METHODOLOGY FOR REARING AND BREEDING THE HERMIT BEETLE

(*Osmoderma barnabita)*

Kristina Guzaitienė

KAUNAS

2021

CONTENT

INTRODUCTION

The hermit beetle (*Osmoderma barnabita)* has been included in the International Red List of the International Union for Conservation of Nature, IUCN. This species is included in annexes II and IV of the EU Habitat Directive and has been ascribed to the species of priority conservation. It is also included in Annex II of the Bern Convention, in the List of Protected Fauna, Flora and Fungi Species of the Republic of Lithuania (The Red Book of Lithuania) and ascribed to the category of vulnerable species (VU).

Over the period from 2017 to 2022, the Lithuanian Fund for Nature, in partnership with Lithuanian Zoological Garden, Daugavpils University Nature Studies and Environmental Education Centre and Kaunas City Municipality, has been implementing a project "Ecological network for *Osmoderma eremita* and other species dependent on veteran trees" (LIFE16 NAT/LT/000701) funded by the European Union environmental financial mechanism „LIFE" and by the Ministry of Environment of the Republic of Lithuania.

The main aim of LZG in this project is establishment of the hermit beetle *ex situ* population in Lithuanian Zoological Garden and release of bred individuals of the hermit beetle to restored historical habitats of the species.

Methodology for Rearing and Breeding the Hermit Beetle has been developed to ensure successful rearing and breeding of this species.

ESTABLISHMENT OF *EX SITU* POPULATION

In the course of the project „Creation of Ecological Network for the Organisms Dependant on Veteran Trees“ (LIFE16 NAT/LT/000701), works for the establishment of *ex situ* population in LZG have been carried out. Project workers authorized for this type of activity were collecting adult beetles and their larvae. Collection of beetles for the establishment of *ex situ* population lasted for three years (from 2019 to 2021).

Collection of beetles in nature

Adult beetles are captured using pheromone traps. Beetles are attracted using synthesised (+)-y-decalactone substance produced by male beetles. Pheromone traps are attached to tree trunks at the height of 2–3 metres so that they are protected against direct sun light from the southern side (*Fig.1*). Traps are attached to old, hollowed oaks growing in open sunny locations. Such trees usually grow in different parks, graveyards, pastures, homesteads, and tree allies of former estates.

During the project, traps were erected in the oakery of Kaunas City (area important for the protection of habitats - LTKAU0020 „Kauno ąžuolynas“). This park is the largest oak forest existing on the city territory overgrown with century-old oak trees. This territory has the largest population of the hermit beetle in Lithuania.

Adult beetles, which grew up in the wild, are flying between June and August in warm and sunny days. Therefore, pheromone traps are installed in June, when average air temperature is +20 ºC (most often from the second week of June), and removed in the middle of August when the air cools down. In sunny and hot days, when air temperature becomes +20 ºC and higher, the traps are checked once a day, from 5 p.m. to 7 p.m. In rainy and cool days, when air temperature drops down below +20 ºC, traps are checked every second day. In such days beetles are slow, thus they fly very rarely.

Fig.1. *Pheromone trap on the tree*

Fig.*2.* *Female hermit beetle in the trap*

Pheromone traps are designed for female beetles, but occasionally male beetles get interested in them too.

Sometimes, beetles are discovered crawling near the trap, therefore, it is important to look around the tree trunk from all the sides.

A captured beetle (*Fig.2*) is transferred from the trap to a plastic container containing several tree leaves (both fresh and dry leaves from the previous year are suitable). The container is tightly closed with a lid to prevent the beetle from flying out. There must be a hole in the lid to ensure air ventilation. Adult beetles are short-lived (they live up to 4 weeks), therefore, it is important to release them as soon as possible into a breeding container where they will be able to lay eggs.

Before releasing the beetles into containers prepared for breeding, they are inspected and measured. Sexing is done based on the features characteristic of this species *(Fig.3)*.

