Review of Existing Measures to Reduce Roadkills and Future Approach

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1. Roadkills on the property and the objective of this report

In parts of the property and surroundings, there have been confirmed car accidents of endemic species and rare species, such as the Amami rabbit Ryukyu long-haired rat, Okinawa rail, Iriomote cat, and crested serpent eagle. These traffic accidents include cases where it was confirmed that such species had been injured or killed by car through, for instance, statements of the parties involved, witness statements, and veterinary medical examinations of dead or injured animals, and cases where autopsy results of dead animals collected in the vicinity of roads found that the injuries or deaths were caused by traffic accidents. The dead bodies of threatened species, such as chicks of Okinawa rails, Anderson's crocodile newts, Ryukyu black-breasted leaf turtles, and Yaeyama yellow-margined box turtles and other small animals were also broadly classified as roadkill when they fell into street gutters, could not get out on their own, and died. Roadkills could have a negative impact on the survival of species. In addition, they could impede the further recovery and distribution of some rare species whose populations are on a recovery trend thanks to the various measures taken. Some of the endemic species and rare species inhabiting the property have an extremely small natural distribution area. Although main roads are built outside the property, it is necessary to pay attention to the occurrence of roadkills not only in the property but also in the Buffer Zone and Surrounding Conservation Area, from the perspective of the survival of these species. At the same time, it must be noted that the target species, status of roadkill incidents, development of countermeasures, and the types and seriousness differ from one island to another.

Meanwhile, cars and roads are essential to the livelihoods of local people. Thus far, based on discussions with local people on the need of roads for their livelihoods, measures were taken such as blocking roads with little traffic and during hours of low use. However, roadkills on roads used by various users, including tourists, remain a challenge. To promote the enhanced prevention of roadkills in the future, it is important to discuss with local people how high-traffic roads and tourism should be managed and share with them a common understanding. This is strongly related to the request on tourism management and is being discussed together.

In response to the request, this report summarizes the past occurrence of roadkills and the current effect of countermeasures in order to organize information for a review of the existing measures and more effective implementation of new measures. In addition, the report provides an update on the subsequent initiatives of the various roadkill countermeasures stated in the nomination document submitted in January 2019 (see 4.a.2.2. “Traffic accidents, etc.” on pp. 182–185) and the various measures reported to the IUCN mission in October 2019.

2. Status of roadkills and their impact on the species survival and the ecosystem functions

Overview

- Roadkill incidents of threatened species, the causes, and the impact on the populations on the four islands have been reviewed based on the information obtained to date. For all species, roadkill incidents have been on the rise or have remained at high levels over a long time. The potential causes of this situation are changes in tourism dynamics and a recovery in, and greater distribution of, the populations of threatened species in recent years due to measures taken against alien species.
- With regard to the Iriomote cat, which is the top predator with a small population, roadkills are considered to have a material impact on the species population and on the ecosystem of Iriomote Island. As for the Amami rabbit and the Okinawa rail, it is estimated that the population and distribution of both species are on a recovery trend. Nonetheless, given their high rankings on the IUCN Red List, it is necessary to continue reducing the impact of roadkills on these species. For the Amami rabbit on Tokunoshima Island, the habitat is fragmented between the southern and northern parts of the island, and the impact of roadkill is of greater concern.
- In addition to these three species, an analysis was conducted on the roadkill trend of the Ryukyu long-haired rat. Furthermore, roadkills of animals on Iriomote Island, including common species, were analyzed. In addition, roadkill data for other rare species are being collected, including Okinawa robins, Okinawa woodpeckers, Ryukyu black-breasted leaf turtles, and spiny rats. The collected data will be analyzed further.

Confirmation methods of roadkill incidents

On each island, when a veterinary investigation or autopsy result has found that a crash with an automobile resulted in the injured or dead animal collected from a road or vicinity following notification from local people or others, such an incident is counted as a roadkill. The counting of the number of roadkills began around the time when the Ministry of the Environment opened a local office or a local conservation group began its activities on an island. It has thus started in 2000 on Amami-Oshima Island and Tokunoshima Island, in 1995 on Northern part of Okinawa Island, and in 1978 on Iriomote Island. Confirmation and assessment methods of roadkills gradually became structured after data collection started. The current methods are shown in Figure 1. For many rare species with a smaller body size (e.g., reptiles and amphibians), in principle a roadkill is determined when a dead body is found run over on the road. The number of roadkills is the number that the Ministry of the Environment could confirm based on reports from local people. The actual number is considered to be higher. Dead animals are often snatched by carnivorous birds such as crows. There are hence many instances where information cannot be collected even when roadkills have occurred.

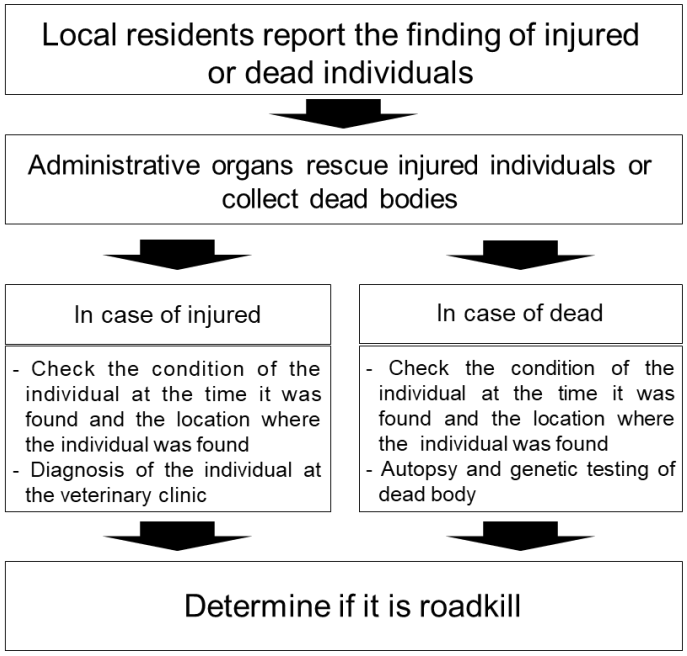


Figure 1: Flow chart from report of roadkill to determination of cause of death

Status of roadkills

The following shows the number of roadkills of flagship species in each area from the year data collection began and up to 2021 and the locations where roadkills were confirmed for the past five years. For Amami rabbits on Amami-Oshima Island however, the locations of roadkills are compiled for the past three years due to the large number of such locations. In addition, roadkills of various animals, including Ryukyu long-haired rats and common species on Iriomote Island, were compiled based on the information obtained to date.

Roadkills of Amami rabbits on Amami-Oshima Island

Data collection on the number of roadkills of Amami rabbits on Amami-Oshima Island began in 2000 when the Amami Wildlife Conservation Center opened. Thereafter, the number peaked in 2009 and subsequently remained at around 20 a year. However, the number again began to rise in 2020. In recent years, there were a few roadkill incidents within the property but these were concentrated in specific sections, such as the Aminoko Pass (municipal road) that connects Amami City and Setouchi Town. In the Buffer Zone and Surrounding Conservation Area there are confined areas where multiple roadkills were confirmed. These include Yamato Village and Uken Village where confirmed roadkill incidents coincided with a recovery in the distribution of the Amami rabbits in recent years.

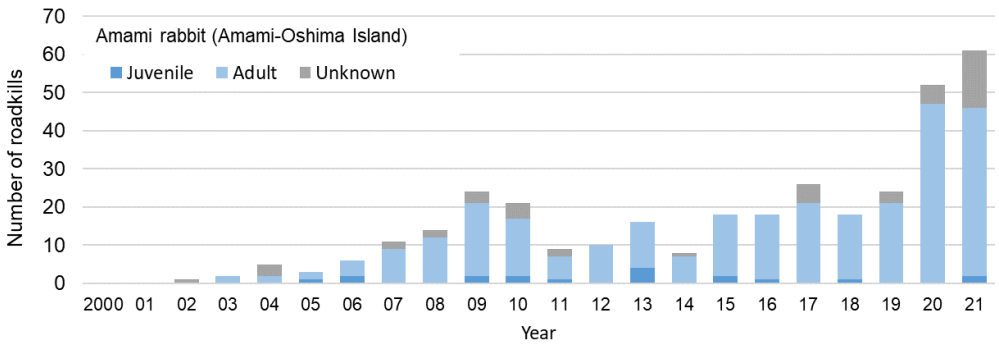


Figure 2: Number of roadkills of Amami rabbits on Amami-Oshima Island (2000–2021)

