CORELLA

(formerly The Australian Bird Bander)

Journal of the Australian Bird Study Association

VOLUME 4 **DECEMBER, 1980** **NUMBER 5**

Foraging Ecology, Territoriality and Seasonality of the Common Paradise Kingfisher at Brown River, Papua New Guinea.

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Data on the kingfisher *Tanysiptera galatea*, taken at Brown River, Papua New Guinea, are presented. The species forages almost entirely in the lower understorey of rainforest or on the ground, with pronounced seasonal change involving foraging at lower levels during the wet season. Food observed was earthworms, large insects and a lizard, the worms being probed for in the ground. Population density is estimated at 50 birds/10 ha. The adults are monogamous, remain paired, hold territory year-round and are extraordinarily sedentary. Territories average about 0.3-0.5 ha. Breeding occurs within the wet season in contrast to other kingfishers in the same area, which commence breeding prior to the wet season. Considerable infraspecific aggression occurs prior to breeding and three possible agonistic displays are described. The nest is tunnelled into arboreal termiteria on lower trunks. In contrast to adults, immatures have high dispersal ability. Lack of food resources are considered to be as important as aggression by adults in contributing to dispersal. Annual adult mortality is at most 25-33% and probably much less, while annual increment of independant young is at least 150%. Moult occurs after breeding and takes two months or less. Immatures attain adult plumage probably 3-4 months after fledging. The bird is considered well-adapted to cope with waxing and waning of suitable habitat.

The Common Paradise Kingfisher *Tanysiptera galatea* is abundant and easily-netted in lowland rainforests of New Guinea. From December 1975 to November 1976 I studied the community ecology of birds in three hectares of rainforest at the Three Mile Experimental Plot, 4.5 km north of Brown River bridge, on the Hiritano Highway, Central Province, Papua New Guinea (Bell 1977). During this study I gained much information on *T. galatea* and I have combined this with my observations elsewhere.

Methods

At Three Mile Plot I censused along a transect for 36 hours each month in 1975-76 and 24 hours each month in 1976-77. Counts were evenly spread from 06:00-18:00 hours and I traversed the route shown in Figure 1 about once every two hours. Birds were recorded by number, sex if known, and height at which first seen. Heights were recorded as ground, 0-1 m, 1-2 m, 2-4 m, 4-6 m, 6-8 m, sub-canopy (*ca.*

8-25 m), lower half of the main canopy (*ca.* 25-30 m), upper canopy (*ca.* 30-35 m) and emergents (*ca.* 35-40 m). Other data such as foraging and aggression were collected on an opportunistic basis. Full details of methods are given elsewhere (Bell 1977).

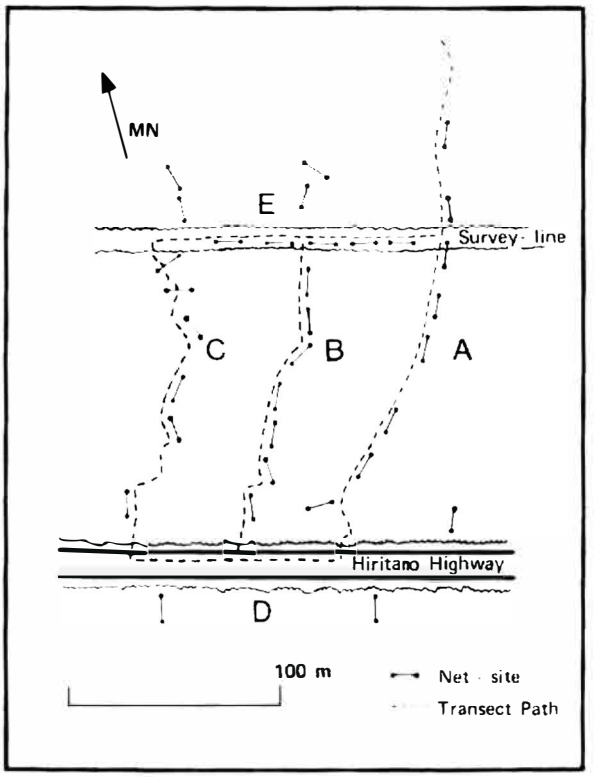
Mist-netting and banding* was carried out from January 1976 onwards. I erected three or four 13 m mist-nets, and rotated sites so that most were netted for equal periods, but not all net-sites were operated for the full study period. Sites were used as follows (see Figure 1): Lines A and C = throughout, Line D from July 1976, Line B from March 1977, Line E in March 1978 only. The increased numbers of sites resulted in more infrequent use of each but each was used at least for six hours every six weeks. I recorded sex (if known), net-site and time of capture for all birds caught. I also recorded weight, wing and tail measurements, description of immature plumage, presence of brood-patches and presence of mud on beak when time permitted. L.W.C. Filewood had banded at this site since 1971, in addition to his usual site 300 m to the north (Filewood 1971).

