

Population trends and status of the Madeira Laurel Pigeon *Columba trocaz*

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Summary

A survey was undertaken in 1995 to assess the conservation status of the Madeira Laurel Pigeon *Columba trocaz*, a threatened species endemic to the Island of Madeira. The first large scale survey was carried out 1986, following the cessation of legal hunting of the species, to provide a baseline for future monitoring of population changes. The current study therefore aims to (1) compare population size with those of 1986 and (2) employ distance sampling methods (not used in 1986) to obtain estimates of population density and size. Eighteen transects (13 repeated from the 1986 survey and five new) were conducted in the four main areas of laurel forest. Pigeon numbers had increased on nearly all transects but some of the highest increases, proportionately and often numerically, were in areas with lower numbers in 1986. We estimate the current population to be 10,400 individuals, a considerable increase since 1986, probably due to a ban on hunting. As laurel forest habitat is now very well protected the Madeira Laurel Pigeon is relatively safe from extinction.

Introduction

Birds limited to islands are frequently susceptible to extinction and feature prominently in the list of the world's most threatened species (Grant 1998). This is the case of the Madeira Laurel Pigeon *Columba trocaz* (Heineken 1829), endemic to the island of Madeira. It is listed as Rare by Collar and Stuart (1985) and Groombridge (1993). Collar *et al.* (1994) classified it as "conservation dependent". In 1986 the species was included in Appendix 1 of the EU Wild Bird Directive, and this was the first step towards achieving a real and effective management policy for this species.

The Madeira Laurel Pigeon is restricted to areas of native laurel forest (the main trees of which belong to the Lauracea family) on the mountainous northern slopes and to a few isolated pockets in the south of Madeira (Bannerman and Bannerman 1965, Zino and Zino 1986). It was probably exceptionally plentiful before the first settlement of the Island but the loss of laurel forest and overhunting have led to a severe decline (Oliveira and Heredia 1996).

Although now well protected, the Madeiran laurel forest only covers around 15% of the island (16,000 ha) (Costa Neves *et al.* 1996). All of the forest area is now included under the jurisdiction of the Parque Natural da Madeira as "Strict Nature Reserves" or "Partial Nature Reserves". As a result the problems of habitat loss, degradation and/or fragmentation have been overcome.

The birds feed on a wide variety of food sources, from the berries of large trees to the leaves and flowers of small plants (Zino and Zino 1986, Oliveira and Jones 1995). During the winter and in the beginning of spring, they also feed on agricultural land, using those fields that are in close contact with the forest and causing significant damage to crops. Agriculture in the areas most affected is a traditional and mainly subsistence activity based on small parcels of land.

Until 1989, the birds were hunted both for sport and because of the damage they cause to crops. Although the ban on hunting was made complete in that year, illegal hunting has continued until now, probably representing, together with poisoning, the main threat to the laurel pigeon today.

The first large-scale attempt to obtain a better understanding of this species's status was made in 1986 when the population was estimated at 2,700+ birds (Jones *et al.* 1989). The timing of this survey was very appropriate as it was followed by the reinforcement of the protection of the pigeons and this allowed an evaluation of the success of these conservation measures. In 1995 we carried out a second survey following the same methods as in 1986 with the aim of highlighting any population changes. We also used distance sampling methods to estimate total population size.

Methods

The fieldwork took place during the last two weeks of August 1995 using a team of 10 people. Data were collected by walking line transects through areas of laurel forest and marginal forest habitats. We divided the laurel forest into four areas, each one representing a semi-isolated group of major basins. Figure 1 shows the positions of four forest areas and the approximate location of the routes taken. A short description of these routes is given in the Appendix. Censusing was carried out from sea level up to an altitude of 1200 m. and covered primary and secondary forest and areas subject to different levels of protection. At the beginning and/or end of some routes, agricultural land and/or exotic forest were also sampled. It was impossible to site the transects randomly or even to stratify them because of the topography; most censusing was from paths set into the mountain sides.

To monitor changes in population numbers, we chose 13 of the 25 transects used on the 1986 survey, six of which were proposed as a minimum sample to monitor changes (Jones 1990). In the majority of cases each transect was walked three times by three different teams of two people (to counter any systematic observer bias). Although the observers walked continuously whilst censusing, the recording period was split into five-minute blocks (as in 1986). All contacts were included regardless of how far away the birds were.

In order to obtain as large sample sizes as possible (for estimating population density – see later), censusing was carried out during the early daylight hours, coinciding with the first of the birds' daily activity peaks (Jones *et al.* 1989). In 1986 data were collected at different times of day so, to facilitate a direct comparison, the 1995 results were corrected with reference to the daily activity information provided by Jones *et al.* (1989).

