

# Insights into the feeding ecology of the Seychelles Black Parrot *Coracopsis barklyi* using two monitoring approaches

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Feeding ecology is an important factor for the survival of a species and knowledge of its parameters is a prerequisite for successful conservation work. In this study we describe the feeding ecology of the endemic Seychelles Black Parrot *Coracopsis barklyi* on Praslin, Seychelles, the only island on which this parrot is resident. We compared two methods to evaluate feeding choices: incidental observations and feeding walks on 25 transects in all habitat types. Black parrots fed on 46 different species, bringing the total number of known food plants to 53 species. They predominantly consumed endemic and native species (58% of observed feeding bouts), mainly their fruit pulp (in 68% of feeding bouts), followed by buds (15%) and seeds (37%) with occasional observations of leaves, bark and scale insects. The incidental method rendered many more observed bouts than the transect approach and the ratios of consumed species differed between methods but the transect results are regarded as more representative. The incidental method is not suitable for quantitative conclusions but complements the transect method, providing information about rarely occurring feeding events.

**Keywords:** *Coracopsis barklyi*, feeding ecology, Indian Ocean, palm forest, parrots, Seychelles Black Parrot

## Introduction

Successful conservation depends *inter alia* on preservation of feeding resources, since food availability influences population numbers directly and indirectly via survival, mortality, fitness, productivity and breeding success (Saunders et al. 1991; Jones 2004). Food preferences and foraging strategies define species' roles as pollinators, seed dispersers or predators, and determine competitive relationships with other species. Knowledge of identity and availability of feeding resources as well as foraging location, timing and habits are thus important prerequisites for conservation. Many conservation projects collect data on feeding ecology, although methods vary and usually have to balance feasibility with the need to record sufficient feeding observations to draw conclusions. Recording incidental observations produces many observations with limited effort (Bollen and van Elsacker 2004; Ortiz-Catedral and Brunton 2009), but such observations, although providing insight into a species' feeding ecology, are typically not representative and do not allow quantitative conclusions. Dedicated feeding transects permit comparisons over time and, depending on the sampling method, between areas (Pizo et al. 1995, Renton 2001).

The Seychelles Black Parrot *Coracopsis barklyi* breeds only on the island of Praslin in the Seychelles, with a population size of 520–900 birds (Reuleaux et al. 2013). Despite its tiny population size and distribution, *C. barklyi* acts as a flagship species for the rare palm forest habitat on Praslin, particularly the UNESCO World Heritage site of the Vallée de Mai. It is also the national bird and an avian cultural

icon of the Seychelles. The Seychelles Black Parrot's single island distribution makes it highly vulnerable to stochastic effects such as forest fires, disease outbreaks and climate change, which, among other impacts, may alter plant phenology cycles. Breeding is seasonal but does not occur every year (Reuleaux et al. 2014), which is likely to be linked to food availability. The fragility of the Seychelles Black Parrot population prompted the development of the Seychelles Black Parrot Action Plan (Rocamora and Laboudallon 2009), which proposes conservation measures and further research into areas including feeding ecology.

Seychelles Black Parrots are known to feed on a variety of fruits and seeds of native and introduced plants (Gaymer et al. 1969; Rocamora and Skerrett 2001; Walford 2008; Rocamora and Laboudallon 2009), but observations have been incidental and limited in time and area. The main aims of this study were therefore to gain an objective understanding of Seychelles Black Parrot feeding ecology, assess the value of incidental feeding observations in small population monitoring, and provide information for future conservation efforts. To achieve these aims we applied and compared two data collection methods—incidental feeding observations and controlled-effort transects—to determine specifically (1) which plant species and parts are eaten by *C. barklyi* and to what extent and (2) whether results from incidental feeding observations can be used as a reliable indicator of the relative importance or preference of food species.

