

Ruddy-headed Goose *Chloephaga rubidiceps*: former plague and present protected species on the edge of extinction

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Summary

The Ruddy-headed Goose *Chloephaga rubidiceps* has two separate and genetically distinct populations, one sedentary that inhabits the Malvinas/Falklands Islands and another migratory, which inhabits continental southern South America. New information suggests that these populations should be considered as different evolutionarily significant units. The latter population breeds in Austral Patagonia (Argentina and Chile) and overwinters in Central Argentina. It was a very common species in Austral Magellanic steppe grasslands before 1931, when it was declared an “agricultural pest” by the Argentinian government, together with other sheldgeese species. Since then, the continental Ruddy-headed Goose population has declined becoming one of the scarcest species in Austral Magellanic steppe. Nowadays, its population is categorised as critically endangered in Argentina and endangered in Chile. We present data from six road censuses conducted in the breeding areas of Santa Cruz and Tierra del Fuego provinces, Argentina, during 2013–2014 and 2014–2015 (>4600 km, 70 days) and review population trends of the Ruddy-headed Goose since the early 1900s. We counted a maximum of 19 individuals in Santa Cruz and 49 in Tierra del Fuego throughout the breeding season. A literature review indicates that during the last 40 years the size of continental population of Ruddy-headed Goose has been < 800 individuals, approximately 10% of the estimated population in the 1900s. This decline matches the period following the application of control techniques and the introduction of exotic predator species in the breeding grounds of Tierra del Fuego. We review and discuss formerly proposed conservation actions that may have a positive and rapid effect on sheldgoose numbers recovery. We suggest that the continental population of Ruddy-headed Goose should on a precautionary basis be treated as a critically endangered population until genetic studies determine whether we are in the presence of a new ‘Critically Endangered’ species.

Resumen

El Cauquén Colorado *Chloephaga rubidiceps* presenta dos poblaciones separadas y distintas genéticamente, una sedentaria que habita las Islas Malvinas/Falklands y otra migratoria que habita la zona continental sur de Sudamérica. Nueva información sugiere que dichos grupos deben ser considerados como unidades evolutivas significativas distintas. La población continental se reproduce en Patagonia Austral (Argentina y Chile) y pasa el invierno en la zona central de Argentina. Fue una especie muy común en la estepa magallánica antes de 1931, año en el que fue declarada “plaga agrícola” por el gobierno argentino junto a otras especies de cauquenes. Desde entonces, la población continental del Cauquén Colorado declinó, convirtiéndose en una de las especies más raras de la estepa magallánica. Hoy en día, su población está categorizada como en peligro crítico en Argentina y en peligro en Chile. Se presentan resultados de

seis censos terrestres realizados durante las temporadas reproductivas 2013-2014 y 2014-2015 en las provincias de Santa Cruz y Tierra del Fuego, Argentina (>4600 km, 70 días) y una revisión de la tendencia poblacional del Cauquén Colorado desde principios de 1900. Contamos un máximo de 19 individuos en Santa Cruz y 49 individuos en Tierra del Fuego durante la temporada reproductiva. La literatura revisada indica que durante los últimos 40 años el tamaño de la población continental del Cauquén Colorado ha sido de menos de 800 individuos, aproximadamente un 10% de la población estimada en el 1900. Dicha declinación coincide con el período posterior a la aplicación de técnicas de control y a la introducción de predadores exóticos en el área reproductiva de Tierra del Fuego. Revisamos y discutimos las acciones de conservación propuestas anteriormente que puedan tener un efecto positivo y rápido en la recuperación de los cauquenes. Sugerimos que la población continental del Cauquén Colorado sea tratada precautoriamente como en peligro crítico hasta que los estudios genéticos determinen si estamos en presencia de una nueva especie 'En Peligro Crítico'.

Introduction

The Ruddy-headed Goose *Chloephaga rubidiceps* is the smallest of the five South American sheldgeese in the genus *Chloephaga* (Casares 1934, Rumboll 1975). It has two separate populations, one sedentary that inhabits the Malvinas/Falklands Islands and another migratory which inhabits continental southern South America (Canevari 1996, Blanco *et al.* 2003). The latter population breeds in Austral Patagonia (Argentina and Chile) and overwinters in Southern Buenos Aires province (Central Argentina). Malvinas/Falkland Islands and continental populations are genetically distinct, reciprocally monophyletic and do not share mtDNA haplotypes (Bulgarella *et al.* 2013). These differences indicate that these populations should be considered as different evolutionarily significant units (Bulgarella *et al.* 2013). New evidence based on nuclear DNA provides extra evidence and reinforces this result (C. Kopuchian pers. comm.).