Study Area

The site shown in Figure 1 is closed-canopy lowland rainforest selectively logged *ca.* 1959. A very narrow belt of secondary growth bordered the road and a narrow survey-line, which only partially removed some understorey vegetation, ran parallel to the road. Rainfall at the Brown River Forestry Station averages 2 010 mm annually and the monthly rainfall for the period of the study is given in Figure 3. The trend is for a wet season from December to May and a dry season from June to November, when there is often no surface water and the ground sets hard. The vegetation is described by Heyligers (1965) and Bell (1977).

Surprisingly little human interference occurred and I saw no other person, except on the road, throughout the study. There is no evidence that *T. galatea* is hunted here even though I have seen the tail-plumes used as decoration in the New Guinea highlands.

* Bands used were provided by the Australian Bird-banding Scheme, Division of Wildlife Research, CSIRO.



● Figure 1. *Study area at Three Mile Plot, Brown River, showing transect paths, net-sites, and net-lines A to E.*

Distribution and habitat

T. galatea occurs throughout New Guinea (Bell 1971) and on some off-shore islands. Primary, lowland rainforest is its main habitat but it occasionally occurs in hill forest up to 600 m (Mackay 1969, Nicholson 1972). It will colonize isolated patches of rainforest: R. D. Mackay and I found an occupied nest at Eriama, Port Moresby (December 1967) in a patch of monsoon forest *ca.* 70 x 30 m, surrounded by savanna. It colonizes secondary growth once the canopy is closed and the ground relatively clear, but its density is much lower in such habitat. While 17.5% of the 411 net-catches I made at Three Mile Plot were of this species, at Brown River Forestry Station nearby, in an area of predominately secondary growth, only 1.8% of 388 birds netted by various banders were *T.*

galatea (Bell 1977). *T. galatea* will also readily colonize plantations of the exotic Teak *Tectona grandis* but is probably limited by the number of nest-sites (Bell 1979).

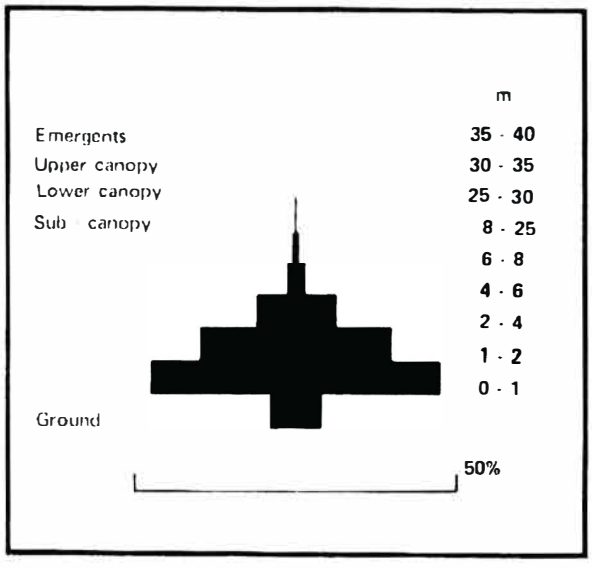
Results

Feeding Ecology

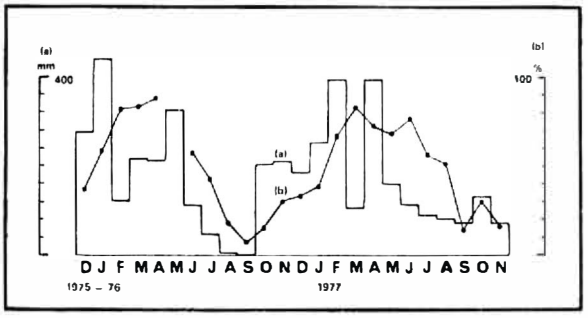
Foraging height

The vertical distribution of birds seen is shown in Figure 2. The species occurs mainly in the lowest two metres of the understorey. However many birds that normally feed on the ground in rainforest are usually first sighted above it, owing to their extreme wariness. The percentage depicted in Figure 2 for the ground level is doubtless an understatement. I also found that, if disturbed, *T. galatea* flies away and upwards, settling on a perch much higher than normal, so many of the higher-level occurrences may not have been associated with feeding. The vertical distribution shown applies only to rainforest conditions. In teak plantations, where there is little understorey, *T. galatea* frequents the canopy (Bell 1979).

No significant diurnal difference in vertical distribution exists, as occurs with the small insectivorous passerines at Three Mile Plot (Bell 1977). This implies that the food resources exploited remain at the same height level during the day. However, significant seasonal change in vertical distribution does occur.



● Figure 2. *Proportional vertical distribution of 801 sightings of Common Paradise Kingfisher at Three Mile Plot — December 1975 to November 1977.*



● Figure 3. *Monthly rainfall (a), at Brown River — December 1975 to November 1977, and monthly percentages of sightings (b) of Common Paradise Kingfisher less than one metre from the ground. (Total sightings 801) (* = no records for May 1976).*

Figure 3 shows the proportion of observations, by months, when *T. galatea* were less than one metre from the ground, and the rainfall at the Brown River Forestry Station. There is a significant correlation between the percentage of sightings close to the ground and the rainfall of the preceding month (Spearman Rank Correlation $P < 0.01$). As the ground dries out foraging obviously shifts to higher levels of the forest. During the dry season at Three Mile Plot the ground sets like concrete.

