Available online at www.sciencedirect.com
SCIENCE DIRECT®

Biological Conservation 122 (2005) 499–503

BIOLOGICAL CONSERVATION

www.elsevier.com/locate/biocon

Short communication

Extinction behind our backs: the possible fate of one of the Darwin's finch species on Isla Floreana, Galápagos

P.R. Grant [a,*], B.R. Grant [a], K. Petren [b], L.F. Keller [c]

[a] Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544-1003, USA
[b] Department of Biological Sciences, University of Cincinnati, Cincinnati, OH 06522-0001, USA
[c] Museum of Zoology, Universität Zürich, Winterthurerstrasse 190, Zürich, CH 8057, Switzerland

Received 14 June 2004

Abstract

Without regular monitoring a rare species may slip into extinction unnoticed. We report a possible case from the Galápagos archipelago. The warbler finch (*Certhidea fusca*) has not been recorded by scientists on Isla Floreana in recent years, and we have been concerned about its status. On a two-day visit to prime habitat in the breeding season of 2004 we used playback of warbler finch song and calls recorded on another island to stimulate an approach of local birds. We failed to find a single warbler finch, whereas we encountered numerous small tree finches (*Camarhynchus parvulus*), medium tree finches (*C. pauper*) and yellow warblers (*Dendroica petechia*). Searches in 1979, 1983, 1997 and 1999 were also unsuccessful. Our continuing failure to find any warbler finches indicates the species must be extremely rare on the island, if not actually extinct. We discuss possible reasons for their demise and draw attention to other species that could be heading in the same direction.

Keywords: *Certhidea fusca*; Endemic subspecies; Monitoring; Song playback; Endangered species; Conservation; Extinction

1. Introduction

Monitoring programs are designed to keep watch on potentially endangered species so that if numbers show signs of decreasing to dangerously low levels a program of management can be designed and implemented (Dunn, 2002; Impey, 2002; Thorbjarnsson et al., 2002; Thomas et al., 2004). Vast numbers of species are not monitored because it is too costly to do so, or they are believed to be in no danger of extinction, or because they are in relatively inaccessible habitats, or they are small, inconspicuous and difficult to find, or they are not even known to science. A challenging task for conservation biologists is to determine when a species deserves the scrutiny of regular monitoring. Species living in remote areas that are difficult to reach present the greatest challenge (Pimm et al., 1994; Mellinck et al., 2002) because in the absence of frequent observation a species may slip into oblivion unnoticed. In this article we describe a possible example, and illustrate the difficulties of both anticipating the fate and assessing its causes.

The warbler finch (*Certhidea*) of the Galápagos occurs on all major islands and some of the small ones (Lack, 1947; Grant, 1999) in two genetic lineages designated *Certhidea olivacea* and *Certhidea fusca* (Petren et al., 1999; also Freeland and Boag, 1999). The population on Isla Floreana (*C. fusca*; Tonnis et al., MS) in the south of the archipelago was first discovered by the Webster–Harris expedition in 1897 (Rothschild and Hartert, 1899). Gifford's (1919, p. 220) field notes pertaining to the California Academy of Sciences' expedition to the Galápagos in 1905–06 are the most explicit

* Corresponding author. Tel.: +1 609 258 5156; fax: +1 609 258 1334.
E-mail address: prgrant@princeton.edu (P.R. Grant).

0006-3207/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2004.09.001

about its status at that time: "On Charles [Floreana] it was rather uncommon. Examples were taken, however, on all three visits, October, February–March, and May–June; most commonly during the last two. They were found all over the wooded interior and on the southern slope of the island, chiefly in lemon and orange groves." It was sufficiently abundant at medium and high elevations to yield a total of 53 specimens to collectors in the decade following its discovery (Swarth, 1931; Lack, 1945).

