Indirect seed dispersal by the feral cats *Felis catus* in island ecosystems (Canary Islands)

Manuel Nogales, Félix M. Medina and Alfredo Valido


In this paper we present an unusual incidence of an introduced Carnivore *Felis catus* as indirect seed disperser of plants that produce fleshy fruits in different ecosystems in the Canary Islands. Four hundred and twenty six seeds from at least 8 fleshy fruit plant species have been identified in the analysis of 1047 scat groups, the majority of them being found in the lower habitats (< 600 m a.s.l) of the Canary archipelago. Seeds from two plant species were significantly matched with the presence of lizard prey, and fruits of *Juniperus phoenicea*, *Neochamaelea pulvulenta* and *Withania aristata* were directly consumed by the cats. Passing through the gut of the *Gallotia galloti* (Lacertidae) and *Felis catus* apparently does not damage the seeds. At the moment, the phenomenon studied in this paper does not seem to have a great quantitative importance in the natural regeneration of the plants if we compare the direct vs indirect seed dispersal.

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The domestic cat (*Felis catus* L.) has been introduced by humans to many parts of the world and has frequently become feral. This phenomenon has also occurred on islands, even those that are uninhabited (Fitzgerald 1988).

Generally, the availability of information on the impact of feral cats on islands is restricted to the direct effect upon animal prey populations. For instance, the decline or extinction of endemic populations of reptiles, birds and mammals has been documented (e.g. Fitzgerald 1988 and references therein). However see Tidemann et al. (1994) for a positive indirect effect of feral cats upon the native species in Christmas Island.

In the Canary Islands, feral cats are widely distributed over all the main islands and islets and are top predators in the food chain in the various ecosystems (Nogales et al. 1992). The oldest bone remains of feral cats in this archipelago has been associated with skeletons of human aboriginal populations (Sarrion 1985, Hutterer 1990), whose first arrival has been estimated as no more than 4000 years ago (Schwiderzky 1976).

Despite the fact that introduced mammals (mainly rabbits) are the most important prey in the diet of feral cats in the Canaries, a large number of omnivorous endemic reptiles (mainly *Gallotia* spp., F. Lacertidae) has been found predated in some habitats (Nogales et al. 1990, Medina and Nogales 1993).


Although the potential of birds of prey as indirect seed dispersers has been indicated by some authors (Ridley 1930, van der Pijl 1982, Howe and Smallwood 1982), little information is available on this phenomenon (Darnstream 1986, Hall 1987, Dean and Milton 1988).

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Table 1. Percentages of prey of Genus spp. in scat groups of Felis catus and number of seeds of fleshy fruit species observed in the scats in the various habitats in the Canary Islands.

<table>
<thead>
<tr>
<th>Habitats and islands</th>
<th>Altitude m a.s.l.</th>
<th>No. of seeds</th>
<th>% occur. of seeds</th>
<th>% occur. of lizards</th>
<th>No. scat groups</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xerophytic scrub (Alegranza)</td>
<td>0–300</td>
<td>1</td>
<td>0.9</td>
<td>4.5</td>
<td>110</td>
<td>Nogales et al. (1992)</td>
</tr>
<tr>
<td>Xerophytic scrub (Tenerife)</td>
<td>600–900</td>
<td>233</td>
<td>13.7</td>
<td>37.5</td>
<td>248</td>
<td>Nogales et al. (1993)</td>
</tr>
<tr>
<td>Juniper forest (El Hierro)</td>
<td>300–600</td>
<td>130</td>
<td>6.7</td>
<td>24.4</td>
<td>135</td>
<td>Nogales et al. (1996)</td>
</tr>
<tr>
<td>Laurel forest (La Gomera)</td>
<td>300–900</td>
<td>10</td>
<td>0.9</td>
<td>74.2</td>
<td>221</td>
<td>Nogales et al. (1998)</td>
</tr>
<tr>
<td>Pine forest (Gran Canaria)</td>
<td>800–1800</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>Santan et al. (1986)</td>
</tr>
<tr>
<td>High mountain (Tenerife)</td>
<td>1800–3700</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>Santan et al. (1986)</td>
</tr>
</tbody>
</table>

Results and discussion

A total of 953 seeds (426 from fleshy and 527 unfleshy fruits) belonging to 12 species has been identified in the analysis of the scats. The highest number of seeds from 8 fleshy-fruit species was found in only two of the five habitats studied (island xerophytic scrub and juniper forest) (see Tables 1 and 2).

