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Christie A Craig, Cayley A Hunter, Adrian JFK Craig, Patrick E Hulley

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AVIAN BIOLOGY

BIRDS FEEDING ON ALOE NECTAR: DO CAMERA TRAPS AND POINT COUNTS PRODUCE COMPARABLE DATA?

Christie A Craig, Cayley A Hunter, Adrian JFK Craig, Patrick E Hulley

Department of Zoology & Entomology, Rhodes University, Grahamstown, 6140

Corresponding author: a.craig@ru.ac.za

Introduction

Aloes are a major source of nectar during winter in many regions of southern Africa (Cousins & Witkowski 2012), and provide both food and water during this resource-scarce season (Symes et al. 2011). *Aloe ferox* is a perennial succulent, growing to a height of 2-3 meters, often in dense stands. Flowering occurs from May to August (Jeppe 1974, Cousins & Witkowski 2012). While both insects, particularly the African honey bee *Apis mellifera*, and birds frequently visit the flowers, birds are the most important pollinators (Hoffman 1988, Botes et al. 2008).

Avian nectarivores can be categorised as generalist or occasional nectarivores and specialist or true nectarivores; we use the terms "occasional" and "true" nectarivore in this paper. Sunbirds (Nectariniidae) are true nectarivores, specially adapted to feed on nectar as their primary source of food. Occasional nectarivores such as the weavers (Ploceidae), mousebirds (Coliidae), bulbuls (Pycnonotidae) and white-eyes (Zosteropidae) feed opportunistically on nectar but do not depend on it as their primary food source; a wide variety of such bird species will feed on aloe nectar when it is available (e.g. Engelbrecht et al. 2014).

Figure 1 – Male Malachite Sunbird feeding, as photographed by camera trap.

A patch of winter-flowering *Aloe ferox* at the study site was surveyed by point counts before, during and after the flowering event for five years. In each year during peak flowering birds were three to five times more abundant than before and after flowering, and this

increase was related to an influx of both true and occasional nectarivores (Kuiper et al. 2015). Point counts provide only brief snapshots of the bird population, so in 2014 we employed camera traps to investigate whether continuous records through the day would provide a different picture of flower visitors (Fig. 1 - 3). Camera trapping has many potential applications in ornithology (O'Brien & Kinnaird 2008), and has already been used to study the pollinators of some aloe species (Arena et al. 2013).

Figure 2 – Malachite Sunbird singing, as photographed by camera traps.

Figure 3 – Female Red-winged Starling with heavy pollen load, as photographed by camera traps.

Study site
Hounslow Farm (33° 12' S 26° 25' E) lies 22 km north-west of Grahamstown in the Eastern Cape, South Africa. The *Aloe ferox* patch covers approximately 17.5 ha. Peak flowering varies between years but usually occurs in July, with between 15 and 62 per cent of aloes in flower at this time (Kuiper et al. 2015). Sheep and goats graze here, but do not feed on the aloes. The study area lies on the border of the Nama-Karoo and Albany Thicket biomes. The dominant vegetation types are Albany Broken Veld (characterized by open grassy karroid dwarf scrubland with low trees) and Albany Thicket (characterized by succulent euphorbias and aloes with a woody under-storey) (Mucina & Rutherford 2006). There is no distinct wet season, but rainfall is higher from February-March and from August to October. The average annual rainfall is < 500 mm per annum and frost can occur in winter (South African Weather Services 2013).

Methods
We surveyed the aloe patch from the 5 April to 1 August 2014 using both point counts and camera trapping. This covered the time from just before aloe flowering until most aloes were going to seed.

Point counts
There were six points, three on either side of a farm track and 150 m apart, located in the same positions as the previous surveys (cf. Fig. 1 in Kuiper et al. 2015). The points were identified using a handheld GPS (Garmin Etrex Handheld GPS Navigator, Southern Africa). The count radius around each point was 30 meters, measured using a Nikon Laser 800S range finder. All birds within this radius were identified visually with 10 x 40 binoculars or by call, but raptors, water birds and aerial foragers were excluded. Cape Weavers *Ploceus capensis*, Village Weavers *Ploceus cucculatus* and Southern Masked Weavers *Ploceus velatus* were in eclipse plumage during the sampling period, and these three taxa were lumped together as weavers *Ploceus sp*.