To estimate "absolute" densities of birds, distances to all contacts were estim-

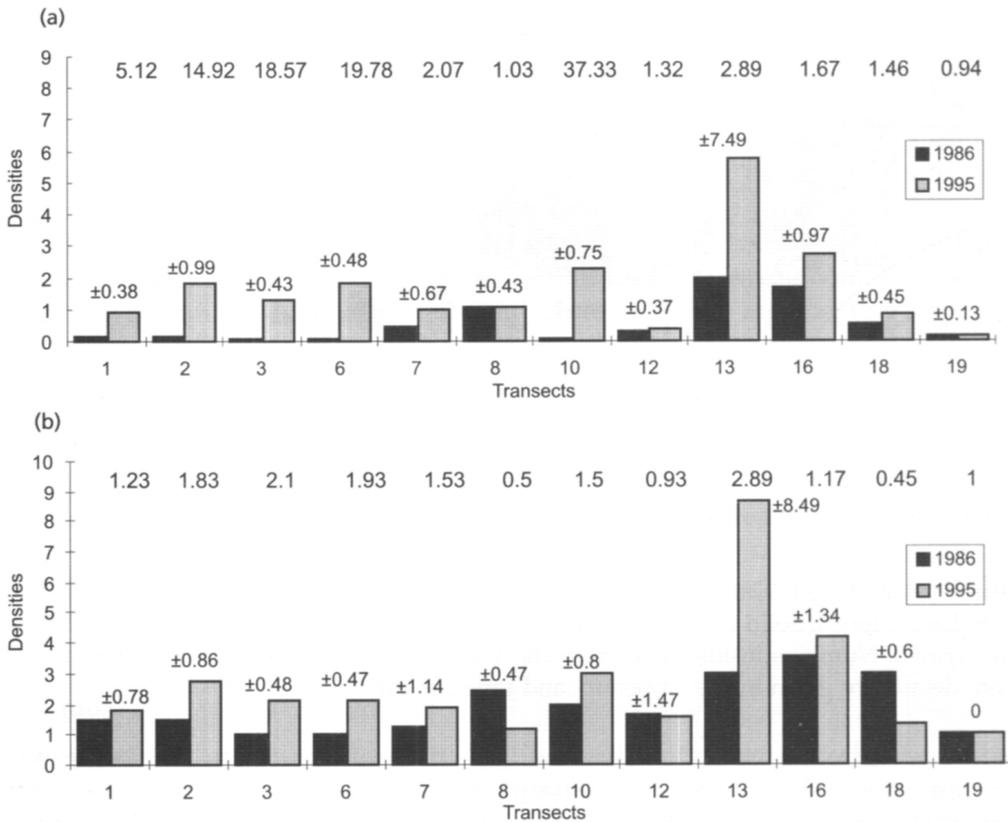


Figure 2a,b. Relative densities found for the 1986 and 1995 surveys. (a) The mean number of pigeons per five-minute walking period and (b) the mean number of pigeons per five-minute period in the better habitat (periods where at least one bird was recorded). The numbers above the bars represent the 95% confidence intervals and the numbers on the top of each graph represent the increase rate found for each transect. (see text for explanation and Figure 1 and Appendix I for location and description of transects).

Results

Population changes 1986 to 1995

Figure 2 shows the relative and (in the case of 1995) corrected densities (average number of pigeons per five-minute period), recorded on transects in 1986 and in 1995. Figure 2a shows the average number of birds per five-minute period on all transects. These figures do not necessarily reflect the relative densities of pigeons in different areas as on some transects much more time was spent walking through suitable habitat. Following Jones *et al.* (1989), a more direct comparison of the density of pigeons within suitable areas is shown in Figure 2b where, for each transect and both years, only the five-minute counts that recorded at least one pigeon are included.

The mean number of pigeons found in 1995 was higher for all transects, except for transect 8, where the means are equal. This transect was located in Ribeiro Bonito, one of the best-preserved areas of laurel forest. Figure 2b shows a generally similar trend, but now there are four cases where the 1986 counts are higher

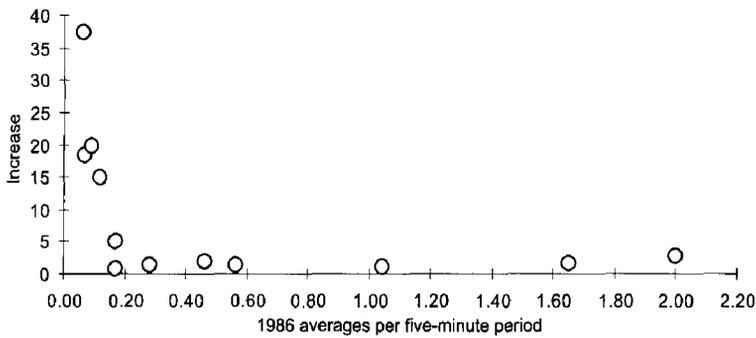


Figure 3. The relationship between the average number of pigeons per five-minute period found in 1986 and the rate of increase between 1986 and 1995.

