RECORDS OF *SAUROMALUS ATER* (DUMÉRIL, 1856) HATCHLINGS AND SUBADULTS ON SAN FRANCISCO ISLAND, GULF OF CALIFORNIA, MEXICO

REGISTROS DE *SAUROMALUS ATER* (DUMÉRIL, 1856) CRÍAS Y SUBADULTOS EN LA ISLA SAN FRANCISCO, GOLFO DE CALIFORNIA, MÉXICO

Adrián Cerdá-Ardura[1]*
[1]*Lindblad Expeditions/National Geographic; Facultad de Ciencias, UNAM, México*

[*]*Correspondence: adriancerda@ciencias.unam.mx*

Resumen.— Seis crías del Cachorón de Roca del Desierto Sonorense (*Sauromalus ater*), con rango de 60 mm a 93 mm (Longitud de Hocico a Cloaca, LHC), y ocho individuos (seis hembras), con rango de 111 mm a 146 mm (LHC) fueron registrados durante tres caminatas en la isla San Francisco, Baja California Sur, Golfo de California, México, en enero y febrero de 2019. Los individuos pertenecen a dos clases de edad o cohortes: seis crías y juveniles, y ocho subadultos, sin intermedios entre clases. Cinco hembras presentan un rango de edad entre 2 y 3 años, mientras que la hembra más grande puede tener cinco o seis años y podría estar entrando en edad reproductora para su próxima primavera. Dos machos presentan un rango de 2 a 5 años en edad. La presencia de estas crías y hembras subadultas podría ser un signo importante de la recuperación y continuo reclutamiento del cachorón de roca luego de la erradicación de gatos ferales y cabras de la isla en los años 1999 y 2000, respectivamente, aún a pesar de la intensa presencia humana (pescadores y turistas) en esta isla. Asimismo, la exploración visual de la vegetación muestra más abundancia, diversidad, y una cobertura mayor que en años previos, facilitando la caracterización del hábitat y su posible correlación con la recuperación de reptiles herbívoros.

Palabras clave.— Crías de Chuckwalla; especies invasoras; restauración; recuperación de biota insular.

Abstract.— Six individuals of the Sonoran Desert Chuckwalla (*Sauromalus ater*) ranging from 60 mm to 93 mm (Snout-Vent Length, SVL) as well as eight individuals (six females) ranging from 110 mm to 146 mm (SVL) were recorded during three walks on the small island San Francisco, Baja California Sur, Gulf of California, Mexico, in January and February, 2019. These individuals belong to two age classes or cohorts, being six hatchlings and juveniles, and eight immatures, with no intermediates between their size classes. Five females are within an age of 2-3 years, whereas the largest female may be in her 5th to 6th year of age and thus might be entering in reproductive age in her next spring. Two males are in the range of 2-5 years in age. The presence of these hatchlings and subadult females could be an important sign of chuckwallas' recovery and of continued recruitment following eradication of feral cats and goats from the island in 1999 and 2000 respectively, and despite the intense presence of humans (fishermen and tourists) on the island. Additionally, the vegetation visually shows more abundance, diversity, and a more extensive covering than in previous years, allowing habitat characterization and a possible correlation to the recovery of herbivorous lizards.

Keywords.— Chuckwalla hatchlings; invasive species; island restoration; insular biota recovery.

INTRODUCTION

San Francisco island forms part of the San José Island group, in the state of Baja California Sur, México (Fig. 1); it lies in the latitude 24°50'00" and longitude 110°35'00", at 2.36 km south of San José Island and 7.29 km from the nearest point in the peninsula of Baja California; its area is 4.49 km^2; its elevation is 210 m a.s.l.; the surrounding ocean depth is 63 m (Murphy

et al., 2002). Its origin is Miocene volcanic and emerged in the Pliocene by block faulting (Carreño & Helenes, 2002). San Francisco's flora and vertebrate biota are composed as follows: 109 plant species (Rebman et al., 2002); 10 reptiles, including *Sauromalus ater*, a herbivorous lizard (Murphy & Aguirre-León, 2002; Hollingsworth, 2004); 23 bird species (Cody & Velarde, 2002); and two native terrestrial mammals (Lawlor et al., 2002; López-Forment et al., 1996).

