J. Biosci., Vol. 19, Number 4, October 1994, pp 369-380.

Non-random foraging in certain bird pests of field crops

S SUBRAMANYA
HPHT Scheme, 'J' Block, University of Agricultural Sciences, GKVIC Bangalore 560 065, India

Abstract. Two systems of bird-crop interactions were studied to explain the between- and the within-field variation in the foraging pattern of bird pests in agro-ecosystems. Weaverbirds and munias select rice fields with greater vegetation complexity and not based on the resource status. Within a selected area the concentration of feeding birds was greater close to vegetation cover and decreased non-linearly with increase in distance. Certain structural features and earhead characters of rice plants predisposed particular varieties for intense grain predation by birds. In the parakeet – sunflower system the extent of damage among plants within a field was closely linked to the foraging pattern of parakeets. The extent of achene predation by parakeets was influenced by certain structural features of sunflower plants and not the resource load of each plant. Selective feeding on sunflower plants was governed by the predator vigilance pattern; parakeets prefer to feed on plants that offered better field of vision. The results suggest that the observed pattern of foraging by bird pests in agro-ecosystems is non-random and is dependent on factors favouring predator avoidance behaviour and not on resource maximization.

Keywords. Argo-ecosystems; bird pests; foraging pattern; plant structure; predator avoidance.

1. Introduction

A number of bird species are pests of agricultural crops (Ward 1965; Murton and Wright 1968; Grist and Lever 1969; Dyer and Ward 1977; Besser 1978; Mehrotra and Bhatnagar 1979; O'Conner and Shrubb 1986). In modified environments such as agro-ecosystems those bird species which appear to be pre-adapted to feed on field crops (Wiens 1976; Wiens and Johnson 1977) cause considerable economic damage to crops (*e.g.* Murton and Jones 1973; Wiens and Dyer 1977; Mehrotra and Bhatnagar 1979). Though much information is available on identity of the species concerned, crops they attack, nature of damage, extent of loss, possible control methods and so on (*e.g.* see Murton and Wright 1968; Grist and Lever 1969; Pinowski and Kendeigh 1977; Mehrotra and Bhatnagar 1979; Wright *et al* 1980; O'Conner and Shrubb 1986), very little is known about the feeding pattern of bird pests in agro-ecosystems.

Stone and Mott (1973) found that foraging by redwinged blackbird, *Ageleaus phoeniceus* (L.) was frequently confined to a very few localized areas, with a great majority of corn fields free from damage. The studies of Bhatnagar *et al* (1982) and Weatherhead and Tinker (1982) indicate selective feeding by bird pests within a crop field. Though these studies reflect on between and within field variation in foraging pattern by bird pests, they do not, however, explain why such patterns occur and what selective forces shape such a non-random feeding. In this paper the results on the foraging behaviour of bird in two agro-ecosystems namely, "weaverbird and munia – rice system" and "parakeet — sunflower system", are presented. The results indicated that the foraging behaviour in these birds is non-random and is primarily influenced by strategies favouring predator avoidance and not resource maximization.

2. Materials and methods

2.1 *Systems*

Two bird-crop systems namely, the weaverbird and munia – rice system and the parakeet – sunflower system were studied.

2.1a *Weaverbird and munia – rice system:* Rice crop maturing towards the end of summer in Bangalore suffer severe grain predation by mixed feeding flocks of the baya weaverbird (*Ploceus philippinus* L.) and four species of munias (*Lonchura punctulata* L., *L. malabarica* L., *L. striata* L., *L. malacca* L.; Subramanya 1991). These birds visited rice fields from roosts found in dense stands of reeds (*Typha* sp.; Subramanya 1991); their foraging activity within the rice growing area was clumped in distribution (as per Southwood 1978; x = 84·76; SD^2 = 26716.19; n = 21; figure 1) indicating a highly localized damage pattern as observed by Stone and Mott (1973).

