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Distribution and habitat description of Junín Rail *Laterallus tuerosi*, Andean Peru

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Summary

Distribution and habitat description of the endangered Junín Rail *Laterallus tuerosi* were assessed during a field study between 6 and 20 February 2014 in the marshes surrounding Lake Junín in the high Andes of Peru, which is the only known locality for the species. By using point counts and playback, we found the species to be present in the marshland all around the lake, with preference for two clearly defined habitat types: one comprising extensively grazed tussocks of *Festuca dolichophylla* and the other of rather uniform stands of *Juncus balticus* with undergrowth, or smaller open spaces, with various low herbs. We estimate the suitable habitat of the species to be a minimum of 100 km^2 and based upon our point count data we provide indicative population figures of 6,200 individuals, which is higher than previous estimates. No records were obtained without playback, although five minutes of silent listening prior to playback were used at each point. All records were in vegetation of at least 0.5 m tall and in the marshy edge on muddy ground with less than 20 cm of water depth. Grazing especially by sheep or cattle is a serious threat to the marsh vegetation structure essential for Junín Rail and the rail is also under pressure from fluctuations in water levels accentuated by regulation for hydroelectric power.

Introduction

The Junín Rail, initially described as *Laterallus jamaicensis tuerosi* Fjeldså 1983, was discovered in October 1977 in the marshes bordering Lake Junín (Chinchaycocha) and is considered endemic to the Junín altiplano in central Peru (Fjeldså 1983a, Schulenberg *et al.* 2007). It was later proposed to recognize it as a distinct species *Laterallus tuerosi*, based on its densely barred and spotted plumage and its limitation to a harsh environment at 4,085 m elevation (Collar and Andrew 1988, Collar *et al.* 1992, BirdLife International 2014, del Hoyo and Collar 2014). However, a full analysis of genetic population structure in the *Laterallus jamaicensis* complex is lacking, and, while *tuerosi* is vocally distinct from *L. j. murivagans* of the coastal wetlands of Peru, it may seem indistinguishable from the more southern *L. j. salinasi* (based on available sound recordings). Thus, this rail is still treated as a subspecies by, for instance, Taylor (1996), Taylor and Van Perlo (1998) and Schulenberg *et al.* (2007). A proposal to elevate Junín Rail to species rank has not yet passed the South American Classification Committee (Remsen *et al.* 2016).

In the three decades since its discovery, this rail has only been reported from two areas in the south-western part of the immense wetlands surrounding of Lake Junín (Fjeldså 1983a, BirdLife International 2014). Surveys done since 2007 by ECOAN (2009, 2010) have found the species at a few additional sites on the south-eastern lakeshore, but apparently at low densities. It has been assumed that it would occur throughout the c.150 km^2 of marshland around the lake (Fjeldså 1983a, Taylor 1996, BirdLife International 2014), but the majority of the wetland has so far remained unexplored and there has been no published analysis of its specific habitat requirements (BirdLife International 2014).

The rail has been classified as globally 'Endangered' (BirdLife International 2014) based on its highly restricted occurrence in only one wetland, where the habitat quality is declining because of human induced water level changes and environmental contamination, and waterbird populations seem to be declining in general (BirdLife International 2014). Hence, more knowledge on the distribution and habitat preference is essential in order to formulate appropriate management plans. This paper presents the results of targeted fieldwork in the marsh around Lake Junín with the aim of 1) collecting distributional data on the Junín Rail, 2) data on its habitat and 3) proposing a methodology and needs for further fieldwork.

