FIRST RESULTS OF RADIO-TRACKING OF *OSMODERMA EREMITA* (COLEOPTERA: CETONIIDAE) IN FRENCH CHESTNUT ORCHARDS

G. Dubois[1] & V. Vignon[2]

Résumé. — *Premiers résultats de radio-pistage d'*Osmodera eremita (Coleoptera: Cetoniidae) *dans les châtaigneraies françaises*. — Le Pique-prune *Osmodera eremita (Coleoptera, Cetoniidae)* est une espèce menacée et emblématique des communautés saproxyliques. Un programme de suivi est mis en œuvre depuis dix ans en France (département de la Sarthe) pour obtenir une meilleure connaissance des enjeux locaux de la conservation de cette espèce protégée. Le suivi s'appuie sur des méthodes de capture-marquage-recapture et de radio-pistage afin d'analyser le taux d'occupation des arbres creux, la taille des populations et le comportement de dispersion des adultes. Nous présentons en particulier les données recueillies durant la première saison de radio-pistage de ce programme. Aucune dispersion n'a été observée par la méthode de capture-marquage-recapture mais celle-ci n'a concerné que les adultes qui n'émergeaient qu'en petit nombre (un à sept par arbre). Le radio-pistage a permis l'observation des déplacements d'un individu. L'étendue de ces derniers s'est élevée à presque 700 m. Une telle distance qui n'avait encore jamais été observée peut conduire à une nouvelle vision des capacités de dispersion d'*O. eremita*. De plus, cette observation nous amène à de premières considérations sur la gestion des châtaigneraies, un habitat clé pour la conservation d'*O. eremita* dans le département de la Sarthe (France). En particulier, nous soulignons l'effet potentiellement positif du maintien d'arbres produisant des drupes et l'effet potentiellement négatif des taillis sur l'efficacité des déplacements individuels.

Mots-Clés: Pique-prune, saproxylique, conservation, capture-recapture, marquage, dispersion.

Summary. — The Hermit beetle, *Osmoderma eremita* (Coleoptera: Cetoniidae) is an emblematic and endangered species of the saproxylic communities. A monitoring programme was planned for ten years in France (Sarthe department) to gain a best understanding of the local conservation stakes of this protected species. The monitoring includes capture – mark – recapture and radio-tracking methods to analyse the occupancy rate of hollow trees, the size of the populations and the dispersal behaviour of the adults. We present in particular the data collected during the first season of radio-tracking of this programme. No dispersal was observed with capture – mark – recapture but this method brought out the adults emerged in small numbers (one to seven adults per tree). Radio-tracking enabled the observation of the movements of one individual. The range of these movements reached almost 700 m. Such a distance had never been observed and could lead to new insights about the dispersal abilities of *O. eremita.* Furthermore, this observation led us to first considerations regarding the management of chesnut orchards, a key habitat for conservation of *O. eremita* in Sarthe department (France). Particularly, we emphasized the potential positive effect of keeping trees producing drupes and the potential negative effect of coppices on the efficiency of individual movements.

Keywords: Hermit beetle, saproxylic, conservation, capture, mark-recapture, dispersal.

---

[1] UMR 6553, Université de Rennes 1, CNRS, Station Biologique de Paimpont. F-35380 Paimpont. E–mail: glenn.dubois@univ-rennes1.fr

[2] OGE – Office de Génie Ecologique, 5 Boulevard de Créteil. F-94100 Saint-Maur-des-Fossés. E–mail: v.vignon@oge.fr

Rev. Écol. (Terre Vie), vol. 63, 2008.

Many insects living in decaying wood or in senescent trees (saproxylic insects) are likely to be threatened by fragmentation of their habitat. It is particularly true for species living in habitats with a low temporal variability and a high spatial variability, such as tree cavities. These species would have low dispersal rates and a low likelihood to establish new remote populations as a result (Hedin *et al.*, 2008).