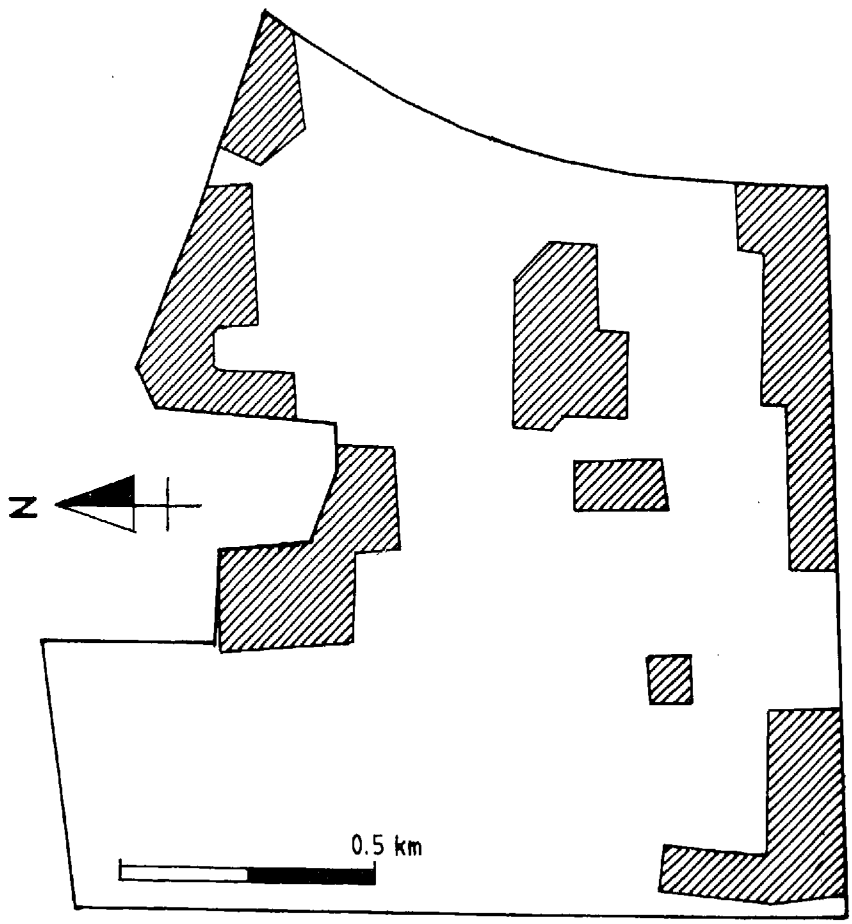

Figure 1. Distribution of damage within a rice growing area in north Bangalore.

2.1b *Parakeet — sunflower system:* The roseringed parakeet (*Psittacula krameri* (Scopoli)) is a serious pest of sunflower crop in India (Mehrotra and Bhatnagar 1979; Ali and Ripley 1984; Babu and Muthukrishnan 1987). In a sunflower field in north Bangalore, the degree of predation of achenes (seed) by parakeets differed considerably among plants within the field (figure 2).

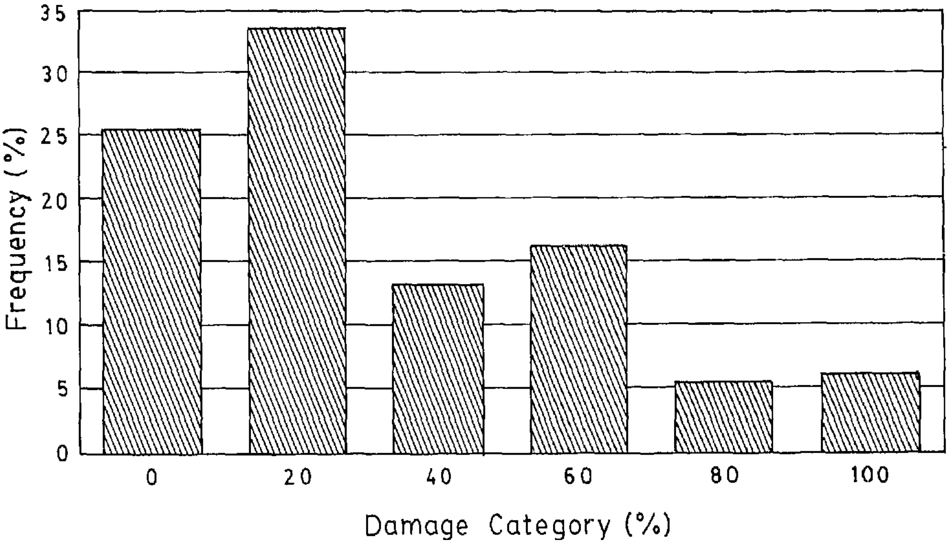

Figure 2. Distribution of parakeet damage within a sunflower field. Sample size = 350 plants.

2.2 *Study sites*

Three rice fields each with an area of 20 acres were selected within a rice growing area in north Bangalore (13°02'-13°03'N, 77°34' —77°37' E). Each of these study sites were foraged by bird pests from a centrally located roost (Subramanya 1991). The Hebbal site (HBL) was about 0·75 km from the roost while Nagavara (NGR) and Kodigehalli (KGH) sites were 1·85 and 3·13 km from the roost site, respectively.

A 1·5 acre sunflower field planted with Mordan variety in the Hebbala campus of the University of Agricultural Sciences was studied to understand the damage pattern by parakeets.

2.3 *Methods*

Each of the selected rice fields were regularly censused four to eight times a month as per Dickson (1979) from April 1983 to June 1984 to obtain details on bird pest abundance. Complexity and diversity of non-rice vegetation (shrubs and trees > 1-5 m height) was estimated for each site using Shannon and Weaver index (Price 1975).