For most of the twentieth century since the California Academy's expedition its status has been unknown. R.I. Bowman visited Floreana for two days in September 1957, and returned to the island in January 1962, but makes no mention of *Certhidea*, a species of prime interest to him (Bowman, 1983). We have spoken to several ornithologists who have visited Floreana in the last half-century, and none have seen it. Tj. DeVries (pers. comm.) did not see it on six to ten visits in the period 1965–75, R. Perry (pers. comm.) did not see it in the late 1960s, and nor did M.P. Harris (pers. comm.) in 1971. Steadman (1986), who excavated four sites in the arid lowlands for fossils, found the bones of seven warbler finches, but failed to see living warbler finches in the non-breeding months of June, July and October. A Field Guide to the Birds of Galápagos states "The Warbler Finch [on Floreana] varies greatly in numbers – some years it is common, others virtually missing" (Harris, 1974, pp. 46–47). However this was based on the experience of the early collectors and not on modern experience (M.P. Harris, pers. comm.). Possibly it has been seen, though rarely. Nevertheless, we did not see it on one-day visits to the agricultural zone and the *Scalesia* forests in the vicinity of the central mountain Cerro Pajas in August of 1979 and 1983. Our suspicions about a population decline were aroused in April 1997 when three of us searched unsuccessfully for it on three days in prime habitat at Cerro Pajas and the vicinity of Asilo de Paz. Therefore two of us returned to the island in November 1999 to make an extensive search on Cerro Pajas, aided by playback of tape-recorded song from the island of Pinta, but again without success. A few warbler finches may have been present but overlooked because they can be cryptic in the non-breeding season. We made a further search in the breeding season of 2004, and this paper describes our attempts to locate it.

2. Methods

We visited the highlands of Isla Floreana in 2004 at a time when small ground finches and small and medium tree finches had active nests as well as dependent juveniles. On March 3 we searched for *Certhidea* in the central part of the bowl of Cerro Pajas (S 01 17 39, W 090 27 22), extensively on the northern inner slope until just below the rim, and less extensively on the southern inner slope. This is the best *Scalesia* forest remaining on the island and our coverage of it was complete. At 12 locations we used playback of *C. fusca* vocalizations recorded on Pinta; song (illustrated in Fig. 2 in Grant and Grant (2002)) and buzz and squeal (Fig. 5 in Grant and Grant (2002)). These recordings have been effective in eliciting responses of both *C. fusca* and *C. olivacea* on other islands (Grant and Grant, 2002, and unpublished), and the technique has been used successfully in a study of the rare mangrove finch *Cactospiza heliobates* (Grant and Grant, 1997). For example playback of *C. fusca* song in 24 territories of *C. fusca* on Genovesa elicited responses of residents and in some cases neighbors in all 24 (Grant and Grant, 2002). On March 4 we searched widely at Finca Cruz (S 01 18 27, W 090 26 22) in guayabillo (*Psidium*) woodland with various mixtures of *Croton scouleri*, *Zanthoxylum fagara* and *Tournefortia* species, riparian woodland and copses of *Pisonia floribunda* and avocado. Two of us used playback at approximately 50–100 m intervals along transects established at the edge of woodlands as well as at right angles to the edge. We played recorded songs at 24 locations. On the same day the other authors played tape-recorded song opportunistically at Cerro Verde in habitat dominated by the introduced guava, lemon and orange trees. Our forays into disturbed sub-optimal habitat covered a very small fraction of the total area of such habitat outside the prime area of Cerro Pajas.

3. Results

Certhidea were not seen or heard at any of the sites visited. At all 36 playback locations except one we observed one or both of the tree finch species. Also present at 26 locations were yellow warblers. Small ground finches and large-billed flycatchers (*Myiarchus magnirostris*) were present as well at most of the locations. These birds responded to playback with agitated flight behavior, but did not fly back and forth above the speaker as *Certhidea* do when tested with playback of their own song (Grant and Grant, 2002). We are therefore confident that the tape-recordings were successful in attracting birds, and the absence of *Certhidea* is real and not attributable to an ineffective technique. We conclude that warbler finches were not present where we searched for them, and since there is no better breeding habitat for them elsewhere on the island as far as we know they may no longer exist on Floreana.