Material and methods

Habitat description and classification

Lake Junín is 4,085 m asl (11°00″S, 76°20″W) and can be divided in some 150 km^2 of marshland and a central lake of about 300 km^2 (150–400 km^2) (Dourojeanni 1968, Harris 1981, Fjeldså 1983b, BirdLife International 2014, this study). Large portions of the marshland are heavily grazed by domestic animals, or even exploited for production of peat (for fuel), and these areas in general have a prostrate vegetation of rosette plants or herbs a few centimetres in height, while other parts are mosaics of short vegetation and taller sedges, depending on the grazing intensity, with tall rushes in the lake. Thus, there is a zone of 1–6 km of reed-marsh, dissected by inlets and channels, surrounding the open lake. In general, large portions of the marshland are difficult to access due to dense reed-marsh vegetation, seasonal flooding of large areas and the existence of deeper drainage channels crisscrossing the area. The wetland is surrounded by *puna* grassland and gently sloping hills on calcareous rocks, with low, scrubby vegetation.

During the study period, the water level increased from 4,089.7 to 4,090.0 m asl and the maximum level for 2014 of 4,090.4 m was reached in April. Water levels in the lake in February (since 1965) have been between 4,088.6 m and 4,091.0 m according to CENERGIA (2016). It is not possible from the data to tell whether the water level in February 2014 was unusual apart from being within the known range.

The lake is included within La Reserva Nacional de Junín comprising 530 km^2 of protected area, at altitudes between 4,080 and 4,125 m (ECOAN 2010) and was declared a Ramsar site in 1996. However, mining interests in Peru generally overrule other regulations and the Junín conservation area is influenced by large mines in the Cerro de Pasco area to the north, filling the lake up with polluted water in the rainy season. Moreover, in order to have enough water for hydroelectric power throughout the dry season, water level is regulated, leading to serious desiccation of the marshlands in some years.

The four main habitat types from dry land towards the open lake are presented in Table 1. These habitats may form complex mosaics, with some variation in habitat distribution from year to year, but certain parts are patterned in a way suggesting 'fossil' Pleistocene polygon soils. Despite the grazing pressure, a 'natural' vegetation succession with 5–6 km wide marsh vegetation is generally maintained in the north-western and eastern sections of the lake.

Census methods

Surveys to document the distribution and abundance of the Junín Rail were performed between 6 and 20 February 2014. Due to difficulty of access caused by water-filled channels crisscrossing the marshland, and tall marsh vegetation, we used the point count method (see Bibby *et al.* 1992) by using playback technique by LD and AC (Sen 2011). We used a tape recorder and digital device connected to a speaker with recordings of vocalisations collected by Cesar Zevallos and ECOAN in 2010. During recent survey work by ECOAN, Junín Rail was found to react well to playback and this approach had been identified as being essential to detect its presence. The marsh towards the lake was investigated by boat, but no point counts were carried out here as vegetation was in

Table 1. Main habitat zones at Lake Junín.

Shore	Shore meadows comprising a mix of dry and more waterlogged ground, and with a vegetation cover that varies according to the level of grazing and harvesting of peat. Dry areas have short grasses and herbs and typical high Andean rosette plants such as *Plantago rigida*, and cushions of *Disticia muscoides* in shallow water. Small creeks crisscrossing the area often have a short vegetation of *Ranunculus limoselloides, Hydrocotyle bonariensi, Hypsella* and *Lilaeopsis*, and locally some sedges (*Eleocharis*). Some areas, e.g. outside the village of Ondores, are dominated by grassy tussocks of *Festuca dolichophylla*.
2–20 cm water	Areas generally covered by 5–20 cm of water (during the wet-season study period), with some dry patches with similar vegetation as above. Extensive areas are covered by calcareous mud (marl) and submergent vegetation of green algae in *Characeae*.
> 25 cm water	Vegetation of emergent sedges in >25 cm of water, mostly the half-meter tall sedge *Juncus balticus* (also variously classified as *J. andicolus* or *J. arcticus*) and in deeper water some patches of the tall sedge *Schoenoplectus californicus* (previously *Scirpus*).
Lake water	The open lake, with submergent vegetation only.

standing water which is not considered suitable habitat according to previous experience of ECOAN and the authors.