At the HBL site the extent of area occupied by mature rice crop was estimated regularly between January and June 1984 when the abundance of birds increased due to post-breeding congregation (Subramanya 1991). The feeding concentration of birds at different distances from non-rice vegetation was recorded along with the type of rice plant (whether tall > 100 cm or dwarf < 100 cm in height) fed upon by the birds at these several sites. The plant height measurements were considered only beyond 30 m from cover as no tail varieties were grown within the 30 m zone.

Using a completely randomized block design (Sundararaj *et al* 1972) seven varieties of rice were grown at the HBL site with three replications each with a plot size of 3 × 3 m and were exposed to bird damage. Ten randomly selected plants of each variety ware scored for six variables namely, plant height, plant spread at earhead level, type of earhead (erect, semierect, drooping), angle of the flagleaf (*i.e.* terminal leaf located immediately below the earhead) from the horizontal, projection of flagleaf above the earhead and per cent damaged earheads per plant.

To understand the damage pattern by parakeets in sunflower, three transects each of 30 m length were laid out (two diagonally and one horizontally) in the middle of the field. Each plant that was in contact with the transect lines was scored for seven morphological variables (table 1).

Table 1. Different plant morphological variables in sunflower.

Variables*	Description
HTH	Height of the highest point of the head from the ground.
HDIA	Diameter of the head.
HANG	Angle of the head in degrees from horizontal (erect head = 90°; downward facing head = 0°).
HTYP	Head type (8 type classes: folded; highly concave; concave; slightly concave; slightly convex; convex; highly convex; and folded).
DHS	Distance of the head from the stem.
DRP	Droop of the head obtained by measuring the depth of variables DHS from the highest point on the plant.
ADMG	Achene damage to the head by parakeet feeding estimated by using the template method recommended by Dolbeer (1975).

*All variables except the angle of the head are in centimeters.

Using a portable cassette recorder, observations on the behaviour of feeding parakeets were recorded with the associated feeding time budgets. Observations on each bird was recorded for a maximum of five minutes and only those that exceeded two minutes of observation were considered for analysis. The observations were later transcribed in the laboratory to obtain the peck rate per minute, time spent looking up (vigilance; Bertram 1980) between two successive pecks and the time spent on each peck. The head angles of each of the plant on which parakeet feeding was observed were measured.

Separately, the highest point on 100 randomly selected plants were measured to estimate the mean height (general canopy level) in the field.

Correlation analysis, X^2 and cluster analysis were conducted wherever necessary.

3. Results

3.1 *Weaverbird and munia– rice system*

The abundance of bird pests in a rice field decreased non-linearly with increase in the distance of the feeding sites from the roost site (figure 3). The HBL site had the highest concentration of birds with greater flock size, and birds visited the site more frequently as compared to the other two sites (table 2). The greater abundance of birds at HBL was not dependent on the availability of mature rice crop (figure 4). The HBL site had greater vegetation diversity and vegetation species richness than the NGR and KGH sites (table 3). Abundance of birds were positively correlated with vegetation species diversity at the feeding sites (r = 0·52; $P < 0.001$; y= exp (1·45 + 1·26x); n= 133).

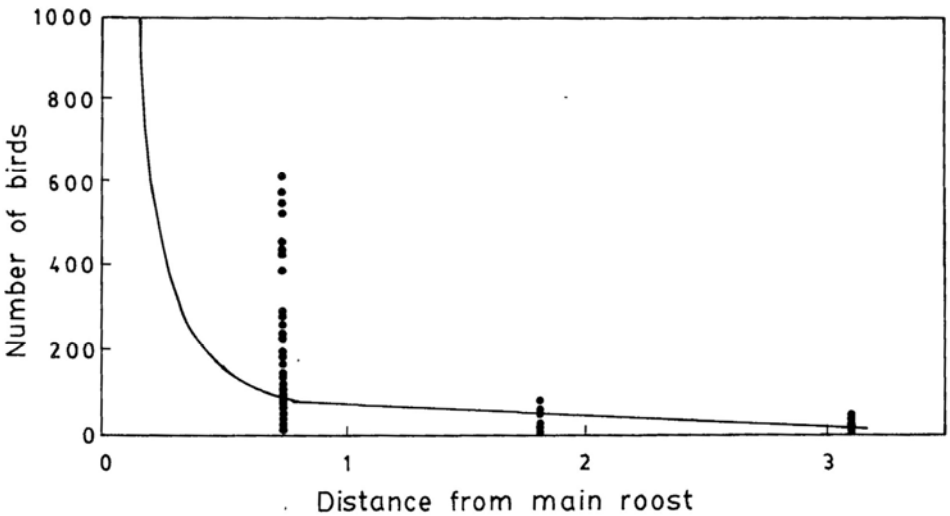

Figure 3. Feeding concentration of bird pests with different distances from main roost r = – 0·72; y = exp (3·73 – 2·02 log x) and n = 133 observations.

Table 2. Details of birds observed at different rice fields.