Hermit beetles of different sizes have been captured during the project – from 25 mm to 33 mm *(Fig.4*).

After recording all the data, beetles are transferred to breeding containers prepared in advance.

Fig.3. *Female of the hermit beetle (on the top) and a male (below)*

Fig.4. *Males of the hermit beetle in different sizes*

Collection of larvae and cocoons in nature

Larvae of the hermit beetle are discovered in the fallen trees, trees that were felled during road reconstructions or in sanitary clearings. They are carefully collected into a plastic container with substrate (2–5 litres of it) and delivered to the specialists responsible for breeding. More substrate (10–30 litres) is taken from the place where larvae is found and placed in a separate container.

Discovered cocoons of the hermit beetle are carefully placed into a plastic transportation container with substrate. It is important not to damage the surface of the

cocoons at the time of transportation. The cocoons protect the pupa from pathogens, predators, mechanical damages, drying out etc. If the cocoon is damaged, it is highly probable that the larvae or pupa inside it will die.

Larvae and cocoons brought to a breeding facility are inspected, weighted, lengths are measured and consistence of the larvae body is assessed.

After the data is recorded, cocoons are transferred to breeding containers prepared in advance and the delivered larvae is placed into containers prepared for rearing and filled with substrate brought together with larvae.

REARING OF BEETLES

Preparation of substrate for breeding containers

Hermit beetles are bred in plastic 40-60-litre containers with lids that can be tightly closed. 10x25cm sized ventilation openings are cut out in the lid of the container and then a plastic mesh is glued on them to prevent entry of mosquitos. A ventilation opening cut out all over the surface of the lid could result in fast drying of the substrate and negative effect on the breeding of beetles (*Fig.5*).

Fig.5. *Containers for breeding hermit beetles*

Beetle breeding containers are filled with substrate specially prepared for the hermit beetles. The substrate is prepared trying to recreate conditions which would be as natural as possible.

The basic part of the substrate (50–60 %) is made of the leaves of the pedunculate oak. Part of the foraging ration of the larvae is made of rotten leaves, therefore, collected leaves

are composted for 6–12 months in field conditions. Before preparing the substrate, leaves are mechanically chopped (*Fig.6*). Large parts (branches, acorns) found in the leaves are removed. Leaves of other deciduous trees (for example, of the lime tree (*Tilia sp.*)) are left together with oak leaves if their quantity in the substrate does not exceed 1%. Oak leaves are composted each year in autumn.

Fig.6. *Leaves composted in the field for 6–12 months (on the left) are chopped to prepare substrate (on the right)*

The remaining part of the substrate (40–50 %) is made of the fine rot of the pendunculate oak (*Quercus robur*) affected by the brown wood rot. The rot is collected from the cavities of the old or fallen oaks. Large parts are mechanically shred to smaller fractions. More solid or less rotten parts, which cannot be crushed, are removed. Pieces of the rot of the size of approximately 5x5 cm may make up no more than 10–20 % of all the quantity of the rot present in the substrate.

Best breeding results are achieved when the substrate is made of the oak rot of the small or average-sized fraction which can be easily mashed on the palm. Much more eggs are usually found in such a rot than in the substrate dominated by the rot of the large and average-sized fraction where small fractions are scarce or absent at all (*Fig.7*).

Fig.7. *Oak rot of the small fraction (on the left) and the rot too large to prepare substrate (on the right)*

Both components of the substrate are placed into one large container and mixed properly. If the substrate is dry, it is watered abundantly. Prepared substrate is poured down into the breeding containers. 3/4th of the content of the container is filled with substrate mixture.

Transfer of beetles to breeding containers and rearing

10–15 individuals are reared per a breeding container. Ratio of the reared female and male beetles in a container is 3:1. The beetles live in a container up to 4 weeks.

Seeking to recreate the best possible natural conditions in breeding containers, they are stored in a dark facility. Lighting can be turned on only during inspection of breeding containers.

