Research Article

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Reducing the availability of food to control feral pigeons: changes in population size and composition

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Abstract

BACKGROUND: As feeding by humans is one of the main food resources to pigeons (*Columba livia*), there is general agreement that public education that aims to reduce the food base may be the most feasible way to reduce pigeon abundance. However, except for the classic example of Basel, the method has rarely been tested or implemented. We provide results from a 1 year study in the city of Barcelona where we tested the effect of public education on pigeon population abundance and composition.

RESULTS: The quantity of food provided by people to pigeons was significantly reduced during the study. Feral pigeon density was reduced by 40% in the two experimental districts, but no variation was detected in the control district. Detailed analyses in one of the districts showed that the reduction was mainly related to the reduction in food availability but not to culling. Pigeons captured at the end of the experiment were larger than at the start of the study, but body condition was reduced.

CONCLUSION: Results show the effectiveness of public information to manage feral pigeon populations in a large city, and that control operations can exert important selection pressure on the population, leading to changes in population composition.

Keywords: feral pigeon; population size; public information; food reduction; culling

1 INTRODUCTION

The size of the populations of feral pigeons *Columba livia* increased dramatically in many cities during the second half of the 20th century both in Europe and in North America.[1] This increase brought with it many problems related to damage to urban architecture and the transmission of infectious diseases,[1−4] giving rise to increasing concern on the part of city authorities and managers. As damage is related to the number of pigeons,[5] we have to reduce their numbers if we want to reduce pigeon damage in cities.

Many methods have been suggested to reduce urban feral pigeon populations.[4,6−10] Nevertheless, population models suggest that restricting the availability of food and nesting resources in the city should be the most effective and long-lasting method.[4,9] As feeding by humans is one of the main food resources to pigeons, public education that aims to reduce the food base may be the most feasible way to reduce pigeon abundance.[1,5] The method was successfully implemented in Basel[5] in the 1980s and more recently in Venice.[4] However, implementation in a large city with high pigeon density[11] and where dispersal movements between close areas can be important may entail more difficulties than in other locations. For instance, Basel had a density of 840 pigeons km^{-2} before public information programmes were undertaken,[5] while Barcelona has a density of 4242 pigeons km^{-2}.[12] Movements within the city between close areas are also important in Barcelona,[13] and they could limit the success of a public information programme about pigeon control. Additionally, and for a proper validation of the method, control populations should also be used to ascertain whether the reduction in feral population is the result of management operations or natural fluctuations in the population.

A topic of great interest from an evolutionary perspective is that reducing food availability and distribution could exert selection pressure that could change population composition and hence select the population towards a different optimum.[14,15] In feral pigeons it has been shown that, in urban populations fed by people, birds adopt a sit-and-wait foraging strategy, which selects for longer tarsi, while short tarsi are selected for in populations with less feeding by humans, which promotes active searching for food.[16]

The aim of this work was to test the success of feral pigeon management based on public education combined with culling operations in Barcelona where pigeon density is high. We used a design with experimental and control areas. Successful public education should entail a reduction in the quantity of food available to pigeons during the study. As a consequence, we expected a concomitant reduction in pigeon density in experimental areas compared with the control area. We predicted that, if public education was the main reason for the reduction in pigeon

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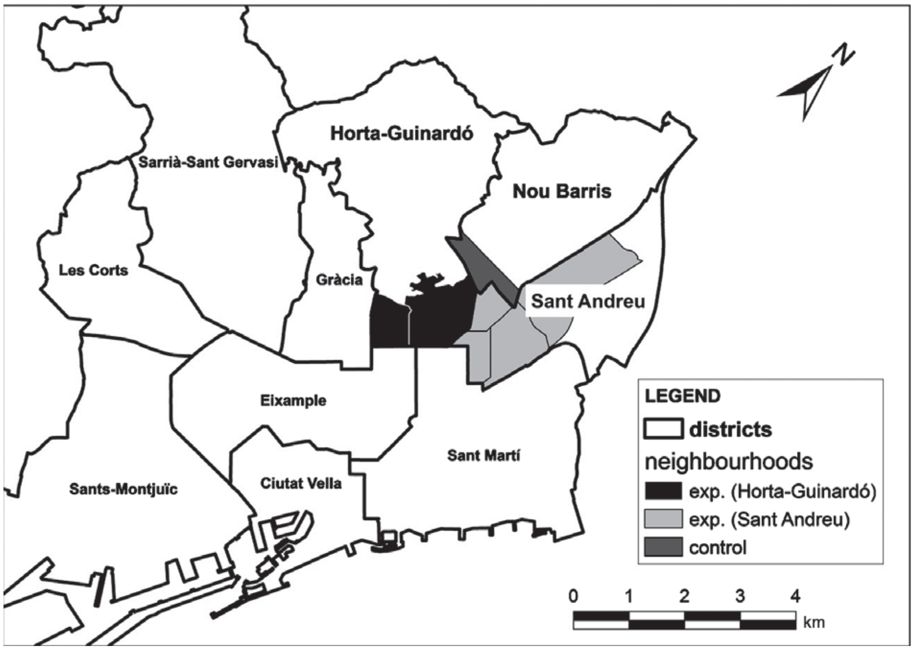