	HBL	NGR	KGH
Mean flock size	130·64 (165·04)	19·61 (17·32)	6·71 (8·45)
Max flock size	858	77	36
Frequency of flock sighting (%)	94·57	26·67	20·73
No. of Visits	92	108	82

Values in parenthesis are standard deviations.

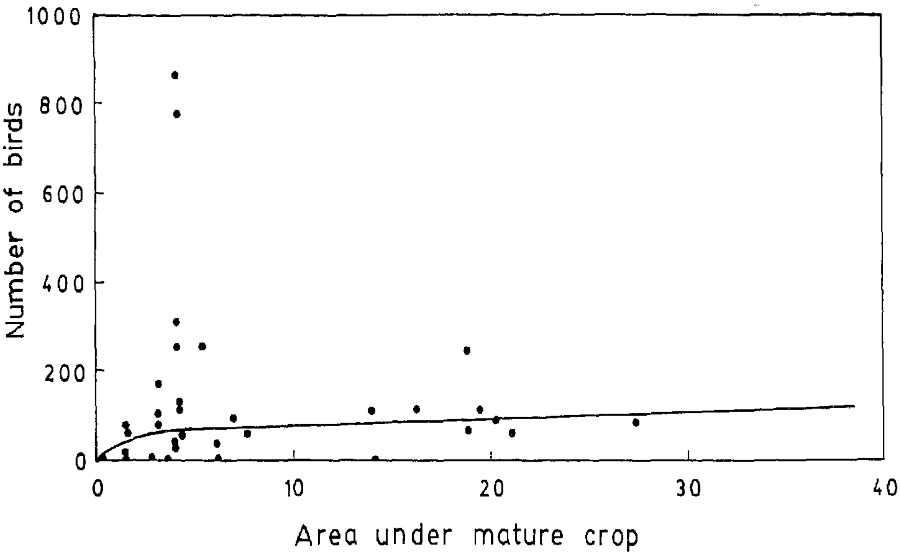

Figure 4. Abundance of bird pests in relation to availability of mature rice crop $r = 0{\cdot}08$; $y = \exp(3{\cdot}4 + 0{\cdot}33 \log s)$ and $n = 49$ observations.

Table 3. Diversity of vegetation at different feeding sites in the rice growing area.

	HBL	NGR	KGH
Richness	16 (306)	2 (5)	6 (59)
Evenness	0·75	0·86	0·75
Diversity	2·08	0·50	1·50

Values in parenthesis indicate the total number of trees + shrubs.

The percentage of birds feeding at the HBL site decreased non-linearly with increase in distance from the vegetation cover; nearly 76% of the birds were concentrated within 5 m from the cover (figure 5). Whenever birds fed more than 30 m away from cover, they significantly preferred to feed on taller rice plants (figure 6; $X^2 = 35{\cdot}71$; $P < 0{\cdot}001$; df = 1).

Tall varieties with open (wide) plant-spread, erect earheads, more horizontal flagleaf and flagleaf not projecting above the earhead (type 1 variety) were preferred by birds as opposed to dwarf plant stature, compact plant spread, drooping earhead, and erect flagleaf that projected above the earhead (type 2 variety; table 4, figure 7).

3.2 *Parakeet— sunflower system*

The correlation among different morphological variables (table 5) showed that, the head height and head angle were positively correlated with extent of achene removed (damage) by parakeets, while the distance of the head from main stem and the

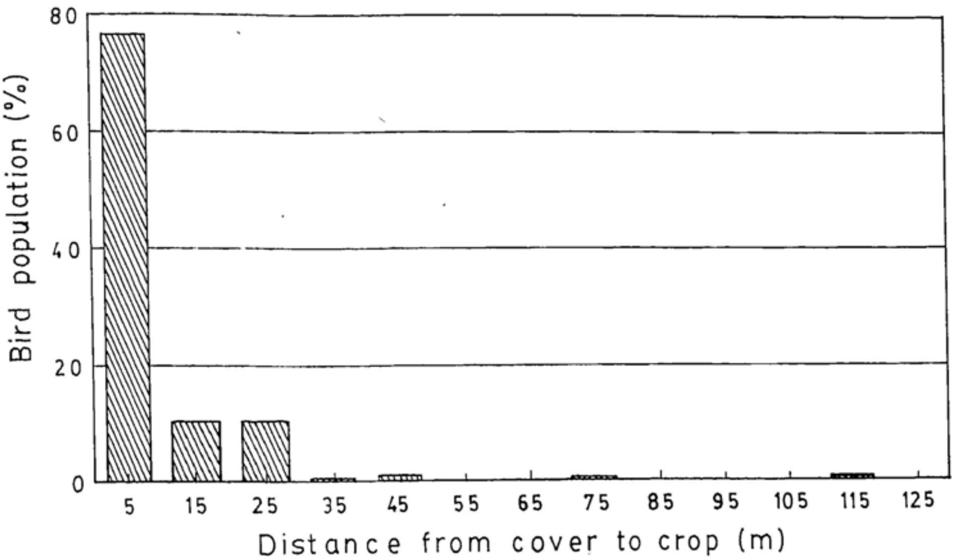

Figure 5. Feeding concentration of bird pests at different distances from cover. $r = -0{\cdot}88$; $P < 0{\cdot}001$ and $n = 23$ observations.

