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Control of *Rattus norvegicus* on Uninhabitable Islands[1a]

- Case of Sasudo Island -

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무인도에서 집쥐 개체군의 포획과 제어[1a]

- 제주 사수도의 사례 -

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ABSTRACT

Brown rats (*Rattus norvegicus*Berkenhout, 1769) were eradicated from Sasudo Island (33°55′13.04″ N, 126°38′19.98″ E), an uninhabited island designated as Natural Monument No. 333 and the largest breeding site for the streaked shearwater (*Calonectris leucomelas*Temminck, 1835) in South Korea. Twelve eradication studies were conducted from November 2015 to February 2021. The survey was conducted using a line census method that entailed slow wandering throughout the island and identifying starting and returning points. Capture traps were installed around traces of *Rattus norvegicus,*such as excrement and identified holes. As a result, 2 to 6 individuals were captured at each instance, except for the last time, when no individuals were captured. It is hypothesized that brown rats arrived at Sasudo Island via vessels arriving at the island for leisure and fishing. After the damage to streaked shearwater caused by brown rats was confirmed in 2006, entry to Sasudo Island was strictly prohibited through security measures, and marine clean-up programs that began in 2013 and continuous capturing since 2015 have been successful in eradicating brown rats. To maintain and manage the condition in Sasudo Island, preservation and management measures, such as strict visitor control, are necessary to prevent the inflow of new brown rats in the future.

KEY WORDS: RATTUS NORVEGICUS, ERADICATION, SASUDO ISLAND, CAPTURE TRAPS, PREVENT THE INFLOW

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요 약

본 집쥐 퇴치 계획은 대한민국 최대 습새 번식지 및 흑비둘기 서식처로 천연기념물 제333호로 지정되어있는 제주특별자치도 소재(33°55′ 13.04″ N, 126°38′ 19.98″ E) 무인도서인 사수도 내 집쥐 퇴치를 위해 이루어졌다. 구제 연구는 2015년 11월부터 2021년 2월까지 총 12차례 진행되었고, 조사는 섬 전역을 천천히 배회하며 출발지점과 도착지점을 동일하게 하여 조사하는 선조사법을 이용하였다. 이 때 확인된 배설물, 터널 등 *Rattus norvegicus* 흔적 주변에 포획트랩을 설치하였다. 그 결과 매 차시 최소 2개체 ~ 최대 6개체가 포획되던 개체가 마지막에는 포획되지 않았다. 집쥐가 사수도에 유입된 경로는 과거 레저 및 어업을 위해 출입하는 배를 통하여 유입되었을 것으로 추정하고 있다. 2006년 집쥐로 인한 습새의 피해가 확인된 후 철저한 경비를 통하여 사수도 출입을 엄격히 금하고 2013년 해양정화 사업과 2015년부터 지속된 포획을 통하여 구제가 성공적으로 이루어지고 있는 것으로 판단된다. 본 상태 유지 및 관리를 위해서 앞으로 새로운 집쥐의 유입을 제어하기 위하여 지속적이고 철저한 출입관리를 이어가 출입자를 엄격히 통제하는 등의 보존 관리방안이 필요하다 할 수 있다.

주요어: 제주특별자치도, 무인도서, 천연기념물, 포획트랩, 유입

INTRODUCTION

Sasudo Island, located at San 121, Yecho-ri, Chuja-myeon, Jeju-si, South Korea, about 23 km east of Chuja Island, (33°55′ 13.04″ N, 126°38′ 19.98″ E) is a small island with an area of about 138,701 ㎡ (13.9 ㏊). The island's highest point is 79 m. It has a steep cliff on the southern slope and a relatively flat intertidal zone in the north (Lee and Yoo, 2002). The island was designated as Natural MonumeNo. 333 in 1982, owing to its value as a habitat for Japanese woodpigeon (*Columba janthina* Temminck, 1830), and also it being the largest breeding ground for streaked shearwater (*Calonectris leucomelas* Temminck, 1835) in South Korea (Cultural Heritage Administration 2014). The main animals inhabiting and breeding on Sasudo Island are Falco peregrinus (endangered wildlife class I in South Korea), Pleske's Grasshopper-warbler (Locustella pleskei Taczanowski, 1890), and Japanese woodpigeon (endangered wild animal class II in South Korea). Sasudo Island is uninhabited, but haenyeo (female divers) fish in the area using barracks from summer to autumn. In addition, in the past, anglers visited the islands frequently to fish, (Lee and Yoo, 2002).

