

環動昆

報 文

- 岩田隆太郎・青木 昌宏・野崎 隆徳・山口 睦子：ルリボシカミキリの生態，およびその屋内・都市近郊貯木場における発生（英文）…………… 83

短 報

- 今村 祐嗣・足立 昭男・藤井 義久：ヒラタキクイムシ食害材から検出されるアコースティック・エミッション（AE）について…………… 98

資 料

- 藤井 義久・築瀬 佳之・今村 祐嗣・奥村 正悟・岡 信治：AEモニタリングによる木造建物内のシロアリ食害の検出 — 土蔵内のヤマトシロアリ食害の検出事例 — …………… 101

解 説

- 齋藤 哲夫：21世紀にむけての応用昆虫学の展開…………… 106
夏原 由博：大阪府における都市化と鳥の多様性…………… 109

- 書 評 …………… 121
会 報 …………… 123

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Some Notes on the Biology of a Hardwood-log-boring Beetle,
Rosalia batesi HAROLD (Coleoptera: Cerambycidae), with
Special Reference to its Occurrences in a Building and a
Suburban Lumberyard¹⁾

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ルリボシカミキリの生態、およびその屋内・都市近郊貯木場における発生 岩田隆太郎・青木昌宏・野崎隆徳・山口睦子²⁾(日本大学生物資源科学部森林資源科学科)

栃木県矢板市栃木県民の森管理事務所に装飾用に設置されていたトチノキ大型丸太より、1986~'88年にルリボシカミキリ *Rosalia batesi* HAROLD 成虫が多数羽化脱出、また1990年代前半に東京都町田市大蔵町の貯木場においてケヤキ丸太に本種が発生するのが観察された。この他群馬県水上町、東京都桧原村等での観察例も加え、本種について次の諸点を明らかにした。幼虫は直径10cm以上の広葉樹丸太の木部をランダムに穿孔し、無樹皮状態でも産卵可能、かつ乾材状態でも幼虫発育が可能であった。推定される樹幹内空間分布も偏在するはずの材内の栄養に左右されずランダムで、幼虫消化管内のセルラーゼ・システムの完備が示唆された。成虫の昼間の活動性は発生のピーク時には気温に左右された。一連の交尾行動は、1回のマウント中に複数回の交接を含み、また雌成虫をめぐり雄成虫間で激しい闘争が行われるのが特徴で、この勝敗は体長におおむね依存していた。この他、成虫触角の計量的特徴や生活史の概略も論じた。

Rosalia batesi HAROLD is a well-known longhorn beetle species, a feature of early summer in Japan. In 1986 through 1988, a mass of adult beetles of this species emerged from huge logs of *Aesculus turbinata* BLUME that had been installed at Tochigi Prefectural Citizens' Park Management Office, Yaita, Central Japan, and also, in early 1990's, this species occurred on logs of *Zelkova serrata* MAKINO at a private lumberyard in Ôkura-cho, Machida, Tokyo Pref. Together with these and other occurrences at Minakami, Gunma Pref., and Hinohara, Tokyo Pref., we obtained the following

1) A part of this paper was presented at the 43rd Annual Meeting of the Kanto Branch of the Japanese Forestry Society (1991) and the Joint Meeting of the 54th Annual Meeting of the Entomological Society of Japan and the 38th Annual Meeting of the Japanese Society of Applied Entomology and Zoology (1994).

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findings : Larvae very randomly bore within the xylem of deciduous broad-leaved tree logs of more than 10 cm in diameter. Ovipositing beetles can lay eggs on barkless logs. Even if the log is placed indoors in dry conditions, larvae can develop there up to adult emergence. The presumed spatial distribution of larvae within the tree trunk is also random, being independent of nutrient localization within the wood, suggesting the larval digestive tract is fully equipped with a cellulase system. Daytime activity of adult beetles was dependent on temperature. Their mating behavior includes multiple copulae during a mounting posture, and is featured by aggressive fights between males for a female, where the larger-sized male usually beats the smaller. Also, biometrical feature of adult antennae and an outline of the life history is discussed.