Figure 1. Map of Barcelona showing in black and light grey the neighbourhoods where we carried out the experimental work (in the Sant Andreu and Horta-Guinardó districts respectively), and in dark grey the neighbourhood used as a control.

density, population size reduction should better correlate with the proportion of public informed than with culling effort. Because larger individuals may enjoy priority access to the reduced food supply,[17,18] we predicted an increase in the size of the pigeons in experimental areas.

2 MATERIALS AND METHODS

The study was carried out in Barcelona city in 2009. Barcelona has an area of 102 km^2, 72% of which is built up. The city is divided into ten districts and 73 neighbourhoods, which allows decentralised local administration. The experimental study was carried out in two districts: Sant Andreu [SA] and Horta-Guinardó [HG]. In SA we sampled four neighbourhoods: (1) Navas, (2) Congres i els Indians, (3) La Sagrera and (4) Sant Andreu. In HG we sampled two neighbourhoods: (5) Guinardó and (6) Baix Guinardó (Fig. 1). An additional neighbourhood, (7) Vilapicina-Torre Llobeta, within the district of Nou Barris, was used as a control area where no experimental action was carried out. We chose this neighbourhood as a control area because it was adjacent to the two experimental districts, so that habitat structure and socioeconomic variables were quite similar, and because it was located between the two experimental districts. We used squares of 250 × 250 m (6.25 ha) as the sample unit (Barcelona contains 1568 of these units). The size of this unit was determined on the basis of the home range area of pigeons in Barcelona, which is about 3.5 ha.[13] The study was based on 44 experimental (32 in SA and 12 in HG) and 12 control squares. The size of the control area was smaller than the SA experimental area but similar to the size of the HG experimental area. We assumed that 12 sample control units should suffice to ascertain whether the reduction in the feral pigeon population was the result of management operations or natural population fluctuations. As a consequence, we concentrated effort in increasing the number of sample units in SA to allow for a powerful multiple regression within the same district to test for the differential effect of public information and culling effort on population size (see below).

In the six experimental neighbourhoods from 1 February 2009 to 22 February 2010, we carried out a campaign of public education aimed to reduce the food base for pigeons. It consisted of distributing a pamphlet explaining the negative effects of feeding pigeons both for pigeons and for the public in a similar way to Haag-Wackernagel.[5] We used seven city council information agents to contact people in city parks, gardens and streets for every working day from 08:00 to 12:00 h (or from 09:00 to 13:00 hours, depending on the week). The agents explained the content of the pamphlet, making a special effort to inform people whom they observed feeding pigeons. They also informed the local shopkeepers about the project. In total, we contacted 2190 citizens. The information agents also collected data on the number of individuals engaged in feeding pigeons ($N = 74$) and the availability of food for pigeons provided in the streets (see below). We ran three capture sessions with the elimination of individuals (pigeons culled 6 March 2009 – 5935, 3 July 2009 – 4083, 13 November 2009 – 2252). As in Haag-Wackernagel,[5] culling was done to adapt pigeon population size to the reduced food supply initiated by the public restriction of feeding. Pigeons were captured using pneumatic cannon nets. Capture areas were baited at the point of capture for 4–5 days prior to capture to increase trapping success.

The experimental and control squares were surveyed by walking along all roads in each sample unit (circuitous path), where we counted all visible pigeons (quadrate counts).[19,20] Because a part of the population can be hidden and remain undetected, bird detection probability must be considered.[20–24] In previous work we derived a correction factor of 3.5 to account for detectability of pigeons based on a double sampling procedure[19] using visual surveys and capture–recapture approaches.[20] As this value was consistent across different cities,[20,25,26] we assumed it to be suitable, although it was derived many years ago. Possible fluctuation in the index through the year[9] should have affected experimental and control areas similarly.

