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POPULATION STATUS OF THE RUDDY-HEADED GOOSE (*CHLOEPHAGA RUBIDICEPS*) IN TIERRA DEL FUEGO AND MAINLAND PATAGONIA (CHILE AND ARGENTINA)*

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Resumen. – Situación de la población del Canquén (Cauquén) Colorado (*Chloephaga rubidiceps*) en Tierra del Fuego y Patagonia continental (Chile y Argentina). – La población del Canquén (Cauquén) Colorado (*Chloephaga rubidiceps*) que cría en Tierra del Fuego (Chile y Argentina) y Chile continental e inverna en el sur de Buenos Aires (Argentina) ha sufrido una seria disminución desde los 50s y recientemente su tamaño poblacional se calculaba en 300–400 individuos. Durante Diciembre 1999 y Marzo 2000, se realizaron censos y se estudió su distribución durante la cría. Los cauquenes fueron observados casi exclusivamente en vegas (mallines) de la estepa. Para el sector chileno, se utilizó una imagen satelital LANDSAT-7, con el fin de localizar hábitat potenciales para la especie (cubriendo el 90% de estos). En Diciembre 1999, se contaron 768 Cauquenes Colorados (634 adultos, 134 crías de 32 nidadas) y en Marzo 2000, un total de 793 individuos (adultos y juveniles). El tamaño poblacional post-reproductivo se calculó en 900 individuos, siendo esta una estimación mínima, ya que, existen áreas potenciales aún no estudiadas. Los grupos familiares se concentraron en pocos sitios en Chile continental, los que se caracterizaron por la presencia de humedales que ofrecían protección contra la predación de zorros. Este tipo de hábitat prácticamente no existe en Tierra del Fuego, donde los cauquenes probablemente no nidifican por falta de sitios reproductivos seguros. La cría exitosa estuvo limitada a escasos sectores, donde el éxito reproductivo es altamente susceptible a las perturbaciones locales. Es imperativo implementar acciones concretas de conservación para estos "sitios claves". La introducción del zorro gris patagónico (*Dusicyon griseus*) en Tierra del Fuego aparece como el principal factor responsable de la disminución y escasa recuperación poblacional. El éxito en la recuperación de esta especie dependerá a largo plazo de la implementación de medidas para incrementar las oportunidades de reproducción en Tierra del Fuego y el continente, mediante la inundación temporal de vegas para reducir el acceso de los zorros a las áreas de nidificación.

Abstract. – The population of the Ruddy-headed Goose (*Chloephaga rubidiceps*) which breeds in Tierra del Fuego (Chile and Argentina) and nearby mainland Chile and winters in the southern Buenos Aires province in Argentina has seriously declined since the 1950s. Recently, the population was estimated at 300–400 individuals. During December 1999–January 2000 and March 2000, surveys of numbers and distribution

*We dedicate this paper to the memory of Pablo Canevari († 22 March 2000) as a tribute to his strive for the conservation of wetlands and waterbirds in South America.

were carried out in the breeding area. Ruddy-headed Geese were almost exclusively associated with wet marshes ("vegas") in the steppe zone. A LANDSAT-7 satellite scene covering the Chilean breeding range was used to locate potential habitats used by the geese. More than 90% of potential areas were surveyed. During December 1999–January 2000, 768 geese (634 adults and 134 young in 32 broods) were counted, and during March 2000, 793 adults and juveniles. The post-breeding population size was estimated at 900 individuals, which was a minimum because potential areas north of the known breeding range remained unsurveyed. Family groups were concentrated in few areas in mainland Chile. Brood-rearing sites were characterized by swamps and/or open water offering retreat in case of predation attempts by foxes. Such habitats are generally lacking in Tierra del Fuego. In Tierra del Fuego, the geese probably refrain from nesting due to lack of predator-free breeding habitat. Successful reproduction is restricted to few areas making productivity highly sensitive to local perturbations. The effective protection of the areas of high breeding success is imperative. The introduction of the grey fox (*Dusicyon griseus*) to Tierra del Fuego seems to be the major factor causing the decline and subsequent lack of recovery of the population. In the longer-term, the restoration of the population will require improved opportunities for breeding in Tierra del Fuego, most realistically achieved by reducing fox access to nesting and brood-rearing areas by temporary flooding of vegas. *Accepted 22 August 2002.*

Key words: *Chloephaga rubidiceps*, conservation, Ruddy-headed Goose, grey fox, population size, Patagonia, Tierra del Fuego.

INTRODUCTION

The Ruddy-headed Goose (*Chloephaga rubidiceps*) occurs in two populations in the southernmost South America: one sedentary population in the Malvinas/Falkland Islands and one migratory population which breeds in Tierra del Fuego (Chile and Argentina) and nearby mainland Chile, and winters in the southern Buenos Aires province, in Argentina. Since the 1950s, serious declines in abundance of the mainland population have been reported, although the historical numerical evidence is weak (e.g., Rumboll 1979, Vuilleumier 1994, Canevari 1996). Based on censuses in the breeding areas in 1985–1988, Vuilleumier (1994) estimated the population at less than 1000 individuals. Intensified surveys carried out in the breeding as well as the wintering range during 1996–1997 resulted in a population estimate of 300–400 individuals, and only few breeding records were made (Gibbons *et al.* 1998). Hence, the available information suggests that the population is in serious risk of extinction.

