POPULATION NUMBERS, HABITAT PREFERENCES AND THE IMPACT OF THE LONG-TOED PIGEON, *COLUMBA TROCAZ*, ON AGRICULTURE

By PAULO OLIVEIRA* & MARTIN JONES**

With 3 figures and 5 tables

ABSTRACT. The aims of the study were: 1) to analyse habitat preferences 2) to identify the factors that lead to the pigeons feeding in agricultural fields and 3) to monitor population changes of the long-toed pigeon, *Columba trocaz*. The field work was carried out in two periods, December 1990 to November 1991 and June 1992 to May 1993. The pigeons were recorded along five different line transects through eight biotypes.

The preferred biotype for most of the year was the one dominated by *Ocotea foetens*. *Laurus azorica* areas were preferred when berries of this species were abundant. Pigeons showed a low degree of selectivity and this did not change from one year to the other or in relation to berry abundance. There was a surprisingly high attraction to the exotic vegetation biotype and this also did not change in relation to the abundance of berries.

We concluded that although the berries of laurel forest trees play an important role in habitat choice, the use of marginal areas of the laurel forest, with exotic vegetation, and the use of agricultural areas suggests that other factors are involved in habitat selection. Feeding in agricultural fields may be a result of the wide variety of food available there, the generally low selectivity in habitat choice and the close proximity between laurel forest and cultivated land.

Finally we suggest that the population has increased between 1986 and 1993 and we estimate the population to be between 3500 and 4700 individuals.

INTRODUCTION

The long-toed pigeon, *Columba trocaz* (HEINECKEN, 1929) is a Red Data Book Species (COLLAR & STUART 1985) which is endemic to Madeira and is restricted to the areas of laurel forest in the north of the island. It feeds on a wide variety of food sources, from the berries of the large trees, such as til, *Ocotea foetens*, (ZINO & ZINO 1986) to small

* Parque Natural da Madeira - Quinta Bom Sucesso. Caminho do Meio - 9050 FUNCHAL
** Manchester Metropolitan University

Bol. Mus. Mun. Funchal, Sup. no. 4: 531-542, 1995 ISSN 0870-3876

plants like *Phyllis nobla*. Despites this large range of natural food sources it frequently uses agricultural areas where it to feeds on cabbages and fruit, particularly cherries and chestnuts.

As laurel forest is now strictly protected, poisoning and shooting by farmers whens birds come to agricultural areas, is the most important threat that the species faces. This problem can only be solved on a long term basis if we understand different aspects of the ecology of the long toed pigeon, namely the way it uses the habitat and is food sources and the relationship between these aspects and the species predation on the cultivated fields.

The objectives of the work were 1) to study habitat preferences 2) to identify the factors that may lead to pigeons feeding on agriculture fields and 3) to monitor population changes.

METHODS

The work was undertaken during two different periods: the first from December of 1990 to November 1991 (Y1) and the second from June 1992 to May 1993 (Y2). Line transects (from 2.4 to 4 Km) were carried out monthly in five distinct working areas in three valleys (Fajã da Nogueira, Rib. de S. Jorge e Rib. da Janela). All pigeons seen on the transects were recorded as inside or outside a main belt of width 40 m either side of the path walked. Birds seen within the main belt were assigned to one of eight biotypes. These biotypes were mapped and their main characteristics are shown in Table 1. The abundance of the berries of *Laurus azorica* and *Ocotea foetens* was assessed on the some monthly transects.

