THE RED SISKIN INITIATIVE: SAVING AN ENDANGERED FINCH IN PARTNERSHIP WITH AVICULTURISTS

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Summary

Aviculturists have much to contribute to the conservation of endangered birds, especially when they join forces with scientists. Recent work with the Red Siskin (*Spinus cucullatus*) points to important ways that such collaboration can help many more species in the future. The Red Siskin is a striking black and red finch that once ranged through northern South America, from the Colombian border, across northern Venezuela, to Trinidad. Its populations have been decimated by unsustainable harvest for the pet trade and by habitat degradation, leaving it Critically Endangered in Venezuela and Endangered worldwide. Recent discovery of a population in Guyana revived hopes of saving the Red Siskin, and prompted us to form the Red Siskin Initiative (RSI, www.redsiskin.org), an international partnership of public and private institutions, communities, and people working to help understand, protect, and restore sustainable populations of this iconic bird in its natural habitat. Not all species can be rescued, but the Red Siskin is an ideal conservation target for multiple reasons, including the logistical, biological and economic ease with which it may be reared in captivity. To fulfill a vision of recovery, RSI has developed six conservation strategies, all of which require collaboration with aviculturists for success, particularly for raising and reintroducing siskins, as well as fighting their unsustainable harvest and illegal trade. To date, teamwork with aviculturists has resulted in the design of two integrated conservation centers in Venezuela, and advances in housing, nutrition and husbandry in a research colony in the US. Ongoing collaboration between scientists and aviculturists will be important for genetic and demographic flock management; creating a cooperative breeding plan among aviculturists; streamlining permitting processes; guiding research on diet, social structure, and vocal communication; developing protocols for pre-conditioning birds for release, and beyond captive management into reducing unsustainable harvest of the species, marketing bird-friendly chocolate and coffee, raising the cultural profile of the species in range countries. The avicultural community has become a key partner for Red Siskin recovery, which provides lessons for the conservation of other species, including Sun Conure (*Aratinga solstitialis*), Gouldian Finch (*Erythrura gouldiae*), and Philippine Cockatoo (*Cacatua haemoturopygia*), as well as non-avian species that are popular pets.

What is a Red Siskin?

The Red Siskin (*Spinus cucullatus*) is a small (~10cm) Neotropical finch with striking sexual dimorphism (Figure 1). It is the only red and black species in a recent evolutionary radiation of 12 Neotropical siskins; all the others are yellow and black (Beckman & Witt 2015). Scientific classification of the species has changed in recent years, reflecting recent molecular studies (Remsen 2011). Synonyms include *Carduelis cucullata* (Swainson 1820; Phelps & Meyer de Schauensee 1979; Hilty

2003), and *Sporagra cucullata* (Reichenbach 1850; Dickinson & Christidis 2014), in addition to *Spinus cucullata* (Hilty & Brown 1986; Gill & Donsker 2013). The Spanish name of the species is *Cardenalito*.

Figure 1. Red Siskin male (left) and female (right), from Audubon de Venezuela (2016)

The historic distribution of the Red Siskin (Figure 2) is thought to have been mainly in northern Venezuela (Collar 1992) stretching from just over the border in Cúcuta, Colombia (López-Lanús 2000), to Trinidad and the associated islands of Monos and Gaspar (Ffrench 1973); although this wide distribution has been reduced to just a handful of relict populations today (Sánchez-Mercado *et al*, unpublished data). Populations have also been reported in Puerto Rico (Raffaele 1983) and Cuba (Lawrence 1860), but their origin and persistence remains uncertain (Collar 1992). Recently a population of a few hundred to a few thousand individuals was discovered in southeastern Guyana (Robbins et al. 2003), and although it is found more than 950 km from the nearest extent of the historic distribution, preliminary molecular studies are consistent with a natural origin (Rodríguez-Clark et al. 2011).

The Red Siskin can use various habitats, at altitudes of 100 to 1400 m, including moist montane tropical evergreen forests, tropical dry/deciduous forests, and agricultural/agroforestry mosaics embedded in any of these. However, in Venezuela, relatively dry, open forests at intermediate altitudes appear to be particularly attractive to Red Siskins, with habitat use governed by the availability of water, food, and nesting trees (J. Miranda, A. Sánchez-Mercado, unpublished data). The species may migrate altitudinally (Hilty 2003), though seasonal and daily movements are poorly understood. In Guyana, habitat use appears to favor lower-altitude, drier and more open areas (Robbins et al. 2003).

Like many others in the family *Fringillidae*, the Red Siskin feeds within these habitats primarily on seeds from a wide variety of grasses and flowering plants, although small insects may be added in the reproductive season (Coats & Phelps 1985; Esuperani 2008; J. Miranda, unpublished data). Other food sources include the leaves, flowers and fruits of *Wedelia calycina*, *Lagascea mollis*, *Cordia curassavica*, and *Erythrina poeppigian* (Rivero Mendoza 2004). Competition is likely to influence Red Siskin ecology: at least 25 other tanagers and fringillids have the same food sources (Coats & Phelps 1985). Predators of adult Red Siskins may include *Falco sparverius*, *Buteo nitidus*, and *Accipiter striatus*, while *Spilotes pullatus* and *Didephis marsupialis* may prey on eggs and nestlings (Coats & Phelps 1985; Rivero Mendoza 2004; J. Miranda, unpublished data). In non-reproductive months, the Red Siskin seems to use highly

social, semi-stable sleeping roosts of 10-50 conspecifics, breaking into smaller flocks for daytime foraging (J. Miranda, unpublished data).