The distribution of *S. ater* embraces southwestern United States, southward to northwestern México, the peninsula of Baja California, and 14 islands in the Gulf of California (Hollingsworth, 2004; Lemos-Espinal et al., 2015). There are four full, strict insular endemic species of *Sauromalus* (*cf.* Cerdá & Langarica, 2018). Grismer (2002) reports *S. ater* (but as *S. obesus*) as "common on San Francisco Island". *Sauromalus ater* reaches a SVL of 224 mm, but on San Diego Island it gets 134 mm (Grismer, op. cit.).

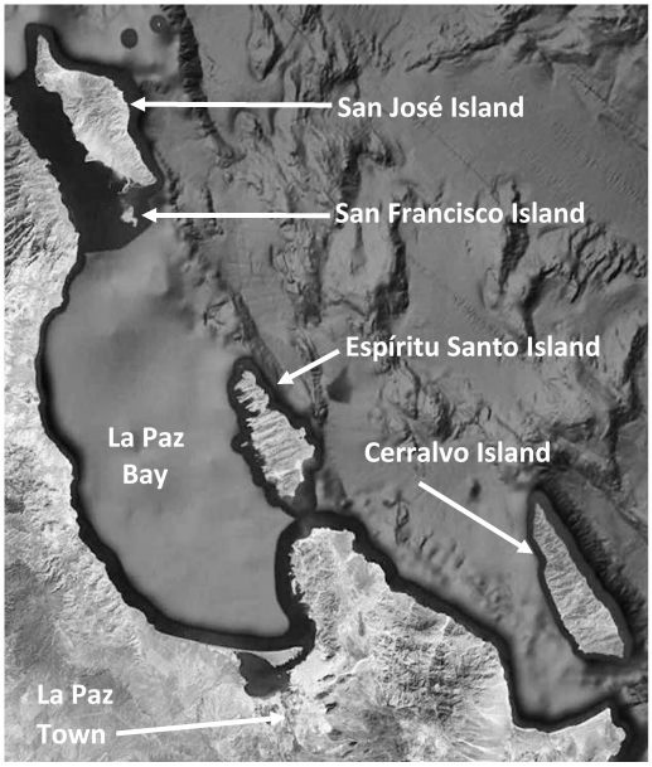

Figura 1. Localización de la Isla San Francisco en el Golfo de California y su relación con otras islas y la Ciudad y Puerto de La Paz; estado de Baja California Sur, México. Foto tomada de Google Earth Pro.

Figure 1. Location of San Francisco Island in the Gulf of California and its relation to other islands, and La Paz Bay and City; state of Baja California Sur, México. Photo from Google Earth Pro.

Many islands in the Gulf of California have experienced the devastating presence of invasive species such as *Rattus rattus* and *R. norvegicus*, *Mus musculus*, *Felis cattus*, *Canis familiaris*, *Bos taurus*, *B. indicus*, *Equus caballus*, *E. assinus*, and *Capra hircus*, all introduced from different sources and at different times (Velarde, 2010; Bahre & Bourillón, 2002; Cerdá, 1986-2019, *pers. observ.*). Bahre and Bourillón (2002) explicitly cite fishermen in temporary camps as being responsible for a major impact in some areas, negatively affecting island ecology by introducing exotic species, disturbing sea-bird nesting areas, poaching, dumping trash, harvesting fuel wood, and trampling vegetation. In many cases, introduction of these invasive species dates to the XVII, XVIII and XIX centuries (Bahre & Bourillón, 2002; Bowen, 2000).

On the Pacific side of the peninsula of Baja California, Guadalupe, Todos Santos and Cedros Islands have lost species of vertebrates directly attributable to invasive species (Velarde, 2009). In the Gulf of California, Monserrat, Coronado and San Roque Islands have lost species for the same causes, as did some islands in the central Pacific of México, like Socorro and María Madre (Aguirre-Muñoz et al., 2011). In San Francisco Island, feral cats and goats have been successfully removed (Aguirre-Muñoz et al., 2008, 2011). Thus, as has been recommended elsewhere (*cf.* Aguirre-Muñoz et al., 2008, 2011; Velarde, 2010), monitoring programs of population recovery are needed as a measure of the impact of protection and natural restoration of island biotas after eradication efforts. This report is intended to be part of that.