The reasons for the decline are unknown, but several explanations have been suggested: (1) increased predation of eggs and young by the grey fox (*Dusicyon griseus*) (Rumboll 1975, Canevari 1996) which was introduced to Tierra del Fuego in the 1950s (Jaksic & Yañez 1983); (2) large-scale collection of eggs in the breeding area during the 1940s–1970s and excessive shooting in the wintering quarters, both actions resulting from geese considered an agricultural pest (Weller 1975, Rumboll 1979, Martin *et al.* 1986); (3) the disappearance of tall grass in the lowlands due to overgrazing by sheep (Fjeldså 1988); (4) competition with the more numerous goose species, the Ashy-headed Goose (*C. poliocephala*) and, especially, the larger-sized and hence dominant Upland Goose (*C. picta*) (Vuilleumier 1994); and (5) sports shooting of geese in the breeding grounds and migratory stop-over areas (Canevari 1996, C. Vinci & R. Lini *in litt.*).

During late November 1999 to late March 2000, we carried out a study of Ruddy-headed Geese in Fuego-Patagonia with the aim to update the status of the population and to describe habitat utilization and behavior of

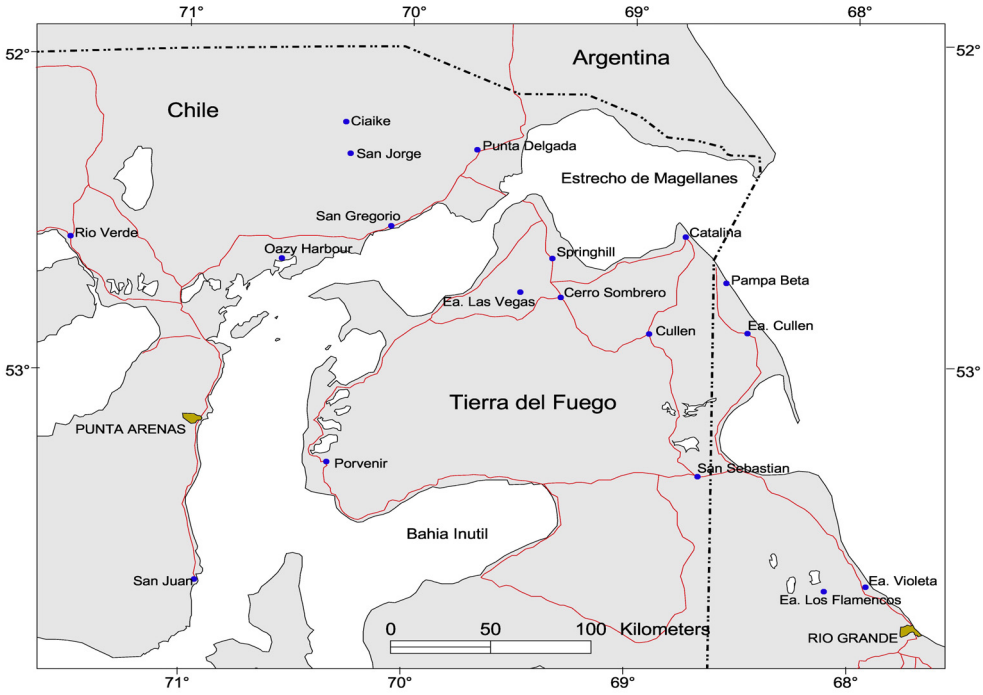

FIG. 1. Study area in mainland Patagonia (Chile) and on Tierra del Fuego (Chile and Argentina). Major roads are shown by lines and the Argentina-Chile border by interrupted line.

the geese, which would hopefully contribute to an understanding of the reasons behind the poor performance of the population.

In this paper we present an update of the numbers and distribution of the mainland population of the Ruddy-headed Goose in the breeding range, and we describe habitat characteristics of brood-rearing areas and feeding areas of non-breeding birds. Finally, we review the current knowledge of potential factors affecting the breeding output of the population, and we suggest options for management and needs for further research.

METHODS

Study area. During the austral spring and summer, the Ruddy-headed Geese occur in the steppe zone of the northern part of Tierra del Fuego and on the Chilean mainland of Patagonia north of the Magellan Strait. South of Punta Arenas, in Chile, the Ruddy-headed Geese also occur in grassland clearings in river mouths in the forest/steppe ecotone. The undulating lowland steppe landscape is dissected by small rivers and streams forming small valleys and dotted, in the lowest parts and in depressions, with ponds, lagoons and temporary flooded wetlands locally called "vegas" or "mallines" (Collantes & Faggi 1999). Tussock-grass vegetation of *Festuca gracillima* dominates the steppes, with varying degree of coverage by shrub plants, the most abundant of which is *Chiliotrichum diffusum*, and patches of heathland with *Empetrum rubrum*. Vegas are common in lowlands and valleys, with abundant grasses dominated by *Deschampsia antarctica, Hordeum halophilum* and

Festuca magellanica, and forbs like *Juncus scheuchzerioides, Carex vallis-pulchrae* and *Caltha sagittata* (Collantes & Faggi 1999). In some vegas, re-seeding has taken place with alien *Poa* spp. and other grasses (Moore 1983). In valleys with poor drainage and slowly flowing waters, shallow swamps with submerged vegetation dominated by *Hippuris vulgaris* are formed. Along ponds, swamps and streams, a wet Juncaceae dominated community forms a transition zone with the *Festuca-Poa* spp. dominated grassland.