Fewer birds were netted during the dry months (Spearman Rank Correlation; monthly catch-rates vs rainfall of the preceding month, $P < 0.01$). The presence of immatures and the increased activity of the breeding season could have produced the high catch-rates of the wet season. Table 1 shows both catch-rates and rates of observation for the period (data for both years combined). Although more birds were seen in the wet season the difference between wet and dry season sightings is far less than the difference in catch-rates. This infers that birds are caught less often in the dry season because they are less often foraging at net-height (i.e. under two metres).

TABLE 1

Rates of sightings, and capture, by months, of Common Paradise Kingfishers at Three Mile Plot 1976-77.

	WET SEASON						DRY SEASON					
Month	D	J	F	M	A	M	J	J	A	S	O	N
Hours of observation	80	72	60	61	66	29	36	66	66	60	60	60
Birds seen /hour of observation	1.5	1.8	1.4	1.1	1.2	1.6	1.1	0.7	0.7	0.6	0.7	1.1
Birds netted	16	14	14	14	10	13	10	7	5	1	3	3
Catch-rate per 100 net-hours	5.9	7.7	7.1	9.1	4.2	11.1	7.1	3.3	1.9	0.5	1.5	1.3

Further evidence of seasonal change in foraging is that, on those days in which I specifically noted soil conditions, 21 out of 22 birds netted when the ground was damp had earth stains on their bills, but when the ground was dry, 13 out of 14 birds netted had clean bills.

Food

In the literature stomach contents of *T. galatea* have been recorded as insects, including a large grasshopper (2 specimens, Hoogerwerf 1971); and insects, including caterpillars (5 specimens, Rand 1942). Gyldenstolpe (1955) mentions grasshoppers as "the principal prey" but without data. Gilliard and LeCroy (1966) recorded a lizard and arthropods, including an armoured centipede, being fed to nestlings. I observed birds taking earthworms (on seven occasions), unidentified large insects (twice) and a lizard.

All observations of earthworms being taken were in the wet season. Three were of birds bringing more than one earthworm at a time to young in the nest. The method of taking earthworms was seen once. The bird flew to the ground from a branch 0.7 m above. It then stabbed the ground and kept probing with its bill embedded in the soil. It then slowly dragged out an earthworm but after 15 seconds the worm broke, the bird being left with a piece about 18 cm long and one cm wide. The bird then flew to a low perch and spent 90 seconds bashing the fragment on the branch and working it through its bill. It then flew to a buttress root and bashed the prey for a further two minutes before flying away.

The two insects I saw taken were snatched off foliage about one metre high, the bird flying from a perch above. Rand (1942) also records this behaviour. However most published reports (e.g. Gyldenstolpe 1955, Gilliard and Le Croy 1966, Rand 1942) are of prey being snatched from the ground. These reports and my own observations indicate that the species watches for its prey from a perch, cocking its head sideways while looking.

Population density and territory

Population density

I estimated the breeding population at 50 birds/10 ha, slightly less than my previous estimate of 60 birds/10 ha (Bell 1977). The estimate is based on territory-size deduced from banding and retrap data. The data indicate that the species is monogamous and is faithful to territory year-round. Although unable to sex birds I was able, in most cases, to deduce which individuals were paired. Catching two birds together was disregarded as evidence of relationship as they are as likely to have been involved in a chase as to have been a pair. I was unable to map all territories until the third (1977-78) breeding season.

Table 2 gives data of wing measurements and weights of presumed pairs in mapped territories, compared with measurements of specimens of

TABLE 2

Wing measurements and weights of 10 presumed pairs of Common Paradise Kingfishers netted at Three Mile Plot, compared to wing measurements of sexed specimens.

Wing	n	Mean + S.D. (mm)	Range (mm)
Male (live)	10	103.0 ± 1.8	101-107
Female (live)	10	100.7 ± 0.6	100-101.5
Male (specimens)	10	107.2 ± 2.2	105-110
Female (specimens)	7	104.4 ± 1.4	103-107
Weight	n	Mean + S.D. (g)	Range (g)
Male (live)	10	51.0 ± 3.0	47-55
Female (live)	10	49.4 ± 4.4	40-53

T. galatea minor (the sub species at Brown River) in the collection of the CSIRO Division of Wildlife Research. Mean difference between male and female wings, in the specimens, is 2.8 mm, the male being significantly larger (Wilcoxon's Sum of Ranks Test, $P < 0.01$). This compares well with a mean difference of 2.6 mm between the "pairs" at the Three Mile Plot. The difference, in Table 2, between my wing measurements and those of the specimens (*ca.* 5 mm) is explained by my reluctance to flatten the wings of living birds while measuring them. Thus I believe it is reasonable to assume, at least in the majority of cases, that the larger bird of the pair is the male.

It cannot be assumed that the species exists in equal densities throughout its range. In 1967 at Nomad River, Western Province, I netted for at least 400 net-hours in primary forest during the wet season. Although the nets were in an area of ca. 100 x 200 m only two individuals of *T. galatea* were caught in three weeks of banding. Professor J. M. Diamond (pers. comm.) found in 1976 the bird to be quite rare at Nomad River in apparently suitable habitat.