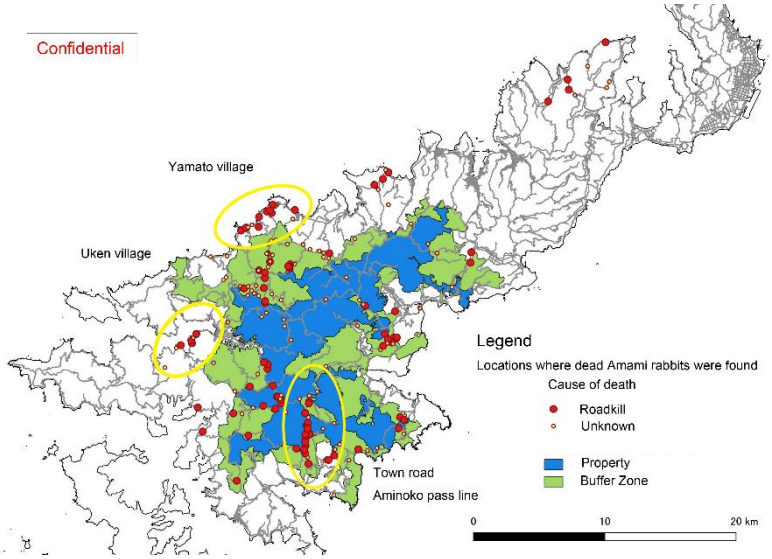


Figure 3: Locations of roadkills of Amami rabbits on Amami-Oshima Island (2019–2021)

*The areas circled by yellow lines are locations where attention should be paid.

Roadkills of Amami rabbits on Tokunoshima Island

Data collection on the number of roadkills of Amami rabbits on Tokunoshima Island began in 2000 when the Amami Wildlife Conservation Center opened. The data collection system has been strengthened since the opening of the Tokunoshima Ranger Office for Nature Conservation (currently, Tokunoshima Ranger Station) in 2013. Nearly twenty roadkills, more than double previous numbers, were confirmed since 2018. In recent years, a very small number of roadkills were confirmed within the property. On the other hand, roadkills were concentrated in the Surrounding Conservation Area, such as Prefectural Road No. 618 between Matsubara and Todoroki, and Prefectural Road No. 629 between Tete and Kanami.

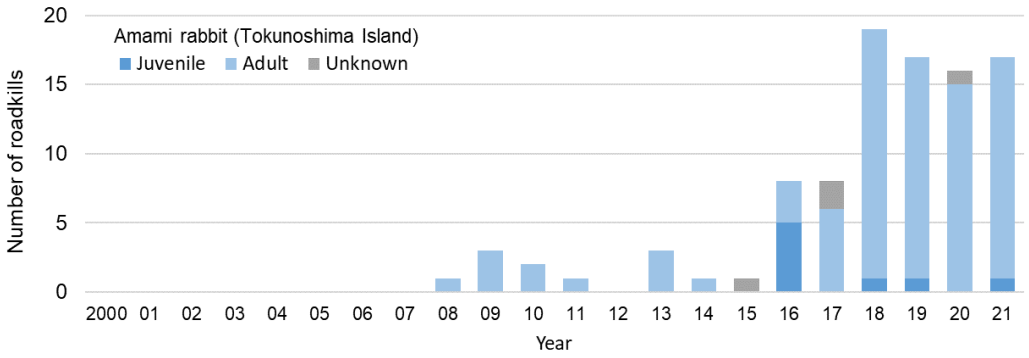


Figure 4: Number of roadkills of Amami rabbits on Tokunoshima Island (2000–2021)

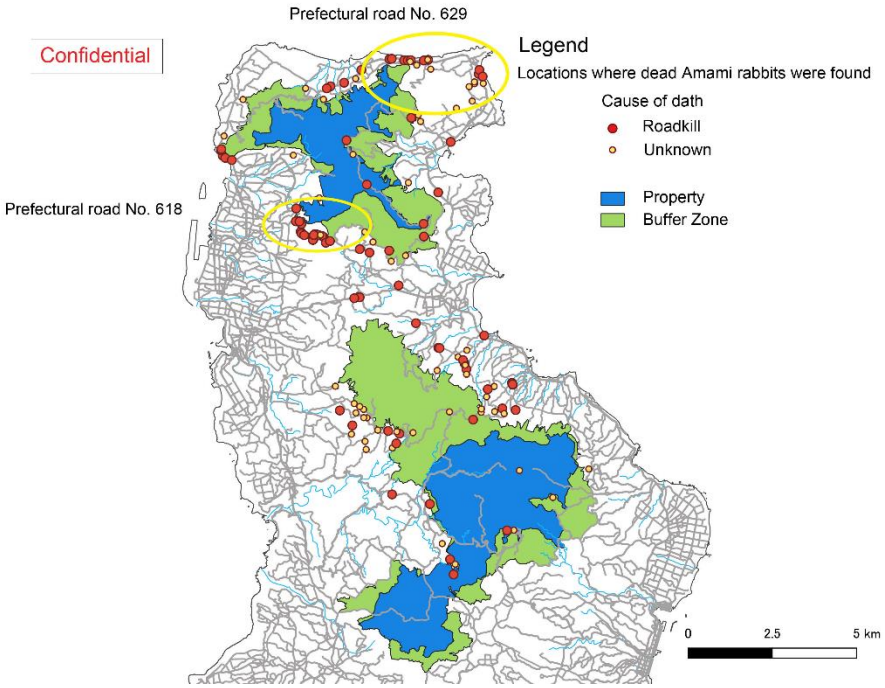


Figure 5: Locations of roadkills of Amami rabbits on Tokunoshima Island (2016–2021)

*The areas circled by yellow lines are locations where attention should be paid.

Traffic accidents of Okinawa rails in Northern part of Okinawa Island

The number of roadkills of Okinawa rails has increased over the long term. While it declined between 2014 and 2018, it has again been increasing slightly in recent years. In recent years roadkills often occurred on Prefectural Road No. 2 that extends across the property and in the eastern part of the property.

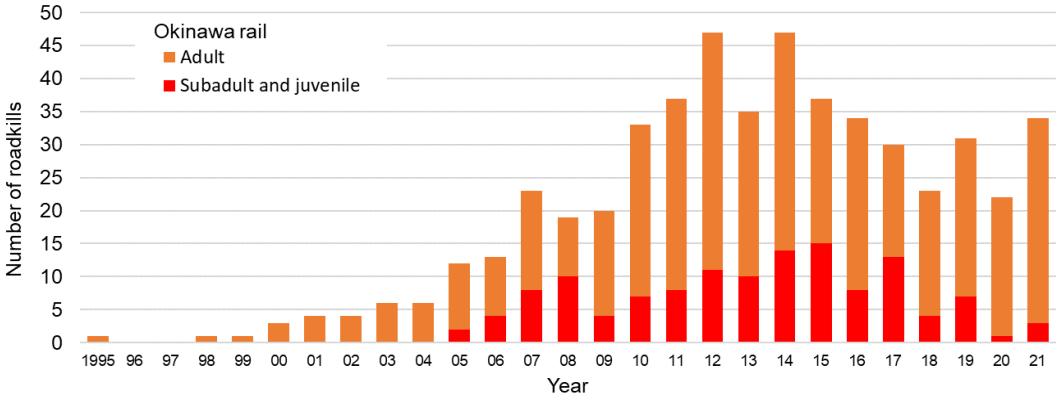


Figure 6: Number of roadkills of Okinawa rails (1995–2021)

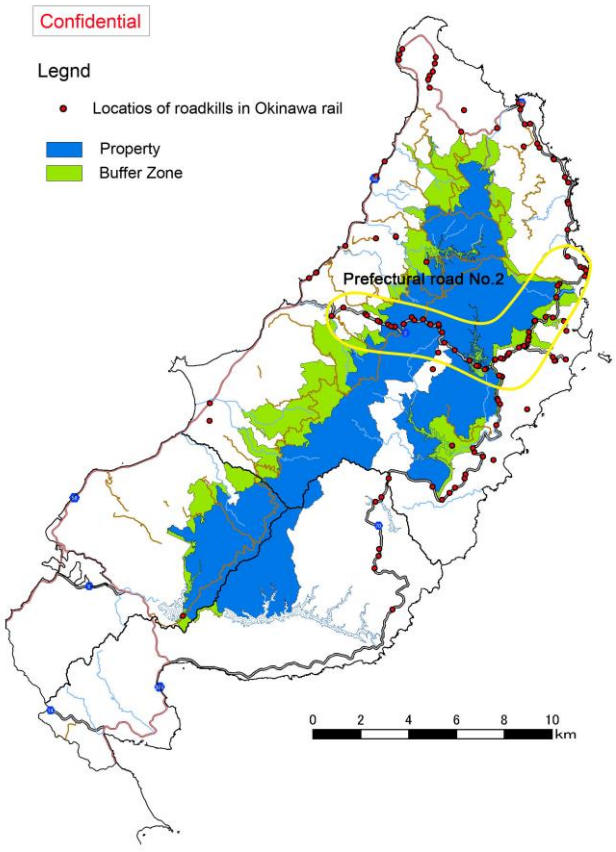


Figure 7: Locations of roadkills of Okinawa rails (2017–2021)

*The area circled by a yellow line is the location where attention should be paid.