Since different invasive species have been totally eradicated from several islands in the Gulf of California, my working hypothesis is that the biota of some of these islands are experiencing a recovery that can be visually detected by surveys and quantitative methods. Thus, the objective of the field surveys I conducted was to detect a possible indication of recovery *S. ater* on San Francisco Island. These records may aid in the species long-term conservation and populations' status update.

MATERIALS AND METHODS

Four trained people and I took three casual, homogeneous walks at the southern part of San Francisco Island in the morning (8:30-12:30) and early afternoon (13:30-17:30) of January 6, and February 12, 2019. The locality surveyed is composed, in the southern part, of a large cove of shallow sea rimmed with a very fine-grained sand beach, called Half Moon Bay by tourists, and a small rocky shore with a tide-pool section on the northern side (Fig. 2). Between both beaches there is a sandy, flat plain

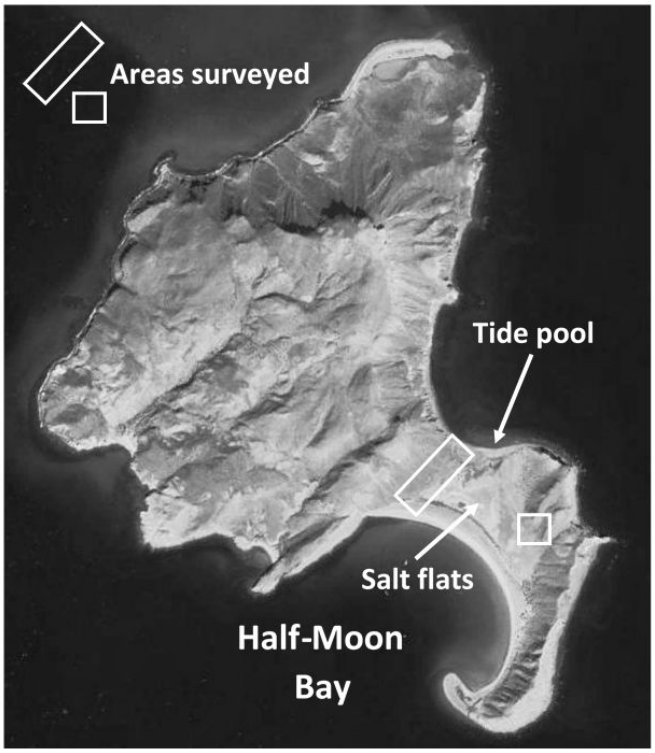

Figura 2. Localidades de estudio en la Isla San Francisco. Foto tomada de Google Earth Pro.

Figure 2. Localities of study on San Francisco Island. Photo from Google Earth Pro.

with small salt-works (man-made pools for salt production) with a couple of tidal entrances. This flat is about 430 m across and some 620 m wide (Fig. 3). The western and eastern sides of the flat plain are rocky slopes of hills that reach between 70 m to 150 m in height (Fig. 4). These slopes consist of broken volcanic rocks, generally small, but sometimes reaching a size of a small car, with abundance of loose flake-like, sharp, cobble-sized rocks and variously sized fragments. Two walks followed linear transects from south to north in the foothills of the western slope of the flat plain (Jan. 6, Feb. 12), and one from north to south on the eastern slope (Jan. 6). The sampling effort was the same in all walks (five people, 4 hours each walk). During the walks, all evidences of chuckwallas presence were searched for (smell, feces, skin, removed soil, etc.). Crevasses and fissures were checked out, and conspicuous, medium to large flat, flake-like volcanic rocks were turned over when there was such an evidence. Once an individual was located, it was gently captured by hand, preventing any damage, stress or discomfort to it. The maximum length time of handling was 5 minutes per individual. Snout-Vent Length (SVL) and Head Width (HW) measurements were taken with a flexible ruler and a standard caliper, respectively. Palpation in the abdomen was also conducted to verify or discard eggs presence. The general body condition, sex, size of femoral pores, coordinates and time of the day were recorded as well. The animals were released after taking a photo and in the same place where they were captured. No analytical treatment of data was conducted. According to their measurements, each animal was assigned to a Size Class, as constructed by Berry (1974), to determine possible age, sex and growing rate. Size, color patterns and designs of the backs and other body parts were used to identify individuals. Species identification was made based on Grismer (2002) and Hollingsworth (2004). Temperature at ground and rocks was recorded with a digital CE Thermometer. To characterize the *Sauromalus* habitat and to show the food items available for the animals, I identified the plant species present during the surveys and provide a brief mention of them.