Territory

Mapped territories are shown in Figures 4, 5, and 6. The use of more net-sites enabled additional territories to be mapped as the study progressed. Only two territories (A and J) could be mapped on all boundaries and their areas were *ca.* 0.54 and 0.28 ha respectively. However, no bird was netted on both the western-most and the eastern-most net-lines (100-120 m apart), or on both the road and the survey-line (130 m apart). This suggests that home ranges are much less than 100 m in diameter.

Table 3 gives the retrap distance from banding-site of 48 adults and 14 immatures. The longest movement recorded by an adult was only 100 m, 262 days and 6 retraps after banding. For another it was 90 m after 967 days and 10 retraps; for a third, 70 m after 270 days and 4 retraps. As shown in Table 3, 43 of the 48 retraps were less than 40 m from banding-site, in the case of two birds a period of two years from banding to recapture was involved. Two other birds, banded by L. W. Filewood in 1971, were caught by me in 1976 no more than 100 m, and probably much less, from the original banding-site. However of the many birds banded by Filewood at his major site (Filewood 1971), 300 m distant, none was recorded at my site. Clearly, adult *T. galatea* are sedentary birds. Immatures, as shown in Table 3, are much less so, one bird travelling 210 m within seven days,

TABLE 3

Distance from banding site of 62 recaptured Common Paradise Kingfishers at Three Mile Plot.

Distance (m)	Banding site	10-20	20-40	40-60	60-80	80-100	100-120	> 200
Adults (48)	19	18	6	2	2	1		
Immatures (14)	4	2	3	2		1	1	1

(Kolmogarov-Smirnov Test, Adults recovered significantly closer to banding-site than randomly expected, $P = < 0.01$; immatures not significantly different to random distribution, $P = > 0.1$)

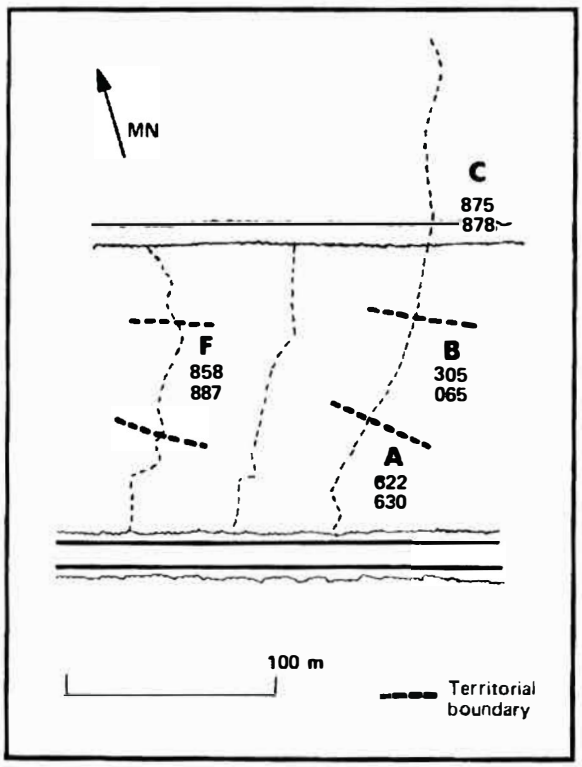
the longest distance between any two of my net-sites. From the above information I consider that territories, at Brown River, are usually 0.3-0.5 ha. in size.

Fidelity to territory

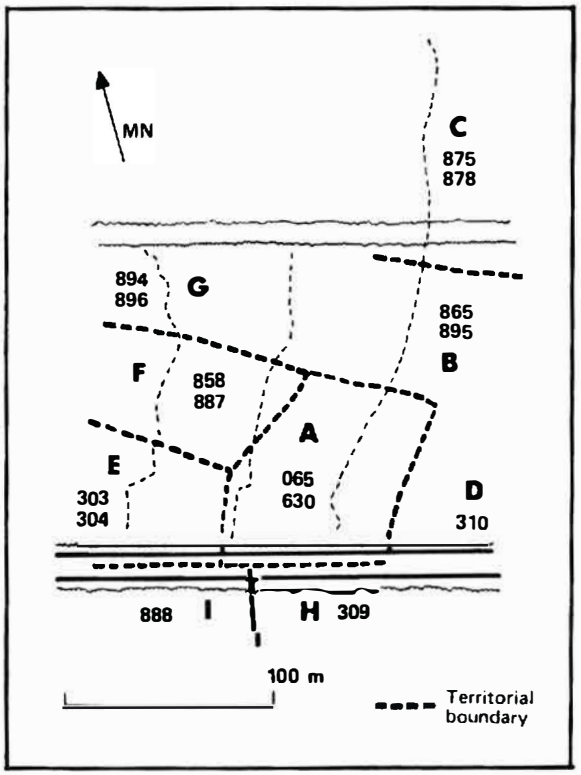
Figures 4, 5 and 6 indicate that there is little change in territories from year to year. A bird in Territory B shifted to Territory A in the second season, possibly caused by disappearance of a bird in each of Territories A and B.