Surveys. Surveys were carried out by the authors in two periods: 25 November to 13 December 1999, with additional observations during 28–30 January 2000, and 14–24 March 2000. The surveys covered the steppe zone of Tierra del Fuego (north of latitude 54ºS) and the Chilean mainland from San Juan in the south to Punta Delgada and Ciaike-San Jorge (south of latitude 52°S) in the north (Fig. 1). The aim of the first survey was to cover the distribution and numbers of Ruddy-headed Geese during the breeding period, while the second survey was carried out to describe post-breeding distribution and numbers.

The surveys focused on all areas known from the censuses in 1996–97 (Gibbons *et al.* 1998) and 1992–98 (Argentina only) (Benegas 1997), with a bigger effort done in the San Juan, San Gregorio, Springhill-Cerro Sombrero areas in Chile, and at Estancia Cullen, Estancia Los Flamencos and TF1-Las Violetas in Argentina (Fig. 1).

To make a more complete coverage of the Chilean part of the range, a scene from the LANDSAT-7 remote sensing satellite taken on 18 September 1999 was obtained from the US Geological Surveys (data granule SC:L70RWRS.002:2000230269 LANDSAT-7 Level-OR WRS-SCENE V002, hhtp://edcwww.cr.usgs.gov/landdaac) to locate hitherto unknown potential sites. On 18 September 1999, the study area was largely free of clouds, except for the hills east of a line from Cerro Sombrero to Porvenir in Tierra del Fuego. In the field we took several positions with a handheld GPS (Garmin 12), for subsequent correction of the satellite imagery to geographical coordinates.

Based on the satellite imagery, classification of vegetation zones was carried out by visual inspection of areas with different reflections. From 18 September to early December 1999, some of the vegas became drier. As a result, the satellite imagery showed the maximal extent of wet areas. Areas of wetlands (swamps, wet and dry vegas, respectively) were digitized for the San Gregorio area (580 km^2) to obtain a relative distribution of different types of habitat.

During the March 2000 survey and with the purpose of locating hitherto unknown potential sites, a vegetation map was used for the Argentine side of the island (M. B. Collantes unpubl.).

Counts of geese were made using binoculars and telescopes (20–60 x zoom). Each Ruddy-headed Goose locality was positioned with the help of GPS. In the Chilean range all birds were plotted on a detailed print of the satellite imagery.

In randomly selected areas with a good overview, we described habitat use by Ruddy-headed Geese, assigning to each individual that was observed while feeding a given habitat type and the estimated distance to the nearest body of open water (river, stream, pond, lagoon, coast) (Madsen *et al.* in prep.).

Searches for hitherto unknown sites were targeted using the vegetation characterization from the satellite imagery for Chile and the vegetation map for Argentina coupled with our observational description of habitat use by Ruddy-headed Geese. Within the known range, the vast majority of potential sites were visited. To check potentially suitable areas outside the known range of the Ruddy-hea-

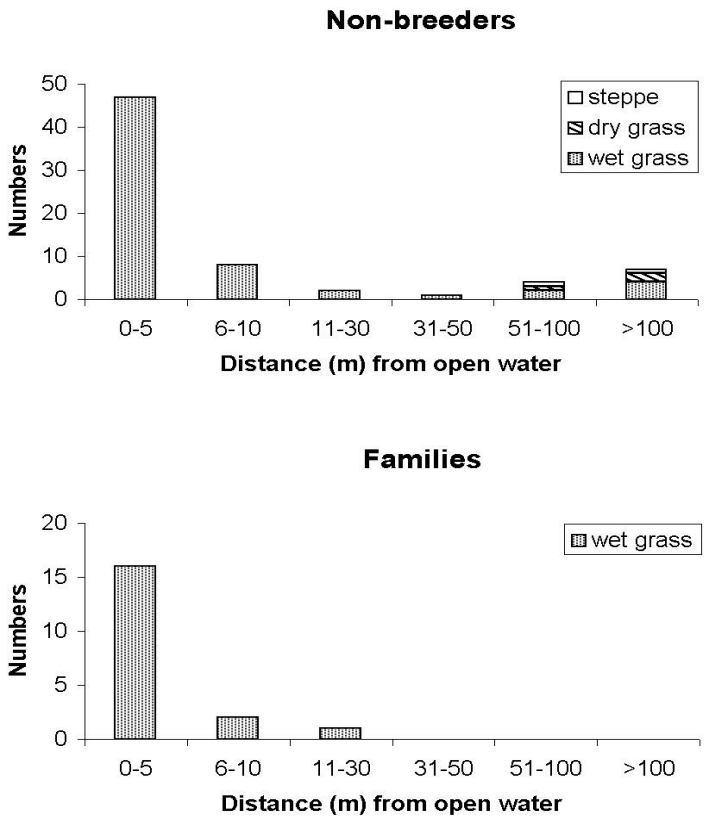

FIG. 2. Habitat use by non-breeding individuals and family groups of Ruddy-headed Geese (*Chloephaga rubidiceps*) expressed as the number of groups (group size ranging from one to six individuals) observed in relation to the distance of the group from open water.

ded Goose, trips were made to areas south of Rio Grande, northwest of San Juan, and to Rio Verde northwest of Punta Arenas.

Brood records. During December 1999 (and supplemented in January 2000), brood sizes of goose families were recorded, and the approximate age (in weeks) of the young was estimated based on size and plumage development, using a classification developed for northern Hemisphere true geese (Anserini) (Owen 1980). Upland Goose young develop flank feathers at an age of four weeks and fledge at an age of about 70 days (Summers 1983). As this development is similar to that of true geese of the same size, we can safely assume a similar timing in Ruddy-headed Geese. From the estimated age, the date of first egg laying was then calculated, assuming an average clutch size of five eggs, an incubation period of 30 days and an interval of two days between each egg laid (Summers 1983, Summers & McAdam 1993). To compare our data with those from previous years, we included records of broods with age estimation from 1992, 1997, and 1998 (R. Matus unpubl., Benegas 1997).

