Evolution Of The Brown Rat

Present Variations

Variations in Brown rats; captivity versus in the wild

For over a century brown rats (Rattus norvegicus) have been used by humans for many reasons. Originally, they were used by rat fanciers (those who breed rats as a hobby for their unique coats etc) and later by scientists who still use R. norvegicus to this day for their research where they gained the name of “model organism”.

Wild animals, including R. norvegicus, are more active and reactive than animals that have been domesticated for many generations.

[image:]Captive environments can be a great stress to wild animals. In comparison to the wild, a captive environment is extremely confined, provides few hiding places, is full of bright lights, and is surrounded by human 'predators' who approach and handle the animal. These stressful conditions frequently lead to death or reproductive failure in captive wild animals, this has led to captive R. norvegicus to be less aggressive compared to their wild counterparts, through evolutionary selection.

Like any animal, R. norvegicus have mutations, these can be varied from curly hair, hairlessness to albinism. All of these can be found in wild rats in extremely small numbers. On the other hand, in captivity these are found often, with almost all laboratory rats being albino R. norvegicus. These rats were originally breed from rat fanciers but are now selectively breed by scientists.

Variations based on location

The brown rat, is found on all continents apart from Antarctica, making it one of the most geographically diverse species on the globe. Though this means the species has had to adapt to its location in almost all places it goes. An example of this is Baltimore and Salvador R. norvegicus, Baltimore rats are shown to be much larger than their Salvador counterparts as the major predator of R. norvegicus, at least in Baltimore, are cats, which preferentially target juvenile animals under 100–200 g. this is not the case in Salvador however, so they have not adapted a relatively larger size.

Sexual Dimorphism

Sexual dimorphism is an attribute whereby the different sexes of a species display variations in characteristics beyond just their sexual organs. Sexual dimorphism is a common trait in many mammal species and sexual-size dimorphism (SSD) is its most common form. Rattus norvegicus is an example of a species that has SSD. The table above (figure 1) shows data of both female and male Rattus norvegicus and the extent of their SSD.

Sexual selection is a large factor in the evolution of R. norvegicus. Certain traits get passed on

through generations as a trait that is desired by the opposite sex. If an individual exhibits those traits, they breed more frequently hence passing the trait down. While a conclusion derived from this may be that sexual selection only passes down traits visible to or heard by the opposite sex of an organism, this is not the case as smell is a major factor, this can be seen in many animals with the use of pheromones. An example of a trait passed on that is smelled is shown in a study published in the scientific journal: Biology of Reproduction. A significant positive correlation was observed between urinary MUPs (major urinary proteins) and the attractiveness ratio of each male rat, suggesting male rats that had higher urinary MUPs were more attractive to females. The results of this are shown in the table below (figure 2). As a result of the male rats with high MUP amounts being seen as more attractive, in future generations, the male R. norvegicus have a higher MUP amount.

Origin

Based on the evidences of fossils of bones, the brown rat most likely came from Northeast China and Southeast and then through the Eurasian steppes into Europe. However, a recent study, suggests southern China as a possible origin of the brown rat meaning the species may have dispersed alongside humans from southern East Asia to other regions.

When brown rats arrived in Europe/Africa is debatable. rat fossils found in the ground suggests that brown rats appeared in Europe during the Medieval Ages and spread during the Industrial revolution. Today brown rats are all over the globe mainly because of being carried through human activities such as European sailing ships etc.

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Speciation

R. norvegicus is a placental mammal, and all placental mammals have been discovered to all come from one tiny, furry-tailed rat-like ancestor (officially known as ‘hypothetical placental ancestor’) that lived in the early Paleocene (approx. 6.5 MYA), a time just after the extinction of the dinosaurs. This species went through an intense speciation period that lead to all the placental mammals we know today. The reason for this speciation was most likely because of the extinction of the dinosaurs, that lead to increased opportunities for this animal to radiate all kinda of forms

The genus of Rattus (from the hypothetical placental ancestor) is thought to have originated in the Indonesian Islands and then spread to continental Asia, New Guinea and Australia. In the past five million years a combination of environmental factors has caused this geographic region to experience major changes in sea level such as tectonic and climatic change. This geographical change has allowed the genus Rattus to form new species due to the reproductive isolation that has come from this.

