THE PERSISTENCE OF ANT-FOLLOWING BIRDS IN SMALL AMAZONIAN FOREST FRAGMENTS.

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SUMMARY

Mist-net captures of army ant-following birds were monitored during the isolation of central Amazonian forest fragments of 1 ha (n = 5), 10 ha (n = 4) and 100 ha(n = 1). Post-isolation captures of the three obligate ant-following birds ***Dendrocincla merula, Pithys albifrons****, and* ***Gymnopithys rufigula*** *decreased significantly in all fragments. Post-isolation captures of four facultative ant-following species were not significantly different in forest fragments of 1 ha and 10 ha, although two species decreased significantly in the 100 ha fragment. Experimental introductions of obligate species into small forest fragments in the absence and presence of introduced* ***Eciton burchelli*** *army ant colonies resulted in significantly greater recaptures of introduced birds when active army ant colonies were present. Of the 105 birds introduced, 58 '55%) crossed 100-320 m od dedorested area and were recaptured in continuous forest.*

INTRODUCTION

The depauperate faunas of land bridge islands and continental forest isolates are well documented (Abbott, 1978; Diamond, 1975; Forman **et al.**, 1976; Galli **et al.**, 1977, Leck, 1979; Terborgh, 1974; Willis, 1974, 1979). The extinction of birds (Diamond, 1972; Terborgh, 1974), mammals (Brown, 1971), and reptiles (Wilcox, 1978) have been related to the isolation area reduction associated with island formation. Some studies demonstrate that extinction probabilities may vary widely among species (Terborgh & Winter, 1980; Willis, 1974, 1979; Karr, 1982) and that faunas of smaller islands have higher extinction rates (Diamond, 1972, 1973; Terborgh, 1974; Soule **et al.**, 1979). However, studies of this type often are based on assumptions with regard to estimating the island's pre-isolation faunal community and the date of island formation. Faunal communities may vary over geographically short distances, and the potential for a sampling or founder effect in island systems is great. Extinctions can be cited erroneously for species that were not present

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on the island at the time of isolation. These important aspects of island studies are often difficult to determine.

Birds are vulnerable to many factors following isolation and area reduction in islands on forest fragments, including habitat alteration, increased abundance of predators, changes in resource levels, or increased abundance of competitors (Abbott, 1980). The most well documented case of species extinctions on a land-bridge island is Barro Colorado Island in Panama. Both census data of the pre-isolation bird community and the date of island isolation are available. Since the island was formed in 1914, the long term insularization effects described by Willis (1974) and Terborgh (1974) have resulted in the loss of at least 45 of the original 208 bird species in about 50 years. Karr (1982) estimates that 50-60 forest bird species have been lost from Barro Colorado Island. Both habitat succession and the increased abundance of certain mammalian predators may help explain many of the extinctions on Barro Colorado Island (Willis, 1974; Terborgh & Winter, 1980).

Although area is certainly an important factor which regulates species loss, both the size and quality of an island or forest fragment are critical in determining the rate and order of species disappearance (Diamond, 1978; Abbott, 1980). The relative quality of a forest fragment may be measured by the quantification of some critical resource for the organism under study. The army ant-following guild of birds is a system for which available resource levels may be estimated by monitoring the number of colonies of the army ant **Eciton burchelli** in the forest fragment. The regular swarming cycle of these army ants provides a dependable source of flushed insect prey for several species of antbirds (Formicariidae), woodcreepers (Dendrocolaptidae) and other birds (Willis & Oniki, 1978). Although most families of birds show mixed susceptibility to extinction (Terborgh & Winter, 1980), antbirds have been cited as extinction prone where the area of continuous forest *has been reduced, such as at Barro* Colorado Island (Terborgh, 1974; Willis, 1974) and in tropical forest isolates (Leck, 1979; Willis, 1979).