## Materials and methods

### Study site

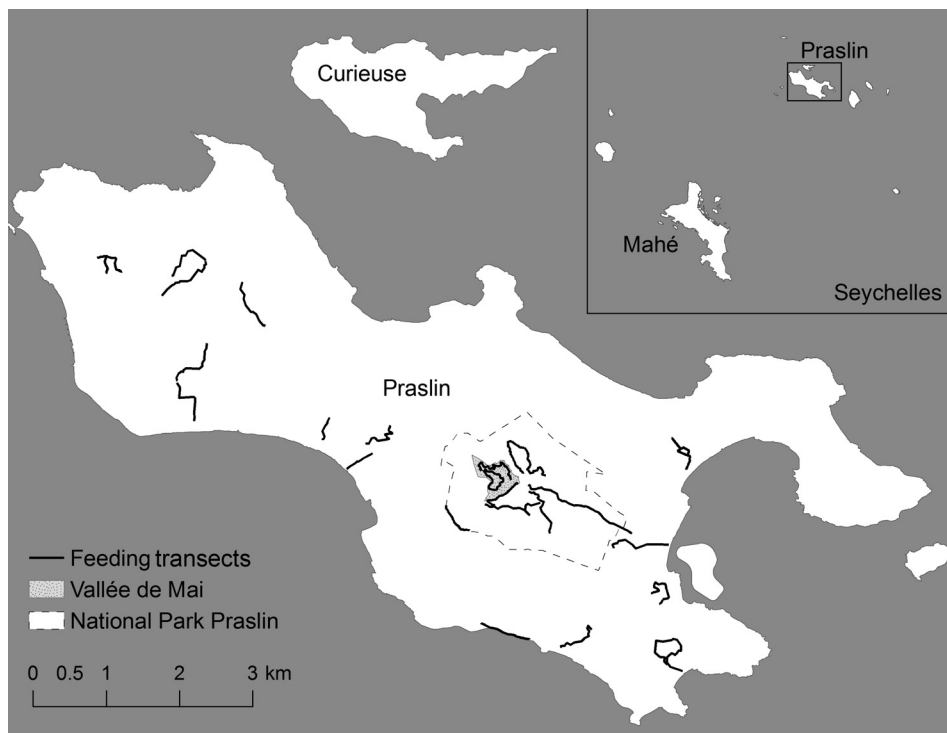
The research was carried out on the island of Praslin in the Seychelles archipelago in the Indian Ocean (Figure 1). Praslin Island (4°19' S 55°44' E; 38 km<sup>2</sup>, 367 m highest point above sea level) is the second largest of the granitic Seychelles islands and is located at 44 km north of the largest granitic island Mahé. The climate is tropical with little variation in monthly mean temperatures of 25–28 °C (Walsh 1984) or humidity (monthly mean 75–80%). Annual rainfall is >2 000 mm. Praslin usually experiences a dry season from May to October and a wet season from December to March (Walsh 1984).

Praslin Island's population of c. 8 500 people is primarily settled around the coast (National Bureau of Statistics 2013). The coastal plain is relatively wide and heavily modified by humans for cultivation, residential areas, tourism and infrastructure. Large areas of the island have been damaged by fire and are covered by secondary vegetation (Meuwly 2002). Hillsides are usually covered in boulders and thick scrub vegetation, whereas hilltops are often eroded bare soil. Only remnants of native palm forest occur in the uplands; the largest of these is protected in the Praslin National Park. Within the National Park lies the Vallée de Mai (19.5 ha), which is dominated by the endemic Coco de Mer palm *Lodoicea maldivica* and has been protected as a UNESCO Natural World Heritage site since 1983 and managed by a public trust, the Seychelles Islands Foundation (SIF), since 1989. This research was carried out as part of a broader research programme on the Seychelles Black Parrots run by SIF since 2008.

### Feeding observations

We used two methods to collect feeding data: incidental feeding observations from October 2009 to August 2013, and transects with controlled search effort during three periods: January–April 2011, February–April 2012 and March–August 2013. For logistical reasons the transect survey period fell at the end of or after the breeding season (November–February) every year. Weather during the study period was typical for the seasons, but October 2011 and January 2012 were unusually wet months.

Consumed plants were identified with binoculars and by examining dropped food items (the latter required many dropped items to be found and collected to distinguish between accidentally dropped items and actively discarded plant parts). The following parameters were recorded for all feeding observations: time, location, observer, food plant species, plant part(s) consumed, number of parrots feeding, and duration of feeding bout. Following other studies we counted feeding observations in bouts; a 'feeding bout' consists of at least one parrot feeding on one or more parts of a certain species, without taking the number of parrots or the time spent feeding in account (Pizo et al. 1995; Renton 2001; Ragusa-Netto 2007). We also recorded the 'parrot feeding time' or 'resource exploitation' for each bout, which is calculated from the number of feeding individuals multiplied by the number of minutes spent feeding (Kristosch and Marcondes-Machado 2001) and is measured in parrots\*feeding minutes. Although this measure is intuitively more representative of the importance of food resources, it is not widely used; most studies assume that number of bouts reflects resource use. We used this measure to check this assumption for our data.



**Figure 1:** Study area with feeding transects, Praslin National Park and Vallée de Mai

Incidental feeding observations were not randomised, i.e. all parrots seen feeding in the course of parrot fieldwork were recorded regardless of time or location.

Due to the low density of parrots across most of Praslin Island, transects were located in areas of high parrot activity using results from a population survey (Reuleaux et al. 2013). Twenty-five transects of c. 800 m length were chosen in 13 locations with known parrot activity and presence of fruiting trees. Habitat type of the transects was determined in the field for each 100 m section using the following categories: (1) palm forest (67–100% endemic palms, canopy height  $\geq 6$  m, canopy cover  $\geq 30\%$ ); (2) mixed forest (any other forest with canopy height  $\geq 6$  m, canopy cover  $\geq 30\%$ ); (3) native scrub (majority of plants native, canopy cover  $< 30\%$  and/or canopy height  $< 6$  m); and (4) cultivated/residential (residential areas, farmland and other land uses). Transects were positioned to cover equal lengths of the four habitat types. In 2011, 19 of the 25 transects were surveyed and the ratio of habitat types for that year was corrected by randomly excluding data from transect sections of the over-represented habitat types.