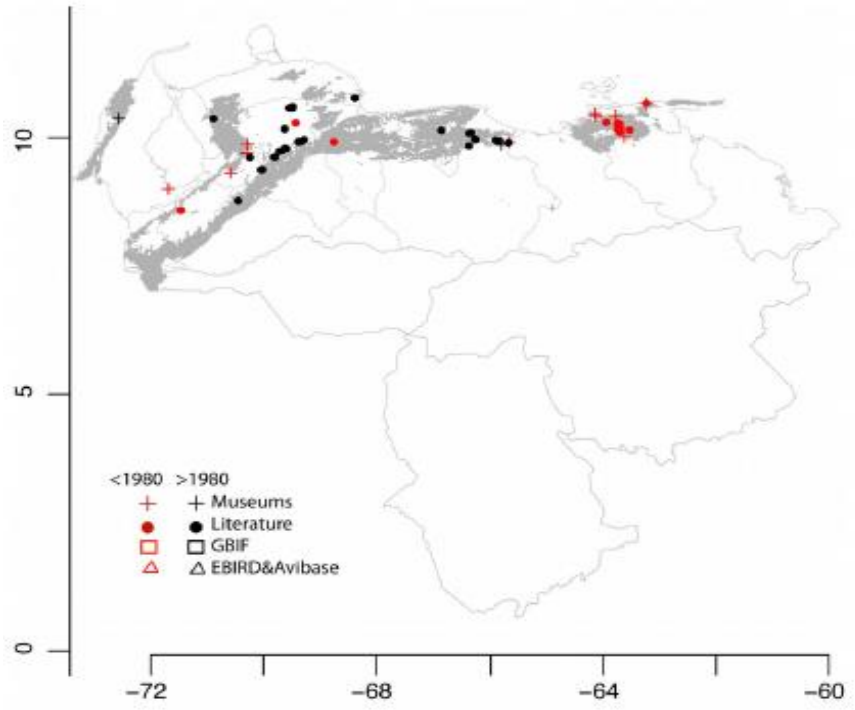

Figure 2. Historical presence records for *Spinus cucullatus* in Venezuela, overlaid on an inferred historical distribution (shaded area; Sanchez-Mercado *et al*, unpublished data). Modern distribution is greatly reduced (not shown). Grey lines represent state boundaries within Venezuela.

Reproduction in wild Red Siskins appears to be influenced by precipitation, temperature, light, and food availability, and is marked by males defending females with long, intricate and melodious songs, and frequent interactions with other males, followed by courtship feeding and joint care of the nestlings (J. Miranda, unpublished data). In captivity, clutches of 2-4 eggs are typical (P. Hansen, S. Davis, unpublished data). In Venezuela, reproduction appears to peak in both April-May and November-December (Hilty 2003), although reproductive activity has been observed in Venezuela in all months except January (J. Miranda, unpublished data). In Guyana, nesting activity appears to be more clustered than in Venezuela, with frequent female-female interaction particularly during nest-building (Robbins et al. 2003). Similar competition between females has been observed *ex situ* (E. Royer, unpublished data). In captivity, Red Siskins will cross readily with several other species (McCarthy 2006) and hybridization could occur in the wild with others, including the Hooded Siskin (*Spinus magellanicus*) and the Yellow-bellied Siskin (*Spinus xanthogastrus*), with which they share habitat in Venezuela (Hilty 2003).

Why are Red Siskins threatened?

The Red Siskin is Endangered globally (A2bcd+3bcd) and Critically Endangered (C2aii) in Venezuela with only several hundred to a few thousand surviving there (BirdLife International 2017b; Rodríguez-Clark et al. 2014). This is due to ongoing unsustainable harvest for the pet trade, habitat loss to urbanization and agriculture, and possibly inbreeding and hybridization, all of which are exacerbated by the present

economic crisis in Venezuela (Figure 3). The one population known in Guyana appears to be robust at the moment, with few threats, although reports of poaching attempts have increased recently (L. Ignacio, unpublished data).

Of these threats, the most important historically has been trapping for human use (BirdLife International 2017b). Although the 19th century saw some demand for the species as a fashion accessory, dramatic declines occurred in the early 20th century, when demand increased from aviculturists in the Northern Hemisphere interested in producing red canaries via hybridization with Red Siskins (Birkhead 2003; Yong 2016). These efforts left aviculturists with a range of color morphs and led to hybridization of Red Siskins with other closely related species as well, including *Spinus atrata, S. carduelis, S. flammea, S. magellanica, S. spinus,* and *S. xanthogastra* (McCarthy 2006).

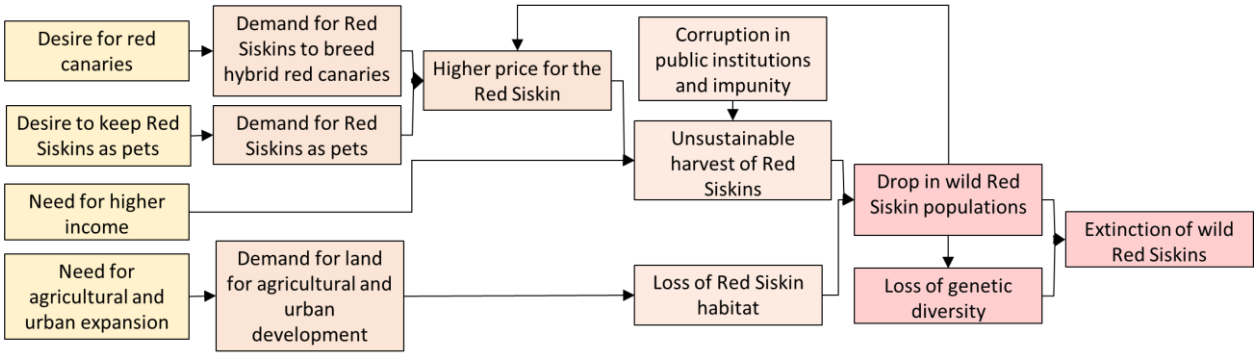

Figure 3: Social, environmental, economic and legal threats affecting Red Siskin populations in Venezuela. Threats are indicated according to their proximity to population declines, including direct (dark pink boxes) and indirect (lighter pink and peach) boxes.