TABLE 1 - BIOTYPES DEFINED

Code	*dom. sp*	*other sp*	*Height*	*% cover.*	*% area*	*area (ha.)*
O1	none	E.g/.pinus sp.	Variable	Variable	25,87	34,08
L1	none	Laurel+Exotic	5\10	50\75	13,35	17,59
L2	Erica sp.	La\Mf\Ca	2\5	75\95	14,25	18,78
L3	La +Pi	Of\Erica sp.	10\20	75\95	14,15	18,64
L4	La	Of\Mf\Laurel	10\20	50\75	5,63	7,41
L5	none	La\Mf\Ca\Of	5\10	50\75	13,18	17,36
L6	O.f	La\Erica sp.	>20	25\50	6,04	7,96
L7	O.f	La\Pi\Mf	>20	75\95	7,53	9,93

Table 1 - MAIN CHARACTERISTICS OF THE 8 BIOTYPES DEFINED AND MAPPED IN THE STUDY AREA. WHERE: E.g.= *Eucaliptous globulosus*; L.a.= *Laurus azorica*; M.f.= *Myrica faya*; C.a.=*Clethra arborea*; O.f.=*Ocotea foetens*; P.i.= *Piconia excelsea*.

A survey of agricultural fields was done directly from observations points and indirectly through inquiries to the farmers. During the first field work period there was 7 observation points distributed in the study area and this was increased to 11 in the second period.

Methods of data analysis

Data were combined bi-monthly to provide larger sample-sizes for analysis. A measure of habitat preference was calculated according to the following formula (DUNCAN 1983):

$$P=\log((Ui/Ai)+1)$$

Where: Ui= % of individuals observed in biotipe i;
Ai=% of the area occupied by biotipe i;

If Ai=Ui, P will be 0.3 and DUNCAN (Op.cit.) suggest that all the values higher than 0.3 will indicate selection of the biotipe and the values lower than 0.3 indicates rejection. However, like FARINHA (1991), we will not follow this suggestion because the birds cannot really reject biotypes where they are present (BIGNAL et al. 1988), therefore the values found for P will be taken as a strictly relative measure.

The measure of the overall degree of preference, or degree of selectivity, for each month, for all biotypes combined is calculated according to the following formula (DUNCAN 1983):

$$S=\sum_{i=1}^{n} |Ui - Ai|$$

Where S, the degree of selectivity, varies from 0, when all biotypes were used in proportion to the area they cover, to 200, when all the observations occur in one small facet.

The abundance index of berries is calculated from

$$A.I.B=[(a.b)+(1.5 * B1)+(3*B2)+(6*B3)] / \text{Total Nr. of trees sampled}$$

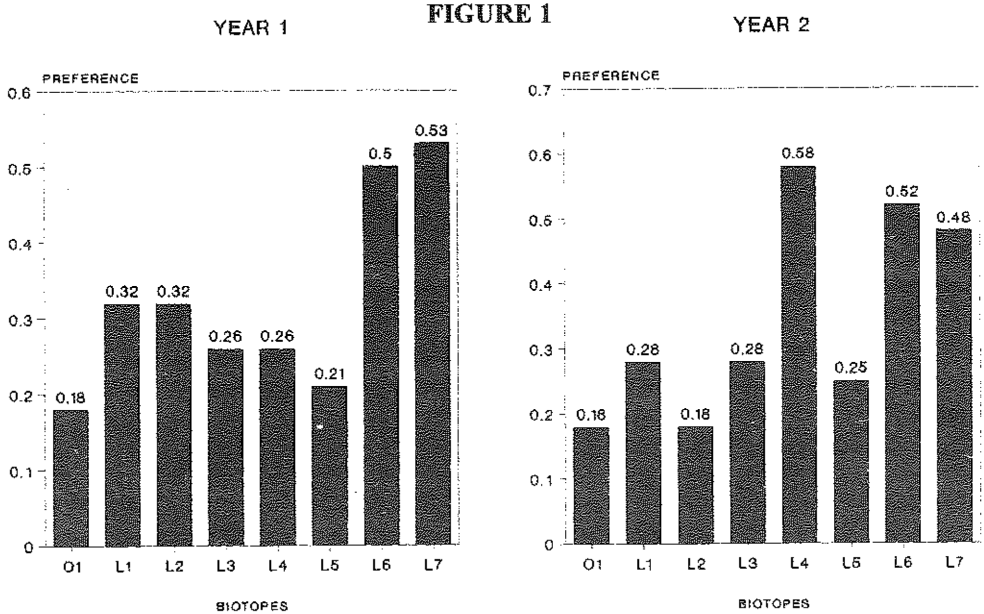
Where: ab=absence of berries; B1=presence of berries in little quantity (1/2 of the "normal" qauntity); B2=presence of berries in "normal" quantities; B3=presence of berries in high quantities (twice the "normal" quantity).