The microhabitat of the Hermit beetle, *Osmoderma eremita* (Coleoptera: Cetoniidae) has a low temporal variability and a high spatial variability (Hedin *et al.*, 2008). *O. eremita* is a threatened species because of its ecological requirement (Fontaine *et al.*, 2007). It still exists in the agricultural landscapes of north-western France (Ranius *et al.*, 2005). *O. eremita* could be considered as an umbrella species of the communities that live in old hollow trees (Ranius, 2002), as a result of which it has benefited since several years from an increasing interest within the frame of theoretical (Ranius, 2007; Hedin *et al.*, 2008) and applied conservation studies (Antonsson, 2002; Blandin *et al.*, 1999; Stegner, 2004; Vignon & Orabi, 2003). The dispersal rate and range of *O. eremita* are key characteristics that have to be known for a good understanding of its conservation stakes. In a Swedish study on the dispersal rate of *O. eremita*, a computer simulation model suggested that 15% of the *O. eremita* adults moved to other trees during their life-time (Ranius & Hedin, 2001). The dispersal range has been observed over a maximal distance of 190 m (Hedin *et al.,* 2008) and has been expected to reach about one or two kilometres (Blandin *et al.,* 1999; Schaffrath, 2003; Ranius, 2006). Based on these dispersal rate and range and on asynchrony characteristics, the organization of neighbouring populations of *O. eremita* corresponds to the organization of a metapopulation (Ranius & Hedin, 2001), with each tree regarded as a habitat patch that hosts local and partly independent populations (Ranius, 2001).

We present here the main results of the first season of radio-tracking of a research programme on *O. eremita*. Some complementary information about capture – mark – recapture is also provided. This programme is led whithin the framework of the mitigation measures of the French A28 motorway impact. It is aimed to gain a better understanding of the conservation stakes of *O. eremita* in the chestnut orchards of the Sarthe department (France), especially by analysing the occupancy rate of hollow trees, the size of the populations, the movement behaviour of the adults and their dispersal.

MATERIAL AND METHODS

Study species

O. eremita is a strict specialist of tree cavities (mainly of deciduous trees) filled with a large amount of wood-mould (Ranius & Nilsson, 1997). *O. eremita* larvae develop in the loose material of dead wood in the tree cavities. After two to three years of larval development in the same cavity, adult beetles emerge the year following the pupation (Ranius *et al.*, 2005). The adults occur mainly in the tree hollows and have a life-time of about one month (Ranius, 2007), between the end of June and the beginning of September in north-western France (Tauzin, 2005).

Study area

The field study took place in Lavernat (department of Sarthe, northwestern France), in one of the largest area where *O. eremita* occurs in France (Vignon, 2005) and in western Europe (Ranius *et al.,* 2005). This area seems to be characterized by a spatio-temporal continuity of landscape structures harbouring senescent trees; that would be a reason of the actual presence of *O. eremita* there (Vignon & Orabi, 2003; Vignon *et al.*, 2005). An original habitat for the species in the study area is composed of grafted chesnut orchards. These orchards are ancient plantations that were traditionally set aside for human consumption in countrysides and can be seen as a substitution habitat for *O. eremita* (Vignon, 2005) in the sense that the species can find there conditions as accurate as those existing in its primeval habitats. Each orchard contained 10 to 60 trees and several orchards were sometimes put side by side. The ground of the orchards was usually kept open by grazing practice. Scattered chestnut trees could also occur on the edges of woods, in the fields or near to the farms. The planting and grafting of chestnut trees was disused at the end of the 19^{th} century and the picking of the fruits was abandoned almost in the 1920's. Many chestnut orchards have been cut down and occasionally converted in coppice for stake or firewood production. However, many isolated trees or orchards have been preserved until today. These 100- to 200-year-old trees generally bear cavities that are suitable for the development of *O. eremita* (Blandin *et al.,* 1999). Chestnut trees were located in Sarthe during previous studies by means of flight over followed by precise localisation with Global Positioning System on the field in a 8,500 ha area.

CAPTURE – MARK - RECAPTURE

We used a four metres long ladder to reach the cavities where the presence of *O. eremita* populations was certain or conceivable. The cavities located at a height from four to ten meters were reached by a tree climbing specialist. To facilitate the capture of individuals, pitfall traps were put in tree cavities. The traps were visited at least every two days and most frequently once a day. Some individuals could be found directly on wood-mould surface or at the entry of cavity. To be recognized at recapture, the individuals were marked by microperforations made in elytra with a thin drill (500 µm in diameter). A combination of a maximum of six perforations allowed the individualization. Fifty-seven hollow chestnut trees were trapped between 3 July and 27 August 2005. The traps were visited five days per week and one time per day. Fifteen trapped trees were host trees of *O. eremita* and the 42 other trees were bearing suitable cavities for the species, but in which the presence had not been proved.