During March 2000, we attempted to record the number of juveniles in the flocks of Ruddy-headed Geese.

TABLE 1. Counts of Ruddy-headed Geese (*Chloephaga rubidiceps*) and Upland Geese (*C. picta*) in mainland Patagonia (Chile) and in Tierra del Fuego (Chile and Argentina), 25 November–13 December 1999, with additional data from January 2000. The number of non-breeding Upland Geese was not systematically counted and therefore not included in the table.

	Ruddy-headed Goose			Upland Goose	
	No. adults	No. broods	No. youngs	No. broods	No. youngs
Mainland Chile					
San Gregorio	222	25	107	21	79
Oazy Harbour-Puesto Panteón-Ciaike[a]	50	0	0	0	0
San Juan[b]	88	5	25	2	5
Punta Delgada	17	0	0	1	5
Subtotal	377	30	132	24	89
Chilean part of Tierra del Fuego					
Springhill-Cerro Sombrero	223	2	2	2	7
Bahia Inutil	3	0	0		
Subtotal	226	2	2	2	7
Argentine part of Tierra del Fuego					
TF1-Ea. Flamencos-Los Chorillos	20	0	0	0	0
Ea. Cullen-Pampa Beta	11	0	0	0	0
Subtotal	31	0	0	0	0
Total	634	32	134	26	96

[a]Surveyed 30 January 2000 (R. Matus).
[b]The number of broods and young as surveyed 28 January 2000 (R. Matus).

Fox abundance. To obtain a crude index of fox abundance, we recorded the number of foxes and fox dens/cubs observed during day trips in December 1999. The daily sum of the number of adult foxes sighted was used to compare relative abundances in Tierra del Fuego and the Chilean mainland.

RESULTS

Habitat use. During December 1999, non-breeding Ruddy-headed Geese (single individuals, pairs, groups of pairs) foraged almost exclusively in the wet zones of vegas (93% of individuals); only 4% were observed in dry vegas and 3% in the *Festuca* steppe. Sixty-eight percent foraged within a distance of five meters from open water (Fig. 2). Fifty-eight percent were observed in relation to streams, 32% in relation to ponds.

Families were observed exclusively in the wet vegas, and 84% foraged within five metres of open water. Eighty-seven percent were observed in relation to ponds/swamps/coasts and 13% in relation to streams.

During March 2000 in Tierra del Fuego, 75% of Ruddy-headed Geese (single individuals, pairs, groups of pairs) were foraging in wet vegas. Ten percent were sighted in dry vegas and another 15% were registered foraging in the *Festuca* steppe and in sheep grazed fens very close to farm buildings.

In the San Gregorio area (total 580 km^2), swamps made up 1% of the total area; wet vegas 2%, and dry vegas 3%. The remaining 94% were covered by various types of dry steppe vegetation and barren ground.

Coverage of surveys. Based on our gained knowledge of habitat use, we searched for geese in

TABLE 2. Counts of Ruddy-headed Geese (*Chloephaga rubidiceps*) in mainland Patagonia (Chile) and in Tierra del Fuego (Chile and Argentina), 14–24 March 2000.

	No. adults	No. broods	No. youngs
Mainland Chile			
San Gregorio	246	2	8
Oazy Harbour-Puesto Panteón-Ciaike	43	1	1
San Jorge[a]	7		
San Juan	3	2	5
Punta Delgada	30	0	0
Subtotal	329		14
Chilean part of Tierra del Fuego			
Springhill-Cerro Sombrero	306	0	0
Cullen area[a]	60	0	0
Road Cerro Sombrero-San Sebastián	41	0	0
Bahia Inutil[b]	-	-	-
Subtotal	407	0	0
Argentine part of Tierra del Fuego			
TF1-Ea. Flamencos-Los Chorillos	41	0	0
Ea. Cullen-Pampa Beta	2	0	0
Subtotal	43	0	0
Total	779	6	14

[a]Not surveyed in December 1999–January 2000.
[b]Not surveyed in March 2000.

all wet vegas that could clearly be identified on the satellite imagery. We estimate that more than 90% of all swamps and wet vegas were visited in the Chilean range. Thus, compared with the 1996–97 survey, the 1999 coverage was improved considerably. In San Gregorio, approximately 20% of the area was covered in 1996–97 compared to 1999; in Springhill-Cerro Sombrero 40%, while in San Juan 100%. The Punta Delgada and Ciaike-San Jorge areas were not visited in 1996–97.

For the Argentine side of Tierra del Fuego the coverage was not assessed in detail, but in view of good local knowledge (Benegas 1997), we assume that coverage was close to complete.

Numbers and distribution. During December 1999–January 2000, the number of adult Ruddy-headed Geese counted was 570 nonbreeding birds and 32 pairs with young, totaling 634 adults. A total of 134 young was registered, so the total number counted was 768 Ruddy-headed Geese (Table 1).

