

EXPERIENCES OF THE VOLUNTARY ZOOLOGISTS AND EXPERTS OF THE CALICUT UNIVERSITY, IN REDUCING BIRD HAZARDS IN THE AERODROMES OF TRIVANDRUM, COCHIN, CALICUT, MANGALORE AND RAMNAD, INDIA.

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ABSTRACT

In 1984 we started studies on bird ecology of Karipur where the new Calicut aerodrome was being built. From 1992 to 1994, financial support from the Aeronautic Research and Development Board (A.R. & D.B.) enabled us to study birds in Trivandrum, Cochin, Mangalore and Ramnad Airports. Our aims were to : 1) Study kinds, numbers, general movements and requirements of birds especially in the Calicut Aerodrome. 2) Trial of some of the known methods of repelling birds from the Aerodromes. 3) To develop new devices for bird scaring and 4) Advising Aerodrome Flight safety officers on controlling birds.

Our studies suggested the Pariah Kites (*Milvus migrans*) to be very numerous and hazardous in the aerodromes where they were attracted to the vast quantities of food in the animal waste thrown out of slaughterhouses and the numerous garbage dumps. After the 22nd meeting of the B.S.C.E. in Vienna 1994 the first author requested the A.R. & D.B. to start a nation-wide campaign for safe disposal of garbage, the movement is showing good results. Some of the deterrent devices we had developed like the one for reflecting sunlight are showing positive results, we could not carry out many trials due to lack of financial support. The work is continued voluntarily. Dr. Russel Mason of Monnell Laboratories Philadelphia, who collaborated with us, demonstrated that a bird aversion agent can be prepared by boiling neem (*Azadirachta indica*) leaves in water: we had supplied the neem leaves. Neem oil was also found to be an effective aversion agent.

Keywords: Pariah Kites, Distress Calls, Neem Products. Repellents. Reflective tapes. Garbage, Roosts

1. INTRODUCTION

The University of Calicut in the Malappuram District of Kerala is 15 Km distant by road from the Calicut Aerodrome in the Village of Karipur ($11^{\circ} 7'N \times 75^{\circ} 55'E$). Construction of this aerodrome started in 1983 and in 1984 the first two authors started studies on the ecology of the birds of the airport site on a voluntary basis. In 1975 the defence ministry had approved a proposal from our department of Zoology for an ecological investigation of bird hazards to aircrafts. We could not take up the project as the Chief Investigator Prof Dr. K.J. Joseph was leaving India. The Bombay Natural History Society (B.N.H.S) and the M.S. University of Baroda both studied the problem in detail in major Research Projects under the leadership of the late Dr. Salim Ali (Grubb 1988), and Prof. Bony Pilo (Pilo 1994) respectively in the eighties. These projects led to considerable reduction in bird strikes in India.

The first author who was involved in Bird-hazard work in 1967, at the BNHS, attended the Round Table session on Bird hazards to aircrafts at the 19th International Ornithological Congress Ottawa in 1986 where it was suggested that University students could help in studying bird hazards in the aerodrome, close to their institutions. Between the years 1986-97 several M.Phil and Ph.D. students worked on problems of bird ecology in the Calicut Aerodrome and buffer zone with the guidance of the first author.

For two years (1992 - 94) the Aeronautic Research and Development Board (A.R. & D.B.) of the Government of India supported us financially, enabling us to extend our work to four other Aerodromes in South India. This paper is based on our work during the years 1984-97.

I. AIMS :

- 1.1 To study the kinds numbers and general ecological requirements of birds specially in the Calicut aerodrome.
- 1.2 To test some of the methods used in agricultural research for repelling birds from crop fields, to remove birds from specific areas in Aerodromes.
- 1.3 Developing some new device for scaring birds
- 1.4 Interacting with the Flight Safety officials of aerodromes on controlling birds.

METHODS:

2.1 Bird Survey:

Intensive studies were carried out at the Calicut aerodrome environs, (Sreekumar 1992), Mahesh Kumar (1993), using methods like line transects and point transects for censusing birds. attributes like species diversity, similarity, equitability, species composition. etc. were observed. The buffer zone area was marked into plots using the multiple stage sampling technique of Skyes and Horril 1977. As the Pariah Kite was the most hazardous species in our area. more attention was given to aspects of its population, biology and behaviour.

2.2 Testing of some known methods of repelling birds.

2.2.1 Reflective Tape: The effectiveness of reflective tapes in keeping birds out of specific areas was tested in four aerodromes.

2.2.2 Products of Neem: Some Neem products were tested for their potential as aversion agents with the expert help of Dr. J. Russel Mason of Monnel Laboratories, Philadelphia, U.S.A.

2.2.3 Distress call of captive Pariah Kite was tape recorded, amplified and replayed in aerodromes where the species was present.

2.3. Light reflecting device

With the help of engineers Prem Raphael and Robert of Beypore Calicut, we fabricated a drum like device on which mirrors were fitted in frames on eight sides. The device was mounted on a pedestal and could be revolved either by hand or a motor to reflect sunlight towards the birds trying to land.

3. RESULTS:

3.1. Species Composition:

Karipur lies close to four other villages viz. Kondotty (which is the nearest town also), Kolathur, Pallickal and Puliamparatmba. Together, the five villages had 100 species of birds belonging to 36 families and 14 orders. Table 1(Appendix). Species diversity (H) calculated by Shannon Weaver formula (Odum 1971) and Equitability (J) calculated by Pielou's (1966) formula were both high showing a rich and evenly distributed population of birds (Table 2).

