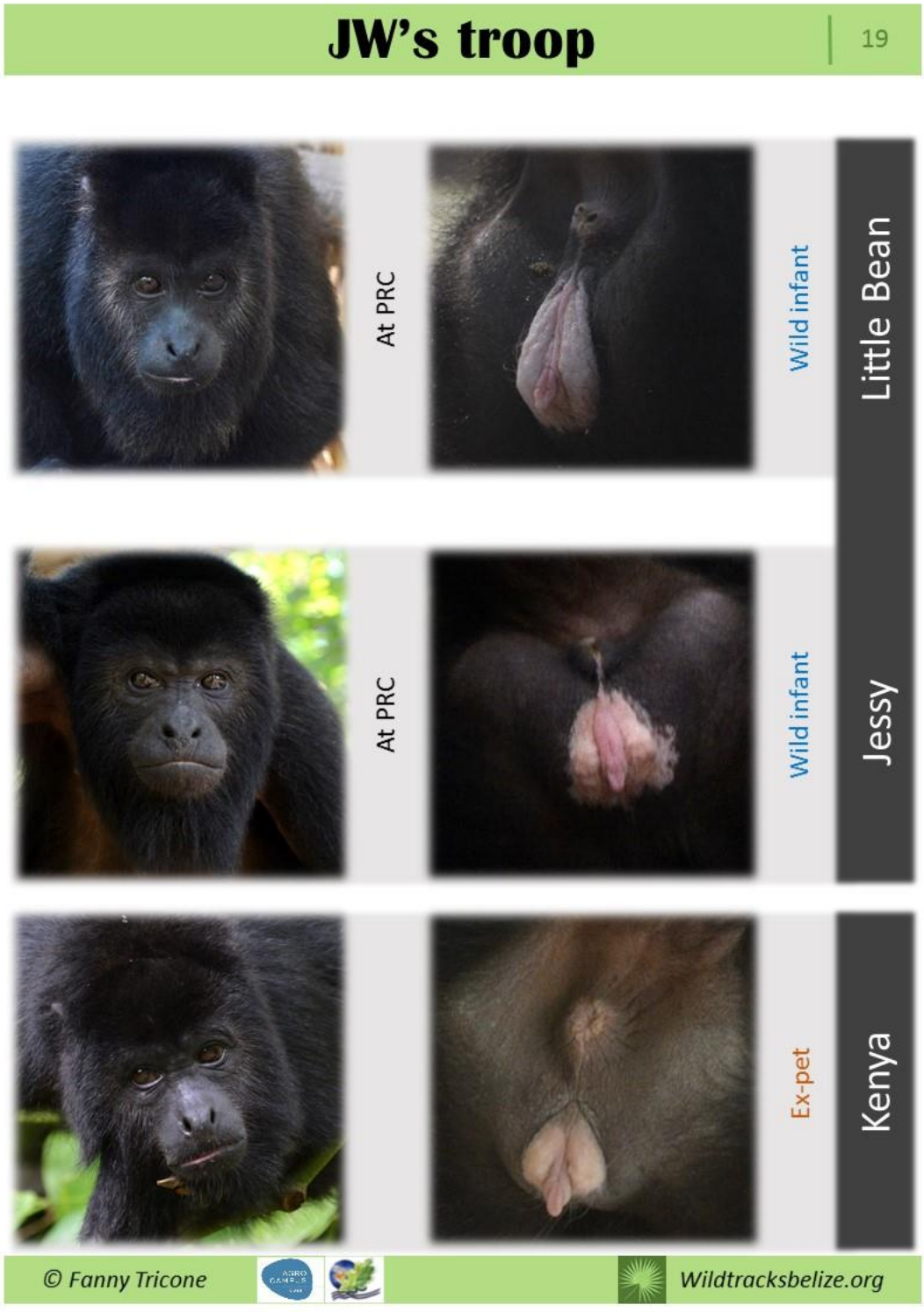

Sam's troop
14
Sam
Released in June 2015
Ex-pet
Peanut
Released in June 2015
Wild infant
Pebbles
Released in June 2015
Ex-pet
Polly
Released in June 2015
Ex-pet
© Fanny Tricone
Wildtracksbelize.org