The marsh was divided into 1 km² blocks, which were assigned to one of four broad sections of the lake: east, west, north, and south, and we aimed to survey Junín Rail in all four sections (Figure 1). Thus 461 km² blocks of potentially suitable habitat (107 km² in south, 58 km² in east, 83 km² in west and 213 km² in north) were identified from the GIS map, representing a much larger area than the assumed 150 km² marsh originally identified as potential Junín Rail blocks (BirdLife International 2014). The precise land use and vegetation structure in most blocks is difficult to interpret from satellite images; hence the precise habitat type for each sampling area was determined *in situ*. Many blocks were found to be intensively grazed or cultivated with no suitable habitat. Furthermore, many blocks were unsuitable because of high water levels with massively dense reed marsh (Fjeldså 1983a, BirdLife International 2014).

From the total of potentially suitable and accessible blocks within each section of the lake, we randomly selected blocks and managed to count in a total of 12 although in two blocks in the north we adjusted according to suitable habitat. In each of these blocks, a number of different points were chosen for census. Such survey points were spaced at a minimum distance of 200 m from each other, at suitable locations to avoid recording the same birds at two different points. Fieldwork was undertaken between 08h00 and 15h00 except for one night count between 20h00 and 23h30 (dark hours). At each point we waited five minutes in silence upon arrival and thereafter undertook three minutes of playback while recording response calls by Junín Rail. All distances to vocal bird(s) when heard the first time was estimated as plus-minus 30 m. The exact distance to a bird is difficult to estimate but 30 m was selected to distinguish between birds nearby and birds further away allowing an attempt to estimate densities. The use of playback gives a potential bias in the estimated distance to the individuals as playback attracts birds to the observer, eventually in some cases to the distance of a few metres. Thus the species has been observed running or quietly sneaking in vegetation cover when attracted by playback (C. Zevallos pers. comm.). This bias is limited by estimating the distance at the first instance a bird is heard. However, this will reduce but not eliminate the bias as the bird might have moved before it became vocal. On the other hand, not all birds may respond to playback i.e. some birds may keep silent and it may be only one in a pair responding. The balance between these biases is not clear.

In order to estimate population density based on our point count data we used the equation density = $\log(e)(n/n2) \times n/m(\text{pi} \times \text{radius}^2)$ (Bibby *et al.* 1992), where n is the total number of birds counted, $n2$ is the number beyond the radius, m is the total number of counts and r is the fixed