Birds removed from their territory quickly return once liberated. I kept no records of "same-day" recaptures but birds liberated at a central banding point were consistently caught soon after in the same net in which they were first caught or another on a direct line with it. One bird on 18 June 1977 re-entered the same net five times in one day. On 7 August 1977 two birds caught at Filewood's old site, and removed to mine for banding, were retrapped on Filewood's site one hour after being liberated on my site. This latter occurrence is important as it indicates fidelity to territory in the dry (i.e. non-breeding) season.

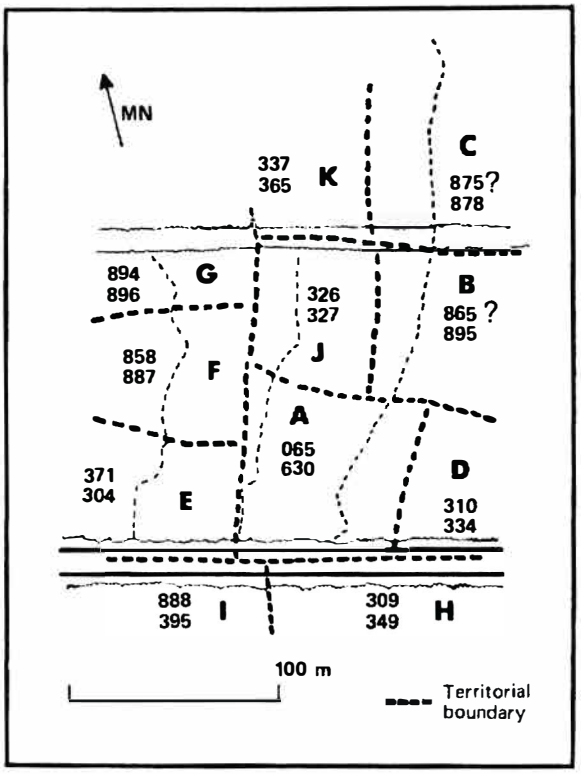
At Nomad River, where I recorded similar "homing" behaviour by several species (Bell 1970), a pair of *T. galatea* released 200 m from their banding site were found 30 minutes later in the original net. These occurrences seem to be too frequent to be mere coincidence. Perhaps the urgency of regaining its territory makes the bird more unwary than usual.



● Figure 4. *Study area, Three Mile Plot, showing known territories of Common Paradise Kingfisher breeding season 1975-76. (Numbers represent last 3 digits of band-numbers, presumed male is top number in each pair).*



● Figure 5. *Study area, Three Mile Plot, showing known territories of Common Paradise Kingfisher breeding season 1976-77.*



● Figure 6. *Study area, Three Mile Plot, showing known territories of Common Paradise Kingfisher breeding season 1977-78. (Birds marked with query not netted, but possibly still present).*

Seasonality

Breeding Season

My own breeding records, those kindly supplied by B. J. Coates, and those published in the *Papua New Guinea Bird Society Newsletter* are summarized by Bell (1977). Breeding of insectivorous birds, including other species of kingfishers (Bell 1977) starts at the height of the dry season (the Austral spring), reaches a peak in the early wet season and then finishes abruptly. *T. galatea*, however, like other ground-feeding species (e.g. pittas, rails and *Eupetes caerulescens*) breeds mainly within the wet season (Table 4), presumably because of the effects of rain upon soil hardness and litter fauna.

Table 5 shows presence of vascularized brood-patches during the 1976-77 season. Although correlation between brood-patches and rainfall is not significant (possibly because I often failed to inspect the brood-patches), the indication is that incubation has largely ceased by April, just before the wet season ends.

Nest

Rand and Gilliard (1976) describe the nest as a hollow in a termitarium but also state, with a query, "in a hole in a branch". At Brown River the nest of the termite *Microcerotermes biroi* seems always used, and nests are 2-6 m from the ground. I have seen both birds of a pair excavating the nest-hole but many abortive attempts seem to be made before a suitable termitarium is chosen. I was not prepared to destroy

TABLE 4

Nesting records* of Common Paradise Kingfishers at Brown River 1967-1977. Correlation between number of breeding records and rainfall is significant (Spearman Rank Correlation Test, $P = < 0.01$).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
No. of Nests	5	2	6	1			1			1	3	10
Mean monthly rainfall (mm) †	261	212	292	218	196	88	51	44	95	164	204	185

* Date of nest is date of discovery of an occupied nest regardless of status (i.e. eggs or young), which is unknown in most cases.
† From McAlpine *et al.* (1975).

TABLE 5

Presence of vascularized brood-patches on adult Common Paradise Kingfisher netted at Three Mile Plot 1976-77.

	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1976		1977											
Birds with brood-patches	2	7	3	1	2						*	2	1	3
Birds without brood-patches	1	1	3	4	1	2	7	4	2	3	*	1		
No records of brood-patches taken		5	5	2	4	3	4	5		1	*			1
Rainfall (cm)	21	27	25	39	16	12	9	8	7	13	7	13	7	11

* No birds captured in September.

TABLE 6

Intra-specific chases by Common Paradise Kingfishers observed at Three Mile Plot 1976-77.