Rattus is known to have originated in Central Asia, China-East Asia, etc., but had spread to Europe in the early 18th century, and is now widely distributed in all regions, except polar (Innes 1990; Yoon *et al.,* 2004; Musser and Carleton 2005; Robins *et al.,* 2008; Kim *et al.*, 2013). There are three species of rat in South Korea: Brown rat (*Rattus norvegicus* Berkenhout, 1769), House rat (*Rattus rattus* Linnaeus, 1758), and Oriental house rat (*Rattus tanezumi* Temminck, 1844) (Koh 1991; Yoon *et al.*, 2004; Bastos *et al.*, 2011; Kim et al., 2013). Globally, the distribution of Brown rats correlates with diverse human activities, such as residential, agricultural, and commercial areas (Meerburg *et al.*, 2009; Arai *et al.*, 2012; Kim *et al.*, 2013).

There have been 115 cases of infestation on 61 islands worldwide, and 75 species of seabirds have been seriously affected by rats. The main damage to seabirds is caused by omnivorous rats that eat eggs or chicks during the breeding season (Caut and Courchamp 2008; Jones *et al.*, 2008; Marjorie and Diego 2015). In general, Procellariformsare highly vulnerable to predators such as Brown rat because they do not return to their nests until night after feeding in the sea during the day. Previous studies have shown that about 83% of the nests are damaged by predators (Warham 1990; Nam *et al.*, 2004).

Globally, rat eradication efforts have mainly included bait station installation using rat poison, and hand and aerial broadcasting. In New Zealand, rat eradication was successful on more than 90 surrounding islands, and the most effective methods were bait station installation and aerial broadcasting (Towns and Broome 2003; Smith 2013). In addition, on Langara Island, Canada, Monito Island, Puerto Rico, and French Saint Paul Island in the Indian Ocean, sea birds and reptiles were endangered due to predation by invasive rat (genus *Rattus*); but the rats

were eradicated using bait stations and aerial broadcasting (Garcia *et al.*, 2002; Micol and Jouventin 2002).

This paper reports on an important rat eradication on Sasudo Island, the largest breeding site for streaked shearwaters in Korea.

MATERIALS AND METHODS

1. Selection of survey areas

In 2006, unmanned island monitoring and a biological resources survey were conducted on Sasudo Island, the largest breeding ground for seabirds in South Korea. In the process, damage to seabirds, such as predation of eggs and chicks, by brown rat was confirmed. Accordingly, monitoring of brown rats on Sasudo Island was initiated in 2015, and a total of 12 eradication drives were conducted (Figure 1). Damage was assessed during the breeding season to prevent any deleterious effects caused by the rodenticide (Table 1).

2. Eradication methods

The habitat survey identified the paths to be used for installing capture traps, by tracing excrement and holes; and a route survey method entailed slow monitoring of the rats throughout the island, identifying the start and return points. After that, traps were installed at around 4 p.m. at the locations where brown rats were expected. The traps were checked every 6 h to check for any capture. After measuring and recording specific information on the captured rats, they were deported from island. The traps used for capture were the Sherman live trap (40 numbers each of size 7.6 × 8.9 × 22.9 cm, Tallahassee, FL, USA), iron form box trap (40 numbers each of size 11 × 19.5 × 9 cm, China), sticky rat trap (40 numbers each of size 22 × 12 × 10 cm, China), and rodenticide trap (10 numbers each of size 11 × 21.4 × 11.8 cm, China). The quadrat method (actual available area / total quadrat area × capture individuals = estimate individuals) was used to estimate individuals.