I selected four species of antbirds and six species of woodcreepers (Table 1) to examine the persistence of individuals in forest fragments of varying area in conjunction with the INPA-WWF Biological Dynamics of Forest Fragments project in Manaus, Amazonas, Brazil. All of these species follow army ants at least facultatively, and three can be considered obligate and followers (Oniki & Willis, 1972; Willis & Oniki, 1978; Willis, 1977; Willis, 1983; Harper, unpubl. data). Often thought to be sedentary and reluctant to cross open areas, antbirds and other ant-following birds are ideal for studying the process of species disappearance in remnant forest fragments. They are common in the forest understory, easily captured and color-banded, and can be approached closely for observation. The birds attend ant swarms for several hours each day and obligate species gain a significant portion of their diet by foraging in this manner. Foraging behavior within the guild is restricted by a weight- and size-structured dominance hierarchy which may exclude smaller species from the most productive part of an ant raid (Willis & Oniki, 1978).

~~There were four objectives to my study:~~ 1) ~~to determine the effects of area and~~

resource reduction on the persistence of these ten bird species in isolated forest fragments, 2) to perform experimental introductions of the species into an isolated 1 ha and an isolated 10 ha fragment to rule out the possibility of a sample effect bias in fragment formation, 3) to determine if post-isolation changes occur in the availability of insect prey in continuous forest and forest fragments in the presence or absence of army ants, and 4) to experimentally and indirectly increase resource availability in a 10 ha forest fragment by introducing colonies of the army and **E. burchelli** to determine the effect of habitat quality on the persistence of ant-following birds in forest fragments.

I predicted that the mist-net captures of obligate ant-following species would decrease significantly in forest fragments of 1 ha, 10 ha and 100 ha, that experimental introductions would demonstrate this to be real and not a sample effect, and leaf litter insect resources would not significantly decline within the forest fragment. I further predicted that introduced obligate ant-following birds would be recaptured in the fragment as long as it contained active colonies of the army ant **E. burchelli**. If individuals of a species disappeared when army ants were present, the greatest decline in numbers would be inversely correlated with the position of that species in the dominance hierarchy. However, for facultative ant-following species, I predicted no differences would be observed between pre- and post-isolation capture rates in the 1 ha, 10 ha 100 ha forest fragments.

METHODS

The presence or absence of the four antbird and six woodcreeper species was examined in five forest fragments of 1 ha, four forest fragments of 10 ha, one partially isolated 100 ha fragment, and in continuous forest (Table 2). These data were obtained through mist-netting, and visual and acoustical censuses. All fragments were mist-netted once every three to four weeks. Approximately 130 mist-net hours (nhrs) were logged in a single banding day for each net line by opening 16 mist-nets at dawn and starting to close these nets at 1400 hrs. This sampling program is described in detail Bierregaard **et al.** (this volume). In addition, the 10 ha fragment used for the experimental introductions was saturated with 52 mist-nets to capture any introduced birds or colonizing individuals which remained in the forest fragment.

These data were analyzed and tested with Friedman two way ANOVAs to compare pre- and post-isolation capture rates for 1 ha (N = 5, Table 3) and 10 ha (N = 4, Table 4) fragments. Because the sample size was only one for the 100 ha fragment, captures per 100 nhrs for pre-isolation banding days were compared to post-isolation captures with Mann-Whitney U tests (Table 5). The predicted decrease in capture rates for obligate ant followers required a one-tailed test, while the lack of directional a priori predictions for facultative ant followers required a two-tailed test.

A total of 61 **Pithys albifrons**, 31 **Gymnopithys rufigula** and 12 **Dendrocincla merula** were experimentally introduced into the isolated 1 ha and 10 ha forest fragments (Table

6). These birds were captured with four to eight mist-nets strung along narrow trails in front of raiding army ant swarms, within 1.5 km of the release site. The nets were left open for approximately 30 minutes with care taken to prevent birds being killed by the ants. Birds were held temporarily in cloth bags for transport and release in the isolated fragments. To determine if the introduced birds remained in the isolated fragments, daily census observations and mist-netting every two or three days were performed until the army ant colony abandoned the fragment.