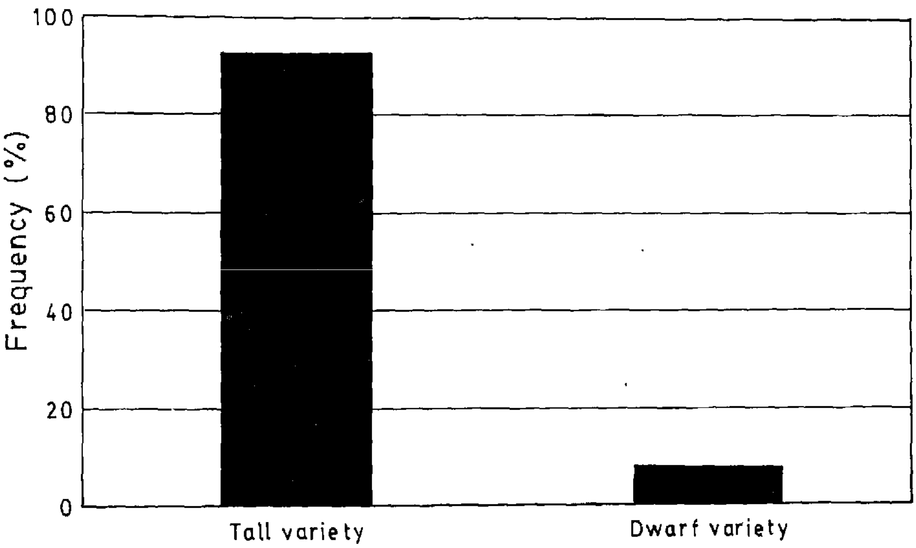

Figure 6. Plant height preferences by bird pests beyond 30 m from cover.

extent of drooping of the head were negatively associated with damage by parakeets. However, the head diameter (size) and head type had no correlation with the damage although head angle was positively associated with head height and negatively with the drooping of the plant (table 5).

The deviation of head heights from the general canopy level (mean plant height = 78·79 cm) in plants with different damage categories showed that heads which were below the canopy level suffered less damage as compared to heads that were

Table 4. Morphological variations in different paddy varieties associated with bird damage.

Varieties	Plant height (cm)	Angle of flagleaf (degrees)	Projection of flagleaf over earhead (cm)	Earhead type	Plant spread (cm)	Damaged earheads (%)
CT-1351	107·08 (8·41)	68·40 (4·17)	6·76 (7·79)	Erect	24·50 (6·97)	97·31 (6·71)
Doddabyra	112·35 (8·52)	56·14 (9·99)	10·20 (9·20)	Semierect	23·82 (3·35)	100·0
IR-36	59·58 (7·13)	79·64 (6·73)	13·24 (3·72)	Drooping-semierect	23·36 (6·30)	14·94 (20·47)
IR-42	52·84 (2·63)	77·27 (4·97)	15·70 (3·79)	Drooping	21·18 (3·95)	2·18 (3·52)
IR-48	59·66 (2·94)	88·75 (2·45)	15·81 (2·47)	Drooping	9·14 (0·99)	0·85 (2·76)
Jenugudu	94·22 (9·62)	76·09 (8·13)	0·33 (4·69)	Erect	19·14 (4·05)	100·0
Pragathi	58·29 (4·12)	89·80 (0·28)	21·03 (5·13)	Drooping	11·50 (3·79)	0·00

Values in parenthesis are standard deviations.