RESULTS

A total of 16 individuals of *S. ater* were found on San Francisco Island. Table 1 shows the identification number, sex, estimated age, SVL (Snout-Vent Length) and HW (Head Width) measurements, coordinates and date of record. Individuals number 04, 05, 06, 10, 11 and 13 (N=6) ranged from 60 mm to 93 mm SVL, and from 12 mm to 18 mm HW (Fig. 5). The

Figura 3. Laderas orientales. La altura máxima es de c. 120 msnm. El plano de inundación es el área arenosa rodeada en su borde por vegetación halófila. La frontera entre los dos ecosistemas, el matorral del Desierto Sonorense y la vegetación costera, puede ser vista fácilmente en el centro de la foto.

Figure 3. Eastern foothills. Maximum height is c. 120 m. The flat plain is the denuded area with the rim covered by halophylic vegetation. The boundry between the two ecosystems, the Sonoran Desert and the Coastal Vegetation, can be easily seen close to the center of the picture.

Tabla 1. Sinopsis de individuos, fechas, datos biométricos, localidad y sexo de crías y subadultos de *Sauromalus ater* de la isla San Francisco.

Table 1. Synopsis of Individuals, dates, biometric data, location and sex of hatchlings and subadult *Sauromalus ater* from San Francisco Island.

No. of individual	Date	SVL	HW	Latitude	Longitude	Sex
1	6-Jan	113	22	24º 49' 31.8"	110º 34.5' 0.9"	Subadult male
2	6-Jan	111	19	24º 49' 34.2"	110º 34' 05"	Subadult female
3	6-Jan	122	24	24º 49' 84.8"	110º 34' 05"	Subadult male
4	6-Jan	93	18	24º 49' 31"	110º 34' 6.6"	Hatchling, sex undetermined
5	6-Jan	81	14	24º 49' 34"	110º 34' 61"	Hatchling, sex undetermined
6	6-Jan	65	13	24º 49' 35.1"	110º 34' 58"	Hatchling, sex undetermined
7	6-Jan	125	23	24º 49' 35"	110º 34' 5.4"	Subadult female
8	6-Jan	111	19	24º 49' 34"	110º 34' 05"	Likely Individual 2
9	6-Jan	110	21	24º 49' 29.1"	110º 34' 12.1"	Subadult female
10	12-Feb	78	14	24º 49' 23.1"	110º 33-51.4"	Hatchling, sex undetermined
11	12-Feb	75	13	24º 49' 32.4"	110º 34' 6.1"	Hatchling, sex undetermined
12	12-Feb	115	19	24º 49' 34.1"	110º 34' 05"	Subadult female
13	12-Feb	60	12	24º 49' 34.4"	110º 34' 5.3"	Hatchling, sex undetermined
14	12-Feb	110	21	24º 49' 29.1"	110º 34' 12.1"	Likely individual 09
15	12-Feb	112	19	24º 49' 33.1"	110º 34' 5.2"	Subadult female
16	12-Feb	146	25.6	24º 49' 35.2"	110º 34' 6.5"	Subadult female

Figura 4. Laderas occidentales, Bahía de la Media Luna, con vista hacia el norte. La elevación máxima aquí es de c. 150 msnm. Las faldas están cubiertas por el matorral del Desierto Sonorense. En la esquina inferior izquierda hay una senita (*Lophocereus schottii*).

Figure 4. Western foothills of Half Moon Bay, view to the north. Maximum elevation here is c. 150 m a.s.l. The slopes are covered by Sonoran Desert Vegetation. At the lower left there is an Old Man Cactus (*Lophocereus schottii*).

larger individuals (N=10) ranged from 110 mm to 146 mm SVL, and from 21 mm to 25.6 mm HW (Fig. 6). From the 10 larger individuals, eight were females. None were missing toes or had eggs. Figure 7 presents the ventral side of legs with the femoral pores of two individuals, indicating that they were females. Size, color patterns and designs of the backs were used to determine differences between them, rendering a total of 14 distinct individuals. Individuals 08 and 14 likely were the individuals 02 and 09 respectively, reducing the number of larger animals to eight. All chuckwallas were in apparent excellent health condition, despite the fact it was winter, and were also alert and combative when handled. Most of them were located under flake-like and loose volcanic rocks, no bigger than 50 cm by 50 cm. The gravel around was 29.3°C, as was the surface of their rock shelters.