Insects were sampled in the presence and absence of swarming army ants with nine 50 x 50 cm clear plexiglas plates and eighteen 15 cm diameter petri dishes covered with Tanglefoot, and equally spaced along a 9 m transect. Traps were left open for twenty minutes before the insects were removed. The insects were stored in 70% alcohol and later dried in an oven for 48 hrs and weighed on a precision balance. Subsamples of these insects were identified at least to family. A minimum of five trap transects were collected in each of three isolated 1 ha fragments, three isolated 10 ha fragments, and the continuous forest. Five transects were collected in front of army ant raids in continuous forest and another five in isolated 10 ha fragments containing army ants, including the experimentally introduced army ant colonies. All samples were collected between 0900 and 1300 hrs on days without rain. Samples were statistically compared with two-tailed Mann-Whitney U tests.

Four colonies of the army ant **E. burchelli** were captured and individually released in the center of the experimental 10 ha fragment (Table 7). Army ant colony introductions involved the capture of the queen during nocturnal nomadic migrations and isolating her in 5 x 3 x 3 cm wire holding cage with 2 mm mesh. This cage was suspended on a structure of palm fronds and sticks in a plastic bucket of approximately 75 liters volume and placed near the new bivouac site. If the ant colony formed a bivouac cluster around the queen during the night, the bucket was sealed before dawn, weighed, moved to the 10 ha fragment and released. The bucket was later weighed again to provide the live weight of the ant colony. Subsamples of live ants were collected, weighed and counted to calculate colony size. Following the release of each of the three largest **E. burchelli** colonies, individuals of the three obligate ant-following bird species also were released into the isolated fragment. None of these individuals had been used in earlier experiments.

All data analysis and statistical tests were performed on a Compaq Plus computer using the statistical software package "Statpak" from Northwest Analytical.

RESULTS

The responses of ant-following birds to forest fragmentation differed markedly (Figure 1, Tables 3, 4 and 5). Figure 1 plots mean post-isolation captures per 100 nhrs against mean pre-isolation captures per 100 nhrs for seven species of ant-following birds. The diagonal line represents equal pre- and post-isolation capture rates. Symbols plotted above the line indicate higher capture rates in forest fragments than in continuous forest; symbols below the line indicate lower capture rates in forest fragments. Standard errors have not been included in Figure 1 but are given in the tables. Lines have been drawn between the symbols to facilitate species identification.

Capture rates for the facultative ant-following species did not siginicantly change in the 1 ha (n = 5, Table 3) and 10 ha (n = 4, Table 4) fragments following forest fragmentation (Friedman two way ANOVA, NS). The three largest ant-following woodcreepers **Dendrocolaptes picumnus**, **Dendrocolaptes certhia**, and **Hylexetastes perrotii** were rarely captured in continuous forest, although this pattern changed somewhat in fragmented forest. Captures of **H. perrotii** decreased in the 1 ha fragments, increased in the 10ha fragments, and remained unchanged in the 100 ha fragment. The woodcreeper **D. certhia** was captured more frequently in the 1 ha fragments after isolation. These three woodcreepers, as well as **D. merula** were observed or captured after having temporarily colonized or invaded isolated 1 ha or 10 ha forest fragments 75-150 m from the adjacent continuous forest. Individuals of **D. certhia** were present in 4 of 5 (80%) 1 ha fragments after a year of isolation, and continued to be captured occasionally in one 1 ha fragment years after isolation. Pre- and post-isolation capture rates for these species were low (Tables 3, 4 and 5), and were therefore not included in Figure 1.

Capture rates of **Dendrocincla fuliginosa** decreased in the 1 ha fragments but remained stable in the larger fragments, and this species continued to persist in forest fragments of all sizes. **Xiphorhynchus pardalotus** was captured considerably more often in the 1 ha and 10 ha fragments following isolation, but not to a significant degree. Captures of the two antbirds, **Hylophylax poecilinota** and **Percnostola rufifrons**, varied between the two sizes of small fragments. While captures of **H. poecilinota** decreased in the 1 ha fragments, this species increased in the post-isolation data of the 10ha fragments. **P. rufifrons** showed the opposite pattern, and increased in the 1 ha fragments while decreasing slightly in the 10 ha fragments.

In the 100 ha fragments (Table 5), captures of **D. fuliginosa** and **H. perrotii** remained stable, while the remaining four facultative ant-following species were captured less frequently after complete isolation, **P. rufifrons** and **H. poecilinota** to a significant degree (two tailed Mann-Whitney U test, P <.025).

