

Comparative and functional morphology of male external genital organs in Muroidea rodents

Takashi O. YATO

Abstract

Background

Many comparative morphological studies have been conducted on the penis; male external genital organs, and baculum; bone of the penis in rodents. Muroidea rodents have medial and lateral bacular mounds in the distal penis, and some species have ossified cartilage. Distal structures of the penis, such as medial and lateral bacular mounds, have been compared among species as taxonomically important traits, but their functional morphology has rarely been discussed. In this dissertation, I aimed to clarify the morphological and functional diversity of the male external genital organs, especially the distal structure of the penis, between Muridae and Cricetidae, using histological methods and three-dimensional (3D) models.

Materials and Methods

I examined six Murinae species (Rodentia: Muridae): *Apodemus speciosus*, *A. argenteus*, *Mus musculus*, *Mu. caroli*, *Micromys minutus*, *Rattus norvegicus*; five Arvicolinae species (Rodentia: Cricetidae): *Alexandromys montebelli*, *Myodes rutilus*, *Craseomys rufocanus*, *C. smithii*, *C. andersoni*; and seven Cricetinae species (Rodentia: Cricetidae): *Phodopus campbelli*, *P. sungorus*, *P. roborovskii*, *Mesocricetus auratus*, *Tscherskia triton*, *Cricetulus barabensis*, and *Nothocricetulus migratorius*. Cricetinae species were obtained from the breeding stock of the Bio-resource Division, Department of Biotechnology, Frontier Science Research Center, University of Miyazaki, Japan, and

SLC, Inc., Japan. I dissected the male external genital organs of these species and examined the samples under a stereomicroscope after staining the bone with alizarin red. Three-dimensional models were designed using a micro-CT scanner (ScanXmate-A080S; Comscantecno, Yokohama, Japan) and Amira 5.2.2 software (Thermo Fisher Scientific). The tissue sections were stained with hematoxylin and eosin and Masson's trichrome stain.

Results

The morphologies of the male external genital organs of Japanese Muroidea species (six Murinae species and five Arvicolinae species) were morphologically compared in Chapter 2. All examined species possessed a medial bacular mound and two lateral bacular mounds, collectively forming a trident structure. In Muridae species, the medial bacular mound was ossified or consisted of cartilage, while the lateral bacular mounds were composed of soft tissue. In contrast, in Cricetidae species, both the medial and lateral bacular mounds were ossified. The presence of cavernous spaces and blood vessels was confirmed in the lateral bacular mounds of both *A. speciosus* and *C. rufocanus*.

The lateral bacular mounds of *Mu. musculus* and *Mi. minutus* were compared, with a focus on the stalk position in Chapter 3. The cavernous spaces of the lateral bacular mounds in *Mus musculus* were well developed, while those in *Mi. minutus* were not. There was no significant difference in the ratio of stalk length to penis length between them, whereas the ratio of protrusion of the medial bacular mound from the internal prepuce in *Mu. musculus* was higher than that in *Mi. minutus*, and the stalk was located at a more distal portion of the penis in the former.

The male external genital organs of seven species of five genera of Cricetinae (*P. campbelli*, *P. sungorus*, *P. roborovskii*, *M. auratus*, *T. triton*, *C. barabensis*, *N. migratorius*) were morphologically compared in Chapter 4. In all the examined species, lateral distal segments were present in the lateral bacular mounds. Keratinous spines between the base of lateral bacular mounds and the internal prepuce were observed in all Cricetinae species, except *Nothocricetulus migratorius*.

Discussion

Histological examination of the penis specimens of *A. speciosus* and *C. rufocanus* suggested that the movement of the lateral bacular mounds was driven by blood flowing into the cavernous space, increasing the cross-sectional area of the glans penis (Chapter 2). Because the lateral bacular mounds are located at the distal end of the stalk, the position of the mobile pivot point of the lateral bacular mounds depends on the stalk position. In *Mu. musculus*, the lateral bacular mound was located in the distal part of the penis. Although the lateral bacular mounds are short, they are thought to contribute to distal penile distention by inducing blood flow into the cavernous space, and this movement increases the distal portion of the penis, as specified in Chapter 3. There were differences in the position of the distal end of the stalk in Cricetinae. The base of the lateral bacular mounds with spines was located at the distal end of the stalk, indicating that the distance to the spines at which females are stimulated differs among species. It can be said that the spines between the base of the lateral bacular mounds and the internal prepuce function as stimulus to the female during mating, as specified in Chapter 4.

Conclusion

This dissertation elucidates the diversity of male external genital organs in Muroidea rodents and reveals a high variation in the structure of the distal penis. The lateral bacular mounds may be involved in stimulating females during copulation by distal penile distention and the spines at the base.