Sampling took place on the following days: 5 April, 25 April, 10 May, 24 May, 5 June, 25 June, 7 July, 29 July. Sampling at each point involved a two minute settling-down period to allow the birds to adjust to the arrival of the observer, followed by eight minutes of recording (Bibby et al. 1992, Buckland 2006). There were three counts on each day one at 8:00, 12:30 and 15:30 to take temporal patterns in bird activity into account.

Aloe surveys
As an index of flowering, all the aloes within 10 meters of each point count site were inspected and categorized as budding, flowering (presence of open flowers on raceme), frosted (flowers or buds damaged by frost), seeding, or inactive.

Camera trapping
Bushnell HD Trophy Cam camera traps with 8 GB memory cards were placed near aloes in a suitable flowering stage (at least some budding or flowers) and at a height of 2-3 m (to include the entire branched inflorescence structure in the photographs). Each camera was attached to a metal pole securely planted in the ground, and set to take photographs at 10 second intervals. Photographs were downloaded and cameras repositioned every two weeks. In total 11 aloe plants were photographed over 17 fortnightly cycles, as in April and during the first two weeks of May only one suitable plant was available. In June and July four cameras were in operation at a time.

Blank images sometimes resulted from camera movement during wind, and in some cases cameras had been reset to default date and time settings apparently after disturbance by animals or weather. There were 764 photographs of sheep and goats and 53 of wild mammals; 2432 photographs of birds were available for analysis (Fig. 1 - 3).

Camera data processing

All bird photographs were imported into Camera Base 1.6 (Free Software Foundation Inc., San Diego, California), and the "events feature" was used to avoid overestimating the number of bird species and individual birds photographed. After 15 seconds a bird was considered to represent a new individual.

Data analysis

Feeding guild

We assigned the birds to three feeding guilds: non-nectar feeders, occasional nectar feeders and true nectar feeders, using the dietary information in Hockey et al. (2005), our own observations, and records by Engelbrecht et al. (2014). We compared the numbers of true and occasional nectarivores recorded each month from April to July by cameras and counts. The analysis was run in R using Spearman's rank order correlation.

Species present

The total number of each species recorded by cameras was compared with the species counts in the point counts using a Spearman's rank order correlation test in R Version 3.2.0. (R Development Core Team 2014). Due to smaller sample sizes in April and May, the data were divided into pre-flowering (April and May) and peak-flowering (June and July). Non-nectar feeders were removed from the data set for this analysis since they were hardly ever recorded by the cameras.

Results

The highest proportion of aloes flowering was observed at the beginning of July (Fig. 4). Up to 80% of the aloes had formed buds, but a much lower proportion of aloes flowered (16.5%) due to frost in June which damaged 38% of the aloes. Streaky-headed Seedeaters *Crithagra gularis* were also frequently recorded feeding on the buds, later on flowers and seeds of the aloes. In spite of this, the avian community responded strongly to the aloe bloom, and the number of individual birds recorded by both counts and cameras increased from May to July (Table 1). The number of individuals recorded increased as more aloes came into bloom. Except in May, point counts recorded more nectar feeding species than camera traps (Table 1).