Capture rates of all three obligate ant-following species, **D. merula**, **P. albifrons**, and **G. rufigula** decreased significantly in fragments of all sizes. Although these species were common in continuous forest, their capture rates approached or reached zero after fragmentation. Actual post-isolation capture rates were higher in the 100 ha fragment than in the fragments of 1 ha or 10 ha. None of the 1 ha nor the 10 ha fragments continuously supported active army ant colonies following isolation. The 100ha fragment was observed to support as many as three army ant colonies after fragmentation, although there were periods when none of these colonies swarmed on a given day.

The dry weight of insect samples collected in the presence of swarming army ants was significantly higher than those samples collected in the absence of ants of ants continuous forest and forest fragments (Figure 2, two-tailed Mann-Whitney U Test, P<.01).

Insect sample weights were not different between the two habitat types in the presence or absence or army ants. In the absence of raiding army ants, the level of available insects was 6-7 times lower than in the presence of an army ant swarm raid. Army ant colonies raiding in isolated forest fragments flushed slightly lower levels of insect prey compared to continuous forest, but not to a significant degree. A subsample of the insects collected in sticky traps revealed 60 families in 14 orders. The majority of these insects were orthoptera (crickets, grasshoppers) and dicoptera (cockroaches), which are prime prey items of ant-following birds.

The experimental introductions of obligate ant-following birds into forest fragments demonstrated that birds quickly disappeared from fragments not containing army ants. Only one individual of **G. rufigula** remained in the isolated 10 ha fragment 48 hrs after the birds were released (Table 6). However, when army ant colonies were captured and individually introduced into this same 10 ha fragment (Table 7), six introduced **G. rufigula** and one **P. albifrons** were captured foraging at the army ant swarms one week after release. The total number of within fragment captures summed over all three species was significantly higher in the presence of the introduced army ants than in their absence (Table 6, G-test, P<.025). This was due to the higher number of captures of **G.rufigula**, which in itself was a significant increase (Table 6, G-test, P<.025). No introduced individuals of **D. merula** were observed or captured in the mist-nets. The null hypothesis that capture rates for each species would be equal in the presence and absence of army ants is rejected for **G. rufigula**. Although the disappearance of the subordinate **P. albifrons** was predicted, the disappearance of **D. merula** was not.

Although no specific effort was made to search the continuous forest for the birds which disappeared from the forest fragments, 55% of the total (58 of 105) birds introduced into the forest fragments were later recaptured in the continuous forest (Table 8). The lowest number of individuals recaptured was for **G. rufigula** at 39% (12 of 32), whereas 62% of introduced **P. albifrons** (38 of 61) and 62% of the introduced **D. merula** (8 of 13) were later recaptured in the continuous forest.

DISCUSSION

Many of the woodcreeper species did not remain restricted to these small isolated forest fragments, but rather moved in and out across the deforested areas. Some of these woodcreepers, notably H. perrotii, D. picumnus, D. certhia, and D. merula were temporarily colonized or invaded isolated 1 ha or 10 ha forest fragments. These 1 ha and 10ha fragments were 75-150 m from the adjacent continuous forest, and these colonizations maintained low capture rates of these species in small forest fragments. In this manner, **D. certhia** may be able to persist in small forest fragments close to a continuous forest source area, although it would disappear from more remote fragments. This species eventually disappeared from the much larger and more isolated Barro Colarado Island after 50 years (Willis, 1974). The large woodcreepers often fly at heights above two meters and their actual abundance as measured with mist-net data may have been underestimated.

Other species, such as **X. pardalotus**, are facultative ant followers that forage more frequently with mixed species flocks than ant-followings flocks, and were frequently captured in mist-nets. The increase in capture rates observed for **X. pardalotus** were most likely due to the influx or crowding of individuals into the forest fragment from the surrounding areas of deforestation. This species was the only one to increase substantially in both the 1 ha and 10 ha forest fragments, where it appeared to persist quite well.

P. rufifrons is frequently encountered along forest edges and in second growth, possibly explaining the observed capture rate increase in the 1 ha fragments and its significant decrease in the interior of the 100 ha fragment. This was probably true of **H. poecilinota** also, which increased in the 10 ha fragment, an area slightly larger its home (Willis, 1982). Banding recoveries indicate that individuals of **H.poecilinota** move between isolated fragments, at times traveling in mated pairs. In this manner, captures remained high. A similar explanation may be involved for **X. pardalotus**, although recovery data was insufficient.

