

First named as a separate species of rodent in 1946, *Tokudaia muenninki*, also known as Muennink's spiny rat or the Okinawa spiny rat, lives in the northern region of Yanbaru Forest on Okinawa Island, Japan. It is part of the family *Muridae* and the genus *Tokudaia* which is comprised of this and two other species (*T. osimensis* and *T. tokunoshimensis*); the members of this genus are the closest living relatives of the European field mouse (*Apodemus*). Each of the three species lives only on one specific island; *T. muenninki* lives on Okinawa Island, *T. osimensis* lives on the island of Amami Oshima, and *T. tokunoshimensis* lives on the island of Tokunoshima. A variety of physical and genetic differences among the species result from this early separation. The other two species within the genus are also endangered; the Okinawa spiny rat, however, has been ranked as critically endangered according to the International Union for Conservation of Nature's list of endangered animals since 2008. (There are at least 27 endangered species living on or near Okinawa Island.) It is the most vulnerable of the species within *Tokudaia* to decline in population because of the following factors: severe habitat fragmentation due to forestry programs, competition with black rats for resources, and predation by non-native species such as the small Indian mongoose (*Herpestes auro punctatus*) and feral cats (*Felis catus*). It is estimated that the remaining members of the species live in an area of about one square mile within the forest. (The Okinawa spiny rats live at altitudes over 984 feet above sea level.) The most recent sighting and capture of wild specimens was in March 2008; before this discovery, it was assumed that the species was extinct in the wild, as there had been no evidence of their continued existence for thirty years.

T. muenninki lives in a subtropical moist broadleaf forest and moves by hopping. It has an average tail length of five inches and an average head and body length of seven inches and can weigh up to seven ounces. Its fur consists of fine hairs as well as grooved, soft spines that

cover most of its body except for areas around its mouth, ears, feet, and tail. Since the spiny rats do not use these spines for protection or defense, scientists are unsure of the spines' purpose. Its fur is brownish above and grayish with an orange tinge below; the spines are white with reddish-orange tips or black. It resembles a large vole in size and general appearance, except for its black and white bicolored tail, and is nocturnal like most mammals. Its diet consists of nuts, such as acorns and chinquapin nuts, and insects. Before mongooses, rats and cats were introduced to the Yanbaru forest, *T. muenninki* seemed to have no major predators.

The genus *Tokudaia* is important to biology and genetics because of its unusual chromosomes. *T. muenninki* has large sex chromosomes for a mammal, and the other two species have an X0 sex-determination system which is rare in mammals. At some point in time, the Y chromosomes in *T. osimensis* and *T. tokunoshimensis* disappeared along with the SRY gene (which is carried on the Y chromosome and greatly important to male development). In these two species, most of the other Y-linked genes were transferred to the X chromosome and are so preserved. To contrast, the X and Y chromosomes in *T. muenninki* fused with autosomes in the past, which explains their size and the fewer number of chromosomes present as compared to *T. osimensis* (*T. muenninki*; $2n=44$; 21 sets of autosomes and two sex chromosomes are present). *T. osimensis*, in comparison, has no Y chromosome ($2n=45$; 22 sets of autosomes and the X chromosome are present), and neither does *T. tokunoshimensis* ($2n=25$; 11 sets of autosomes and the X chromosome are present). Since both male and female members of these two species are X0 (possessing only one X chromosome), the mechanisms surrounding sex determination are unclear. Males of all species in the genus have multiple copies of the CBX2 gene (thought to suppress development of ovaries) while females have only one. The cascade effects of this gene seem to control in these two species of *Tokudaia* what SRY usually would in other mammalian

genera. Incidentally, *T. muenninki* carries multiple copies of the SRY gene on its Y chromosome. (The genus *Ellobius*, or “mole vole”, also contains out of five species one with X0 determination and another with XX/XX determination-- it and *Tokudaia* seem to be the only two genera in mammals which display non-XX/XY determination systems.) The members of the *Tokudaia* genus display genetic features not commonly seen in mammals; because of this, their genetic diversity is important to understand the function and history of different genes. Although *T. muenninki*'s genetic features are less obviously interesting than the others', it, like all other endangered species, is still worthy of study and protection against extinction.

If the Okinawa spiny rat were to disappear, the Yanbaru forest ecosystem would be negatively affected. As secondary consumers, Okinawa spiny rats consume insects whose populations would otherwise experience uncontrolled growth. Mongooses also eat insects; however, their diet is much more varied and the insect population would still increase in the absence of the Okinawa spiny rat. In the current situation, the stress placed on *T. muenninki* leads to degradation of the temperate forest ecosystem, as their place in the food web is threatened.

Although the species is legally protected, it is still critically endangered. Two things need to happen before the Okinawa spiny rat population can begin to increase: predator management and habitat control. Predator management means that animals known to prey on members of the genus *Tokudaia* need to have their populations brought under human control. For example, the population of feral cats would have to be lowered in the living area, whether by relocation or inhibiting survival of a certain percentage of cats. Also, developing ecologically sound plans with forest managers would go far in preserving the habitats of all members of the genus *Tokudaia* and so protect all the species within the genus. (There is already some sort of protection and management system in place for the land and water distribution systems within

the forest.) With two of the threats to the spiny rats' existence so controlled, the continuing predation by mongooses and competition with black rats would not pose as much of a threat as these factors do now. However, the mongoose population would also need to be closely monitored to determine how much it should be lowered to ensure the continued existence of Okinawa spiny rats. Of course, some existing educational programs about endangered animals already include them in the curriculum; by making sure all include this species and increasing the public's awareness, more people would support these programs. With these protective measures in place, the population should stabilize and eventually increase.

I have given thought to my place in reversing the trend of population decline in these animals. At present, I am limited to raising awareness through my school; however, I plan to affiliate myself with a scientific organization such as a branch of the World Wildlife Fund so that public awareness of this species increases. I am also going to use social media to let everyone know about the importance of saving this and other endangered species. My reasoning behind raising awareness is that I am personally interested in genetics; the preservation of this species is important to me partially because of its direct relevance. Preservation of *T. muenninki* and other critically endangered species preserves genetic diversity; careful study of its genetic traits could lead to a better understanding of mammalian genomes, which would benefit humans in the long run.

The Okinawa spiny rat represents a great benefit to genetic studies, but it is critically endangered. Its survival depends on a number of factors, such as the level of awareness and willingness of individuals and the Japanese government to preserve its place in the Yanbaru forest, and the scope of conservation measures to be taken. It is imperative that they remain in their environment to preserve the balance of production and consumption and to conserve unique

behavioral mechanisms present in the species. To prevent the population size from decreasing any further, organizations should prioritize controlling the population of invasive species such as mongooses and feral cats and revising forestry programs in the region.

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