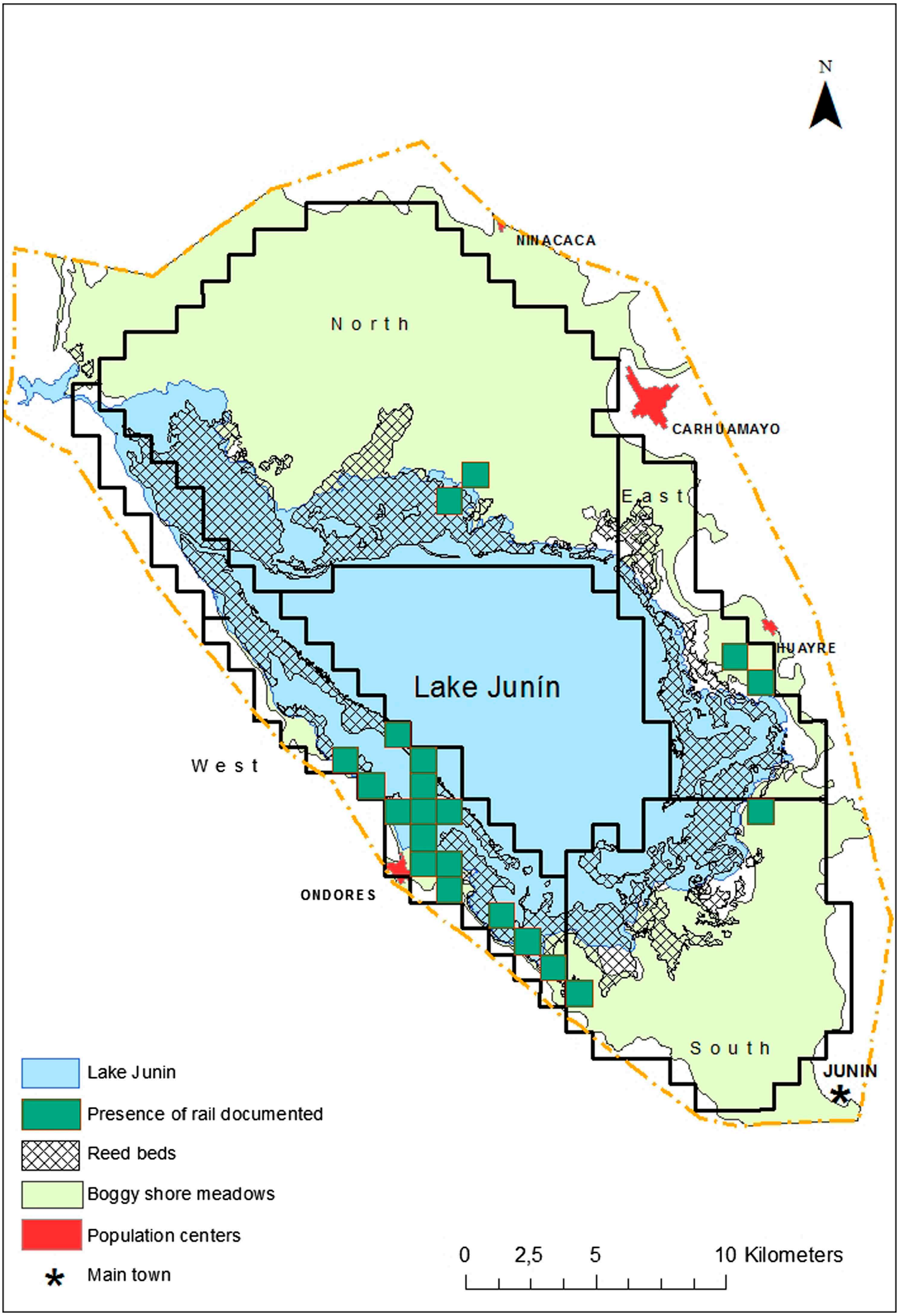

Figure 1. Records of Junin Rail *Laterallus tuerosi* in marsh vegetation around Lake Junin: February 2014 (this study, 6 blocks) supplemented with records by ECOAN in 2007-2009 (10 blocks) and by Jon Fjeldså in 1979-81 (5 blocks).

radius (30 m). The use of this formula is based on the survey blocks chosen randomly in our study, i.e. covering 461 km^2 study area which however included large areas of clearly unsuitable habitat for the rail and excluding four point counts with six recorded rails in the northern section surveyed due to their high potential as rail habitat and general inaccessibility.

A conservative estimate based on examination of aerial maps after the survey suggests a minimum 100 km^2 of suitable habitat at the time of our survey. The extension of suitable habitat may undoubtedly vary over the year(s), depending especially on fluctuations in water level. A description of the habitat was undertaken at each observation point, recording the following parameters within an estimated radius of about 50 m: a) average height of vegetation (m); b) dominant plant species (with some photo-documentation for identification); c) level of grazing: 1) none, 2) moderate, 3) intensive; d) influence of water: 1) dry land, 2) wet marsh, 3) waterlogged 5–20 cm, 4) water level > 20 cm. Time and the location of each point (coordinates) was recorded as well. In order to concentrate on the vocalisation of the rail only the first five other bird species were recorded during each point count. In future surveys we would, however, propose to make a full list of species during the count. If the wind was over 10 m/s data collection was abandoned. In one block, seven points were marked with poles and data collected during the night between 20h00 and 24h00 for comparison to the day count one week later.

