

Notes on Occurrence and Feeding of Birds at Crater Mountain Biological Research Station, Papua New Guinea

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Summary: During 1989–93, 170 species of birds were observed and 1787 individuals captured in mist nets at the Crater Mountain Biological Research Station, Chimbu Province, Papua New Guinea. Populations of many species fluctuated on annual or supra-annual schedules; 46 species were considered transients. Areas of the forest where many understorey trees had been removed exhibited reduced mist

net capture rates. Comparisons among four other sites in southern Papua New Guinea reveal striking similarities among sites in number of species and trophic organisation. Range extensions, weights and natural history observations are reported for many species. Feeding observations of nectarivorous and frugivorous birds at over 50 species of plant are reported.

In a review of the ecology of New Guinea's avifauna, Beehler (1982) reported that no long-term field studies had been carried out in diverse avian communities of New Guinea. Since then there has been some progress, mostly in lowland sites (Bell 1982a, 1982b, 1982c, 1983a, 1983b; Driscoll 1985). Most studies dealt with relatively short-term surveys (Gilliard & LeCroy 1966; Diamond 1972) or concentrated on a few species, such as the Paradisaeidae (Beehler 1983, 1988; Beehler & Swaby 1991; Diamond 1986; Pruett-Jones & Pruett-Jones 1986). In a comprehensive survey of the conservation status of world birds, 30% of the species listed as 'data deficient' were from New Guinea (Collar et al. 1994). The study of Papuan birds lags far behind those of most other tropical rainforests where multi-site comparisons of long-term studies are possible (Karr et al. 1990).

Middle elevations of the southern scarp in the main ranges of New Guinea and the Purari drainage are particularly poorly known (Beehler 1993). This paper reports preliminary efforts to remedy this and by identifying the resident avifauna of a rainforest site along the southern slope of the Central Ranges lays the foundation for longer-term studies at that site, and reports natural history observations.

Methods

Study area

The Crater Mountain Biological Research Station (CMBRS) lies within the Crater Mountain Wildlife

Management Area, a conservation project based on land-use management by the traditional Pawaiian and Gimi landowners. The station is 10 km east of Haia in Chimbu Province, Papua New Guinea (6°43.4'S, 145°5.6'E) at c. 900 m asl (Fig. 1). The principal study area lies within 850–1300 m asl and encompasses the transition from lowland to hill forest to lower montane forest (Paijmans 1972). The site receives about 6.5 m of rainfall annually with no pronounced seasonal variation (CMBRS unpubl. data 1989–93). A strict moratorium on hunting began with this study and continues to the present.

Most of the study area is primary forest but there were areas of regrowth from seven to more than 50 years old in abandoned gardens (in 1989 when the study began) and areas of secondary growth in natural disturbances (landslips and treefalls). The flora is very diverse with no markedly dominant tree species (ALM & DDW unpubl. data).

Field work was undertaken by observations and mist netting. We were in residence at the site from November 1989 to June 1993. Many interesting observations were made from the station buildings (Beehler et al. 1992) and more than 1000 observer-field-days were spent in a roughly 260 ha study area. Although most of this field time was devoted to other studies, this did not prevent extensive observations of birds (Mack 1994). Fruiting and flowering plants were monitored for short periods to observe visiting birds; mixed species flocks were followed and any unusual birds or unfamiliar vocalisations were tracked down whenever encountered. We are confident that we observed most of the resident avifauna.

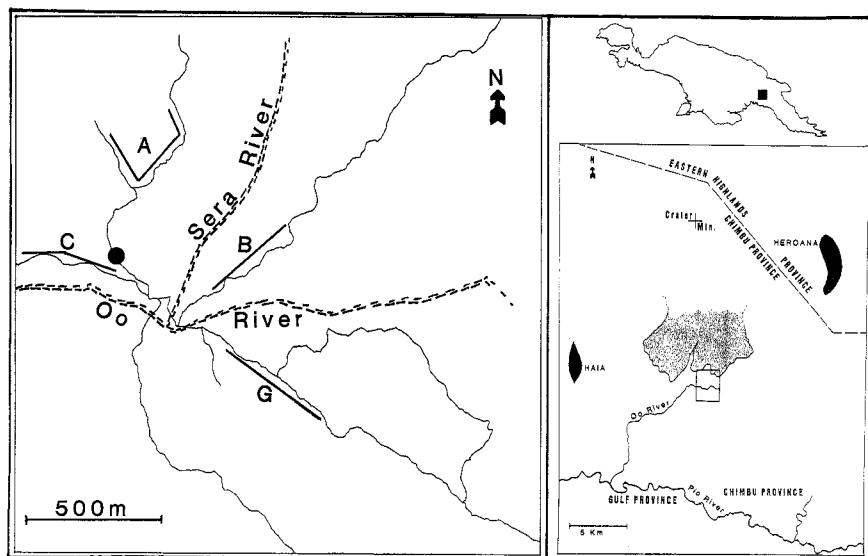


Figure 1 Maps of the study area. Location in New Guinea of the 2600 km² Crater Mountain Wildlife Management Area is shown in the upper right. Location of the study area in the CMWMA is shown in lower right; the dark-shaded areas show the two main villages in the area and the light-shaded area shows the plateau that abuts the study area. The study area (left) shows the trails (thin black lines), main rivers (double-dashed lines), netting areas (thick black lines labelled A, B, C and G) and the helipad (black circle) where many birds were observed.

Mist netting was done on and near trails. These trails did not exist before the study and were minimally cleared so it is unlikely their use for net lanes altered capture frequencies. Twenty-five netting sessions (mean length = 26.4 h) were conducted between 9 February 1991 and 5 June 1993 for a total of 114 915 net-metre hour. We tried to run nets for three days each session but this was not always possible given frequent, heavy rains at Crater. We rotated net locations among four separate areas, so at least two months (mean interval = 5.5 months) elapsed before netting again on the same net line. The length of net line and the hours the nets were run were recorded for each session; capture rates are expressed as numbers captured per net metre hour as a standard that can be compared to other netting studies.

During the first ten netting sessions all captures were marked by clipping a rectrix so recaptures could be identified at least during the same netting session. After the tenth netting session, birds were banded with numbered aluminium bands provided by the Australian Bird and Bat Banding Authority.

The following data were collected for all captures: weight, bill length (from base of skull) and wing chord (flattened). Sex and age were recorded when apparent from external morphology. Notes on fat score, breeding condition and moult were also collected; these data will be presented elsewhere.

Results

Field observations

One-hundred-and-seventy species were recorded during the study period October 1989–June 1993; an annotated list is given in Appendix 1. Birds considered transients represented 27% of these species with significantly more non-passerines than passerines (Table 1, $\chi^2 = 6.6$, $d.f. = 1$, $0.02 > P > 0.01$); more non-passerines were considered 'rare' (Table 1, $\chi^2 = 10.2$, $d.f. = 3$, $0.01 > P > 0.001$). Some species that were expected on the basis of

Table 1 Subjective determinations of relative abundances of 170 bird species recorded at Crater Mountain Biological Research Station based on three years of field work.

Status ¹	Non-passerines		Passerines	
	<i>n</i>	%	<i>n</i>	%
Abundant	14	17.8	22	24.2
Common	25	31.6	43	47.3
Uncommon	22	27.8	21	23.1
Rare	18	22.8	5	4.4
Transient	30	38.0	16	17.6
Permanent resident	49	62.0	75	82.4

¹ See Appendix 1 for descriptions of status classes.

Table 2 Trophic structure of avian communities at several Papuan sites. Guild categories follow Bell (1982a).