RADIO-TRACKING

Capture – mark – recapture method does not enable to accumulate precise data on the individual movements. Radio-tracking with telemetry is a more accurate method we used during the same period as capture – mark – recapture. This method was first used with the species in Sweden (Hedin & Ranius, 2002) and was only used on two other species of flying beetles, the dynastid *Scapanes australis* (Coleoptera: Dynastidae) (Beaudoin-Ollivier *et al.,* 2003) and the lucanid *Lucanus cervus* (Coleoptera: Lucanidae) (Sprecher-Uebersax & Durrer, 2001; Rink & Sinsch, 2007). We used the same equipment as for the Swedish study on *O. eremita* (Hedin & Ranius, 2002) (for the transmitters, see: HOLOHIL Systems Ltd., model LB-2, Ont., Canada, http://www.holohil.com; for the hand-held radio receiver, see: Televilt AB, model RX-900, Sweden, http://www.positioning.televilt.se) so that comparisons could be done between results of the two regions. The technique was particularly suitable owing to the long-wave signal that enabled to follow precisely individuals equipped with radio-transmitters where dense vegetation (such as coppice) predominates (Hedin & Ranius, 2002). We measured the length of the movements as Euclidian distances between each point of observation of the individuals.

BODY SIZE MEASUREMENT AND MASS MONITORING

Only the largest and heaviest individuals were equipped with transmitters so that the equipment mass (mean = 0.41g, SD = 0.03g, n = 5) did not exceed 30% of the individual mass, as in Swedish experiments (Hedin & Ranius, 2002). The total body length and the maximal pronotum width were measured in the field with a calliper rule. The total body length was measured roughly (precision of 1 mm) because of the lack of precision caused by the elasticity of the intersegmental teguments. The pronotum width was measured with a precision of 0.05 mm. Individuals were weighed at each capture and recapture with a portable electronic balance (precision of 10 mg).

RESULTS

The fifty-seven trapped hollow chestnut trees were inspected 1796 times in total between 3 July and 27 August 2005. No movement was observed with capture – mark - recapture i.e. either the beetles stayed in the cavity, either they escaped without further recapture. We caught 17 individuals (7 females and 10 males) during the same period. The total body length, the maximal pronotum width and the live weight at the first capture were significantly highest for the males (Tab. I).

TABLE I

Body size measurement and live weight (Mean ± SD) at first capture of the individuals of O. eremita caught in the study area in 2005. All the differences between males and females are significant (P < 0.05, unilateral Mann and Whitney U test)

	Males (n = 10)	Females (n = 7)
Total body length (mm)	30.40 ± 1.50	29.15 ± 1.15
Maximal pronotum width (mm)	11.20 ± 0.70	9.15 ± 0.45
Live weight at first capture (g)	2.06 ± 0.54	1.70 ± 0.19

The individuals were captured in seven chestnut trees (one to seven adults per tree). Five of the individuals (two females and three males) were suitable for the equipment with radio-transmitters. The weight of the two females was 1.70 g and 1.86 g at the first capture, and 2.30 g, 2.59 g and 2.84 g for the three males. The equipment load averaged 15-25% of the individual mass at the beginning of the radio-tracking.

We followed one displacement (Fig. 1) with a radio-transmitter equipped female. The four other equipped individuals stayed in their cavities. We found the female in the humus (B, Fig. 1) at the first time we tracked it, three days after and at almost 120 m from the cavity where the first capture occurred (A, Fig. 1). The transmitter was set on 29 July 2005 at the time of the capture. The individual was monitored until its death that occurred after 18 days of tracking (E, Fig. 1).

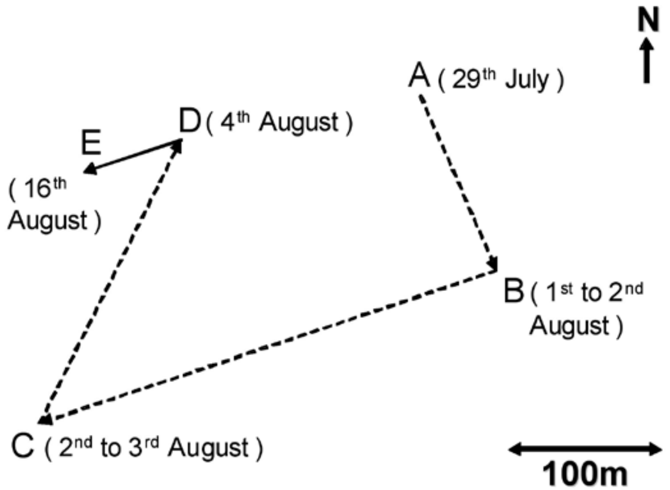

Figure 1. – Movements of the radio-transmitter equipped female between 29 July and 16 August 2005. Dotted lines represent flight movements and plain lines movements on the ground.

