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Nest sites and breeding ecology of the Másafuera Rayadito (*Aphrastura masafuerae*) on Alejandro Selkirk Island, Chile

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Abstract The first nest sites of the endemic Másafuera Rayadito (*Aphrastura masafuerae*) are described, the first one being found on 16 December 1992. Másafuera Rayaditos breed in small natural holes in steep rocks, the nest being hidden within the rock and not visible through the 3 cm-wide entrance. All nest sites were located in the summit region of Alejandro Selkirk Island above 1,200 m altitude, characterised by fern stands. Nesting has been reported from early December to late January. Feeding frequency increases only slightly during nestling time. Both parents feed the nestlings in similar proportions. During the daily round no regular variation in feeding frequency occurs, although it is often higher during the first hours after sunrise. In general, it decreases strongly when a Másafuera Hawk (*Buteo polyosoma exsul*) is present close to the nest site. It hunts intensively on Rayaditos, both adults and juveniles. Habitat destruction and predation pressure have caused the Másafuera Rayadito to be the most endangered bird species in Chile (total population c. 140 individuals). More detailed studies on its breeding ecology are urgently needed, especially on reproductive success.

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Introduction

The Másafuera Rayadito (*Aphrastura masafuerae,* Furnariidae) is an endemic species of Alejandro Selkirk (formerly Másafuera) Island. It was the last land bird species of the Chilean Juan Fernández Archipelago to be described, by Philippi and Landbeck (1866). Only a few records of this species exist: Bäckström observed four individuals in 1917 (Lönnberg 1921) and Philippi recorded three in 1928 (Johnson and Goodall 1967). Over the next more than 50 years the bird was not seen (Johnson and Goodall 1967; Torres and Aguayo 1971), and therefore categorised as probably extinct (Vaurie 1980). Then, in 1983, Bourne (1983) saw four individuals. A small population was confirmed in 1986 by Brooke (Brooke 1988) and during 1992 to 1995 by Hahn (Hahn and Römer 1996; Hahn 1998), thus classifying the Másafuera Rayadito as endangered species. It carries the status "in danger" in the *Red List of the Terrestrial Vertebrates of Chile* (Glade 1993; Schlatter 1987) and is, along with the Juan Fernandez Firecrown (*Sephanoides fernandensis*) of this archipelago, classified as "vulnerable" (Stattersfield et al. 1998; Stattersfield and Capper 2000). However, the red list status is just about to be updated (BirdLife International, in preparation), as a census in 2002 showed the population to now be as low as c. 140 individuals (own unpublished data).

Másafuera Rayaditos are small buff-brownish birds, easily identified by the reddish spine-like tail feathers and the light superciliar stripe (Remsen 2003; Ridgely and Tudor 1994). Restless and acrobatical, they search the vegetation for arthropod prey, only flying for short durations and distances. Modes of behaviour are similar to several old world genera, such as tits (*Parus*) when foraging hanging upside down in the foliage, of treecreepers (*Certhia*) when running up trunks, and of wrens (*Troglodytes*) when showing antagonistic behaviour and

uttering warning calls. The common call (a churring "trrrt") is used by both sexes to stay in continuous vocal contact; the song is uttered by the male only before sunrise (Hahn and Mattes 2000).

The poor knowledge regarding the Másafuera Rayadito is the result of various factors: the remoteness of the island, the extremely difficult terrain, the small distribution area and population size, and the Rayadito's preference for dense vegetation. Referring to observations of the Thorn-tailed Rayadito (*Aphrastura spinicauda*) on the mainland, Vaurie (1980) suggested that the nest of the Másafuera Rayadito is "probably constructed in a crevice or some irregularity of the trunks of tree ferns". Brooke (1988) observed an adult Másafuera Rayadito carrying food on 2 February 1986, but he was not able to follow the bird to find the nest. Up to now, no information on the breeding ecology has been published, and no nests of this species had ever been found. Here we present the first observations of a small breeding population. Since the total population size of the Másafuera Rayadito is very small and in threat of extinction, basic information is highly important for future conservation activities.