The Ruddy-headed Goose is generally associated with the Upland Goose *C. picta* and Ashy-headed Goose *C. poliocephala* (Carboneras 1992). The three species were once considered harmful to agriculture and declared "agricultural pests" by the Argentinian government in 1931 (Pergolani de Costa 1955). This promoted massive destruction of eggs at the breeding grounds, while hunting and the use of aircraft to move them away from crops were common control techniques in the wintering areas (Delacour 1954, Weller 1975, Blanco *et al.* 2003, Petracci *et al.* 2008). Since then, continental Ruddy-headed Geese populations, that were very common in Austral Magellanic steppe grasslands before 1950 (Crawshaw 1907, Blaauw 1916, Casares 1934, Olrog 1948), became extremely scarce. The increase in populations of introduced predators, such as South American grey fox *Pseudalopex griseus* and American mink *Neovison vison*, in the breeding grounds of Tierra del Fuego, combined with the disappearance of tall grasses due to overgrazing by sheep and cows, could also have facilitated the predation of eggs, chicks and adults.

Whilst the Malvinas/Falklands population appears to be of least concern (i.e. 40,000–80,000 mature individuals; Blanco *et al.* 2003, Wetlands International 2014), the maximum size recorded for the genetically distinct continental population during the last 15 years has been 779 adults (reproductive season 2000; Madsen *et al.* 2003). As a result, this population has been categorised as critically endangered in Argentina (AA/AOP and SAyDS 2008), endangered in Chile (CONAMA 2009), and was declared a "Natural Monument" in Buenos Aires and Santa Cruz provinces (Argentina).

In this work we present the results of recent censuses and a multi-source compilation of population data of the continental population of the Ruddy-headed Goose in order to encourage an urgent evaluation of the worrying conservation situation of the species. Finally, we discuss the different hypotheses on threats and the management actions that have been suggested and describe how unintended negative effects have changed with time.

Methods

Study site

The study was conducted in the breeding areas of continental Ruddy-headed Goose population in Argentina, in southern Santa Cruz Province (below latitude 51°38'S) and the northern part of the main Island of Tierra del Fuego Province (above latitude 54°07'S). These areas are included in the Magellanic steppe, dominated by the tussock grasslands, mainly *Festuca gracillima*, associated with bushy vegetation in varying percentages. Lowland parts are associated to shallow lakes, streams or temporary flooded areas called 'vegas' or 'mallines' where other grasses (*Deschampsia antarctica*, *Hordeum halophilum*, *Festuca magellanica*) as well as rushes and *Carex* spp. dominate (Madsen *et al.* 2003, Petracci *et al.* 2014).

Censuses

We conducted six censuses using the line transect census technique (Bibby *et al.* 1992). For each census, we conducted road transects following main and secondary roads in a vehicle at 40–60 km/h (Figure 1). We recorded the number of Ruddy-headed Geese observed in a strip of 500 m on both sides of the road. Observations were made using 10 x 42 and 8 x 32 binoculars, and