4. Discussion

The lesson to be learned from the fate of *Certhidea* on Floreana is that we should be sensitive to early warnings of a species in difficulties. There were three such warnings from Floreana. First, the history of land vertebrates on the island is one of extinction following human settlement in 1832 (Steadman, 1986). The island was occupied by humans earlier than any other in the archipelago (Lack, 1947). Elsewhere it has been found that the longer an island has been settled the greater is the decline and loss of indigenous organisms (e.g. Thibault et al., 2002). The large ground finch (*Geospiza magnirostris*), sharp-beaked ground finch (*G. difficilis*) and Floreana mockingbird (*Nesomimus trifasciatus*) were all present when Darwin visited the island in 1835 but apparently extinct by the end of the nineteenth century. This should have been a signal that other species were likely to follow.

Second, warbler finches on Floreana were not common when first encountered. Darwin and subsequent visitors in the next few decades did not collect them or refer to them in their writings. The Floreana population was the last of eight taxonomically distinct populations to be described (as *Certhidea ridgwayi*) following its discovery in 1897 (Rothschild and Hartert, 1899), but the next expedition to the island failed to find any (Snodgrass and Heller, 1904) and concluded they must be rare. Gifford (1919, p. 220), writing about the experiences of the last of the collecting expeditions of this era (1905–06), referred to them as "rather uncommon". This should have been a warning of a potentially unsustainable population on a human-occupied island.

Another, albeit ambiguous, early warning signal was the presence of apparent hybrids in the collection of specimens for museums. Swarth (1931) described a new species (*Camarhynchus conjunctus*) on the basis of two specimens from Floreana. They are morphologically intermediate between *Certhidea* and *Camarhynchus parvulus* (Lack, 1945), and are now thought to be F_1 hybrids or backcrosses (Bowman, 1983; Grant, 1999). Although avian hybridization with introgression is a natural process in the Galápagos (Grant and Grant, 1992; Grant et al., 2004), it also occurs under human influence in other places when habitats are altered and one of a pair of related populations becomes rare (e.g. Cade, 1983; Clarke et al., 2001). One outcome is extinction of the rare species, but persistence of some of its genes in the other, surviving, species (Grant and Grant, 1982).

Few people could have responded to these warnings. There are no resident biologists on Floreana, the human population is about 100 and scientists rarely visit the island.

4.1. Causes of the decline

When bird populations on islands decline towards extinction as a result of human activity several potentially causal factors operate simultaneously (Thibault et al., 2002). This makes it difficult to identify a single or predominant factor. It is even more difficult to identify causes retrospectively, as for example with the Hawaiian honeycreepers in the nineteenth century (Grant, 1995) or more generally elsewhere on Pacific islands and at earlier times of human influence (Milberg and Tyrberg, 1993; Pimm et al., 1994; Steadman, 1995). In the case of the Floreana warbler finches the causes were probably complex. Native vegetation on Floreana was cleared for agriculture and further degraded or destroyed by feral cattle, donkeys and alien plants. Native animals were preyed upon or molested by cats, rats, dogs and other introduced mammals.

The only relevant comment from an observer a hundred years ago pinpoints predation as a causal factor in the rarity of warbler finches on Floreana. According to Rothschild and Hartert (1902, p. 385) "Mr. Beck [a collector] says that perhaps the cats, which are common on Albemarle [Isabela] and Charles [Floreana] Islands, have caused the decrease in *Certhideae*. This, however, does not agree with the observation that cats as well as *Certhideae* are plentiful on Chatham Island [San Cristóbal]; but Beck found a nest which he believed to be that of a *Certhidea* 12 ft. [$\sim$3.5 m] high on that island, while they nest quite low on Albemarle and Charles, and this, Beck thinks, may explain the facts that he observed." Cats may have depleted the populations of large ground finches, sharp-beaked ground finches and mockingbirds in the nineteenth century, and propelled them towards extinction. All three species on other islands forage on the ground to a large degree and are approachable. Vulnerability of the much more arboreal warbler finches is questionable, however, unless the nests were placed unusually low in the vegetation. On Santa Cruz Island they build nests at a lower height than tree finches do (Kleindorfer et al. MS), but typically above 3 m (unpubl. obs.).