Guild	Crater Mtn ¹ No. of species (%)	Brown River ² No. of species (%)	Moroka ³ No. of species (%)	Lakekamu Basin ⁴ No. of species (%)	Varirata ⁵ No. of species (%)
Total	170 (100)	174 (100)	177 (100)	167 (100)	181 (100)
Carnivore–insects	49 (28.8)	49 (28.2)	59 (32.8)	51 (30.5)	60 (33.1)
Carnivore–vertebrates	19 (11.2)	24 (13.8)	23 (13.0)	21 (12.6)	28 (15.5)
Total 'carnivores'	67 (39.4)	73 (42.0)	82 (46.3)	72 (43.1)	88 (48.6)
Frugivores	18 (10.6)	20 (11.5)	17 (9.4)	22 (13.2)	19 (10.5)
Frugivore–granivore	10 (5.9)	12 (6.9)	11 (6.1)	9 (5.4)	10 (5.5)
Frugivore–granivore–nectarivore	2 (1.2)	2 (1.1)	2 (1.1)	1 (0.6)	1 (0.6)
Frugivore–nectarivore	5 (2.9)	4 (2.3)	3 (1.7)	5 (3.0)	2 (1.1)
Granivores and herbivores	5 (2.9)	4 (2.3)	3 (1.7)	3 (1.8)	2 (1.1)
Total 'herbivores'	40 (23.5)	42 (24.1)	36 (20.0)	40 (24.0)	34 (18.8)
Insectivore–frugivore	22 (12.9)	17 (9.8)	22 (12.4)	20 (12.0)	23 (12.7)
Insectivore–frugivore–granivore	4 (2.4)	5 (2.9)	4 (2.2)	3 (1.8)	3 (1.7)
Insectivore–frugivore–nectarivore	15 (8.8)	16 (9.2)	14 (7.9)	15 (9.0)	16 (8.8)
Insectivore–granivore–herbivore	1 (0.6)	2 (1.1)	1 (0.6)	2 (1.2)	1 (0.6)
Insectivore–nectarivore	13 (7.6)	12 (6.9)	11 (6.2)	10 (6.0)	9 (5.0)
Omnivore	7 (4.1)	7 (4.0)	7 (4.0)	5 (3.0)	7 (3.9)
Total 'mixed feeders'	62 (36.5)	62 (35.6)	59 (33.3)	55 (32.9)	59 (32.6)

¹ This study. ² Bell 1982a. ³ Bell 1984. ⁴ Beehler et al. 1994. ⁵ B.M. Beehler pers. comm.

their known distributions but were not observed are discussed in Appendix 2.

Diets of these birds were categorised, following the classification of Bell (1982a) and supplemented with data from Coates (1985, 1990) and personal observations. The distribution of species in the different categories of diet did not substantially differ from those at other sites in Papua New Guinea (PNG) (Table 2).

Observations of frugivorous and nectarivorous birds using food plants are presented in Appendix 3.

Netting results

There was a total of 1787 captures during the 25 netting sessions. Of these, 269 were known recaptures and 906 were banded. Capture rates declined during each three-day session (McNemar test $\chi^2 = 7.8$, $d.f. = 2$, $n = 22$, $P < 0.02$) [Fig. 2]. A total of 69 species (40% of all species observed) were netted at least once. The cumulative species area curve was still increasing by the end of the study (Fig. 3), reflecting the dynamic nature of avian populations in this forest and the large number of species that occur at low densities. Over half (35) of the species captured were caught five or fewer times and

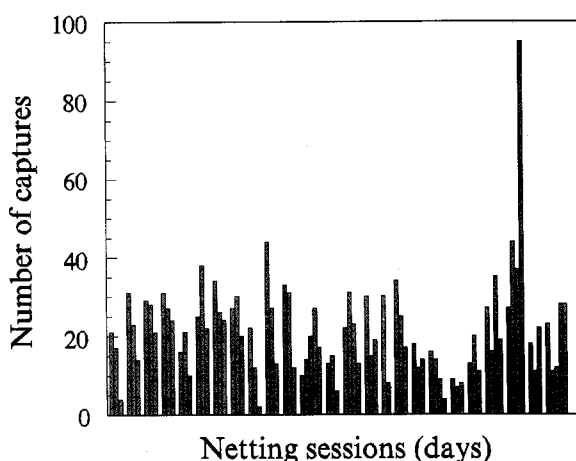


Figure 2 Mist netting captures during 25 sessions. Each column represents the number of captures during a day of netting. Some sessions included a fourth day and some were only two days, due to heavy rains. Most sessions exhibited diminished numbers of captures by the third day of netting. The pattern is obscured in the last four netting sessions due to a surge in *Erythrura trichroa* captures (see Fig. 4).

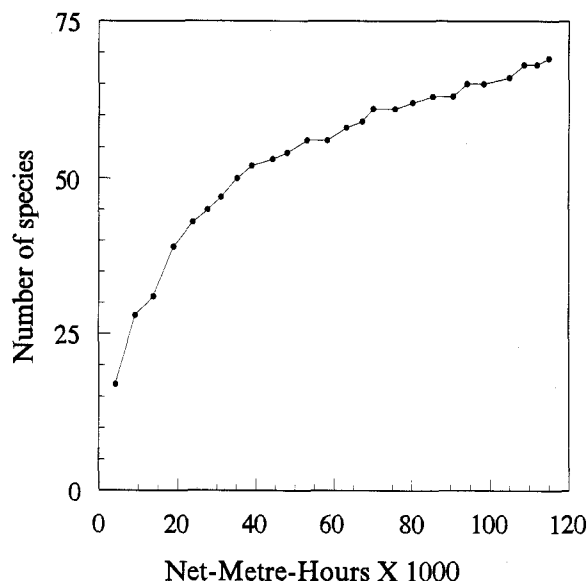


Figure 3 Cumulative species area curve. The cumulative number of species netted during 25 netting sessions 1991–93, expressed in terms of net metre hours.

only eight species were captured 60 or more times. The avian community was not temporally uniform, but rather, some species' abundances changed markedly even among the commonest resident species and over the relatively short time span of this study. A dramatic change in the population of *Erythrura trichroa* occurred in late 1992 to early 1993 (Fig. 4).

There were 159 recaptures of banded birds, most were close to the site of initial capture, but 12 (7.5%) moved more than 250 m (Table 3).

Netting was undertaken in four general zones, separated by topographic boundaries: labelled A, B, C and G (Fig. 1) corresponding to different trails. Capture rates, corrected for unequal sampling effort, were not equivalent in the four areas ($\chi^2 = 43.3$, $df = 3$, $P < 0.01$); capture rate in area C was roughly half that of the other three areas (Table 4). Area C was in disturbed forest that had been selectively logged in order to construct the station buildings and for fuelwood.

Comparison with other sites in southern PNG

Species lists are available for four other sites in southern lowland and hill forest PNG. Descriptions of three of the sites are published (Table 5). The fourth site, Varirata National Park (9°27'S, 147°21'E, 820 m asl), is

seasonal rainforest near the transition to dry savanna. The total number of species (excluding water birds, as some sites lack large rivers) and how they are apportioned into different trophic groups is shown in Table 2. Indices of turnover, showed similarity in all pairwise comparisons among the sites, are given in Table 5 (Index = $1 - (C(T_1 + T_2) / 2T_1T_2)$, where C = number of species shared between species lists T_1 and T_2 [Cody 1990]).

Table 3 Recaptures of banded birds at greater than 250 m between capture sites ($n = 159$ recaptures). Distances marked * indicate movements across valleys to roughly similar altitudes (see discussion).

Species	Distance between captures (m)
<i>Melanocharis nigra</i>	740, 345
<i>Melilestes megarhynchus</i>	290*, 435, 495
<i>Toxorhamphus poliopterus</i>	780 *
<i>Oedistoma lilolophus</i>	320, 735
<i>Meliphaga mimikae</i>	295 *
<i>Erythrura trichroa</i>	425, 1650*
<i>Sericornis spilodera</i>	600

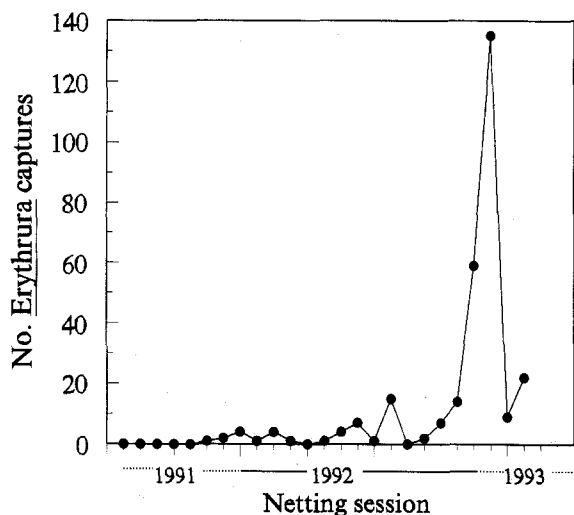


Figure 4 Number of individuals of *Erythrura trichroa* captured in 25 netting sessions. Very few of this species were netted or observed in 1991 and most of 1992. In late 1992 and early 1993 a huge influx of birds occurred, followed by breeding and an even larger surge in numbers in early 1993 (session 23) when many fledglings were captured.

Discussion

The rainforest avifauna in New Guinea is not as diverse as those in many tropical regions. The number of species recorded at CMBRS and four other PNG sites is less than half those recorded at four neotropical sites (Karr et al. 1990). Nonetheless, the avifauna at CMBRS resembles other tropical avifaunas by the high preponderance of rare (low-density) species (Table 1) and a species area curve slow to reach an asymptote (Fig. 2).