During the months of June and August, room temperature ranges from +20 ºC to +22 ºC. Air conditioning system maintains regular room temperature. Optimal temperature for the rearing of the beetles ranges from +18 ºC to +22 ºC. If the temperature is higher, beetles become very active, waste a lot of energy for the movement and metabolism processes intensify resulting in the shorter life span of the beetles.

Relative humidity of 75 % – 85 % is maintained in the containers. In order to maintain required humidity, the substrate is moistened with water using a plant sprayer. Humidity and temperature during the project were recorded by a digital device Elitech GSP-6 (*Fig. 8*).

It is generally thought that in the wild beetles are not foraging or foraging on tree juice. Several cases have been recorded of the adults found on the flowers of the plants. *Ex situ* bred hermit beetles are fed with pieces of exotic fruit (banana, kiwis, oranges, grapes). The food is replaced daily *(Fig.9).*

Fig.8. *Digital thermometer/hygrometer* ***Fig.9.*** *Eating hermit beetles*

INCUBATION

Most of their life beetles spend while burrowed in the substrate. They appear on the surface of the substrate just when they forage. Mating also takes place in the deep layers of the substrate.

After mating females lay greyish-white eggs of 2-3 mm in different layers of the substrate. During incubation, egg colour changes from greyish-white to greyish-yellow. At the same time, the size of the eggs changes too, from 2–3 mm to 4–5 mm (*Fig.10*). Based on these external features, it is possible to decide when the eggs were laid. The eggs can be easily damaged, therefore, they are left in the substrate until larvae hatch.

The eggs are incubated in a temperature ranging from +20 ºC to +22 ºC. Air conditioning system maintains regular room temperature.

Relative air humidity from 75 to 85 per cent is maintained in the containers with incubated eggs. Required humidity in the substrate is maintained by moistening it with water using a plant sprayer.

During the project, female hermit beetles would lay in the substrate 20–30 eggs in average.

Fig.10. *Eggs of the hermit beetle*

Egg incubation lasts 14–20 days. Incubation duration depends on the temperature. Eggs incubated in lower temperature develop longer.

The length of the larva hatched from the egg is from 6 to 7 mm (*Fig.11*). Larvae can be easily damaged during this period of development, therefore, they are left in the substrate until September.