For the survey and eradication, a blood coagulation

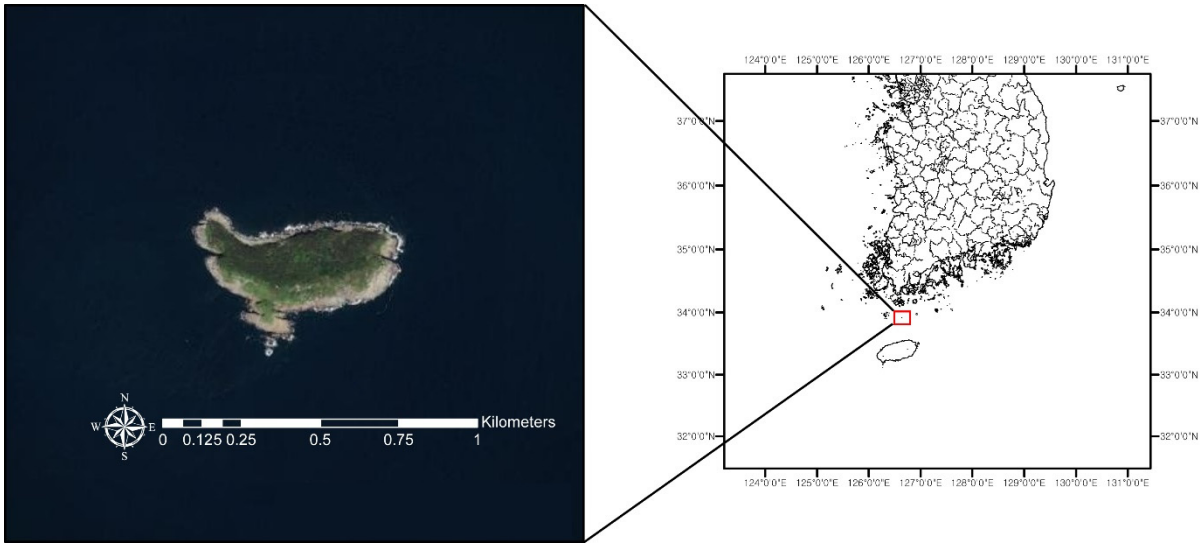

Figure 1. Location map of Sasudo Island. Sasudo Island is located in 33 55 13.04" N, 126 38 19.98" E between the mainland of south Korea and Jeju Island and is a small island with an area of 138,701 ㎡.

Table 1. Field research date

Times	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Years	2015	2016	2018	2019				2020			2021	
Month	Aug.	May. - Jun.	Sept.	Jan.	Mar.	Apr.	May.	Nov.		Dec.	Feb.	
Day	2~3	31~1	7~8	4~6	1~2	3~4	23~25	11~12	3~5	20~22	3~5	19~20

Figure 2. used baits and traps. A: Sherman live trap, B: iron box trap, C: rodenticides trap, D: glue pad trap, E: bait; sausage, F: bait; fish cake, G: blood coagulation inhibitors.

inhibitor was mixed with the bait. The baits were strong-smelling substances such as fish cake, sausages, anchovies, and nuts. Two types of blood coagulation inhibitor (Flocoumafen) were used (one from Chong Jin Pamrma Co., Ltd., and another from Green Worldpharm Co., Ltd.). To protect against secondary toxicity, a general bait was used with iron box traps and glue pad traps; while the Sherman live traps and rodenticide traps had covers and rat glue pad, so brown rat couldn't escape, so the rodenticide (17.5 g include 0.005% flocoumafen) could be mixed with the bait. (520 g) (Figure 2).