Methods

The study area is Alejandro Selkirk Island, the westernmost island of the Juan Fernández Archipelago. It is located in the south-east Pacific Ocean (33°45′S, 80°45′W) off the coast of Chile, to which it belongs politically. Alejandro Selkirk Island is 167 km west of Robinson Crusoe Island, the other major island, and about 769 km from the South American continent (Castilla and Oliva 1987). Alejandro Selkirk encompasses an area of approximately 44.6 km^2, about 10 km long from north to south, and 6 km from east to west. Reaching 1,320 m of altitude at the Pico del Inocentes (own measurement 1995 and 2002), Alejandro Selkirk is the highest island of the archipelago. The entire island is part of the national park "Juan Fernández Archipiélago", which was founded in 1935. Because of its international value, the archipelago was declared a UNESCO World Biosphere Reserve in 1977. More detailed geographical descriptions can be found in Castilla and Oliva (1987) and Skottsberg (1920–1956).

We have organised expeditions to the island together since 1992. Field work has been carried out on Alejandro Selkirk during the austral summers from 25 November 1992 to 1 February 1993, 15 December 1994 to 9 February 1995, and 15 January to 8 February 2002 by I.H. R.S additionally made comparative data from southern Chile available. Visual field identification of birds was straightforward, based on Araya et al. (1992) and the original species description (Philippi and Landbeck 1866). Acoustic identification was possible after learning the bird vocalisations while they were under visual observation (Hahn and Mattes 2000). Statistical evaluations were carried out using the software program CSS-Statistica. A Geographical Positioning System (Garmin eTrex summit) was used in 2001/2002 to get coordinates of nest sites.

Results

Nesting habitat

All discovered nest sites were located in the summit region of Alejandro Selkirk above 1,200 m altitude. The habitat type and vegetation of this area is described as autochthonous fern stands of the alpine summit region. The fern *Lophosoria quadripinnata* is the only dominant plant species above 1,100 m, growing only 1–1.5 m tall. These fern stands are monotonous and dense, normally providing 95–100% cover. However, numerous rocks, partly covered by mosses and lichens, project from them. Registered home ranges indicate that Másafuera Rayaditos also breed in two other habitat types, but within these only above 800 m altitude (as these habitats reach further downhill). The autochthonous tree-fern stands of the sub-alpine region are characterised by the tree-ferns *Dicksonia externa* and *Blechnum cycadifolium* and the tree *Drimys confertifolia*, all growing no more than 5 m tall. The vegetation of steep rock walls and canyon sides is mainly a mosaic of low-growing *Lophosoria*, *Gunnera*, *Anthoxanthum*, *Stipa*, and *Hymenophyllum* on wet sites. More detailed information of plant species composition and vegetation structure can be found in Hahn (1998, 2000).

Nest sites

The first nest site of this species was discovered on 16 December 1992. In total, four nest sites were found, two in the 1992/1993 season and two in the 1994/1995 season (Table. 1). All nest sites were discovered by observing food-carrying adults. The Másafuera Rayadito breeds in small natural holes in steep rock walls. The basaltic

Table 1 Nest site parameters of the Másafuera Rayadito (*Aphrasturamasafuerae*) on Alejandro Selkirk Island, Chile

Nest parameters	Nest site 1	Nest site 2	Nest site 3	Nest site 4
First observation	16.12.1992	05.01.1993	27.12.1994	09.01.1995
Description of position	400 m WSW of Pico Inocentes	400 m W of Pico Inocentes	50 m W of Pico El Hombre	400 m W of Pico Inocentes
Latitude	33°47′07.4″S	33°47′05.4″S	33°46′01.4″S	33°47′05.4″S
Longitude	80°47′59.9″W	80°47′58.0″W	80°48′41.0″W	80°47′58.3″W
Altitude (above sea level)	1,240 m	1,245 m	1,206 m	1,242 m
Height (above ground)	1.5 m	9.6 m	5.0 m	7.5 m
Distance (below top of rock)	10.5 m	2.1 m	13.0 m	4.2 m
Total height of rock	12.0 m	11.7 m	18.0 m	11.7 m
Structure of rock	Rock wall	Exposed tower rock	Rock wall	Exposed tower rock
Direction faced	205° SSW	84° E	284° W	314° NW
Incline	86°	90°	85°	90°

rocks are of volcanic origin; the holes may originate from primary lava bubbles or secondary micro-geological shift. No nest hole was directly accessible from the ground. Except for nest site 1 (1.5 m above the ground), the holes were located at least 5 m above the ground. The direction of nest entrances varied: nest site 1 was exposed to SSW, thus to the strong southerly winds.