Month	S	O	N	D	J	F	M	A	M	J	J	A	S
Chases by adults of other adults	4	9		4	2								
Chases by adults of immatures								1	1	1	1	1	
Chases by immatures of other immatures							1	1					

nests for inspection. However, one termitarium that fell from a tree contained a nest from which the young had just flown. The nest-chamber was 13 cm in diameter, with an entrance tunnel 15 cm long. The size of this chamber seems a tight fit for a sitting bird and birds are frequently seen with bent or broken tail-plumes.

Ramsay (1878) records a clutch of five eggs, at Laloki River, near Brown River, Gill (1964) records 3-4 for the closely-related *T. sylvia*, at Innisfail, North Queensland and a breeding period of 2.5 months from commencement of tunnelling to fledging of young. I have no information on whether or not both sexes of *T. galatea* incubate. Certainly, both feed young in the nest and one bird can often be seen waiting with food in its bill, while the other is inside the nest. I have only once seen adults feeding young out of the nest and suspect that the young are soon left to fend for themselves.

No evidence was seen of nests being dug out by predators even though monitors *Varanus indicus* and *V. prasinus* were abundant. However, I have twice seen occupied nests abandoned before they were expected to fledge young, suggesting predation. The most likely predator capable of entering the nest-tunnel is the nocturnal Brown Tree-snake *Boiga irregularis*.

Seasonal activity

T. galatea rarely calls in the dry season, when it is difficult to locate. In September, calling increases noticeably and, by October, intra-specific aggression becomes incessant. Table 6 gives instances of aggression actually recorded, although many more were observed.

Aggression is of three types. One adult will often be seen perched while two others repeatedly swoop at it until the first bird flies out of the area. I presume this is a resident pair attacking an intruder. The second type is a direct chase. On 24 November 1977 I saw one adult fly from Territory C (see Figure 6) into Territory B but before it could perch, two birds flew at it and chased it back into Territory C, the two aggressors then returning to Territory B. On 21 November 1976, two adults chased one another backwards and forwards three times, presumably over a territorial boundary. Such chases seem to be about 20-30 m, i.e. half the width of a territory. The third type of aggression consists of two adults (a pair?) perching, faced towards two others similarly perched, both pairs calling loudly. One bird then swoops at another of the opposite pair and after a few minutes both pairs fly off in different directions. Rand (1942) recorded similar gatherings (in August and September, in the Fly River area). This may be a territorial demarcation display.

Aggression probably tapers off in the mid-breeding season owing to preoccupation with nesting activity because any young of the previous

season's nesting, still present in spring, have long since been expelled. I witnessed no chases in the mid dry season but all birds caught at that time, other than the few young still present, were caught within their own territories.

Dispersal of young

After fledging the young birds appear to feed mostly on the ground, which is damp at this time of the year. Immatures caught are invariably mud-stained with soil-encrusted bills. The young are much noisier than the adults and are aggressive towards each other and towards other species. I saw one strike at a Black-headed Pitta *Pitta sordida*, and another rather unwisely, attacked a Greater Coucal *Centropus menbeki*.

Young birds appear to move out of their natal territory soon after independence. One immature (050-77305) had travelled 210 m, crossing three territories in seven days after banding. Three others crossed three territories and moved more than 120 m within 50 days of banding. Immatures moved much further from banding sites than adults, even within the confines of my study area (Table 3).

As the breeding season progresses "new" adults appear i.e. unbanded birds in adult plumage (Table 7). The first immatures appear in December and "new" adults in March. One immature (050-77325) caught as it appeared to leave a nest on 16 March was retrapped on 26 May in adult plumage but with incomplete tail-plumes. Acquisition of adult plumage could thus take about 70 days, or less .Two other immatures were re-trapped in full adult plumage, including tail-plumes, 114 days from banding. It is therefore likely that the "new" adults in Table 7 are young of the year as they do not appear until three months after the first young are netted.

TABLE 7

Number of individual Common Paradise Kingfishers netted at Three Mile Plot, August 1976 — October 1977, by known adults, "new" adults, and immatures.

Month	A 1976	S	O	N	D	J	F 1977	M	A	M	J	J	A	S	O
Adults previously banded	2	1	1	3	8	7	4	2	1	4	2	2	1		3
"New"* adult-plumaged								2	1	3	2		2		
Immature-plumaged					5	4	3	3	3	4	5				

* "New" = a fully adult-plumaged bird not previously netted.

TABLE 8

Retraps of Common Paradise Kingfishers and elapsed time to last recapture at Three Mile Plot, 1 December 1976 to 30 November 1977.

	n *	Retrapped later	Elapsed time to last capture 0-90 days	90-180 days	> 180 days
Adults banded prior to 1.12.76	12	9 (27 times)	1	1	7
"New" adults	6	nil			
Immat.	23	8 (10 times)	5	3	

* Note numbers do not correspond to Table 3 which includes birds netted outside the period covered by this table.

Table 8 gives retrap figures for 1 December 1976 to 30 November 1977, for adults, "new" adults and immatures. Even with the modest netting-rate (*ca.* 96 net-hours monthly) most adults were retrapped and were still present during the later half of the period. No "new" adult was seen again suggesting that once fully-plumaged they are driven away. Only one-third of the immatures were retrapped, only three more than three months from banding, and none after six months. Most of the young of the year therefore either perish or are forced away, as Table 7 suggests, at the end of the wet season.

