The Forestry Authority
Forestry Commission

# Research Information Note 224

**Issued by the Research Division of the Forestry Authority**

**This Note supersedes RIN 124**

## *RHIZOPHAGUS GRANDIS* AS A MEANS OF BIOLOGICAL CONTROL AGAINST *DENDROCTONUS MICANS* IN BRITAIN by N.J Fielding

**Abstract**

The predatory beetle *Rhizophagus grandis* Gyll. was introduced into Britain in 1983 as a potential biological control agent against the newly discovered spruce bark beetle *Dendroctonus micans* (Kug.). An artificial breeding and mass release programme began in 1984 and continues to the present day. Details of this programme are described along with recent information on the behaviour and biology of *R.grandis* in the field. The introduction of *R.grandis* appears to have been successful, and the predator has now become established as a breeding species in Britain.

### Background

1. Experience in Belgium and Russia has shown that the specific predator *R.grandis* is effective in reducing damaging levels of *D.micans*. *R.grandis* adults were obtained for trial in Britain from a source in Belgium in mid-1983. Following trials in 1984, mass breeding and field introduction of the predator was adopted by the Forestry Commission as part of its control strategy.

### The mass breeding programme

2. Breeding units with controlled environments were set up at Ludlow, Shropshire. Breeding of *R.grandis* was at 20°C and relative humidity of 65-70% in order to accelerate development and to maintain moisture in the spruce logs. Initially, the breeding method closely followed the natural process. *D.micans* larval broods were established in fresh spruce logs, after which a pair of *R.grandis* adults were introduced to breed amongst their natural prey. During 1986 a 'box' breeding method that did not rely on spruce logs was introduced. This has reduced disease problems and has substantially reduced requirements for both staff and other resources.

### The release programme

3. In 1984, the number of *R.grandis* released per site was based on the number of trees showing symptoms of attack:

   sites with more than 100 infested trees received 50 pairs

   sites with 50-99 infested trees received 25 pairs

   sites with 5-49 infested trees received 15 pairs

   sites with 1-4 infested trees received 10 pairs.

   These low density releases were intended to cover as many sites as possible. Release numbers were based upon conservative estimates of the number of *R.grandis* to be produced in the first year of mass-rearing.

4. Yields of adult *R.grandis* during 1984 proved to be nearly double the expected figure of 20 000 beetles. As a result the release criteria for 1985 and 1986 was altered. Each site received three predators for each infested tree recorded. No distinction was made between Forestry Commission and privately owned woodlands. Mass breeding continued for three years, until all *D.micans* infested forest blocks identified in surveys had received treatment.

5. The predator rearing programme continues to the present. Releases are now concentrated on new outbreaks found around the edge of the known *D.micans* infested area. This area is surveyed annually and so monitors any outward movement of *D.micans*. Releases also take place in any new locations found to contain the spruce bark beetle, within the infested area. Releases since 1986 have consisted of 100 *R.grandis* per infested site. Releases are summarised in Table 1.

**Table 1. Numbers of *Rhizophagus grandis* released in Britain, 1984 to 1991**

| Year | Number of *R.grandis* released | Number of sites treated |
|---|---|---|
| 1984 | 31 072 | 950 |
| 1985 | 39 392 | 661 |
| 1986 | 17 438 | 527 |
| 1987 | 10 700 | 83 |
| 1988 | 7 875 | 74 |
| 1989 | 6 600 | 66 |
| 1990 | 8 100 | 80 |
| 1991 | 10 600 | 106 |
| TOTALS | 131 777 | 2547 |

**Release methods**

6. During 1984, each release contained equal numbers of males and females, one pair being released at the base of each infested tree. Following the result of an experiment in 1984 to investigate the effects of a mass release of *R.grandis* adults from a single point within an infested plantation, the release procedure was modified. This showed that *R.grandis* adults are capable of searching an area and locating even low densities of their prey. Furthermore, breeding data showed a natural sex ratio of 1:1, thus removing the need for careful sexing of insects prior to release. All introductions since 1985 have, therefore, been made *en masse* within infested spruce stands.