TABLE (2) Diversity And Equitability of birds in five selected plots around the Calicut Airport.

PLOT	DIVERSITY INDEX $H = -\sum p; \log p;$	EQUITABILITY INDEX (J') = $H / \log eS$
Karipur	3.6067	0.8672
Kolathur	3.4951	0.8644
Kondotty	3.6526	0.8383
Pallickal	3.7466	0.8760
Puliyamparamba	3.3806	0.8597

As Pariah Kites were more *hazardous* than others we paid more attention to that species.

3.1.2. Seasonal variation in numbers.

Year long studies showed that there, were fewer Pariah Kites at Karipur during the rainy months of June-July (Figure 1 Appendix). This kite never occurred in large numbers in the aerodrome premises but there were large concentrations of the bird in Calicut City's Municipal waste dump, Calicut beach (Mahesh Kumar Op. Cit) and Parappanangadi a coastal town 15 Km west of the aerodrome (Sreekumar Op. Cit).

3.1.3. Hourly variation in Kites flying low.

More Pariah Kites flew low over the operational area in the forenoon (Figure 2A & 213 Appendix).

3.1.4. Population of Kites before and after commissioning:

There was not much change in the numbers and activity pattern of the Pariah Kites after the opening of the aerodrome for flights (Figure 3 Appendix).

3.1.5. Factors attracting the Pariah Kites to the airport.

The Pariah Kites feed on a variety of food including earthworms, winged termites, locusts, crickets, grasshoppers, frogs, chicken, rodents, and bats, in addition to garbage (Ali and Ripley 1969). The presence of many open untidy slaughtering places and garbage dumps close to Calicut aerodrome (Table 3 - Appendix) attracted Pariah Kites and other omnivorous and carnivorous species of birds. Immediately after the starting of flight operations wastes from Flight Kitchens were also being dumped close to the runways. This was subsequently stopped when in addition to birds, dogs also assembled to consume wastes. The presence of many coconut and other trees provided nesting sites to kites. When the construction was completed Pariah Kites used the runways for resting and feeding on the bits of food brought from outside and trees for nesting and roosting (Table 10 - Appendix).

3.1.6. Number of Pariah Kites in the Operational area of Calicut aerodrome

The Pariah Kite population in the operational area was never more than 20 (average of 10). There were always much larger populations of Kites in urban areas, 15-30 Km away from Karipur. The airport officials usually had a tendency to under estimate the hazards to aircraft from birds and our toughest task was to persuade some officials to take preventive action in time

3.1.7. Natural checks on Kites:

The Jungle Crow (*Corvus macrorhyncos*) which appeared to be superior to kites in transspecific hierarchy, never tolerated Pariah Kite's presence close to it. All the present authors had observed instances of crows pecking Pariah Kites away. The crow appeared to be a natural check on the Pariah Kite in the aerodrome. (Sreekumar Op. Cit).

3.1.8. Bird-strikes at Calicut aerodrome:

Calicut aerodrome started functioning with two flights per week in 1988: by 1991 it had four flights, and in 1996. one hundred flights a week. Between 1992 May and September 1994 there were four collisions of aircrafts with Kites. These were the months in which Pariah Kites birds were recorded flying low (Figure 213 Appendix).

Table 4. Bird strikes at Calicut Aerodrome, Karipur

Date	Time	Flight Phase & Parts struck	Altitude of bird / strike speed	Bird species involved
1. 07.05.92	6.35	Landing roll. Landing gear. Pilot could not see the bird	Ground 175 Kts. approx	Pariah Kite Flight not affected
2. 11.05.92	7.05	Landing roll. Engines 1 & 2 shut down. Bird ingested & aircraft grounded	Ground 130 Kts.	2 Kites Bird flew from the side of RI towards the Aircraft
3. 18.05.92	6.45	Landing roll. Front light on wing, Nose headlight glass broken	Ground 136 Kts	Kite No effect on the flight
4. 22.09.94	16.40	Takeoff run. Damage not reported	300 AGL 140 Kts	Only single Kite Flight not affected Flew to Muscat as per plan

In 1994, after attending the 22nd meeting of the BSCE in Vienna the first author requested the AR & D Board, New Delhi to start a nationwide campaign against indiscriminate dumping of garbage anywhere in the open. There was some action taken against slaughtering in the open and some improvement in the collection of garbage in Calicut also. Throughout the period 1990 to 97 our team members attended all meetings of the Calicut Airport's environmental committee. After 1994 September no bird strike has been recorded there.

3.2 Cochin Naval Air Station :

This station which also serves as civilian aerodrome is situated (Long 957°N lat. 76013°E) close to the large Vembanad Lake and the Arabian Sea-coast. It has rich growth of grasses and trees and within one year of study we recorded 46 species of birds from 22 families and 12 orders. Bird diversity index was 2.41 and equitability 0.59. There were innumerable trophic and space niches for birds and bird distribution was not even. Upto 1992 the airport's VOR was surrounded by a broken up fence and up to 50 Pariah Kites found comfortable perches on that fence (Mathew 1997). In 1992, at our request this fence was knocked down. For considerable time there after. Pariah Kites would attempt to land in this area as though looking for perches on the nonexistent fence and then return. It took them some time to erase this conditioned behaviour!

The Naval Airstation had a total of 280 flights altogether (including both landings and taking, off) per week in 1996. The flight safety division of Cochin is very poorly equipped to reduce bird strikes. After 1994 there was general reduction in the amount of garbage accumulating in the buffer zone and some reduction in the number of bird hits. (Table 5).