The nest itself is located within the rock and cannot be inspected through the small opening. All four nest openings were only slightly larger than necessary for the Másafuera Rayaditos to enter, approximately 3 cm in diameter. The depth of nest hole 1 was measured (using a wire) at 65 cm sloping downwards a little (10°). The nest opening was completely determined by the natural structure of the rock. It was not modified by the Másafuera Rayaditos as is observed for several other species of ovenbirds (Furnariidae). It is not known how the interior part of the nest hole is arranged.

Since the nest and the brood themselves are placed inaccessibly within the rock, no detailed information on them can be given here. The clutch size of the Másafuera Rayadito probably consists of two to three eggs. However, this is only assumed from tape-recordings of the nestling begging calls heard in the hole. Since the young birds keep permanently concealed within the ferns after fledging, their number is also always difficult to obtain. The size of a family party in the fern stands was confidently identified on two occasions: on 22 December 1992 four birds (two adults and two juveniles) were seen, and on 26 January 2002 three (two adults and one juvenile) were observed.

Nesting time and brood care behaviour

The temporal extension of the Másafuera Rayadito's breeding season derives from the four pairs at the nest sites. Adult feeding flights and juvenile begging calls were recorded from mid-December (16 December 1992) through to late January (25 January 1995). The duration of the nestling time was recorded for the juveniles of nest site 4 (Fig. 1), because in January 1995 observations were carried out for several hours close to the site. On 4 January, no adult feeding activity and no juvenile begging calls were noted. Thus, the nestling time ranged from a minimum of 17 days (9–25 January) to a maximum of 27 days (controls on 4 January and 1 February). On 1 February, no adult or juvenile birds were observed returning for the night. Therefore, we suggest that the juveniles do not return to the nest after fledging. On 22 December 1992, a family party was observed in the shelter of fern stands, indicating that breeding also takes place in early December. The duration of the breeding period seems to be related to food availability and will be discussed by Hahn (in preparation).

Brood care activity was observed as foraging, approaching, entering and leaving of the nest hole by adult Másafuera Rayaditos. They usually forage for arthropod prey inside the dense fern vegetation. However, during the nestling period they can be seen flying above the vegetation cover (average 0.5–2 m) to enter and exit the nest hole. Thus, they seem to be pressed for time during this period. Both parents were observed flying into the nest to feed nestlings. Distinguishing the sexes in the field is still uncertain (Hahn and Römer 1996), but using records of the feeding frequency of persistently monitored individuals it was concluded that both adults feed nestlings in similar proportions. Throughout the day no regular differences in feeding frequency were found. The number of feeding flights was high during the first hours after sunrise, but may sometimes have also been high during midday and/or single evening hours (Fig. 2).

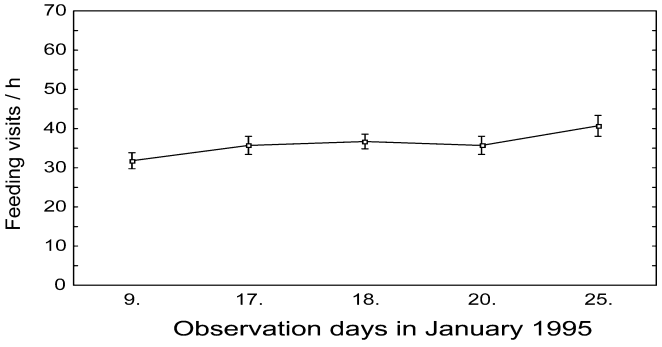

Fig. 1 Feeding visits of two adult Másafuera Rayaditos (*Aphrastura masafuerae*) on 5 days during nestling time of the same brood at nest site 4 on 9 January (1430–2000 hours, $n = 5.5$ h), 17 January (1700–2000 hours, $n = 3$ h), 18 January (1600–1900 hours, $n = 3$ h), 20 January (1300–1500 and 1700–1800 hours, $n = 3$ h), and 25 January (1200–1500 hours, $n = 3$ h) 1995. Only hours without the presence of Másafuera Hawks (*Buteo polyosoma exsul*) were taken into account