Trapping and trade in wild Red Siskins in Venezuela is illegal, and so appears to be furtive, taking place mostly via close personal relationships and the Internet (Asmussen 2009). In Venezuela, however, the threat may be increasing due to the worsening security situation and an increase in other illicit trades. Although the structure of the trafficking chain is not yet well understood, it may rest on rural poverty, existing distribution networks for other illicit goods, official corruption, and unchecked demand both nationally and internationally, combined with a lack of understanding of how the red factor is transmitted and maintained in colorbred lineages (Rivero Mendoza 2004; Sánchez-Mercado *et al*., unpublished data), and that captive-reared siskins are more cage-hardy and disease resistant when well-managed genetically.

Habitat loss is the other major threat to Red Siskins in Venezuela. Tropical dry forests, used by this species because of its ready supply of small seeds (Collar 1992), are among the most threatened ecosystems worldwide (Miles et al. 2006). These forests are Endangered in Venezuela due to urbanization and agricultural expansion, declining 30% between 1986 and 2001, and with projected losses at 84% in the next 20 years (Rodríguez et al. 2010). Presently, more than 85% of Venezuela's human population lives in tropical dry forest areas (INE 2011), which are underrepresented in this country's otherwise generous protected area network (Aymard 2011). However, it is encouraging that some human impacted areas appear to be compatible with Red Siskin presence, particularly agroforestry systems and forest edges created by human activities, including shade coffee (J. Miranda, unpublished data).

Once wild populations become small, the probability of crosses between close relatives increases, bringing with it the risk of inbreeding depression, a decline in fitness due to deleterious recessive alleles (one of two or more alternative forms of a gene that arise by mutation and are found at the same place on a chromosome) that inbreeding has made homozygous (i.e., a pair of matching alleles, which are the two copies of a gene that influence a particular trait; Keller & Waller 2002). Alee effects in the wild may also reduce reproduction if species accustomed to large social groupings no longer have the stimulation required for breeding. Small population sizes may also lead Red Siskins to mate more frequently with other, more common species, creating hybrids with reduced fertility (Todesco et al. 2016).

Why save the Red Siskin?

Unfortunately, over one in eight of all bird species are threatened today (Birdlife International 2017a). So it is valid to question efforts to conserve any one particular species: why save a Red Siskin and not something else? The Red Siskin is an ideal target for conservation because of a combination of factors, including its urgent risk status; compelling history and current cultural relevance; appealing appearance and behaviours; potential as an umbrella species whose conservation will benefit a wide variety of other endangered endemic and migratory bird species, as well as species threatened by unsustainable harvesting, and ecosystems such as the tropical dry forest; the possibilities its threats and recovery present for multi-stakeholder collaboration; and finally, the relative logistical, biological and economic feasibility of rearing it in captivity.

In addition to the urgent risks outlined above, the Red Siskin has a dramatic and complex story that helps attract public attention, starting with Nazi and eugenics sympathizers leading a demand for wild birds to create an impossible "genetically pure" red canary (Birkhead 2003). While their fantasies created the world's first deliberately genetically engineered organism, the popularity of attempting to breed a red canary through hybridization devolved into an unsustainable harvest that drove the species to the brink of extinction (Yong 2016). Many ornithologists had largely given up hope for survival before the exciting discovery of Red Siskins in Guyana revived hope for range-wide recovery (Robbins et al. 2003) and catalyzed an international partnership that continues to grow in size and scope.

Running through this history is the thread of the cultural importance of the Red Siskin in Venezuela, made more poignant by Venezuela's present challenges. Waves of European immigrants brought aviculture to Venezuela, prizing Red Siskins for their beautiful color and songs, lively interactions, ability to hybridize with canaries, and their relatively easy adaptation to captivity (Coats & Phelps 1985). There is even a park named for this bird, Parque Jardín Botánico "El Cardenalito" (Palencia 2013), at the heart of the species' historic distribution, where it is also the official bird of Lara state. The species is also the mascot of the junior baseball team mentored by the wildly popular Lara Cardenales (Figure 4), and it adorns signs on roads welcoming visitors to this state capital.

The cultural importance of the Red Siskin has made it a national symbol for the protection of Venezuela's natural heritage. A national education initiative that received much attention created a textbook entitled "El Cardenalito" for language arts classes, promoting writing and reading, as well as conservation of Venezuela's endangered species (Figure 5a). Provita, a leading Venezuelan conservation NGO, published a scientific evaluation of the threat status of all of Venezuela's vertebrates,

the "Libro Rojo," and chose an image of the Red Siskin to represent the plight of these endangered species (Figure 5b).

Figure 4: The Venezuelan little-league team the Cardenalitos is sponsored by the Lara Cardenales in the capital city of Lara state where the Red Siskin is the official bird.

And, most prominently, in 2008, the Venezuelan Central Bank elected to celebrate the Red Siskin on the highest-denomination currency, with an illustration by a nationally famous artist, Mercedes Madriz. This selection has been maintained in the new banknotes being brought into circulation in 2017 (Figure 5c).

Figure 5: a. *El Cardenalito* Language Arts book (Barreto *et al.* 2014)
b. El Libro Rojo de la Fauna Venezolana (Rodríguez & Rojas-Suárez 2008).
c. Highest-denomination currency in Venezuela.

Similarly, the cultural value of the Red Siskin is apparent across multiple media. In music, for example, one of Venezuela's most popular traditional musicians, Reynaldo

Armas, launched his best-selling album in 1994 entitled *Aquí está el Cardenalito* (Here's the Red Siskin), which contains a popular song by the same name (Agobian 2013). Similarly, several traditional songs about the Red Siskin are holiday staples. In painting, one of Venezuela's most well-known artists, Arturo Michelena, included a Red Siskin in his 1884 work, *Cardenalito* (Figure 6a; Calzadilla 2013). Presently, many folk artists use this iconic species as a source of inspiration in their work, festivals, and traditional dance contests, often including Red Siskin costumes to represent dance groups from Lara state (Figure 6b). Thus, even as this bird has become rare in the wild, its persistence in the popular imagination is a testament to an enduring societal connection.