Table 5. The bird hits on aircrafts recorded from 1991 in Cochin.

Years	Total No. of bird-hits	
	Military Aircraft	Civilian Aircraft
1991	8	3
1992	9	4
1993	6	1
1994	2	2
1995	4	1
1996	5	1

The SFSO does his best to prevent bird hits, but is helpless without funds.

Immature naturalists and friends of trees would often interfere with the removal of trees in Cochin airport confusing the SFSO, and making things worse!

3.3 Mangalore Airport

This airport (12°6'1"N x 74° 50'E), is situated on a hill about 300 m in elevation and about 4-5 Km distant from the sea-coast. It had a rich and varied biotic community which supported 44 species of birds from 23 families and 10 orders. Bird diversity Index and equitability were both high at 3.3 and 0.88 respectively. There were numerous Pariah Kites and over 20 species of other birds which had potential to endanger aircrafts. There were fewer garbage dumps and we could not see any slaughtering sites, close to the airport. In 1996 there were only 15 flights landing and 15 taking off and in 1995-96 there were no bird strikes. The airport grounds must be cleared of its thick vegetation to prevent bird hits on aircrafts as air-traffic here expands.

3.4 Trivandrum International Airport

Trivandrum is on the sea-coast (8°28'N x 76°55'E) and has many fish landing areas in its buffer zone and the biggest population of Pariah Kites we had observed. In 1996, there were 100 landings plus 100 take offs of aircrafts per week. The Bombay Natural History Society (Grubb 1988) did a lot of work in this aerodrome. The airport's authorities did their best to implement the measures recommended for reducing bird hazard. They have shifted a nearby municipal waste dump to a distant locality. The public still throw garbage and animal waste around the aerodrome. There is endless flow of Pariah Kites into the airport and the hardworking security personnel remove all Pariah Kites found on the runway before every landing and takeoff of planes and have reduced bird-strikes to zero during 1996. There were 53 bird-hits (or roughly 10 bird strikes per 10,000 flights) from 1980 to 86.

3.5 Naval Air Station Ramnad:

This small aerodrome (9°27'N x 79° E) is maintained for training Naval pilots. We could record only 34 species of birds within the few visits. The airstation has very thick growth of coastal shrubs which support a very complex web of life including large variety of insects, lizards, snakes and small mammals. There could be many more species of birds than what we have observed.

Swarming of locusts occurred periodically and locusts were taken by the birds. We used a locust infested area to test the effectiveness of reflective tapes against birds. (Table - 6 A Appendix)

In 1996 a Pariah Kite hit an islander aircraft on the take off at a height of 100 ft. and damaged a wing. There could be many more strikes here in future as the district has a lot of fish processing centres and large number of kites.

We tried replaying of amplified tape records of distress calls of the Pariah Kite to scare the bird in many places in the buffer zone of Ramnad NAS and in every case the kites moved away within 5 minutes. The airport officials did not have the same success with tile tapes given by us. As pointed out by Blokpoel (1976) replay of distress calls could be combined with other frightening stimuli like the firing of flares for better effects.

3.5.1. Comparison of bird hazard in the 5 aerodromes:

Factors leading to bird strikes in the five aerodromes are stated in Table 7 (Appendix). The factor common to almost all aerodromes appears to be faulty management of waste. Failure to trim and control the height of ground vegetation appears to be the second. This is most severe in Cochin aerodrome which looks like part of a tropical rain forest. Water logging is another factor attracting birds. In the Trivandrum International Airport the deficiencies in waste control of the town is compensated by the vigilant, permanent security staff.

3.6 Methods of repelling birds:

3.6.1. Neem products:

Products of the Neem plant have been used widely in India to protect crops (Shivnarayanan and Rao 1988) from animal pests. In collaboration with the American biochemist Dr. J. Russel Mason we tested some of the Neem products as aversion agents.

1. Neem Cake:

In the first experiment 250 g. of Neem cake were fermented in one litre of water and after 10 days the pungent liquid was sprayed on the vegetation where the birds visit, in our botanical garden. The number of bird visits in this spot and a control plot which was sprayed with water were compared. There was statistically significant difference between the number of birds visiting the two plots. (Table 8 - Appendix). 2.

2. Neem Oil :

In a second experiment a captive Pariah Kite in healthy condition was given weighed quantities of meat adulterated with Neem Oil alternatively with normal meat on 10 successive days. The results suggested that Neem oil had acted as an aversion agent. Many more standard trials are required to establish this. We did not have the facilities to do that. (Table 9).

3.6.2. Dr. Russel Mason's experiments on European Starlings (*Sturnus vulgaris*).

In the first experiment twenty starlings in groups of 5 were presented with feed adulterated with Nimin prepared by Godrej Agrovet Limited (Bombay 400 079) India, sent by us. In 4 day trials each group was presented with a different order of feed sample containing 0.0 to 1.5% Nimin in 2 hour 1 cup tests. There were significant differences among concentrations $F = 17.7; 3.48 \text{ df.}$ ($P < 0.00001$) post-hoc evaluation of this effect showed only that consumption of food adulterated with the highest neem concentration was less than the consumption of plain feed (Mason Pers. Comm. 1995).

Table 10 - The responses of birds to the light reflected by mirrors.