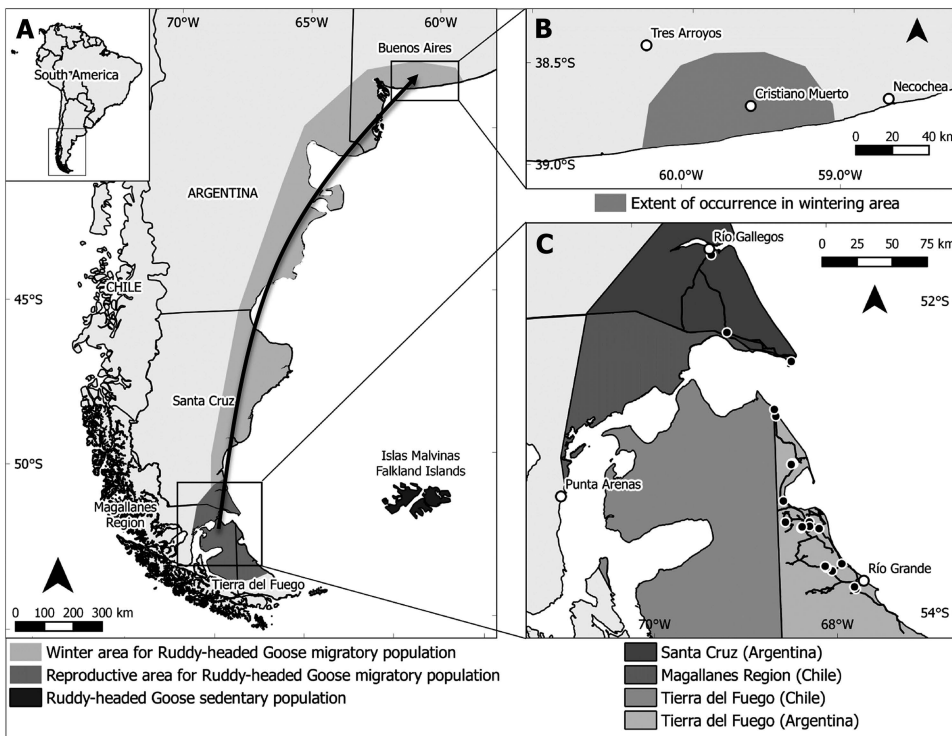


Figure 1. (A) Distribution of Malvinas/Falklands and continental Ruddy-headed Goose *Chloephaga rubidiceps* populations and possible migratory route (black arrow) based on BirdLife International (2015) and Petracci *et al.* (2014). (B) Winter grounds based on Petracci *et al.* (2014) showing extent of occurrence. (C) Reproductive grounds with locations with Ruddy-headed Goose sightings (black dots) in Santa Cruz and Tierra del Fuego (Argentina) and census transects (black lines) (present work). White dots indicate location of cities.

a 20–60 x spotting scope. We censused along 1,080 km in November–December 2013 (Santa Cruz and Tierra del Fuego, 18 days), 720 km in January–February 2014 (Tierra del Fuego, 9 days), 465 km in April–May 2014 (Santa Cruz and Tierra del Fuego, 9 days), 728 km in October 2014 (Santa Cruz and Tierra del Fuego, 10 days), 1,160 km in January–February 2015 (Santa Cruz and Tierra del Fuego, 11 days) and 464 km in April–May 2015 (Santa Cruz and Tierra del Fuego, 13 days). Even though all censuses were planned along the same transects, it was not possible to maintain survey effort across censuses due to strong road dependence on climatic conditions (melting snow and rain).

Bibliographic review

We sought information on Ruddy-headed Goose censuses or sightings in all available publications including “grey literature” (Appendix S1 in the online supplementary material). We included information collected between 1907 (year of the first publication with data on populations of Ruddy-headed Goose) and 2014, published in 12 scientific papers, eight technical reports and one book. We also included information from two conversations with experts. We extracted information on the date of the survey/sighting, type of survey methodology when reported (systematic census or isolated sighting), region and number of Ruddy-headed Goose adults, goslings or nests reported. From Imberti *et al.* 2007 we only extracted information from “Estancia Cóndor” since counts were not simultaneous at the different locations. Also, we extracted recommended management actions from 17 publications and grouped them into 10 different categories involving ‘habitat restoration’, ‘creation of protected areas’, ‘hunting control’, ‘outreach’, ‘promotion of scientific studies’, ‘cooperation policies’, ‘*ex situ* reproduction’, ‘control of invasive species’, ‘enclosures at the breeding areas’ and ‘economic compensation’, and indicated their level of implementation. We excluded actions that were out of date. ‘Region’ information was classified as *wintering grounds* (Buenos Aires and north of Rio Negro provinces, continental Argentina), *reproductive grounds of Santa Cruz province* (continental Argentina), *reproductive grounds of Magallanes* (continental Chile), *reproductive grounds of Tierra del Fuego province* (insular Argentina), and *reproductive grounds of Tierra del Fuego Chile* (insular Chile). Periods after 1970 were divided into decades. Since available data sets were the result of different or undefined survey methodologies and isolated records, for the evaluation of population trends we only used the maximum number of individuals recorded.