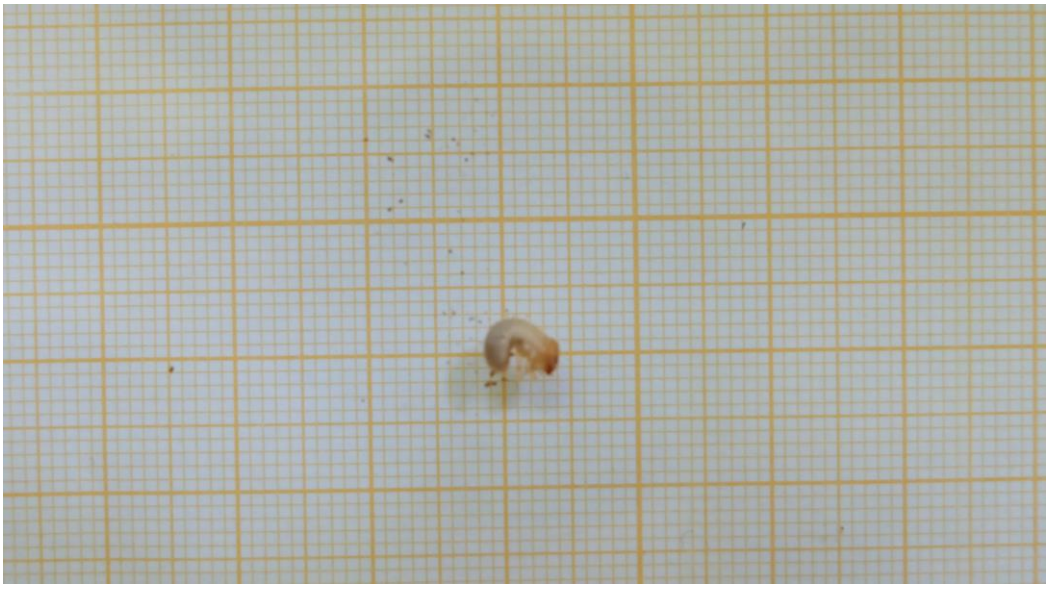

Fig. 1. *Larva of the hermit beetle at the age of 1-2 days*

INSPECTION OF BREEDING CONTAINERS

60-90 days following release of the beetles (but no later than in September), the first inspection of breeding containers is carried out. When October comes, substrate and larvae in

the containers are not disturbed. Larvae are left in peace to prepare for a wintering period. If larvae in the containers have not been checked by the month of October, the process of inspection is postponed to spring.

Larvae are growing fast and, two-three months after they hatched from the eggs, they weigh in average 0, 3–2, 0 g and are 15–30 mm long. Larvae are coiled in a form of letter „C“, therefore, sometimes it is difficult to measure their length. Such a form is characteristic of the larvae of the hermit beetle.

Fig.12. *Process of inspecting a breeding container*

At the time of inspecting breeding containers, substrate with larvae is carefully dumped on the spread polyethylene sheet (*Fig.12*). Dumped substrate is manually and gently turned over to find larvae. If substrate in the container is of a fine fraction, it is sifted through the sieve (*Fig.13*). Diameter of the sieve holes is 10x10 mm or 5x5 mm. At the time of inspection, selected larvae are scrutinized, counted, measured and weighted. Since larvae in the container are of different sizes, they are sorted out based on the weight established when they are weighted. Larvae, which weigh up to 1 g, and larvae, which weigh more than 1 g (*Fig.14*), are divided into two groups. Larvae of different sizes are settled in different containers.

Having recorded all the parameters, sorted larvae are transferred to larvae rearing containers for the continuation of their development process.

Fig.13. *Larvae in the substrate (on the left) and sieves (on the right)*

Fig.14. *Larvae weighted and sorted by weight*

REARING OF LARVAE

Preparation of substrate in rearing containers

Larvae are bred in 40–60-litre plastic containers with covers that can be tightly closed. A ventilation opening of 10x25 cm is cut out in the lid of the container and then a plastic mesh is glued on it to prevent entry of mosquitos. A too big ventilation opening results in fast drying of the substrate.

Substrate for the larvae in rearing containers is prepared in the same way as for the beetles (see chapter *„Preparation of Breeding Containers for Beetles“*). Additionally, each newly prepared container is filled with 5–6 litres of substrate from the container in which the beetles had laid their eggs.

Larvae will live in such a substrate for 2–4 years. This time is needed for the development cycle of the hermit beetle‘s larvae. The cycle for the development of larvae

consists of three stages: L1, L2, and L3. Depending on the stage larvae have different sizes. A larva of stage L1 is hardly 6 mm in length, whereas a larva of stage L3 can be up to 75 mm.

Quantity of composite parts of the substrate, while larvae are foraging and growing, is slightly changing. Oak leaves and rot is supplemented by particles of larvae excrements (*Fig.15*). Larvae form wintering chambers and cocoons from tree rot and excrements. Excrements also supplement larvae‘s ration (due to larvae nutrition peculiarities and microorganisms involved in the digestion process, a large quantity of nitrogen is found in the excrements).

Removal of larvae into rearing containers

After the first inspection of rearing containers, counted and sorted larvae are removed to the rearing containers prepared for them. From 30 to 50 individuals are reared in each container. Larvae, which weigh up to 1 g, and larvae, which weight more than 1 g, are settled in different containers. Such a sorting ensures a more even development of the larvae in the containers.