RESULTS

Habitat Preferences

The comparison between the proportional area covered by each biotipe and the number of pigeons recorded, showed that these different areas of habitat are not occupied randomly in either of the two study periods (X2=25.764, df=7, P<0.05; and X2=32.64, df=7, P<0.05). The preference indices for each biotipe in each year (all months combined) are shown in Figure 1.

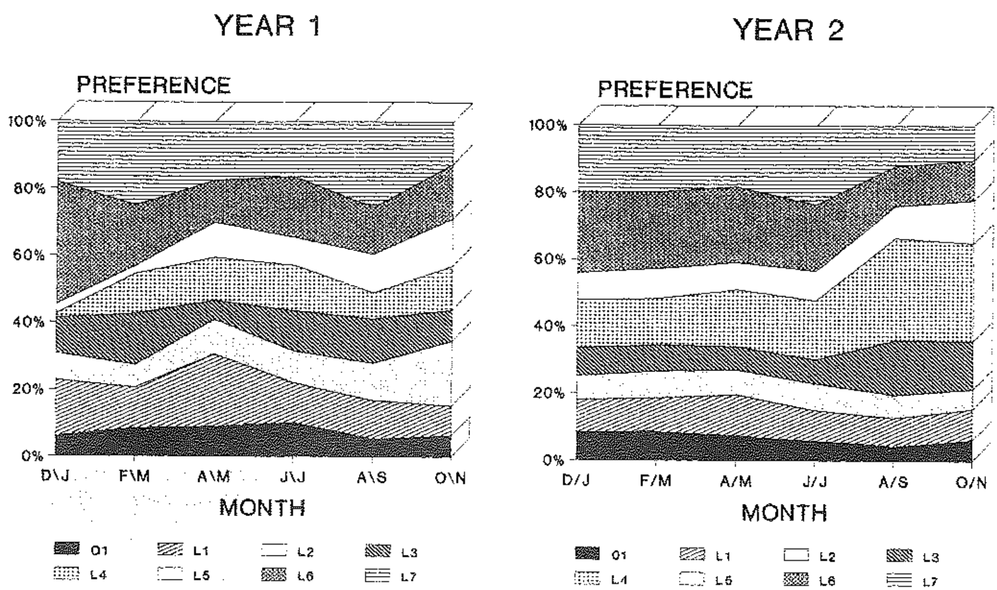
FIGURE 1



It can be seen that the highest preferences were not the same for Y1 and Y2. In Y1 the preferred biotypes were L6 and L7, dominated by *Ocotea foetens*. During Y2 these biotypes still have high indices but the highest preference is associated with L4 wich is dominated by *Laurus azorica*.

Biotipe O1 (exotic vegetation), L3 (dominated in equal proportions by *Laurus azorica* and *Persea indica*), and L5 (with different laurel species in equal proportions), show very similar values for both years. Biotypes L1 (very damaged laurel forest) and L2 (dominated by Erica spp.), have a much lower preference in Y2. In Figure 2 the variation in preference variation through the year is shown.

FIGURE 2



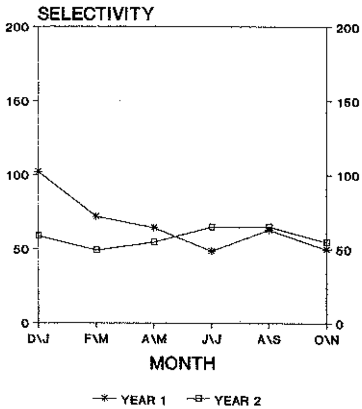
It's clear that the preference for each biotipe changes from month to month. In Y1 it can be seen that L6 and L7 have the higher preference indices; in Dec./Jan they make up over 50% of the index when taken together and although this declines in Oct./Nov., these two biotypes still remain important.