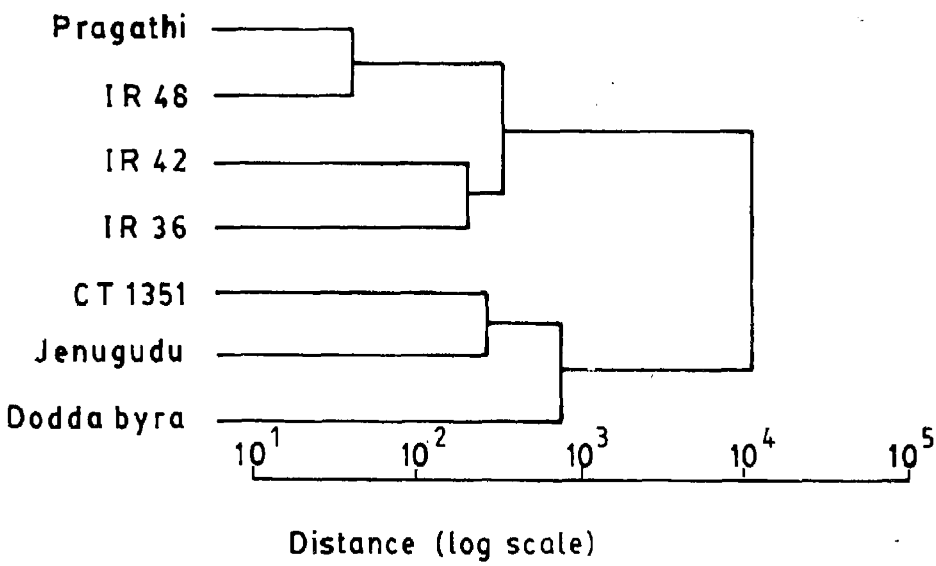

Figure 7. Cluster dendogram of the varietal preferences by bird pests at Hebbal area.

above it (figure 8). Thus parakeets preferred to feed on tall sunflower plants with vertical heads (90°; type 1 plant) as against plants that were bent down with their heads horizontally (0°) facing the ground (type 2 plant). The choice was not based on the resource load (head diameter) on a particular plant.

Analysis of the time budgets of parakeets feeding on sunflower heads, with

Table 5. Correlation matrix for six sunflower variables scored against damage by parakeets.

	HDIA	HANG	HTYP	DHS	DRP	HDMG
HTH	0·33*	0·68*	0·29	–0·51*	–0·54*	0·57*
HDIA		0·22	0·36*	0·17	0·04	0·23
HANG			0·18	–0·59*	–0·59*	0·78*
HTYP				0·05	–0·04	0·10
DHS					0·83*	–0·44*
DRP						–0·53*

n = 125; *Values significant $P < 0{\cdot}001$.

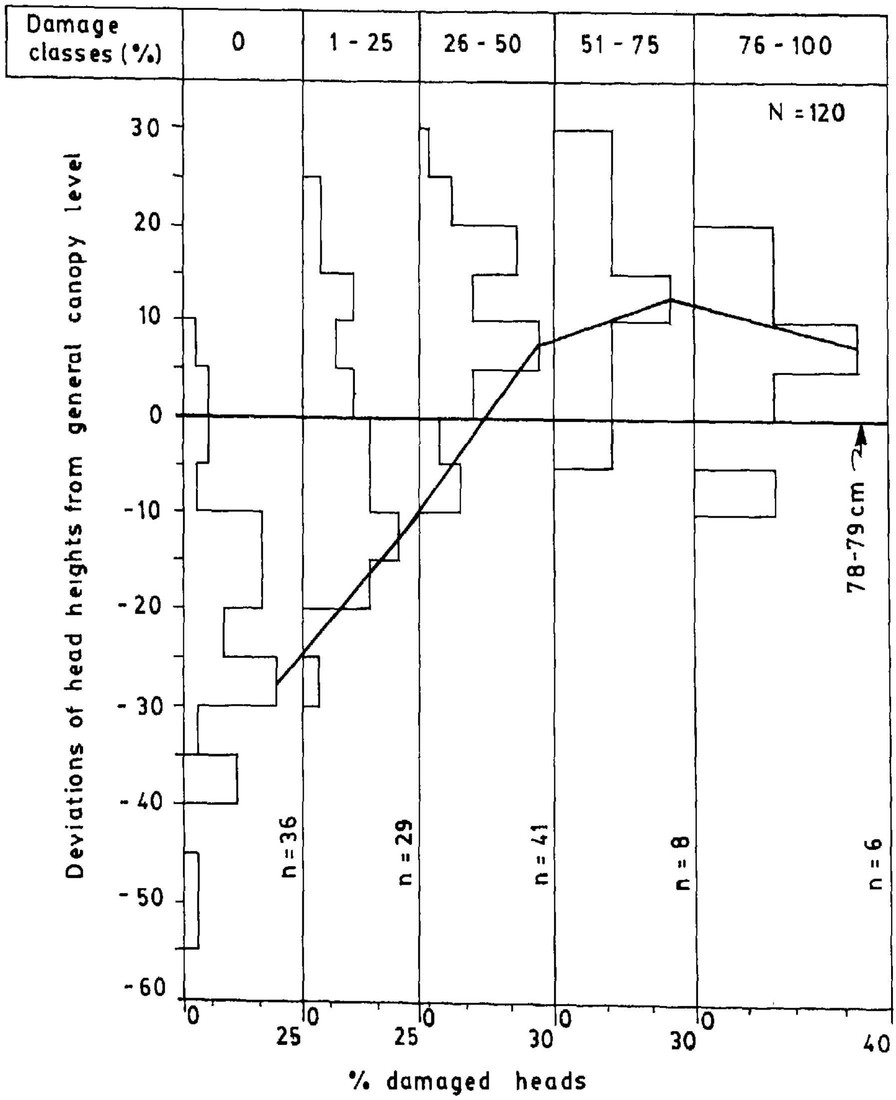

Figure 8. Deviations of sunflower head heights and variation in bird damage pattern. The modal classes in each damage category are joined to indicate the damage pattern.

different head angles revealed that the time spent on vigilance decreased significantly with increase in head angle; birds spent less time on vigilance while feeding on vertical heads. Consequently, the peck rate per minute increased with head angle and the time spent per peck increased with decrease in head angle (table 6).