Among five sites in southern PNG there is remarkable similarity in both the number of species and their breakdown into different categories by diet (Table 4). The turnover indices among the five sites averaged 26.9% (Table 5). This is similar to the turnover Cody (1990) found among Queensland rainforest sites comparable distances apart. There was not a significant correlation between turnover and distance between sites (Spearman $\rho = 0.06$, $P > 0.07$, $n = 10$) and an altitudinal effect was only noticeable between CMBRS and the two lowest sites, Brown River and Lakekamu Basin (Table 5).

Although rainforest communities were once considered stable, the usual consensus now is that there is considerable temporal heterogeneity in populations of rainforest organisms (Karr & Freemark 1983). A sub-

stantial proportion of the observed avifauna were rare and/or transient species. The dynamics of rainforest bird populations, and their causes and cues are poorly understood (Levey 1988). At CMBRS considerable changes in relative abundances of many species occurred through time. When the trees of the common genus *Melicope* (see Appendix 3) came into flower (March–June) numbers of lorikeets increased dramatically. *T. goldiei*, uncommon much of the year, became numerous; *C. multistriata* and *C. wilhelminae* were only observed during this period and the fairly common species of *Charmosyna* and *T. haematodotus* became much more numerous. *Pseudeos fuscata* did not increase when *Melicope* flowered but did when *Sloanea* sp. flowered. These observations suggest lorikeets track flower and nectar availability over large areas, both altitudinally (e.g. *C. wilhelminae*) and longitudinally, along mid-elevations on the southern side of the central ranges (e.g. *C. multistriata*).

Most dramatically, *Erythrura trichroa* went from being absent to the most abundantly netted species by an order of magnitude (Fig. 5). Both parrot-finch species moved into the area when their food plants, bamboos including *Schizostachyum* sp., came into seed. Presumably, they move over large areas tracking seed availability (Majnep & Bulmer 1977) following unknown routes, hence their movements are termed nomadic (Coates 1990). The rather sudden and dramatic surge in their population suggests nomadic wanderers did not accumulate in the area but instead there was a focused immigration into the area by thousands of birds that was followed by breeding.

Conservation in New Guinea will be hampered until we have a greater understanding of the movement patterns of birds. For example, the Striated Lorikeet, considered a near-threatened species (Collar et al. 1994), might require a much larger range than would be apparent from what is currently known of its distribution. How habitat modifications, such as logging, in part of the range of 'nomadic' or transient species affect that species' conservation is unknown and requires immediate attention given the recent rapid growth of logging operations in PNG.

Rainforest understory birds are often considered relatively sedentary (Bell 1971). The netting protocol was not designed to reveal long-distance movements or home range sizes of birds. However, given the distances between the different net sites (Fig. 1) and the relatively small number of net-days, the result of 7.5% of the recaptures exceeding 250 m is somewhat surprising. Dia-

Table 4 Capture rates at four separate areas at Crater Mountain Biological Research Station where mist nets were regularly set.

Area	No. of sessions	Net m hours	No. of captures	Captures per m hours
A	6	26 010	461	0.0177
B	5	26 642	527	0.0200
C	6	25 800	231	0.0090
G	8	36 461	566	0.0160

Table 5 Turnover indices among five sites in PNG south of the Central Ranges. See methods for formula to calculate index. Values can range zero to one, with zero indicating total similarity and one indicating no similarity. Sources as in Table 2.

	Brown R.	Varirata	Crater Mt.	Moroka
Lakekamu	0.190	0.211	0.383	0.284
Brown R.		0.267	0.366	0.236
Varirata			0.298	0.201
Crater Mt.				0.262

mond (1972) found many montane birds had narrow altitudinal ranges. If true, such taxa might forage more widely than lowland taxa within their preferred altitude along the sides of steep mountains; movements might be constrained on two sides leading to greater lateral movement. Altitudinal constraints could cause individuals to cross long distances over valleys between bands of appropriate habitat. Five of the 12 'long' distance movements (Table 3) were of birds that crossed steep river gorges to recapture sites at roughly equal elevations.

The capture rate of birds was considerably lower in the disturbed area 'C.' Most of the timber and fuelwood needed for the station were extracted from this part of the study area, but most of the large trees were not disturbed. This reduction in capture rate is probably due to thinning of the forest subcanopy. Bell (1979) attributed depauperate avian communities in teak plantations to the reduced subcanopy of these sites. The use of smaller trees for housing is typical among the Pawaiian people and also for most forest-dwelling Papuans without access to chainsaws or heavy equipment. Hence, the forest in area C is typical of forest that surrounds Pawaiian residences (ALM & DDW pers. obs.) and probably those of many land owners in PNG. The reduction in the understory bird population was not due to hunting because hunting is strictly banned in the area. Aerial surveys of forest cover might, in some cases, overestimate some birds' habitat because substantial disturbance can exist at sub-canopy levels.

It is common dogma that there is a dawn peak of avian activity. Although this might be true for vocalisations, netting data showed low capture rates at the earliest hours. On nine days the nets were left open all night to capture bats and in most other sessions the nets were opened by 0715 h but bird captures peaked 0800-0900 h. Bell (1970) found captures did not peak at dawn. Our experience at several rainforest sites (PNG and Sabah) has been that avian activity and mist net captures in rainforest peak when direct sunlight first penetrates the canopy — this is later in steep valleys than in level forest or on ridgetops.

Many Papuan rainforest birds have complicated population dynamics, often tied to poorly known plant phenologies that sometimes cycle on supra-annual schedules. Furthermore, many species normally occur in low densities, erratically move between habitat patches or have unknown migratory movements covering large areas. Hence, data gathered on short trips to rainforests might provide useful first approximations of

bird populations, but long-term monitoring is needed to understand what is required to maintain viable bird populations. Long-term studies are needed to raise Papuan ornithology to a level comparable to most biogeographic regions.

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References

- Beehler, B.M. 1981. Ecological structuring of forest bird communities in New Guinea. Pp. 837-861 in *Biogeography and Ecology of New Guinea*, Monographiae Biologicae, Vol. 42. Ed. J.L. Gressitt. Junk, The Hague.
- Beehler, B.M. 1983. Frugivory and polygamy in birds of paradise. *Auk* 100, 1-12.
- Beehler, B.M. 1988. Lek behavior of the Raggiana Bird of Paradise. *National Geographic Research* 4, 343-358.
- Beehler, B.M. 1993. Biodiversity and conservation of the warm-blooded vertebrates of Papua New Guinea. Pp. 77-155 in *Papua New Guinea Conservation Needs Assessment*, Vol. 2. Ed. B.M. Beehler. Biodiversity Support Program, Washington, D.C.
- Beehler, B.M. & Swaby, R.J. 1991. Phylogeny and biogeography of the *Ptiloris* riflebirds (Aves: Paradisaeidae). *Condor* 93, 738-745.
- Beehler, B.M., Pratt, T.K. & Zimmerman, D.A. 1986. *Birds of New Guinea*. Princeton University Press, Princeton.
- Beehler, B.M., Crill, W., Jefferies, B. & Jefferies, M. 1992. New Guinea Harpy-Eagle attempts to capture a Monitor lizard. *Emu* 92, 246-247.

