Using Mealworms (Arthropoda: Tenebrionidae) to Prepare Rat Skeleton

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ARTICLE INFO

Article History
Received : 03.03.2022
Accepted : 06.10.2022
DOI: 10.33988/auvfd.1082368

Keywords
Anatomy
Mealworm
Rat
Skeleton

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How to cite this article: Selviler Sizer S, Kurt S, Onuk B, Kabak M (2023): Using Mealworms (Arthropoda: Tenebrionidae) to Prepare Rat Skeleton. Ankara Univ Vet Fak Derg, 70 (2), 227-230. DOI: 10.33988/auvfd.1082368.

ABSTRACT

In anatomy, various methods such as boiling, maceration, and dissection are used to prepare the skeleton. However, while the existing methods are used in the skeleton preparation stage of small animals, the integrity of the skeleton is impaired, and there are difficulties in the reassembly of the bones. For this reason, it is planned to create small animal skeletons without loss and damage by using mealworms. In the study, 1100 mealworms (Arthropoda: Dermestidae) with a total weight of approximately 110 grams and three rat carcasses with a weight of approximately 177 grams were used. To observe the carcass cleaning performance of the mealworms, the initial weight and final weight of the carcass were measured with a precision scale. It was observed that on days of 3rd-5th, the meat on the rib was eaten and the ribs appeared. The vertebral column became more evident in the 6th-8th days. In the 6th-9th days, the ribs were completely cleared, and the extremity bones were visible. The skull and extremities were evident in all their details between the 9th-12th days. At the end of the 15th day, it was determined that mealworms had completely exposed the rat skeleton. As a result, in this study, it was observed that approximately 1100 mealworms consumed 159 g of meat in 15 days, resulting in a lossless and undamaged rat skeleton. In addition, the advantages and disadvantages of creating small animal skeleton using mealworms were determined in this study.

Boiling, maceration, burying and dissection methods are frequently used in the preparation of skeletal material in anatomy (9). The boiling method requires large equipment and a special area. During this process, which takes a lot of time, a bad odor is emitted into the environment. It also needs to be constantly checked by the employee (3, 23). In the maceration method using additional chemicals, it is mentioned that the bones are removed from the soft tissue in a short time and the bones obtained are quite clean. However, it should not be forgotten that there may be a risk of damage to the bones by chemicals during this method (1, 17). Again, in this method, manual removal of the tissues adhered to the bone is often considered a waste of time. In addition, another disadvantage of the maceration method is the high cost of chemicals and the bad odor produced by bacteria that reproduce in the water or chemical solution (22). Creating a skeleton with another method that is the embedding method takes time. In this method, while the preservation of bone integrity is an advantage, there is also the possibility of damaging the bones of some carnivorous animals (20). The biggest disadvantage of the dissection method, in which a skeleton can be formed in a short time with minimum equipment, is that the tools are used to damage the worker and the bone (15, 23).

Since these methods mentioned above usually require intensive work and equipment, some insect species such as *Dermestes maculatus larvae* are used in forensic entomology, zoology, anthropology and museums for cleaning bones for skeleton construction (14, 18). While the use of these insects saves time and work, it does not cause any damage to bone morphology. The most important issue for the establishment of the *Dermestes maculatus* (Arthropoda: Dermestidae) colony and the continuity of the colony is the creation of suitable environmental conditions (11, 15, 18). In addition, other processes are needed to purify the obtained bones from insects (16).

Apart from all these methods, in 1950, mealworms were tried in species such as marmoset, monkey, wildcat,

and raccoon to obtain skull bone, and it was shown that mealworms (Arthropoda: Tenebrionidae) cleaned the head and exposed the bone (2). After that, no study was found on this subject. Mealworms are easy to obtain, maintain and reproduce (8, 21). The life cycle of mealworms consists of four stages: egg, larva, pupa, and adult, and the whole process takes place in the same ecosystem (5). This study was targeted to create skeletons in small animals using mealworms and to reveal the advantages and disadvantages of this method compared to other classical methods. In addition, we aimed to determine the meat consumption amount and duration of these arthropods and contribute them to the literature.

Approximately 1100 mealworms (Arthropoda: Tenebrionidae) weighing 110 grams were commercially purchased for 8 dollars. In the study, performed in the Department of Pathology, Faculty of Veterinary Medicine, Ondokuz Mayıs University, three rats used in the control group were used.

Commercially purchased mealworms (Arthropoda: Tenebrionidae) larvae were stored in a plastic container at room temperature. 500 g crumbled bran was placed on the bottom of the plastic container as a substrate. Photographs were taken every two days until the carcass was cleaned and turned into a skeleton. In order to determine the meat consumption rate and amount of mealworms larvae, the initial weight and final weight of the carcass were measured with a precision scale. The carcass was wrapped in a damp cloth to prevent the muscle tissue from drying out.

Small pieces of meat were given for 7 days to increase the adaptation of mealworms, which are known to eat vegetables as food. Afterward, rat carcasses, whose skin and organs were removed, were used. In addition, during this process, the container containing the carcass was examined every day, and the mealworms larvae that became pupae and adults were removed from the colony and kept in a separate container. Large pieces of vegetables (potatoes, cucumbers) were kept in the container to meet the water needs of the colony and to balance the ambient humidity.