Figure 6: a. Painting, *El Cardenalito*, by Arturo Michelena (1884).
b. Dancer in Lara state dressed in a Red Siskin costume.

The cultural relevance of the Red Siskin also facilitates success in cooperation between Venezuelan and international institutions. Local Venezuelan governments, communities and institutions have welcomed partnerships with US institutions around Red Siskin conservation (Sánchez 2014). In a nation that is facing political and economic challenges, such partnerships provide crucial support for maintaining conservation capacity and scientific expertise in one of the top ten most megadiverse countries on the planet (Mittermeier et al. 1997), and building these through the Red Siskin Initiative is especially important when few other international conservation organizations presently work in Venezuela at any scale.

Modern conservation theory recognizes that protecting a single species in isolation rarely makes sense (Groom et al. 2006; Primack & Sher 2016). However, focusing on

larger problems through the lens of a single species empowers stakeholders to act locally while thinking globally, and connect their efforts to the conservation of other species and ecosystems. As an umbrella species, the Red Siskin's conservation could potentially benefit a wide variety of other endangered endemic and migratory bird species, as well as ecosystems (Roberge & Angelstam 2004).

For example, efforts focused on Red Siskin habitat are a step toward conserving and retaining the carbon stocks of tropical dry forests, an ecosystem perhaps less well known but even more threatened than tropical rain forests or coral reefs. They also aid cultural conservation and promotion of sustainable livelihoods, including farmers and entire agricultural communities that grow shade coffee, which preserves habitat for siskins and other species. Traditional shade coffee farming has defined the socio-economic context for settlements across many thousands of acres in northern Venezuela for many generations (Price 1994). This way of life is now threatened by national price controls, which make coffee production unprofitable, spurring farmers to cut down their trees to grow unregulated, moderately more profitable sun crops, such as eggplants (Baumhardt 2015; L. Arrieta, unpublished data). This also creates treeless areas that Red Siskins cannot use, decreasing available habitat.

However, most traditional shade coffee plantations meet Smithsonian "Bird Friendly" criteria, which include standards for organic production and tree diversity, among other factors (Migratory Bird Center 2017). Such certification in Venezuela qualifies coffee as "gourmet," and thus exempt from price controls, allowing farmers to sell it at a fair price while conserving habitat and heritage, rather than eliminating valuable habitat. Bird-friendly shade coffee certification thus is an entrée to the larger issue of biodiversity-friendly agriculture (Tscharntke et al. 2012), an approach to ameliorating the effects of the single largest human driver of habitat destruction, and a necessary innovation in a world where protected natural areas alone will never be large enough to conserve critical biodiversity (Rodrigues et al. 2004).

Conserving Red Siskins in Guyana also includes the larger issue of ecotourism, in which the conservation of other attractive species such as the Sun Parakeet (or Conure, *Aratinga solstitialis*) and the jaguar (*Panthera onca*) are also key. Expanding secure Red Siskin habitat also protects key habitat for threatened Neotropical migrant birds, including the Cerulean Warbler (*Setophaga cerulea*), Golden-Winged Warbler (*Vermivora chrysoptera*) and the Connecticut Warbler (*Oporornis agilis*), in the first forests birds arrive at after crossing the Caribbean (Hilty 2003). Lastly, efforts to study and reduce unsustainable harvest of Red Siskins helps tackle overexploitation in all Venezuelan species, a major threat that has been shown to increase in the face of economic crises (Rodríguez 2000). On a global scale, outreach to large avicultural communities to understand poaching patterns and the use of this species becomes part of the international effort to fight unsustainable harvests and associated illegal wildlife trafficking, which has recently been targeted by the US and other governments as a priority for concerted reduction (USAID 2017).

In addition to the above factors favoring Red Siskin conservation, the most compelling may be the logistical, biological and economic ease with which it may be reared in captivity and restored in the wild. A small-bodied species, it is inexpensive to maintain in terms of space and feed, and its popularity as a cage bird means that a large number already in captivity may be available to help restore wild populations. Aviculturists have developed reliable techniques for maintaining and reproducing Red Siskins, and the possibly accidental establishment of feral populations in Puerto Rico and Cuba may indicate that reintroductions can succeed, even when inadvertent. Moreover, the present economic situation in Venezuela makes investments from other countries go a very long way, producing tremendous benefits at low cost, especially

when compared to many other conservation efforts with much lower investment returns.

What has been tried to save the Red Siskin?

Internationally, the Red Siskin has been included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora since 1975 (CITES 2013) and in the United States Endangered Species Act since 1976 (USFWS 2017). The 1992 Wild Bird Conservation Act (WBCA), combined with subsequent enforcement lawsuits, resulted in an effective ban on US imports of certain families of birds, as well as all CITES-listed species (American Federation of Aviculture 2017). Imports to Europe have also declined, apparently due to strict disease prevention measures imposed on bird imports since late 2000 (Commission of European Communities 2007). In Australia, the last known importation of Red Siskins was in 1949 (Davis 2015). Import of Red Siskins was formally banned in 1962 and reinforced by the Environmental Protection and Biodiversity Conservation Act in 1992 (Government of Australia 1999). The Avicultural Federation of Australia and American Federation of Aviculture each had separate conservation programs in the 1990s aimed at reintroduction of the Red Siskin to Colombia and Trinidad, respectively, but neither proceeded to release (Collar 1992).

