

## Rainfall patterns - an overlooked ecological influence

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Periodic cycling of weather patterns in the western Indian Ocean were first noted by Aspin (1976) and subsequently discussed in detail by Stoddart & Walsh (1979). These publications demonstrated the existence of regular cycles of high and low rainfall at meteorological stations throughout the region, although cycles are less apparent in the coralline islands where rainfall is extremely low and erratic. Examination of the rainfall data for Seychelles demonstrates the continuance of the reported cycles and suggests some interesting correlations with ecological data.

Cyclical rainfall in Seychelles takes the form of alternating wet and dry phases. In wet phase years annual total rainfall is above the long term mean (2400mm) whereas dry phase rainfall remains below 2400mm. These phases are of equal length (approximately 16 years, range 14-20 years). Dry phases occurred in 1905-22, 1938-58 and 1975-89. A 16 year cycle is also apparent in the available census data for Seychelles magpie robins (*Copsychus sechellarum* Oustalet, 1878) on Fregate island. Accurate censuses date from 1974 although there are subjective estimates from 1959 (Gretton 1990-92; Komdeur 1988-90; McCulloch 1992-95), there are insufficient data to demonstrate long term periodicity but population and rainfall peaks coincide. Rainfall data from Fregate only date from 1990 (Gretton 1990-2; McCulloch 1992-5) but these 5 years of data are consistently 20% lower than the corresponding values for Mahé. In the



following analysis Fregate rainfall has been reconstructed for the years 1959-89 as 80% of the Mahé values for those years (Fig. 1.). From this it can be seen that development of the 1974-89 dry phase was accompanied by a dramatic decline in the magpie robin population and the recovery in 1990 by increased rainfall

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resulting from the start of the current wet phase. A lack of correspondence prior to 1974 is probably due to numbers being estimated subjectively by different observers. Linear regression of the 1975-95 data is significant ( $F=16.78$ ,  $P<0.001$ ).

The correlation indicates that rainfall is an important underlying influence on the population. The recovery since 1990 appears to result from increased survival of chicks to one year (McCulloch 1993); other demographic factors fluctuate and do not correlate to the population increase (Table 1.). During this period territory size has also decreased slightly. This combination of factors can be related to rainfall patterns by food availability. Invertebrate sampling studies have not detected an increase in invertebrate abundance (Gretton 1990-2; McCulloch 1992-5) but, as demonstrated elsewhere, rainfall influences distribution, not numbers (Gerlach 1995). During dry weather many invertebrates adopt a patchy distribution, congregating in damp areas. This effect of rainfall on prey distribution is shown on Fregate by the significant negative correlation between rainfall and the variance of invertebrate numbers (Spearman's  $r=0.95$ ,  $n=12$ ,  $P<0.001$ ; data from McCulloch 1992-5). Clumped prey distributions reduce predatory efficiency (Hassell & May 1974), consequently dry years, with clumped prey, will have less food availability than wet years. Food availability will influence adult survival and territory size to some extent but will be most important to young birds with little foraging experience (yearling foraging efficiency is half of adult efficiency - Komdeur 1988). The Magpie Robin Recovery Plan's supplementary feeding of nestlings and fledglings will mask any influence on these stages but survival to one year will remain heavily influenced by prey distribution and hence rainfall.

From this it appears that much of the increase in magpie robin numbers since 1990 results from improved climatic conditions. With the 16 year cycle dry conditions should return in approximately 10 years, when conditions for magpie robin recruitment will deteriorate. With this scenario, during a dry phase the carrying capacity of Fregate is probably much closer to the 21 individual minimum of 1974-89 than the current high numbers. With periodic fluctuations of rainfall population bottlenecks will recur with severe implications for groups introduced to Cousin, Cousine and Aride. Despite the dramatic success of the Cousin introduction none of these islands can support a viable population in a dry phase. For population stability much larger areas need to be occupied, preferably on islands retaining extensive areas that are always subject to high rainfall. On these islands population fluctuations are inevitable on the dry plateaux but these would be buffered by more stable populations in damp lowland and mid-altitude forests.

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**Table 1.** Magpie robin demography

(data from Gretton 1990-92; Komdeur 1988-90; McCulloch 1992-95)

	Year								
	88	89	90	91	92	93	94	95	
Number (December)	20	22	21	22	27	39	47	51	
Adult survival (%)	80	84	80	90	90	95	89	96	
Eggs per pair	1.7	1.5	1.5	3.0	2.0	3.5	?	?	
Hatching rate (%)	72	75	59	57	92	55	?	?	
% chicks fledged	40	78	57	62	73	70	80	80	
% independent	50	70	75	61	88	100	90	63	
% survival to 1 year	0	56	67	80	100	100	100	-	