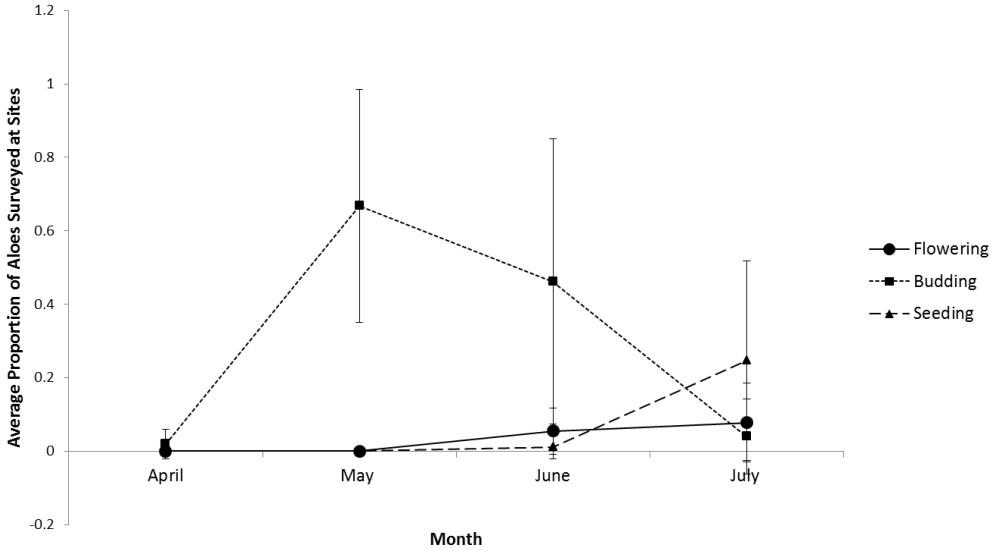

Figure 4 – The average proportion of the aloes within a 30 meter radius of each point count station in bud, flowering and in seed, from April to July 2014

The relative abundance of non-nectar feeders at the site varied little, while occasional and true nectarivores increased in abundance as more aloes came into bloom (Fig. 5). As more cameras were in use during peak flowering, this would influence the trends in this data set.

	Number of birds *n*	Number of taxa (*S*)
Counts April	45	12
Cameras April	43	7
Counts May	20	9
Cameras May	89	9
Counts June	95	13
Cameras June	314	6
Counts July	130	14
Cameras July	336	9

Table 1 – The number of individual birds (*n*) and species (*S*) record by counts and cameras from April-July 2014

From April to July a total of 32 species was recorded during point counts, of which 19 have not been recorded feeding on *Aloe ferox* nectar, while 12 species were captured by the cameras. The camera traps recorded *Ploceus* weavers most frequently, followed closely by Malachite Sunbirds *Nectarinia famosa* and Speckled Mousebirds *Colius striatus*. Malachite Sunbirds were the nectar-feeding species most often recorded during point counts, followed by *Ploceus* weavers and Red-winged Starlings *Onychognathus morio*. Throughout the sampling period the cameras captured just one non-nectar feeding species, a Familiar Chat *Cercomela familiaris*, on one occasion in July (Fig. 6). This species is a common resident, which frequently perches on elevated vantage points. The frequencies of species recorded by the two methods differ notably for *Ploceus* weavers and Speckled Mousebirds, but the high number of Speckled Mousebirds in the camera trap data was largely due to one event where 13 individuals were recorded on a single photograph.

During peak flowering count and camera species numbers were significantly correlated (ρ_{20} = 0.5; p = 0.02). Thus point counts and camera data showed similar frequencies of true and occasional nectarivores known to feed on *Aloe ferox* from April to July. Of the 15 species which are known to feed on *Aloe ferox* recorded at the site, 10 were recorded by both the cameras and point counts (Fig. 4). Three species, Karoo Prinia *Prinia maculosa*, Yellow-fronted Canary *Serinus mozambicus* and Southern Double-collared Sunbird *Cinnyris chalybeus* were recorded only during point counts (Fig. 4), while Black-headed Oriole *Oriolus larvatus* and Green Woodhoopoe *Phoeniculus purpureus* were recorded only by the cameras.

Discussion

The influx of both occasional and true nectarivores to flowering aloes has been reported in previous studies (Botes et al. 2008, Symes et al. 2008, Arena et al. 2013, Engelbrecht et al. 2014, Kuiper et al. 2015). For *Aloe marlothii* in the Suikerbosrand Reserve near Johannesburg, the peak flowering period in August corresponded to an increase in the diversity and abundance of the bird community (Symes et al. 2008). A wide range of birds visited the aloe patch and 59 % of the species fed on nectar, but the majority of the birds were occasional nectarivores and very few true nectarivores were recorded (Symes et al. 2008). The African Red-eyed Bulbul *Pycnonotus nigricans* and the Cape Weaver were the most commonly recorded species at this site (Symes et al. 2008).