Seeds from two of the plant species mentioned in the Table 2 co-occurred significantly with remains of lizards, Rubia fruticosa (\(\chi^2 = 12.4\), p < 0.001) and Plocca pendula (\(\chi^2 = 4.79\), p < 0.05) both species being dispersed by lizards (Valido and Nogales 1994). These results could indicate that seeds of P. pendula and R. fruticosa are also dispersed indirectly by the cats. At this respect, when comparing the mean number of seeds/ dropping and the frequency of appearance of seeds/ dropping of P. pendula and R. fruticosa, it is important to stress that direct seed dispersal (sauchochory) is more highly relevant than indirect seed dispersal. The mean number of seeds appeared in lizard’s droppings is 18.9 (P. pendula) and 4.8 (R. fruticosa) vs 0.2 and 0.01 respectively, and if we also take into account the frequency of occurrence, a markedly difference is observed (66.5% and 80.5% vs 7.5% and 3.5%, respectively). Furthermore, the density of lizards is clearly larger than cats in practically all the habitats of the Canary Islands.

Most of these lizards, which are widely distributed throughout all the islands (Klemmer 1976), play an important role in the seed dispersal of fleshy fruits in the Canary Islands (Barquin and Wildpret 1975, Barquin et al. 1986, Valido and Nogales 1994).

From the rest of the species mentioned in the Table 2 non significant matched differences were found with the lizard’s presence (p > 0.05). In the case of Juniperus phoenica, Neochamaelea pulverulenta and Wixhinta aritata, the analysis indicate that this fruits could be dispersed both by directly consume and by predation upon lizards (p > 0.05). The opposite case is observed in Opuntia dilleni, where the cats feed directly on its fleshy-fruit (\(\chi^2 = 12.09\), p < 0.001).

It is important to mention that the fruit size consumed directly are markedly bigger than fruits ingested incidentally (9.6–34.6 vs 3.5–5.6 mm respectively). Furthermore the direct consumption of several Juniperus fruit species by other species of Carnivora has also been

Study area and methods

The Canary archipelago is situated in the Atlantic Ocean ca 100 km (at the closest point) from the African continent, between 27°37'–29°25'N and 13°20'–29°25'W.

A total of 1047 scat groups of feral cats has been analyzed in the last eight years in the main habitats (see references in Table 1).

The habitats are distributed basically as a function of altitude and orientation. The xerophytic scrub is located in the lower zones which are characterized by species belonging to the genus Euphorbia and other xerophytes that produce fleshy fruits (Plocca pendula, Rubia fruticosa, Neochamaelea pulverulenta, etc.). The open Juniperus forest is still present in the upper parts of some islands as El Hierro and it is basically constituted by trees of J. phoenicea and some fleshy-fruit scrub species. The dense evergreen laurel forest along the north-facing slopes of the western islands is constituted by trees and bushes that present fleshy fruits, such as Laurus azorica, Poreea indica, Ilex convivente, Viburnum tins, among others. The next habitat in altitude is the monospecific pine forest of Pinus canariensis, a open and dry woodland. The vegetation of the highest parts are occupied by the high mountain scrub, which is dominated by two species of leguminous plants (Spartocytisus supranubus and Adenocarpus eicosus). Generally the last two habitats show a lack of plant species that produce fleshy fruits. (For more information of the vegetation from the Canaries, see González et al. 1986 and Brumwell and Bramwell 1990).