In Y2 L6 and L7 are again associated with high preferences but their importance declines after Jun/Jul. At this time (when the laurel berries are actually ripening) it is L4, dominated by L. azorica wich is preferred. Another very important aspect of the results is the preference that is shown for 01. This biotipe shows a relatively high level of occupation throughout the year for both periods of fieldwork. This preference is maintained for every month with a little decrease for Aug./Set. for both Y1 and Y2,

Selectivity in habitat choice for both years is represented in Figure 3 Considering that the maximum value for the index is 200, most of the values are very low, with a maximum of 100 in Dec./Jan. It is important to note that for most bi-montthly periods the values are similar in Y1 and Y2; between Jun./Jul. and Oct./Nov. there are exactly the same trends.

FIGURE 3

SELECTIVITY



Relationship between abundance of berries and the presence of pigeons

Tables 2a and 2b show the values for the index of berry abundance for *O. foetens*, the numbers of pigeons in areas occupied by *O.foetens* and the Spearman rank correlation coefficients calculated between these values.

TABLE 2a & 2b

Correlations between berries abundance and pigeons numbers.

TABLE 2a Y1

Tr.		JUN.	JUL.	AGO.	SET.	OUT.	NOV.	DEZ.	JAN.	FEV.	MAR.	ABR.	MAI.	Rs(P)
1	IA	1,4	1,3	1,5	1,6	1,6	1,9	1,6	1,9	1,9	2,2	1,6	1,5	.7224
	n	2	1	4	8	2	4	2	7	11	7	2	1	(.0166)
2	IA	1,1	1,02	1,02	1,02	1,08	1,04	1,9	1,7	1,3	1,2	1,4	1,1	.5226
	n	0	2	1	0	2	1	1	14	5	3	7	1	(.0831)
3	IA	1,9	1,7	1,6	1,9	1,5	1,1	1,4	1,7	1,5	1,6	1,8	1,8	.6929
	n	15	9	3	15	10	3	6	10	10	6	7	11	(.0216)
4	IA	1,4	1,5	1,6	1,4	1,5	1,5	1,4	1,4	1,2	1,6	1,8	1,4	.0320
	n	5	2	6	5	11	7	1	1	2	1	1	2	(.9156)
5	IA	1,6	1,5	1,6	1,6	1,7	1,5	1,2	1,4	1,4	1,3	1,5	1,3	.6248
	n	8	7	9	5	9	7	1	9	8	1	7	1	.0382

TABLE 2b Y2

Tr.		DEZ	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	Rs(P)
1	IA	1,4	1,2	1,1	1,02	1,3	1,6	1,5	1,2	1,2	1,3	1,3	1,7	.0723
	n	11	4	4	6	5	7	11	9	4	4	3	2	(.8104)
2	IA	1,8	1,3	1,2	1,3	1,5	1,8	2,1	1,2	1,4	1,8	1,1	1,3	.0036
	n	3	1	1	6	3	2	2	4	10	6	4	2	(.9905)
3	IA	1,3	1,2	1,02	1,1	1,7	2,2	1,8	1,7	1,3	1,3	1,6	1,5	.8196
	n	12	11	6	6	15	14	15	15	11	14	11	14	(.0066)
4	IA	1,5	1,4	1,2	1,3	1,6	1,4	1,3	1,9	1,4	1,3	1,4	1,2	.6041
	n	11	11	8	9	13	11	9	9	5	5	7	3	(.0451)
5	IA	1,4	1,4	1,4	1,3	1,5	1,5	1,8	1,8	1,7	1,8	1,7	1,5	.7713
	n	12	13	15	10	15	16	18	16	14	17	14	13	(.0105)

TABLE 2a AND 2b - VALUES OF THE INDEX OF BERRY ABUNDANCE FOR *O. FOETENS*, I.A., PIGEONS NUMBERS IN AREAS OCCUPIED BY *O. FOETENS*, N, AND THE SPEARMAN RANK CORRELATION COEFFICIENTS, RS, CALCULATED BETWEEN THESE VALUES FOR BOTH PERIODS OF WORK, Y1 AND Y2 AND EACH SGNIFICANCE LEVEL, P.