Traffic accidents of Iriomote cats on Iriomote Island

The number of roadkills of Iriomote cats was one or two in most years between 1978 and 2010, but began to show a clear rising trend from around 2010. In recent years slightly more incidents have occurred in the western part.

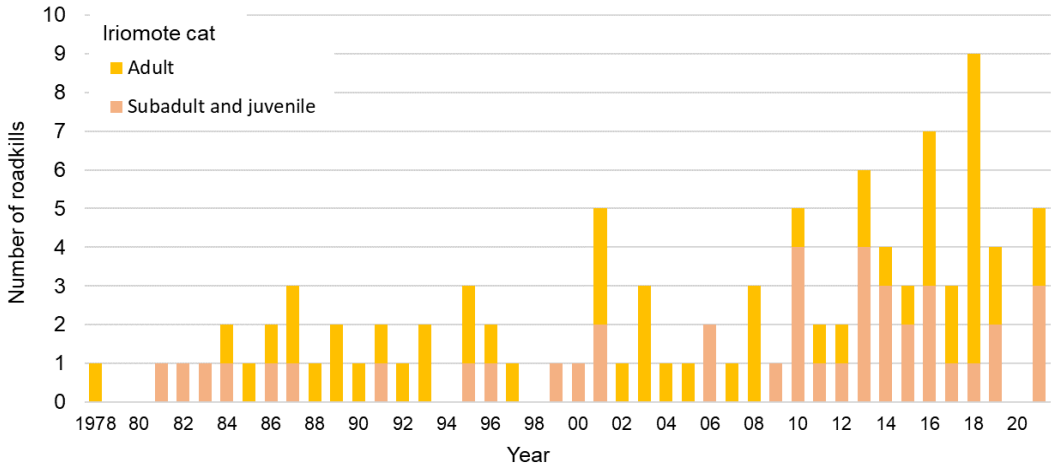


Figure 8: Number of roadkills of Iriomote cats (1978–2021)

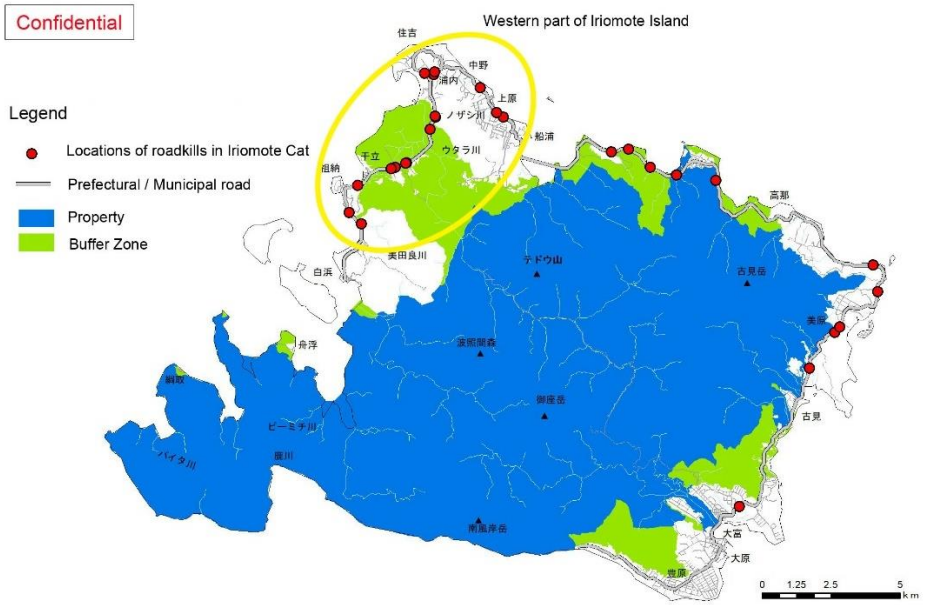


Figure 9: Locations of roadkills of Iriomote cats (2016–2021)

*The area circled by yellow line is the location where attention should be paid.

Traffic accidents of other rare species

The number of roadkills of Ryukyu long-haired rats has been smaller when compared to Amami rabbits and Okinawa rails. However, it is characterized by extremely large fluctuations from one year to another (Figure 10). This may be attributable to the strong influence that fluctuations in population size have on the number of roadkills, as it was observed that the population size of long-haired rats may be related to the yield of Castanopsis nuts, which is known to fluctuate very widely. A survey of night roadkills of various animals, including common species, in JFY2020 and JFY2021 on the main roads of Iriomote Island, revealed that most roadkills were frogs and crabs (Figure 11).

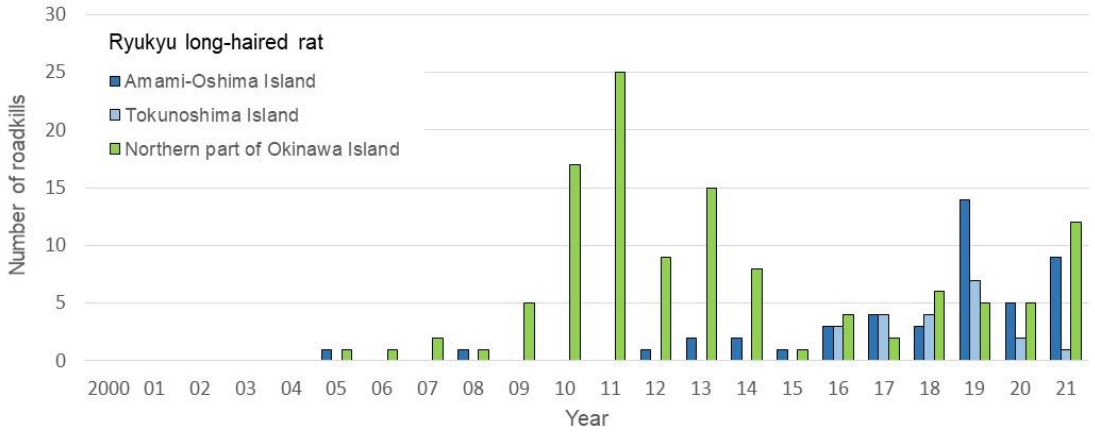


Figure 10: Number of roadkills of Ryukyu long-haired rats on Amami-Oshima Island, Tokunoshima Island, and Northern part of Okinawa Island (2000–2021)

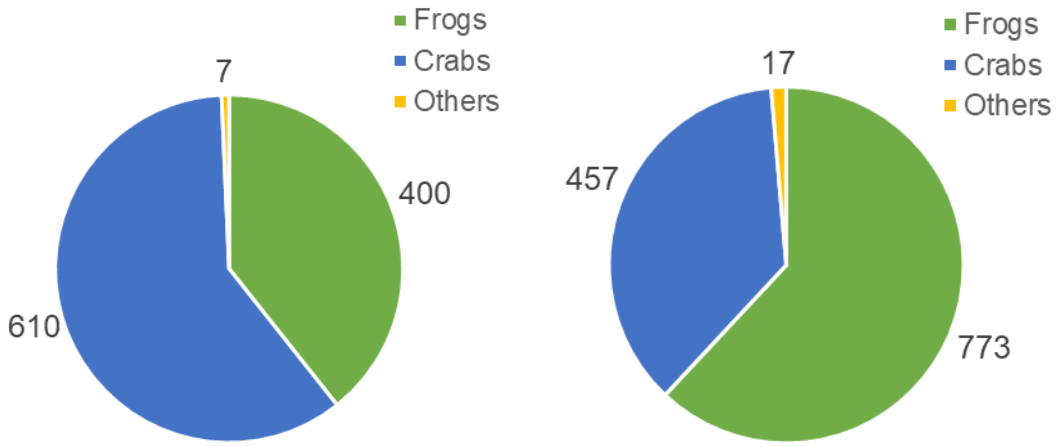


Figure 11: Number of roadkills by taxon on Prefectural Road 215, Shirahama Haemi Line, on Iriomote Island in JFY2020 (left) and JFY2021 (right)

*Census surveys were conducted approximately 80 times between 20:00 and 23:00 from July to February of each fiscal year.