Key Words : *Rosalia batesi* HAROLD, Cerambycidae, Drywood borer, Spatial distribution, Adult behavior, Life history

Introduction

Rosalia batesi HAROLD (Coleoptera : Cerambycidae) (Fig. 1) is a well-known splendid colored longhorn beetle, a feature of Japanese mountains in summer, distributed in low-montaneous to subalpine zones of Japan proper. It is a borer of many hardwood species, having a habit of ovipositing on and boring into lumberyard logs, standing dead trees, felled trunks, and outdoor-preserved firewood of many hardwood species, as has been reviewed by KOJIMA and NAKAMURA (1986). In spite of the adult beetle's splendid appearance, its detailed life history, biology, and manner of wood boring have not been documented except in Hayakawa and HORI's (1971) brief note.

In 1986 through 1988, a mass of adult beetles of this species were observed to emerge from huge logs of Japanese horse-chestnut (*Aesculus turbinata* BLUME) which had been installed at Tochigi Prefectural Citizens' Park Management Office, Yaita, Tochigi Pref., Central Japan, and this has been preliminarily documented by us

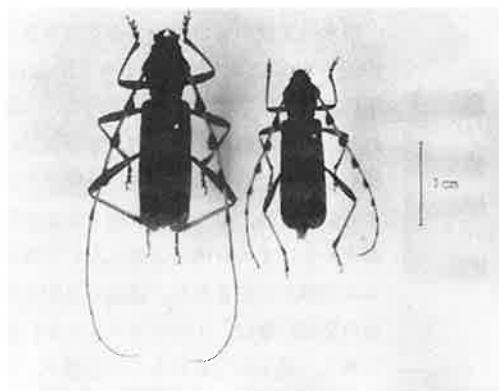


Fig. 1 Adults of *Rosalia batesi* HAROLD. Left, male ; right, female.

(AOKI *et al.*, 1992). In addition, in the early 1990's, a mass occurrence of this longhorn species on Japanese zelkova (*Zelkova serrata* MAKINO) logs was observed at a private lumberyard in Ôkura-chô, Machida, Tokyo Pref. (SHIBATA, 1997). These observations, as well as occurrences on standing dead hardwood trees, including SIEBOLD's beech (*Fagus crenata* BLUME), at Nihon University Training Forest at Minakami, Gunma Pref. and occurrences on some hardwood fuels preserved

beneath the eaves of houses at many places, including Hinohara, Tokyo Pref., led to accumulation of knowledge about the species biology. This is to report several aspects of the biology of *R. batesi*, including ecological and behavioral characteristics of larvae and adults. Morphological descriptions of the egg and the larva, using those obtained herewith, will appear elsewhere.

Materials and Methods

Sites of field study and animal capture for laboratory observation

1. At a deciduous broad-leaved forest of Minakami Training Forest ("Minakami Enshūrin") of Nihon University, Fujiwara, Minakami, Gunma Prefecture (a naturally grown secondary forest stand of *Quercus mongolica* var. *grosseserrata* (BL.) REHD. et WUB. and *Fagus crenata* BLUME) (alt. 850 m), female adult beetles of *R. batesi* were observed to oviposit on some dead trees of *F. crenata* in

July through August. We collected some *R. batesi* adult beetles and *F. crenata* logs infested by *R. batesi* larvae to supply them for the laboratory experiments and observation.