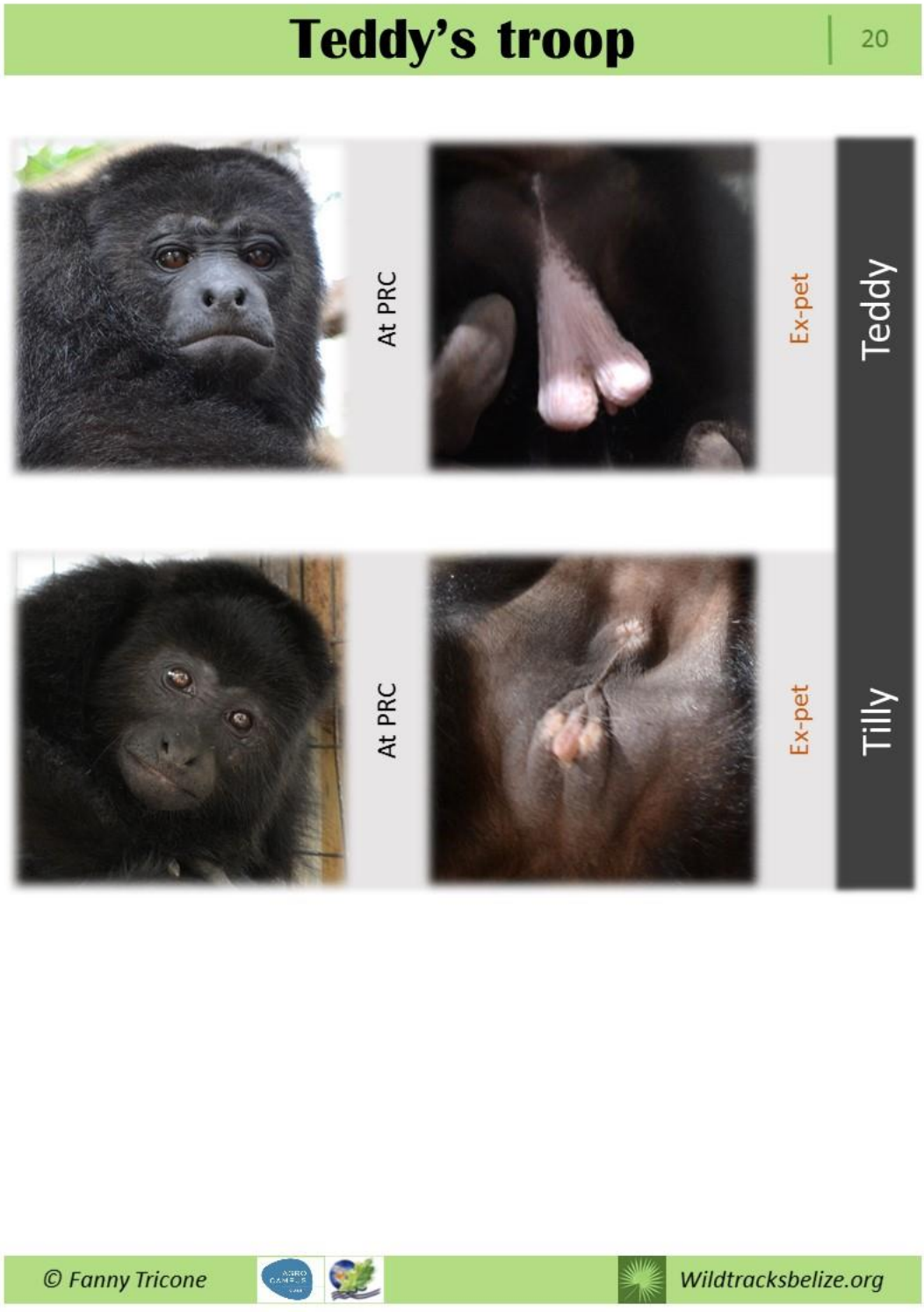

Ty's troop
15
At PRC
Ex-pet
Ty
At PRC
Ex-pet
Beth
© Fanny Tricone
Wildtracksbelize.org