Predator-prey relations

Másafuera Hawks (*Buteo polyosoma exsul*), as the only autochthonous predators, were observed actively seek-

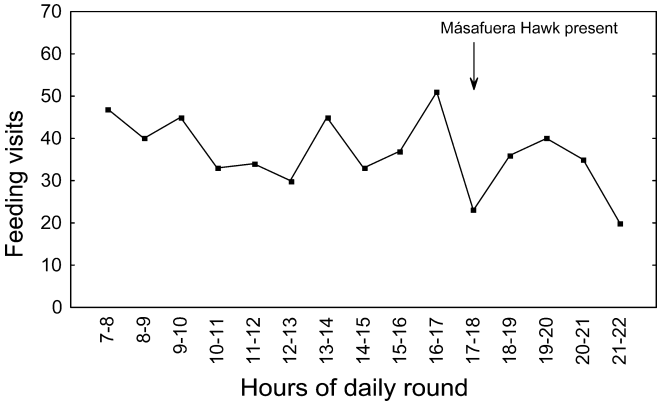

Fig. 2 Feeding visits of two adult Másafuera Rayaditos throughout the day at nest site 2 on 6 January (1400–2200 hours) and 11 January (0700–1400 hours) 1993. Only during one hour (1700–1800 hours) did a Másafuera Hawk stay near the nest site and hinder feeding activity

ing for Másafuera Rayadito nest sites. When a hawk had detected the nest hole, it tried to prey on the nestlings and watched for long periods nearby. Even at nest site 4, where the opening was located under a projecting rock, a Másafuera Hawk snatched with its talons into the nest hole, still hovering, and later was repeatedly observed sitting on top of the rock. At nest site 2, a Másafuera Hawk perched exactly in front of the opening, while an adult Rayadito was alarming from a close distance. In all cases observed, the attacks on nestlings were not successful, probably because of the small nest openings and the hard rock substrate. Másafuera Hawks may also lie in wait for adult Másafuera Rayaditos, either by hiding in the vegetation or flying. In the centre of Másafuera Rayadito home ranges, Másafuera Hawks were observed soaring harrier-like directly above (0.5–1 m) the fern cover at various occasions. Knowing the nest site location, they were obviously watching out for nest leaving Rayaditos leaving their nests.

A Másafuera Hawk was present near the nest during 7 of 42 observation hours (17%) covering all four nest sites. During these 7 h, adult Rayaditos entered the nest only 24 times per hour on average. During the 35 h without the presence of a hawk it was 43 times per hour on average, nearly double the frequency. Thus, Másafuera Rayaditos strongly reduce brood care activities while a Másafuera Hawk is around. Further antagonistic behaviour was observed. For example, as Rayaditos had to leave the fern stands to enter the nest, they first checked the surrounding area from under the cover of the ferns, and then often briefly again from a rock projecting out of the ferns. These rocks held numerous arthropods, but no protection from hawk attacks. A similar situation (food sources without shelter) was characteristic for the tops of fern fronds. Thus, the exclusively short duration of visits to the upper parts of the habitat structures was obviously not caused by the lack of food resources, but by the predation pressure of Másafuera Hawks.