Results

Censuses

We counted 24 Ruddy-headed Geese (five in Santa Cruz and 19 in Tierra del Fuego) in November–December 2013, 37 in Tierra del Fuego in January–February 2014, 36 (nine in Santa Cruz and 27 in Tierra del Fuego) in April–May 2014, 26 (six in Santa Cruz and 20 in Tierra del Fuego) in October 2014, 56 (16 in Santa Cruz and 40 in Tierra del Fuego) in January–February 2015 and 54 (five in Santa Cruz and 49 in Tierra del Fuego) in April–May 2015. In the January–February 2015 census, we sighted a pair with three goslings 25 km west of Río Grande city, Tierra del Fuego.

Bibliographic review

Table 1 shows the maximum numbers of Ruddy-headed Geese reported since 1907. Since 2000, the maximum count at the wintering grounds in Argentina was 386 individuals, while at the breeding grounds the counts were 122 individuals in Chile, 34 in Santa Cruz and 49 in Tierra del Fuego, Argentina.

The most recommended management actions were ‘outreach’ and ‘promotion of scientific studies’ (Table 2). For the reproductive grounds, most authors highlighted the importance of

Table 1. Maximum numbers of Ruddy-headed Goose reported ordered by periods (decades after 1970). 100s and 1000s indicate hundreds and thousands respectively (used when exact numbers were not reported). ND stands for 'no data'. Superscripts C, R and C-R indicates counts-census, isolated records and undefined-mixed methodology in that order. Letters 'g' and 'p' indicates goslings and pairs. SC: Santa Cruz Province, Argentina. MGL: Magallanes Region, Chile. TDFA: Tierra del Fuego Province, Argentina. TDFCH: Tierra del Fuego, Chile.

Decade / Period	Wintering grounds	Reproductive grounds SC	Reproductive grounds MGL	Reproductive grounds TDFA	Reproductive grounds TDFCH
Before 1950s	100s (Grant 1911)	ND	Reproduction (Blaauw 1916).	1000s (Crawshay 1907), very common (Blaauw 1916)	ND
1950-60s	ND	ND	0 (Olrog 1948)	100s, evidence of reproduction, *egg destruction (Olrog 1948)	0 (Olrog 1948)
1970s	252 ^C (1976, Rumboll 1979)	10 ^R (1975, Rumboll 1979)	<20 ^R (1975, Rumboll 1979)	16 ^C (1973, Rumboll 1975)	14 ^C (1973, Rumboll 1975)
1980s	44 ^C (1984, Martin <i>et al.</i> 1986)	ND	5 ^R (1988, Vuilleumier 1994)	ND	6g ^R (1985, Vuilleumier 1994)
1990s	284 ^{R-C} (1999, Blanco <i>et al.</i> 2003)	27 ^R , 1g (1997/98, Imberti <i>et al.</i> 2007)	329 ^C , 132g (1999/2000, Madsen <i>et al.</i> 2003)	43 ^C , (2000, Madsen <i>et al.</i> 2003)	407 ^C , 2g (1999/2000, Madsen <i>et al.</i> 2003)
2000s	156 ^C (Petracci <i>et al.</i> 2009)	34 ^R , 3g (2004/2005, Imberti 2007)	**122 ^C (Mattus 2007 in Blanco <i>et al.</i> 2009)	27 ^C (Blanco <i>et al.</i> 2008)	**122 ^C (Mattus 2007 in Blanco <i>et al.</i> 2009)
2010s	386 ^R (2014, P. Petracci pers. comm.)	16 ^C (2015, this work)	ND	49 ^C (2015, this work)	c.85 ^C (2012, R. Matus & O. Blank pers. comm.)

*Massive egg destruction campaign in reproductive area in TDFA. **122 individuals is the number informed for both reproductive areas in Chile (MGL + TDFCH).

Table 2. List of recommended management actions (Action) extracted from the literature, authors, region (Reproductive grounds, Wintering grounds and All distribution range) and state (implemented = YES, not implemented = NO, partially implemented = PARTIALLY). BAP 2013* Binational Action Plan for Ruddy-headed Goose Conservation in Chile and Argentina.