Negative impact on the survival of species and the functioning of the ecosystem

The number of roadkills is influenced by various factors, including the frequency that local people, etc. provide information, the volume of traffic in a particular year, the population and distribution of rare species, changes to road structures, and the impact of various roadkill prevention measures. For this reason, sufficient attention must be paid to correlations with these factors when assessing the trend in the number of roadkills. The following are examples where these factors might have impacted the number of roadkills.

One of the reasons for the rising number of roadkills among the Amami rabbit population on Amami-Oshima Island could be the recovery trend of its population and distribution area achieved by progress in control of the small Indian mongoose, an alien species that had a material impact on the habitat of endemic species. While an accurate population is unclear, one estimate placed the population of Amami rabbits between 2,000 and 4,800 in 2004 (Sugimura and Yamada, 2004). Although the Ministry of the Environment's protection and recovery project for the Amami rabbit is currently re-estimating their population using multiple analysis techniques and due to complete calculations by the end of fiscal year 2022, past monitoring and survey results of this species indicate a clear growth trend in its population (Figure 12). However, the Amami rabbit is assessed as "EN" by the IUCN and MOEJ Red Lists. To facilitate further recovery of this species, roadkill prevention measures will continue to be enhanced.

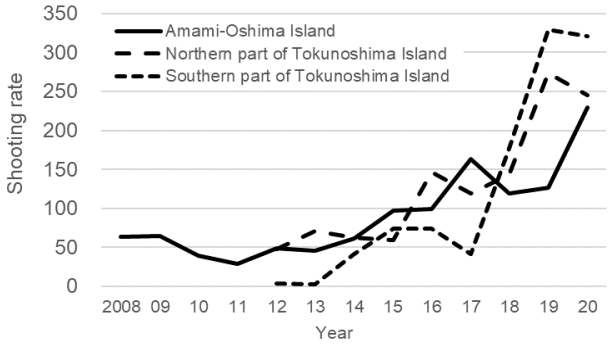


Figure 12: Change in the shooting rate of Amami rabbits by automatic cameras (number of photos taken/number of days when cameras were installed x 1000)

*Number of cameras installed: approx. 400 on Amami – Oshima Island, approx. 9 on northern Tokunoshima Island, approx. 20 on southern Tokunoshima Island

With respect to the Amami rabbit population on Tokunoshima Island, the population and distribution area are also recovering due to the effect of the feral cat control project. This is considered one of the reasons for the increase in the number of roadkills of this species in recent years. While an accurate population count is unclear, one estimate placed the population of Amami rabbits at around 200 in 2004 (Sugimura and Yamada, 2004). As in the case of the population in Amami-Oshima Island, the population on Tokunoshima Island is currently being re-estimated using multiple techniques. Meanwhile, there is a concern that the impact of roadkills on the species survival may be relatively greater on Tokunoshima Island compared with Amami-Oshima Island as the former's area is smaller and the habitats of Amami rabbits are divided into north and south.

Table 1: Number of roadkills and estimated population for each species

Species	Number of annual roadkills for the past 3 years	Estimated population	IUCN Red List	Area (property+ buffer zones)
Amami rabbit (Amami-Oshima Island)	22–59	Approx. 2,000–4,800 (2004)	EN	26,145 ha
Amami rabbit (Tokunoshima Island)	16–17	Approx. 200 (2004)	EN	5,327 ha
Okinawa rail (Northern part of Okinawa Island)	22–34	Approx. 1,500 (2021)	EN	11,119 ha
Iriomote cat (Iriomote Island)	0–5	Approx. 100※ (2008)	CR	24,416 ha

※Estimated population of resident adults

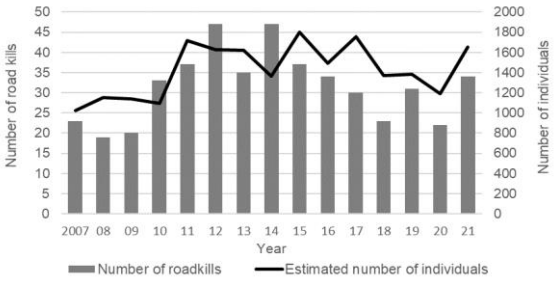


Figure 13: Relationship between the number of roadkills and estimated population of the Okinawa rail

*95% confidence interval for estimated population is omitted.

*Figures for 2021 are preliminary.

Although it is not as apparent as Amami rabbits, the population and distribution area of Okinawa rails have also been recovering due to the control project of the small Indian mongoose, an alien species (see p. 169 of the nomination document). A feature that differs from Amami rabbits is that the number of roadkills of Okinawa rails fell temporarily up to 2020 after peaking in 2014 (Figure 6). This temporary decline could be attributable to factors such as: the designation of locations with frequent traffic accidents as the priority areas for roadkill countermeasures and the introduction of speed limits to these areas; the potential contribution of the seven underpasses constructed at the time; and a potential link to changes in the population (Figure 13). Unlike other species, a population estimate survey of Okinawa rails using the playback method is conducted every year in approximately 250 locations in Northern part of Okinawa Island. Currently, a more detailed analysis taking into account the expert opinions is being conducted on the relationship between the population size and roadkill incidents on a more local level. As for Iriomote cats, four surveys have been carried out in the past to estimate the population. Each of these surveys estimated the population of resident adults at around 100. Due to the small size of the estimated population and the lack of alternative populations on other islands, there is great concern about the negative impact of roadkills on the species survival. Furthermore, being the top predator, the impact of the extinction of this species on the overall ecosystem of Iriomote Island is immeasurable. This is why roadkill prevention initiatives for this species have been promoted as priority. While there could be many different factors behind the rise of roadkills in recent years, one of the factors may be that the form of tourism on Iriomote Island has changed in recent years, with an increase in nature

experience-oriented tours using rental cars and eco-tour operators which has led to a shift away from circular tours using large buses.

Roadkills of Ryukyu long-haired rats are thought to occur as this species enter roadways to collect food or when they are on the move. The number of roadkills of Ryukyu long-haired rats (Figure 10) shows particularly large fluctuations compared with other species. Concerned experts and locals have made empirical observations that the particularly large fluctuations in Northern part of Okinawa Island could be explained by changes in the population of Ryukyu long-haired rats depending on the yield of Castanopsis nuts, the main food for this species during the breeding period (Figure 14). To date, no survey has been conducted on the population of this species, but an ongoing survey is being conducted on the density of nuts on Amami-Oshima Island, Tokunoshima Island, and Northern part of Okinawa Island. In addition, research was undertaken on the feeding habits of this species (Kudaka and Kudaka, 2017). Future analyses will be conducted bearing in mind that the population of this species could increase in the year following a good yield of nuts, which may also increase the number of traffic accidents. In addition to Ryukyu long-haired rats, roadkill data is collected for each species, such as Okinawa robins, Okinawa woodpeckers, Ryukyu black-breasted leaf turtles, Anderson's crocodile newts, and spiny rats. The data will be individually analyzed and countermeasures are examined as necessary.

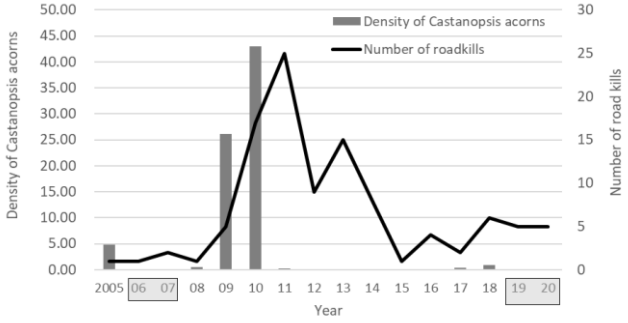


Figure 14: Relationship between the number of roadkill of Ryukyu long-haired rats and density of acorns in Northern part of Okinawa Island (conducted at Yona Field, University of the Ryukyus)

*No data available for 2006 and 2007

*Data are being compiled for 2019 and 2020

According to the results of a survey on roadkills of various animals, including common species on Iriomote Island (Figure 11), roadkills have often occurred on sections of roads flanked by forests or adjacent to ponds, swamps or paddy fields. The survey did not identify the species of all roadkills, but many cases were confirmed of Sakishima rice frogs (common species) and Owston's green treefrogs (NT on the IUCN Red List) among frogs, and *Sesarmops intermedia* (common species) among crabs. The threatened species that experts are concerned about population reduction due to roadkills include: Sakishima beauty snakes (VU); Yaeyama yellow-margined box turtles (EN); Yaeyama pond turtles (CR); and *Birgus latro* (VU); in addition to the above-mentioned Iriomote cats (CR). Much effort was made to identify these species, but only one roadkill incident of *Birgus latro* was confirmed in JFY2021. Iriomote Island abounds with frogs and crabs which perform the ecological role of

supporting diverse rare species, such as Iriomote cats (Watanabe and Izawa, 2005; Watanabe et al., 2005; Nakanishi and Izawa, 2016). For this reason, a reduction in these small animals has an indirect negative impact on rare species. It is also pointed out that roadkills of these small animals have a direct impact as the bodies of frogs and crabs killed by traffic accidents attract rare species to the roads, thereby causing secondary roadkill. There are no research results or expert opinions suggesting a clear declining trend in the populations of Sakishima rice frogs, Owston's green treefrogs, and *Sesarmops intermedia*, for which many roadkills were confirmed in the survey. From the viewpoint of conserving the ecosystem, however, attention must be paid to the impact of roadkills of these species. Furthermore, given that new species and newly recorded species of crabs are frequently discovered even now, it is necessary to consider collecting data based on the identification of species.