The vegetation found in the study area constitutes food for the lizards (Cerdá *unpublished data*), and is represented by different families of flowering plants. There is a sharp distinction between the salt flats and the foothill in terms of substrate (flats have only fine sand mixed with salt) and in type of vegetation, factors

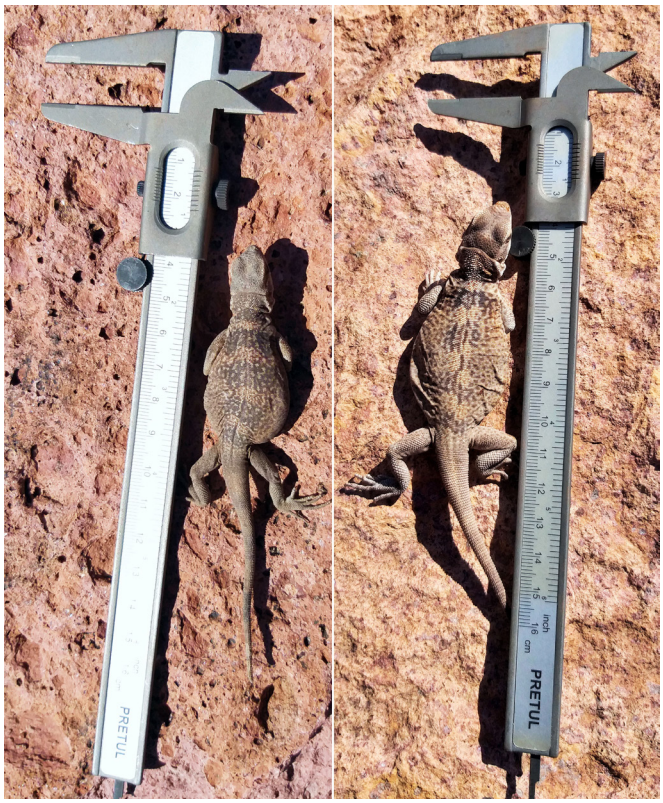

Figura 5. Izquierda, hembra subadulta de *Sauromalus ater* número 12 (LHC=115 mm; AC= 19 mm). Derecha, hembra subadulta número 15 (LHC=112 mm; AC=19 mm). Fecha: 12 de febrero, 12, 2019.

Figure 5. Left, subadult female of *Sauromalus ater* No. 12 (SVL=115 mm; HW= 19 mm). Right, subadult female No. 15 (SVL=112 mm; HW=19 mm). Date: Feb. 12, 2019.

determining the distribution of lizards on the island. On the salt flats dominate halophytes: *Artiplex* sp., *Allenrolfea occidentalis*, *Amaranthus* sp., *Stenotis mucronata*, *Bouteloua* and introduced grasses (*Bromus* and *Cynodon*) (Rebman & Roberts, 2012). This vegetation extends to the sand dunes, berm and beach, and *Sauromalus* is not present on these. The foothills are dominated by desert scrub, with bushes represented by *Agave sobria*, *Cylindropuntia alcahes*, *C. cholla*, *Opuntia tapona*, *Pachycereus pringlei*, *Stenocereus thurberi*, *S. gummosus*, *Lophocereus schottii*, *Mammillaria dioica*, *M. albicans*; *Jacquemontia eastwoodiana*; *Simmondsia chinensis*; *Ditaxis lanceolata*, *Euphorbia misera*, *Jatropha cuneata*; *Bursera microphylla* and *B. hindsiana* (Rebman & Roberts, 2012). All *Sauromalus* were encountered in this environment.

DISCUSSION

To put data in perspective, I compare my results with those of Berry (1974); she divided 116 chuckwallas by size into three age classes: Age Class I, with all hatchlings in their first year (46 to 60 mm SVL, plus juveniles, 60 to 99 mm SVL); Age Class II (100 to 149 mm SVL, termed immatures usually in their second to fifth spring); and Age Class III (potential breeders; females from 150 to 205 mm and males from 150 to 220 mm). In her study, hatchlings appeared in the fall (October and November) and late winter (February and March), and by the end of their first spring they might have doubled in length (90 to 100 mm SVL in June or July). Immature males' mean growth was 23 mm/year (range 19-38 mm), entering age class II in 1.5 years. Females grew slower (mean increase in SVL= 10.8 mm/year, range 0-25 mm). Females remain from three to six years in Age Class II.