Days	Number of Pariah Kites trying to land on the runway	No. repelled by the reflecting device.
1	44	36
2	71	63
3	66	52
4	62	47
Total	243	198

Trial 2 – Calicut Beach

Birds	Number of attempts to land	Number of birds repelled by the device
1. Pariah Kite	40	40
2. Brahminy Kites	3	3
3. Cattle Egrets	102	102

As our funding agency withdrew its financial support we could not carry out more trials, but have handed over the device to the agency.

4. Conclusion

The long term studies described in this paper helped us to compile information useful in controlling birds in the Calicut Aerodrome. Our experiences were useful to the Flight Safety Divisions in reducing bird hazards to aircrafts in some other aerodromes also.

Tile comparatively inexpensive methods of repelling birds like the replaying of distress calls, use of neem products as aversion agents and reflective plastic tapes which we have tried in aerodromes were all useful in repelling birds. The aerodromes which are hard pressed for funds to fight bird hazards can try some of these methods.

The few trials we had made with a device for reflecting sunlight with mirrors to scare birds appeared to be effective. But many more trials are required to confirm this. The device was effective only against birds trying to land and not against birds on the ground.

The most common proximate cause for bird hazards to aircrafts in the aerodromes in India is the unscientific disposal of garbage and animal wastes. The ultimate cause is over crowding of humans in urban areas of the buffer zones of aerodromes without any scientific planning of land use.

Failure to control the luxuriant growth of vegetation in the airport ground is another factor leading to bird hazards.

The Jungle Crows appeared to be a natural factor regulating the presence of Pariah Kites in the aerodromes and buffer zones.

The example of the Trivandrum International Airport shows how a very alert security division can reduce bird strikes to minimum by timely action. They detect and remove hazardous birds like the Kites from the runways before the birds hit the aircrafts.

It must be pointed out that after the action taken to improve disposal of garbage and waste in 1994 there were fewer bird strikes in the aerodromes we had studied.

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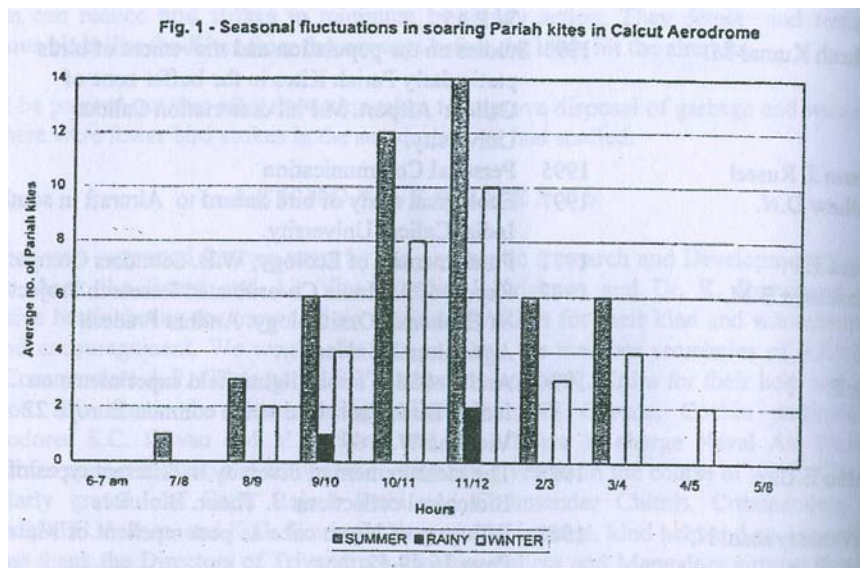
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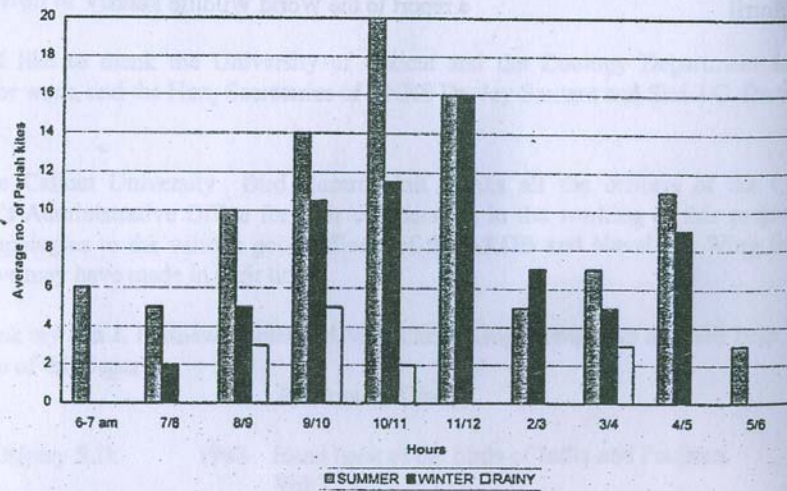
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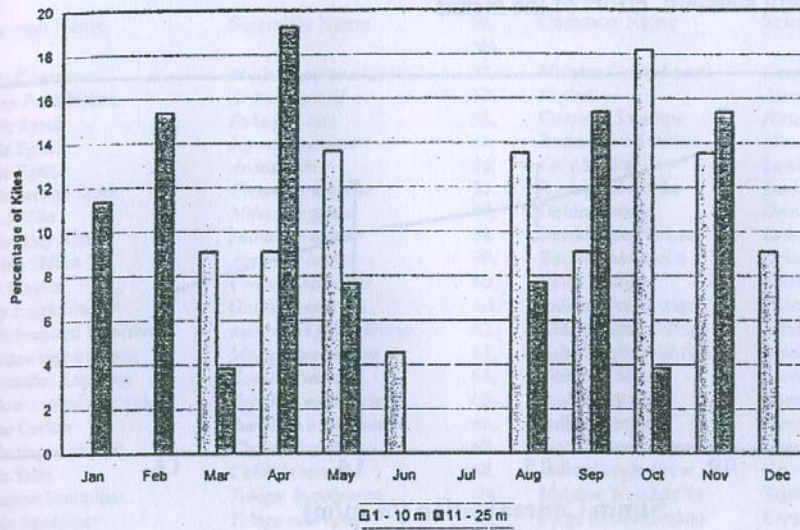
SUMMER	0	1	3	6	12	14	6	6	0	0
RAINY	0	0	0	1	0	2	0	0	0	0
WINTER	0	0	2	4	8	10	3	4	2	0