Transects followed footpaths, firebreaks and roads because difficult terrain did not allow walking off-track while concentrating on detecting parrots. Due to the density of the vegetation the visually surveyed area per walked distance was limited and, in combination with the low density of feeding parrots, it was necessary to include aural detections in the survey. In 2011 each of the 19 transects was walked four times, twice in the morning (06:00–10:30) and twice in the late afternoon (15:30–18:30), during hours of high *C. barklyi* activity (Reuleaux et al. 2013). With increased knowledge of the parrots' behaviour the methods were improved in 2012 and 2013 by including two more time slots in the middle of the day, to investigate potential diurnal movements between habitat types, resulting in four time slots at 06:00–09:30, 09:30–12:00, 12:00–15:30 and 15:30–18:30, which were all surveyed once on each transect each year. Transects were not surveyed in moderate or heavy rain or strong winds. Walking speed was c. 1 km h<sup>-1</sup>. Attempts to locate parrots heard within 50 m of the observer were made and transects were left for this if necessary. If the parrot was not found within 5 min the transect was resumed. Each feeding observation was counted as one feeding bout, regardless of the number of parrots. If the birds stopped feeding on one plant and moved to a different species or a tree of the same species  $> 20$  m away, a new feeding bout started and was marked as a second record for the same individual(s). Feeding parrots were followed until they were lost. Non-feeding parrots were abandoned after 3 min.

Between January and April 2011 both methods were carried out in parallel by two different observers. Only these data were used for comparison of the methods.

### Statistical analysis

All means are presented  $\pm 1$  SD unless stated otherwise. We used two data sets: transect data (bouts observed on all transects) and incidental data (bouts observed incidentally). All statements requiring representative sampling are based on the transect data set. For comparison of the methods

we created two subsets: incidental feeding observation data collected from January to April 2011 were compared with the data collected from feeding transects during the same period. We used a two-sided Fisher's exact test with simulated *p*-value (Monte Carlo simulation based on 2 000 replicates) to compare frequency of plant species in number of feeding bouts between the two methods. To ensure that samples from the feeding transect data were independent, we used only the first bout of each individual and tree.

Pearson's product-moment correlation with log-transformed variables was used to confirm if the number of feeding bouts reflects the parrots' feeding time (or 'resource exploitation' = parrots\*feeding minutes).

Statistical analysis was performed using R version 2.10.1 (R Development Core Team 2013) with packages 'reshape', 'chron' and 'psych' (Wickham 2007; James and Hornik 2013; Revelle 2013). Rarefaction and species accumulation curves were produced using the 'vegan' package (Oksanen et al. 2013) and the function 'rarefaction' (Jacobs 2009). A Lomolino model was fitted to the food species accumulation and used to calculate the asymptote for the number of food species (Lomolino 2000; Tjørve 2003).

### Results

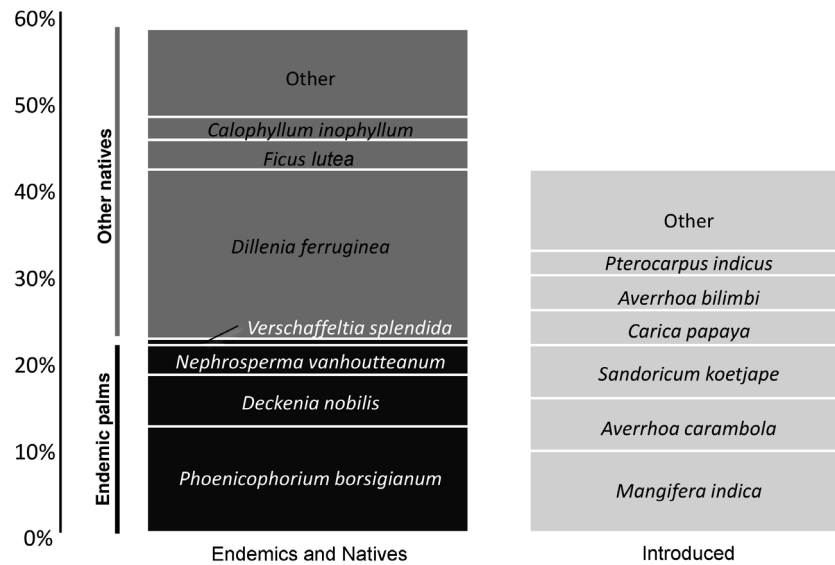
A total of 1 903 incidental feeding observations were recorded between November 2009 and August 2013, predominantly in the Vallée de Mai. Over the whole study period the incidental method rendered more observations than the transect approach (148). During our study 46 plant species were observed to be eaten by *C. barklyi*, bringing the total observed (including previous studies) to 53 plant species from 43 genera and 28 families that have been documented to be consumed by *C. barklyi* (Table 1). The asymptote of a species accumulation curve produced by a Lomolino model using all observations is 73.4 species. Twelve of these food species were observed to be eaten only once by parrots. Twelve of the consumed plant species are endemic to Seychelles, 12 others are native and 29 have been introduced.