During March 2000, the number of adult Ruddy-headed Geese counted was 779; 14 young were registered in mainland Chile and Tierra del Fuego, yielding a total of 793 individuals (Table 2). In the same month, the discovery of new localities with Ruddy-headed Geese in northern Chilean Tierra del Fuego (along the road from Cerro Sombrero to San Sebastián and to the Cullen area) and north of San Gregorio (San Jorge) in mainland Chile yielded 108 additional individuals. Assuming that these geese were also there in December 1999, the difference in numbers counted in December 1999 and March 2000 was 83 individuals. The difference in numbers of young/juveniles between the two surveys is probably primarily due to difficulties in field identification of juveniles in March.

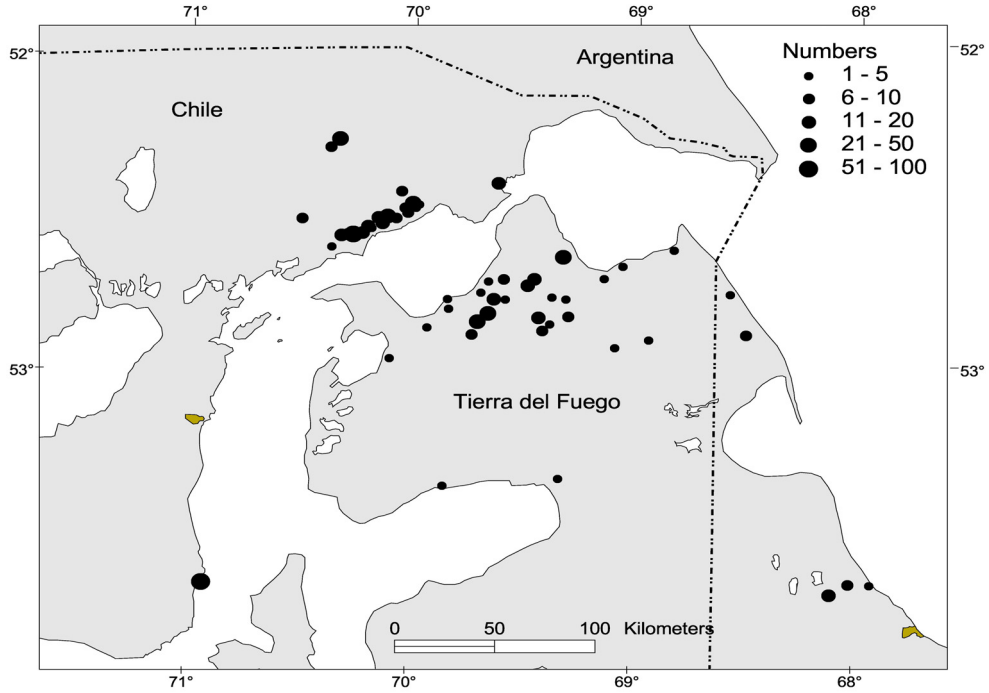

FIG. 3. Distribution of Ruddy-headed Geese (*Chloephaga rubidiceps*) during the survey in December 1999, supplemented by observations in January 2000.

The December 1999–January 2000 census showed that the majority of Ruddy-headed Geese was concentrated around San Gregorio (49% of total numbers), Springhill-Cerro Sombrero (29%) and San Juan (15%) (Table 1; Fig. 3). During March 2000, the majority was concentrated in the Chilean part of Tierra del Fuego (51%) and at San Gregorio (39%), whereas only 1% was registered at San Juan (Table 2; Fig. 4).

During December 1999–January 2000, twenty-five families were observed in the San Gregorio area, five in San Juan and two in Estancia Las Vegas south of Springhill. Hence, in most areas in Tierra del Fuego and at Punta Delgada there was no evidence of breeding activity. Lack of breeding was confirmed by the observation of generally passive behavior of pairs; in San Juan, most Ruddy-headed Geese were flocking with Upland Geese and Ashy-headed Geese.

For comparison, the number of broods of Upland Geese observed during December 1999–January 2000 is included in Table 1. This species showed similar geographical variation in breeding success as the Ruddy-headed Geese.

Brood sizes and time of egg-laying. The average brood size in the 32 Ruddy-headed Goose broods observed in December 1999–January 2000 was 4.4 ± 2.8 (mean ± SD) (range 1–12). The estimation of time of egg-laying shows that the first pairs started during mid September, with a peak during the first two weeks of October (Fig. 5). Observations from earlier years show similar distribution. Late egg-laying dates