Results

Distribution

A total of 26 individuals were recorded during our survey in 2014 during daytime at 15 points (46 point counts in total; Table 2) in six out of the 13 surveyed blocks in the south, west and north sections. Thus our surveys in 2014 combined with ECOAN studies since 2007 (ECOAN 2009, 2010) resulted in records of Junín Rail in all four sections around the lake and these and records by JF in the 1970s are included in the distribution map (Figure 1). Seven of the 26 birds recorded by playback in 2014 were estimated to be closer than 30 m to the observation point. The species was not recorded during the initial five minutes of listening at any point (Table 2) in daytime. Hence, playback proved to be essential to detect the presence of the species. The locations of each of the point counts and records of Junín Rail are presented in Appendix S1 in the online supplementary material.

Habitat

Brief habitat descriptions at each point count are presented in Appendix S1. All records are in marshes with high vegetation cover (0.5 m or more) with moderate or no grazing. Furthermore, Junín Rail was confined to marshes with low water levels, up to 20 cm deep but in the latter areas in a mosaic with shallow and dry patches. It is present in two different habitat types, one comprising large grassy tussock of *Festuca dolichophylla*, often with a moderate level of grazing, another pure stands of *Juncus balticus* with low herbs and sometimes a mix of the two habitats depending on water and grazing levels. In the 1970s JF has occasionally seen the rail running for shelter in *Juncus* vegetation surrounding open muddy areas with little vegetation, suggesting that it may like mosaic areas where it can forage in the open but reach vegetation cover in a few seconds. Waterlogged creeks in these open areas often have high densities of small invertebrates such as bugs (*Corixidae*), snails (*Taphius*) and brinefly larvae (Ephydridae).

Other birds recorded at the points with Junín Rail were Correndera Pipit *Anthus correndera* (at 60% of the points with Junín Rail), Puna Snipe *Gallinago andina* (56%), Plumbeous Rail *Pardirallus sanguinolentus* (53%) and Puna Ibis *Plegadis ridgwayi* (40%). The largest overlap was with the Puna Snipe, of which almost two-thirds (62%) of the records were at points were the rail was also present.

Table 2. Blocks (1 km²) with or without Junín Rail *Laterallus tuerosi* identified in point counts including one night count on 16 February. For more details on location, vegetation, grazing pressure and water level at the individual points see appendix 1.

Block	No. 5 min silence	No. response to play back (3 min)	Birds within 30 m from point	2014 date	Total no. of points in block
365 (west)	0	5	0	8 Feb	8
365 (west, night)	2	0	0	16 Feb	7
350 (west)	0	2	0	9 Feb	3
281 (west)	0	0	0	14 Feb	4
397 (west)	0	0	0	8 Feb	3
303 (west)	0	8	1	14 Feb	8
348 (west)	0	0	0	9 Feb	2
423 (south)	0	5	1	12 Feb	8
417 (south)	0	0	0	11 Feb	2
429 (south)	0	0	0	11 Feb	2
149 (east)	0	0	0	10 Feb	1
170 (east)	0	0	0	10 Feb	1
164 (north)	0	1	0	19 Feb	2
185 (north)	0	5	5	19 Feb	2

Night census

The results from a night survey between 20h00 and 23h30 in block 365 on 16 February are shown in Table 2. The species did not respond to play back at any of these points as it did during the day at four of the points with one or two individuals. Calls from two birds known to be used by Junín Rail in flight (C. Zevallos pers. comm.) were recorded from one point at night.

Discussion

Distribution

The Junín Rail is present in all the four marsh sections around the lake. This supports the idea that Junín Rail occurs throughout the marshes (Fjeldså 1983a, BirdLife International 2014). Changes in water levels might force it to move in drought years, but so far there are no records away from the lake, and only tiny patches of similar habitat can be found in the surrounding highlands.

Examination of aerial maps after the survey suggests a minimum 100 km² of suitable habitat at the time of our survey. The extension of suitable habitat may undoubtedly vary over the year(s), depending especially on fluctuations in water level. This is based on a more detailed knowledge of the habitat requirements of the rail than the previous estimates of 150 km² of habitat (e.g. BirdLife International 2014).