The transect method showed that the majority (58%) of feeding bouts was on endemic and native plant species (Figure 2). Endemic palm species accounted for almost one-quarter of parrot feeding bouts and *Dillenia ferruginea*, a widespread endemic broadleaf, was the most consumed species.

Parrots were observed feeding on fruits, buds, seeds, flowers, leaf petioles, bark and scale insects. Fruits were targeted in 68% of the observations, buds in 15%, seeds in 38%, and flowers, leaves, bark and scale insects were each consumed in  $< 1\%$  of observations. Percentage of fruits consumed was higher on endemics (81% on palms, 79% on other endemics) than on introduced species (61%; aov  $F = 3.03$ ; Tukey HSD,  $p$  adj = 0.045). Fruits and seeds were eaten ripe (29%) or unripe (19%), while ripeness stage remained unknown in 52% of feeding bouts. Food processing habits were particularly notable on endemic palm fruit as little substance appeared to be consumed: for example, unripe palm fruit (*Phoenixophorium borsigianum* and *Nephrosperma vanhoutteanum*) before seed development were picked, punctured and then dropped; after picking

**Table 1:** Plant species documented to have been eaten by *Coracopsis barklyi* on Praslin Island showing status (E = endemic to Seychelles, N = native to Seychelles, I = introduced to Seychelles), part eaten (Fr = fruit, ur = unripe, rp = ripe, bd = bud, sd = seed, lf = leaf [usually only the petiole], si = scale insect from leaf, fl = flower), and source (1 = Gaymer et al. 1969, 2 = Evans 1979, 3 = Walford 2008, 4 = Rocamora and Laboudallon 2009, 5 = this study)

Family	Scientific name	Vernacular name	Status	Part eaten	Source
Anacardiaceae	<i>Mangifera indica</i>	Mango	I	Fr(ur, rp), Bd	2, 4, 5
	<i>Spondias dulcis</i>	Golden apple	I	Fr(ur)	2, 3, 4
Asclepiadaceae	<i>Tylophora indica</i>	Indian ipecac	I	Fr	4
Bignoniaceae	<i>Colea seychellarum</i>		I	Fr	1, 2
Bombacaceae	<i>Ceiba pentandra</i>	Kapok	I	Bd, Fl	2, 4, 5
Caricaceae	<i>Carica papaya</i>	Papaya	I	Bd, Fl, Fr(rp)	4, 5
Casuarinaceae	<i>Casuarina equisetifolia</i>	Common ironwood	N	Sd, Fr(ur)	3, 4, 5
Chrysobalanaceae	<i>Chrysobalanus icaco</i>	Coco plum	I	Fr	2, 5
Clusiaceae	<i>Calophyllum inophyllum</i>	Takamaka	N	Bd, Fl, Si	5
Combretaceae	<i>Terminalia catappa</i>	Indian almond	N	Fr (rp)	5
Cyperaceae	<i>Lophoschoenus hornei</i>		E	Sd	5
Dilleniaceae	<i>Dillenia ferruginea</i>	Red wood	E	Fr(ur, rp), Sd, Bd, Lf	2, 4, 5
Erythroxylaceae	<i>Erythroxylum sechellarum</i>		E	Fr (ur), Lf, Bd	5
Euphorbiaceae	<i>Phyllanthus acidus</i>	Gooseberry tree	I	Sd, Si	5
	<i>Phyllanthus pervilleanus</i>	Kastik	N	Fr(ur, rp), Bd, Sd	3, 5
Fabaceae	<i>Delonix regia</i>	Flamboyant	I	Fl	5
	<i>Pterocarpus indicus</i>	Dragon tree	I	Bd, Ba	5
	<i>Tamarindus indicus</i>	Tamarind	I	Sd, Fr	3, 5
Goodeniaceae	<i>Scaevola sericea</i>	Beach naupaka	N	Lf, Fl	5
Lamiaceae	<i>Premna serratifolia</i>	Premna	N	Bd	5
Lauraceae	<i>Cassytha filiformis</i>		N	Fr	5
	<i>Cinnamomum verum</i>	Cinnamon	I	Fr, Bd	5
Melastomataceae	<i>Memecylon eleagni</i>		E	Fr(ur), Sd	5
Meliaceae	<i>Azadirachta indica</i>	Neem tree	I	Fr	5
	<i>Sandoricum koetjape</i>	Santol	I	Fr(rp)	4, 5
	<i>Swietenia macrophylla</i>	Big leaf mahogany	I	Bd	5
	<i>Swietenia mahagoni</i>	West Indies mahogany	I	Bd	5
Mimosaceae	<i>Adenanthera pavonina</i>	Red sandalwood	I	Fr, Sd, Bd	5
Moraceae	<i>Ficus bojeri</i>		E	Fr	5
	<i>Ficus lutea</i>	Giant-leaved fig	N	Fr, Sd	1, 5
	<i>Ficus rubra</i>	Fig	N	Fr	2, 3
	<i>Syzygium cumini</i>	Jamun	I	Fr(rp)	2, 4, 5
Myrtaceae	<i>Psidium cattleianum</i>	Strawberry guava	I	Fr(ur, rp), Sd	1, 2, 5
	<i>Psidium guajava</i>	Common guava	I	Fr, Sd	3, 4, 5
	<i>Syzygium jambos</i>	Jambrosade	I	Fr	2, 5
	<i>Syzygium malaccense</i>	Malay apple	I	Fr(rp), Fl	4, 5
	<i>Syzygium samarangense</i>	Bell fruit	I	Fr, Sd	5
	<i>Syzygium wrightii</i>		E	Fl, Lf	1, 2, 4, 5
Oxalidaceae	<i>Averrhoa bilimbi</i>	Bilimbi	I	Sd, Fr(ur, rp)	1, 2, 3, 4, 5, 5
	<i>Averrhoa carambola</i>	Star fruit	I	Sd, Fr(ur)	3, 4, 5
Palmae	<i>Cocos nucifera</i>	Coconut palm	N	Sd, Fr(ur)	3
	<i>Deckenia nobilis</i>	Cabbage palm	E	Fr(ur, rp), Bd	1, 2, 3, 5
	<i>Nephrosperma vanhoutteanum</i>	Seychelles palm	E	Fr(ur, rp), Bd	2, 5
	<i>Phoenicophorium borsigianum</i>	Thief palm	E	Fr, Sd, Bd, Fl	2, 3, 5
	<i>Roystonea</i> sp.	Unidentified exotic palm	I	Fr(ur)	5
	<i>Verschaffeltia splendida</i>	Seychelles stilt palm	E	Fr(gr, rp)	2, 5
Passifloraceae	<i>Passiflora edulis</i>	Passion fruit	I	Fr, Sd	5
	<i>Passiflora suberosa</i>		I	Fr (ur, rp)	5
Polygonaceae	<i>Antigonon leptopus</i>	Coral vine	I	Fl, Fr	5
Rubiaceae	<i>Canthium bibracteatum</i>		N	Fr, Fl, Bd	5
	<i>Craterispermum microdon</i>		E	Fr(ur), Fl	4, 5
	<i>Paragenipa wrightii</i>		E	Lf, Bd, Fr(ur, rp)	5
Sapotaceae	<i>Pouteria obovata</i>		N	Fr(ur, rp)	5