The mean weight of three rat carcasses whose skin and internal organs were removed, before being fed to the mealworms was 177±12.24 g. It was observed that the worms started to feed on the first day when rat carcasses were given to the adapted mealworms (Fig. 1). It was observed that the meat was eaten on the ribs and the ribs appeared on average 3^{rd}-5^{th} days for all carcass. In 6^{th}-8^{th} days vertebral column became more prominent. By 6^{th} -9^{th} days the ribs were completely cleared and the extremity bones were visible. Between days the 9^{th} and 12^{th}, the cranium and extremities were evident in all their details. At the end of the 15^{th} day, it was determined that the mealworms revealed the rat skeleton as a whole without any damage to the bone structure. The final weight at this stage was 18.3 ± 2.08 g on average. It was observed that the consumption rate slowed in the ligaments and the skin parts of the tail, where mealworms quickly consumed the muscle and adipose tissue of the carcass. The consumption rate was decreasing due to drying on the carcass over time. During this process, there was no offensive odor. Mealworms in the colony were not prone to escape and were easy to care for. It was observed that mealworms, which started their life cycle with eggs, continued as larvae, pupae and adults (Fig. 2). It was determined that while the larva and adult form in the life cycle ate meat, the pupa form was in minimum motion and did not consume meat. It was remarkable that as the number of pupae in the colony increased, the meat consumption rate decreased, and mealworms from different life cycles had to be present in the colony to obtain a constant consumption rate. In this way, it was observed that the colony consumption rate could be kept constant without adding new mealworms.

Various methods have been used to prepare skeletons from past to present (1, 18, 20, 23). It has been reported that these methods have disadvantages such as time, cost, labor, bad odor, bone damage, bone loss, and deterioration of skeletal integrity (1, 6, 12, 20, 23). In this study, a complete skeleton was obtained in rats without bone loss by using mealworms (7). The literature states that apart from the methods mentioned above, insects such as *Dermestes* spp. are also used to prepare skeletons (7, 10, 13). It has been reported that the skeleton was obtained without causing any damage to the bone with the use of these species (18). However, the disadvantage of this method is the difficulty of obtaining *Dermestes* spp. and maintaining the colony (4, 19). In the study, it was revealed that mealworms, which are readily available, can be easily obtained skeletons from small animals without requiring a particular area and special care.

Obtained bone using mealworms (Arthropoda: Tenebrionidae), but they did not mention the advantages or disadvantages of this method in their studies (2). Again in this study, data about the total time, colony living conditions, number of mealworms in the colony, and consumption rate were not included. For the first time in our study, the approximate number of mealworms to be used to form a rat skeleton with mealworms was determined as 1100 pieces, and the meat consumption rate of these worms was determined as 159 gr.

In conclusion, with this study, the advantages and disadvantages of using mealworms in the creation of small animal skeletons such as rats were determined.

While this method has the advantages of being low-cost, easy to obtain and care for mealworms, not causing any damage to the bone, being an odorless method, and requiring minimum labor, the disadvantage of the method meat consumption rate decreased due to an increase in the number of pupae in the colony. With the data we obtained from this study, we believe that the mealworms used in the preparation of small animal skeletons can also be used in cleaning the bones of large animals.

DOI: 10.33988/auvfd.1082368

Figure 1. Stages of formation of rat skeleton using mealworm.
A: Rat carcass, skin, and internal organs removed and were given to mealworms; B: The view of the carcass on the 3rd-5th days; C: The view of the carcass on the 6th-8th days; D: The view of the carcass on the 8th-9th days; E: The view of the carcass on the 9th-12th days; F: Emergence of rat skeleton at the end of day 15th.

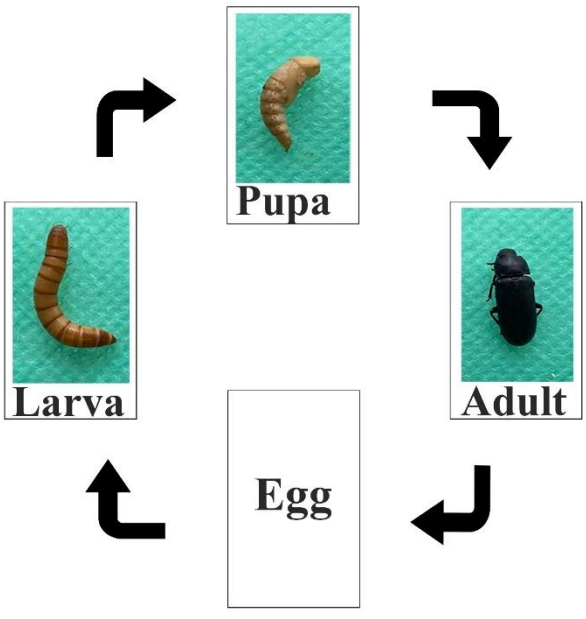

Figure 2. Mealworms life cycle.

Acknowledgement

A part of this study was presented as a poster presentation in the congress named "International Congress on Biological and Health Science, Online" held between 26-28 February 2021.

Financial Support

This research received no grant from any funding agency/sector.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

SSS, SK, BO, and MK conceived and planned this study. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

Since no live animals were used in the study, there is no need for an ethics committee.

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