Fig. 2A - Hourly distribution of Pariah kites in Calcut Aerodrome in three seasons



SUMMER	6	5	10	14	20	16	5	7
WINTER	0	2	5	10.5	11.5	16	7	5
RAINY	0	0	3	5	2	0	0	3

Fig. 2B - Distribution of kites flying at low altitude in Calcut Aerodrome Fig.2



1-10 m	0	0	9.10	9.10	13.63	4.54	0	13.53	9.10	18.18	13.53	9.10
11-25m	11.53	15.36	3.84	19.23	7.65	0	0	7.69	15.38	3.84	15.38	0

Fig. 3 - Monthly Distribution of kites in Calcut Aerodrome during 1985 - 87 & 1988 - 90

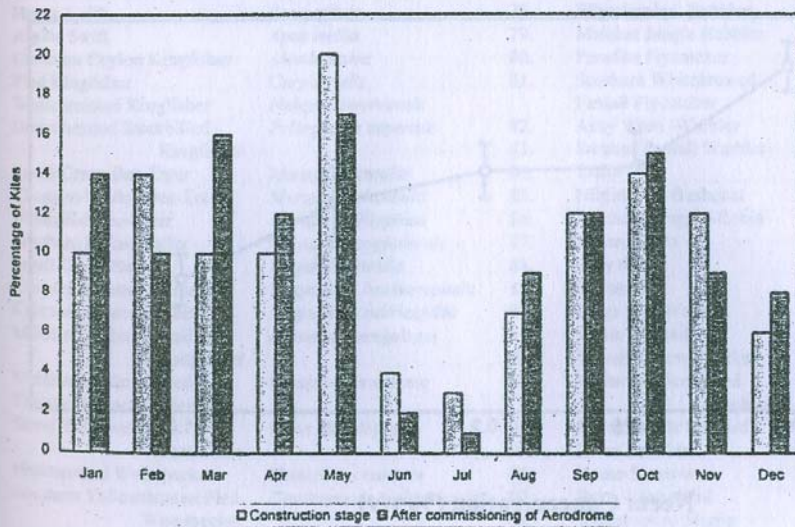


Fig. 4 Mean consumption of feed adulterated with Nimin by European starlings. Capped vertical bars represent standard errors of the means

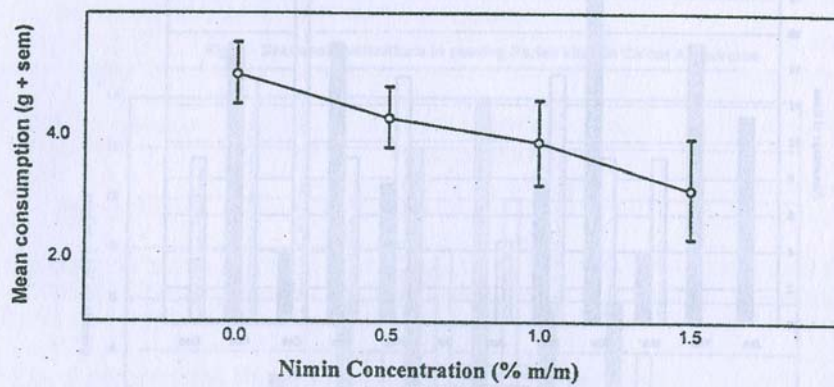


Fig 5. - Mean Consumption of an aqueous extract of neem leaves, and three serial dilutions of this extract. Consumption of 0.0 % (volume/volume) extract is mean drinking during the pretreatment period. Capped vertical bars represent standard errors of the means