In Venezuela, between 1940 and 1944, the Ministry of Agriculture banned the sale and collection of the Red Siskin, although this had the unfortunate effect of increasing its market value abroad (Coats & Phelps 1985; Rivero Mendoza 2004). The Species Survival Commission of the International Union for Conservation of Nature (IUCN) visited Caracas in 1952 to monitor the situation of the Red Siskin, and subsequently decided to include it in the IUCN list of endangered species (Coats & Phelps 1985). Venezuela then implemented a permanent ban on hunting, and named it officially as a nationally "Endangered Species" (Venezuela 1996a; Venezuela 1996b). Although no protected areas were established particularly for the species, several protected areas may be key for its conservation (Lentino et al. 2005; Oficina Nacional de Diversidad Biologica 2013). In more recent years, conservation work has been sporadic on behalf of the Red Siskin. It is the focus of an official state-level conservation program in Lara, led by Parque Zoológico y Botánico Bararida, in Barquisimeto (Gobernación del Estado Lara 2005). This program has included a city-wide parade on International Wildlife Day, and the summer day camp, *Alito, mi amigo el Cardenalito*, (Alito, my friend the Red Siskin) in which children learned about this and other endangered birds (Figure 7; Prensa del PZBB 2013). Efforts also included the environmental campaign "Lara 2014," which proposed the idea that those holding illegal captive Red Siskins could hand them over in an amnesty.

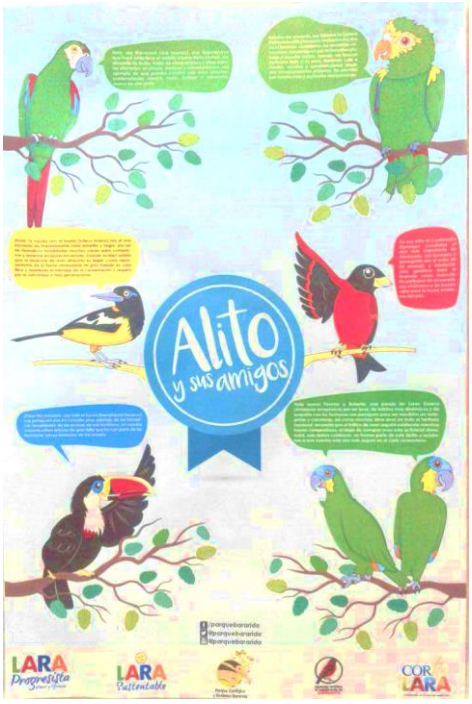

Figure 7: Educational poster from the summer day camp *Alito el Cardenalito* sponsored by the Government of the State of Lara at Parque Zoológico y Botánico Bararida (Barquisimeto, Venezuela).

The Red Siskin Initiative

To promote the conservation of the Red Siskin, in 2015 we founded the Red Siskin Initiative (RSI), formerly known as the Red Siskin Recovery Project. The RSI is an international consortium of public and private institutions, communities and individuals who work to understand, protect and restore populations of this iconic endangered bird in its natural habitat across its historic range in Venezuela and Guyana, through research, threat reduction, captive breeding, reintroduction, and habitat protection and restoration, including biodiversity-friendly agroforestry, such as shade coffee and cacao (Red Siskin Initiative 2017). Consortium members include The Instituto Venezolano de Investigaciones Cientificas (IVIC – a research institute in Caracas), Parque Zoológico y Botánico Bararida (PZBB – a zoo in Lara state), Parque Zoólogico El Pinar (a zoo in Caracas), Provita (an NGO in Caracas), the Smithsonian Institution, and the South Rupununi Conservation Society (an NGO in Guyana). These members rely on the support and collaboration of many other crucial partners (listed in the Acknowledgements).

Achieving our goal of replenishing self-sustaining populations of Red Siskins across their natural historical distribution will be an important success for conservation in the region. We envision the Red Siskin as a source of local and national pride, as well as a symbol of commitment to the preservation of range countries' natural heritage. We aim to do this using a multi-stakeholder approach (Hemmati et al. 2002), involving all who care about the Red Siskin in some way, using the latest scientific tools such as genomics, remote sensing, drone technology, and OnePlan conservation planning, but also incorporating low-tech, well-established approaches such as alternative livelihoods, environmental education, economic development, and cultural preservation.

In the near term, RSI aims to:

By 2020:

- Understand the Red Siskin's ecology, distribution, and evolutionary history sufficiently to develop a program to prevent its extinction.
- Implement outreach programs for the main stakeholders in the Red Siskin's future.
- Establish two captive conservation centers for Red Siskins in Venezuela supporting rescue, conservation, education, outreach and reintroduction efforts.
- Declare a protected area for the Red Siskin in Guyana.
- Implement bird-friendly coffee certification emphasizing the Red Siskin on multiple coffee farms in the species' historical distribution in Venezuela.
- Understand the basic structure of the unsustainable harvest of Red Siskins.
- Encourage public servants to improve law enforcement against illegal activities.

By 2025:

- Measurably reduce human threats across the areas where wild Red Siskins persist.
- Establish two captive Red Siskin colonies supporting conservation and reintroduction.
- Initiate a breeding and reintroduction plan for Red Siskins in 15 locations within the species' historic distribution.

- Measurably increase awareness and sympathy in human communities near Red Siskin populations about their situation, and active participation in their conservation.

To achieve this vision and these goals, we have identified the following six major conservation strategies, or objectives (Red Siskin Initiative 2017):

1. **Understand the Red Siskin:** Use interdisciplinary, collaborative science to reach an integral understanding of the Red Siskin's biology, including its natural history, behavior, evolution, ecology, and distribution.
2. **Fight unsustainable harvesting:** Propose and execute actions to counter unsustainable harvests of Red Siskin, once this threat is better understood. This may include both demand reduction, via alternative market strategies and education, as well as supply reduction, via law enforcement and legal reform.
3. **Expand safe habitats**: Identify and encourage the creating of public and private spaces that can serve as new safe habitats for the Red Siskin and other species. This implies a review of existing protected areas, establishing new ones, partnering with private landholders, facilitating Smithsonian bird-friendly coffee and cacao certification, supporting ecotourism and other alternative livelihoods based on the continued survival of Red Siskins, as well as active ecosystem restoration.
4. **Connect with people:** Connect stakeholders and the general public with the Red Siskin's plight and encourage individual actions to improve its conservation status; stakeholders include aviculturists, farmers, participants in the trafficking chain, the Venezuelan and Guyanan public, and US/European/Australian/consuming public, and spans marketing, communications, and educational efforts.
5. **Breed and release more Red Siskins:** Carry out *in situ* and *ex situ* interventions such as captive breeding and reintroduction in safe habitats to guarantee the viability of wild populations. This includes rescuing and rehabilitating trafficked birds, improving captive husbandry and reproduction, implementing a detailed genetic/demographic management plan, and developing and implementing strategies for releasing individual birds so that they may successfully reproduce in the wild.
6. **Ensure the sustainability of RSI:** Guarantee the human, economic, and institutional and human resources needed to secure the project's success, through training and supporting the talent required in range countries, non-profit fundraising campaigns, and strengthening institutional resources and connections to support project execution.