The abundance of *O. foetens* berries in the study area was not very high in either year and the values of the abundance index are probably lower than for a "normal" year. In Y1 and Y2 there were 3 significant correlations ($P<0.05$) between berry abundance and pigeons, although the areas concerned are different in each year.

Table 3a and 3b shows similar data to those in Table 2a and 2b for berries of *L. azorica*. There is a great difference in the abundance of berries in Y1 and Y2-low numbers in all areas visited in Y1 but a much higher abundance in Y2. For Y1 there was one significant correlation between the presence of pigeons and the abundance of berries, and this was the only area where there was a significant abundance of berries. For Y2 we have four significant correlations, the only non-significant one was in area 2 where low densities of pigeons were recorded throughout the year.

TABLE 3a & 3b

Correlations between berries abundance and pigeons numbers.

TABLE 3a Y1

Tr.		AGO.	SET.	OUT.	NOV.	Rs(P)
1	IA	1,06	1,05	1,09	1,08	.8000
	n	7	9	19	16	(.1659)
2	IA	1	1,09	1,07	1,08	-.2582
	n	2	2	3	2	(.6547)
3	IA	1,05	1,2	1,3	1,1	.9487
	n	4	18	18	13	(.1003)
4	IA	1,09	1,1	1,9	1,7	1
	n	8	8	33	25	(.0000)
5	IA	1,2	1,12	1,15	1,1	.4000
	n	30	8	11	13	(.4884)

TABLE 3b Y2

Tr.		AGO.	SET.	OUT.	NOV.	Rs(P)
1	IA	2,06	3,05	2,09	1,4	1
	n	2	6	5	1	(.0000)
2	IA	2,1	3,1	3,4	2,5	-.3162
	n	2	1	1	0	(.5839)
3	IA	2,5	2,1	2,7	2,5	1
	n	10	7	11	9	(.0000)
4	IA	1,09	1,7	2,9	1,7	1
	n	10	13	14	10	(.0000)
5	IA	1,2	1,5	3,15	2,1	1
	n	9	7	15	14	(.0000)

TABLE 3a AND 3b.-VALUES OF THE INDEX OF BERRY ABUNDANCE FOR *L. AZORICA*, I.A., PIGEONS NUMBERS IN AREAS OCCUPIED BY *L. AZORICA*, n, AND THE SPEARMAN RANK CORRELATION COEFFICIENTS, RS, CALCULATED BETWEEN THESE VALUES FOR BOTH PERIODS OF WORK, Y1 and Y2, AND EACH SIGNIFICANCE LEVEL, P.

It can be seen that, overall, there is a similar level of correlation between Pigeons and *O. foetens* in Y1 and Y2 but for *L. azorica* there is a closer correlation for Y2 than for Y1. This may partly be due to the low abundance of *L. azorica* berries in Y1 and to the equal abundance of *O. foetens* in Y1 and Y2

Observations from agricultural areas

In Table 4a and 4b the numbers of pigeons on cultivated fields is shown for both fieldwork periods. Although the numbers seen are very low, the results of inquiries to farmers and visits to different fields presents a different scenario as very high damage accured in some areas in both years. This damages was in the same areas, normally in fields near dense vegetations and on steep slopes in deep valleys. The difference between the apparent pigeon presence and the level of damage will be discussed later.