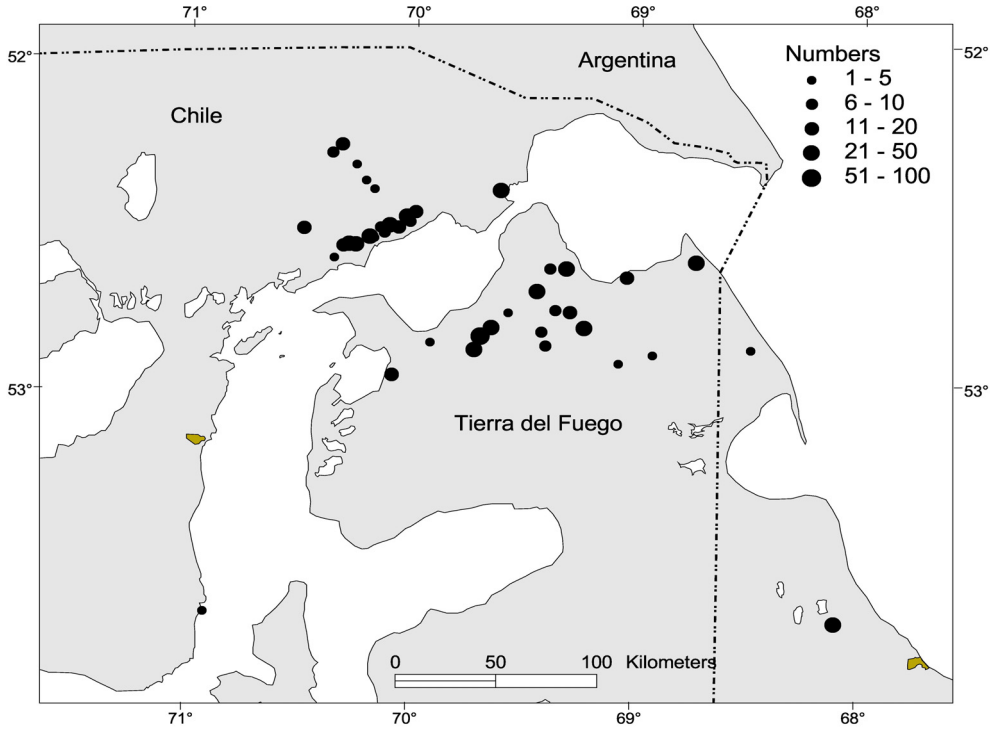

FIG. 4. Distribution of Ruddy-headed Geese (*Chloephaga rubidiceps*) during the survey in March 2000.

are likely to represent replacement clutches.

Abundance of foxes. Grey foxes were frequently registered in both Tierra del Fuego and mainland Chile. During December 1999, the average daily number of foxes for the three day's trip in the Argentine part of Tierra del Fuego was 10; in the Chilean part of Tierra del Fuego, six foxes (three day trips) and in the Chilean mainland eight foxes (five day trips). Hence, there appeared not to be major differences in abundance between areas.

DISCUSSION

Population estimate. The numbers of 768 and 793 Ruddy-headed Geese observed during the two surveys in December 1999–January 2000 and March 2000 represent a minimum population size for two reasons. Firstly, we probably missed some birds within the known range due to the dispersion of birds in small groups in correlation with the distribution of suitable habitat in some part of the surveyed range. Secondly, we failed to locate all sites outside the known range. With an approximate coverage of 90% of all suitable habitat within the known range, the estimated summer population is approximately 900 individuals including young birds. This remains a minimum population estimate, because we may still miss sites outside the known breeding range, for example in the river catchment areas north of San Gregorio (Chile) and in the southern Santa Cruz province (Argentina) (S. Imberti pers. com.).

The population estimate based on the

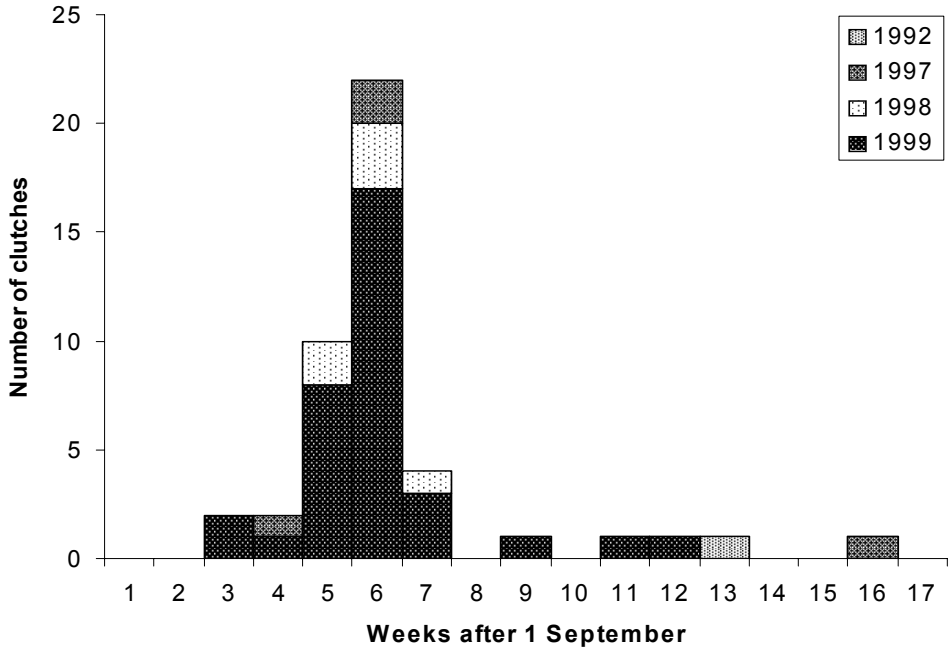

FIG. 5. Timing of laying of first egg of Ruddy-headed Geese (*Chloephaga rubidiceps*), extrapolated from the age of young in broods observed during 1992–1999.

1999–2000 survey almost triples the previous estimate of 300–400 individuals based on surveys in breeding areas in 1996–97 and wintering areas in 1996–97 and 1999 (Gibbons *et al.* 1998, Blanco *et al.* unpubl.). The apparent increase represents probably improved coverage of the breeding range and not a genuine population increase, since numbers in breeding areas with good coverage in 1996–97 were similar to those in 1999–2000 (see also Vuilleumier 1994 for 1985–1988 and 1993).

The question of where the additional individuals spend the winter is open. From observations in Tierra del Fuego and mainland Chile, it is documented that the majority of birds leave in late April/early May and reappear in late August. However, few individuals have been observed in San Gregorio in July (R. Matus unpubl.). Possibly, more birds stay in the newly discovered areas. Furthermore, not necessarily all geese spend the winter in the Buenos Aires province but somewhere else, not yet discovered.