How have aviculturists helped so far?

Teamwork with aviculturists has played a key role in almost all important advances in RSI accomplishments to date. Initially in the US, collaboration began simply, with organizations such as the National Finch and Softbill Society (NFSS) providing genetic samples of captive stock to scientists for genetic studies, via sending individuals that had died of natural causes to scientific collections for further study (i.e., Rodríguez-Clark et al. 2011). Venezuela also has a long tradition of aviculture, which grew further with an influx of European immigrants in the mid 20th century, and is organized into clubs such as the Federación Ornitológica de Venezuela (FOV), Asociación Venezolana de Canaricultores (AVC) and the Sociedad de Ornitología y Canaricultura de Venezuela (SOCAV). These groups have also provided crucial material for genetic study in Venezuela -- of Red Siskins, hybrids, and various canary breeds -- but in addition they have helped PZBB develop protocols for rehabilitating

confiscated individuals received from wildlife authorities, including input on management, manipulation, nutrition, and husbandry. These contributions allowed PZBB to successfully maintain the first group of Red Siskins received in 2008, and to improve the quality of life for other birds in the PZBB collection. The most outstanding contribution made by Venezuelan aviculture to date is the book "El Cardenalito" (Rivero Mendoza 2004), by Antonio Rivero, a professor of biology and eager aviculturist. This work is the first and only book about Red Siskins in the wild and captivity in Lara state, and still represents one of the most comprehensive collections of information about the species anywhere.

With respect to wild populations in Venezuela, the detailed understanding that aviculturists have of Red Siskins has been fundamental in guiding field research on the natural history, distribution, movements, and unsustainable harvest of individuals for the pet trade. Theoretical models of survivorship and reproduction built for demographic projections to guide planning for captive populations and reintroductions are frequently populated with parameter values provided by aviculturists (Ballou & Traylor-Holzer 2011). Fieldwork on reproduction in the wild has been advanced greatly by the precise understanding of chick development, including feathering and molts, derived from aviculturists (J. Miranda, unpublished data). Most important in Venezuela, however, has been the information that aviculturists have provided about the wild origins of their birds. This has advanced RSI understanding of where wild populations may remain and/or be under the greatest threat, as well as our understanding of the drivers of unsustainable harvests, trafficking routes and modes of communication used. Networks of trust and inter-relationship built by aviculturists have been key to understanding this threat and in imagining future creative alternatives for bringing harvests to sustainable levels. These networks have been key in providing information about not only the harvest of Red Siskins, but also the unsustainable capture that takes place more widely with Venezuelan species popular in the pet trade (e.g.,Sánchez-Mercado *et al.* 2016).

To further support this growing understanding of Red Siskins in the wild, as well as to initiate the process of developing captive populations for exclusively conservation purposes, a colony of Red Siskins was established at Smithsonian National Zoological Park and Conservation Biology Institute in 2016, which recently celebrated the fledging of its first chick (NZP-SCBI Newsroom 2017). Although their avian team has many years of experience caring for and propagating rare and endangered bird species (e.g., Guam Rails *Hypotaenidia owstoni*, White-Naped Cranes *Grus vipio*, Loggerhead Shrikes *Lanius ludovicianus*, and Micronesian Kingfishers *Todiramphus cinnamominus*; NZP-SCBI 2017), all species are unique and have very specific needs. When Red Siskins were first brought to SCBI, no other AZA-accredited zoo was currently holding Red Siskins. Thus, aviculturists were vital to starting the new colony, generously offering guidance on everything from basic husbandry, medical issues and enrichment, to nutrition and reproduction.

The two most significant aspects of siskin husbandry that aviculturists have assisted with are nutrition and reproduction. Most of the current diet items used for Red Siskin at SCBI were derived from guidance offered by aviculturists. Nest materials, nest basket types, breeding behaviors and vocalizations, parental care, neonatal care, breeding diet, neonatal diet, and banding offspring are just a few of the topics of which aviculturists have offered their expertise. Furthermore, almost all of the founding members of the Red Siskin population at SCBI were sourced from aviculture. While the SCBI has had successful breeding attempts, bringing in new birds and new genetic lines is essential in maintaining the health and vitality of the flock. It also allows for further study of flock dynamics, which may allow for a better understanding of social interactions in their wild conspecifics.

Finally, the most advanced aviculture-science collaboration that RSI has fostered to date has been in the development of designs for the two integrated conservation centers for the Red Siskin in Venezuela, at Parque Zoológico El Pinar in Caracas, and Parque Zoológico y Botánico Bararida in Barquisimeto (Figure 8a-d). These centers have been designed to receive and rehabilitate birds confiscated from the illicit trade, as well as to breed and maintain a resident flock, produce individuals for reintroduction, educate visitors, and serve as a focal point for education, communication, marketing, and outreach activities. Aviculturists from the US, Venezuela, Australia, and other countries worldwide have contributed in workshops and ongoing exchanges, with ideas ranging from cage options and ventilation to infrastructure for foster-nest species.