3. Review of the effectiveness of traffic control measures and future approach

Overview

- To review the effectiveness of traffic management measures, a list of the existing measures was organized and examination results of the effectiveness of some of these measures in reducing roadkills were compiled. The results showed that many of the measures were effective, but that in some areas the measures were not fully implemented despite the high risk of roadkill. In response to these results, the enhancement of existing measures and implementation of additional measures are under consideration. These include the installation of animal blocking fences on Amami-Oshima Island and Tokunoshima Island, and an examination of the construction of new underpasses and further traffic surveys on Iriomote Island.
- The roadkill prevention measures will be enhanced, including the installation of additional structures and raising driver awareness on the four islands, while maintaining a collaborative relationship with various entities, such as relevant government organizations, interested parties, and experts, bearing in mind that roads are essential to the livelihoods of local people.
- In enhancing roadkill prevention measures, the identification of the locations and content of measures that require such enhancement will continue, based on the status of roadkill incidents, traffic conditions, and road structures, in order to adopt the optimal measures for each of these locations. In addition, the effectiveness of the measures taken will be examined through, for instance, an analysis of their degree of impact on threatened species. Furthermore, actions such as an examination of the mechanism of roadkill occurrence will be facilitated to develop more effective countermeasures and approaches.

The existing roadkill countermeasures comprise diverse initiatives implemented by various organizations. The organizations implementing these initiatives form a conference body which meets annually to ensure collaboration and to share the progress of their roadkill countermeasures (Table 2). The following section lists measures that have so far been implemented on each island and provides an overview of measures that are large in scale, measures whose impact has been assessed, and the results of the newly conducted impact studies in response to the request. A higher level of expertise is ensured when implementing various measures by obtaining outside expert advice, such as from universities, where needed (see p. 264 of the nomination document on expert meetings).

Table 2: List of meetings responsible for coordination among organizations implementing roadkill prevention measures

Region	Name of the meeting	Constituent Organizations	Period
Amami-Oshima Island and Tokunoshima Island,	Amami Island Group Rare Wildlife Protection Program Council	Ministry of the Environment, Forestry Agency, Kagoshima Prefecture, municipalities, police	2010–Present
Northern part of Okinawa Island	Liaison Meeting on Yambaru Region Roadkill Prevention	Ministry of the Environment, Forestry Agency, Cabinet Office Okinawa General Bureau, Okinawa Prefecture, municipalities, police, NPOs	2004–Present
Iriomote Island	Liaison Meeting on Prevention of Traffic Accident Occurrences Involving Iriomote Cats	Ministry of the Environment, Forestry Agency, Okinawa Prefecture, Taketomi Town, Police, NPOs, private companies	2013–Present
Iriomote Island	Liaison Meeting on the Iriomote Cat 10-Year Conservation Plan	Ministry of the Environment, Forestry Agency, Okinawa Prefecture, Taketomi Town, NPOs	2022–Present

Amami-Oshima Island and Tokunoshima Island

Tables 3 and 4 show the objectives, targets (drivers or animals), and the implementing entities of various roadkill countermeasures that have been implemented on Amami-Oshima Island and Tokunoshima Island.

Table 3: Measures implemented to date to reduce roadkills on Amami-Oshima Island

Measure	Purpose	Target	Implementing body
Underpass (1 unit)	Prevention of entry	Animals	Kagoshima Prefecture
Improvement of gutters	Prevention of entry	Animals	Kagoshima Prefecture
Animal blocking fences (1 location)	Prevention of entry	Animals	Yamato Village
Improvement of viewing distance	Visibility improvement	Driver	Kagoshima Prefecture
Grass cutting	Visibility improvement	Driver	Road management departments of the relevant organizations
Restrictions on passage through forest roads	Impact mitigation	Driver	Ministry of the Environment, Forestry Agency, Kagoshima Prefecture, 5 municipalities
Rescue of injured/sick animals and their return to	Impact mitigation	Others	Ministry of the Environment

Measure	Purpose	Target	Implementing body
the wild			
Signage	Call for attention	Driver	Ministry of the Environment, Kagoshima Prefecture, 5 municipalities
Mobile signage	Call for attention	Driver	Ministry of the Environment
Road markings and deceleration zones	Call for attention	Driver	Kagoshima Prefecture, 5 municipalities
Public awareness activities	Call for attention	Driver	Relevant organizations
Identification and trend analysis of traffic accidents	Study and evaluation of measures	Others	Ministry of the Environment
Examination of cause of death	Study and evaluation of measures	Others	Ministry of the Environment

Table 4: Measures implemented to date to reduce roadkills on Tokunoshima Island

Measure	Purpose	Target	Implementing body
Animal blocking fences (2 locations)	Prevention of entry	Animals	Amagi Town, Tokunoshima Town
Grass cutting	Visibility improvement	Driver	Road management departments of the relevant organizations
Restrictions on passage through forest roads	Impact mitigation	Driver	3 towns※, Forestry Agency, Ministry of the Environment, Kagoshima Prefecture
Rescue of injured/sick animals and their return to the wild	Impact mitigation	Others	Ministry of the Environment
Signage	Call for attention	Driver	Ministry of the Environment, 3 Towns※
Mobile signage	Call for attention	Driver	Ministry of the Environment, 3 towns※
Road markings and deceleration zones	Call for attention	Driver	Kagoshima Prefecture, 3 towns※
Public awareness activities	Call for attention	Driver	Relevant organizations
Identification and trend analysis of traffic accidents	Study and evaluation of measures	Others	Ministry of the Environment
Examination of cause of death	Study and evaluation of measures	Others	Ministry of the Environment

※Measures taken by the three towns include activities by the Tokunoshima District Nature Protection Council (a council formed by the three towns and local experts).

Concerned parties, including management organizations, are severely concerned about the rapid increase in recent years of roadkills of Amami rabbits on Amami-Oshima Island. Ongoing countermeasures are made to continue or scale up many of the efforts, with a focus on implementing measures in cooperation with local people, such as the installation of new speed bumps with local middle school students (Figure 15). Animal blocking fences are a new measure started in 2020/2021 in response to the rapid increase in recent years of roadkills of Amami rabbits. To assess their effectiveness and impact on the target species and ecosystem, the fences are being monitored using automatic cameras. In addition, discussions are underway on the installation of new fences. Consideration will be given to expand these measures in the future based on assessment results and expert opinions. With respect to traffic control, night-time usage regulations of the Santaro Line on Amami-Oshima Island were agreed upon after the exchange of opinions with local people and tourism businesses. Following this, the operation began in October 2021 (Figure 16). The regulations restrict the number of vehicles driving on the Santaro Line at night by allowing only one vehicle to enter the Santaro Line from its eastern and western entrances respectively every 30 minutes. Drivers need to make a booking in advance using a website (https://coubic.com/santaro). In addition, a device that detects the speed of vehicles and displays a warning on an electronic noticeboard is installed at each entrance. The past traffic management measures on the property were all permission-based traffic management based on the applicants' purpose of road usage (Amami-Oshima Island, Tokunoshima Island, and Northern part of Okinawa Island). The measure on the Santaro Line is the first booking-based traffic management on the property to set the ceiling of traffic volume on a public road that is also used for the livelihoods of local people. The rules will be improved based on the usage status and the occurrence of roadkills.