- Beehler, B.M., Burg, C.G., Filardi, C., & Merg, K. 1994. Birds of the Lakekamu-Kunamaipa basin. *Muruk* 6, 1-8.
- Beehler, B.M., Sengo, J.B., Filardi, C. & Merg, K. 1995. Documenting the lowland rainforest avifauna in Papua New Guinea – effects of patchy distributions, survey effort and methodology. *Emu* 95, 149-162.
- Bell, H.L. 1970. Field notes on birds of the Nomad River sub district, Papua. *Emu* 70, 97-104.
- Bell, H.L. 1971. Field-notes on birds of Mt Albert Edward, Papua. *Emu* 71, 13-19.
- Bell, H.L. 1982a. A bird community of lowland rainforest in New Guinea. I. Composition and density of the avifauna. *Emu* 82, 24-41.
- Bell, H.L. 1982b. A bird community of lowland rain forest in New Guinea. 2. Seasonality. *Emu* 82, 65-74.
- Bell, H.L. 1982c. A bird community of New Guinean lowland rainforest. 3. Vertical distribution of the avifauna. *Emu* 82, 143-162.
- Bell, H.L. 1983a. A bird community of lowland rainforest in New Guinea. 6. Foraging ecology and community structure of the avifauna. *Emu* 84, 142-158.
- Bell, H.L. 1983b. A bird community of lowland rainforest in New Guinea. 5. Mixed-species flocks. *Emu* 82, 256-275.
- Bell, H.L. 1984. The importance of hill forest in the diversity of rainforest birds in New Guinea. *Emu* 84, 225-235.
- Bell, H.L., Coates, B.J. & Layton, W.A. 1979. Notes on Wallace's Wren-Warbler *Tododopsis wallacii* Gray, with a description of the nest and eggs. *Emu* 79, 152-154.
- Coates, B.J. 1985. Birds of Papua New Guinea: Non-passerines, Vol. I. Dove Publications, Alderley.
- Coates, B.J. 1990. Birds of Papua New Guinea: Passerines, Vol. II. Dove Publications, Alderley.
- Cody, M.L. 1993. Bird diversity components within and between habitats in Australia. Pp 147-158 in *Species Diversity in Ecological Communities*. Eds R.E. Ricklefs & D. Schluter. University of Chicago Press, Chicago.
- Collar, N.J., Crosby, M.J. & Stattersfield, A.J. 1994. Birds to watch 2: The world list of threatened birds, BirdLife Conservation Series, Vol. 4. BirdLife International, Cambridge.
- Diamond, J.M. 1972. Avifauna of the eastern highlands of New Guinea. Publication of the Nuttall Ornithological Club 12, 1-438.
- Diamond, J. 1986. Biology of birds of paradise and bower-birds. *Annual Review of Ecology and Systematics* 17, 17-37.
- Driscoll, P.V. 1985. The effects of logging on bird populations in lowland New Guinea rainforest. Ph.D. Thesis, University of Queensland, Brisbane.
- Dunning, J.B. Jr. (ed.) 1993. *CRC Handbook of Avian Body Masses*. CRC Press, Boca Raton, USA.
- Gilliard, E.T. & Lecroy, M. 1967. Annotated list of birds of the Adelbert Mountains, New Guinea. *Bulletin of the American Museum of Natural History* 138, 51-81.
- Healey, C.J. 1976. Sympatry in *Parotia lawesii* and *P. carolae*. *Emu* 76, 85.
- Karr, J.R. & Freemark, K.E. 1983. Habitat selection and environmental gradients: dynamics in the 'stable' tropics. *Ecology* 64, 1481-1494.
- Karr, J.R., Robinson, S.K., Blake, J.G. & Bierregaard, R.O.J. 1990. Birds of four neotropical forests. Pp. 237-269 in *Four Neotropical Forests*. Ed. A.H. Gentry. Yale University Press, New Haven.
- Levey, D.J. 1988. Spatial and temporal variation in Costa Rican fruit and fruit-eating bird abundance. *Ecological Monographs* 58, 251-269.
- Mack, A.L. 1994. Notes on the nests and eggs of some birds at the Crater Mountain Research Station, Papua New Guinea. *Bulletin of the British Ornithologist's Club* 114, 176-181.
- Majnep, I.S. & Bulmer, R. 1977. *Birds of my Kalam Country*. Auckland/Oxford University Press, Auckland.
- Pajmians, K. (ed.) 1976. *New Guinea Vegetation*. Australian National University Press, Canberra.
- Pratt, T.K. 1984. Examples of tropical frugivores defending fruit-bearing plants. *Condor* 86, 123-129.
- Pruett-Jones, S.G. & Pruett-Jones, M.A. 1986. Altitudinal distribution and seasonal activity patterns of birds of paradise. *National Geographic Research* 2, 87-105.
- Terborgh, J.W. & Diamond, J.M. 1970. Niche overlap in feeding assemblages of New Guinea birds. *Wilson Bulletin* 82, 29-52.

Appendix 1 Annotated species list.

Abbreviations used: A = abundant, C = common, U = uncommon (species of regular occurrence but with few individuals in the area), R = rare (five or fewer sightings), t = transient, migrant or temporary resident, and p = permanent resident. Initials refer to other observers noted in the Acknowledgements.

Altitudinal observations are given where they extend the known upper or lower limit given by Beehler et al. (1986) or Coates (1985, 1990). Nomenclature follows Beehler et al. (1986).

Notes on field observations are included when these add to what has been previously published (Coates 1985, 1990).

Mean weights of netted individuals, followed by the standard deviation and sample size are given in brackets. Unless otherwise specified data include males and females. These data add substantially to data available for known body masses of New Guinean birds, for many of which there are only small sample sizes and no data on variation (Dunning 1993). Three species

reported here (*Ninox theomacha*, *Melanocharis longicauda* and *Dicrurus hottentotus*) were not included in Dunning's (1993) compendium.

Casuarus bennetti Dwarf Cassowary. U, p. Approximately three to five individuals were resident; population seemed to vary with fruit availability. This species was the subject of extensive research by the authors; details of its biology and diet will be published elsewhere.

Anas waiguiensis Salvadori's Teal. U, t. Resident at higher elevations and only sporadically visiting the study area.

Henicopernis longicauda Long-tailed Buzzard. U, p.

Haliastur indus Brahminy Kite. R, t. More commonly seen c. 600 m along major rivers. A few sightings of immature birds passing over.

Accipiter novaehollandiae Grey Goshawk. R-U, p. A display observed (PB and HGSG) was of a bird flying high across the valley with slow, mechanical, butterfly-like wingbeats, then it tucked in its wings for a series of undulations across the valley and down into the canopy.

A. poliocephalus Grey-headed Goshawk. U, p.

A. meyerianus Meyer's Goshawk. R, t? Lone birds seen twice (fide PB, HGSG). This species is only recorded from scattered localities in PNG and not previously from the eastern highlands region.

Harpyopsis novaeguineae New Guinea Harpy-Eagle. U, p. At least two pairs resident. Fresh remains of *Spilocuscus gymnotis* and *Pseudocheirus forbesi* found were probably prey items of the Harpy Eagle. The *Pseudocheirus* head and viscera were eaten, but the rest of the body, including pouch young (still alive), was intact. Beehler et al. (1992) observed an immature bird attempt to take a monitor lizard *Varanus indicus* at the station. One bird on an exposed perch was mobbed by a Blyth's Hornbill *Rhyticeros plicatus* and a Sulphur-crested Cockatoo *Cacatua galerita*.

Aquila gurneyi Gurney's Eagle. U, t? Lone birds observed sporadically throughout the study soaring over ridgetops on clear, sunny days.

Hieraetus morphnoides Little Eagle. U, p. Diamond (1972) noted this species as absent from the area. One to three birds were fairly often seen soaring; one was observed plunging from high above the forest straight into the canopy. Sometimes seen perched at the edge of the helipad clearing.

Falco berigora Brown Falcon. R, t.

F. peregrinus Peregrine Falcon. R, t.

Megapodius freycinet Common Scrubfowl. C, p. [\bar{X} = 800 g, n = 1]

Talegalla jobiensis Brown-collared Brush-turkey. C, p. Previously it was believed but unconfirmed that records of *Talegalla* on the southern slope of the central ranges were of this species (Diamond 1972; Dwyer 1981; Coates 1985). We clearly observed individuals numerous times up to 1400 m elevation. *T. jobiensis* probably occurs extensively along the southern flank of the central ranges above the altitude of the lowland *T. fuscirostris*.

Aepyodius arfakianus Wattled Brush-turkey. C, p. Less conspicuous and less common than the two preceding species.

Macropygia amboinensis Brown Cuckoo-Dove. A, p.

M. nigrirostris Black-billed Cuckoo-Dove. C, p. Ecological segregation of the two sympatric *Macropygia* are complicated as discussed by Diamond (1972). At CMBRS no clear segregation

was evident; observations suggest *amboinensis* is found more in young disturbances and *nigrirostris* more in old second growth. Both have been observed in primary forest, but *amboinensis* seems to be more common there; *nigrirostris* was observed close (within 5 m) to the ground more often than *amboinensis*. [\bar{X} = 85 g, n = 1]

Reinwardtoena reinwardtsi Great Cuckoo-Dove. C, p.

Henicophaps albifrons New Guinea Bronzewing. R, t. Only seen once.

Gallicollumba jobiensis White-bibbed Ground-Dove. R, t. Observed only in May 1990 and May-June 1992. This species is probably a 'nomadic' granivore as are *Erythrura* spp. [\bar{X} = 135 g, n = 1]

G. rufigula Cinnamon Ground-Dove. U, p. Up to 1200 m elevation.

Otidiphaps nobilis Pheasant Pigeon. C, p.

Ptilinopus magnificus Wompoo Fruit-Dove. R, t. Common at lower elevations outside study area. Heard once at c. 1100 m when *Elmerillia tsiampaca* were in fruit (see Appendix 3).

P. perlatus Pink-spotted Fruit-Dove. C, p. Generally confined to lower elevations of the study area.

P. ornatus Ornate Fruit-Dove. C, p.

P. superbus Superb Fruit-Dove. C, p. More solitary than *P. ornatus*.

P. cornulatus Coronated Fruit-Dove. R, t. One sighting; probably a stray from lower elevations.

P. rivoli White-breasted Fruit-Dove. C, t. Not as common as *ornatus* or *perlatus* and possibly absent during periods of low fruit availability.