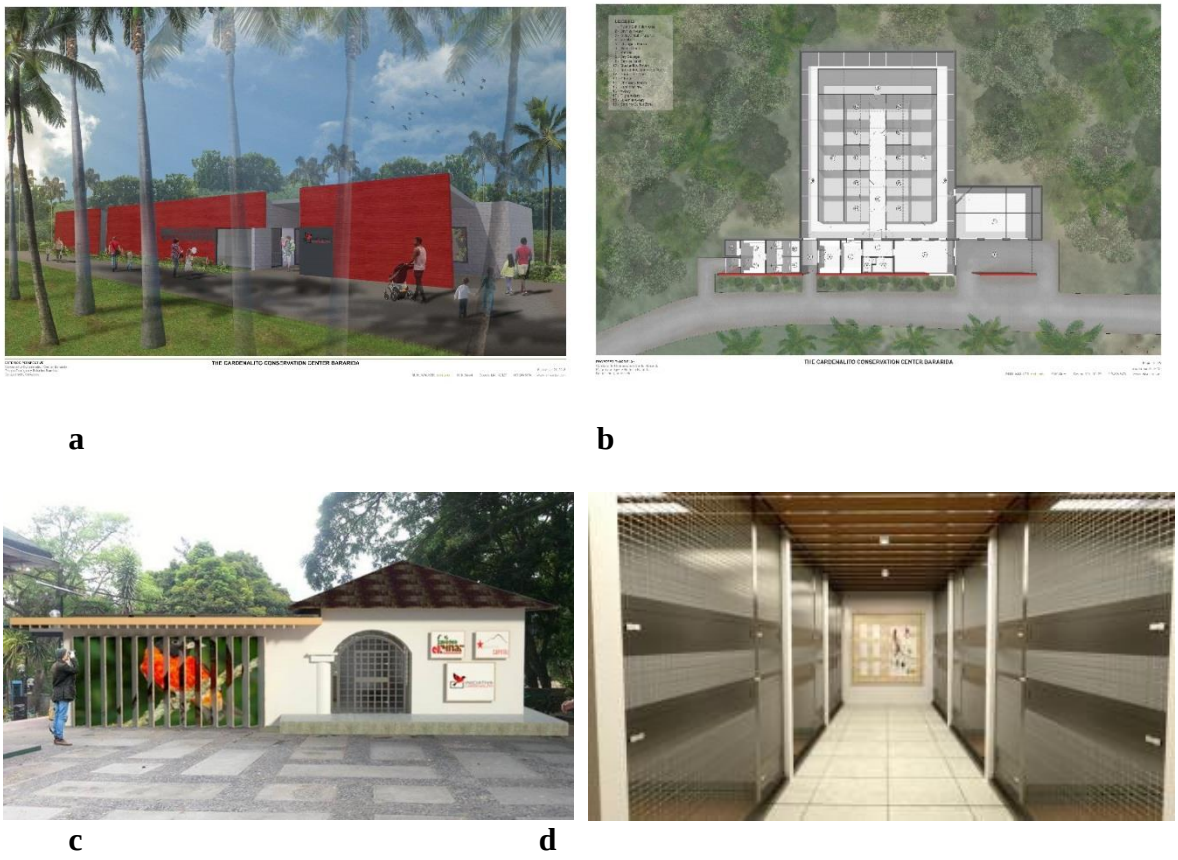

Figure 8: Conceptual designs for integrated facilities for the *ex situ* conservation of Red Siskins in **a, b.** Parque Zoológico y Botánico Bararida (Barquisimeto, Lara state, Venezuela; Ruhl Walker Associates, 2017), and **c, d.** Parque Zoológico El Pinar (Caracas, Venezuela; Proyectos TOARCA, 2015).

How can aviculturist-scientist collaborations grow in the future?

Aviculture is a largely untapped and economical source of knowledge and skills accumulated over hundreds of years (Birkhead & van Balen 2005). The observations possible in an aviary environment focus on detail impossible to gather in the field. Expert aviculturists continue to tweak their husbandry in response to individual bird behaviors. Such detailed trial, error, adjustment is analogous to the scientific method: formulation, testing, and modification of hypotheses. Indeed, aviculture is often defined as the science (and art) of bird keeping and breeding (Rutgers & Norris 1970).

Ongoing collaboration between scientists and aviculturists will be vital into the future as tools are developed for genetic and demographic flock management; to guide fieldwork in diet, social structure, and vocal communication; to develop protocols for pre-conditioning birds for release -- and beyond captive management into combating unsustainable harvesting, marketing bird-friendly chocolate and coffee, and raising the cultural profile of the species in range countries via international exchanges.

Conservation scientists support avicultural organizations that advocate strongly and frequently for responsible pet ownership and illegal trade, ensuring that aviculture ceases to be a driver of unsustainable harvests in the wild. They dream of help with reintroductions and population recovery in the wild, both through the donation of individual birds, knowledge, and data, and also through the active organization of outreach events to other aviculturists, to spread the word about the Red Siskin Initiative and develop a broader, explicit code of ethics guiding the acquisition and rearing of bird species. Both in the US and Venezuela, zoos represent an ideal forum for such collaboration, where aviculturists are natural allies in educational campaigns, in promoting the sustainable and legal use of wild species, and in participating in amnesty events when they are offered (e.g., Government of St. Vincent 1987).

However, the benefits of greater collaboration between aviculture and conservation science can go in both directions: dreams for future collaboration are not limited to scientist visions of what aviculturists can contribute; aviculturists also have a wish list for scientists. Bird breeders and advanced hobbyists are eager to learn and apply the latest scientific techniques and information about genetics, nutrition, habitat characteristics, mating, nesting, and flock dynamics, all of which can help improve breeding success and overall avian husbandry. Most aviculturists are keen observers of their birds and their behavior, and want to learn and share the latest breakthroughs with their colleagues. Of course, many aviculturists also want greater opportunities to contribute to conservation of species in the wild.