Habitat use. Our observations of habitat use showed that Ruddy-headed Geese forage in the narrow wet zone of vegas. During brood-rearing, the zone which is used is even narrower, probably because they need the proximity to open water as a refuge for the young in case of attempts of predation by terrestrial predators. In three cases where we observed Grey foxes approaching Ruddy-headed Goose families feeding close to a pond, the families ran to the water edge and swam to the other side of the pond (Madsen *et al.* in prep.).

Characteristics of brood-rearing areas. Observa-

tions of behavior and spacing of families showed that parental Ruddy-headed Geese defend a territory, not only intraspecifically but also against Upland Geese. Hence, in a study area in San Gregorio families of Upland and Ruddy-headed Geese partitioned the suitable marshes with close access to open water (Madsen *et al.* in prep.). Summers (1983) showed that Upland Geese maintained a territory from the time of pre-nesting to fledging of the young, although some pairs moved from nesting to nearby post-hatching areas. Assuming that Ruddy-headed Geese maintain the same territory throughout breeding, or only move a short distance between nesting and post-hatching territories, we can compare areas with successful hatching with areas without hatching success. Brood-rearing areas (and assumed nesting areas) are characterized by wet vegas with ponds, swamps or estuaries with islets that provide protection against fox predation during nesting and brood-rearing. In most sites in Tierra del Fuego, these habitat features are lacking (except for Estancia Las Vegas) and there, geese stayed along streams or edges of lakes (with no islets). Some of the pairs showed territorial behavior (aggression and extreme alertness by males) but with no sign of nesting activity. It is possible that pairs due not attempt to nest at all because of high predator abundance. In Brent Geese (*Branta bernicla*) it is known that in years with high abundance of Arctic foxes (*Alopex lagopus*) in the breeding areas, the geese do give up the attempt to nest, except for islets free from foxes (Madsen *et al.* 1992, Spaans *et al.* 1998).

In order to reveal causal relationships affecting nesting success, there is an imminent need for studies of nesting behavior and habitat use during late September through October.

Causes of decline and lack of recovery. Grey foxes are abundant in the mainland as well as in Tierra del Fuego and successful breeding by Ruddy-headed Geese seems to be achieved only in sites that offer safe brood-rearing (and probably nesting) areas. Before the introduction of the Grey fox to Tierra del Fuego (Jaksic & Yañez 1983), geese were probably not so dependent on sites with such characteristics, because no natural terrestrial predator existed in the steppe zone (except for aboriginal Indians). It is therefore highly likely that the introduction of foxes has been the main cause of the decline and subsequent lack of recovery of the Ruddy-headed Goose. The observation that Upland Geese showed the same geographical difference in breeding success as Ruddy-headed Geese indicates that the fox predation problem may be more general.

With regard to the other suggested causes of decline, they may very well have been contributing factors. The large-scale egg collection, which primarily took place in Argentina, probably aggravated the reduction. However, despite the stop of egg collection in the 1970s, the population did not recover, suggesting that one or more other factors were controlling the population size (Vuilleumier 1994). The disappearance of the tall-grass steppe vegetation due to sheep grazing, especially along rivers and around lakes, may have caused losses of nest cover (Fjeldså 1988). On the other hand, sheep grazing and ranching have facilitated goose usage partly because sheep have opened much habitat and partly because the introduction of pasture grasses such as *Poa pratensis* has lead to improved food quality (Summers & Grieve 1982).

Interspecific competition for food resources is probably not a major problem outside brood-rearing areas. We recorded many suitable feeding areas which were not used or only extensively used by either Ruddy-headed Geese or Upland Geese. However, our observation suggest that at

present the available suitable area for brood-rearing (and probably nesting) is restricted to the wet vegas with swamps and ponds, primarily found in San Gregorio. At one study site in San Gregorio, the marsh was partitioned between Upland and Ruddy-headed Geese and territories were maintained by interspecific aggression (Madsen *et al.* in prep.). In this critical part of the annual cycle, interspecific competition for space may therefore be significant locally, potentially controlling the number of successful breeding pairs.

There exists no concrete information about past and present hunting pressure on Ruddy-headed Geese, but indiscriminate shooting and persecution in the wintering quarters are likely to affect the species (Canevari 1996, Blanco *et al.* unpubl.). We can only assume that at the present low population size any shooting will add significantly to natural mortality. Therefore, even the kill of tens of geese is likely to have a negative effect on population size.

'All eggs in one basket'. San Gregorio appears to be the major area where substantial reproduction takes place, while in Tierra del Fuego, reproduction is only sporadic. Despite several years of intensive monitoring since 1992, only two broods have been recorded in the Argentine sector of Tierra del Fuego (Benegas 1997 and unpubl.). We have no information about dispersal patterns within the population, but it is realistic to suggest that numbers in Tierra del Fuego can be maintained only with immigration of birds from the mainland. Hence, this may represent a case of a source-sink relationship, and the short-term future population development will depend on continued successful breeding in especially San Gregorio.

Management implications. The major anthropogenic threats to the Ruddy-headed Geese during the breeding period at present appears to be disturbance through human activity in the nesting and brood-rearing areas. Potentially disturbing activities include ranching, pipeline maintenance work, recreational activities and sport shooting. Because the most sensitive areas are so small, it appears that there is scope for taking effective protection measures to mitigate these negative effects by the creation of reserves with access regulations.