**Figure 2:** Percentage of the most important food species of *C. barklyi* based on 148 observations on transect walks (2011–2013) with equal coverage of all habitat types; dark fill: endemic palm species; medium grey: other endemic and native species; light grey: introduced species

ripe fruit, parrots would first extract and drop the seed before scraping the bill inside the fruit and then drop the pulp as well. Dropped fruit parts did not visibly lack any flesh.

Among the food items, scale insects (Coccoidea), which the parrots scraped from leaves of *Calophyllum inophyllum* and *Phyllanthus acidus*, were the most unusual observations. This is the only invertebrate documented to be consumed by *C. barklyi*.

Larger exotic fruit targeted for its seeds (e.g. *Averrhoa bilimbi* and *A. carambola*) were regularly dropped before half the seeds had been extracted. Many fruits with a single bite mark were found underneath parrot feeding trees. *Mangifera indica* fruits were shared by several parrots.

Average group size during feeding transects was  $2.34 \pm 1.73$  (range: 1–9; 13 individuals was the maximum group size recorded during incidental observations). Feeding bouts lasted  $529 \pm 505$  s (range: 20–2 849 s) and each one comprised  $26.0 \pm 48.9$  parrot\*feeding minutes (range: 0.3–420, median = 11.9). The results from feeding bouts and parrots feeding time (parrot\*feeding minutes) were strongly correlated ( $r(27) = 0.77$ ,  $p < 0.00001$ ), indicating that it is legitimate to use number of bouts as an estimate for the extent to which a resource is used.

#### Habitat and time of the day

Despite equal sampling effort of transects in all habitat types, most feeding bouts were in palm forest (32%) and cultivated/residential areas (39%), followed by mixed forest (18%) and native scrub (11%). Food species and the proportion of endemics consumed depended on habitat type (Fisher's exact test:  $p < 0.001$  and  $p < 0.001$ , respectively), with more endemics consumed in palm forest (82%) and native scrub (88%) than in mixed forest (52%) and cultivated/residential areas (9%). The share of endemic palms among the food plants was much higher in palm forest (45%) and much lower in cultivated/residential areas (2%) than the other habitats.

The transect data show that observed feeding bouts were equally likely at all times of the day when pooling all habitats ( $\chi^2 = 3.73$ ,  $df = 3$ ,  $p = 0.29$ ). The likelihood of observations over the day, however, was influenced by habitat (Fisher's exact test:  $p = 0.003$ ): in palm forest, feeding observations occurred more often in the early morning and late afternoon than expected from the search effort, whereas in the middle of the day fewer bouts were observed ( $\chi^2 = 9.70$ ,  $df = 3$ ,  $p = 0.021$ ). The other habitat types did not show significant differences to the expected daytime distribution.

