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Short Note

Preliminary Diet Analysis Reveals the Dispersal of an Exotic Plant by Two Native Bulbuls in an Early Successional Habitat, Krabi, Southern Thailand

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Frugivorous birds play a dominant role in mutualisms with plants as seed dispersers in the tropics[1,2]. The potential role of birds in seed dispersal can be investigated directly through diet studies [3-5]. Bulbuls (Family Pycnonotidae), are well known as generalist frugivores which feed on fruits of numerous plant species[3,6-9], and they are possibly the most important small-bodied seed dispersal agents in the Oriental region[1]. Furthermore, in the few regional studies available, bulbuls have been shown to be numerically dominant as visitors to fruiting plants in both primary[9] and successional habitats[10]. However, studies of seed dispersal by bulbuls are still few and investigations of diet of these bulbuls could provide valuable additional information on the role of bulbuls as seed dispersers.

Of particular interest is the role of dispersers such as bulbuls in the dispersal of exotic, invasive species[4,11]. The introduced shrub, *Clidemia hirta* for example has the potential to be dispersed by bulbuls given the plant's ecology. It is a shade tolerant, understorey species, which can be found in disturbed habitats, agricultural areas and along roadsides[12]. This plant has the ability to compete with native shrubs, and it is reported globally as an invasive species in the tropics[13]. *Cl. hirta* produces numerous berry fruits which can attract both native[14] and exotic frugivores[4,15]. It has been suggested that, possibly, the invasive *Clidemia* was mainly dispersed on the Silhouette Island, Republic of Seychelles by the indigenous bulbul, *Hypsipetes crassirostris*[14]. Thus, due to its ornitochoric fruit production and aggregated population, it is highly likely that native bulbuls in early successional areas of South-East Asia could include the introduced *Clidemia* in their diet. However, to date, there are no official reports of how this plant interacts with native frugivores in this region.

Red-eyed bulbul (*Pycnonotus brunneus* Blyth, 1845) and yellow-vented bulbul (*Pycnonotus goiavier* Scopoli, 1786) are common birds found in early successional

areas. They have similar body sizes which range from 24 to 37 g[8]. Although these birds are widely distributed in Southern Thailand, only *P. goiavier* can be found in central Thailand having a considerably wider distribution range than *P. brunneus*[8]. The aim of our study was to examine the diet of *P. brunneus* and *P. goiavier* in an early successional habitat and to quantify the composition of both native and introduced plants in their diets.

The study was conducted in the Khao Pra Bang Khram Wildlife Sanctuary, located in Krabi Province, southern Thailand (8°10' N, 98°80' E). The study site is approximately 20 hectares and is surrounded by continuous forest. There is a small stream which runs across the middle of the study site, although it remained dry from the end of February to the end of March 2012. The climate is classified as tropical wet seasonal[16] with an annual precipitation ca. 2,905 mm in the year of study (November 2011 to October 2012). The majority of rainfall (61.0%) occurred from mid April to October (rainy season) while less rain fell during November to March (39.0 %). The average minimum temperature was lowest in August and September (19.5°C) and peaked in April (20.8°C). The average maximum temperature was highest in February (33.5°C), and it was lowest in December (31.0°C). Majority of vegetation within the sanctuary, is lowland (25-100 m asl) tropical forest consisting of primary evergreen or seasonal forest, and mixed floras of hardwoods and bamboos[17]. This protected area is mostly surrounded by oil palm and rubber plantations, and small remaining forest patches. The study site consists of patches of grassland mixed with secondary growth in the protected area. Previously, the study area had been used illegally as cropland, and it was abandoned after establishment of the protected area approximately 25 years ago. The patches of grassland consist of a variety of weeds and grasses (e.g. *Ageratum conyzoides* L., *Imperata cylindrica* (L.) P. Beauv. var. major (Nees) C.E. Hubb. ex Hubb. &Vaugh. and *Eupatorium odoratum* L.), woody species (e.g. *Melastoma malabathricum* L. ssp. *malabathricum*). The pioneer tree species, *Callicarpa arborea* Roxb. var. *arborea*, is commonly interspersed in this grassland[17].

Pycnonotus brunneus and *P. goiavier* were captured with mist nets (2.5 x 9 m^2) in the study site two days per month from November 2011 to October 2012. During each trapping day, six mist nets were set adjacent to bird feeding routes near the forest edge, the center of grassy areas and near the stream where many bird species used for bathing. Mist nets were placed in these sites from 0700h to 1700h, with a total trapping effort of 1,440 net-hours. Mist nets were closed temporarily during strong winds or rain. All deployed mist nets were monitored every ten minutes to check if there were any birds trapped. If *P. brunneus* and *P. goiavier* were trapped, they were individually put in cloth bags (10 x 20 cm^2) for 30-45 minutes, longer than the

mean gut passage time of these bulbuls (23 minutes) (T. Kerdkaew, unpubl. data) to ensure that birds would defecate. All faeces were kept in 1.5 ml Eppendorf tubes and preserved with 70% ethanol. After faecal collection, birds were released nearby from where they were trapped. In the laboratory, all faeces were dried in petri dishes. Then the food contents were examined using a stereo microscope and sorted. The plant food items were identified to at least genus by comparing with a seed reference collection which was previously developed from the study site following plant nomenclature from a previous study of vascular plants in this area[17]. Animal remains could be classified only to Order because most were incomplete, rather than intact specimens. The presence of each food component was counted to estimate the percent frequency of occurrence (%F), percent volume (%V), and percent importance value (%IV)[18,19] by following these equations:

Percent frequency of occurrence (%F) = (frequency of each item/ total number of faeces) x 100

Percent volume (%V) = total percent volume of each item/ total number of faeces

Importance value = (%F x %V)/100

Percent importance value (%IV) = (importance value/$\sum$ importance value) x100

The percent volume (%V) of each diet item was determined by visual estimation to the nearest 1% in relation to other items in the same faeces. The food items present in very small amounts were estimated at 1% of volume. We used percent importance values (%IV) for describing the contribution of each food item because it has the benefit of describing food components that occurred frequently but in small amounts in the faecal samples[18].

We collected 35 and 31 faecal samples from *Pycnonotus brunneus* and *P. goiavier*, respectively. Based on the percent importance value (%IV) (Table 1), the diet composition of *P. brunneus* consisted of 97.0% plant items containing at least 13 plants species, and 3.0% comprised of animal parts all of which were insects. For *P. goiavier*, 98.9% of the samples consisted of plant material, of at least 10 species, and 1.1% of the diet components were insects. The three most important items of the *P. brunneus* samples were *Callicarpa arborea* (62.8 %), *Clidemia hirta* (24.7 %) and *Ficus* spp. (5.6 %), whereas in the *P. goiavier* samples, *Ca. arborea* (66.0%), *Melastoma malabathricum* (27.6%) and *Cl. hirta* (3.1%). The native pioneer tree, *Ca. arborea* was the main food resource of both bulbuls as it had the highest percent importance in the diet. Shrubs in family Melastomataceae contributed significantly to the diets of both bulbuls. *M. malabathricum*, a native shrub, was dominant in the diet of *P. goiavier* while

TABLE 1. The percent frequency of occurrence (%F), percent volume (%V) and percent importance value (%IV) of each food item in the faecal analysis of *Pycnonotus brunneus* (N=35) and *Pycnonotus goiavier* (N=31) in an early successional habitat at the Khao Pra Bang Khram Wildlife Sanctuary from November 2011 to October 2012. The plant species with asterisks denote alien species.

			Pycnonotus brunneus			***Pycnonotus goiavier***		
Diet types	**Order/Family**	**Species**	**%F**	**%V**	**%IV**	**%F**	**%V**	**%IV**
Plant Items	Phyllanthaceae	*Antidesma ghaesembilla* Gaertn.	5.71	3.21	0.62	9.68	5.64	1.18
	Phyllanthaceae	*Breynia vitis-ideae* (Burm.f.) C.E.C. Fisc.	-	-	-	3.23	0.81	0.06
	Flagellariaceae	*Flagellaria indica* L.	2.86	0.36	0.03	-	-	-
	Loranthaceae	*Scurrula parasitica* L.	-	-	-	3.23	2.42	0.17
	Melastomataceae	*Clidemia hirta* (L.) D. Don *	28.57	25.67	24.66	16.13	8.87	3.10
	Melastomataceae	*Melastoma malabathricum* L. ssp. *malabathricum*	5.71	1.27	0.24	45.16	28.2	27.55
	Moraceae	*Ficus chartacea* (Wall. ex Kurz) Wall. ex King	11.43	6.74	2.59	3.23	2.42	0.17
	Moraceae	*Ficus* sp.	11.43	7.86	3.02	-	-	-
	Myrsinaceae	*Ardisia quinquegona* Bl.	2.86	0.71	0.07	-	-	-
	Rhamnaceae	*Ziziphus oenoplia* (L.) Mill.	2.86	0.71	0.07	-	-	-
	Rubiaceae	*Ixora cibdela* Craib.	-	-	-	3.23	0.81	0.06
	Rubiaceae	*Lasianthus kurzii* Hk. f. var. *kurzii*	-	-	-	3.23	2.42	0.17
	Cannabaceae	*Trema orientalis* (L.) Bl.	2.86	0.14	0.01	-	-	-
	Lamiaceae	*Callicarpa arborea* Roxb. var. *arborea*	57.14	32.7	62.82	70.97	42.9	65.98
	Lamiaceae	*Vitex* sp.	8.57	8.57	2.47	-	-	-
	Costaceae	*Cheilocostus speciosus* (J.Konig) C.Specht	-	-	-	6.45	3.23	0.45
		Unknown species1	2.86	2.86	0.27	-	-	-
		Unknown species2	2.86	1.43	0.14	-	-	-
Animal items	Hymenoptera		8.57	3.21	0.93	-	-	-
	Coleoptera		2.86	2.14	0.21	-	-	-
		Other Insects	22.86	2.40	1.84	22.58	2.27	1.11

C. hirta, an alien shrub was common in the diet of *P. brunneus*. *C. hirta*, was also marginally present in the diet of *P. goiavier*.