Discussion

Detailed comparisons with the breeding ecology of the closely related, and on the mainland widely distributed, Thorn-tailed Rayadito are not yet possible because of missing observational data for the latter species. Our excursions to the Valdivian and Patagonian rainforest and data from Johnson and Goodall (1967) lead to the suggestion that Thorn-tailed Rayaditos may have a similar breeding behaviour. However, they occupyvery different nest sites, being adaptable birds of high breeding plasticity and found nesting in holes of trees, in cracks, crevices under the bark, in stumps of trees, in earth holes, in bank sides, under a bridge (man made sites) and, on the Diego Ramírez Islands, even in tussock grasses (Housse 1945; Johnson and Goodall 1967; Schlatter and Riveros 1997; Vaurie 1980). In contrast, all four nests of Másafuera Rayaditos were located in small natural holes of steep rocks. It does not seem likely that they nest in crevices or irregularities of tree-fern trunks as suggested by Vaurie (1980). Depending on the predation pressure by Másafuera Hawks such broods might not be successful. However, there is the chance that nests might also be placed in well protected holes of such trees as *Drimys confertifolia* and *Myrceugenia schulzei*.

The clutch size of the mainland Thorn-tailed Rayadito seems to vary from three to four eggs. Johnson and Goodall (1967) state it to be usually three in number (egg length: 18.3 ± 0.25 mm, egg breadth: 14.4 ± 0.07 mm, n not given), but R.S. collected two clutches near Valdivia each containing four eggs (length: 18.59 ± 0.113 mm, breadth: 14.55 ± 0.052 mm, $n = 10$; own measurements of the clutches and two additional ones at UACH in March 2002), an exceptionally high furnariid clutch size (J. Fjeldså, personal communication). Quoting several examples, Carlquist (1974) demonstrated that clutch sizes of island forms are generally smaller than those of their relatives from the mainland, but egg and body sizes are larger. Indeed, larger size is the case for some body measurements of the insular Másafuera Rayadito (e.g. wing: 64.8 ± 2.81 mm, bill: 15.3 ± 0.59 mm, $n = 5$) compared to the mainland Thorn-tailed Rayadito (wing: 58.5 ± 0.43 mm, bill: 12.1 ± 0.30 mm, n not given) (Johnson and Goodall 1967; Vaurie 1980).

Potential Rayadito predators are introduced feral cats and rats. I.H. documented both Black Rats (*Rattus rattus*) as well as Brown Rats (*R. norvegicus*) on Alejandro Selkirk Island. Habitat destruction, mainly by grazing and trampling of feral goats and cattle, is another major threat for the Másafuera Rayadito. It is therefore very probable that its population size is much smaller than before man had discovered the Juan Fernández Islands (Brooke 1988; Hahn 1998). Although interactions with the Másafuera Hawk are a natural part of the island biocoenosis, there are indications of high predation pressure: probably the hawk population has increased during the last four centuries in relation to introduced prey species. Originally it had to feed on native birds and sea-shore carrion only, now goats, rats, mice, and domestic fowl are additionally present. Preliminary results of systematic censuses show an increase of the Másafuera Hawk population from 1994 to 2002 (own unpublished data), induced by the decrease of illegal hunting of hawks. Thus, not only has predation pressure on Másafuera Rayaditos been increased by introduced mammals, it now additionally may also be occuring by native Másafuera Hawks.

Conservation management is necessary to prevent the Másafuera Rayadito from becoming extinct, like the endemic hummingbird of Alejandro Selkirk already has in the early 20th century. Principal consequences and conservation goals must be the total eradication of introduced mammals, namely feral goats, cattle, cats, mice, and rats. For practical reasons, activities should start with eradicating goats and cattle. For a specific

discussion of conservation see Bourne et al. (1992) and Hahn and Römer (2002).

Further research needs are more detailed studies on the breeding ecology, especially on reproductive success. Simultaneously, population studies need to be continued. To gain more information about the Rayadito's requirements, comparisons are needed with the three Thorn-tailed Rayadito subspecies. To learn about island community functions, comparisons are desirable with the insectivorous Juan Fernandez Tit-Tyrant (*Anairetes fernandezianus*) of neighbouring Robinson Crusoe Island (Roy et al. 1999) and with the other small insectivorous bird on Alejandro Selkirk, the Másafuera Cinclodes (*Cinclodes oustaleti baeckstroemii*).

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