than the 1995 ones. These transects are numbers 8, 12, 18 and 19 (Ribeiro Bonito, Chão da Ribeira, Ribeira da Janela (levada) and Ribeira da Ponta do Sol, respectively). Transect number 19 was located on a poor area of laurel forest on the south side of the island but the other three were located in areas of very well-preserved forest.

Although there does seem to be a general increase in numbers, it is also obvious that there are differences between transects. The rates of increase (mean number per five-minute count in 1995 divided by the 1986 figure) are shown in Figures 2a and 2b and the data from "all" counts are plotted in Figure 3 against the mean number of pigeons found in 1986. The transects with the lowest densities in 1986 have the highest rates of increase. This trend for the more marginal habitats to exhibit higher increases is confirmed when the "all" and "good" data sets are compared: the former have significantly higher increase rates than the latter (Mann-Whitney $U_{12,12} = 36.5$; $P < 0.05$).

Accuracy of the distance estimates

A runs test showed that none of the observers had a significant tendency to make any systematic error, i.e. none of the observers systematically under- or overestimated the distances ($Z = 0.74$, $P = 0.45$; $Z = 1.39$, $P = 0.16$; $Z = 1.60$, $P = 0.11$; $Z = 1.21$, $P = 0.22$; $Z = 0.28$, $P = 0.78$). The mean absolute deviation of the distance estimates was 0.72 at between 3 and 10 m, 2.2 m at between 20 m and 30 m, 8.5 m at between 40 m and 50 m, 11.22 m at between 60 m and 70 m. The majority of contacts with pigeons were at distances of less than 40 m so we suggest that the errors were indeed relatively small and random.

Population density and size

Table 1 shows the density per square kilometre and the abundance of birds in each of the four areas into which our survey was divided. The highest density was found in Area 3 (S. Vicente Este e Ribeira de S. Jorge) where we have almost 100 birds/km², the lowest is Area 4 (Fajã da Nogueira e Funduras) with 31 birds/km². Adding the number of birds per area we calculate a total population of 10,400 individuals, which represents a more than threefold increase over the 1986 estimate.

Table 1. Densities per Km² and the abundance on each of the four areas into which our survey was divided

Area (cover of forest)	Sample size transects (n)	E.S.W. ^a (95% conf. intervals)	Model selected ^b	Density per km ² (95% CI)	Abundance (95% CI)
1. Fajã da Nogueira e Funduras (16.4 km ²)	7 (93)	63.8 (49.6; 81.9)	Hazard/ polynomial	31 (1.9; 5.1)	508 (303; 814)
2. S.Vicente Este e Rib. de S. Jorge (66.6 km ²)	13 (92)	74.0 (57.5; 95.7)	Half-normal/ cosine	99 (5.5; 17.9)	6599 (3661; 1917)
3. Rib. do Seixal e S.Vicente Oeste (31.1 km ²)	9 (112)	27.6 (17.0; 45.0)	Hazard/cosine	37 (1.9; 6.9)	1149 (615; 2144)
4. Rib. da Janela (35.8 km ²)	11 (109)	56.2 (42.5; 74.4)	Hazard/ polynomial	59 (3.8; 9.2)	2116 (1302; 3096)
Total population:					10359 (5,875; 7,977)

^aEffective strip width (metres).

^bThe models for the detection function are selected based on their relative performance in relation to each data sub-set (for details refer to Buckland *et al.* 1993)

Discussion

Our first major conclusion is that the Laurel Pigeon population has increased between 1986 and 1995. The increase has occurred all over the island but is proportionately and often numerically greater in the areas which supported lower densities in 1986 (apart from transect 13). The simplest explanation is that as population size increases a density-dependent mechanism leads to greater use of more marginal areas. Habitats which are intrinsically less suitable may be quite tolerable if population densities there are lower than in prime habitats (Cody 1985). Since the laurel forest occurs in discrete patches between which the different tree species do not have a homogeneous distribution (Costa Neves *et al.* 1996), it is likely that they will vary in attractiveness to pigeons.