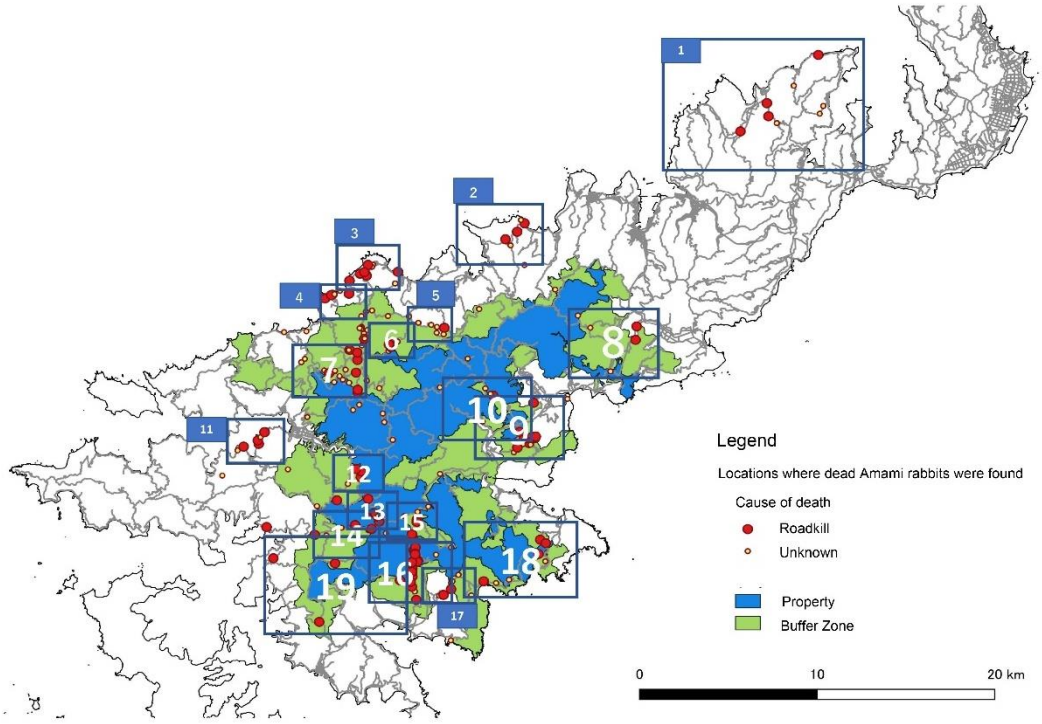
Figure 15: Installation of speed bumps by Ryukoku Junior High School in Tatsugo Town (April 2022)

Figure 16: Entrance to the Utilization Management Zone
*A sign stating rules and a device that detects the passage of vehicles have been installed.

In response to the request, an analysis was conducted on Amami rabbits to select the areas that should be prioritized for the future expansion of measures to reduce roadkills. Hiragi et al. (2017) already analyzed the locations with frequent roadkills and the seasonal variations for this species, and other issues, regarding the tendency of roadkill incidents of Amami rabbits. This time, a risk map was prepared to identify the locations that should be prioritized to implement measures. To conduct an analysis, the locations of roadkills over the past three years on Amami-Oshima Island, and over the past five years on Tokunoshima Island, were mapped and empirically classified into different areas based on the situation of roadkills and the degree of their concentration. Each area was further broken down as necessary into sections of roads that were subject to assessment. Each location was then

assessed on a three-point scale (A: 3 points; B: 2 points; C: 1 point) based on two perspectives: the degree of urgency and the ease of assessment. The total score, ranging from 2 to 6, determined the priority of each location in terms of implementing roadkill countermeasures.

As a result of the area classification, Amami-Oshima Island had 46 road sections in 20 areas, while Tokunoshima Island had 16 road sections in 10 areas. Figure 17 shows the classified areas.



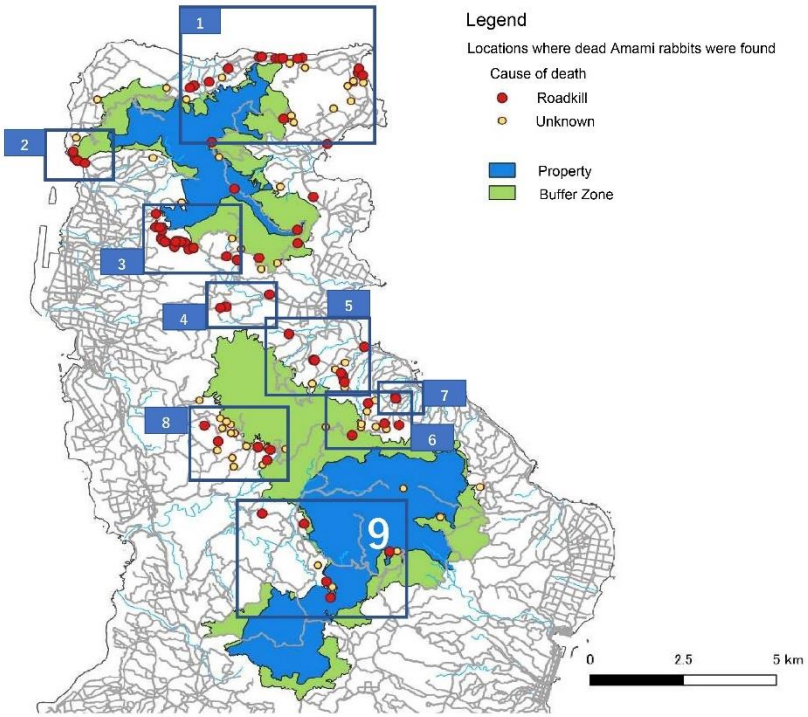


Figure 17: Classified areas of traffic accidents on Amami-Oshima Island (top) and Tokunoshima Island (bottom)

*The numbered boxes indicate the areas extracted as a result of the analysis.

The areas with a high total score (higher priority for the implementation of measures) on Amami-Oshima Island were: the area around Mt. Yuwandake (Area 7); the area around Aminoko Pass (Areas 15 & 16); the area of Prefectural Road No. 85 connecting Mt. Yuwandake and Aminoko Pass (Areas 12 & 13); Prefectural Road No. 612 extending from Prefectural Road No. 85 through the community of Shinokawa (Area 14); Santaro Line (Area 9); and Prefectural Road No. 79 through Yamato Village and Uken Village (Areas 4 & 11).

The area extending from Mt. Yuwandake to Aminoko Pass on Amami-Oshima Island is a major habitat for rare species, such as the Amami rabbit. It is an area where rare species are frequently sighted on the roads. At the same time, it is a road used by local people to travel to and from Amami City, Yamato Village, Uken Village, and Setouchi Town. This condition is likely to be conductive to roadkill for both drivers and animals. Given that the road is built through many parts of the property, it is assigned the highest priority in implementing measures. Based on this result, animal blocking fences were installed in some sections of roads near Mt. Yuwandake (7) in September 2021, and monitoring to assess their effectiveness were initiated (Figure 18). The installation of additional fences will be considered based on the assessment result. Prefectural Road No. 79 through Uken Village (Area 11) is an area where roadkills were often confirmed in recent years. With the frequent sighting of this species along the road, it is deemed desirable to promptly comprehend the current status and implement measures for both drivers and animals. The Santaro Pass (Area 9) is an area known for frequent sightings of Amami rabbits. As a result, in recent years many tours were conducted to see the rabbits. For this reason, the usage of the Santaro Pass has been regulated under the afore-mentioned night-time usage regulations to reduce negative impacts on rare species, including Amami rabbits, and their habitats.

Figure 18: Animal blocking fence installed on the road in the vicinity of Mt. Yuwandake (7) on Amami-Oshima Island

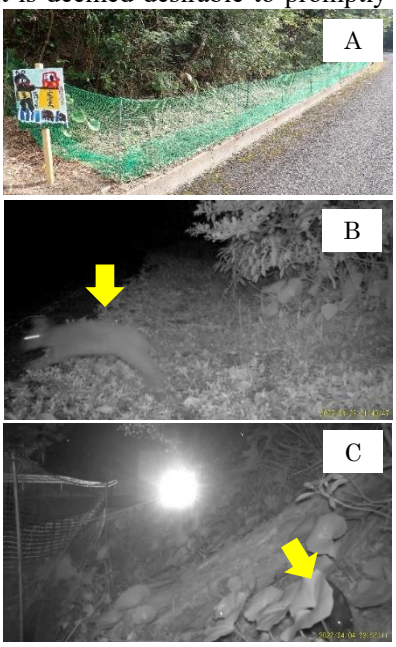


Figure 19: A: Animal blocking fence installed on Prefectural Road 618 (3) on Tokunoshima Island.
B and C: Examples of photos of the Amami rabbit taken during monitoring (left side of the photo: road, right side of the photo: forest). (B: unfenced section, C: fenced section. Arrows indicate Amami rabbits.)