Table 6. Feeding time budgets of parakeets feeding on sunflower.

	Angle of the head
Peck rate/min	0·931
Vigilance time/peck	–0·822
Time/peck	–0·461

All values significant at P < 0001; n = 33.

4. Discussion

The results on both the weaverbird and munia-rice system and the parakeet — sunflower system indicate that feeding preferences of bird pests in both agro-ecosystems is primarily dependent on considerations of predator avoidance.

At the HBL site, the abundance of bird pests was dependent on vegetation complexity than resource status of the field. Dependence on vegetation appears to be characteristic of bird pests (Mathew 1976; Ward 1965). Kendeigh (1975) stated that small birds are relatively safe within the cover of vegetation as predators cannot operate within dense cover. Hence, the availability of safe feeding sites providing immunity from predation appears to out-weighed the changes in resource status for bird pest feeding at the HBL site. Nakamara and Mutsuoka (1991), who based on their study of foraging rufous turtle doves *Streptopelia orientalis*, indicate that the site selection by birds in agro-ecosystem appear to be not dependent on the resource status of the site, Within a feeding site such as HBL, the feeding concentration of birds decreased with increase in the distance from cover. This tendency of birds to feed closer to vegetation appears to be a predator avoidance tactic. Most of the predatory birds rely on swift flight and surprise attack to capture birds (Rudebeck 1951; Morse 1973; Subramanya 1991). For an avian prey species, vegetation cover is a relatively safer place, but reaching the safety of this cover when they forage far away may be hazardous. With increase in distance from cover, the chances of these birds reaching it safely decreases as birds of prey can outfly the small prey species and can capture them before they are able to reach cover (Pulliam and Mills 1977). Thus foraging close to shrub and tree vegetation permit weaverbirds and munias to reach cover quickly in the event of predator attack.

In sunflower fields, while feeding on type 2 plant, the visibility of the surroundings is reduced to the parakeets as, in addition to feeding on the undersurface of the head, the adjacent plants curtail the view of a feeding parakeet. As a consequence a parakeet harvests less food and invests more time on vigilance. Feeding shorebirds similarly increase their anti-predatory vigilance when their visibility is curtailed due to the presence of objects close to them (Metcalf 1984), Thus, parakeets prefer to feed on tall plants with erect heads (type 1 plant) which affords a better view of the surroundings as evidenced by enhanced feeding rate, reduced vigilance and less time spent on each peck.

Vigilance, which enables a bird to detect a predator early and consequently to avoid it, can affect the time and energy budget of a feeding bird (Bertram 1980; Perrins and Birkhead 1983). Vigilance among a given flock members is shared as it depends on the number of neighbouring birds that an individual within the flock can see while feeding (Pulliam 1973; Diamond and Lazarus 1974; Treisman 1975; Pulliam *et al* 1982) and any factor that curtails the vision of the bird would negate the advantage accrued by flocking. Type 2 varieties and type 2 sunflower plant are avoided or fed upon less due to the reduced vigilance of the bird.

Hence the tendency to forage close to cover and reduced preference for plant types that enhance the time spent on vigilance are strong anti-predator behaviour among bird pests. Thus, predation appear to be a major selective force shaping the foraging pattern of birds in resource rich situations such as agro-ecosystems. The observed localized pattern of damage in rice and selective feeding in sunflower is a consequence of this phenomenon.

Acknowledgements

Helpful comments were made by Dr R Uma Shaankar while the manuscript was under preparation. Part of the study was supported by CSIR research fellowship. The cooperation of the farmers who provided access to their rice fields is gratefully acknowledged.

References

Ali S and Ripley S D 1984 *Handbook of the birds of India and Pakistan* Compact edition (Delhi: Oxford Univ. Press)

Babu R S and Muthukrishnan T S I987 Studies on the damage of *Psiltacula krameri* (Scopoli) and *Passer domesticus* (Linnaeus) on certain crops; *Trop. Pest. Manage.* **33** 367-369

Bertram B C R 1980 Vigilance and group size in ostriches; *Anim. Behav.* **28** 278-286

Besser J F 1978 Birds and sunflower; in *Sunflower science and technology* (*ed.*) J F Carter (Madison, Wisconsin: American Society of Agronomy) pp 263-277

Bhatnagar R K, Sarup P K N, Mehrotra K N, Raizado M, Marwaha K, Panwara V P S and Siddiqui K H I982 Bird damage to maize cobs: Relationship between susceptibility of maize germplasms and spathe configuration; in *Proceedings of the seminars on management of problem birds in aviation and agriculture* (eds) R A Agarwal and R K Bhatnagar (New Delhi: IARI) pp 233-234