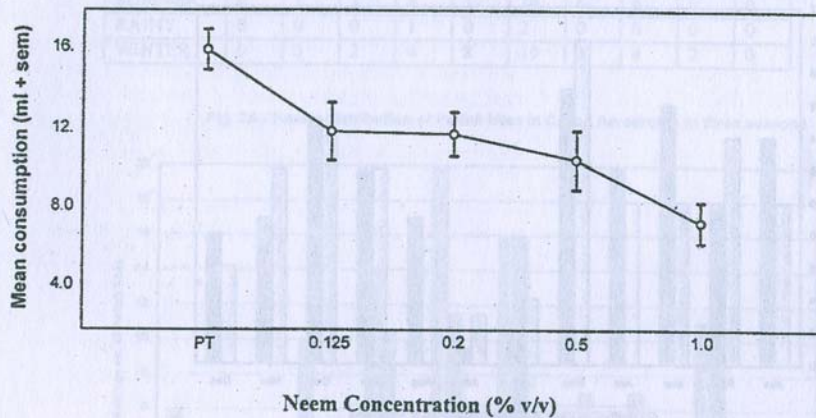


Table 1 - List of birds recorded in and around Calicut Aerodrome

Sl. No.	Common Name	Scientific Name	Sl. No.	Common Name	Scientific Name
1.	Little Cormorant	<i>Phalacrocorax niger</i>	51.	Malabar Crested Lark	<i>Galerida malabarica</i>
2.	Indian Pond Heron	<i>Ardeola grayii</i>	52.	Skylark	<i>Alauda gulgula</i>
3.	Cattle Egret	<i>Bubulcus ibis</i>	53.	Common Swallow	<i>Hirundo rustica</i>
4.	Little Egret	<i>Egretta garzetta</i>	54.	Redrumped Swallow	<i>Hirundo daurica</i>
5.	Little Egret	<i>Ardea alba</i>	55.	Grey Shrike	<i>Lanius excubitor</i>
6.	Whitenecked Stork	<i>Ciconia episcopus</i>	56.	Baybacked Shrike	<i>Lanius vittatus</i>
7.	Pariah Kite	<i>Milvus migrans</i>	57.	Golden Oriole	<i>Oriolus oriolus</i>
8.	Brahminy Kite	<i>Haliastur indus</i>	58.	Blackheaded Oriole	<i>Oriolus xanthornus</i>
9.	Ceylon Shikra	<i>Accipiter badius</i>	59.	Backnaped Oriole	<i>Oriolus chinensis</i>
10.	Pale Harrier	<i>Circus macrourus</i>	60.	Black Drongo	<i>Dicrurus adsimilis</i>
11.	Grey Junglefowl	<i>Gallus sonneratii</i>	61.	Indian Grey Drongo	<i>Dicrurus leucophaeus</i>
12.	Whitebreasted Waterhen	<i>maurornis phoenicurus</i>	62.	Racket-tailed Drongo	<i>Dicrurus paradiseus</i>
13.	Bronzewinged jacana	<i>Metopidius indicus</i>	63.	Ashy Swallow-Shrike	<i>Artamus fuscus</i>
14.	Redwattled Lapwing	<i>Vanellus indicus</i>	64.	Common Myna	<i>Acridotheres tristis</i>
15.	Yellowwattled Lapwing	<i>Vanellus malabaricu</i>	65.	Brahminy myna	<i>Sturnus pagodarum</i>
16.	Stone Curlew	<i>Burhinus oedicnemus</i>	66.	Indian Treepie	<i>Dendrocitta vagabunda</i>
17.	Little ringed plover	<i>Charadrius dubius</i>	67.	Ceylon House Crow	<i>Corvus splendens</i>
18.	Little Stint	<i>Calidris minutus</i>	68.	Indian Jungle Crow	<i>Corvus macrorhynchos</i>
19.	Common Sandpiper	<i>Tringa hypoleucos</i>	69.	Malabar Woodshrike	<i>Tephrodornis virgatus</i>
20.	Green Sandpiper	<i>Tringa ochropus</i>	70.	Large Indian Cuckoo	<i>Coracina novaehollandiae</i>
21.	Indian Blue Rock Pigeon	<i>Columba livia</i>		Shrike	
22.	Indian Spotted Dove	<i>Streptopelia chinensis</i>	71.	Malabar small Minivet	<i>Pericrocotus cinnamomeus</i>
23.	Roseringed Parakeet	<i>Psittacula krameri</i>	72.	Scarlet Minivet	<i>Pericrocotus flammeus</i>
24.	Blossomheaded Parakeet	<i>Psittacula cyanocephala</i>	73.	Common Lora	<i>Aegithina tiphia</i>
25.	Common Hawk -Cuckoo	<i>Cuculus varius</i>	74.	Goldfronted Chloroosis	<i>Chloropsis aurifrons</i>
26.	Indian Plaintive Cuckoo	<i>Cacomantis passerinus</i>	75.	Goldmantled Chloroosis	<i>Chloropsis cochinchinensis</i>
27.	Indian Koel	<i>Eudynamys scolopacea</i>	76.	Southern Indian Redvented Bulbul	<i>Pycnonotus cafer</i>
28.	Southern Crow Pheasant	<i>Centropus sinensis</i>	77.	Southern Redwhiskered Bulbul	<i>Pycnonotus jocosus</i>
29.	Spotted Owllet	<i>Athene brama</i>			
30.	Palm Swift	<i>Cypsiurus parvus</i>	78.	Whiteheaded Babbler	<i>Turdoides affinis</i>
31.	House Swift	<i>Apus affinis</i>	79.	Malabar Jungle Babbler	<i>Turdoides striatus</i>
32.	Alpine Swift	<i>Apus melba</i>	80.	Paradise Flycatcher	<i>Terpisiphone paradisi</i>
33.	Common Ceylon Kingfisher	<i>Aleedo atthis</i>	81.	Southern Whitebrowed Fantall Flycatcher	<i>Rhipidura aureola</i>
34.	Pied Kingfisher	<i>Ceryle rudis</i>			
35.	Whitebreasted Kingfisher	<i>Halcyon smyrnensis</i>	82.	Ashy Wren -Warbler	<i>Prinia socialis</i>
36.	Brownheaded Storkbilled Kingfisher	<i>Pelargopsis capensis</i>	83.	Sreaked Fantail Warbler	<i>Cisticola juncidis</i>
37.	Small Green Bee-Eater	<i>Merops orientalis</i>	84.	Tailor Bird	<i>Orthotomus sutorius</i>
38.	Chestnut-headed Bee-Eater	<i>Merops leschenaultii</i>	85.	Nilgiri Pied Bushchat	<i>Saxicola caprata</i>
39.	Bluetailed Bee-Eater	<i>Merops philippinus</i>	86.	Southern Magpie-Robin	<i>Copsychus saularis</i>
40.	Southern Indian Roller	<i>Coracias benghalensis</i>	87.	Indian Robin	<i>Saxicoloides fulicata</i>
41.	Small Green Barbet	<i>Megalaima viridis</i>	88.	Grey tit	<i>Parus major</i>
42.	Crimson breasted Barbet	<i>Megalaima haemacephala</i>	89.	Indian Pipit	<i>Anthus novaeseelandiae</i>
43.	Crimson throated Barbet	<i>Megalaima rubricapilla</i>	90.	Large pied Wagtail	<i>Motacilla maderaspatensis</i>
44.	Malabar Goldenbacked Woodpecker	<i>Dinopium bengalense</i>	91.	White Wagtail	<i>Motacilla alba</i>
45.	Malabar Goldenbacked Threetoed Woodpecker	<i>Dinopium javanense</i>	92.	Tickell's Flowerpecker	<i>Dicaeum erithrorhynchos</i>
46.	Small Yellownaped Woodpecker	<i>Picus chlorolophus</i>	93.	Indian Purple Sunbird	<i>Nectarinia zeylonica</i>
47.	Heartspotted Woodpecker	<i>Hemicircus canente</i>	94.	Indian Purple Sunbird	<i>Nectarinia asiatica</i>
48.	Southern Yellowfronted Pied Woodpecker	<i>Dendrocopos mahrattensis</i>	95.	Loten's sunbird	<i>Nectarinia lotenia</i>
49.	Indian Pitta	<i>Pitta brachyura</i>	96.	House Sparrow	<i>Passer domesticus</i>
50.	Ceylon Bush Lark	<i>Mirafa assamica</i>	97.	Baya Weaverbird	<i>Ploceus philippinus</i>
			98.	Whitebacked Munia	<i>Lonchura striata</i>
			99.	Blackheaded Munia	<i>Lonchura malacca</i>
			100.	Spotted Munia	<i>Lonchura punctulata</i>