The distance covered by the female reached nearly 700 m. The Euclidian distance between the first and the last points of observation is 250 m (distance AE, Fig. 1). The first period of movement (from 29 July to 4 August 2005) was composed of three long distance flights (the first of 120 m (AB, Fig. 1), the second of 300 m (BC, Fig. 1) and the last one of 200 m (CD, Fig. 1)) that were separated by short periods on the ground that lasted up to one day as a maximum. Only the flight take-off of the 300 m flight was observed and we can not say if the two other flights (AB and CD, Fig. 1) really occurred in one step. The second period of movement (from 4 to 16 August 2005; DE, Fig. 1) was mainly composed of movements on the ground at a distance of almost 60 m. We never found again the individual in a tree cavity during the radio-tracking.

The female made one or several attempts of flight take-off each afternoon, when the air temperature was 20-22°C. It took shelter in humus or in tunnels of voles (*Clethrionomys glareolus*) from the end of the afternoon to the beginning of the morning. The attempts were seen only after the individual had climbed up a tree. The 300 m long flight was initiated at 13:00 after climbing up during 45 min to the top of a 20 m high chestnut tree. This flight probably occurred above the canopy of the chestnut orchard.

We observed a gain of weight of the individual (100 mg) that occurred in less than 24 h (between points C and D, Fig. 1). After we had seen the individual defecating for preparing a new attempt of flight take-off (point D, Fig. 1), its weight lost 100 mg and became the same as before the increase again. The individual weighed 1.86 g at the beginning of the tracking and 1.62 g at its death.

The female did not seem to have left the wooded area in spite of the fact that it ended up at least one time at the edge of the stand. During the last 12 days of its life, the female covered about 60 m (distance DE, Fig. 1) in a much closed chestnut tree coppice six metres high and with an impenetrable canopy. Its movements occurred then mainly on the ground. The attempts to climb the trees and to fly did not succeed and only one short flight of 8 m was observed 3 m above the ground. The smooth texture of the bark and the fine and dense structure of the branches prevented the individual from climbing and taking off flight respectively. The individual was finally found dead in a vole tunnel 15 cm down.

DISCUSSION

Long range movements

The displacement range of *O. eremita* reached nearly 700m in our study site, i.e. more than three times longer than the longest one measured in Sweden. However such a displacement cannot be considered as dispersal as defined by Ranius (2007) because we did not recapture the individual in a cavity until its death. Only dispersal movements were described in Sweden (Ranius 2007) and no displacement not ending in a suitable cavity such as in our observation. This new record confirms prior assumptions about displacement abilities of *O. eremita* (Blandin *et al.*, 1999; Schaffrath, 2003) and is of similar magnitude as observations made on other radio-tracked saproxylic beetles (Beaudoin-Ollivier *et al.,* 2003; Sprecher-Uebersax & Durrer, 2001; Rink & Sinsch, 2007).

In Sweden, a negative exponential function has been used to describe the distribution of the proportion of dispersing *O. eremita* individuals in function of the dispersal ranges exceeding certain distances. With this dispersal function, it could be predicted that 1.6% of the dispersing individuals move at distances longer than 250 m in this part of Europe. This way, in small stands of hollow trees with only some tens of beetles emerging every year, there would be about one beetle moving more than 250 m every 10 years (Ranius, 2006). Our observation could have been made very fortunately, or it could be a first evidence of a difference between populations from France and Sweden. One explanation of a difference of dispersal rate and range could be done by the density of hollow trees and by the size of the stands of hollow trees. But, in Sweden, the dispersal range does not seem to be much larger when the stands of hollow trees are small (Ranius, 2006).

The data collecting will continue during the next years of the programme in order to determine the frequency of such a long displacement range in Sarthe. For a better understanding of the field data collected in the Swedish and French studies, laboratory experimentation with flight-mills would be necessary to assess the potential flight abilities and physiological limits in the dispersal range of *O. eremita* (Ranius, 2006). Then, a study of the role of external factors, such as sunlight or volatiles from the nutritional resources, would help explain what factors influence the effective flight abilities in the field, within a potential nutritional displacement purpose, or a reproductive dispersal purpose.