On Tokunoshima Island, the areas with a high total score (higher priority for the implementation of measures) were: Prefectural Road No. 629 in the Tete Kanami district, along the northern edge of the island (Area 1); Prefectural Road No. 629 in the Yonama district of the northwestern part of the island (Area 2); Prefectural Road No. 618 in the southern part of Mt. Ogusuku (Area 3); the Omo-Asahigaoka-Todoroki Line in the Boma district (Area 5); and the agricultural side road in the Boma district (Area 7). All these roads are in the Surrounding Conservation Area. It is thought that accidents on these roads are increasing due to the expansion of Amami rabbit habitat in recent years. Of these roads, Prefectural Road No. 618 near the foot of Mt. Ogusuku (Area 3) is a section where roadkill frequency is especially high with a total of 18 between 2016 and 2021. As Amami rabbits are often spotted on this road, the road's priority in terms of implementing roadkill

countermeasures is deemed highest. Road markings were already painted and warning signage installed in this section. Based on the result of this analysis, however, it was determined that further enhancements to measures were needed, resulting in the installation of animal blocking fences in November 2021 (Figure 19) and the monitoring commenced. Traffic management on the Yama Kubiri Line of forest roads (Areas 1 & 10) started in July 2019. Since its implementation, roadkills declined from five to zero.

Based on the analysis result, discussions are currently taking place to install animal blocking fences in the areas around Aminoko Pass (Areas 15 & 16) and on Prefectural Road No. 85 that connects Mt. Yuwandake and Aminoko Pass (Areas 12 & 13) on Amami-Oshima Island. The locations and structure of the new fences to be installed will be discussed based on monitoring results of fences already installed and on expert opinions.

Northern part of Okinawa Island

Table 5 shows the various roadkill countermeasures that have been implemented to date in Northern part of Okinawa Island.

Table 5: Measures implemented to date to reduce roadkills in Northern part of Okinawa Island

Measure	Purpose	Target	Implementing body
Underpasses (10 units)	Prevention of entry	Animals	Okinawa Prefecture
Animal blocking fence (1 location)	Prevention of entry	Animals	North National Road Office
Improvement of gutters	Prevention of entry	Animals	North National Road Office, Okinawa Prefecture
Cleaning of gutters	Prevention of entry	Animals	Ministry of the Environment
Putting cement on the surface of roadside slopes	Visibility improvement	Drivers	Okinawa Prefecture
Grass cutting	Visibility improvement	Drivers	Road management departments of the relevant organizations
Restrictions on passage through forest roads	Impact mitigation	Drivers	Okinawa Prefecture, Kunigami Village
Establishment of speed limit sections	Impact mitigation	Others	Liaison Meeting on Yambaru Region Roadkill Prevention
Rescue of injured/sick animals and their return to the wild	Impact mitigation	Others	Ministry of the Environment, NPOs
Warning signage	Call for attention	Drivers	North National Road Office, Okinawa Prefecture, private companies, etc.
Mobile signage	Call for attention	Drivers	Ministry of the Environment

Measure	Purpose	Target	Implementing body
Road markings and deceleration zones	Call for attention	Drivers	North National Road Office, Okinawa Prefecture
Public awareness activities	Call for attention	Drivers	Relevant organizations
Identification and trend analysis of traffic accidents	Study and evaluation of measures	Others	Ministry of the Environment
Examination of cause of death	Study and evaluation of measures	Others	NPOs, etc.

Figure 20: Magnet sticker to promote awareness of daytime lighting and low-speed driving (left) and magnet sticker to promote awareness of preventing roadkill of Ryukyu long-haired rats (right)
*Daytime lightning has been suggested to have a certain effect by a local NPO.

It is recognized that in Northern part of Okinawa Island, it is especially important to implement measures for Prefectural Road No. 2 with a total length of approx. 17 km. It is the only main road across the property where roadkill incidents of Okinawa rails and Ryukyu long-haired rats have often been confirmed. This road is also important for the livelihoods of local people. For this reason, roadkills of flagship species are shared real time among relevant organizations using a mailing list. Furthermore, the Yambaru Wildlife Conservation Center and local NPOs implement activities focusing on education and raising awareness as well as grass cutting in cooperation with local municipalities. These educational and awareness raising activities include: distributing flyers and magnetic stickers (Figure 20); raising awareness at meetings of district heads, etc.; and when necessary declaring states of emergency. Unlike Amami rabbits and Iriomote cats which are nocturnal, Okinawa rails are diurnal. Many local residents and tourists thus encounter this species on the road during the daytime. It is therefore deemed especially important to conduct continuous educational activities, bearing in mind the need for measures targeting inbound tourists, such as offering multilingual information.

In 2015, a speed limit section of approximately 1.5 km on Prefectural Road No. 2 was established as a traffic management measure, recommending driving at 30 km/h or less. There was research on the effectiveness of this measure (Tamanaha et al., 2017). Regarding Prefectural Road No. 2, this measure covers 33% of the section with higher incidents of roadkill and sightings of Ryukyu long-haired rats. In addition, an underpass was built in this section. Additional measures will be implemented based on insights into the mechanism of various types of roadkills mentioned above and the effectiveness of the measures taken. A similar speed limit measures was implemented on Prefectural Road No. 70, a main road extending north/south in the eastern section of Northern part of Okinawa Island. In addition,

night-time traffic has been banned since 2016 on Kunigami Village forest roads to prevent roadkill and the illegal collection of various threatened species, including reptiles and amphibians, on many forest roads on the island, which are of less importance to the livelihoods of local people. For prefectural forest roads, a proof-of-concept experiment for night-time traffic ban concluded in 2021. Based on the results, more effective road management methods will be examined starting 2022. These initiatives may be revised in the future based on the latest data.

As an infrastructure measure, a total of 10 underpasses were constructed on Prefectural Road No. 2 and Prefectural Road No. 70 between 2008 and 2020. A monitoring survey conducted over a few years using automatic cameras has confirmed that these underpasses are used by animals, such as Okinawa rails. Currently, their effect on reducing the number of roadkills is being examined. On National Route No. 58, animal blocking fences were installed intermittently over an approximately 3 km long section. It has been confirmed that these fences stop Okinawa rails from entering the road. The challenges with the fences are their ineffectiveness due to breakages caused by typhoons and the labor needed to repair them. Future modifications to the fences is thus under consideration.

In addition, as an action targeting drivers, concrete has been laid on roadside slopes to control weeds on the roadsides, which will alert drivers to wildlife entering the road. Putting cement on the surface of the slopes where plants normally grow on the exposed soil prevents the growth of vegetation and is expected to reduce roadkill by improving the driver's viewing distance. On this slope, the surface was roughened with a broom to create bumps and dips to offer footing to animals to climb the slope. There have been confirmed sightings of animals using them to climb up the slope (Figure 21). In addition, there have been cases where small animals, such as baby Okinawa rails, Anderson's crocodile newts, and Ryukyu black-breasted leaf turtles, had fallen into gutters, were unable to get out on their own, and died. To address these cases, gutters have been modified to have a slope on one side or to have small side steps, taking into account the target species' ability to climb slopes (Figure 22).

Figure 21: Concrete slopes with roughened surfaces. Okinawa rails and Ryukyu black-breasted leaf turtles have been confirmed climbing up the improved slopes. (Maintenance and Management Section, Okinawa Prefecture Hokubu Regional Public Works Office, 2010)

Figure 22: Improvements to single-slope gutter and gutter with steps (Maintenance and Management Section, Okinawa Prefecture Hokubu Regional Public Works Office, 2010)

*Both types of gutters have been modified to allow animals to escape to the forest side. Ryukyu black-breasted leaf turtles and sword-tailed newts have been observed climbing up the slopes.

While no specific examination has been conducted on the effectiveness of these measures to reduce roadkill, this work has been incorporated as basic construction methods to mitigate small animal deaths by traffic accidents or falls into gutters. It is thought these measures will become more effective to reduce roadkill through the regular cleaning of gutters, cutting the grass near them, and educational activities such as roadkill prevention campaigns. Relevant organizations will promote various efforts, including the examination of their impact in reducing roadkill.

Iriomote Island

The following shows the various roadkill countermeasures that have been implemented on Iriomote Island to date.