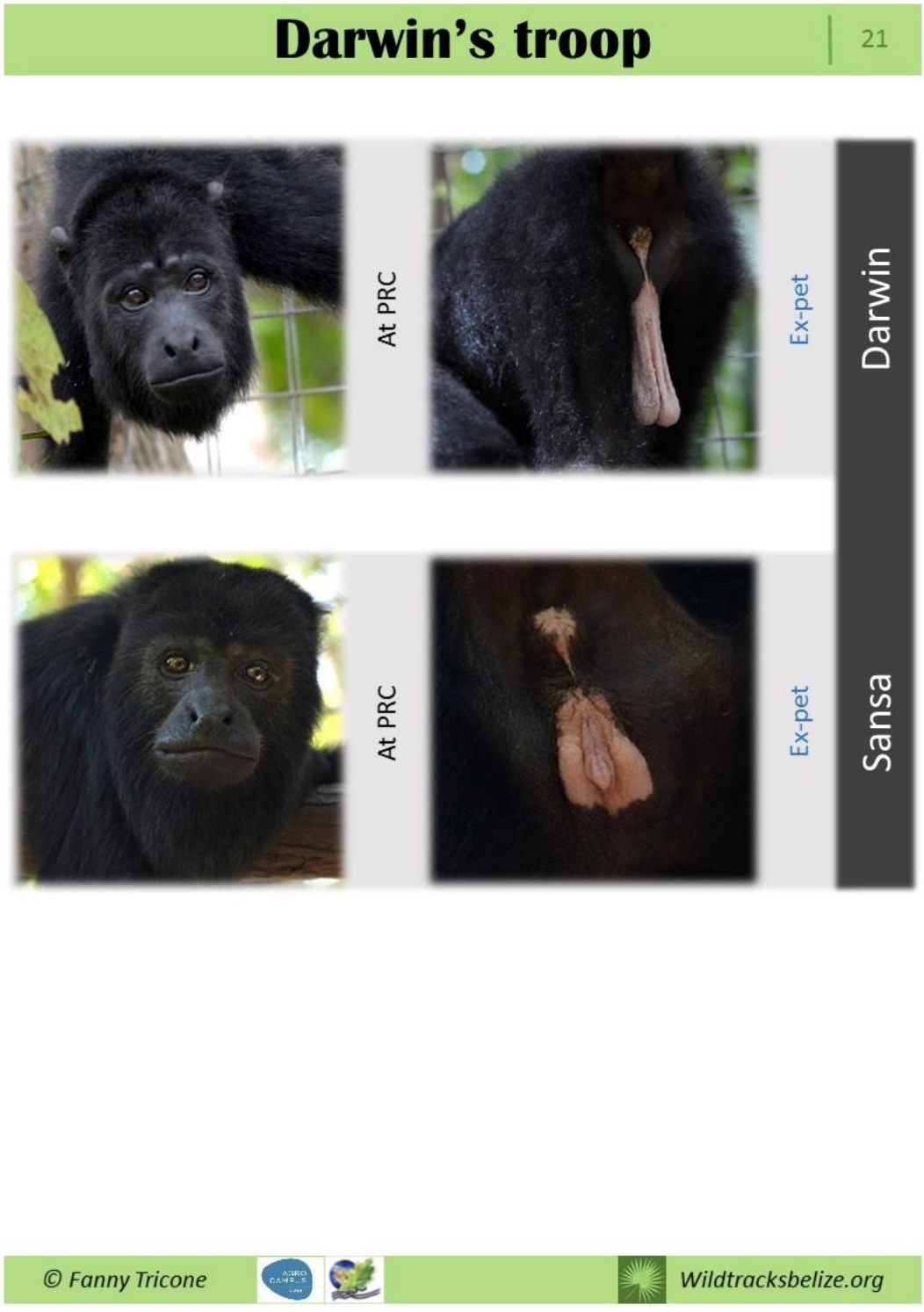

Individuals
16
At PRC
Ex-pet
Pachuco
At PRC
Ex-pet
Jo
© Fanny Tricone
Wildtracksbelize.org