As predicted, the three obligate ant-following species, **D. merula**, **P. albifrons**, and **G. rufigula**, virtually disappeared from all the forest fragments regardless of size. Although army ant colonies were observed in the 100 ha fragment, the irregular swarming cycle of these colonies resulted in periods with no active ant swarm available for the birds. Interestingly, the capture rates of these obligate ant-following species remained very slightly above zero, indicating rare colonization of the the forest fragment by birds in search of ants.

The recovery data from the experimental introduction of birds into the isolated 1 ha and 10 ha fragments (Table 6) revealed only one **G. rufigula** recaptured in the fragment in the absence of ants. This single recapture occurred less than 48 hrs after the bird was released. No individuals of **P. albifrons** were captured in either the 1 ha or the 10 ha fragment. It was not surprising that ant-following birds did not remain in areas as small as 1 ha or 10 ha, as this size was considerably below the area of their home range. The interesting result was the tendency and speed with which the birds left the fragments. In one case, an individuals **P. albifrons** was recaptured at the original continuous forest capture site only 1.75 hrs after it was released in a a 10 ha fragment without army ants. All but one of the introduced individuals disappeared from the fragment in less than 48 hrs in the absence of ants. These birds left the isolated forest fragments and crossed the deforested area into the adjacent forest. It was unlikely that any of the introduced birds perished in the isolated fragments, and 55% were recaptured later in the continuous forest.

In addition to the recaptures of introduced birds in the presence of introduced army ants, two **G. rufigula** and one **D. merula** that entered the fragment from the surrounding continuous forest were captured foraging at the ant swarms. The number of colonizing individuals undoubtedly was higher; several other individuals were observed foraging with the ants, but were not captured nor identified by the observation of color bands. Efforts to stabilize the ant colony within the 10 ha forest fragment were unsuccessful, and the ants wandered out of the fragment eight days after release. Although the ant-fillowing birds appeared to leave the fragment following the departure of the ants, an examination of banding recoveries indicated that individuals of G. rufigula temporarily colonized this 10 ha fragment at least seven times, often in the absence of army ants. These observations suggest that ant-following birds enter forest fragments to search for active army ant colonies, and do not simply follow raiding columns across deforested areas. Unfortunately, the ephemeral nature of these colonization events makes an estimate of their frequency difficult.

All of the birds which entered this 10 ha forest fragment, as well as those which were introduced and later recaptured outside, crissed the deforested area which separates the fragment from the continuous forest. This deforested area was between 100 m and 150 m in width. Those individuals which left the isolated 1 ha fragment crossed a distance of at least 320 m of cleared area to reach the continuous forest (Table 8). It is interesting to note that "at its nearest point, BCI [Barro Colorado Island] is [approximately] 200 meters from a peninsular extension" of the mainland forest (Karr,1982). Although areas of deforestation represent a less severe dispersal barrier than open water, understory ant-following birds can cross significant open areas between forest fragments and continuous forest.

Although actual levels of insects in the forest fragments were not different from the continuous forest (Figure 2), the lack of an active **E. burchelli** colony and the accompanying decrease in food availability resulted in the disappearance of the ant-following birds. The immediate major effect of isolation was the sample effect of whether army ants were present, and not any changes in microclimate that may have affected the absolute level of leaf litter insect abundance and the survival potential of ant-following birds. The capture and release of colonies of the army and **E. burchelli** into forest fragments raised the relative quality of the fragment to a sufficient level to at least temporarily support the ant-following bird community. Although the absolute levels of insect resources were not altered, the introduced army ants and their foraging raids made these resources available to the ant-following birds.