P. pulchellus Beautiful Fruit-Dove. A, p. As described by Diamond (1972) there is little overlap between this species and *cornulatus*. [\bar{X} = 68 g, n = 1]

Ducula zoeae Zoe Imperial Pigeon. A, p.

D. pinon Pinon Imperial Pigeon. R, t. A lowland species usually found below 750m elevation. Two separate sightings at 950 m probably represent wandering birds.

D. rufigaster Purple-tailed Imperial Pigeon. U, p. A displaying bird flew out over the valley, closed its wings into a gentle dive, then swooped upwards until it stalled, then dived steeply with a 360° spiral before alighting in a treetop.

D. chalconota Rufescent Imperial Pigeon. U, p (t?). Beehler et al. (1986) record as rarely as low as 1400 m but Coates (1986) records down to 1100 m. We recorded as low as 1000 m and fairly regularly at 1100-1200 m.

Gymnophaps albertsii Papuan Mountain Pigeon. A, t. Present in large numbers when certain trees fruit, particularly *Elmerillia tsiampaca*, (see Appendix 3) and totally absent at other times though flocks can be observed passing high over the area.

Columba vitiensis White-throated Pigeon. R, t.

Pseudeos fuscata Dusky Lory. A, t (p?). Large flocks pass over often. Birds stay in area when certain trees flower (e.g., *Sloanea* Elaeocarpaceae) but absent at times of low flowering.

Trichoglossus haematodus Rainbow Lorikeet. A, p.

T. goldiei Goldie's Lorikeet. A, t. This, like several other species of lorikeet (see below) seems to come and go at CMBRS in relation to the flowering schedules of several canopy trees and lianas. It is interesting to note Majnep & Bulmer (1977) found this species in the Kaironk Valley of the Schrader Range in large num-

bers during December–January, when they are conspicuously absent from CMBRS.

Lorius lory Western Black-capped Lory. A, p. Unlike other lorries, these are quite sedentary and pairs are found in the same vicinity year-round. At CMBRS the races *somu* and *erythrothorax* mix. Individuals with full neck collars, no neck collars and partial, pale neck collars have been observed, sometimes together.

Charmosyna placensis Red-flanked Lorikeet. A, p.

C. pulchella Little Red Lorikeet. U, t. Present when large *Melicope* trees flower (see Appendix 3), absent or rare at other times.

C. wilhelminae Pygmy Lorikeet. R, t. Only seen during peak flowering and then only rarely 1–2 birds in larger mixed species aggregations.

C. multistriata Streaked Lorikeet. U, t. Not previously recorded east of Mt. Bosavi in western PNG. Sightings at CMBRS extend its known range 250 km eastward. Appeared in mixed nectarivore aggregations in flowering trees during periods of greatest flowering usually March–July. The red vent is a good fieldmark unmentioned in Beehler et al. (1986) or Coates (1985).

Probosciger aterrimus Palm Cockatoo. C, p. Although considered a lowland species, several birds were present most of the time and additional birds appeared when food plants (see Appendix 3) fruited (July–October). Birds occasionally come to the ground and feed upon seeds in cassowary droppings. In Pawaiian folklore this is the 'brother' to the cassowary — knocking many fruits to the ground for the cassowary to consume and feeding on the seeds from cassowary droppings.

Cacatua galerita Sulphur-crested Cockatoo. C, p. Sometimes groups of up to 18 birds pass through the area, otherwise several resident pairs.

Micrositta pusio Buff-faced Pygmy-Parrot. R, t. Previously recorded west only to the Eloa River (Coates 1985) and the mouth of the Purari (Beehler et al. 1986) and only up to 830 m elevation. Several sightings of small flocks probably represent wandering groups.

Cyclopsitta guiliemiterti Orange-breasted Fig-Parrot. A, p. Reported as rare up to 800 m (Beehler et al. 1986) and once at 1100 m on Mt. Karimui (Diamond 1972). At CMBRS present year round in flocks up to ten birds and common up to 1100 m.

C. diophthalma Double-eyed Fig-Parrot. U, t. Pairs or lone birds observed occasionally. Coates (1986) and Beehler et al. (1986) report this species as rarely sympatric with *C. guiliemiterti*. Birds observed at CMBRS were usually in secondary forest and never seen feeding.

Psittaculirostris desmarestii Large Fig-Parrot. U, p.

Geoffroyus simplex Blue-collared Parrot. C, t. Only seen in flocks flying high over the area.

Eclectus roratus Eclectus Parrot. C, p. Two or three pairs in the study area.

Psittirichas fulgidus Vulturine Parrot. C, p. Appears to be a dietary specialist on a few species of fig (see Appendix 3).

Alisterus chloropterus Papuan King-Parrot. U, p.

Loriculus aurantiifrons Papuan Hanging Parrot. R, t.

Cuculus saturatus Oriental Cuckoo. R, t.

Cacomantis castaneiventris Chestnut-breasted Cuckoo. A, p. [\bar{X} = 30.5 g, n = 1]

C. variolosus Brush Cuckoo. A, p.

Chrysococcyx meyerii White-eared Bronze-Cuckoo. C, p. Mostly in secondary forest. [\bar{X} = 22 g, n = 1]

Microdynamis parva Dwarf Koel. C, p. Observed defending a *Ficus* sp. tree, chasing away *Meliphaga* spp. and *Coracina boyeri*. Sometimes sings at night.

Eudynamis scolopacea Common Koel. U, p.

Centropus menbeki Greater Black Coucal. U, p.

C. phasianinus Pheasant Coucal. R, t. A probable wanderer in the young second growth around the station seen once and a juvenile bird killed by a predator.

Tyto tenebricosa Sooty Owl. U, p.

Ninox theomacha Papuan Boobook. C, p. Observed roosting in dense vine tangles by day. [\bar{X} = 185 g, n = 1]

Podargus ocellatus Marbled Frogmouth. U, p. [\bar{X} = 185 g, n = 1]

Hemiprocne mystacea Moustached Tree-swift. C, t. Seems to be mostly absent October–March though occasional lone birds were sighted during these months; fairly numerous and regular the rest of the year.

Collocalia esculenta Glossy Swiftlet. A, p. Flocks of up to 50 swiftlets, mostly this species, often form at the leading edges of storm fronts.

Collocalia sp. unidentified swiftlet. C, p. Numerous sightings of swiftlets that are possibly *Col. vanikorensis* and/or *Col. hirundinacea*; species not readily distinguished in flight.

Mearnsia novaeguineae Papuan Spine-tailed Swift. U, t.

Melidora macrorrhina Hook-billed Kingfisher. A, p. [\bar{X} = 108.2 ± 6.8 g, n = 6]

Clytoceyx rex Shovel-billed Kingfisher. C, p. Not on steep slopes, but in boggy basins and bases of old landslips with large boulders.

Dacelo gaudichaud Rufous-bellied Kookaburra. C, p. Sometimes mobbed by small passerines. [\bar{X} = 145 g, n = 1]

Halcyon sancta Sacred Kingfisher. R, t. Seen once, May 2 1992.

H. torotoro Yellow-billed Kingfisher. R, t? Netted and observed up to 1200 m. Once being mobbed by *Monarcha axillaris*. Never heard. [\bar{X} = 44 g, n = 1]

Ceyx lepidus Dwarf Kingfisher. U, p. [\bar{X} = 15.7 ± 1.8 g, n = 3]

C. azurea Azure Kingfisher. U, p. [\bar{X} = 35.5 ± 0.7 g, n = 2]

Merops ornatus Rainbow Bee-eater. C, t. Usually in March to early April and less often in September large flocks move above the canopy and sometimes alight in emergent trees. Probably en route to and from wintering grounds to the north in more open terrain.

Rhyticeros plicatus Blyth's Hornbill. C, p.

Eurystomus orientalis Dollarbird. U, p.

Coracina caeruleogrisea Stout-billed Cuckoo-shrike. C, p. [\bar{X} = 155 g, n = 1]

C. boyeri Boyer's Cuckoo-shrike. U, p. Not recorded above 1000 m.

C. schisticeps Grey-headed Cuckoo-shrike. C, p. As suggested by Diamond (1972) this species' distribution seems to complement that of *C. morio*, which was never recorded at the station.