The proportion of aloes flowering at Hounslow in 2014 was low in comparison to previous surveys, when between 15 and 62% of the aloes were flowering at their peak (Kuiper et al. 2015). However, there was still a marked increase in the numbers of nectar feeding birds recorded by point counts as in previous years. Point counts in

May recorded few species, which was attributable to the weather conditions. One sampling day in May was particularly cold and windy, which appeared to reduce both foraging and movement of birds at the patch. This is where camera traps can be advantageous, as they provide a continuous sample so that factors such as bad weather on particular days are not as relevant to sampling.

While the majority of species known to feed on *Aloe ferox* nectar were recorded by both methods, the exceptions are of interest. The Yellow-fronted Canary was only recorded once during the point counts, so this record can be seen as a chance encounter. However the Karoo Prinia was recorded on a number of occasions during point counts, most frequently at two stations where aloe density was low. While this species has been recorded feeding on *Aloe ferox* nectar, it is primarily an insectivore (Hockey et al. 2005, Forbes et al. 2009). The Southern Double-collared Sunbird (a true nectarivore) is uncommon at Hounslow even though it is known to feed on *Aloe ferox* nectar, and Southern Double-collared Sunbirds were seen feeding on mistletoe and *Aloe striata* during our observations. This small sunbird may have been displaced by larger birds at *Aloe ferox.* Malachite Sunbirds in particular spend much of their time chasing both conspecifics and other species.

The cameras recorded Green Woodhoopoe and Black-headed Oriole, which were not recorded during point counts in 2014. Green Woodhoopes have been recorded feeding on the nectar of *Erythrina* flowers and *Aloe marlothii*, while Black-headed Orioles regularly feed on *Aloe marlothii* (Guillarmod et al. 1979, Engelbrecht et al. 2014). Green Woodhoopoes seem to visit the Hounslow site to feed on nectar, since they were seen only during the flowering period in previous years (Kuiper et al. 2015). Black-headed Orioles have been seen feeding on *Aloe ferox* at this site and elsewhere in previous years (Forbes et al. 2009). Thus here the cameras provided supplementary data on the species actually feeding on nectar. The camera records of more Speckled Mousebirds than Red-faced Mousebirds *Urocolius indicus* were rather surprising, as in previous years the Red-faced Mousebird has been more commonly recorded both in point counts and in mist-net captures (Craig et al. 2015). This may suggest that we have underestimated the frequency of Speckled Mousebirds as occasional nectarivores at this site.

The camera trap data showed that *Ploceus* weavers fed most frequently at the aloes, while the point count data suggested that Malachite Sunbirds were visiting the aloes more frequently than *we*avers. This could be an effect of sampling bias. During point counts in June and July, we often saw flocks of *Ploceus* weavers just beyond our 30 metre count radius. It is possible that the weavers kept away from aloes in the presence of the observers, whereas the sunbirds fed more readily close to people. A major advantage of camera traps is that they will capture species which are shy of humans. Male Malachite Sunbirds in their metallic green breeding plumage are visually striking, and this could also result in the more conspicuous Malachite Sunbirds being recorded more frequently than the duller weavers. Conspicuousness is a known source of error in point counts (Herremans 1995).