RESULTS AND DISCUSSION

1. Eradication and Capture of Brown rat2

During the whole survey of the island, brown rat excrement was identified at 3 locations, two around the haenyeo barracks and one on the northwest slope close to the streaked shearwater breeding ground. Brown rat holes were identified at 15 points. The altitude ranges at which the hole points were identified were 0–10 m (2 hole points), 10–20 m (1 hole point), 30–40 m (3 hole points), 40–50 m (3 hole points), 50–60 m (4 hole points), and 60–70 m (2 hole points). Overall, the locations were concentrated on the northern slope, where streaked shearwater breeding grounds were located, and most of them were on gentle plains. In total, 41 individuals were captured (Table 2; Figure 3). In the previous survey in 2006, approximately 800 to 900 brown rats (Oh 2007) were estimated to inhabit the island; however, in the first field survey in 2015, the estimated population calculated using the quadrat method was much lower at 166.5. In addition, no individuals were captured in the 12th attempt, it suggests that eradication is being carried out successfully.

2. Management of Brown rat

Excrement and holes of the brown rat, living on Sasudo Island were found around the streaked shearwater breeding areas, which is a potential food source, and around haenyeo barracks rich in food such as rice. Sasudo Island is deserted with limited food sources for the brown rat. Therefore, the rats mainly feed on eggs and young birds, fish and shellfish on the beaches, and also the food eaten by haenyeo. This survey was mainly conducted in winter, during which the main food source for rats is plants and capturing them using bait is relatively easy.

Rodents such as brown rat can swim approximately 0.8 km, and mainly move between islands by swimming or travelling in a boat (Russell *et al.*, 2008). Sasudo Island is 23.3 km from Chujado Island and about 18.5 km from Soando Island, making it almost impossible for rats to reach it by swimming; thus they were most likely introduced to adjacent islands via boat. Rodents such as brown rat can move relatively easily by boat (Moors *et al.*, 1992), and it is assumed that rats were introduced by

Table 2. Capture data of brown rat individuals

Times	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Capture	5	4	2	4	3	2	3	3	4	6	5	0
Estimated population	166.44	133.15	66.58	133.15	99.86	66.58	99.86	99.86	133.15	199.73	166.44	0

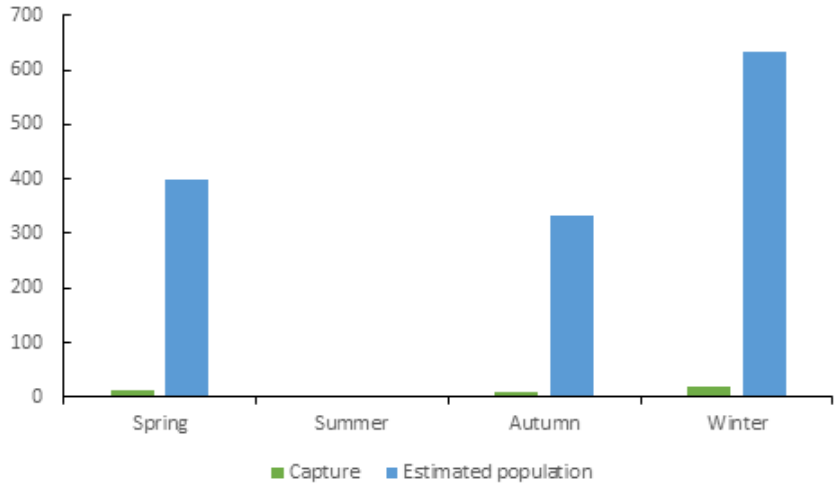

Figure 3. Seasonal brown rat capture and estimated individuals.