All counts were carried out between 09:00 and 14:00 h, which is the period with maximum detectability.[11] We carried out a minimum of three counts per square within each sample period and used the mean of the three values. Whenever one of the censuses was clearly different from the mean value (>50%), we carried out two additional censuses and used the mean value. Population size surveys were carried out on 9–25 February, 8–24 June, 19 October–4 November and 28 December–15 January. These periods are denominated as the February, June, October and January census.

Data were analysed with a repeated-measures ANOVA, where census data from each district were paired. Feral pigeon density (number of pigeons per 6.25 ha) in each of the sampled squares was the dependent variable. Independent variable 'time' included the four paired census periods previously detailed (February, June, October and January). Independent variable 'district' included the two experimental districts (SA and HG) and the control district.

For the district of SA, where most squares were monitored, we tested several variables for correlation with population size:

(i) *Food availability provided by people.* We ranked food deposited in streets as follows: 1 = <200 g, 2 = 200–500 g, 3 = 500–1000 g, 4 = 1000–3000 g of food per square and day. Food availability was estimated by information agents while visiting each square to inform people about pigeon food reduction. The quantities of food found at different points within each square were summed to obtain a daily estimation of food available per square. Values estimated at different days were averaged.

(ii). *Reduction in food supply.* The main aim of the information agents was to make citizens aware of the problems of feeding pigeons so that people no longer provided food to the birds. We computed an index of variation in food availability as the quantity of food available in the period between the first two censuses minus the quantity of food available in the period between the last two censuses. The reduction in food supply in SA district was tested by comparing the quantity of food available to pigeons [semi-quantitative scale, see (i)] between the two periods [see (ii)] within each square, which were paired, using a non-parametric Wilcoxon matched-pair test.

(iii). *Culling effort.* We used the total number of pigeons captured per square. This dataset was analysed with a multiple regression, using ranked data to avoid problems related to the lack of normality in the variables used.[27,28] The dependent variable included the reduction in the number of pigeons in the squares of the SA district (census 4 – census 1), and independent variables included absolute quantity of food provided by people (i), reduction in the quantity of food available per square since the start of the experiment (ii) and number of pigeons culled in each square (iii) ($N = 32$ squares).

Body measures were recorded for a sample of individuals ($N = 483$) from the different sampling units at the start (1 February) and at the end of the experiment (13 November). For each individual we measured body mass, skull length and wing length with a ruler to the nearest mm. Additionally, an index of body condition was computed by regression using standardised residuals of body mass and skull length.[29]

3 RESULTS

The density of pigeons varied according to both the time since the start of the study and the district (RMANOVA analysis: district,

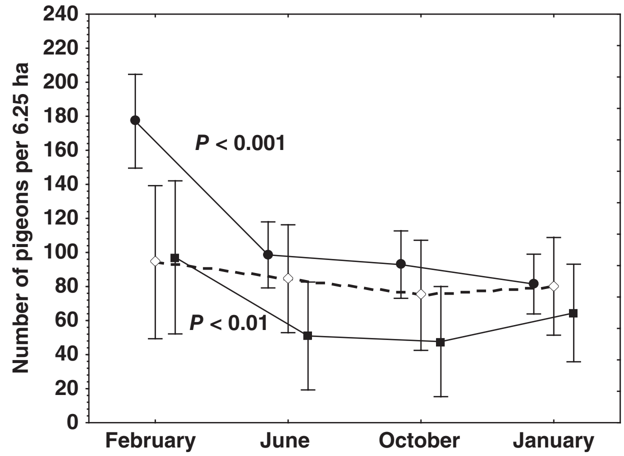

Figure 2. Variation in population density of feral pigeons in the two experimental districts (Sant Andreu – black circles, Horta Guinardó – black squares) and the control district (Nou Barris – open diamonds), according to the population surveys. Error bars refer to SE.

$F_{2,159} = 5.13$, $P < 0.01$; time, $F_{3,159} = 13.17$, $P < 0.001$; district × time, $F_{6,159} = 3.60$, $P < 0.001$) (Fig. 2). At the start of the experiment, the density of pigeons in the SA district was higher than in the HG and control districts (*post hoc* planned comparison tests: SA versus HG, $F_{1,53} = 9.26$, $P < 0.01$; SA versus CTL, $F_{1,53} = 9.92$, $P < 0.01$; HG versus CTL, $F_{1,53} = 0.01$, $P = 0.93$) (Fig. 2). The number of pigeons at the two experimental districts was reduced by 40% between February and June (*post hoc* planned comparison tests: SA, $F_{1,53} = 75.90$, $P < 0.001$; HG, $F_{1,53} = 9.84$, $P < 0.01$) (Fig. 2). The number of pigeons at the control district did not vary during the study (February versus June: $F_{1,53} = 0.44$, $P = 0.51$; whole period: $F_{1,53} = 0.51$, $P = 0.48$) (note the significant interaction between district and time) (Fig. 2). Comparisons between census 3 and census 4 indicated similar results for the three districts (all $P > 0.23$).