In September the temperature in which larvae are reared is lowered from +20 ºC to +15 ºC. Air conditioning system is used to maintain regular room temperature.

Relative humidity of 75 % – 85 % is maintained in the container. In order to maintain required humidity, substrate is moistened with water using a plant sprayer.

Fig.15. *Excrements of the hermit beetle‘s larvae*

The first wintering period of the larvae

During October and November, the temperature in the room where larvae are reared is lowered from +15 to +10 °C. The temperature is lowered in order to recreate most natural possible conditions and prepare larvae for the wintering period. When the temperature falls down, larvae stop foraging and start forming cavities called “chambers” There must be a sufficient quantity of the substrate in a container, so that larvae could form a suitable wintering chamber. Larvae winter in the lower layer of the substrate where there is a lot of small rot and excrements.

A coiled larva spends all the wintering period in the chamber (from October to April). Sometimes chambers are formed at the wall of the plastic container, therefore, it is possible to observe larvae all over the wintering period and record a precise date when they leave their chambers (*Fig.16*).

Sometimes larvae form chambers in the tree rot of the average fraction when their quantity is not more than 10–20 % of all the quantity of the rot present in the substrate (*Fig.17*).

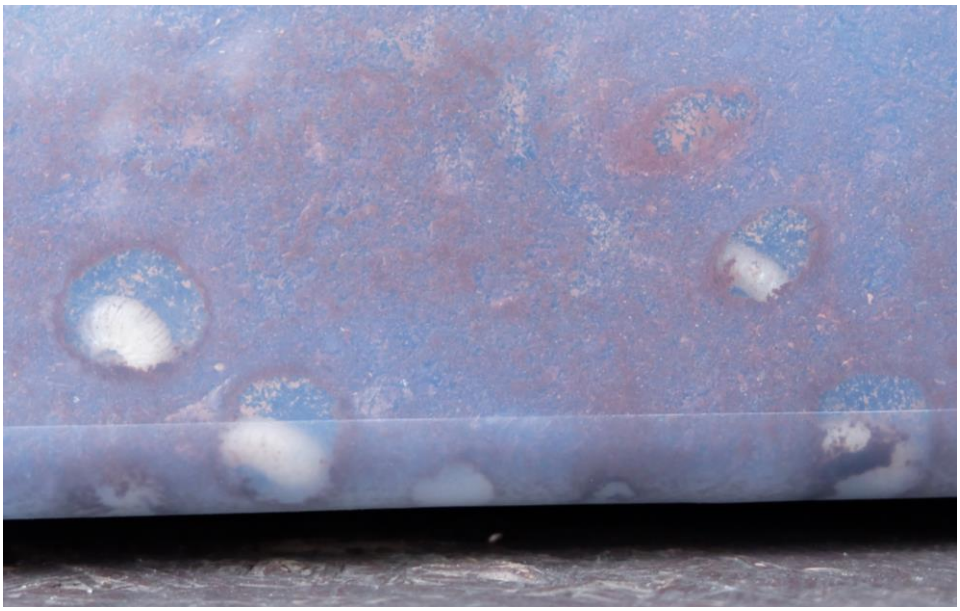

Fig.16. *Chambers formed at the wall of the plastic container*

Fig.17. *Chambers in oak rot*

Fig.18. *Larvae reared in containers*

The rest period of the larvae in rearing containers lasts from December to November. By this time, all larvae had already formed chambers in which they winter. Wintering temperature ranges from 0 °C to +5 °C. Air conditioning system is used to maintain regular room temperature. Larvae can successfully winter in negative temperature too.

Relative humidity of 75 % – 85 % is maintained in the container. If necessary, substrate is moistened one or two times during the wintering period taking into account parameters of the hygrometer.

At the end of March and beginning of April, the temperature is gradually increased from +10 to +15 °C. When the temperature increases, larvae wake up and leave wintering chambers.