The dominance of Malachite Sunbirds and weavers during the aloe bloom matched the point count data from previous years (Kuiper et al. 2015). Botes et al. (2008) recorded birds feeding on five aloe species, including *Aloe ferox,* in the Gamtoos River Valley (Eastern Cape, South Africa), where they also found that the most frequent visitors were weavers *Ploceus* sp. followed by Malachite Sunbirds and Speckled Mousebirds. It has been suggested that plants producing dilute nectar will attract occasional nectarivores rather than true nectarivores, which prefer more concentrated nectar (Botes et al. 2008, Brown et al. 2010). Symes et al. (2008) and Arena et al. (2013) drew similar conclusions from their studies of *A. marlothii* and *A. peglerae. Aloe ferox* produces nectar comparable in quantity and

concentration to *A. marlothii* (*A. ferox:* 180 µl per flower with 8 - 12.6 % sugar content, *A. marlothii:* 250 µl with 12% sugar content) and has a similar floral structure to *Aloe marlothii.* However, *Aloe ferox* does attract large numbers of Malachite Sunbirds, a true nectarivore (Hoffman 1988, Kuiper et al. 2015).

This paper represents a single season of camera trapping at aloes. We found that point counts recorded more species and therefore gave a broader picture of species diversity in the area. The differences between the two methods indicate caution in relying on just one method for this type of survey. Since camera traps focus on the aloes, they capture primarily birds feeding on nectar. The two methods should be regarded as complementary, since both an overview of the avifauna and the activity of individual species is important in analysing differences between seasons.

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Figure 5 and 6 to follow.