The quantity of food available to pigeons from the start to the end of the study was significantly reduced in the study area (median 1.5 versus 1.0 units of food by square; Wilcoxon matched-pair test: $Z = 2.58$, $P < 0.01$; $N = 32$). The reduction in the number of pigeons in the squares of the SA district (census 4 – census 1) was correlated with the reduction in the quantity of food available per square since the start of the experiment ($r_{partial} = 0.37$, $P < 0.05$), so that squares with a higher reduction in food availability reduced population size to a higher degree. The number of pigeons culled in each square (mean value = 159; 95% CI: 94–224) and the absolute quantity of food provided by people had no effect on the reduction in pigeon density (culled individuals $r_{partial} = 0.07$, $P = 0.72$; food availability $r_{partial} = -0.18$, $P = 0.33$; $N = 32$ squares).

Pigeons captured at the end of the experiment were larger by 1–3% than at the start of the study before culling and public information were implemented (ANOVA results for body mass: $F_{1,481} = 8.70$, $P < 0.01$; skull length: $F_{1,481} = 64.17$, $P < 0.001$; wing length: $F_{1,481} = 12.35$, $P < 0.001$) (Fig. 3). The body condition of pigeons, however, was reduced during the study by 6% ($F_{1,481} = 32.65$, $P < 0.001$) (Fig. 3).

4 DISCUSSION

The sustainable reduction in the number of pigeons in urban habitats is one of the main aims of urban wildlife managers.[4] As in the case of other urban nuisance wildlife, reducing the