TABLE 4a & 4b

OBSERVATIONS ON AGRICULTURAL AREAS

Table 4a Y1

Y1	LOCAL						
	A1	A2	A3	A4	A5	A6	A7
JUN	0	0	0	0	1	0	1
JUL	0	0	0	1	0	0	0
AGO	0	0	0	0	0	0	0
SET	0	0	0	0	0	0	1
OUT	0	0	6	1	0	0	0
NOV	0	0	0	0	0	0	0
DEZ	0	0	0	0	0	0	1
FEV	0	0	0	0	0	0	0
ABR	0	0	0	0	0	1	1

Table 4b Y2

Y2	LOCAL										
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
JUN	0	0	0	0	1	0	1	0	0	0	0
JUL	0	0	0	0	2	0	0	2	0	2	0
AGO	0	0	0	0	0	0	0	0	0	1	0
SET	0	0	2	0	0	0	1	0	0	0	0
OUT	0	0	0	0	0	0	0	0	0	2	0
NOV	1	0	0	2	0	0	0	0	0	1	0
DEZ	0	0	0	0	0	0	1	0	0	3	0
FEV	0	0	0	0	1	0	0	0	0	2	1
ABR	0	0	0	0	0	0	1	1	0	2	0

TABLE 4a AND 4b.-NUMBER OF PIGEONS RECORDED IN THE AGRICULTURAL AREAS. IT'S ONLY SHOWN THE MONTHS THAT WERE DONE OBSERVATIONS IN Y1 AND IN Y2.

Population numbers and trends

Assuming that we have sampled representative areas of Laurel forest, it is possible to estimate the population size of *C. trocaz* from the numbers recorded in the main belt along the transects. This was done separately for each year's data using the average and confidence intervals of the numbers seen in each bi-monthly period. By multiplying the average density from the area sampled by the coverage of suitable habitat (12000 ha), the figures in Table 5 were produced.

TABLE 5

POPULATION ESTIMATE

Year	From average	From confidence intervals
1	4178	3415 4938
2	4147	3561 4727

Table 5 - POPULATION ESTIMATE FOR BOTH PERIODS OF WORK.

The population estimates for both years are very similar with the most recent estimate being 4147 with confidence limits of 3581 to 4727. For reasons discussed later this estimate should be treated with some caution.

DISCUSSION

One of the main objectives of this study was to analyse habitat preferences and the factors that are related to these preferences. We have seen that the pigeons show a high preference for the areas dominated by *Ocotea foetens*. The only exception to this is the periods when L.azorica berries are abundant and the pigeons are then found in areas dominated by this tree species. The differences between the results from Y1 and Y2 suggest that the abundance of berries plays an important role in habitat choice. This is supported by the correlation's found between the abundance of berries and presence of pigeons. In other words we can say that the berries of *O. foetens* and *L. azorica* are very important food sources that have a significant role in habitat choice.

An interesting and surprising aspect of the results was the presence of large numbers of pigeons in areas of exotic vegetation even in months when the *L. azorica* berries were ripe. Remembering that there was an almost total lack of berries in Y1 and a high abundance in Y2 leads to the suggestion that there may be no direct relationship between the availability of berries and the use of these marginal areas.

Columba trocaz shows very low selectivity in habitat choice during both periods of work, with no significant differences in habitat between Y1 and Y2. This again suggests that the abundance of berries is not the only factor that plays an important role in habitat choice and habitat selectivity.

As far as the predation of agricultural crops is concerned it's important to note that the low numbers that were recorded from the observation points do not give a real idea of the size of this problem. Information from farmers and visits to potentially affected areas showed that the damages are very localised. It is likely that these areas favoured by the pigeons (near dense vegetation and/or on the sides of deep valleys) were not adequately sampled from the observation points. Although the numbers of pigeons in agricultural areas may have been underestimated, the counts, inquiries and the visits to these areas indicate that equal numbers were feeding on agricultural crops in Y1 and Y2. This suggests that the feeding on agriculture fields is not related, at least directly and exclusively, with the lack of berries in the forest. It also shows that the pigeons are not fully dependent upon berries.