Action	Reproductive grounds	Wintering grounds	All distribution range	Implemented
Creation of protected areas	Canevari 1996, Blanco <i>et al.</i> 2001, Madsen <i>et al.</i> 2003, BAP 2013*	Petracci <i>et al.</i> 2012, Petracci <i>et al.</i> 2013a		PARTIALLY
Control of invasive species	Rumboll 1979, Blanco <i>et al.</i> 2001, Madsen <i>et al.</i> 2003, Blanco <i>et al.</i> 2009, Petracci <i>et al.</i> 2013b			NO
Enclosures at the breeding areas (by fences or flooded areas)	Blanco <i>et al.</i> 2001, Blanco <i>et al.</i> 2009, Petracci <i>et al.</i> 2013b, BAP 2013*			PARTIALLY
Hunting control		De la Balze & Blanco 2002, Blanco <i>et al.</i> 2008, Petracci <i>et al.</i> 2008, Petracci <i>et al.</i> 2009, Petracci <i>et al.</i> 2010, Petracci <i>et al.</i> 2012, Petracci <i>et al.</i> 2013a Pedrana <i>et al.</i> 2014, Petracci <i>et al.</i> 2014	Blanco <i>et al.</i> 2001, Blanco <i>et al.</i> 2009, BAP 2013*	PARTIALLY
Outreach		Canevari 1996, Blanco <i>et al.</i> 2008, Blanco <i>et al.</i> 2009, Petracci <i>et al.</i> 2010, Petracci <i>et al.</i> 2012, Petracci <i>et al.</i> 2013a	Blanco <i>et al.</i> 2001, De la Balze & Blanco 2002, Petracci <i>et al.</i> 2013b, BAP 2013*	YES
Habitat restoration (by vegetation restoration, feeding stations and crop timing management)	Blanco <i>et al.</i> 2009	Blanco <i>et al.</i> 2001, Blanco <i>et al.</i> 2003, Petracci <i>et al.</i> 2008	BAP 2013*	NO
Economic compensation	Blanco <i>et al.</i> 2009	Blanco <i>et al.</i> 2001, De la Balze & Blanco 2002	Canevari 1996	NO
Promotion of scientific studies		De la Balze & Blanco 2002, Blanco <i>et al.</i> 2008	Canevari 1996, Blanco <i>et al.</i> 2001, Blanco & de la Balze 2006, Petracci <i>et al.</i> 2008, Blanco <i>et al.</i> 2009, Petracci <i>et al.</i> 2010, Petracci <i>et al.</i> 2012, Petracci <i>et al.</i> 2013a, BAP 2013*	PARTIALLY
Cooperation policies			Canevari 1996, Blanco <i>et al.</i> 2001, Blanco & de la Balze 2006, Blanco <i>et al.</i> 2009	PARTIALLY
<i>Ex situ</i> reproduction			BAP 2013*	NO

'control of invasive species', whilst 'hunting control' was the most recommended conservation practice for the wintering grounds. Among the 10 conservation practices listed, one can be classified as "implemented", five as "partially implemented" and four as "not implemented".

Discussion

During the last 40 years, the continental population of Ruddy-headed Goose has been sustained with less than 800 individuals and since early 1900s it has declined by 90%. This reduction in population size was associated with the application of control techniques after sheldgeese were declared a plague. Egg destruction was particularly important in Tierra del Fuego, where 250,000 and 150,000 *Chloephaga* spp. and other anatid eggs were destroyed in 1947 and 1972–1973 respectively (Delacour 1954, Weller 1975). Because the Ruddy-headed Goose is the only migratory sheldgoose that reproduces exclusively in the Magellanic steppe of Austral Patagonia (the Upland Goose and the Ashy-headed Goose reproduce in a wider Patagonian area; BirdLife International 2015), the effect of egg destruction is likely to have affected this species more than the other two. Once the declining situation prompted the protection of the Ruddy-headed Goose, in 1983 in Argentina and 1996 in Chile (Blanco *et al.* 2001) and former actions were banned, new threats appeared. In 1951 the South American grey fox was introduced to Tierra del Fuego to control European Rabbit *Oryctolagus cuniculus* (Jaksic and Yáñez 1983). This predator faced a habitat with a declining rabbit population after introduction of the myxomatosis virus. Additionally, during 1930–1950, American mink were imported to southern Chile and Argentina (Jaksic *et al.* 2002). Wild mink increased in Tierra del Fuego in the early 1960s, a product of accidental escapes and intentional releases from fur farms (Valenzuela *et al.* 2014). Both foxes and mink prey on sheldgeese in the Fuegan Archipelago (Atalah *et al.* 1980, Ibarra *et al.* 2009). These predators show occupancy levels over 0.9 in northern Tierra del Fuego and artificial nest trials show high levels of predation pressure, mostly attributable to South American grey fox (authors' unpubl. data). These facts likely explain why the Ruddy-headed Goose population has not recovered since the species has been protected.