The enrichment of a forest fragment through the introduction of army ant colonies mat help maintain populations of ant-following birds as long as army colonies in the fragment. Large areas and several army ant colonies would be necessary to preserve the ant-following bird community on a long term basis, and habitat suitability, resource availability and predation risk should be assessed carefully to avoid the failure of the introductions (Morton, 1978). Small forest fragments, like those examined here, hold little conservation value; the nomadic behavior of army ants make it likely that a colony will wander out of the reserve boundaries, and the army ants or ant-following birds might reduce or eliminate populations of other organisms before leaving or dying out themselves. Large forest fragments, and the maintenance of forested corridors and short separation distances among them, would reduce the risk of species disappearance and community decay. However, the ability to capture and release intact army ant colonies and ant-following bands. Efforts to stabilize the ant colony within the 10 ha forest fragment were unsuccessful, and the ants wandered out of the fragment eight days after release. Although the ant-fillowing birds appeared to leave the fragment following the departure of the ants, an examination of banding recoveries indicated that individuals of G. rufigula temporarily colonized this 10 ha fragment at least seven times, often in the absence of army ants. These observations suggest that ant-following birds enter forest fragments to search for active army ant colonies, and do not simply follow raiding columns across deforested areas. Unfortunately, the ephemeral nature of these colonization events makes an estimate of their frequency difficult.

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RESUMO

Capturas com rede de passāros seguidores de formigas-de-correição foram monitoradas durante o isolamento de fragmentos de mata da Amazōnia Central de 1ha (n = 5), 10 ha (n = 4) e 100 ha (n = 1). Capturas pōs-isolamento de três espēcies de passāros seguidores de formiga ***Dendrocincla merula, Pithys albifrons,*** *e* ***Gymnopithys rufigula*** *diminuiram significativamente em todos os fragmentos. Capturas pōs-isolamento de quatro espēcies facultativas seguidoras de formigas não foram significativamente diferentes em fragmentos de mata de 1 ha e 10 ha, embora duas espēcies diminuissem consideravelmente no fragmento de 100 hs. Introduções experimentais de espēcies obrigatōrias em pequenos fragmentos na ausência e presença de colônias introduzidas de formiga-de-correição* ***Eciton burchelli*** *resultaram em significativamente maiores taxas de recapturas de passāros introduzidos quando as colônias ativas de formigas estavam presentes. Dos 105 passāros introduzidos, 58 '55% atravessaram cerca de 100-320 m de mata devastada e foram recapturados na mata continua.*

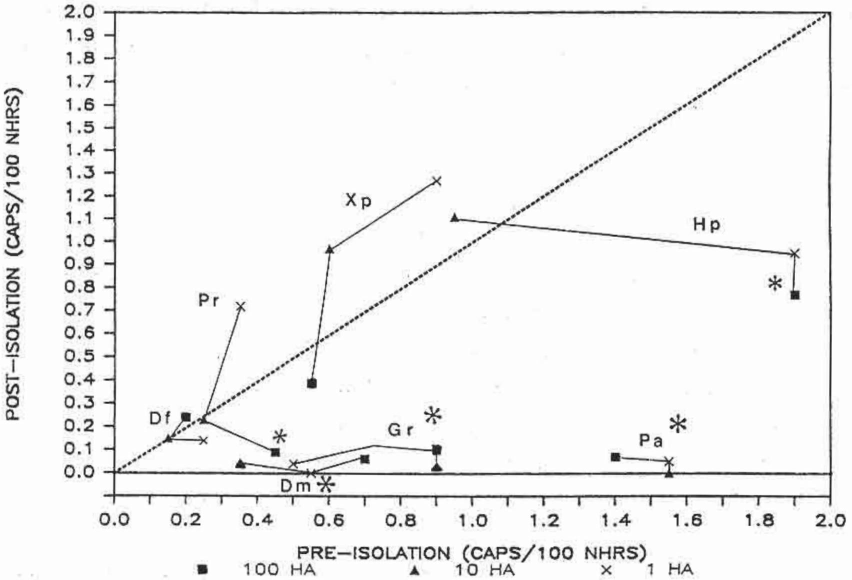

Fig. 1. Mean captures per 100 nhrs for seven ant-following birds. Points represent means of pre-isolation banding data and post-isolation banding data from five 1 ha, three 10 ha, and one 100 ha forest fragment, (Tables 3, 4, and 5). Lines between symbols are to aid species identification only. Large asterisks represent significant decreases in fragments of all sizes. Small asterisks represent decreases in the 100 ha fragment only. Species codes: Df = **Dendrocincla fuliginosa**, Dm = **Dendrocincla merula**, Xp = **Xiphorhynchus pardalotus**, Pr = **Percnostola rufifrons**, Pa = **Pithys albifrons**, Gr = **Gymnopithys rufigula**, Hp = **Hylophylax poecilinota**.