2. A mass occurrence of adult beetles of this species was observed within and on the building of The Tochigi Prefectural Citizens' Park Management Office ("Tochigi-ken Kenmin no Mori Kanri-Jimusho"), Nagai, Yaita, Tochigi Prefecture in 1986 through 1988 (AOKI *et al.*, 1992). They emerged from three huge barkless logs of Japanese horse-chestnut (*Aesculus turbinata* BLUME), all being 3 m long and about 90 cm in diameter. Two of them were used semi-outdoors as ornamental wood pieces at both sides of the entrance gate (Fig. 2), and another was used indoors also as an ornamental wood piece for a display corner on the ground floor, reaching the ceiling (Fig. 3). These logs had been felled at a national forest along Umasaka Forest Road, Yunishigawa, Kuriyama, Tochigi Pref. in Oct. 1980, preserved



Figs. 2-3 Barkless logs, about 90 cm in diameter, of Japanese horse-chestnut, *Aesculus turbinata*, installed at The Tochigi Prefectural Citizens' Park Management Office ("Tochigi-ken Kenmin no Mori Kanri-Jimusho"), Nagai, Yaita, Tochigi Prefecture (reproduced from AOKI *et al.*, 1992). 2, Two logs used semi-outdoors as ornamental wood pieces at both sides of the entrance gate (arrows); 3, one used indoors also as an ornamental wood piece for the display corner at the ground floor.

at a lumberyard along the forest road, and then carried into and installed at the building in Yaita in Oct.-Nov. 1981.

3. Since 1989, at a private lumberyard, about 2500 m² in area, adjacent to an elementary school, in Ôkura-chô, Machida, Tokyo Pref. (Fig. 4), a population of this species was observed to occur successively on half-decayed logs of Japanese zelkova (*Zelkova serrata* MAKINO), with their bark being wholly or mostly peeled off. The logs were about 3 m in length with an average diameter of about 70 cm, and numbered 27 in 1993, and they disappeared in 1994, when *R. batesi* adults were found no longer. This lumberyard (altitude about 40 m) is situated in the southern-most part of "Tama Kyûryô" (the low hill region west of Tokyo), where *Z. serrata* trees and small-scaled private lumberyards are not uncommon around it.



Fig. 4 The lumberyard in the western suburbs of Tokyo, Ôkura-chô, Machida, with *Zelkova serrata* logs infested by *R. batesi*.

4. The senior author (R. I.) has had some opportunities to encounter *R. batesi* adult beetles at some places in Honshu, including Senzu Lumberyard, Honkawane, Shizuoka Pref. (1976), Mt. Gomadan, Wakayama Pref. (1978), Kami-ogawa Lumberyard, Katashina, Gunma Pref. (1979 and 1984), Deai Lumberyard,

Sekimiya, Hyôgo Pref. (1984), Ko-yoshibe-zawa Lumberyard, Kawai, Iwate Pref. (1989), Kazuma-kami, Hinohara, Tokyo Pref. (1993), and some others. The specimens obtained in these occasions were supplied for biometry to give the body length range and biometrical differences between the sexes.

Boring pattern and distribution of larvae within logs

In Minakami a standing dead *F. crenata* tree, being infested and inhabited predominately by *R. batesi* larvae, with its DBH being 15 cm and the bark mostly peeled off, was harvested to cut into short logs in May and Nov. 1990, and they were brought into the laboratory (Fig. 5) to observe the adult beetle emergences from them and to check the boring manner and distribution of the larval gallery inside.

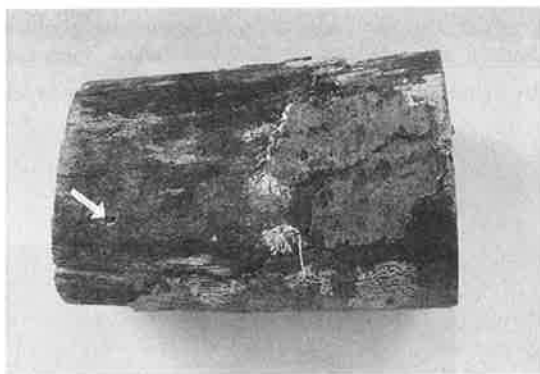


Fig. 5 *Fagus crenata* log, 14 cm in diameter, infested and inhabited predominately by *R. batesi* larvae (reproduced from AOKI *et al.*, 1992). An adult emergence hole is shown by arrow.