Another possible factor is food. On other islands in similar habitat the diet of warbler finches is composed primarily of arthropods obtained from leaf clusters, bark or epiphytes (Bowman, 1961), supplemented by occasional nectar. Floreana warbler finches may have suffered because some components of their diet drastically declined, perhaps as a result of introduced predators such as fire-ants (*Solenopsis invicta*), wasps (*Polistes versicolor* and *Brachygasta* sp.) or unknown parasitoids. In contrast the small and medium tree finches have persisted in abundance because their diets are different; they are largely vegetarian. The diet of the warbler finch is most similar to that of the yellow warbler. The absence of yellow warbler fossils suggests the species may have arrived on Floreana in the last few hundred years (Steadman, 1986). They are now distributed throughout the island, and abundant as our observations showed. Possibly they had a competitive influence on warbler finches, but this can be only a partial explanation of the latter's decline because on other islands in the same habitat warbler finches are abundant in the presence of numerous yellow warblers (Lack, 1947; Bowman, 1961; Grant and Grant, 2002).

A parasitic fly (*Philornis downsi*) that is capable of killing finch nestlings has recently been discovered in the Galápagos (Fessl and Tebbich, 2002; Kleindorfer et al. MS), including Floreana but at relatively low mean density per nest on that island (S. Kleindorfer, pers. comm.). It has been present in the Galápagos since 1981 (Kleindorfer et al. MS). If warbler finches were present in the 1980s their decline may have been partly caused by the flies. *Solenopsis* fire-ants are also potential killers of nestlings (e.g. Stake and Cimprich, 2003). An unanswered question about both of these potential mortality agents is why, if either seriously afflicted warbler finches, they have not done the same to tree finches on Floreana, or to warbler finches on Santa Cruz island that has both of them.

4.2. Other species

The population of large tree finches (*Camarhynchus psittacula*) on Floreana is possibly endangered. We failed to see any members of this species on the same five visits to the island. In September 1957 Bowman (1961) observed an individual feeding in the highlands, and tape-recorded another in 1962 (Bowman, 1983, fig. 69). Steadman (1986) did not see it and listed it as possibly extinct. However three birds were captured in a recent study by Sonia Kleindorfer (pers. comm.), and the nest of one was found (Kleindorfer et al. MS). The status of the species is difficult to assess because it has always been rare, to judge from the small number of specimens collected, 17 in total (Lack, 1945), its late discovery in 1888 (Rothschild and Hartert, 1899), and the fact that an expedition in 1899 failed to find it (Snodgrass and Heller, 1904). The California Academy of Sciences collectors obtained nine specimens in both the wet (May) and dry (October) seasons (Swarth, 1931), which probably indicate residence and not transience a hundred years ago. Its presence in arid and humid zones (Gifford, 1919) cautions that a more widespread search throughout the island, with song playback, is needed to determine its status.

The vegetarian finch (*Platyspiza crassirostris*) may be heading in the same direction, as we saw only one individual on the fifth and last visit to the island. It was in the agricultural zone. However birds of this species have survived on the island, and may continue to do so, by taking advantage of flowers, fruits and leaves of horticultural and agricultural plants introduced to this highly disturbed habitat (Gifford, 1919; Bowman, 1961). The same has been reported for the cactus finch (*G. scandens*) (Gifford, 1919; Lack, 1947; Bowman, 1961), another uncommon species. Associated with a drastic decline in *Opuntia* cactus the cactus finch has adopted the habit of opening and feeding on oranges, and large tree finches have been observed to take advantage of the access thereby afforded (Bowman, 1961).