Table 6: Measures implemented to date to reduce roadkills on Iriomote Island

Measure	Purpose	Target	Implementing body
Underpasses, etc. (123 units)	Prevention of entry	Animals	Okinawa Prefecture, Taketomi Town
Animal blocking fence (1 location)	Prevention of entry	Animals	Okinawa Prefecture
Mobile animal blocking fence	Prevention of entry	Animals	Ministry of the Environment
Improvement of gutters	Prevention of entry	Animals	Okinawa Prefecture
Grass cutting	Visibility improvement	Drivers	Okinawa Prefecture, Taketomi Town
Gathering information on sightings	Prediction of occurrence	Others	Ministry of the Environment, Okinawa Prefecture
Speed warning system	Call for attention	Drivers	Ministry of the Environment
Laser sensor system	Call for attention	Drivers	Ministry of the Environment
Warning signage	Call for attention	Drivers	Taketomi Town
Mobile signage	Call for attention	Drivers	Ministry of the Environment
Road markings and deceleration zones	Call for attention	Drivers	Okinawa Prefecture
Rescue of injured/sick animals and their return to the wild	Impact mitigation	Others	Ministry of the Environment, NPOs
Public awareness activities	Call for attention	Drivers	Relevant organizations
Identification and trend analysis of traffic accidents	Study and evaluation of measures	Others	Okinawa Prefecture
Traffic survey	Study and evaluation of measures	Drivers	Okinawa Prefecture
Information gathering after an accident (on-site inspection, interviews)	Study and evaluation of measures	Others	Ministry of the Environment
Examination of cause of death	Study and evaluation of measures	Others	Kagoshima University

On Iriomote Island there is a concern about the impact of roadkills on Iriomote cats. Data collection of roadkills of this species began in 1978, and the trend analysis has been conducted based on factors, such as the effectiveness of various measures, seasonal variability, hour of the day, local characteristics, gender and age of animals involved in the accident, analyses of sighting information immediately before the accident, examination of accident scene, autopsies of animals involved in the accident, changes in traffic volume and car speed by season and time of day, and distribution of prey on the road and surroundings. The results of the analysis were compiled in the "Basic Plan for Traffic Accident Prevention Measures for Iriomote Cats" prepared by Okinawa Prefecture in 2018 to present basic data to discuss future measures. A total of 11 specific factors are identified which led to traffic accidents involving Iriomote cats. These include factors attributable to drivers/roads, such as locations where it is difficult for drivers to spot cats; excessive speeding; and factors arising from ecological features, including use of the environment by cats and the location of their home range. An example of the latter is a reduction of suitable feeding sites around roads resulting in Iriomote cats being led to the corpses of small animals killed by traffic accidents. A survey of traffic conditions using Bluetooth scanners is scheduled to continue in cooperation with research institutions to gain a more accurate understanding of the causes of roadkills of this species and to comprehend changes in tourism dynamics before and after the COVID-19 pandemic.

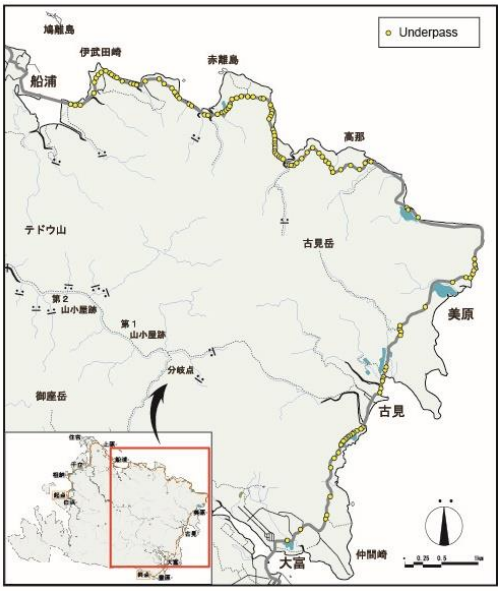


Figure 23: Location of 123 underpasses on Iriomote Island

Of the measures taken so far, the construction of a total of 123 tunnel underpasses and a total of 16 passes under bridge beams are the largest in scale. For most of these structures, usage by wildlife was monitored using automatic cameras for about a year. After detailed analysis of usage frequency of each underpass during the breeding, parenting, and dispersing periods of Iriomote cats, causes were examined for underpasses which were not frequently used and improvement measures were implemented. In addition, on the main road animal blocking fences designed to stop Iriomote cats from entering the road by guiding them to underpasses were built, and since 2017 an approximately 600-m section was completed on the eastern side of the island. Monitoring confirmed that Iriomote cats and other animals moved alongside the fence, were led to the exit/entrance of the underpass, and frequently used it. Furthermore, after installation of the fences, no roadkill of this species has been confirmed in the said section. In response to the request, the examination of a construction plan began in 2021 for the construction of multiple underpasses in the western area where underpasses are few

and many traffic accidents have occurred in recent years. There is a concern that fences might divide the habitats of various animals that are difficult to guide to the underpass, such as reptiles and amphibians. The examination will therefore progress cautiously based on expert opinions.

Surveys using automatic cameras have confirmed that usage frequency of these underpasses by wildlife declines if their exits/entrances are covered with vegetation or piles of driftwood due to typhoons or heavy rain. To maintain the effectiveness of underpasses, certain levels of cost and labor are required for their cleaning and maintenance, which includes pruning and grass cutting. Accordingly, discussions are underway on how to maintain underpasses more efficiently using a fund or volunteers. To obtain a broader understanding of the function of underpasses, an actual underpass will be displayed at the Iriomote Wildlife Conservation Center to educate and raise the awareness of tourists and to enhance local environmental studies. The number of roadkill incidents of Iriomote cats reached a record high of nine in 2018. In response, in addition to existing measures, roadkill countermeasures using new method were looked into in an effort to explore more fundamental solutions. These include the trial introduction of a warning device for exceeding the speed limit and the examination of its effects; examination and development of mobile animal blocking fences for specific individuals frequently crossing roads; and a trial application of a system that warns drivers when the appearance of this species on the road is detected using a laser sensor.

On Iriomote Island, sighting information of Iriomote cats on roads is efficiently collected using every possible means including telephone and SNS. The collected data is used to evaluate the risks of individual cases. Concretely, if reports of Iriomote cats sightings on a specific road keep coming in, action will be taken in real time, such as warning drivers and local people about that location or specific individual, putting up a signboard, and/or patrolling the site. In many cases, these actions have prevented accidents. Because sighting information is effective, continuous efforts will be made to collect them.

As educational and awareness-raising activities, various measures were taken together with local communities. These include in-class lessons at local primary schools; installation of mobile signboards in places with a high risk of traffic accidents based on sighting information; preparation of maps to raise awareness of drivers; distribution of flyers to local people and tourists; raising awareness through websites and SNS; art competitions with the theme of roadkill prevention; and real time sharing of roadkill information with relevant local organizations. According to the results of surveys conducted in recent years, the percentage of respondents who felt that roadkills of Iriomote cats was a problem stood at 90% among local people, but only 40% among tourists. Based on this result, efforts are currently made to enhance the understanding of tourists and improve multilingual information.
The above measures mainly target Iriomote cats. Given that the Iriomote cat is at the apex of the food

chain on Iriomote Island and has adapted to the island by preying on various animals, it is deemed necessary to also reduce traffic accidents involving other animal species. Traffic accidents involving small prey animals not only decrease animal species but also cause secondary accidents as their dead bodies entice other animals to enter roads. The same can be said about the impact on crested serpent eagles, which is a rare species. Accordingly, Iriomote Island considers the entire group of animals, including common species, to formulate measures to reduce traffic accidents.

4. Summary of future approach

All four islands have the need to reduce the impact of roadkill incidents involving rare species. In particular, the impact of roadkills is material for Iriomote cats whose population is small and for Amami rabbits on Tokunoshima Island whose habitat is divided into north and south. Based on this understanding, the existing measures will continuously be examined and enhanced.

In enhancing measures to reduce roadkills, the identification of the locations and efforts that require such enhancement will continue based on the status of roadkill incidents, traffic conditions and road structures, and optimal measures will be adopted for each location where efficient and effective measures should be implemented. In addition, the effectiveness of the measures taken will be examined through, for instance, an analysis of their degree of impact of roadkill incidents on threatened species. Furthermore, actions such as the examination of the mechanism of roadkill occurrence, which is necessary to develop more effective countermeasures and approaches, will be facilitated.

Table 7 summarizes the measures scheduled for each island. Measures to reduce roadkills will be organized from a shared perspective of the entire area. In addition, four islands will exchange information and establish the identical factor analysis and measure evaluation methods, as needed.

Table 7: Specific actions to be taken

Amami-Oshima Island	- Improve rules for night-time use of the Santaro Line based on the status of usage and roadkill incidents. - Examine the effectiveness of animal blocking fences and consider installing new fences based on the result.
Tokunoshima Island	- Examine the effectiveness of animal blocking fences and consider installing new fences based on the result.
Northern part of Okinawa Island	- Examine more effective road management methods based on the results of nighttime traffic closure demonstration experiments on prefectural forest roads. - Examine modifications to animal blocking fences.
Iriomote Island	- Conduct a traffic survey using Bluetooth scanners in cooperation with research institutes. - Consider constructing multiple underpasses in the western part where many traffic accidents have occurred in recent years. - Examine roadkill countermeasures using new methods.
Common in 4 regions	- Continue examining and enhancing existing measures. - Continue identifying locations and measures that need to be enhanced. - Examine the mechanisms of roadkill occurrence. - Promote measures targeting inbound tourists, such as multilingual information.

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