C. melaena Black Cuckoo-shrike. C, p. Below 1100 m.

C. montana Black-bellied Cuckoo-shrike. C, p. Usually above 1100 m, becoming more common the higher one ascends.

- Lalage leucomela* Varied Triller. C, p.
- Ptilorhoa castanonotus* Chestnut-backed Jewel-babbler. A, p. [\bar{X} = 75.5 \pm 4.2 g, n = 8]
- Phylloscopus trivirgatus* Island Leaf-Warbler. R, t. Seen only twice, at the edge of the helipad.
- Sipodotus wallacii* Wallace's Fairy-Wren. U, p? t? Until recently not recorded between Mt. Bosavi and the Port Moresby area (Coates 1990; Beehler et al. 1986). The patchy distribution of this species has been attributed to incomplete collecting (Bell et al. 1979). Reported at Lakekamu Basin (Beehler et al. 1995). Occasionally groups were seen in vine tangles and second growth in areas worked frequently but long intervals passed without seeing any. Groups probably wander between widely-dispersed patches of second growth, thus making them more easily overlooked during short surveys.
- Crateroscelis murina* Rusty Mouse-Warbler. A, p. [\bar{X} = 16.2 \pm 1.4 g, n = 53]
- Sericornis spilodera* Pale-billed Scrub-wren. A, p. Up to 1200 m elevation. Sometimes mimics songs of other species. [\bar{X} = 11.6 \pm 1.1 g, n = 48]
- Se. arfakianus* Grey-green Scrub-wren. A, p. Overlaps widely with *Se. spilodera* down to 900m elevation. Tends to be in closed primary forest more than *spilodera* which prefers disturbances, but they often overlap. Observed in mixed species flocks with both *Se. spilodera* and *Se. nouhuysi*. [\bar{X} = 9.2 \pm 0.9 g, n = 23]
- Se. nouhuysi* Large Scrub-wren. U, t. Occasionally down to 1000 m but seems to be absent much of the time. [\bar{X} = 15 \pm 1.4 g, n = 2]
- Gerygone chrysogaster* Yellow-bellied Gerygone. C, p. Occasionally up to 1050 m. [\bar{X} = 8 g, n = 1]
- G. palpebrosa* Fairy Gerygone. C, p.
- Rhipidura threnothorax* Sooty Thicket-Fantail. C, p. Up to 1100 m. [\bar{X} = 18.5 \pm 1.5 g, n = 7]
- R. atra* Black Fantail. C, p. [\bar{X} = 13.0 \pm 1.8 g, n = 14]
- R. hyperythra* Chestnut-bellied Fantail. A, p. [\bar{X} = 11.3 \pm 1.1 g, n = 19]
- R. rufiventris* Northern Fantail. C, p. As noted by Diamond (1972) usually in disturbances while the previous species is usually in closed forest. [\bar{x} = 14 g, n = 1]
- R. leucophrys* Willie Wagtail. R, t. Seen once at the helipad (KI).
- Monarcha axillaris* Black Monarch. C, p. Mostly above 950 m. [\bar{X} = 15.5 \pm 0.7 g, n = 8]
- M. frater* Black-winged Monarch. C, p. [\bar{X} = 19.5 g, n = 1]
- M. guttula* Spot-winged Monarch. A, p. Up to 1100 m. [\bar{X} = 17.5 \pm 1.2 g, n = 22]
- M. chrysomela* Golden Monarch. U, p. Below 1150 m.
- Arses telescopthalmus* Frilled Monarch. C, p. [\bar{X} = 19.3 \pm 1.2 g, n = 6]
- Machaerirhynchus flaviventer* Yellow-breasted Boatbill. C, p. Up to 1200 m. [\bar{X} = 12.9 \pm 2.2 g, n = 4]
- Monachella muelleriana* Torrent Flycatcher. C, p.
- Microeca flavovirescens* Olive Flycatcher. C, p. [\bar{X} = 15.4 \pm 1.3 g, n = 8]
- Tregallasia leucops* White-faced Robin. C, p. Rarely down to 1000 m, usually above 1200 m.
- Drymodes superciliaris* Northern Scrub-Robin. C, p. [\bar{X} = 58.7 \pm 2.3 g, n = 3]
- Peneothello bimaculatus* White-rumped Robin. C, p. Up to 1200 m. Usually in old second growth or disturbed primary forest. [\bar{X} = 24 \pm 5 g, n = 11]
- Pachcephalopsis poliosoma* White-eyed Robin. A, p. [\bar{X} = 36.9 \pm 3.3 g, n = 48]
- Pachycare flavogrisea* Dwarf Whistler. C, p. [\bar{X} = 18.6 \pm 1.6 g, n = 8]
- Pachycephala soror* Sclater's Whistler. C, p. [\bar{X} = 25.3 \pm 1.9 g, n = 5]
- P. simplex* Grey Whistler. C, p. More common below 1200 m and in disturbed forest. [\bar{X} = 24.3 \pm 1.1 g, n = 2]
- P. hyperythra* Rusty Whistler. A, p. More common in old forest than *P. simplex*; sometimes in loose, vocal groups of 3-5 birds. [\bar{X} = 29.7 \pm 3.2 g, n = 25]
- Colluricincla megarrhyncha* Little Shrike-thrush. A, p. [\bar{X} = 35.4 \pm 2.5 g, n = 61]
- Pitohui kirhocephalus* Variable Pitohui. U, p. [\bar{X} = 89.3 \pm 3.2 g, n = 3]
- P. dichrous* Hooded Pitohui. U, p.
- P. ferrugineus* Rusty Pitohui. C, p. Below 1000 m.
- P. cristatus* Crested Pitohui. C, p. Up to 1300 m. [\bar{X} = 97.5 \pm 13.2 g, n = 4]
- Melanocharis nigra* Black Berrypecker. A, p. [\bar{X} = 14.1 \pm 1.4 g, n = 73]
- M. longicauda* Fan-tailed Berrypecker. U, t. Uncommon in 1990 and not recorded again until 1993; perhaps being displaced by *M. nigra*, as discussed by Diamond (1972). Altitudinal boundaries between congeners (e.g. *Melanocharis*, *Sericornis*, etc. noted by Diamond [1972]) could be temporally dynamic. [\bar{X} = 14.3 \pm 2.1 g, n = 6]
- Dicaeum pectorale* Papuan Flowerpecker. C, p. [\bar{X} = 6.8 \pm 0.4 g, n = 2]
- Nectarinia aspasia* Black Sunbird. C, p.
- Zosterops atrifrons* Black-fronted White-eye. C, p. Usually found on ridgetops where *Nothofagus* grow. Particularly vocal on sunny afternoons when most other birds are silent.
- Z. novaeguineae* New Guinea White-eye. C, t. Commonly in flocks December–February but largely absent at other times.
- Melilestes megarrhynchus* Long-billed Honeyeater. A, p. [\bar{X} = 45.5 \pm 3.8 g, n = 74]
- Toxorhamphus poliopterus* Slaty-chinned Longbill. A, p. Normally abundant in the nets, capture rates dropped dramatically November 1992–February 1993. Observed gleaning from spider webs. [\bar{X} = 12.0 \pm 1.5 g, n = 201]
- Oedistoma iliolophus* Dwarf Honeyeater. A, p. [\bar{X} = 13.4 \pm 1.5 g, n = 118]
- O. pygmaeum* Pygmy Honeyeater. C, t? Flocks irregularly seen up to 1050 m, perhaps vagrant groups from lower elevations.
- Glycichaera fallax* Green-backed Honeyeater. U, p. Not recorded by Diamond (1972) in the Eastern Highlands region. [\bar{X} = 11.8 \pm 0.4 g, n = 2]
- Myzomela eques* Red-throated Myzomela. U, p. The only *Myzomela* seen and netted in understory. [\bar{X} = 18.3 \pm 1.1 g, n = 2]
- M. cruentata* Red Myzomela. U, p? Possibly emigrates, like other nectarivores, during periods of low flower availability (December–March?).
- M. nigrita* Papuan Black Myzomela C, p? Possibly, like *M.*

cruentata, not a permanent resident.

M. rosenbergi Red-collared Myzomela. U, t. Only seen during times of peak flower availability. Relative abundance *nigrita* > *eques* > *cruentata* > *rosenbergi*.

Meliphaga mimikae Spot-breasted Meliphaga. A, p. Throughout area; somewhat less common at higher elevations. [\bar{X} = 28 ± 2.6 g, *n* = 72]

M. orientalis Mountain Meliphaga. C, p. Commoner at higher elevations.

M. albonotatus Scrub White-eared Meliphaga. U, p. Only found in the young disturbances around the station and helipad.

M. aruensis Puff-backed Meliphaga. U, p. More commonly in and around old (> 20 year) second growth. [\bar{X} = 28.7 ± 1.9 g, *n* = 3]

M. analoga Mimic Meliphaga. U, p. [\bar{X} = 24.5 g, *n* = 1]

M. flavirictus Yellow-gaped Meliphaga. R, p. Usually observed in the canopy.

Lichenostomus obscurus Obscure Honeyeater. C, p. [\bar{X} = 26.5 ± 2.4 g, *n* = 20]

Xanthotis flaviventer Tawny-breasted Honeyeater. A, p. [\bar{X} = 42.6 ± 4.4 g, *n* = 15]

X. polygramma Spotted Honeyeater. C, p. [\bar{X} = 20.5 ± 1.9 g, *n* = 16]

Pycnopygius ixoides Plain Honeyeater. U, p. Mostly in old second growth. [\bar{X} = 26.1 ± 0.9 g, *n* = 5]

Philemon buceroides Helmeted Friarbird. A, p. Confined to treetops along edges of the river and large patches of old second growth.