Rearing of larvae after the first wintering

After the wintering period is over, larvae are allowed to gain strength, therefore, containers are inspected only in May. Inspection of containers is carried out in the same way as before the first wintering (*see chapter „Inspection of Rearing Containers“*). Larvae are newly weighted, measured, counted and their status is assessed.

Having waken up in spring, larvae intensively forage on substrate present in the environment, therefore, its quantity rapidly diminishes. When the volume of substrate in the container reduces by one fourth, it is supplemented with composted, shredded leaves of the pendunculate oak. Depending on the quantity of larvae in a container, containers are again

supplemented two or three times until the next wintering period. Quantity of the wood rot in the substrate doesn‘t change significantly, therefore, there is no need for supplementation.

In May, room temperature where larvae are reared is increased from +15 to +20 ºC.

Over June and August, the temperature is set from +20 to +22 ºC.

From September, the temperature is little by little lowered again from +20 to +15 °C.

Over October and November, the temperature is further lowered from +15 to +10 °C. When the temperature drops down, larvae are getting ready for the second wintering period (*Fig.18*).

Over this entire period of larvae rearing after wintering, relative humidity of 75 % – 85 % is maintained in the containers. In order to maintain required humidity, substrate is moistened with water using a plant sprayer.

The second wintering period of larvae

Over the period of breeding the beetles, females lay the eggs at different times. In autumn, due to this reason and due to individual features of the larvae, part of larvae reach a development stage L2, and the other part of them reach a development stage L3.

When the second wintering period approaches, larvae of stage L2 again form chambers similar to those before the first wintering.

In autumn, larvae reaching a development stage L3 form cocoons and winter in them.

Over December and February, rearing containers are in the rest period. During this time larvae are wintering in the chambers and cocoons. Wintering temperature ranges from 0 °C to +5 °C. Air conditioning system is used to maintain regular room temperature. Larvae can successfully winter even if the temperature is negative.

At the end of March – beginning of April, the temperature is gradually increased from +10 to +15 °C. When the temperature rises, larvae wake up and leave their wintering chambers.

Relative humidity of 75 % – 85 % is maintained in the container. If necessary during the wintering period, substrate is moistened one or two times taking into account parameters of the hygrometer.

Monitoring larvae and cocoons after the second wintering

After waking up and leaving their chambers at the end of March and beginning of April, larvae start foraging intensively. Such larvae weigh about 4,70 g – 7,10 g and their average length is 50 mm (*Fig.19*). When autumn comes, they will be preparing for the third wintering period.

However, after the second wintering period, part of larvae reach stage L3 (approximately 60–75 mm long) and form cocoons from the substrate present in the environment. Cocoon's length is approximately 30–40 mm (*Fig.20*). After 6-12 days, larvae in them turn to pupae. The stage of the pupa lasts from 2 to 4 weeks. The period of development depends on the temperature. In lower temperature the pupa develops slower. Following the metamorphosis, an adult beetle spends in a cocoon by 1 or 2 weeks more.

It is necessary to ensure for the larvae a period of peace at the time of cocoon formation. If formation of the cocoon is disturbed, there is risk that the larva will perish without completing the process. Cocoon formation requires huge efforts. On-time disturbance of the cocoon formation process will prevent the larva from forming a cocoon for the second time. Thus, after the second wintering period of the larvae, containers are checked only at the end of May.

Larvae, which form cocoons in autumn, successfully winter in them and continue developing. Irrespective of when the larva formed a cocoon (in spring or in autumn), metamorphosis in it occurs only in spring or in summer.

Over the months of June and July, when the temperature is increased from +20 °C to +22 °C, hermit beetles hatch from the cocoons.

Fig.19. *Larvae after the second wintering*

Fig.20. *Cocoons after the second wintering*

TRANSFER OF LARVAE TO NATURE

Larvae are transferred to nature during the months of May and June, when average air temperature becomes +12 °C and higher. Larvae manage to adapt themselves and prepare for the wintering period.