This demonstration of the importance of habitat and abiotic factors makes it worth re-examining data behind the view that the distribution of magpie robins (and other species) results from predation by introduced cats and rats. All available data on the last definite record of magpie robins, earliest records of predators and approximate dates of complete lowland forests clearance are summarised in Table 2. Of the 9 islands with definite records 2 have no useful data subsequent to 1768 (St. Anne and South-east). On the remainder magpie robins coexisted with cats and rats for a considerable number of years (over 70 years in 3 cases). Even on the small island of Fregate they coexisted for 31 years. On two other islands there may not have been any overlap between cats, rats and magpie robins at all. Two records are particularly important as the claim that cats and rats have been the primary cause of extinction rests upon them (Watson 1984). On Aride magpie robin extinction is generally reported to have followed some 10-15 years after the introduction of cats whereas, in fact, the last record of magpie robins is 13 years before the cat introduction (its survival into the 1930s being only unsubstantiated hearsay evidence quoted by Vesey-Fitzgerald 1940) and the absence of specimens from 1907 (when Lord Walter Rothschild's collector visited the island) suggests that the population became extinct 11 years before cats were introduced. Alphonse, by contrast, is the only island where extinction caused by cats can be supported; the extinction followed 5-15 years after cat introduction was reported to have occurred. There are only three records of magpie robins from Alphonse, the first was Abbott in 1892 who reported its introduction (Ridgway 1895), the second is the imprecise report of its abundance in 1936 (Vesey-Fitzgerald 1940) and the last sighting was of a single bird in 1962 seen by Lousteau-Lalanne (Gaymer *et al.* 1969). The exact date of introduction is unknown but it was probably shortly after the island was settled and the coconut plantation established - before Abbott's visit. The plantation appears to have remained unchanged until after the magpie robins extinction with the only change being the introduction of cats at an unknown date in the 1950s (Gaymer *et al.* 1969). With the relatively simple environment of a coconut plantation the potential for heavy

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**Table 2.** Distribution, predator and habitat data from magpie robin islands

(Betz 1940; Bullock 1989; Collar & Stuart 1985; Gaymer *et al.* 1969; Lucking & Ayrton 1996; Malavois 1768; Nevill 1868; Newton 1867; Nicoll 1906; Oustalet 1878; Pike 1871; Ridgway 1895; Scott 1912; Veazy-Fitzgerald 1940; Watson 1984; Rothschild collection. - American Museum of Natural History)

Island	Last record	Extinction	Cats present	Rats present	Overlap	Lowland clearance
Mahé	1867	1871-1878	<1787	<1787	84-91	complete by 1875
St. Arme	1768	1768-1936	<1787	<1787	?	complete by 1787
South-east	1768	1768-1936	?	?	?	?
Praslin	1878	1878-1893	<1787	<1787	91-106	complete by 1875
La Digue	1871	1871-1878	c1800	c1800	71-78	complete by 1875
Aride	1905	1905-1907	1918-50	-	0-18	partial by 1905
Marianne	1893	1893-1905	>1867	>1867	0-38	complete by 1900
Fregate	present	present	1951-82	1995	31	partial by 1900
Alphonse	1962	1962-1965	1950s	>1936	5-15	complete by 1892

predation on fledgelings is clear and the approximately 15 year coexistence corresponds closely to what would be expected if cats were preventing recruitment and causing population senescence. The small size of Alphonse and its complete dominance by coconuts is a most exceptional situation for a magpie robin island and this simple, unstable system would have been extremely vulnerable to perturbation caused by the introduction of any species. For these reasons it is unwise to rely too heavily on conclusions based on what is an unrepresentative situation.

The other islands are more complex and a greater level of disruption would be required to cause extinction. Such large scale disruption may have come from the complete clearance of lowland vegetation accompanying the expansion of the large coconut estates. Although plantations had been established by 1787 on the main islands they occupied a relatively small area until the late 1800s; expansion was occurring by 1867 (Nevill 1868; Newton 1867), by 1910 all lowland forests had been cleared on all the islands. Of the magpie robin islands only Aride, Fregate and La Digue were incompletely cleared with small areas of woodland surviving on the plateaux. On Aride this would have been restricted to 1-2 hectares; too small to support a population. All the La Digue woodland was restricted to the densely settled plateau and extinction is most likely to have resulted from nest robbing by humans (Newton 1867). In contrast, on Fregate, the birds received some degree of protection at this time (Pike 1871). Where lowland forests were cleared extinction occurred within 0-3 years of clearance in 3 cases, 3-18 in one case and in a further 2 cases sometime within 0-38 years of clearance. The Alphonse case is again an exception with magpie robins adapting successfully to plantations, however, it should be noted that they were introduced after the clearance phase of development and that Alphonse, in common with other Amirante islands, had a much lower human population with far less leisure time

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available for nest robbing than on any of the granitic islands. This would be sufficient to allow the species to persist.

Although the data on magpie robin extinction and population changes are too poor to identify definite causes of extinction or long-term patterns they are unequivocal in demonstrating that introduced predators were not significant in the granitic islands. Predation was the most likely cause of extinction only in the extremely simple and unstable environment of Alphonse. Habitat factors, with the additional influence of cyclical weather patterns, are major influences on population cycles and recruitment (of 5 granitic islands with reasonable data extinction occurred in dry phases in 3-4 cases). This area has considerable research potential and may be of paramount importance in field conservation and management projects. Researchers and conservationists would be well advised to monitor population changes, speciation events and general habitat changes in this light. It should also be borne in mind that all robust ecosystems are dynamic and that dynamism and periodicity may mean that systems continuously switch between increase and decline. For insular systems such switching will probably result in populations regularly falling to a crisis point, for, despite our hardest efforts, frequent extinction is an inevitable and natural part of island life.

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