Table 3 - Distribution of factors attracting birds in the Calicut aerodrome environs.
(Sreekumar 1992).

Place	Approximate distance from the aerodrome in m	Factors attracting birds				
		Open slaughtering centres	Chicken dressing centres	Meat stalls	Fish stalls	Garbage dumps
Eastern boundary of aerodrome	100	1	-	1	1	-
Tharayittal	500	1	-	-	1	-
Melangadi	250	1	-	1	1	1
Kumminiparamba	1500	1	-	1	1	-
Karipur	250	1	-	1	2	-
Puliyamparamba	2000	1	-	1	2	1
Kolathoor	225	1	1	2	3	1
Pallikkal	2500	2	2	2	3	2
Kondotty	125	4	5	11	5	4

Table 6A -Response of birds to reflective tapes in Ramnad Naval Airstation

Bird Species	No. of birds entering E & C												Total
	I Day		II Day		III Day		IV Day		V Day				
	E	C	E	C	E	C	E	C	E	C	E	C	
<i>Milvus migrans</i>	29	61	25	48	26	66	50	78	20	46	150	299	
<i>Haliastur indus</i>	5	15	6	18		15	10	18	2	9	23	75	
<i>Circus macrourus</i>		1								1		2	
<i>Falco tinnunculus</i>		3		2				1		1		7	
<i>Perdica asiatica</i>	1										1	1	
<i>Centropus sinensis</i>				1								1	
<i>Cypsiurus parvus</i>		43			38	12	4	14		18	42	87	
<i>Apus affinis</i>		18										18	
<i>Apus melba</i>					3							3	
<i>Coracias benghalensis</i>		1		2	1	1		1		2	1	7	
<i>Merops orientalis</i>				5				8				13	
<i>Merops philippinus</i>										3		3	
<i>Ichthyophaga ichthyateus</i>		1		6	1	4		3		4	1	18	
<i>Anthus novaeseelandiae</i>		2										2	
<i>Hirundo daurica</i>		6		26	15					2	15	34	
<i>Dicrurus adsimilis</i>		5				2	1			1	1	0.8	
<i>Artamus fuscus</i>	1	8		4		9	16			20	17	41	
<i>Corvus macrorhynchos</i>				9								9	
<i>Acridotheres tristis</i>		8		3		4		28				43	
<i>Turdoides striatus</i>											254	671	

E – Experimental area; C-Control area

The assumption is that the arrival of birds at the experimental and control areas are distributed as Poisson with possibly different arrival rates.

Mean arrival per day at the experimental area	=	2.54
Mean arrival per day at the control area	=	6.71
Calculated value of z statistics	=	-13.96436
Table value (at 5% level of significance)	=	-1.645

There is significant difference in the arrivals at the experimental and control areas. Hence we can conclude that reflective tapes are effective.

Table 6-B – Response of birds to reflective tapes in Trivandrum International Airport

No. of birds entering E & C						
BIRD SPECIES	I Day		II Day		TOTAL	
	E	C	E	C	E	C
<i>Milvus migrans</i>	138	236	50	243	188	479
<i>Haliastur indus</i>	5	10	13	23	18	33
<i>Corvus splendens</i>	148	395	103	448	251	842
<i>Corvus macrorhynchos</i>		3				3
<i>Egretta garazetta</i>		1	2	1	2	2
<i>Phalacrocorax niger</i>	2	1			2	1
<i>Charadrius dubius</i>				6		6
<i>Louchura punctulata</i>				8		8
Total					461	1374

E- Experimental Area; C-Control Area

The assumption is the arrival of birds at the experimental and control areas are distributed as Poisson with possible different arrival rates.