These fragmentary observations provide warning signals of other species whose long-term persistence on the island is in doubt. Dunn (2002) makes a strong point in stressing the need for ecological detail in addition to numerical trends in declining bird populations in order to develop species-specific conservation strategies. This certainly applies to the situation on Floreana.

4.3. Coda

A search-and-research program is needed to determine if warbler finches have indeed become extinct or are rare and restricted in distribution. Floreana warbler finches differ from others elsewhere in the archipelago in having a larger bill and distinctly streaked juvenal plumage, with traces of streaking dorsally remaining in older plumages (Swarth, 1931). In all of these features they resemble *Camarhynchus* tree finches (Swarth, 1931), as well as the ground finches, and as such are potentially valuable in helping us to understand morphological transitions in the evolutionary history of Darwin's finches. Regrettably song, behavior, feeding and breeding ecology were not studied before they became too rare to find. Despite possessing these distinctive features, the population has approached and possibly crossed the brink of extinction. Although this is but a single example, the generalizable lesson to be learned from it is that numerous populations elsewhere in the world may be in danger of the same fate through neglect, which can only be rectified with better programs designed for detecting early warnings of populations in distress.

Acknowledgment

We were greatly helped by Felipe and Claudio Cruz in guidance, transportation, information and access to the family farm, and by Karin Schiegg and Gilberto Pasinelli in fieldwork. We thank the Galápagos National Parks Service for permission to do this research and for continuing long-term support, and the Charles Darwin Research Station for logistical support. Funding was provided by the National Science Foundation (USA).

References

Bowman, R.I., 1961. Adaptation and differentiation of the Galapagos finches. University of California Publications in Zoology 58, 1–302.

Bowman, R.I., 1983. The songs of Darwin's finches. In: Bowman, R.I., Leviton, A.E., Berson, M. (Eds.), Galápagos Organisms. American Association for the Advancement of Science, Pacific Division, San Francisco, CA, USA, pp. 237–537.

Cade, T.J., 1983. Hybridization and gene exchange among birds in relation to conservation. In: Schonewald-Cox, C.M., Chambers, S.M., MacBryde, B., Thomas, W.L. (Eds.), Genetics and Conservation. Benjamin/Cummings, Menlo Park, CA, USA, pp. 288–309.

Clarke, R.H., Gordon, I.R., Clarke, M.F., 2001. Intraspecific phenotypic variability in the black-eared miner (*Manorina melanotis*); human facilitated introgression and the consequences for an endangered taxon. Biological Conservation 99, 145–155.

Dunn, E.H., 2002. Using decline in bird populations to identify needs for conservation action. Conservation Biology 16, 1632–1637.

Fessl, B., Tebbich, S., 2002. *Philornis downsi* – a recently discovered parasite on the Galápagos archipelago – a threat for Darwin's finches. Ibis 144, 445–451.

Freeland, J.R., Boag, P.T., 1999. Phylogenetics of Darwin's finches: paraphyly in the tree-finches, and two divergent lineages in the warbler finch. Auk 116, 577–588.

Gifford, E.W., 1919. Field notes of the land birds of the Galápagos Islands and of Cocos Island, Costa Rica. Proceedings of the California Academy of Sciences ser. 4 (2), 189–258.

Grant, B.R., Grant, P.R., 1982. Niche shifts and competition in Darwin's finches: *Geospiza conirostris* and congeners. Evolution 36, 637–657.

Grant, B.R., Grant, P.R., 1997. The rarest of Darwin's finches. Biological Conservation 11, 119–126.

Grant, B.R., Grant, P.R., 2002. Lack of premating isolation at the base of a phylogenetic tree. American Naturalist 160, 1–19.

Grant, P.R., 1995. Commemorating extinctions. American Scientist 83, 420–422.

Grant, P.R., 1999. Ecology and Evolution of Darwin's finches. Princeton University Press, Princeton, NJ.