Sink effect of coppices

Many chesnut groves have been converted to coppice. This practice causes the disappearance of tree cavities by cutting hollow trees and by preventing their growing and senescence. In addition, an unexpected effect could be that the coppice would constitute a trap for the dispersing individuals. Many factors seem to be important for *O. eremita* movements in a chestnut tree coppice. The climbing looks much more difficult on the smooth bark of the young (less than 20 cm in diameter) stems of chestnut trees than on the rough bark of older stems. In addition the closer space available under the coppice canopy seems to be unfavourable for the good course of the flight. Furthermore, it has been proved that the openness of a habitat can influence not only the dispersal but also the presence (perhaps sometimes as a result) of any species (Millán de la Peña *et al.,* 2003). In the case of *O. eremita* in Sweden, host trees have been mostly observed in open or semi-open habitats (Ranius & Nilsson, 1997).

Burdening of the transmitters

The transmitter could be seen as a huge burden that would slow down or stop the movements of the equipped individual. In the Swedish studies on *O. eremita*, the rate and range of dispersal movements observed with telemetry were of the same magnitude as those estimated in the concurrent capture – mark – recapture investigation, suggesting that if such effect exists, it is not large (Ranius & Hedin, 2001). Selection of larger individuals to carry transmitters may cause a bias if larger individuals disperse more or less than smaller individuals, but again, the capture – mark – recapture study provided no evidence for such a relation (Ranius & Hedin, 2001). The choice of a 30% threshold of the body mass for the load is supported by a study on the flight of radio-tagged Colorado potato beetle (*Leptinotarsa decemlineata*). This study seemed to prove that taking flight is not disrupted as long as the load does not exceed 30% of the body mass in the case of this species (Boiteau & Colpitts, 2001). With *O. eremita*, which is more voluminous than the Colorado potato beetle, this threshold could be expected to be at least of the same magnitude. A difficulty with the choice of individuals to be equipped is that the threshold of 30% risks to be crossed because of the likely weight loss of adults during starvation periods. Nevertheless, this threshold was never crossed with the individuals that we recaptured. The antenna of the LB-2 transmitter is flexible and a compromise between size and emission power can be found (Riecken & Raths, 1996). Complementary remarks may be proposed about the burdening of the transmitter. It could provoke a change of the flight pattern by raising the centre of gravity of the individual. We also observed several times the equipped female blocked by thin twigs or by the serrate edge of chestnut tree leaves when it was walking on the ground or climbing trunks. This braking could shorten the movement performances especially if no nutritional resources are present in the habitat.

Nutritional resources for adults

The unexpected gain of weight of the moving individual may be explained by the crossing of a small area (almost 100 m^2) of the undergrowth (point C, Fig. 1) where the ground was scattered with hundreds of fermented wild cherries (*Prunus avium*) representing a potential source of food. Fruit chafer beetles are very sensitive and selective for fruit-emitted volatiles (Stensmyr *et al.,* 2001) and *O. eremita* could be expected to have such abilities. We did not see the individual feeding but the defecation behaviour we observed before a take-off has been described (Schaffrath, 2003) and could corroborate this hypotheses. But this behaviour could be only an ejection of meconium that can happen without previous ingestion (Schaffrath, 2003). Up to now, only one female of *O. eremita* has been observed feeding on a ripe yellow plum (Ranius *et al.,* 2005). Feeding with fruits is expected to extend the life span of adult *O. eremita* (Tauzin, 1994). Thus, a longer life span should allow greater displacement range and this assumption could explain partially our peculiar observation. Management of fruit trees with summer ripening fructification, like *Prunus avium* would be an important aspect for the species conservation.

The first precise description of the displacement behaviour of an individual *O. eremita* outside cavities has been brought. We have now to collect more data in order to precise the frequency of such a long displacement range. Such information will help to get a more accurate estimation of metapopulation viability. In a landscape ecological context, one of the main issues of such a study is to put forward management priorities of the spatial layout of suitable hollow trees for the conservation of *O. eremita*.

ACKNOWLEDGEMENTS

The company COFIROUTE ensured the financial support of the study. We thank the team of the research consultancy OGE which invested in the inventories in the field, especially C. Le Châtreux, C. Doaré and O. Martin. We also thank J. Hedin, P. Le Gouar, T. Ranius and P. Vernon for their very helpful advice. We are thankful to an anonymous reviewer for comments that improved the text.