Larvae are transferred to the „nesting boxes" (*Fig.20*) specially designed for the hermit beetles. Substrate in the „nesting-boxes" is in conformity with the substrate present in

the containers. At the time of transfer, the „nesting-box“ is additionally supplemented with 20–40 litres of the substrate of the breeding container in which larvae was growing and in which cocoons were formed.

At the time of transfer, larvae are taken from large containers and placed to the smaller ones. Smaller containers are easier and more conveniently lifted up to the top of the „nesting-box“. The lid of the nesting-box is opened and larvae are carefully poured into.

TRANSFER OF COCOONS TO NATURE

Cocoons are transferred to nature in May, when average air temperature ranges from +12 °C to +16 °C. If this is done too late, it might be not the cocoons which will be transferred to nature but the hermit beetles.

Cocoons, like larvae, are transferred to „nesting-boxes“ specially designed for the hermit beetles. Substrate in the „nesting-boxes“ matches the one of the breeding containers.

Cocoons are transferred to the “nesting-boxes” carefully, one by one, trying not to damage their surface. A substrate layer 10–20 cm thick is gently poured over them to prevent the cocoons from drying out.

When larvae and cocoons are transferred at the same time, larvae will be the first to go to the „nesting-box“, where they burrow deep in the substrate, and cocoons will follow only after that.

Fig.20. *Transfer of larvae and cocoons of the hermit beetle to a "nesting-box"*

REFERENCES

Baranauskas K., Dagys M., Gudžinskas Z. et al. 2015. Lietuvos griežtai saugomos rūšys. Vilnius. Petro ofsetas. 9–11.

Bastytė D., Guzaitienė K., Švitra G.,Valainis U., Niūriaspalvio auksavabalio (*Osmoderma barnabita*) veisimo programa.

Endrestøl, A., Hanssen, O. & Flåten, M. 2016. Kartlegging og overvåking av eremitt Osmoderma eremita i Norge 2015 – NINA Rapport 1252. 38 s.

Hilszczan´ski J., Jaworski T., Plewa R., Jansson N. 2014. Surrogate tree cavities: containers with artificial substrate can serve as temporary habitat for Osmoderma barnabita (Motsch.) (Coleoptera, Cetoniinae). J Insect Conserv (2014) 18:855–861

Landvik M., 2017. Some observations and brief guidance to *Osmoderma* larvae rearing.

Landvik M., Niemela P., Roslin T. 2016. Mother knows the best mould: an essential role for non-wood dietary complements in the life cycle of a saproxylic scarab beetle. Oecologia 182(1):163-75.

Makomaska-Juchiewicz M. 2010. Modyfikacja metodyki monitoringu opublikowanej. Monitoring gatunków zwierząt. Przewodnik metodyczny. Część I. GIOŚ, Warszawa.

Ranius, T., Aguado, L. O., Antonsson, K., Audisio, P., Ballerio, A., Carpaneto, G. M., Chobot, K., Gjurašin, B., Hanssen, O., Huijbregts, H., Lakatos, F., Martin, O., Neculiseanu, Z., Nikitsky, N. B., Paill, W., Pirnat, A., Rizun, V., Ruic|nescu, A., Stegner, J., Süda, I., Szwa»ko, P., Tamutis, V., Telnov, D., Tsinkevich, V., Versteirt, V., Vignon, V., Vögeli, M. & Zach, P., 2005. Osmoderma eremita (Coleoptera, Scarabaeidae, Cetoniinae) in Europe. Animal Biodiversity and Conservation, 28.1: 1–44.

Ranius T., Hedin J. 2001. The dispersal rate of a beetle, Osmoderma eremita, living in tree hollows. Oecologia 126(3):363-370.

Schaffrath U. 2003. Zu Lebensweise, Verbreitung und Gefährdung von Osmoderma eremita. Kassel University, Kassel.