Melipotes fumigatus Common Smoky Honeyeater. R, t. At 1200 m a few sightings, probably wandering down from higher elevations.

Erythrura trichroa Blue-faced Parrot-Finch. A, t/p. This species was not recorded until late 1991 then became abundant when bamboos seeded (Fig. 2; Appendix 3). [\bar{X} = 15.6 ± 1.4 g, *n* = 250]

E. papuana Papuan Parrot-Finch. U, t/p. Not recorded until well into the period that *E. trichroa* was present; mostly female and juvenile birds. Juvenile birds of both *trichroa* and *papuana* show a two-toned bill, the lower and upper surfaces dark brown to black and the margins ivory white. Recent fledglings show blue wart-like gape marks. [\bar{x} = 19.6 ± 0.9 g, *n* = 6]

Lonchura tristissima Streak-headed Mannikin. C, t. Flocks of up to 12 birds appear occasionally around the station and helipad, then seem to move on after a few to 30 days. Nesting attempted once (Mack 1994). These birds were mostly typical *tristissima* but some showed varying amounts of integration with *L. leucostigma* plumage. CMBRS is in the area where these two species meet.

Mino dumonti Yellow-faced Myna. C, p.

Chaetorhynchus papuensis Mountain Drongo. A, p. [\bar{X} = 38.3 ± 3.7 g, *n* = 36]

Dicurus hottentotus Spangled Drongo. C, p. [\bar{X} = 76.7 ± 5.8 g, *n* = 3]

Oriolus szalayii Brown Oriole. A, p.

Grallina bruijnii Torrent Lark. C, p. [\bar{X} = 31 ± 7.1 g, *n* = 2]

Artamus maximus Great Wood-swallow. C, p.

Cracticus quoyi Black Butcherbird. U, t? Rarely observed until November 1992 then seen several times and several netted during the next four months, then not observed again. [\bar{X} = 171.7 ± 10.4 g, *n* = 3]

C. cassicus Hooded Butcherbird. C, p. Pairs have roughly linear territories along rivers. One attempted to catch a *Cyclopsitta gulielmiterti*.

Peltops montanus Mountain Peltops. C, p.

Ailuroedus buccoides. White-eared Catbird C, p. [\bar{X} = 135.3 ± 11.4 g, *n* = 18]

A. melanotis Spotted Catbird. U, p. Replaces *buccoides* on the plateau above the station at 1300 m. All sightings below the plateau were *buccoides*. Usually the transition for this species is around 800-900 m (Coates 1990; Beehler et al. 1986). Diamond (1972) noted the transition as unusually high (1220 m) at Karimui due to the unusual lowland conditions of the basin. CMBRS lacks the lowland conditions of the Karimui basin, but had a similarly high transition zone, probably due to steep cliffs in the 1200-1400 m zone.

Manucodia chalybata Crinkle-collared Manucode. C, p. Often observed defending fruiting trees from other frugivorous birds, as reported by Pratt (1984).

Ptiloris magnificus Magnificent Riflebird. A, p. A recent revision of *Ptiloris* (Beehler & Swaby 1991) found that the contact zone between the sister taxa *magnificus* and *intercedens* occurred in the Purari basin. The study site is in this zone. Singing males of the two forms are readily distinguished by their different song types. At the study site nearly all songs heard were of the *magnificus* type. The *intercedens* song type, however, has been heard at the station (H. Gomez de Silva pers. comm.), making this the first known area where the two forms co-occur though overlap in their ranges has been suggested (Coates 1990). [\bar{X} = 140.3 ± 17.6 g, *n* = 3]

Epimachus albertsii Buff-tailed Sicklebill. U, p.

Parotia carolae Carola's Parotia. U, t. Recorded more often than *lawesii*.

P. lawesii Lawes' Parotia. U, t. Like *carolae*, female-plumaged birds and sub-adult males present March–September, probably representing altitudinal migrants from higher elevations. Overlaps extensively with *P. carolae* in the Crater Mountain area, well outside the described zone of overlap (Healey 1976). At higher elevations nearby, both species of *Parotia* occur on the same display courts (M. LeCroy pers. comm.).

Cicinnurus regius King Bird of Paradise. R, t. Fairly numerous up to 600 m elevation. A female plumaged bird netted at 1100 m. [\bar{X} = 48 g, *n* = 1]

C. magnificus Magnificent Bird of Paradise. A, p. [\bar{X} = 87.6 ± 7.7 g, *n* = 27]

Paradisaea raggiana Raggiana Bird of Paradise. A, p.

Corvus trisitis Grey Crow. C, p.

Appendix 2 Potentially expected species.

Species notably absent but which might be expected to occur based on recorded distributions (Beehler et al. 1986; Coates 1985, 1990; Diamond 1972). Some of these are secretive and/or rare and might have been overlooked; these species are denoted by 'O'. Other species are more conspicuous or easily netted and these probably were truly absent; these species are marked by 'A'. *Ptilinopus nanus* A, *Aviceda subcristata* O (observed 10 km away at Haia), *Megatriorchis doriae* O, *Elabeornis plumbeiventris*

O. Rallina tricolor O, *Chalcophaps stephani* A, *Caliecthrus leucolophus* O, *Aegotheles wallacii* O, *Pitta erythrogaster* A, *Coracina morio* A (Diamond 1972 speculated that this species does not occur where *C. schisticeps* does), *Gerygone chloronotus* O, *Rhipidura rufidorsa* A, *Monarcha manadensis* A, *Zoothera dauma* A, *Microeca griseiceps* O, *Poecilodryas placens* A Diamond 1972 found this species common at the same elevation at nearby Mt. Karimui. Like many species in New Guinea, there are unoccupied areas of seemingly suitable habitat (see Diamond 1980), *Manucodia keraudrenii* A.

Appendix 3 Feeding observations.

Feeding observations of birds at flowering or fruiting plants at the Crater Mountain Biological Research Station. The numbers in parentheses refer to the author's catalogue numbers identifying voucher specimens. Vouchers are deposited in the collections of the National Herbarium of the Forestry Research Institute (Lae, PNG), the University of PNG (Port Moresby, PNG) and Missouri Botanical Garden (St. Louis, USA). Because of the difficulty of identifying plant specimens from New Guinea, particularly the poorly known southern scarp of the Central Range, determinations are provisional (Paul Katik pers. comm.).

Dracontomelon sp. Anacardiaceae (AM#252). Fruits taken by *Rhyticeros plicatus*.

Rhus sp. Anacardiaceae. Fruits taken by *Cacatua galerita*, *Pitohui kirhocephalus*, *Dicrurus hottentottus*.

Cerbera floribunda Apocynaceae (AM#1). *Probosciger aterrimus* take unripe fruits, hold them in one foot and chew off the sticky pulp from one end of the large seed. Then the birds shear through the woody seed with their massive bills, exposing the soft endosperm which is scooped out with the maxilla tip and tongue, and eaten. The killed seed is then dropped and the bird vigorously wipes the sticky latex from its bill before taking another fruit. The entire process takes, on average, 5.6 min ($n = 12$).

Schefflera spp. Araliaceae. These common canopy epiphytes produce a single large inflorescence that is a major source of nectar. Nectar production is probably confined to the afternoon; inflorescences under observation never had avian (or insect) visitors before 1300 h and visitation peaked after 1400 h. Inflorescences produce copious nectar (nectar droplets occasionally visible from the ground) that attract large numbers of nectarivores (up to eight birds and many hymenoptera, lepidoptera and coleoptera seen feeding on a single inflorescence simultaneously). Although numerous displacements and aggressive interactions occur among birds on inflorescences, birds were never observed completely excluding other nectarivores. No ecological segregation among nectarivorous birds, as observed at flowering trees at Karimui (Terborgh & Diamond 1970), was apparent at these presumably rich resources. Typical visitors to *Schefflera* inflorescences include: *Lorius lory*, *Trichoglossus haematodus*, *Charmosyna placensis*, *Nectarinia aspasia*, *Oedistoma pygmaeum*, *O. iliophus*, *Toxorhamphus poliopterus*, *Myzomela cruentata*, *Myz. eques*, *Melilestes megarhynchus*, *Meliphaga mimikae*, *Melip. orientalis*, *Xanthotis polygramma*, *X. flaviventer* and *Lichenostomus obscurus*. (Note: *Philemon buceroides* was not observed although it is common in the area and not likely to be competitive-

ly excluded.) *Schefflera* spp. could be found in flower at most times of year; thus, it could be a keystone resource to nectarivores. *Cicinnurus magnificus* commonly feed upon the fruits. This system merits greater study.