An estimate of population density based on our point count data gives 0.62 individuals per hectare using the equation density = log(e)($n/n2$) x n/m(pi x radius²); (Bibby *et al.* 1992), where n is 26 (the total number of birds), $n2$ is 19 the number beyond the radius, m is 46 (the total number of counts) and r is the fixed radius (at 30 m). This corresponds to 62 individuals per km² in suitable habitat and a best estimate of 6,200 individuals (100 km² x 62 individuals) at the time of our survey. This is thought to be a conservative estimate but larger than previous estimates and based on a minimum estimate of the extent of suitable habitat.

For comparison, if the estimate is limited to the surveyed blocks chosen randomly in our study, i.e. excluding four point counts with six recorded rails in the northern section, it results in a density of 16 individuals per km² for the 461 km² study area which included large areas of clearly unsuitable habitat for the rail. Thus by this method a total of about 7,300 individuals is estimated (16 individuals x 461 km²). These estimates are based on a conservative assumption that all individuals have responded to playback which may indeed not be the case. Only a few birds were recorded closer than 30 m at the observers although the use of playback on the other hand may have attracted birds towards the observers before responding.

The population of Junín Rail was estimated at 600–1,700 mature individuals (BirdLife International 2014). Another estimation based on records obtained during 2008–2009 in the eastern and western part of the lake and by using mist-nets outside Ondores, was about 2,000 individuals (Chamorro *et al.* 2010). The range of Junín Rail is the smallest of any taxon in the "Black Rail" *L. jamaicensis* group, including *L. j.salinasi* of Chile, *L. j. murivagans* of coastal Peru and *L. spilonota* of the Galapagos Islands (Taylor 1996).

Since night surveys did not lead to additional records, we consider the 2014 daytime survey to be effective for recording Junín Rail. However, it is known to be active during the dark hours by flying over the margins of the swamp at the village of Ondores in February (C. Zevallos pers. comm.) and during the night survey in February 2014 two flying birds were recorded.

Vegetation and grazing

Junín Rail was found in two main habitat types. Outside the village of Ondores, the rail was found in humid tussock swamp habitat of 50 cm to 1 m tall *Festuca* vegetation extensively grazed by cattle, while in the north-eastern and northern sections and certain areas in the western section it was recorded at apparently high densities in extensive areas with patchy ground and 1.5 m tall *Juncus balticus*. The results indicate that the water and grazing levels are key parameters. It has been suggested for Black Rail *L. jamaicensis* that vegetation structure may be more important than plant species composition (Taylor 1996) and this may be the case for Junín Rail as well. It is assumed not to be a genuine swimmer (see also Taylor 1996 for *L. jamaicensis*), which may explain its restriction to marginal marsh habitats at the lake.

At several places the changes in habitat structure are abrupt because of shifts in moisture and access for grazing animals. In the meadows outside the village of Ondores, a fence prevented sheep from grazing in a tussock swamp with tall *Festuca* vegetation, and this area had Junín Rail. In other grazed areas there was no suitable vegetation cover for the species. Similar examples were observed in the northern section where fenced pastures abruptly changed to tall stands of *Juncus balticus* where Junín Rail was recorded. Grazing pressure was high all the way around the lake and the fact that Junín Rail is not recorded in intensively grazed areas suggests that grazing is a main factor limiting the distribution of marsh vegetation that provides essential cover for the rail. Overgrazing was considered as a major threat to the wetland habitat of Austral Rail *Rallus antarcticus* in Argentina and Chile (Barnett *et al.* 2013). In the wet season, rising water levels may force the rails landwards, and this is where the most intensive grazing occurs and the threat from common domestic predators is likely to be greatest. Hence, intensive grazing will seriously constrain the distribution of the rail´s habitat.

Burning of marsh especially in the dry season is done by farmers to increase their pasture areas. Burning destroys rail habitat and the loss of rail nests has been observed (ECOAN 2010). Due to awareness raising and training of farmers, the burning has decreased and is today quite rare (ECOAN 2010, C. Zevallos pers. comm.). Our study reveals that the Junín Rail had the greatest overlap with Puna Snipe as well as Correndera Pipit and Plumbeous Rail. However, while the latter species was present in vegetation of *Juncus* and *Schoenoplectus*, Puna Snipe and Correndera Pipit was most often found among the *Festuca dolichophylla* tussocks.