REFERENCES

ANTONSSON, K. (2002). — *The Hermit Beetle (*Osmoderma eremita*) – Ecology and habitat management.* Swedish Environmental Protection Agency. Stockholm, Sweden.

BEAUDOIN-OLLIVIER, L., BONACCORSO, F., ALOYSIUS, M. & KASIKI, M. (2003). — Flight movement of *Scapanes australis australis* (Boisduval) (Coleoptera: Scarabaeidae: Dynastinae) in Papua New Guinea: a radiotelemetry study. *Aust. J. Entomol.,* 42: 367-372.

BLANDIN, P., LUCE, J.-M. & VIGNON, V. (1999). — *L'impact de l'autoroute A28 sur les populations sarthoises de trois espèces de coléoptères protégées au titre de la Directive «Habitats» (*Osmoderma eremita*,* Lucanus cervus *et* Cerambyx cerdo*). Diagnostic et préconisations, Rapport final.* Muséum National d'Histoire Naturelle pour COFIROUTE.

BOITEAU, G. & COLPITTS, B. (2001). — Electronic tags for the tracking of insects in flight: effect of weight on flight performance of adult Colorado potato beetles. *Entomol. Exp. Appl.,* 100: 187-193.

FONTAINE, B., BOUCHET, P., VAN ACHTERBERG, K., ALONSO-ZARAZAGA, M.A., ARAUJO, R., ASCHE, M., ASPOCK, U., AUDISIO, P., AUKEMA, B., BAILLY, N., BALSAMO, M., BANK, R.A., BARNARD, P., BELFIORE, C., BOGDANOWICZ, W., BONGERS, T., BOXSHALL, G., BURCKHARD, D., CAMICAS, J.-L., CHYLARECKI, P., CRUCITTI, P., DEHARVENG, L., DUBOIS, A., EENGHOFF, H., FAUBEL, A., FOCHETTI, R., GARGOMINY, O., GIBSON, D., GIBSON, R., GOMEZ LOPEZ, M.S., GOUJET, D., HARVEY, M.S., HELLER, K.-G., VAN HELSDINGEN, P., HOCH, H., DE JONG, H., DE JONG, Y., KARSHOLT, O., LOS, W., LUNDQVIST, L., MAGOWSKI, W., MANCONI, R., MARTENS, J., MASSARD, J.A., MASSARD-GEIMER, G., MCINNES, S.J., MENDES, L.F., MEY, E., MICHELSEN, V., MINELLI, A., NIELSEN, C., NIETO NAFRIA, J.M., VAN NIEUKERKEN, E.J., NOYES, J., PAPE, T., POHL, H., DE PRINS, W., RAMOS, M., RICCI, C., ROSELAAR, C., ROTA, E., SCHMIDT-RHAESA, A., SEGERS, H., STRASSEN, R.Z., SZEPTYCKI, A., THIBAUD, J.-M., THOMAS, A., TIMM, T., VAN TOL, J., VERVOORT, W., & WILLMANN, R. (2007). — The European union's 2010 target: Putting rare species in focus. *Biol. Cons.*, 139: 167-185.

HEDIN, J. & RANIUS, T. (2002). — Using radio telemetry to study dispersal of the beetle *Osmoderma eremita*, an inhabitant of tree hollows. *Comput. Electron. Agr.,* 35: 171-180.

HEDIN, J., RANIUS, T., NILSSON, S.G., & SMITH, H.G. (2008). — Restricted dispersal in a flying beetle assessed by telemetry. *Biodiv. Cons.*, in press.

MILLÁN DE LA PEÑA, N., BUTET, A., DELETTRE, Y., MORANT, P. & BUREL, F. (2003). — Landscape context and carabid beetles (Coleoptera: Carabidae) communities of hedgerows in western France. *Agr. Ecosyst. Envir.,* 94: 59-72.

RANIUS, T. (2001). — Constancy and asynchrony of *Osmoderma eremita* populations in tree hollows. *Oecologia,* 126: 208-215.

RANIUS, T. (2002). — *Osmoderma eremita* as an indicator of species richness of beetles in tree hollows. *Biodiv. Cons.,* 11: 931-941.

RANIUS, T. (2006). — Measuring the dispersal of saproxylic insects: a key characteristic for their conservation. *Popul. Ecol.,* 48: 177-188.