Osmoxylum sp. Araliaceae. Fruits taken by *Reinwardtoena reinwardtii*.

Fagraea sp. Clusiaceae (DW#360). Inflorescences visited by *Melilestes megarhynchus*.

Terminalia sp. Combretaceae (AM#240). *Probosciger aterrimus* shear through the entire fruit in one bite and extract the endosperm in 9-10 seconds. A bird will kill dozens of seeds in a single foraging bout.

Elaeocarpus sp. Elaeocarpaceae (AM#390). *Trichoglossus goldiei*, *Charmosyna pulchella* and *C. wilhelminae* observed feeding at inflorescences.

Elaeocarpus sp. Elaeocarpaceae (DW#302). Fruits taken by *Ptilinopus pulchellus*, *Coracina schisticeps* and *Ailurodeus bucooides*.

Sloanea sp. Elaeocarpaceae. Inflorescences visited by *Pseudeos fuscata*, *Melilestes megarhynchus* and *Oedistoma iliophus*. Seeds taken by *Cacatua galerita*. Fruits taken by *Cicinnurus magnificus*.

Dimorphophanthera sp. Ericaceae (AM#434). Inflorescences visited by *Trichoglossus goldiei*, *Charmosyna placensis*, *C. multistriatus*, *Meliphaga* sp. and *Xanthotis flaviventer*.

Macaranga sp. Euphorbiaceae (AM#609). Seeds taken by *Macropygia amboinensis*.

Glochidion sp. Euphorbiaceae (AM#650). Fruits broken apart and seeds consumed by *Cyclopsitta guilielmi*.

Albizia sp. Fabaceae. Inflorescences visited by *Myzomela nigrita* and *Oedistoma pygmaeum*.

Mucuna sp. Fabaceae. Inflorescences visited by *Dicaeum pectorale* and *Melilestes megarhynchus*.

Dichrotrichium sp. Gesneriaceae (AM#426). *Oedistoma iliophus* observed feeding at inflorescences.

Decaisnina holhungii Lorantheae (AM#414). *Melilestes megarhynchus* and *Toxorhamphus poliopterus* observed feeding at inflorescences.

Pauanthes albertisii Lorantheae. Inflorescences visited by *Nectarinia aspasia*.

Elmerrillia tsiampaca Magnoliaceae (AM#237). Fruiting trees produce thousands of fruits that are avidly consumed by columbids such as *Ptilinopus rivoli*, *Pt. ornatus* (once observed on ground taking fallen *Elmerrillia* fruits), *Ducula rufigaster*, *D. zoeae*, *Gymnophaps albertisii* and also the bird of paradise *Paradisaea raggiana*. *G. albertisii* becomes abundant when this common tree fruits in the study area (April-June) and is much less common the rest of the year.

Hibiscus sp. Malvaceae (DW#699). Inflorescences visited by *Melilestes megarhynchus*.

Astronia sp. Melastomataceae (AM#350). *Myzomela nigrita* and *Oedistoma pygmaeum* were observed probing inflorescences.

Dysoxylum sp. Meliaceae (AM#304). Fruits taken by *P. raggiana*.

Dysoxylum sp. Meliaceae (AM#664). Fruits taken by *Coracina boyeri*, *C. schisticeps*, *C. melaena*, *Oriolous szalayii*, *Manucodia chalybata* and *P. raggiana*.

Aglaia sp. Meliaceae (AM#317). Fruits taken by *P. raggiana* and *Ducula zoeae*.

Ficus dammaropsis Moraceae. The large, persistent bract-enclosed figs are often found hollowed out on the tree. Fruit-eating birds probably remove the pulp and seeds from within the bracts. *Melilestes mearnsianus* and *Meliphaga* sp. were observed probing open figs.

Ficus sp. Moraceae (AM#347). This is an unusual fig in that it has a hard pericarp that is fully eaten by *Psittichas fulgidus* or partially consumed by weaker-billed *Psittaculirostris desmaresti*. Figs that have been opened by strong-billed birds (probably mostly parrots) subsequently have their softer mesocarps eaten by weaker billed species such as: *Meliphaga* spp., *Xanthotis polygramma*, *X. flaviventer*, *Oriolus szalayii*, *Mino dumonti*, *Manucodia chalybata* and *Paradisaea raggiana*. This unusual situation was noted by Diamond (1972, p. 143); the weaker-billed species are probably the seed dispersers whereas the strong-billed species probably mostly consume pulp without dispersing seeds. The hard pericarp of this *Ficus* may be unique (D. McKey pers. comm.).

Ficus sp. Moraceae (AM# 423). Fruits taken by *Rhyticeros plicatus*.

Ficus sp. Moraceae (AM#536). Fruits taken by *Ptilinopus pulchellus*, *Microdynamis parva*, *Rhyticeros plicatus*, *Coracina boyeri*, *Pitohui kirhocephalus*, *Oriolus szalayii* and *M. chalybata*.

Ficus sp. Moraceae (DW#106). Fruits taken by *Cyclopsitta guiliemiterti*.

Ficus sp. Moraceae (DW#449). Fruits taken by *Manucodia chalybata*.

Myristica fatua (AM#330) Myristicaceae. Fruits taken by *Rhyticeros plicatus*.

Gynotroches spp. Rhizophoraceae (AM#428, AM#522). Fruits taken by *Ptilinopus rivoli* and *Meliphaga mimikae*.

Musa spp. Musaceae. Inflorescences visited by *Melilestes mearnsianus* and *Oedistoma iliolophus*. Fruits visited by *Paradisaea raggiana*.

Myristica subaluata Myristicaceae (DW#25). Fruits taken by *M. chalybata* and *Parotia lawesii*.

Acmena sp. Myrtaceae (DW#513). Inflorescences visited by *Oedistoma iliolophus*. A male *Dicaeum pectorale* appeared to defend a flowering tree.

Syzygium sp. Myrtaceae (AM#586). Inflorescences visited by *Charmosyna pulchellus*, *C. placentis*, *Oedistoma iliolophus*,

Myzomela rosenbergi, other *Myzomela* spp. *Melilestes mearnsianus* and *Meliphaga* sp.

Syzygium sp. Myrtaceae (DW#265). Fruits taken by *Ducula rufigaster*.

Pandanus penicillatus Pandanaceae (DW#24). *Probosciger aterrimus* shear through the tough, fibrous and woody endocarps to extract the seed. The heavily-armored unripe infructescences afford the seeds protection from these seed predators, but they become vulnerable when the infructescence ripens and dehisces.

Pandanus limbatus Pandanaceae. Infructescences were guarded and eaten by *Manucodia chalybata*.

Piper sp. Piperaceae (DW#814). Infructescences taken by *M. chalybata*.

Piper spp. Piperaceae. Infructescences taken by *Melanocharis nigra*, *Meliphaga mimikae*, *M. chalybata*, *Ailuroedus buccoides* and *Paradisaea raggiana*.

Schizostachyum sp. Poaceae (AM#334). Seeds taken by *Erythraea trichroa* and *E. papuana*.

Helicia sp. Proteaceae (AM#537). Inflorescences visited by *Oedistoma iliolophus*.

Psychotria sp. Rubiaceae. Fruits taken by *Meliphaga orientalis*, *Philemon buceroides* and *Cicinnurus magnificus*.

Melicope sp. Rutaceae (AM#614). Inflorescences visited by *Charmosyna placentis*, *C. multistriata*, *Oedistoma pygmaeum* and *Xanthotis flaviventer*. When these trees flower, lorikeet numbers dramatically increase and *C. multistriata* become numerous whereas they are absent at other times of year.

Heritiera sp. Sterculiaceae. Fruits taken by *Cracticus cassicus*.

Symplocos sp. Symplococaceae. (AM#659). Fruits taken by *Macropygia amboinensis*, *Meliphaga analoga*.

Eurya sp. Theaceae (AM#531). Fruits taken by *Melanocharis nigra*.

Poikilospermum sp. Urticaceae (AM#542). *Cyclopsitta guiliemiterti* appeared to eat inflorescences, and inflorescences visited by *Meliphaga aruensis*, *Xanthotis flaviventer*, *Dicaeum pectorale* and *Nectarinia aspasia*.

Poikilospermum sp. Urticaceae (DW#310). Fruits taken by *Glycichaera fallax*.

Poikilospermum sp. Urticaceae (DW#451). Inflorescences visited by *Trichoglossus goldiei*, *Charmosyna placentis*, *C. multistriata*, *Oedistoma iliolophus*, *Myzomela cruentata*, *M. nigrita* and *Lichenostomus obscurus*.