Concretely, immediate future collaborations with scientists could focus on two key concerns for aviculturists: assistance in the genetic and demographic analysis and management of their flocks, to maintain maximum bird health and welfare; and providing scientific input in regulatory processes to ensure that permitting requirements truly fulfill the protective role intended, without becoming onerous. Sophisticated genetic analyses are routine in other captive species thanks to scientific-enthusiast collaborations (e.g. Wisdom Panel 2017), and should be straightforward in the Red Siskin in the future, thereby limiting the negative effects of inbreeding commonly observed in poorly-managed flocks (e.g. twirling, low hatch rates, and parasite and disease susceptibility – such as spider mites, airsac mites and respiratory infections; P. Hansen, unpublished data).

As for permitting, presently the Wild Bird Conservation Act allows for limited importation of "qualified" species under two exceptions available to breeders in the United States. The first is called a "Cooperative Breeding Program" or CBP (LePage 2017). Under a CBP, clubs or aviculturists create a cooperative breeding program for the conservation of a species. Participants may be authorized to import certain numbers of the target species as breeding stock to meet the stated objectives of an approved CBP. However, imported may not be imported for the purpose of resale, and strict quotas and member-to-member transfer requirements ensure compliance. USFWS requires that imported birds be captive-bred in a country not their origin, and importation of CITES I species are only rarely allowed and may enter only to special breeding facilities. When imported birds are transferred to a new owner for any reason, s/he must become a CBP member. The manager of the CBP must file a report with the US Fish and Wildlife Service every two years giving the status of all

imported birds, and the disposition of all offspring produced under the CBP. At that time, the USFWS decides if goals are being met and either extends or discontinues the program.

Criteria for bringing together a Conservation Breeding Program include ongoing and significant donation of funds to range countries for *in situ* conservation interventions; a full accounting of the origin of captive birds acquired; a written exception from the CITES Secretary for Appendix 1-listed birds; a network of willing and experienced participants, each with at least five years of studbook records; and a talented and dedicated network manager. This implies that the potential benefits of a CBP are many, including *in-situ* conservation actions for the species; better animal welfare; improved population genetic, demographic and medical health; and an increase in behaviors consistent with responsible pet ownership. However, in practice, overcoming the considerable challenges requires collaboration with conservation scientists. Challenges include copious confusing paperwork; difficult reporting requirements; a lack of guidance on how to maintain required data on deaths, offspring, sex, transfers, and loans; high permit costs; and most inexplicably, limited contact information-sharing, making close collaboration among CPB participants nearly impossible, and limiting the ability of CPB participants to screen newcomers for skill levels and sufficient resources.

Building on RSI efforts, we hope to further strengthen ties and increase collaboration with aviculturists globally, to one day create a broader conservation program that focuses on other endangered species popular as pets. Aviculturists have invaluable expertise with many rare species, unique outreach ability and crucial genetic resources that complement conservation scientists' efforts to restore populations in the wild. The synergistic combination of these motivated communities could have a powerful impact on conservation of many iconic species, the success of which will benefit much broader conservation of other species and ecosystems. We also hope this program will serve as a model to expand efforts to unite conservation scientists and breeders of non-bird species in the same way to save wild populations.

Conclusions

Red Siskin recovery efforts, including those spearheaded by the RSI, have shown the synergistic benefits that can come from combining the expertise of scientists employed by academia, conservation NGOs, and government agencies, with the practical knowledge of bird breeders. The same approach is being applied to other avian species worldwide, including the Sun Conure (*Aratinga solstitialis;* Bird Recovery International 2017), the Gouldian Finch (*Erythrura gouldiae*; Save The Gouldian Fund 2017), and the Philippine cockatoo (*Cacatua haemoturopygia*; García et al. 2017).

Although both communities seek to protect species in the wild, past relationships between conservation biologists and aviculturists have tended to range from barely tolerable at best to overtly hostile at worst. While this past tension can be attributed to the negative impacts the pet trade has had on wild populations, these two groups have much more to gain by working together than if they are at cross purposes. The accelerating pace of climate change and habitat destruction mandate that new partnerships like these be forged. Individual examples of successful collaboration abound, beyond those discussed above (i.e., Loro Parque Fundación 2017; The Society for Conservation in Aviculture 2017). However, recent years have also seen failures, highlighting the importance of combining these individual examples together into a broader, and more cohesive movement.

Aviculture could be the latest example in which hobbyists, sportsmen, and non-scientist nature lovers directly engage in conservation and ecosystem service campaigns to protect wildlife and habitats. In the U.S., duck hunters have long advocated on behalf of wetlands (Ducks Unlimited 2017); fishing enthusiasts are among the strongest supporters of The Nature Conservancy (e.g., Kaufman 2011); crocodile farmers have helped preserve Florida's Everglades (Thorbjarnarson et al. 1992); and ranchers support captive breeding programs of critically endangered megafauna like rhinos and lions (Conservation Centers for Species Survival 2017). The Red Siskin Initiative, together with other initiatives like it, can be a game-changing catalyst that unites a number of disparate but like-minded communities to achieve more together than any could accomplish alone.

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About the author

This multi-authored paper was presented at Finches '17 by Prof. Jonathan Fink Jonathan developed an interest in birds and aviculture early and converted various rooms in his parents' houses into aviaries for African and Australian waxbills, while growing up in New York and St. Louis in the 1960s. It was only decades later, when he was a professional volcano geologist that Jon got to see these birds in the wild. He met parrot expert Joseph Forshaw, who encouraged him to contact World Wildlife Fund in the U.S. about helping with captive bird legislation. Jon subsequently became the CITES representative for the American Federation of Aviculture, attending the 8th Conference of the Parties in Kyoto in 1992, and bringing an avicultural perspective to the design of the U.S. Wild Bird Conservation Act. More recently, he has served on advisory boards for the Smithsonian's National Museum of Natural History and The Nature Conservancy, where he has been promoting greater interaction between conservation organizations and scientifically-oriented aviculturists. He is currently a

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Please visit www.redsiskin.org or www.cardenalito.org.ve to learn more about Jon's co-authors.

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