During the early dry season the species may turn up in unusual places. Lindgren (1970) reported one in a suburban garden and at least 10 km from the nearest rainforest and quoted another seen in the Port Moresby airport terminal. I have seen an immature in a scrubby gully in dry savanna and also heard of other occasional, but regular, reports of birds seen in parks and home gardens. The young can also colonize secondary growth rainforest but scarcity of termitaria would make breeding impossible for many birds in this habitat.

In two instances I recorded significant weight-loss by immatures. Most retrapped immatures weighed 2-4 g less than when first netted; this is to be expected after fledglings become active. However, an immature bird weighed 53 g on 18 June 1977, and when retrapped on 8 August weighed only 39 g, and could hardly fly. Another weighed 50 g on 20 April 1977, and when retrapped 50 days later weighed 41 g and also appeared feeble. Fogden (1972), in Borneo, recorded similar cases of immature birds of several species losing weight, and dying in the net, in the post-breeding period.

The territorial defence by adults in the Spring drives out any surviving young, other than those that replace deceased adults. However, I suggest that the most important factor in the dispersal of the young is the drying-out of the ground at the end of the wet season, when most young disappear. If immatures feed mainly on ground fauna, as they seem to, they would be ill-equipped to compete with experienced adults in the presumably more difficult foliage-gleaning. Once dry conditions dictate aboreal foraging (see Figure 3) the young may have to either disperse or die.

The record of Draffan (1978) of an adult on Darnley Island, Queensland, 76 km from New Guinea possibly indicates considerable potential for dispersal. However, since village people sometimes rear young kingfishers, the bird on Darnley Island may have been carried on one of the many Kiwai canoes that ply between Daru and the Torres Strait islands. It is noteworthy that *T. galatea* has not successfully colonized nearby New Britain; all the island members of the superspecies (except perhaps *T. g. vulcani* on Manam Island which is very close to the mainland) are glacial relicts (Mayr 1942).

Longevity, Mortality and Annual Increment

Survival

The longest elapsed time so far for a recovery of a Common Paradise Kingfisher is five years six months (Anon 1978). This bird, and another recovered after five years three months were both banded by L. W. Filewood and recaptured by me in Territories A and B (see Figure 6), but neither were recorded after the 1975-76 breeding season. Banding in New Guinea has been mostly intermittent and sustained effort at one location would probably show that the longevity

TABLE 9

Survival data of Common Paradise Kingfishers netted in Territories A, B, C, E and F * at Three Mile Plot.

Breeding season	Nov. 75-Oct. 76	Nov. 76-Oct. 77	No. 77-Mar. 78
Adults			
Banded before	8	6	5
First banded 1976-77 season		3	2
First banded 1977-78 season			1
"New" adults (i.e. not caught until later half of season)			
Banded 1975-76	4	1	—
Banded 1976-77		2	—
Banded 1977-78			—†
Immatures			
Banded 1975-76	5	—	—
Banded 1976-77		16	—
Banded 1977-78			—†
Net-hours in area	1 125	872	180

* See Figures 4-6.

† Note netting ceased early in breeding season, but immatures should have been netted by March (see Table 8 for 1976-77 season).

TABLE 10

Sightings of adult-plumaged and immature Common Paradise Kingfishers at Three Mile Plot, April-September 1977.

Month	Hrs. of observation	Adult-plumaged	Immature-plumaged	Total
Apr	24	25	41	66
May	24	11	18	29
June	36	28	8	36
July	24	11		11
Aug	24	16	1	17
Sep	24	19		19

of *T. galatea* is as great, or greater, than some passerines at Brown River already known to have survived 10 years.

Table 9 gives survival data, based on retraps of birds occurring in Territories A, B, C, E and F (see Figures 4-6). The sample is too small for significance. The late onset of the 1977-78 wet season resulted in very low catch rates so some of the birds "missing" at that time may still have been alive. However, these data suggest an annual loss of a quarter to a third of the adult population, though I am confident that future research will show it to be much lower. (Fodgen [1972] found the mortality rate for 24 adults of three species of kingfishers in Borneo to be 12.5%).

From Table 9 and Figures 4-6 it can be seen that two adults in each of Territories A and B disappeared after the 1975-76 season (these are the two long-term retraps referred to earlier). The presumed male in Territory B then paired with the presumed female in Territory A, where both remained for the following two seasons. Territory B was occupied by two "new" birds, the presumed female having been netted in full adult plumage inside Territory B at the close of the breeding season. The pair in Territory E were unbanded in the 1975-76 season.

Following the second season (1976-77) Territory E lost the presumed female which was replaced by another bird. In the 1977-78 season the presumed male of B and C were not found but as no other previously unrecorded adults were caught this may reflect the small sample netted rather than actual loss.