7. Predator releases have taken place between April and October each year during favourable weather conditions, avoiding rain, high winds and low temperatures. Experiments undertaken during 1987 and 1988 showed that offspring from *R.grandis* adults that lay eggs between April and July, will develop into adults before the end of the year. This 4-month period is now considered the best time for predator releases.

**Establishment of the predator**

8. In 1985, one year after the first releases of *R.grandis,* 47 sites were sampled to see if predators could be recovered. *R.grandis* were recovered in various stages of development at 47% of the sites, thus confirming their establishment under British forest conditions. Carefully conducted random samples were taken at three sites in 1986. These showed that 34% of the available *D.micans* broods were attacked by the predator. By 1987 this figure had doubled to 68%, and by 1988 (at one site) 80% of prey broods were attacked. It is now rare to find a site infested with *D.micans* that does not contain *R.grandis*.

**Predatory behaviour and biology of *R.grandis***

9. Adult *R.grandis* are highly effective at locating their prey, sensing the chemical signals emitted from *D.micans* broods systems. Once under the bark *R.grandis* adults feed on *D.micans* eggs if no larval prey are present. If *D.micans* larvae are available, the predators will mate and lay their eggs amongst them. As the *R.grandis* eggs hatch, the parent beetles wound *D.micans* larvae to assist their progeny in their initial feeding. The predatory larvae aggregate upon their victim, mining into and totally consuming the soft body tissues, leaving only the husk of the *D.micans* larva. As they grow through their three larval moults (instars) they can attack and consume prey directly. When fully fed, *R.grandis* larvae enter a prepupal stage and leave the *D.micans* brood, dropping from the tree to enter the soil below the trees. Here they pupate and become adults which eventually emerge to begin a fresh breeding cycle.

10. Information gained on the life cycle timings and behaviour of the larval, prepupal and adult stages of *R.grandis* demonstrates that this species has an excellent survival strategy. The insect has the ability to survive for long periods, both under bark and in the soil and is thus able to exploit effectively its specific host, most stages of which can be found at all times of the year.

**Dispersal of *R.grandis***

11. Adult dispersal of up to 200 m during the first year appears to be common in British and continental observations. Other observations show that the predator can locate and establish itself in new *D.micans* populations, with flight ranges of up to 9 km being recorded.

## Conclusion

12. *R.grandis* is now well established and widely distributed throughout the area of *D.micans* infested forests. The combination of the predator's long-range dispersal and effective host-finding can be expected to result in comprehensive distribution throughout *D.micans* infested forests in the future. The recorded infestation levels of 80% of individual *D.micans* broods in the study plots are encouraging. Forest managers can safely remove the worst affected *D.micans* infested trees during routine thinning and felling operations since it appears that *R.grandis* is capable of tolerating such activities and will survive and breed at very low prey population levels. *R.grandis* will continue to be released at newly discovered *D.micans* infested sites at the edge of the known infested area. This will hopefully stop these *D.micans* outbreaks becoming too serious.

13. Evidence is gradually accumulating to indicate that, in Britain, *R.grandis* has almost reached a level of predation sufficient to regulate *D.micans* populations at low endemic levels. This situation has been reported both from Belgium — where 80% of *D.micans* broods are colonised by the predator and damage by *D.micans* is considered unimportant — and from the Republic of Georgia, where artificial introductions of *R.grandis* are credited with limiting damage to forests of Oriental spruce.

## Further reading


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Issued by:
Technical Publications Officer
Forest Research Station
Alice Holt Lodge
Wrecclesham
Nr Farnham
Surrey
GU10 4LH

June 1992



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ISSN 0267 2375



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Phototypeset and Printed by: Forestry Commission, 231 Corstorphine Road, Edinburgh EH12 7AT