#### Comparison between incidental and transect methods

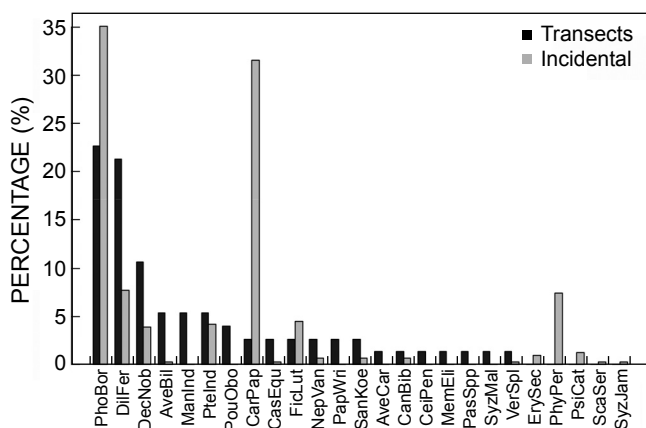
Between January and April 2011, the period when both methods were carried out in parallel, 311 incidental and 53 transect observations were collected. This corresponds to 17 and 19 different food species, and 1 264 and 385 parrot\*feeding minutes, respectively.

The proportions of plant species in the feeding bouts differed between the two methods (Fisher's exact test:  $p < 0.001$ ; Figure 3). After removal of all observations obtained in the Vallée de Mai car park (55), which was walked past several times a day, the results from the two methods still differed ( $p < 0.001$ ).

Over the four-year study period, species accumulation and rarefaction curves show that the incidental data set comes closer to an asymptote of total number of consumed species (Figure 4).

#### Discussion

The large number of plant species and parts on the list of *C. barklyi*'s food items indicates that it is a generalist frugivorous-granivorous-herbivorous feeder, similar to several other parrot species (Galetti 1993; Vaughan et al. 2006; Contreras-González et al. 2009). Since 12 of the plant species were only observed to be eaten once it is likely that further research will reveal more infrequently consumed

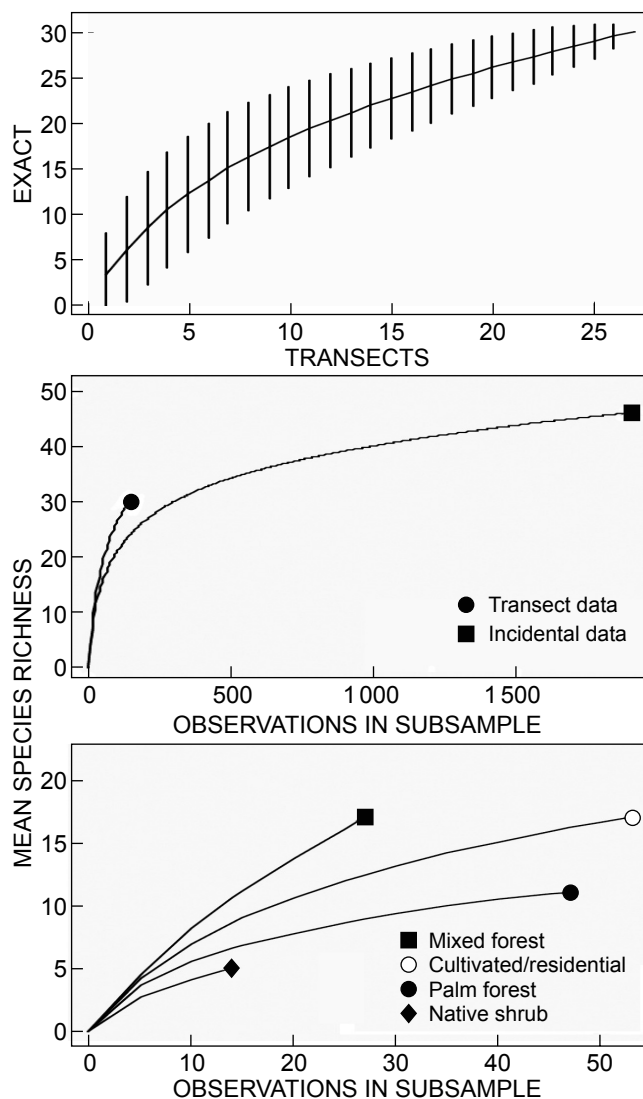


**Figure 3:** Percentage of total number of feeding bouts of each food species observed in transects and incidental observation methods (based on data from January–April 2011;  $n = 53$  [transects] and  $n = 314$  [incidental])

species, which is congruent with the asymptote of the species accumulation curve. The number of consumed species observed in this study is larger than in earlier studies of Seychelles Black Parrots (Gaymer et al. 1969; Evans 1979; Walford 2008; Rocamora and Laboudallon 2009) as expected with the longer survey period and substantial search effort. Bollen and van Elsacker (2004) found a similar number of species (40) to be consumed by *C. nigra* in Madagascar.