RANIUS, T. (2007). — Extinction risks in metapopulations of a beetle inhabiting hollow trees predicted from time series. *Ecography,* 30: 716-726.

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., RUICANESCU, A., STEGNER, J., SÜDA, I., SZWALKO, P., TAMUTIS, V., TELNOV, D., TSINKEVICH, V., VERSTEIRT, V., VIGNON, V., VÖGELI, M. & ZACH, P. (2005). — *Osmoderma eremita* (Coleoptera, Scarabaeidae, Cetoniinae) in Europe. *Anim. Biodiv. Cons.,* 28: 1-44.

RANIUS, T. & HEDIN, J. (2001). — The dispersal rate of a beetle, *Osmoderma eremita*, living in tree hollows. *Oecologia,* 126: 363-370.

RANIUS, T. & NILSSON, S.G. (1997). — Habitat of *Osmoderma eremita* Scop. (Coleoptera: Scarabaeidae), a beetle living in hollow trees. *J. Insect Cons.*, 1: 193–204.

RIECKEN, U. & RATHS, U. (1996). — Use of radio telemetry for studying dispersal and habitat use of *Carabus coriaceus* L. *Ann. Zool. Fennici,* 33: 109-106.

RINK, M. & SINSCH, U. (2007). — Radio-telemetric monitoring of dispersing stag beetles: implications for conservation. *J. Zool.,* 272: 235-243.

SCHAFFRATH, U. (2003). — Zur Lebensweise, Verbreitung und Gefärdung von *Osmoderma eremita* (Scopoli, 1763) (Coleoptera; Scarabaeoidea, Cetoniidae, Trichiinae), Teil 1. *Philippia,* 10: 157-248.

SPRECHER-UEBERSAX, E. & DURRER, H. (2001). — Verhaltensstudien beim Hirschkäfer mittels Telemetrie und Videoaufzeichnungen (Coleoptera, *Lucanus cervus* L.). *Mitt. Naturforsch. Gesellsch. Basel,* 5: 161-182.

STEGNER, J. (2004). — Bewertungsschema für den Erhaltungszustand von Populationen des Eremiten (*Osmoderma eremita*). *Naturschutz und Landschaftsplanung,* 36: 270-276.

STENSMYR, M., LARSSON, M., BICE, S. & HANSSON, B. (2001). — Detection of fruit- and flower-emitted volatiles by olfactory receptor neurons in the polyphagous fruit chafer *Pachnoda marginata* (Coleoptera: Cetoniinae). *J. Comp. Physiol. A,* 187: 509-519.

TAUZIN, P. (1994). — Le genre *Osmoderma* Le Peletier et Audinet Serville, 1828 (Col. *Cetoniidae*, *Trichiinae*, *Osmodermatini*). Systématique, Biologie et Distribution (Deuxième Partie). *L'Entomologiste*, 50: 217-242.

TAUZIN, P. (2005). — Ethology and distribution of the "Hermit beetle" in France (Coleoptera, Cetoniidae, Trichiinae, Osmodermatini). *Cetoniimania,* 4: 131-153.

VIGNON, V. (2005). — Le rôle des habitats de substitution (bocage, parcs, arbres d'alignement) pour la survie des espèces cavicoles et saproxyliques – Implications et synergie avec la conservation en milieu forestier. Pp 293-300 *In:* D. Vallauri, J. André, B. Dodelin, R. Eymard-Machet & D. Rambaud (eds), *Bois mort et à cavités: une clé pour des forêts vivantes.* Lavoisier Tec et Doc, Paris.

VIGNON, V. & ORABI, P. (2003). — Exploring the hedgerows network in the west of France for the conservation of saproxylic beetles (*Osmoderma eremita, Gnorimus variabilis, Lucanus cervus, Cerambyx cerdo*). Pp 36-38 *In*: C.P. Bowen (ed.), *Proceedings of the second pan–European conference on saproxylic beetles, Royal Holloway, University of London, 25th–27th June 2002.* London: People's Trust for Endangered Species.

VIGNON, V., ASMODÉ, J.-F. & RAPAPORT, P. (2005). — Heterogeneity of the spatial distribution of *Osmoderma eremita* (Scopoli) populations in a hedgerow network (France, Normandy). Pp 109-115 *In*: M.V.L. Barclay & D. Telnov (eds), *Proceedings of the 3rd symposium and workshop on the conservation of saproxylic beetles, Riga / Latvia, 07th-11th July 2004.* Latvijas entomologs, Supplementum VI.