Annual Increment

There is a large annual production of young, most of which disappear in their first year. The breeding season seems long enough for two clutches, although there is no evidence for this. The clutch, even if not normally the five eggs reported by Ramsay (1878), is probably not less than the 3-4 known for *T. sylvia*. Given the usual high success-rate of hole-nesting species, young of the year probably outnumber parents. Belatedly I counted immatures separately in my transect counts and Table 10 gives figures for adults and immatures seen at the end of the 1976-77 breeding season.

Table 10 shows that in April and May sightings of immatures outnumbered those of adults by approximately 3:2. I have no reason to believe that immatures are easier to see than adults; indeed, they are better camouflaged. This ratio is probably greater in reality because by April some young of the year are known to move away into marginal habitat. Also, as shown earlier (Table 7) some young are already in adult plumage by April. Even if a territory loses one adult each second year, as inferred in Table 9, it may produce six more young in that period.

Plumage

Moult

No data were taken on moult but measurements were taken of tails and their central plumes. These are given, for four birds, in Table 11, combined with data on brood-patches; these were the only individuals for which I had varying

TABLE 11

Tail length and presence of brood-patches of retrapped adult Common Paradise Kingfishers at Three Mile Plot, breeding season of 1976-77.

Month	Dec	Jan	Feb	Mar	Apr	May	June
050-18895							
Tail (mm)	107	106 ←		121 days		→ 102	
Central plumes (mm)	254	254				194	
Brood-patch	Yes	Yes				No	
050-61065							
Tail (mm)	108	108	107	106 ←	57 days	→ 62	
Central plumes (mm)	265	266	265	265		116	
Brood-patch	Yes	Yes	Yes	Yes		No	
050-18858							
Tail (mm)	95		96 ←	62 days	→ 60		
Central plumes (mm)	202		204		100		
Brood-patch	Yes		Yes		No		
050-77304							
Tail (mm)	101		100 ←		120 days		→ 103
Central plumes (mm)	235		234				204
Brood-patches	Yes		Yes				No

measurements within one breeding season. Acquisition of new tail-plumes, as indicated by the shorter lengths, is in each case, accompanied by a disappearance of brood-patches. This suggests that moult takes place after breeding.

Two of the birds in Table 11 (050-61065 and 050-18858) had acquired new plumage, albeit with short tails, only two months after they were netted in the old plumage. I did not catch any birds that appeared to be undergoing moult of body feathers, and only saw one that appeared to be. This suggestion that birds in heavy moult, as to be expected, are secretive. Towards the end of the breeding season birds in old plumage were all soiled, with worn, broken and mud-stained tail-plumes.

Immature Plumage

Iredale (1956) describes the immature plumage and illustrates an immature of *T. g. minor*. Young are brown with a blue tinge on the crown and upper nape, and buffish underpart feathers which are tipped with brown. The tail is brown with two elongated central feathers (*ca.* 160 mm long) edged with a blue tinge. The beak is black with a reddish tinge. The beak becomes noticeably redder while the bird is still in immature plumage. One bird (050-18889), retrapped after 77 days, had two coloured central tail plumes growing, with perfectly-formed racquets on the tips. The plumes were growing over the existing two immature central tail feathers but had not reached their tips (159 mm). This was the only case I saw of adult tail-plumes on a "brown" bird. I did not net, and apart from the above bird only once saw, a bird not in either full adult or full immature plumage.

Reference was made earlier to an immature (050-77325) being caught in full adult plumage (less fully-grown tail plumes) only 71 days after having been seen to leave a nest. However, two

● *Adult Common Paradise Kingfisher.*

Photo: W. Peckover

● *Immature Common Paradise Kingfisher.*

Photo: W. Peckover

other immatures were still in immature plumage 57 and 77 days after initial capture, and 050-18889, referred to before, had only the two tail plumes of the adult plumage 77 days later. This suggests that either the time taken to attain adult plumage varies widely or that 050-77325 seen leaving a nest had fledged previously and had re-visited its own or another nest.

As mentioned before there were also two immatures that were caught in full adult plumage, including tail-plumes, 114 days after initial capture in full immature plumage. This, and the data in Table 7, suggest that the usual period for acquisition of adult plumage is in the order of 3-4 months from fledging.

Conclusion

Tanysiptera galatea is a species of extraordinarily sedentary habits among adults, even for a bird of tropical rainforest. Even if not distributed in equal densities over the available habitat its total population probably runs to millions or tens of millions. Its ability to colonize artificial or secondary habitats is combined with high dispersal ability of the young and a high ratio of reproductive potential to adult mortality. Thus it could cope with the waxing and waning of lowland rainforest as postulated by Nix and Kalma (1972), being able to maintain viable populations in small areas of suitable habitat, yet having the ability to colonize new habitat as the rainforest expanded.

Acknowledgements

I owe thanks to B. J. Coates for use of his breeding data and to L. W. C. Filewood for allowing me to follow-up his earlier banding in the study area. Ms Sylvia Spring assisted in checking CSIRO banding records held by the Department of Natural Resources, Papua New Guinea. Dr R. Schodde, CSIRO Division of Wildlife Research, kindly made available the specimens of *T. galatea minor* in the National Collection and Mrs H. B. Gill assisted with supplying data. Photographs were kindly supplied by Mr W. Peckover. Dr H. A. Ford and Mr R. Noske criticized the draft.

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