Mean arrival per day at the experimental area	=	28.8125
Mean arrival per day at the control area	=	85.875
Calculated value of z statistics	=	-21.3134
Table value (at 5% level of significance)	=	-1.645

There is significant difference in the arrivals at the experimental and control areas. Hence we can conclude that reflective tapes are effective.

Table 7 - Comparison of environmental conditions and bird hits in aerodromes in Southern India.

Aerodrome	Calicut	Mangalore	Cochin	Trivandrum	Ramnad
No. of species of birds	40 *	44	43	43	34
Diversity index of birds	2.3	3.3	2.41	-	-
Equitability	0.86	0.88	0.59	-	-
1. Garbage	+++	+	+++	+++	-
2. Slaughter/Fishery wastes	+++	-	++	+++	+++
3. Grass, Shrubs, Trees	+	++	+++	+	++
4. Water logging	+	+	+++	+++	-
5. Availability of artificial perches	+	+	+++	+++	+
6. Nests and roosts of bird	+++	++	++	+	-
No. of flights per week	100	30	280	200	about 100
No. of bird aircraft collisions 1994 January - 1996 December	2	Nil	11	Nil	1

- = Nil + = Moderate ++ = High +++ = Severe

- Including buffer zone Calicut aerodrome had 100 species of birds.

Table 8. Number of birds visiting plots sprayed with Neem cake solution (E) and those sprayed with water (C)

Bird species	Day 1st		2nd		3rd		4th	
	Time 6-18 hrs		6-18 hrs		6-18 hrs		6-18 hrs	
	E	C	E	C	E	C	E	C
1. Pond heron		2					2	1
2. Spotted dove			1					
3. The common Myna		3	1	2			1	2
4. White headed Babbler	1	3		4			1	4
5. Koel		1			1		1	
6. Redwattled Lapwing	1							
7. Black Drongo	2	4		1	1	3	2	1
8. White breasted Kingfisher		1			1		1	
9. Common Wood Shrike					1			
10. Purple Sunbird		1			1			
11. Treepie					1			
12. Redvented Bulbul			1				1	
13. Jungle Crow		1					2	
Total visits	4	16	1	9	1	8	3	12

E - Experimental; C - Control

Total no. of visits in Experimental area : 9
 Total no. of visits in Control area : 54

Statistical analysis

It is assumed that the arrivals of birds in the experimental and control areas are distributed as poisson with possibly different arrival rates.

Mean arrival per day at the experimental area = 1.8
 Mean arrival per day at the control area = 10.8
 Calculated value of z statistics = -5.669467
 Table value (at 5% level of significance) = -1.645

There is significant difference between arrival of birds between E & C. The neem cake solution is effective as a bird repellent.

Table 9. Experiment with neem showing the response of Pariah Kite towards meat sprayed with neem oil.

No.	Date	Experiment	Concentration of Neem Oil (ml/10ml H ₂ O)	Weight of meat supplied	Weight of meat remaining after one day	Weight of meat consumed
1.	12.7.93	Control	--	250 g	0	250 g
2.	13.7.93	Control	--	250 g	0	250 g
3.	14.7.93	Test	1	250 g	248 g	2 g
4.	15.7.93	Control	--	250 g	41.5 g	208.5 g
5.	16.7.93	Test	0.5	250 g	248.5 g	1.5 g
6.	17.7.93	Control	--	250 g	22 g	228 g
7.	18.7.93	Test	0.25	250 g	242 g	8 g
8.	19.7.93	Control	--	250 g	12.5 g	237.5 g
9.	20.7.93	Test	0.1	250 g	239 g	11 g
10.	21.7.93	Control	--	250 g	8.5 g	241.5 g

(Mahesh Kumar 1993.)

Table 10 - Showing the distribution of activities of the Pariah Kites on 13 species of trees in the Calicut aerodrome.

Tree sps	Activities in %			
	Resting	Preening	Feeding	Roosting
1. <i>Mangifera indica</i> *	16.91	19.60	5.76	6.28
2. <i>Artocarpus heterophyllus</i>	2.94	Nil	1.8	Nil
3. <i>Casuarina equisetifolia</i>	Nil	1.96	Nil	0.78
4. <i>Ceiba pentanodra</i>	8.83	7.84	3.7	11.41
5. <i>Cocos nucifera</i> *	30.14	37.25	50.94	66.14
6. <i>Caryota uren</i>	8.08	11.76	3.77	3.14
7. <i>Delonix regia</i>	2.64	3.92	Nil	0.79
8. <i>Macaranga peltata</i>	4.41	3.92	7.54	1.57
9. <i>Anacardium occidentale</i>	4.41	1.96	Nil	Nil
10. <i>Areca catechu</i>	2.20	1.96	24.52	4.72
11. <i>Alstonia scholaris</i>	12.50	5.88	Nil	2.36
12. <i>Tamarindus indica</i> *	3.67	3.92	1.8	0.79
13. <i>Ficus religiosa</i>	3.24	Nil	Nil	2.0
Total No. of Observations	136	51	53	242

(Gangadharan - unpublished)

* These species and the neem tree were used for nesting by the Pariah Kite.