Although at the time of the survey there were differences in densities between transects and also between areas, this may not be a permanent feature. Fruit-eating birds generally have to deal with strong spatiotemporal patterning that will affect the way they use their habitat (Herrera 1985) and subtle changes in resources such as berry density may promote changes in habitat use (Cody 1985). Although the Laurel Pigeon is not an exclusive frugivore, we know that at the time of the year at which our surveys were conducted, the berries of the bay tree *Laurus azorica* play an important role on this bird's habitat selection (Oliveira and Jones 1995). The existence of a wide year-to-year variability in fruit production of some Lauraceae has been shown for other forests (Wheelwright 1986) and there is strong evidence that we have the same situation in Madeiran laurel forest (Oliveira and Jones 1995). Thus the pattern of habitat occupancy we have recorded is likely to vary both within and between years.

Seasonal and annual changes in habitat use may also affect comparisons of the

four major forest blocks. However, the considerably higher densities found in areas 2 and 4 and the greater areas of laurel forest within these areas suggest that they will always be of critical importance for the preservation of the pigeon.

Our total population estimate of 10,400 individuals suggests a considerable increase over the 2,700+ birds estimated in 1986. The earlier estimate may not be particularly reliable but the comparison of the transects covered in both years confirms that there has been a significant increase. It is possible that natural fluctuations may be responsible for this change but we suggest that the ban on hunting has made an important contribution. In the last legal shooting period – five consecutive Sundays in January and February 1985 – in just one site (Chão da Ribeira), one party of four guns shot 64 birds in four days and over 140 were shot in this valley during the five Sundays (Zino and Zino 1986). If this level of hunting occurred in just a few other areas (and according to Zino and Zino (1986) it probably did) then more than 20% of the population could have been lost. The ban on hunting may therefore have removed one of the major constraints on population growth.

Our general conclusion is that with a population of over 10,000 individuals (or even the lower confidence limit of 5,875) and habitat loss and hunting under control, the Madeira Laurel Pigeon is relatively secure. However, the species's "conservation dependent" status is still appropriate as other threats remain, namely illegal shooting and poisoning and particularly, predation of eggs and nestlings by rats *Rattus rattus* (Oliveira and Heredia 1996). Recent studies in the Canary Islands show that this type of predation is responsible for the low breeding success of both the Bolle's Laurel Pigeon *Columba bollii* and the White tailed Laurel Pigeon *Columba junoniae* (Hernandez *et al.* 1999).

In Madeira, rats are found at high densities in laurel forest (foraging in the canopy of even the tallest trees) and the steep-sided ravines with sparser vegetation (A. Easby, pers. comm.). Considering that the Madeira Laurel Pigeon builds its nest in forest trees and in cavities in cliffs (Bannerman and Bannerman 1965, Zino 1969, Cramp 1985), it would be surprising if rat predation does not have some effect on breeding output. Further research on this is obviously needed.

As long as the appropriate procedures are adopted (allowing for the variation in visibility) we suggest that distance sampling or particularly the "variable distance line transect method" we used is appropriate for use in this type of terrain. Although the transect routes should not ideally follow existing paths or habitat features, in Madeira we had little choice. However, the paths that we primarily used have very little impact on the vegetation. Even though the estimates produced have quite large confidence intervals they are certainly more reliable than the previous tentative guesses (Zino and Zino 1986, Jones *et al.* 1989, Oliveira and Jones 1995). The total population estimate is essential for confirming the conservation status of the species and, in combination with the comparison of encounter rates on transects between years, assessing population changes. With this in mind we recommend that the monitoring scheme begun in 1986 be continued. The minimum sample could be the one proposed by Jones *et al.* (1989) but we strongly believe that, due to the conditions under which the work is carried out, the repeat of all the transects presented on this paper would provide more reliable information. Distance sampling techniques and procedures described here should be used again on future surveys.

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Appendix I. Transect routes.

Location and details of the transects that are common to both surveys can be found in Jones (1990). For practical reasons 1986 survey transect numbers were changed as it follows: 6 to 16; 7 to 15; 9 to 2; 10 to 3; 11 to 6; 15 to 7; 17 to 10; 19 to 8; 20 to 13; 23 to 19; 25 to 18. Only the location and details of the transects that were carried out in 1995 are shown here.

Transect number/description	Altitude (m) (start/end)	Length (km)	Walking time (in 5 minute units)
4 Ribeira Seca to Ribeira das Lages along the "Levada" da Serra do Faial	1050 / 1050	3.4	14
5. Casa da Água above Fajã do Penedo to Ribeira João Fernandes along "Levada" dos Tornos	510 / 510	3.6	15
11. Casa da Agua das Ginjas to Ribeira do Seixal along the "Levada" do Norte	1010 / 1010	1.8	
14. Paul da Serra to Montado dos Pessegueiros down the walking track	1200 / 25	5.7	23
15. From Rabaçal do Galhano along Ribeira da Janela river bed.	850 / 480	4.1	24

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