The Black Parrot's assumed tolerance for high tannin contents, known from *C. nigra* in south-eastern Madagascar (Bollen and van Elsacker 2004), makes them independent of ripeness in most fruits. This is an advantage for avoiding competition with other frugivores and granivores that rely on ripe fruit. According to the definition by Hulme and Benkman (2002), the Black Parrot should be considered a pre-dispersal seed predator for most species as it takes fruits before they are ripe and the seeds are either eaten and digested or destroyed. This is true for all regularly consumed introduced species. The consumption of ripe endemic palm fruit is a different case as the seeds are viable and are not consumed but usually dropped directly underneath the tree, making the parrot an inefficient seed disperser. The Black Parrot has potential to disperse seeds of the endemic *Versaffeltia splendida*, *D. ferruginea* and *Ficus lutea* because the fruits are eaten when ripe and occasionally carried before consumption; the seeds of the latter two species are small and often stick to the bill.

The proportion of plant parts consumed in this study differs from findings of *C. nigra* in Madagascar. Of the plant species observed to be consumed there, 68% of bouts were on seeds, 22% seeds and pulp, and 10% only pulp (Bollen and van Elsacker 2004). The proportion of species eaten for their seeds is much lower in our study. The vegetation in south-eastern Madagascar is fundamentally different from Praslin Island's and the overlap in food species is minimal (one). The low importance of seeds and in particular endemic palm seeds in the diet of *C. barklyi* is notable. In other parrot species, seeds often account for more than half of consumed plant parts (Forshaw 1989; Galetti 1993;



**Figure 4:** Seychelles Black Parrot food species accumulation curve (a) with increasing number of transects (exact method, 100 permutations), (b) rarefaction curves comparing number of consumed species between methods of data collections and (c) between habitats in the overall transect data set

Matuzak et al. 2008). Seeds have a high energy content and their consumption increases foraging efficiency (Hulme and Benkman 2002), so the fact that endemic palm seeds passed through the parrots' beaks but were then regularly discarded instead of consumed is surprising. In Seychelles, the fruit pulp of native plants is generally lower in energy content than invasive species (Kueffer et al. 2009), which may explain the parrot's attraction to introduced species. Inefficient foraging would explain food stress despite year-round availability of most consumed food plants.

In Bollen and van Elsacker's (2004) study of *C. nigra*, flowers played a similarly minor role as in *C. barklyi*, whereas Hampe (1989) described a shift from pure fruit consumption to c. 80% flower consumption in the course of his three-week study period in *C. nigra* in western Madagascar. Insectivory in parrots is not a new observation (e.g. Forshaw 1989;

Greene 1998; Renton 2001), including *Poicephalus* spp. (Perrin 2012), but it has never been documented for any *C. nigra*, *C. barklyi* or *C. sibilans* population. Kearvell et al. (2002) report that Orange-fronted Parakeets *Cyanoramphus malherbi* and Yellow-crowned Parakeets *C. auriceps* in New Zealand also consume scale insects.

In contrast to the results of this study, Evans (1979) concluded from his observations of parrot distribution (concentrated at the Vallée de Mai) that the endemic palm *V. splendida* was an important food source and could be a crucial factor for parrot feeding and distribution. We found no support for this claim. Only 2% of incidental and less than 1% of transect feeding observations were on *V. splendida* making it the least consumed of the four endemic palm species in our study. Seasonality may play a role; Evans' (1979) study period in August falls in our least surveyed period and 70% of our incidental observations on *V. splendida* were between October and December, when the fruits were ripe. Our data may underestimate the importance of this species as a food item; however, it is unlikely that a single species, which peaks in fruit production at the same time as most other food species, and is only moderately consumed when available, limits the distribution on a small island such as Praslin, where parrots travel half the island's width regularly.

#### **Relative importance of native and exotic species**

Despite covering a variety of habitats, the two species most commonly consumed by *C. barklyi*, comprising more than one-third of all observed feeding bouts, were endemics: *P. borsigianum* and *D. ferruginea* are particularly important due to their year-round high availability in most habitats. Some native species (e.g. *N. vanhoutteanum* and *Paragenipa wrightii*) seem to be preferred but are relatively rare and bear few fruits at one time: parrots in these trees rarely leave before all ripe fruits or buds have been consumed. Other species, such as *F. lutea* and *A. carambola*, promote communal feeding as they bear many fruits that ripen simultaneously, attracting large groups of parrots. Most but not all parrot food species are available year-round but neither of our methods covered the annual cycle sufficiently to allow conclusions across the whole year.