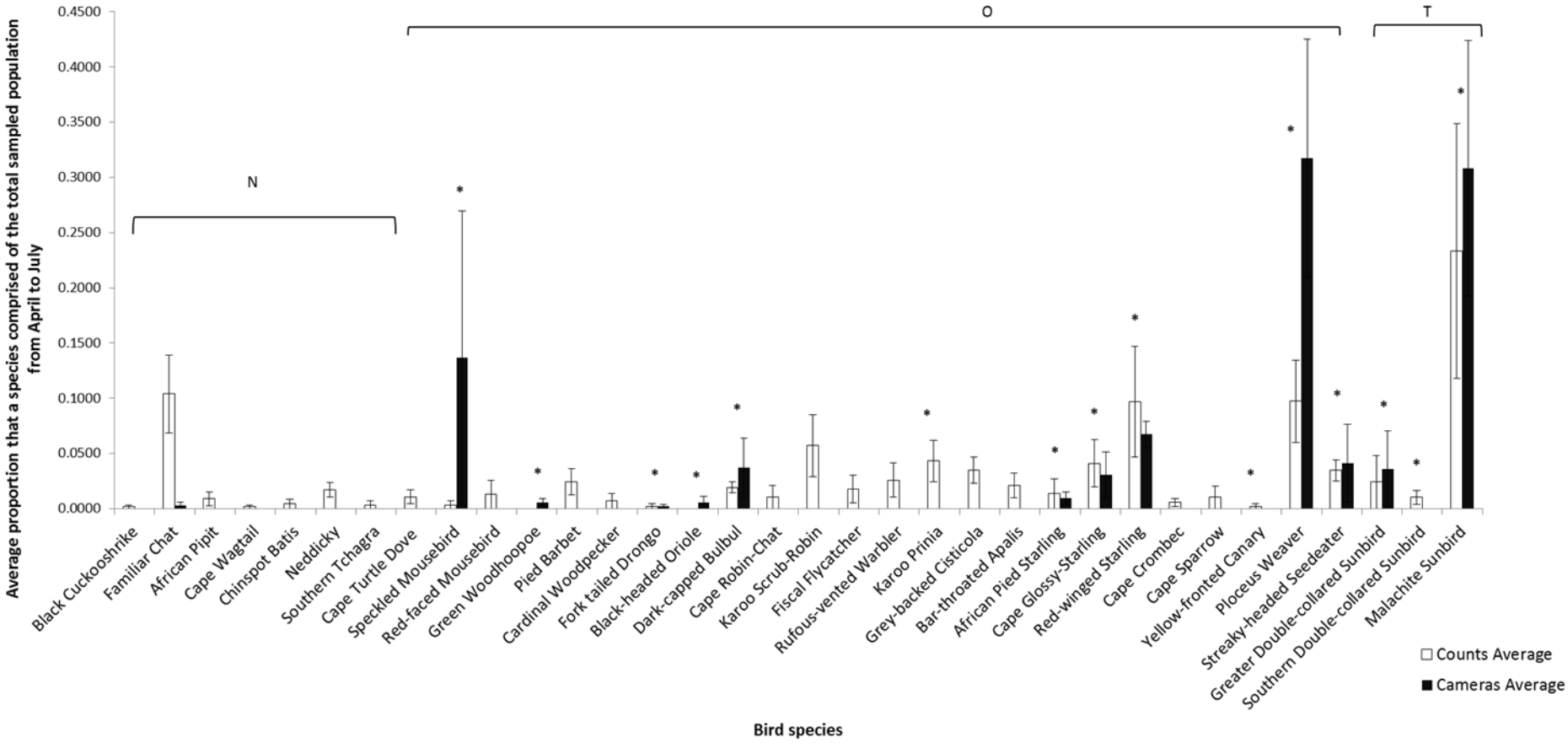

Figure 5 – The relative abundance of birds recorded from April-July 2014 using cameras and point counts (Error bars= standard error of the mean) (N = Non-nectar-feeders, O = Occasional nectarivores, T = True nectarivores).
* = Species has been recorded feeding on *Aloe ferox* according to Hockey *et al*. 2005, Forbes *et al*. 2009 & observations by authors.

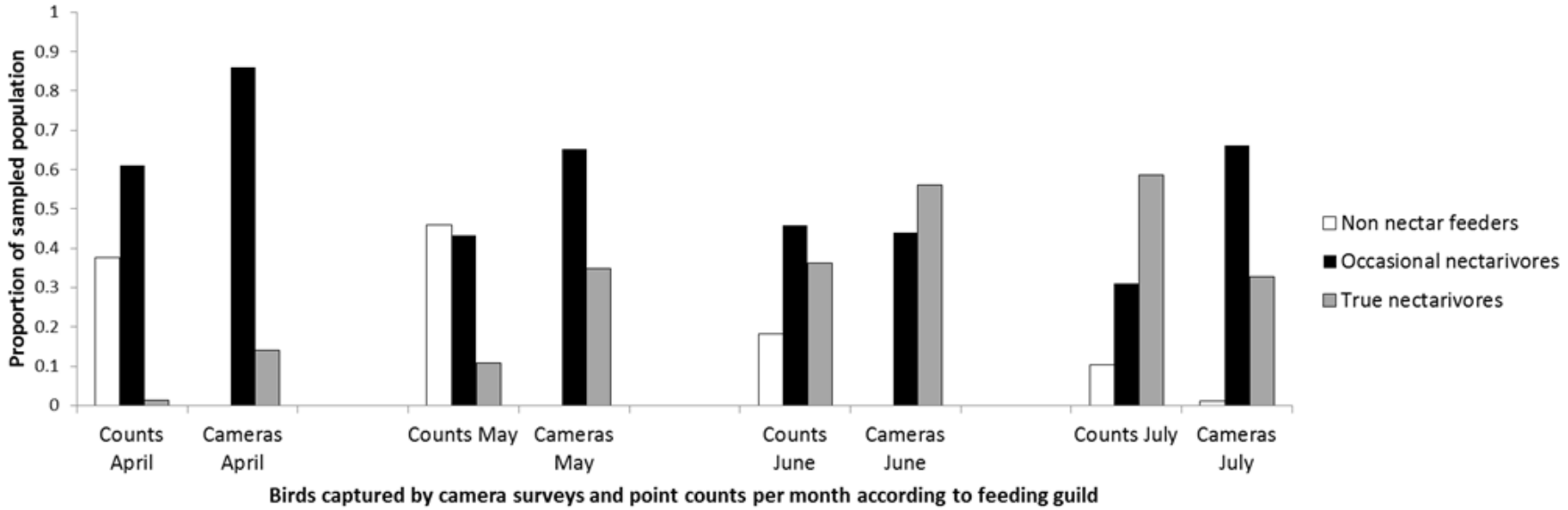

Figure 6 – The number of birds according to feeding guild recorded by cameras and point counts from April to July 2014