The recent sighting of a pair with goslings is the first successful reproductive event recorded since 1993 in the Argentinian part of Tierra del Fuego Island (Benegas 1997 in Petracci *et al.* 2014). Since the 1970s, maximum counts in this area have not exceeded 50 individuals, contrasting with those before 1950 that were over 1,000 individuals. Similarly, there has been a reduction in the number of Ruddy-headed Geese observed in the Chilean part of Tierra del Fuego (407 in the 1990s, 122 in the 2000s and 84 in the 2010s; Table 1). Although reproduction continues on the continent both in Argentina and Chile (P. Irazoqui and R. Matus pers. comm.), the numbers since the 1990s are extremely low for Santa Cruz Province (< 40 individuals) and a decreasing trend has been reported for the continental Magallanes Province in Chile (R. Matus pers. comm.).

Management actions

The only action that we considered as already implemented was 'outreach', as several educational activities were organized by different institutions (Governmental and Non-Governmental Organizations). Although some areas of the Ruddy-headed Goose distribution are protected, we consider the 'creation of protected areas' action class as "partially implemented" with most of the protected areas focused on the breeding distribution of the species. In San Juan River, Magallanes, Chile, the Área de Protección para el Canquén Colorado (Area of protection for the Ruddy-headed Goose) was created in 2003 to protect its breeding habitat. In Argentina, there are two reserves in Santa Cruz Province that are frequently used by the Ruddy-headed Goose: Reserva Costera Urbana de Río Gallegos (Río Gallegos Urban Coastal Reserve) and Reserva Provincial Cabo Vírgenes (Cabo Vírgenes Provincial Reserve), where they breed occasionally. There are no protected areas either on Tierra del Fuego Island (both Argentinian and

Chilean portions) or in the winter grounds. Another “partially implemented” action is ‘enclosures at the breeding areas’. There are two areas managed in this way in Chile (area of protection for the Ruddy-headed Goose in San Juan River and Leñadura Center of Rehabilitation) where fences protect the sheldgeese from foxes and dogs. Regarding hunting control, even though in Argentina hunt is banned for all sheldgeese (Resolution n° 551/2011 SAYDS), illegal recreational hunting still occurs in Buenos Aires province (Aves Argentinas pers. comm.). Thus, we consider ‘hunting control’ as “partially implemented” because regulation of this resolution requires improvement and reinforcement. In Chile, only the hunting of Ruddy-headed Goose is prohibited, but due to its resemblance to the female of the Upland Goose, the former is usually affected as result of misidentification. In Argentina, there had been several organisations involved in sheldgeese censuses and studies, both governmental (INTA, SAYDS-National Wildlife Agency and OPDS-Buenos Aires Province wildlife agency, CONICET-including the present work) and non-governmental (Wetlands International, Aves Argentinas/AOP, Asociación Ambiente Sur). However, we considered the action ‘promotion of scientific studies’ as “partially implemented” because not all the important aspects of sheldgoose ecology have been covered yet (e.g. migratory routes, intra-seasonal movements). Also, in the management and conservation of small-population species, it is of major concern to study the genetic variability of the population and determine parameters such as observed and expected heterozygosity and inbreeding coefficients (Hedrick and Kalinowski 2000, Witzemberger and Hochkirch 2011) as an indirect indicator of lack of recruitment and small emigration or immigration among different subpopulations.

Regarding ‘cooperation policies’, as the mainland Ruddy-headed Goose population is listed in Appendixes I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), Argentina and Chile signed a Memorandum of Understanding on the conservation of this species, which became effective in 2006. In 2009, both countries drew up a Binational Action Plan for Ruddy-headed Goose Conservation in Chile and Argentina, which was signed in 2013. However, we consider the action might be taken as “partially implemented” because concerted actions between the two signatory countries were never fully implemented. Finally, ‘control of invasive species’, ‘habitat restoration’, ‘economic compensation’ and ‘*ex situ* reproduction’ are recommended management actions that were never implemented.