However, to restore the population to the levels it had in the 1940s and 1950s, our observations suggest that it will be necessary to find means to reduce fox predation of eggs and young. This can be achieved either by control of foxes or habitat management which will reduce fox access. The former may be possible in some specific areas; however, the control of foxes on large scale, e.g., in Tierra del Fuego, will require a massive campaign, to be coordinated between Chile and Argentina. Habitat management therefore seems to be the most realistic way forward for the immediate future. Reduced fox access can be achieved by temporary flooding of vegas by means of stems or dams, which will create islets and swamps with no fox access. Water levels should be maintained high at least from before egg-laying (preferably from the establishment of territories) to fledging of young, i.e., from approximately late August to late December). This type of water management is actually actively practiced in some farm areas to maintain wet and productive grasslands for sheep, for example in Estancia Las Vegas south of Springhill, the only area with successfully breeding Ruddy-headed Geese in Tierra del Fuego during this study. Several other areas have similar potential. To become operational, such habitat modification work will require active collaboration with landowners who need to understand potential conservation benefits as well as economic incentives in relation to sheep grazing opportunities.

CONCLUSION

The Fuego-Patagonian population of Ruddy-headed Goose was estimated at approximately 900 individuals. Successful reproduction is restricted to few areas making the productivity highly sensitive to local perturbations. Effective protection of the areas with good breeding success in San Gregorio and San Juan (mainland Chile) is imperative. Restoration of the population will require improved opportunities for breeding in Tierra del Fuego, most realistically achieved by reducing fox access to nesting and brood-rearing areas by temporary flooding of vegas.

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REFERENCES

Benegas, L. G. 1997. El Cauquen Cabeza Colorada en Tierra del Fuego (Arg.). Museo de Ciencias Naturales e Historia, Municipalidad de Rio Grande, Rio Grande, Argentina.

Canevari, P. 1996. The austral geese (*Chloephaga* spp.) of southern Argentina and Chile: a review of its current status. Gibier Faune Sauvage, Game Wildl. Sci. 13: 355–366.

Collantes, M. B., & A. M. Faggi. 1999. Los humedales del Sur de Sudamérica. Pp. 15–25 *in* Malvárez, A. I. (ed.). Tópicos sobre humedales subtropicales y templados de Sudamérica. UNESCO-ORCYT-MAB, Montevideo, Uruguay.

Fjeldså, J. 1988. Status of birds of steppe habitats of the Andean zone and Patagonia. ICBP Tech. Bull. 7: 81–95.

Gibbons, J. E., R. Matus, Y. A.Vilina, D. E. Blanco, S. Zalba, & C. Belenguer. 1998. Desarrollo de un plan de conservación para el Cauquén Cabeza Colorada (*Chloephaga rubidiceps*), en la región austral de Argentina y Chile. Internal report. Wetlands International, Buenos Aires, Argentina and CONAF, Santiago, Chile.

Humphrey, P. S., D. Bridge, P. W. Reynolds, & R. T. Peterson. 1970. Birds of Isla Grande (Tierra del Fuego). Smithsonian Institution, Washington, D.C..

Jaksic, F., & J. L.Yañez. 1983. Rabbit and fox introductions in Tierra del Fuego: history and assessment of the attempts at biological control of the rabbit infestation. Biol. Conserv. 26: 367–374.

Madsen, J., T. Bregnballe, & A.. Hastrup. 1992. Impact of the arctic fox *Alopex lagopus* on nesting success of geese in Southeast Svalbard, 1989. Polar Res. 11: 35–39.

Martin, S. I., N. Tracanna, & R. Summers. 1986. Distribution and habitat use of Sheldgeese populations wintering in Buenos Aires Province, Argentina. Wildfowl 37: 55–62.

Moore, D. M. 1983. Flora of Tierra del Fuego. Anthony Nelson, Oswestry, UK.

Owen, M. 1980. Wild geese of the world. B. T. Batsford, London, UK.

Rumboll, M. A. E. 1975. Notas sobre Anseriformes: el Cauquén de Cabeza Colorado

(*Chloephaga rubidiceps*), una nota de alarma. Hornero 11: 315–316.

Rumboll, M. A. E. 1979. El estado actual de *Choephaga rubidiceps*. Act. Zool. Lilloana 34: 153–154.

Spaans, B., H. Blijleven, I. U. Popov, M. E. Rykhlikova, & B. S. Ebbinge. 1998. Dark-bellied Brent Geese *Branta bernicla bernicla* forego breeding when arctic foxes *Alopex lagopus* are present during nest initiation. Ardea 86: 11–20.

Summers, R. W. 1983. The life cycle of the Upland Goose *Chloephaga picta* in the Falkland Islands. Ibis 125: 524–544.

Summers, R. W., & J. H. McAdam. 1993. The Upland Goose. Bluntisham Books, Huntingdon, UK.

Summers, R. W., & A. Grieve. 1982. Diet, feeding behavior and food intake of the Upland Goose (*Chloephaga picta*) and Ruddy-headed Goose (*C. rubidiceps*) in the Falkland Islands. J. Appl. Ecol. 19: 783–804.

Vuilleumier, F. 1994. Status of the Ruddy-headed Goose *Chloephaga rubidiceps* (Aves, Anatidae): a species in serious danger of extinction in Fuego-Patagonia. Rev. Chil. Hist. Nat. 67: 341–349.

Weller, M. W. 1975. Habitat selection by waterfowl of Argentine Isla Grande. Wilson Bull. 87: 83–90.