In agreement with Berry, I assigned individuals 04, 05, 06, 10, 11 and 13 (mean SVL = 75.3 mm, range 60 to 93 mm) as to hatchlings/juveniles in their first year (Age Class I, hatched probably in last fall (October-November), or even December for individuals 06 and 13 as judged by their very small size (60 and 65 mm). The remaining eight different individuals, ranging from 110 to 146 mm SVL (mean SVL = 119.25) are considered immatures in this study, belonging to Berry's Age Class II, with a growing rate of 22 mm/year for six females, and a maximum growth rate of 33 mm/year for two males. There was a sharp distinction between the mean size of hatchlings/juveniles (SVL=75.3 mm) and the mean size of subadults (SVL = 119.25) in this study, a

Figura 6. Izquierda, cría de *Sauromalus ater* número 13 (Longitud Hocico-Cloaca [LHC]=60 mm; Anchura Cabeza [AC]=12 mm). Derecha, cría número 10 (LHC=78 mm; AC=14 mm). Fecha: 12 de febrero, 2019.

Figure 6. Left, hatchling of *Sauromalus ater* No. 13 (SVL=60 mm; HW=12 mm). Right, hatchling No. 10 (SVL=78 mm; HW=14 mm). Date: Feb. 12, 2019.

Figura 7. Izquierda, hembra subadulta de *Sauromalus ater* número 14 (LHC=112 mm; AC=21 mm). Derecha, hembra subadulta número 16 (LHC=146 mm; AC=25.6 mm). Fecha: 12 de febrero, 2019.

Figure 7. Left, subadult female of *Sauromalus ater* No. 14 (SVL=112 mm; HW=21 mm). Right, subadult female No. 16 (SVL=146 mm; HW=25.6 mm). Date: Feb. 12, 2019.

mean difference of 43.7 mm, which is also in agreement with Berry's estimated growing speed from Age Class I to Age Class II . No intermediate sizes between the biggest hatchling/juvenile (SVL=93 mm) and the smallest subadult (SVL=110 mm) were found.

In relation to reproductive size/age, Berry found that females smaller than 120 mm had spherical follicles 0.5 to 2 mm in diameter; females 120 to 140 mm had 2-5 mm follicles, and one female 134 mm had 6 ovarian eggs 8.5 to 9.0 mm in diameter. She estimated that females around 140 mm or larger would have ovarian eggs greater than 10 mm in April, May, and June. The smallest female with enlarged (>10 mm) ovarian eggs was 145 mm, with eight ovarian eggs ranging from 15.5 to 18.6 mm. A female from Sonora, 148 mm, had six ovarian eggs 11-14 mm. Thus, animals at 150 mm or longer must be considered mature adults. Female 16 in this study may be a potential breeder as she had attained the size to accommodate ovarian eggs and maturity to mate, as derived from Berry's system.

As stated above, goats and feral cats were eradicated from San Francisco Island (Aguirre-Muñoz et al., 2008, 2011). The lack of big and voracious food competitors (goats), and devastating predators (cats) has released the local reptile populations from tremendous destructive forces. Likewise, eradication of feral cats from Santa Catalina Island in 2004 favored the increase in population size and abundance per hour of searching of *Sauromalus klauberi* and *Dipsosaurus catalinensis* (Arnaud, 2015), and of *Crotalus catalinensis* (Cerdá, *unpublished data*). Up to April 2018, 60 populations of invasive mammals have been removed from 39 islands, 30 of which are now completely free of invasive mammals (Aguirre-Muñoz et al., 2018). Eradication of 83 invasive mammal populations from other 34 islands is in various stages. Islands ranked as priority where eradication is feasible are Socorro, Espíritu Santo, María Cleofas, and María Magdalena with 11 invasive mammal populations, that would yield a further 35,813 ha free of exotics, thus reducing risk of extinction of 80 endemic species (Aguirre-Muñoz et al., 2008, 2011).

CONCLUSSION

Based on the existence of hatchlings, juveniles and subadult individuals of *Sauromalus ater* (one female close to entering in reproductive age) it is concluded that *Sauromalus ater* may be

increasing its population by recruitment, which may account for a general trend of biota recovery in San Francisco Island after the effective eradication of feral cats and goats.

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