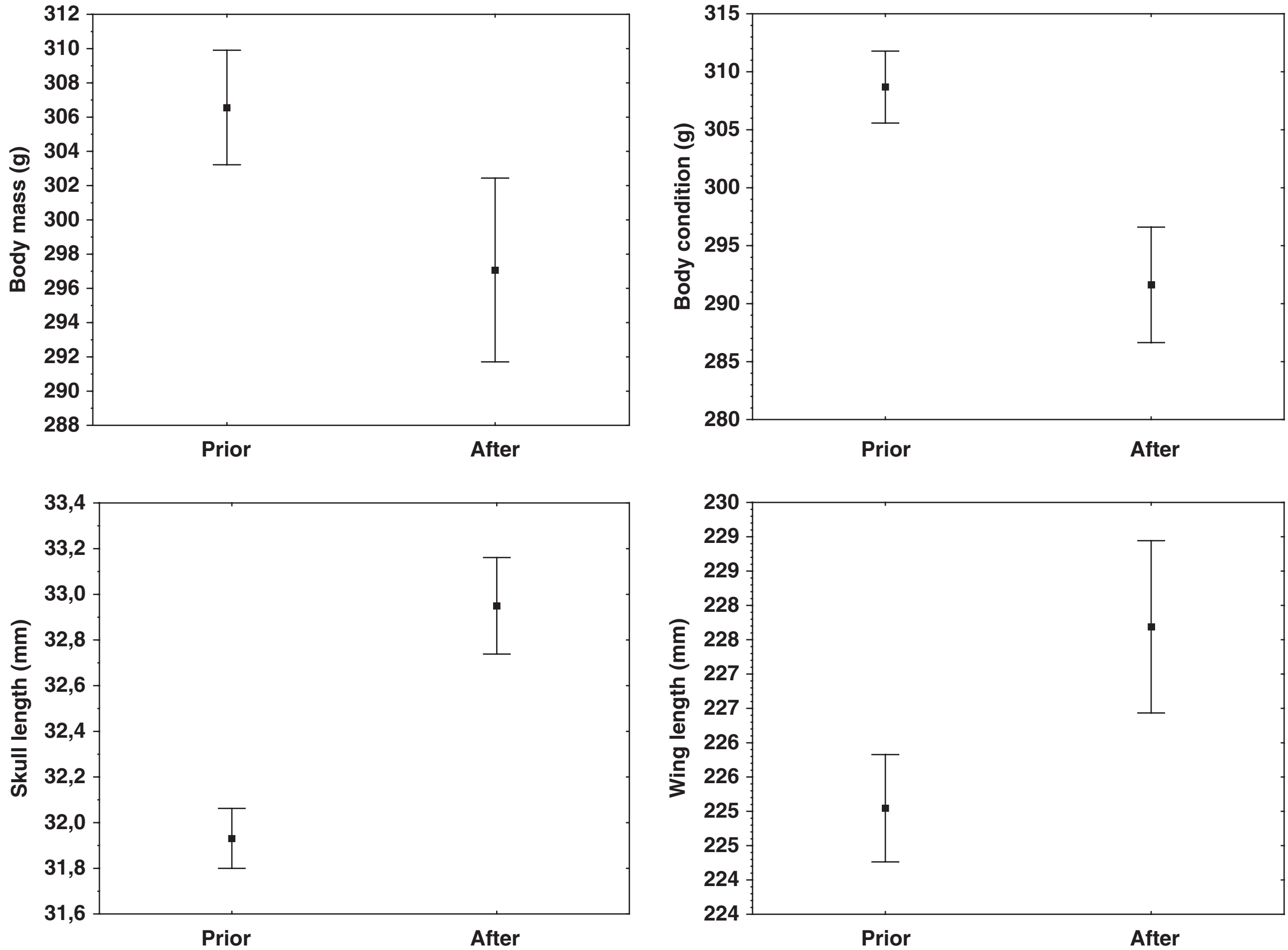

Figure 3. Variation in morphometry of feral pigeons captured in the Sant Andreu district prior to and after management operations. Error bars refer to SE.

food provided by humans should be the target of managers.[4,9,30] However, this is rarely attempted, especially in large cities (see exceptions in Haag-Wackernagel[5] and Giunchi *et al.*[4]). Results from our experimental study in Barcelona city showed that public education aimed at reducing the food base succeeded in reducing both food available and feral pigeon abundance.

Pigeon abundance was reduced by 40% between February and June and did not increase until the following January. The effect was not apparent in the control areas, where no action was carried out. The reduction in the number of pigeons was mainly affected by the reduction in the quantity of food available to pigeons rather than by the culling actions. In fact, culling reduced pigeon density at the capture sites, but if food abundance is not reduced simultaneously the pigeons from the surroundings quickly refill the emptied area so that in a few days the density recovers.[13] Instead, the reduction in food availability has permanent effects, as the area cannot hold the same number of pigeons as before. Hence, data strongly support the view that reduction in the carrying capacity of the environment through food reduction is the best way to attain an efficient feral pigeon population size control.[4,5]

The main reduction in pigeon abundance was attained in just 4 months. This period probably may be enough to cause a reduction in pigeon survival and breeding success when linked to a reduction in food availability. However, given the fast dispersal response of feral pigeons to variation in food availability and pigeon density,[13] it is also possible that a part of the population emigrated from the experimental squares to other areas of the city, so that the reduction found in pigeon numbers could be the combined effect of both processes. Nevertheless, and from the perspective of a city manager, pigeon numbers were successfully reduced permanently whatever the main reason for the reduction was.

The lack of variation in pigeon density in the control area over the year is surprising. Population size should increase, for instance, during and after the breeding season, and should decrease after the late summer population crisis. We think that the stability found in the control area may be a byproduct of using a constant detectability over the year, when in fact this detectability most probably changes according to period.[9] During the breeding season, detectability should be reduced and the correction factor should increase, as many females may be incubating and hence are not available during census. Detectability of juvenile birds may also be different from that of adult birds. All of this can mask census values. Nevertheless, we have to emphasise that this did not seem to affect the main results of the paper, as we were comparing experimental and control sample units and detectability should have been similar.

It has been shown earlier that, in urban pigeon populations where people provide abundant food, pigeons are selected for longer tarsi, while short tarsi are selected for in populations with less feeding.[16] Population size management also had an effect on the size and body condition of the pigeons. Skull and wing length increased and body mass and body condition decreased. This could be a consequence of a trapping bias, if the first captures were a biased part of the population. However, this is improbable, as the birds to be trapped first, and removed from the population, would have been dominant and large individuals that monopolise abundant food sources.[17] Alternatively, our results could be interpreted as a consequence of dominant and hence larger individuals being favoured because of their priority of access to the reduced food supplies.[17,18] It could also be that the smaller birds (young individuals or females) emigrated first from the experimental squares. In both scenarios, the presence of high competence to access reduced food resources may have caused the reduction in the body condition of the birds. Whatever the case, results show how reducing food availability and distribution through control operations can exert important selection pressure that can change population composition.

Summarising, reducing feral pigeon abundance in cities is achieved by reducing the food provided by humans, and public education aimed to reduce the food base should be the target of managers.

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