From what has been said we can draw the general conclusion that the food sources, in this case the berries of *L. azorica* and *O. foetens,* play an important role in habitat choice. But, on the other hand, the abundance of berries is not directly related to the feeding in cultivated fields or the use of marginal areas of its "natural" habitat. This goes against what as been said by several authors, including us, (BANNERMAN & BANNERMAN 1965; CRAMP *et al.* 1985; ZINO & ZINO 1986; JONES 1990; OLIVEIRA 1992) and raises the question: what are then the factors that are behind this predation? We can speculate that the predation on fields is due to factors inherent to the species and to the environment where it lives and can be explained if we consider three major points: 1) the highly elastic food choices 2) the low selectivity in habitat choice and 3) the proximity between laurel forest and cultivated fields.

What is not clear is the reason why the numbers of pigeons that feed on the cultivated fields changes from year to year, sometimes very significantly (allthough not in this study). This may be due to overall population oscillations or to migration within the laurel forest. The existence of these was shown in a previous study (OLIVEIRA 1992).

Prior to this study the most recent estimate of population numbers was 2700+ individuals (JONES 1989 *at al*,, based on fieldwork in 1986). Our latest estimate of over 4000 birds indicates that the *C. trocaz* population has increased significantly. Also, the comparisons between the relative densities obtained for these two years of work (not presented here) with the ones obtained during the 1986 survey, give us further, strong evidence that the population is increasing.

The population estimate should be treated with same caution for a number of reasons: 1) it is possible that some pigeons were recorded more than once, 2) it is impossible to be sure that we recorded all the pigeons inside the main belt, 3) the estimated area of the laurel forest may not be accurate and, 4) we do not know how representative our sampling is in relation to the area that each biotype makes up of the laurel forest habitat.

We suggest that the estimates can only be taken as a rough guide, but considering the nature and habitat of the long-toed pigeon, it is difficult to envisage how more accurate estimates can be obtained. The main importance and uses of the estimates as they are is to allow further comparisons, using similar methods in the future.

A result of the probable increase in the pigeon population may be more serious management problems in the future. Further research on diet, behaviour in fields, methods of scaring birds away from fields as well as continued population monitoring are obviously required to help tackle problem.

REFERENCES

BANNERMAN, D. A. & BANNERMAN, W. M.:
1965. *Birds of Atlantic Islands*. Vol 2. Olivier & Boyd, Edinburgh London.

BIGNAL, E. M., D. J. CURTIS & J. L. MATHEWS:
1988. *Birds habitat and nature conservation*. Part 1: Land use and birds on Islay. NCC Chief Scientist Directorate, report n° 809, Part1.

COLLAR, N.J. & STUART, S. N. :
1985. *Threatened birds of Africa and related Islands.* The ICBP/IUCN Red data Book Part 1 3rd. Edition.

CRAMP, S. (ED):
1985. *The birds of the western Palearctic* Vol 4. Oxford Univ. Press, Oxford.

DUNCAN:
1983. Determinants of the use of habitat by horses in the mediterranean Wetland. *Journal of Animal Ecology* **52**: 93-10.

FARINHA, J. C.:
1991. Garça-boeira, Bulbucus ibis, na região de Sagres-S.Vicente: biótopos de alimentação e grau de associação com o gado. *Airo* **2**: 2-9.

JONES, M. J., HAMER, K., HILL. J., HOUNSOME, M. V., JEPSON, P., LACE, L. A., READ, H. & TURTLE, C.:
1989. A survey of the distribution and habitat preferences of the long toed pigeon, *Columba trocaz* in Madeira. ICBP Study report N° 32.

JONES, M. J.:
1990. A survey of the distribution and habitat preferences of the long toed pigeon, *Columba trocaz* in Madeira. *Boletim do Museu Municipal do Funchal*, **42** (219) 71-86.

OLIVEIRA P.:
1992. Alguns aspectos da ecologia e do comportamento do pombo trocaz, *Columba trocaz.* Relatório para a Licenciatura em Recursos Faunísticos e Ambiente na Faculdade de Ciências da Universidade de Lisboa. Unpublished.

ZINO, F. & ZINO, P. A. :
1986. An account of the habitat, feeding habitats, density, breeding and need of protection of the long toed Wood pigeon, *Columba trocaz Bocagiana* **88**: 1-16.