The scats were analyzed according to the groups in which they were found and their contents were treated as a single sample. Each scat segment were immersed in water and the contents separated. For more information on methodology see Jones (1977), Santana et al. (1986) and Nogales et al. (1988). Damaged seeds were counted in each scat.
Table 2. Number of seeds and frequency of occurrences of each plant species observed in the scat analysis of feral cats Felis catus in the Canary Islands. Data from xerophytic scrub on Tenerife and from the juniper forest on El Hierro (between brackets).

<table>
<thead>
<tr>
<th>Plant species</th>
<th>No. of seeds</th>
<th>% seeds damaged</th>
<th>% occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placuna pendula</td>
<td>194</td>
<td>1</td>
<td>7.5</td>
</tr>
<tr>
<td>Rubia fruticosa</td>
<td>12 (61)</td>
<td>(-)</td>
<td>3.5 (6.5)</td>
</tr>
<tr>
<td>Sideritis hamaeranthoidalis</td>
<td>4</td>
<td>(-)</td>
<td>1.0</td>
</tr>
<tr>
<td>Nodchamaelea pulexulentum</td>
<td>3</td>
<td>(-)</td>
<td>1.5</td>
</tr>
<tr>
<td>Withania aritata</td>
<td>14</td>
<td>7.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Opuntia dilleni</td>
<td>66</td>
<td>15.2</td>
<td>19.0</td>
</tr>
<tr>
<td>Opuntia ficus-barbarica</td>
<td>1 (1)</td>
<td>(-)</td>
<td>0.4</td>
</tr>
<tr>
<td>Juniperus phoenicea</td>
<td>71 (71)</td>
<td>1.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>


Despite the high frequency of occurrence of lizards consumed in the high mountain scrub, no seeds from fleshy fruits has been found, because fleshy fruit plants are absent.

The results in Table 2 show that passing through the gut of Galloita galioti and Felis catus does not cause any apparent external damage to the seeds.

Hall (1987), working on secondary seed dispersal by raptors, observed that the majority of the seeds (from fleshy and unripe fleshy fruits) were also undamaged. Available data on raptors suggest that the phenomenon is common enough (see also Dean and Milton 1988).

In the Canary Islands, the majority of the species cited in this paper are actively dispersed by several species of reptiles and birds (Barquin et al. 1986, Valido and Nogales 1994, Valido and Nogales unpubl.). As the feral cat has been recently introduced by man, it seems unlikely that natural regeneration of this species is strongly dependent upon seed dissemination by the Carnivora. Furthermore, a potential disadvantage is that the scats of F. catus remain unaltered for very long periods of time before disintegrating. For this reason, in these dry habitats environmental factors, such as temperature, could have an effect on the dehydration of the seeds and act negatively in the establishment of many seeds.

The results obtained in this paper do not show a movement of seeds among the main habitats (with different environmental conditions). However, the high predation of Galloita spp. by F. catus could produce a wider spatial pattern of the seeds within each habitat (xerophytic scrub and juniper forest) than occurs with limited range of movement of Galloita. Nevertheless, it is not very important if we compare the direct vs indirect seed dispersal commented before.

Widespread indirect seed dispersal could also occur naturally as a consequence of the intensive predation upon the lizards by the kestrel Falco tinnunculus, a raptor indigenous to the Canaries (Carrillo et al. 1994).

Finally, now a days, this case does not seem to have great quantitative importance in the recruitment of some plant species with fleshy fruits, because the population density of the lizards in the Canary Islands is very high. Apart from that, the majority of plant species cited in the Table 2 are being actively dispersed by other agents such as warblers, ravens, blackbirds, etc (Barquin and Wildpret 1975, Barquin et al. 1986, Nogales unpubl.).

Nevertheless, the indirect seed dispersal could be important in those cases in which two factors coincide: 1) the frugivorous species could be actively consumed by introduced predators (producing a marked decline in their populations), and 2) there are some plant species that could have a high mutualistic dependence (for the reproductive biology) on this animal prey.

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References