Grant, P.R., Grant, P.R., 1992. Hybridization in bird species. Science 256, 193–197.

Grant, P.R., Grant, B.R., Markert, J.A., Keller, L.F., Petren, K., 2004. Convergent evolution of Darwin's finches caused by introgressive hybridization and selection. Evolution 58, 1588–1599.

Harris, M.P., 1974. A Field Guide to the Birds of Galapagos. Collins, London.

Impey, A.J., Coté, I.M., Jones, C.J., 2002. Population recovery of the threatened endemic Rodrigues fody (*Foudia flavicans*) (Aves, Ploceidae) following reforestation. Biological Conservation 107, 299–305.

Kleindorfer, S., Vinueza, C., Torres, S., Dudaniec, R., Christensen, R., Robertson, J., MS. Nestling mortality in Darwin's tree finches and warbler finches in relation to parasitism by the introduced fly *Philornis downsi*.

Lack, D., 1945. The Galápagos finches (*Geospizinae*): a study in variation. Occasional Papers of the California Academy of Sciences 21, 1–159.

Lack, D., 1947. Darwin's Finches. Cambridge University Press, Cambridge.

Mellinck, E., Ceballos, G., Luévano, J., 2002. Population demise and extinction threat of the Angel de la Guarda deer mouse (*Peromyscus guardia*). Biological Conservation 108, 107–111.

Milberg, P., Tyrberg, T., 1993. Naïve birds and noble savages – a review of man-caused prehistoric extinctions of island birds. Ecogeography 16, 229–250.

Petren, K., Grant, B.R., Grant, P.R., 1999. A phylogeny of Darwin's finches based on microsatellite DNA length variation. Proceedings of the Royal Society of London B 266, 321–329.

Pimm, S.L., Moulton, M.P, Justice, L.J., 1994. Bird extinctions in the central Pacific. Philosophical Transactions of the Royal Society of London B344, 27–33.

Rothschild, W., Hartert, E., 1899. A review of the ornithology of the Galápagos islands. With notes on the Webster–Harris expedition. Novitates Zoologicae 6, 85–205.

Rothschild, W., Hartert, E., 1902. Further notes on the fauna of the Galápagos islands. Novitates Zoologicae 9, 381–418.

Snodgrass, R.E., Heller, E., 1904. Papers from the Hopkins–Stanford Galápagos expedition, 1898–99. XVI. Birds. In: Proceedings of the Washington Academy of Science 5, pp. 231–372.

Stake, M.M., Cimprich, D.A., 2003. Using video to monitor predation at black-capped vireo nests. Condor 105, 348–357.

Steadman, D., 1986. Holocene vertebrate fossils from Isla Floreana, Galápagos. Smithsonian Contributions to Zoology, No. 413.

Steadman, D.W., 1995. Prehistoric extinction of Pacific island birds: biodiversity meets zooarchaeology. Science 267, 1123–1131.

Swarth, H.S., 1931. The avifauna of the Galápagos Islands. Occasional Papers of the California Academy of Sciences 18, 1–299.

Thibault, J.-C., Martin, J.-L., Penloup, A., Meyer, J.-Y., 2002. Understanding the decline and extinction of monarchs (Aves) in Polynesian Islands. Biological Conservation 108, 161–174.

Thomas, J.A., Telfer, M.G., Roy, D.B., Preston, C.D., Greenwood, J.J.D., Asher, J., Fox, R., Clarke, R.T., Lawton, J.H., 2004. Science, 1879–1881.

Thorbjarnsson, J., Wang, X., Ming, S., He, L., Ding, Y., Wu, Y., McMurry, S.T., 2002. Wild populations of the Chinese alligator approach extinction. Biological Conservation 103, 93–102.

Tonnis, B., Grant, P.R., Grant, B.R., Petren, K., MS. Habitat-mediated phylogeographic structure of the Galápagos warbler finches (*Certhidea olivacea* and *C. fusca*).