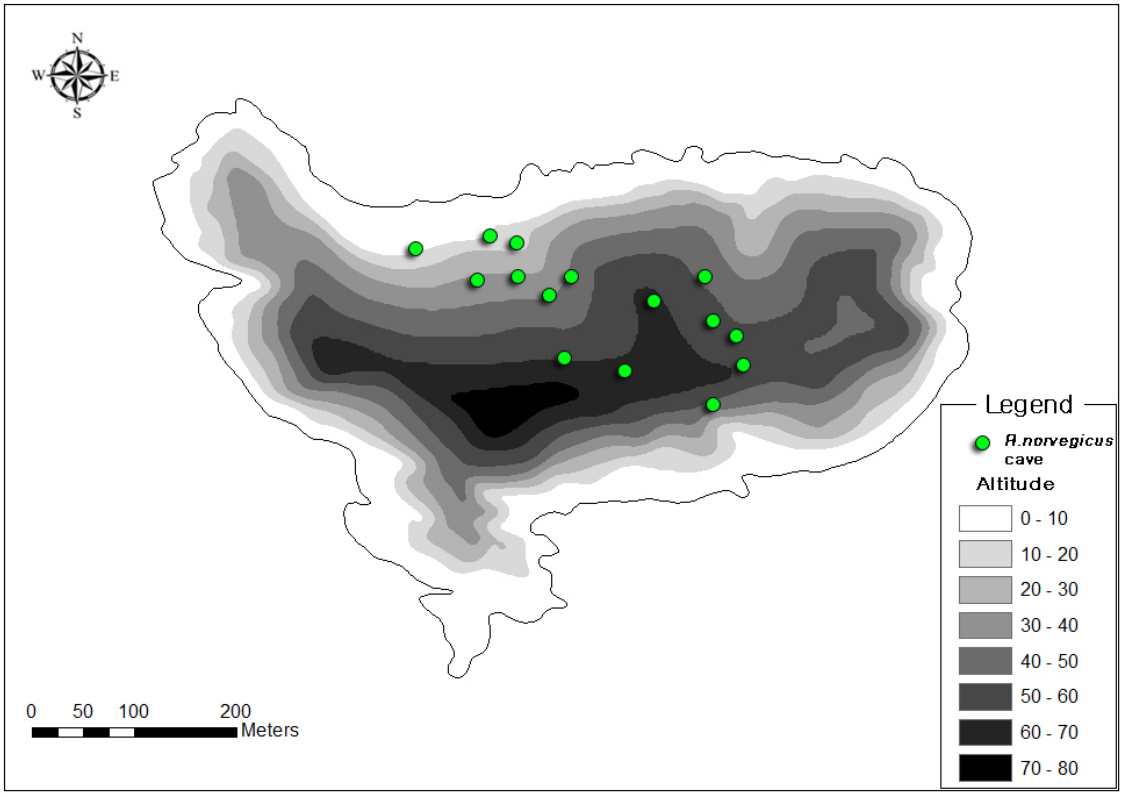

Figure 4. Location of the brown rat holes identified at the altitude of sasudo island.

vessels anchoring at Sasudo Island for leisure, fishing, and research, and by haenyeo who regularly arrive at and leave Sasudo Island.

The reason why the current estimated population of the streaked shearwater is smaller than that in 2005 is that leisure and fishing activities were carried out actively at Sasudo Island in the past, resulting in maximum reproduction by the brown rats, utilizing food waste discarded by people visiting the island. However, after the disturbance in breeding of streaked shearwater by brown rats was revealed in 2006, public was strictly prohibited from entering the site following strengthening of patrolling and security measures by the maritime police. Access for leisure and fishing activities was also restricted.

As a result of indirect investigation, about 200 to 300 brown rats were captured by the members of Yecho-ri fishing village societies as a part of marine purification project in the winter of 2013, Therefore, it is believed that the estimated population of brown rat decreased rapidly during the first survey in 2015.

The breeding success rate of the streaked shearwater increased from 22.5% to 29.3% due to the capture and eradication of brown rat in 2019. The breeding failure rate attributed to brown rat predation was 85.5% in 2014, and 77.4% in 2016, but decreased to 27.6% in 2019 (Nam *et al.,* 2014; Shin 2016). This result also indicates that the number of brown rats has decreased gradually.

As brown rats have not been observed on Sasudo Island since December 2021, it is believed that eradication was successful; however, future preservation and management measures will be important for maintaining this condition. To prevent the introduction of new brown rats, the government should continue its security posture by strictly prohibiting public entry in the island and allowing only researchers enter with permission. No brown rat was spotted or captured post the eradication, indicating successful elimination of brown rats, and preserving streaked shearwater breeding sites. Further follow-up management and investigation will be needed in the future to maintain the breeding sites of the seabirds.

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