Overall, *Pycnonotus brunneus* and *P. goiavier* were highly frugivorous as fruit contributed to more than 95% of their diets. This high level of frugivory with little insectivory especially outside the breeding period, is also found in other bulbuls including Chinese bulbuls (*Pycnonotus sinensis*)[20], red-vented bulbuls (*Pycnonotus cafer*)[21], red-whiskered bulbuls (*Pycnonotus jocosus*)[4,11]. However, the proportion of arthropods in the diet probably increases during the breeding season because protein is particularly important for developing offspring[22]. For example, it has been suggested that *P. sinensis* increased the animal component of the diet from 1.8% to 55% when breeding[20]. In addition, we observed seasonal fluctuations in the species of fruit consumed by these bulbuls, although our sample sizes were relatively small. *P. goiavier* fed mainly on *Callicarpa arborea* (IV 73%) during the wet season along with a small percentage of *Melastoma malabathricum* (5.4% IV), but the latter fruit (51%) become as important as the former fruit (46%) during the dry season. Similarly, when fruit of *Ca. arborea*, was less available during the dry season, *P. brunneus* feed much more on *Clidemia hirta* and *Ficus*. This seasonal variation appears to reflect the availability of fruit observed in the study area (T. Kerdkaew, pers. obs.).

Our findings indicated that both bulbuls fed primarily on successional plants both native and exotic and may play a key role in seed dispersal of these plants in this area. Invasive plants comprise the majority of the diet of the introduced red-whiskered bulbul (*Pycnonotus jocosus*) on Mauritius, approximately 53%[11] and on Reunion Islands (87%)[4]. Several studies indicate that bulbuls have a high degree of flexibility in their diets as they are found to consume numerous fruiting plants[3, 9]. Generally, bulbuls feed on fruits not larger than 1 cm, the maximum bulbul gape width, and the gape width of red-whiskered bulbul, *P. jocosus*, which has similar body size of our study species, is 9.7 mm[23]. When feeding on fruits, bulbuls typically swallowed them whole and carried seeds in their gut, which could also have additional positive effects on germination[3]. For example, it has been found that ingested seeds of *Clidemia hirta*, which passed through the bulbul gut, germinated faster than seeds that had not passed through the gut and also had higher germination success[15]. Quantitatively, red-whiskered bulbuls (*P. jocosus*) in Reunion Island could defecate up to 2,000 *Cl. hirta* seeds per dropping[4]. This evidence suggests that bulbuls can be effective seed dispersers of both native and exotic plants. We also observed other bulbuls, such as olive-winged bulbul (*P. plumosus*), and flowerpeckers, such as scarlet-backed flowerpecker (*Dicaeum cruentatum*) and orange-bellied flowerpecker (*D. trigonostigma*), feed on *Cl. hirta* (T. Kerdkaew, unpubl. data).

Currently, *Clidemia hirta* has been reported as an invasive species in South-East Asia. This exotic species can be found in dense colonies in secondary forests, forest edges, forest gaps, trails and also in open areas which are relatively moist and shady[24]. It has also invaded the understories of vast areas of secondary and primary forest in Singapore[25] and at Pasoh in Malaysia by competing with native plants that depend on gaps as their primary habitat for establishment[12]. In some areas of Thailand, this shrub has gradually expanded its distribution and has become a major weed in rubber and oil palm plantations (J. Sae Wai, pers. obs.). Invasive plants such as this can directly and indirectly affect native fauna. For example, the invasive plant, *Lantana camara* L., decreased the diversity of canopy and insectivorous birds in deciduous forest in southern India[26]. It is therefore extremely important to monitor the invasion of *Cl. hirta* into tropical forest of South-East Asia, a global biodiversity hotspot[27]. To date however, there is very limited literature available on the effects of invasive plants on native organisms in this region.

In South-East Asia, large areas of forest have been converted for agriculture especially rubber (*Hevea brasiliensis* Müell. Arg.) and oil palm (*Elaeis guineensis* Jacq.)[28] and thus causing habitat fragmentation[29,30]. Landscape fragmentation can cause significant increases in exotic plant dispersal, as some native frugivores predominantly forage in edge habitats where many invasive plants colonize[31]. Since exotic plants have the ability to alter landscape communities and often tolerate disturbance more than native plants[32], such interactions may accelerate the invasion process of *Clidemia hirta* in the lowland tropical forests of this region. Currently, it is still unknown whether the introduced *Cl. hirta* can alter native community interactions, and therefore further intensive studies as well as management are likely needed to control such alien plant invasions in lowland tropical habitats.

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