Around Junín Lake, domestic dogs are common and are used for herding of sheep, cattle or llamas. Andean fox (Culpeo fox) *Pseudalopex culpaeus* was recorded on two occasions and can be considered a potential predator in line with domestic dogs, while flying predators are of limited importance. The colocolo or pampas cat *Leopardus colocolo* is found in the *Juncus* vegetation (Fjeldså 1983a) and will be a potential predator as well. Predation and possibly disturbance can be important factors in determining the distribution and density of Junín Rail. High densities of

Junín Rail were recorded in the most remote parts of the inner marsh (e.g. the northern section well away from settlements) and with limited access to feral dogs but quantitative studies are lacking to determine the importance of these factors.

Water level

Inundation of the extensive marsh zone with shallow water may be crucial for the Junín Rail. By far the majority of the records (85%) were in areas with less than 5 cm of standing water interspersed with firm but moist ground; here the shallow water with short vegetation of *Lilaeopsis*, *Lachemilla*, *Hydrocotyle* and *Ranunculus limoselloides* is often teeming with aquatic arthropods. No records were obtained in areas with water levels above 20 cm. A dead bird was found on 14 February (deposited at the Zoological Museum of Copenhagen as a loan) and dead birds have been reported annually in the wet season in February and March, presumably immatures which may have drowned (C. Zevallos pers. comm.). Sudden flooding resulting in rapidly rising water levels may have a severe impact on breeding success and survival, and depends on spells of bad weather, as well as the regulation of water levels at the Upamayo Dam. Moreover, a rapid increase in water table may force birds into areas where they are more exposed to predators and unsuitable habitat.

Water contamination from local mining activities is assumed to seriously have affected the waterbird community (ECOAN 2010) and fish populations have collapsed (SERNANP pers. comm.). The effect of contamination on the population of the Junín Rail is unknown. The species lives in the rather dense inner marsh vegetation and depends on invertebrates, larvae and seeds (Taylor 1996, ECOAN 2010) and it is assumed that invertebrate assemblage will depend on the water quality (e.g. Passuni and Fonkén 2015), but further studies are needed.

Methodological considerations and future research needs

Census of elusive waterbirds such as rails in a large wetland is notoriously difficult and the Junín Rail is no exception. The point count method used in this study, however, proved to be effective compared to more systematic surveys and can therefore be recommended in future studies, with modifications depending on the scope of the study. Transect counts are largely impossible in the marsh and spot-mapping difficult and time consuming, because only small areas are accessible. Undertaking the census during daytime proved to be optimal as the birds responded well to playback in contrast to night-time. Furthermore, an initial silence of 5 minutes with no play back found no birds; but the noise from observers walking between points in the marsh should be taken into consideration and for this reason the initial period of silence may be needed. One of the challenges in the preparations was how to select blocks for survey at random, given the difficult access to many parts of the wetland. A study of the globally threatened Austral Rail in Argentina and Chile (Barnett *et al.* 2013) did use playback but a different census technique of walking at moderate pace following along the edges of rushes or grassy areas and playing song bouts every 100–150 m and waiting up to 20 min for a response. Using this method they surveyed 58 different localities and recorded the elusive Austral Rail at 22, but did not attempt to collect quantitative data on habitat variables or species density.

Future surveys may carefully map the potential habitats based on the results from this study and targeted research could include tagging Junín Rail to monitor movements in relation to feeding opportunities and fluctuating water level. It is crucial to understand such home range movements to better understand the habitat bottlenecks in the wet and dry seasons where birds may be forced towards the marsh margins by the rising water levels, or when some areas dry out they will be prone to burning and/or become accessible to predators and grazing.

Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/S0959270916000599

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