The relatively large proportion of introduced species in *C. barklyi*'s diet (39%) contrasts with the diet of *C. nigra* in Madagascar, which is only recorded to include one introduced species (Hampe 1989; Bollen and van Elsacker 2004). This could indicate a shortage of native food on Praslin Island or simply reflect availability, or a combination of both. Madagascar is a much larger island with higher species richness, a lower proportion of invasive plants and relatively higher availability of native species (Simberloff 1976; Kueffer et al. 2009). *Coracopsis sibilans* in the Comoro Islands shows similar habitat preferences to *C. barklyi* and feeds on introduced species in gardens (Stevens et al. 1992).

An increase in introduced plant species has been proposed as a reason for the increase in *C. barklyi* numbers and range (Rocamora and Laboudallon 2009) but not enough is known about the history of the Black Parrot's feeding habits in gardens and on farmland. Furthermore, conflicts with fruit farmers are thought to be a threat for

*C. barklyi* (Watson 1984; Rocamora and Laboudallon 2009). Particularly owners of *A. carambola* trees, which are more valuable than *A. bilimbi* and are eaten more wastefully than *M. indica*, complain about parrot damage to their fruit, demand compensation (Rocamora and Laboudallon 2009) and threaten to take action against the crop pest (AR, HR and TP pers. obs.).

#### **Diurnal feeding patterns**

It is common practice to conduct parrot feeding studies in hours of high parrot activity (Renton 2001; Ragusa-Netto 2007; Matuzak et al. 2008), which may be problematic if the study species prefers certain habitat types at different times of the day. Evans (1979) noted regular diurnal movements between the Vallée de Mai and coastal regions, which concurs with our observations of parrot traffic in the mornings and afternoons. Restricting our study to early mornings and late afternoons would have favoured palm forest species and underestimated the importance of garden species. Frequency of feeding observations is linked to detectability: in more open habitats parrots are detected more easily, even when not calling. Black Parrots call more frequently in the mornings and evenings (Gaymer et al. 1969; Reuleaux et al. 2013), making them easier to detect in closed habitats, such as palm forest. It is therefore possible that the low number of feeding observations in palm forest in the middle of the day was caused not by the absence of feeding parrots, but by our inability to detect them. Detectability does not, however, explain the absence of feeding parrots in native scrub in the late morning.

#### **Comparison between incidental and transect methods**

Incidental feeding observations render more observations per time unit because locations with the highest parrot feeding activity are targeted repeatedly. The much higher number of feeding observations from this method (six times as many bouts as in the transect approach) and its rarefaction curve, which approaches the asymptote, show that incidental observations are useful if the aim is to compile a list of consumed species. One should not conclude from incidental observations, however, that the results accurately reflect proportion of observed food species or plant parts in the diet, feeding duration or flock size. For example, in this research, a few favoured parrot feeding trees (*Carica papaya*), at the entrance to the Vallée de Mai, concentrated observers' efforts and had a clear impact on the incidental feeding observation data in that this species was substantially over-represented. If quantitative information is required, it is important to control for, or record, search effort, across habitats and times of the day (and season).

Incidental observation data has its uses, however, and with little additional effort can be collected alongside other work. One strength of this method is anecdotal information about rare incidents that can be important for small populations. Feeding on scale insects, for example, would not have been found had we only focused on transects. Furthermore, incidental observations can increase understanding of how food items are processed, e.g. determining exactly which plant part is eaten may require multiple observations and a good view, which is not

always possible from transects. Having different observers could have caused some differences between the methods but the divergence between them was so marked that it is unlikely to be the only reason.

Thus, the two methods are not mutually exclusive alternatives, but complementary. Deciding which method to adopt depends on the aims of the research. A transect survey provides data for quantitative questions, including identification of key food species, feeding preferences, group size and times of day, while incidental feeding observations can produce supporting information, help to clarify feeding strategies, and assist in compiling a non-prioritised list of food species in a short time, especially in cases where very little is known about a species' feeding ecology. Parameters such as feeding duration and number of individuals did not produce reliable information from incidental observations in this study.

### Conclusions and conservation recommendations

Our research underlines the importance of endemic palm species for the Seychelles Black Parrot, not only as breeding habitat, but also as ideal feeding habitat. Exotic species also play a role in the parrots' diet and may compensate for seasonal fluctuations in availability of native species. Year-round transect survey feeding data would determine seasonal changes in parrot feeding habits and, in combination with ongoing phenology monitoring, provide more insight into seasonal food shortages and potentially breeding fluctuations.

To ensure sufficient year-round food availability for *C. barklyi* on Praslin, and for potential translocations to other islands, the abundance of palms and native food species in mixed forest and scrub should be increased. For apparently preferred native species with locally limited availability, e.g. *N. vanhoutteanum*, *F. lutea* and *P. wrightii*, supplementary planting should be considered. Planting exotic fruit trees to increase food availability, as has often been suggested by the general public, is not recommended. Not only are endemic and native trees more important food sources for the parrots, planting of exotics counteracts the principle of a flagship species and may increase, not lessen, conflict with local farmers. Increased public education efforts would help to raise awareness among fruit tree owners that parrot-caused damage is relatively limited and may trigger greater understanding and appreciation of the Seychelles' national bird.

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