Diamond S and Lazarus J 1974 The problem of vigilance in animal life; *Brain Behav. Evol.* **9** 60-69 Dickson J G 1979 Seasonal population of insectivorous birds in a mature bottomland Hardwood forest south Louisiana; in *The role of insectivorous birds in forest ecosystems* (eds) J C Dickson, R N Connor, R R Fleet, J A Jackson and J C Kroll (New York: Academic Press) pp 26I-268

Dolbeer R A 1975 A comparison of two methods for estimating bird damage to sunflower; *J. Wildl. Manage.* **39** 802-806

Dyer M I and Ward P 1977 Management of pest situations; in *Granivorous birds in ecosystems* (eds) J Pinowski and S C Kendeigh (Cambridge: Cambridge Univ. Press) pp 267-300

Grist D H and Lever R J A W I969 *Pests of rice* (London: Longman)

Kendeigh S C 1975 *Ecology with special reference to animals and man* (New Jersey: Prentice-Hall)
Mathew D N 1976 Ecology of weaverbirds; *J. Bombay Nat. Hist. Soc.* **72** 204-206
Mehrotra K N and Bhatnagar R K 1979 *Status of economic ornithology in India* (New Delhi, India: ICAR)
Metcalf N B 1984 The effect of habitat on the vigilance of shorebirds: Is visibility important?; *Anim. Behav.* 32 10-42
Morse D H 1973 Interaction between tit flocks and sparrowhawks (*Accipiter nisus*)*; Ibis* **115** 591-593
Murton R K and Jones 1973 The ecology and economics of damage to Brassicae by wood-pigeons *Columba palumbus; Ann. Appl. Biol.* **75** I07-122
Murton R K and Wright E N I968 *The problem of birds as pests* (London: Academic Press)
Nakamara K and Matsuoka S I991 Food resource utilization of the rufous turtle dove (*Streptopelia orientalis*) in cultivated fields; in *Nestling mortality of granivorous birds due to microorganisms and toxic substances* (eds) J Pinowski, B P Kavanagh and W Gorski (Warsaw: Polish Scientific Publishers) pp 61-69
O'Conner R J and Shrubb M 1986 *Farming and birds* (Cambridge: Cambridge Univ. Press)
Perrins C M and Birkhead 1983 *Avian ecology* (London: Blackie)
Pinowski J and Kendeigh S C 1977 *Granivorous birds in ecosystems* (London: Cambridge Univ. Press)
Pulliam H R 1973 On the advantages of flocking; *J. Theor. Biol.* **38** 419-422
Pulliam H R and Mills G S 1977 The use of space by sparrows; *Ecology* **58** 1393-I399
Pulliam H R, Pyke G H and Coraco T 1982 The scanning behaviour of Juncos: a game theoretical approach; *J. Theor. Biol.* **95** 89-103
Price P W 1975 *Insect ecology* (New York: John Wiley)
Rudebeck G 1951 The choice of prey and modes of hunting of predatory birds with special reference to their selective effect; *Oikos* **3** 200-23I
Southwood T R E I978 *Ecological methods* (London: Chapman Hall)
Stone C P and Mott D F 1973 Bird damage to ripening field corn in the United States, 1971; *US Dept. Interior Fish Wildlife Serv. Leaflet* **505** 1-8
Subramanya S 1991 *Studies on birds of rice fields with special reference to certain pest species,* Ph D thesis, University of Agricultural Sciences, Bangalore
Sundararaj N S, Nagaraju M N, Venkataramu and Jagannath M K I972 *Design analysis of experiments* (Bangalore: Univ. Agric. Sci.)
Treisman M I975 Predation and the evolution of gregariousness. I. Model for concealment and evasion; *Anim. Behav.* **23** 801-825
Weatherhead P J and Tinker S H 1982 Maize ear characteristics affecting vulnerability to damage by redwinged blackbirds; *Prot. Ecol.* **5** 167-175
Ward P 1965 Feeding ecology of the black-faced dioch *Quelea quelea* in Nigeria; *Ibis* **107** I73-2I4
Wiens J A I976 Population responses to patchy environments; *Annu. Rev. Ecol. Syst.* **7** 81-I20
Wiens J A and Dyer M I I977 Assessing potential impact of granivorous birds in ecosystems; in *Granivorous birds in ecosystems* (eds) J Pinowski and S C Kendeigh (London: Cambridge Univ. Press) pp 205-268
Weins J A and Johnson R F 1977 Adaptive correlates of granivory in birds; in *Granivorous birds in ecosystems* (eds) J Pinowski and S C Kendeigh (London: Cambridge Univ. Press) pp 301-340
Wright E N, Inglis I R and Feare C J 1980 *Bird problems in agriculture* (Croydon: British Crop Prot. Council)