Regional assessment of Ruddy-headed Goose conservation status

IUCN (2012) suggests conducting a regional assessment for species to evaluate the situation of populations or groups that are not representative of the whole species. The regional assessment guidelines (Step 3) also led us to consider the high importance of conducting an evaluation, as there was strong evidence to consider that the continental population was independent and genetically distinct from the larger Malvinas/Falkland Islands population (Bulgarella *et al.* 2013, C. Kopuchian pers. comm.), so exchange of genetic material capable of rescuing the continental population is not expected. According to the criteria on population size, the continental population of Ruddy-headed Goose qualifies as ‘Endangered’ (EN C1 or EN C2a(i)) as the population holds between 250 and 2,500 mature individuals (EN C), and shows a continuing decline, observed, projected or inferred (EN C2) with a structure (EN C2a) in the form of no subpopulation estimated to hold more than 250 mature individuals (EN C2a(i)). Nevertheless, the present low numbers (c.380) are much closer to the lower limit of the EN category. Although there is no quantitative analysis yet, we consider that with the continuing deterioration of environmental conditions and continuing direct threats, this population might have a high probability of extinction in the wild (at least 50% within 10 years or three generations, CR E), and this will cause the continental population numbers to cross the threshold between the EN (Endangered) and CR (Critically Endangered) categories in the short term. So, we suggest that the continental population of Ruddy-headed Goose should be categorized as CR on a precautionary basis.

Our regional categorization assessment was prompted by the urgent situation of the continental population and the new evidence showing that it is unlikely that the Malvinas/Falklands population can rescue the continental group. More importantly, Bulgarella *et al.* (2013) indicate that we might be in the presence of two distinct species, and if this were the case, the continental species would be facing a very high risk of extinction. For this reason, we consider that the continental group should be precautionarily treated as a separate conservation unit matching the CR status criteria and deserving global attention to overcome the effects that prevent its recovery.

Information gaps and required management actions

There are still information gaps to fill in order to carry out a conservation plan for the Ruddy-headed Goose. First, it is very important to study the migratory route to improve our knowledge of the network of direct and indirect threats across the distribution range. This study also would provide information about unknown wintering and breeding sites as there are inconsistencies between wintering and breeding numbers. Secondly, studies focusing on sheldgoose movements within wintering and breeding grounds would help to set up strategies that include sensitive areas.

Among the actions that may have a positive and rapid effect on sheldgoose recovery, we highlight those that favour the restoration of reproductive conditions and those that increase survivorship of the reproductive population: restoration of breeding sites by controlling introduced carnivores, preserving protective vegetation cover and preventing sheldgoose hunting. With these actions unaddressed, the persistence of the continental population of Ruddy-headed Goose relies on the present number of adults and thus, the group is susceptible to environmental and demographic stochasticity (Frankham *et al.* 2002).

Even when the information about the species and its threats is nowadays insufficient, the urgent situation of the continental population of Ruddy-headed Goose deserves an adaptive conservation programme that allows incorporation of the information gathered during the process (Salafsky *et al.* 2001). The conservation plan should involve monitoring of Ruddy-headed Geese in wintering and breeding grounds as an urgent mitigation action until direct threats are addressed. Monitoring activities both at the breeding and wintering grounds should continue but protocols (schedule and design) need to be redefined and improved while techniques should be standardised, as largely used single visit designs can lead to important inconsistencies regarding maximum numbers.

A hand-rearing programme could also be conducted by retrieving eggs from wild pairs and releasing young individuals, which will force pairs to a second nest attempt and thus maximising recruitment per season per wild pair. The economic costs of such a breeding programme would be an order of magnitude smaller than the creation of enclosures large enough to allow high recruitment. Nowadays, there are similar initiatives in Chile.

Finally, while this revision seeks to complete an overview of the conservation situation of one of the most endangered species of Patagonian waterfowl we consider that the strategy and actions applied to attend the urgent situation of the Ruddy-headed Goose will also have an immediate positive effect on Upland and Ashy-headed Goose. Moreover, they will be also positive for other bird species that breed in the northern portion of Tierra del Fuego, as several authors have pointed out the important reduction of reproductive events in this area (Petracci *et al.* 2013b, 2014). Also, the species shares threats with two other endangered species from Austral Patagonia (*Podiceps gallardoi*; Roesler *et al.* 2012 and *Rallus antarcticus*; Barnett *et al.* 2014). We foresee that implementation of a regional control programme for invasive carnivores will have a positive impact on biodiversity conservation in Austral Patagonia.

Supplementary Material

To view supplementary material for this article, please visit <https://doi.org/10.1017/S0959270916000101>

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