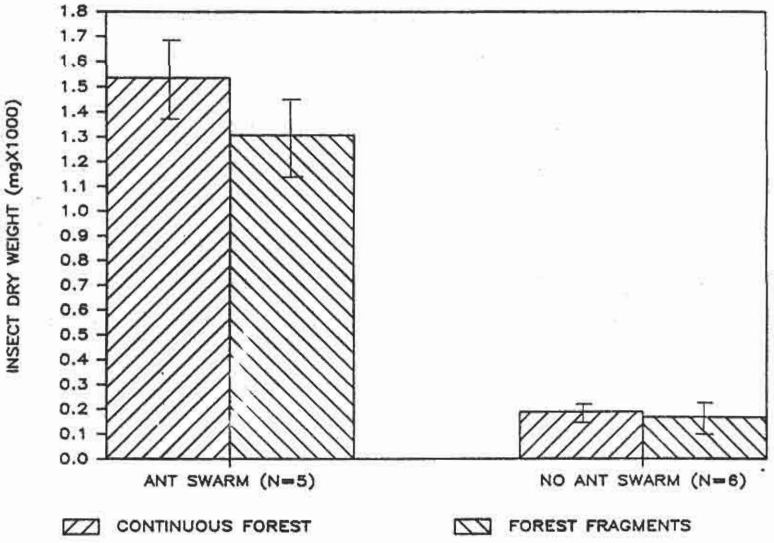

Fig. 2. Dry weights (mg x 1000) and standard errors of insect samples collected in continuous forest and forest fragments in the presence amd absence of swarm raids of the army ant **Eciton burchelli**.

Table 1. Weights of ant-following birds at Manaus, Brazil.

	Weight (g)	S. D.	N
DENDROCOLAPTIDAE			
Dendrocincla fuliginosa	40.2	3.4	104
Dendrocincla merula	52.8	4.1	224
Hylexetastes perrotii	114.3	7.7	55
Dendrocolaptes picumnus	78.7	6.6	12
Dendrocolaptes certhia	66.2	5.7	43
Xiphorhynchus pardalotus +	37.8	3.0	318
FORMICARIIDAE			
Percnostola rufifrons	28.9	2.1	254
Pithys albifrons	20.2	1.3	689
Gymnopithys rufigula	29.0	2.1	473
Hylophylax poecilinota	16.8	1.6	654

(+) Although **X. pardalotus** follows army ants, it is more common in understory mixed species flocks.

Table 2. Pre- and post-isolation banding days and nethours (nhrs) for each forest fragment.

Fragment	Pre-isolation		Post-isolation		Total	
	Days	Nhrs	Days	Nhrs	Days	Nhrs
1 HA (n = 5):						
1104	11	798	42	2,735	53	3,533
1112	13	858	16	1,045	29	1,903
2107	34	2,214	11	708	45	2,922
2108	29	1,864	11	723	40	2,587
3114	6	390	18	1,197	24	1,587
Total	93	6,124	98	6,408	191	12,532
10 HA (n = 4):						
1202	12	1,403	45	5,943	57	7,346
1207	15	1,987	14	1,795	29	3,782
2206	34	4,477	11	1,451	45	5,928
3209	10	1,310	20	2,548	30	3,858
Total	71	9,177	90	11,737	161	20,914
100 HA (n = 1):						
3304	57	7,130	46	5,667	106	12,797
Total net-hours, all fragments (1 ha, 10 ha, 100 ha)						46,243

Table 3. Ant-following bird captures/100 nhrs in 1 ha fragments (n = 5).