- the age at which Rattus diverged from other members of the Asian clade is uncertain, but
- most likely it would have occurred within the past 8 million years because of these reasons.

After it arose, the Rattus genus underwent two episodes of intense speciation, one about 2.7 million years ago, and another began about 1.2 million years ago and may still be ongoing

The ancestors of Rattus norvegicus and R. rattus diverged from each other about 2 million years ago. The closest relative to the species of R. norvegicus is R. cf moluccarius. The split between these two species occurred around 0.5 million years ago during the second intense speciation event for the genus rattus which most likely occurred as a result of geographical changes to the environment such as climate change. This split can be seen in figure 4. Today, there are 51 species within the genus Rattus.

Changes Compared to the Black Rat (Rattus Rattus)

rattus norvegicus split from rattus rattus only around 2million years ago, though they both have some major differences. This is because of the changes that have occurred to both species respectively. Rattus norvegicus has developed a shorter tail while rattus rattus has developed a longer one, rattus rattus has developed a pointed snout while rattus norvegicus has developed a slanted one, and there are many more differences.

What Caused these Changes?

Currently there are little resources on what has caused these recent changes, though most likely the reason would be the location changes of the rattus norvegicus. Unlike most of the rattus

genus, rattus norvegicus has spread away from Australia and Asia, and has spread throughout the world, this location change would have brought out new predators (such as cats) and new environmental conditions (such as colder weather) which forced rattus norvegicus to evolve to survive these conditions.

Evidence of Evolution

The main source of evidence of the brown rats is fossils. These fossils have proven many things such as the origin of the species and evolution. The first known appearance of Murinae (subfamily of muridae) in the fossil record is about 14 million years ago of which the rattus norvegicus evolved. So this shows that this is around the time the first muridae appeared. Rat fossils that have been shown to be linked to the brown rat are quite different to the brown rat today, with different characteristics such as being larger.

Another way scientists have proved the evolution of the brown rat has been through Comparative anatomy, that is, the study of similarities and differences in the anatomy of different species. Scientists actually don’t have any fossils of this species, though using comparative anatomy, fossils they do have from other species and information from living species, they can map out the traits they do know and work their way up the branches, to form a very good idea of what it would have been like. international researchers have been able to trace R. norvegicus all the way back to the first placental mammal by building this tree of life. An interpretation of this species can be shown below in figure 6. this species is thought to have been the ancestor of all placental mammals, from whales to brown rats, and even to humans.

Natural Selection

Natural selection can be seen in many ways for R. norvegicus. Many have already been mentioned, such as the Baltimore R. norvegicus, being larger than their Salvador counterparts, the reason for this is because the cats have eaten all the smaller R. norvegicus. This is different to artificial selection, as it happens naturally, that is, without the interactions of humans. Apart from the selective breeding by humans, Natural selection is also what has caused all the changes to the R. norvegicus linage, from the first placental mammal to the R. norvegicus today. Another example of this natural selection is that in the colder climates such as near the arctic, R. norvegicus has developed more fur to combat the colder climate. Sometimes this natural selection doesn't happen to certain parts of the species like with the Baltimore rats, but effects the whole species itself. For this the same selection pressure must exist throughout the species, so this is seen more often when the r. norvegicus lived in close proximity to each other.

An example of this would be during the intense speciation events to the genus rattus, specifically the one 2.7 MYA (million years ago). During this time the rattus genus lived in the same region around south Asia, so whatever selection pressure caused this, would have most likely affected the whole species, such as a tectonic change or new predator appearing in the region. If for example there was a new predator introduced to the region of rattus (it's uncertain what actually caused this intense speciation but it most likely was climate or tectonic change based on the time it happened, predator just being an example) all the rats would die off that couldn't defend themselves from the predator, leaving only the 'better' rats left. This is an example of natural selection.

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