Jazz's troop
17
At PRC
Ex-pet
Jazz
At PRC
Wild infant
Little Pea
© Fanny Tricone
Wildtracksbelize.org


JW's troop
18
At PRC
Ex-pet
JW
At PRC
Ex-pet
Hobbes
At PRC
Ex-pet
Suri
© Fanny Tricone
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JW's troop
19
At PRC
Wild infant
Little Bean
At PRC
Wild infant
Jessy
Ex-pet
Kenya
© Fanny Tricone
Wildtracksbelize.org


Teddy's troop
20
At PRC
Ex-pet
Teddy
At PRC
Ex-pet
Tilly
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Darwin's troop
21
At PRC
Ex-pet
Darwin
At PRC
Ex-pet
Sansa
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Titre français : Bilan de la réintroduction d'une population d'Hurleurs du Guatemala

Titre Anglais: Assessment of a Yucatan black howler monkey population reintroduction

Résumé : Une population réintroduite de singes hurleurs a été évaluée pour déterminer l'état actuel des singes relâchés et de leur réintroduction. Des critères ont été définis pour évaluer le statut de chaque individu, comme la reproduction, la cohésion à une troupe et la réponse à la présence d'humains. Une étude démographique a été effectuée pour caractériser la population à ce jour, et des études sur l'établissement du domaine vital, sur la survie et sur l'identification des espèces alimentaires ont été faites pour améliorer le succès des remises en liberté futures et pour trouver de nouveaux sites de lâchers.
L'état actuel de la réintroduction de la population a été évalué avec succès et des indications ont été données pour les futurs lâchers. 75% des singes relâchés ont été localisés, et un seul des singes disparu a été retrouvé mort. 76% des singes relâchés avait établi un domaine vital, 71% appartenait à des troupes stables, 24% de la population avait commencé à se reproduire avec succès, et 95% des singes retrouvés avaient atteint la maturité sexuelle.
Une intervention par le Centre de réhabilitation sera nécessaire pour une seule troupe qui a été vue sur le sol et attirée par la présence de personnes. Cette étude a montré un exemple de succès d'une réintroduction de population, et la nécessité de faire des suivis post-libération à long terme pour évaluer le succès des remises en liberté. Comme l'établissement d'une population viable implique le succès de la reproduction de la progéniture, d'autres évaluations seront nécessaires pour évaluer les taux de reproduction futurs.

Abstract: The reintroduced howler monkey population was assessed to determine the current status of the released howler monkeys and of their reintroduction. Criteria were defined to assess the status of each individual such as health condition, reproduction, troop cohesion and establishment, and response to human presence. A demographic study was conducted to characterize the population to date, and studies on their home range establishment, on the survival and on the identification of feed species were done to increase the success of future releases and to find new release locations.
The current status of the population reintroduction was assessed successfully and base-lines were given for the future releases. 75% of the released howler monkeys were found and located after at least one year since release in good condition, and only one of the missing monkeys was found dead. 76% of the released monkeys have established a home range, 71% have stable troops, 24% of the population has started reproducing successfully, and 95% of the monkeys found reached sexual maturity.
Intervention by the Rehabilitation Centre will be needed for only one troop of three monkeys that were recorded on the ground and attracted by the presence of people. This study showed an example of a successful population reintroduction, and the need of doing long term post-release monitoring to assess the success of releases. As the re-establishment of a viable population implies the successful reproduction of offspring, further assessments will be needed to evaluate reproduction rates.

Mots-clés : Réhabilitation, translocation, Belize, ex-animal de compagnie, domaine vital, défense territoriale, hurlement, survie, reproduction, commerce des animaux de compagnie, évaluation, écologie alimentaire, conservation de la vie sauvage, suivis, suivis après remise en liberté, primate, biodiversité, espèces en voie de disparition, remise en liberté

Key Words: Rehabilitation, translocation, Belize, ex-pet, home range, territory defense, howl, survival, reproduction, pet trade, evaluation, feeding ecology, wildlife conservation, survey, post release monitoring, primate, biodiversity, endangered species, release