Facultative ant followers	Pre-isolation (6,124 nhrs)			Post-isolation (6,408 nhrs)	
	mean	se		mean	se
D. fuliginosa	0.25	(0.09)		0.14	(0.03)
H. perrotii	0.18	(0.07)		0.01	(0.01)
D. picumnus	0.01	(0.01)		0.00	
D. certhia	0.05	(0.02)		0.18	(0.09)
X. pardalotus	0.89	(0.25)		1.27	(0.19)
P. rufifrons	0.33	(0.09)		0.72	(0.17)
H. poecilinota	1.90	(0.29)		0.95	(0.22)
Obligate ant followers					
D. merula	0.55	(0.07)	*	0.00	
P. albifrons	1.56	(0.15)	*	0.02	(0.02)
G. rufigula	0.53	(0.11)	*	0.04	(0.02)

(*) = P < Friedman two-way ANOVA.

Table 4. Ant-following bird captures/100 nhrs in 10 ha fragmemts (n = 4).

Facultative ant followers	Pre-isolation (9,177 nhrs)			Post-isolation (11,737 nhrs)	
	mean	se		mean	se
D. fuliginosa	0.14	(0.02)		0.15	(0.03)
H. perrotii	0.09	(0.04)		0.21	(0.09)
D. picumnus	0.03	(0.02)		0.01	(0.01)
D. certhia	0.04	(0.03)		0.05	(0.01)
X. pardalotus	0.59	(0.13)		0.97	(0.30)
P. rufifrons	0.27	(0.07)		0.23	(0.07)
H. poecilinota	0.95	(0.10)		1.11	(0.15)
Obligate ant followers					
D. merula	0.35	(0.13)	*	0.04	(0.02)
P. albifrons	1.54	(0.28)	*	0.00	
G. rufigula	0.90	(0.17)	*	0.07	(0.04)

(*) = P <.05, Friedman two-way ANOVA.

Table 5. Ant-following bird captures/100 nhrs in a 100 ha fragments (n = 1).

Facultative ant followers	Pre-isolation (7,130 nhrs)		Post-isolation (5,667 nhrs)	
	mean	se	mean	se
D. fuliginosa	0.22	(0.08)	0.24	(0.07)
H. perrotii	0.11	(0.05)	0.11	(0.06)
D. picumnus	0.00		0.00	
D. certhia	0.04	(0.02)	0.00	
X. pardalotus	0.57	(0.12)	0.39	(0.10)
P. rufifrons	0.44	(0.12) **	0.09	(0.05)
H. poecilinota				
Obligate ant followers				
D. merula	0.71	(0.18) ***	0.06	(0.03)
P. albifrons	1.41	(0.24) ***	0.07	(0.03)
G. rufigula	0.89	(0.18) ***	0.08	(0.03)

(**) = P <.025, (***) = P <.01 Mann-Whitney U test.

Table 6. Number of individuals of three species of obligate ant-following birds experimentally introduced into a 10 ha forest fragment in the presence and absence of introduced **E. burchelli** army ants.

Army ants:	**Absent**		**Present**		**Total by species**
Recaptured in fragment?	**yes**	**no**	**yes**	**no**	
D. merula	0	5	0	4	9
P. albifrons	0	19	1	17	37
G. rufigula	1	11 *	6	6	24
All birds	1	35 **	7	27	
Total introduced	36		34		70

G-tes: * = P <.05, ** = P <.025

Table 7. Introductions of **E. burchelli** army and colonies into a 10 ha. forest fragment.

Date Introduced	Estimated Colony Size	Colony Phase	Birds Introduced Also?
Sep 14, 1983	146,000	nomadic	no
April 6, 1984	595,000	nomadic	yes
May 14, 1984	228,000	statary	yes
May 29, 1984	529,000	nomadic	yes

Table 8. Number of obligate ant followers esperimentally introduced (I) into forest fragments and the number recovered (R) in continuous forest. The 1 ha fragment was separated from the continuous forest by a 320 m wide clearing, the 10 ha fragment by 100-150 m.

	Fragment size:				**Totals:**		
	1 ha		**10 ha**				
Species	**I**	**R**	**I**	**R**	**I**	**R**	**%**
D. merula	4	(3)	9	(5)	13	(8)	62%
P. albifrons	24	(17)	37	(21)	61	(38)	62%
G. rufigula	7	(4)	24	(8)	31	(12)	39%
Total birds:	35	(24)	70	(34)	105	(58)	35%

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