Also, trials were made at Yaita to measure the positions and sizes of adult emergence holes and pupal chambers made in the infested logs. The distribution pattern of insects within logs as seen in longitudinal and radial directions enabled us to speculate on the nutritional utility of space for the insects. For the longitudinal distribution pattern of the holes, Iwao's (1968)

analyzing method was used. The distribution in the tangential direction, as expressed by the distribution of emergence holes among compass directions, was not investigated because the logs were perpendicularly installed by half embedding in the building walls. We measured the size (δ), position (height above the floor ; h) and depth (down to the pupal chamber ; D) of each of the adult emergence holes, semi-elliptic in shape (Fig. 6). The *R. batesi* pupal chambers were observed in infested *F. crenata* wood from Minakami to angle down deep into the xylem either straightly or archwise. By inserting a piece of soft aluminum wire down to the bottom of the pupal chamber, its depth (D) was measured. The major (a) and minor (b) axes of each semi-elliptic hole were measured with alide calipers, and the size of its opening was calculated by the following equation, and was used as an index of the degree of development of the individual :

$$\delta = (\pi / 4) ab.$$

This is based upon some assumptions : the holes are nearly elliptic ; the hole opening is nearly equal to, or at least proportional to, the maximum area of cross section of the emerging adult beetle body, as it is in other cerambycid species (IWATA, unpublished) ; the cross section area of the emerging adult beetle body is proportional to the degree of development of each individual at the final stage of the larva. The correlation between D and δ , and that between h and D, were calculated as well.

Daily activity pattern of adults

In Okura-chō lumberyard, Machida, on 3, 9, 11, 14, and 21 July 1992, we did direct field observation on adult activity from 6:00 to 19:00 at one-hour intervals, with each bout lasting 10-15 min. The adults found there were categorized into 8, namely struggling, mounting, copulating, ovipositing, feeding, flying, walking, and resting. The number of individuals

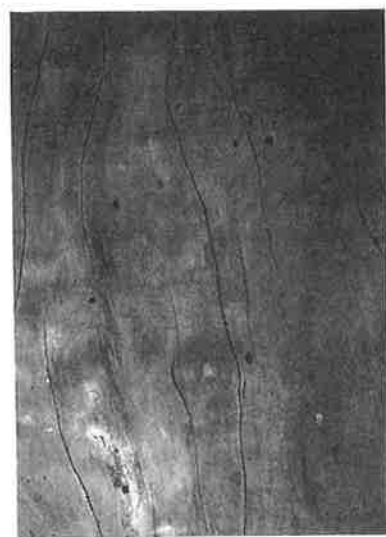


Fig. 6 Adult emergence holes of *R. batesi*, elliptic in shape, on a log of Japanese horse-chestnut, *Aesculus turbinata*, shown in Fig. 2 (reproduced from AOKI *et al.*, 1992).

showing each activity was counted by visually checking all the area of the lumberyard. Temperature at each observation time was recorded at a shaded spot about 1 m above the ground, and the moisture content of each log was roughly measured by pressing an automatic moisture content measurer against the cross-cut surface.

Also, at the same place, in 1993, when the population was reduced due to disappearance of most of the logs, a rough census was done: From 26 May to 29 July (18 times) all the adult beetles found in the lumberyard from 11:00 to 13:00 were counted, and the temperature at a shaded spot (1.2 m above the ground) was recorded at 13:00.

Adult biometry

All the available specimens that had been obtained from Honshu, Japan, were measured for body length, body thickness at the mesothorax, and antennal length to give the body length range and biometrical features of the species.

Mating behavior and struggle between males

1. In Minakami adult beetles were captured at the same place in July 1990 and July-August 1991 to supply them for the observation of mating and other adult behavior in the laboratory. Beside the general observations, we made 2 pairs (Pairs I and II) and each pair was released onto an empty petri dish, 9 cm in diameter, 6 cm high, to record the sequence of their mating behavior and the duration of each of the contacts and copulae at normal room temperature.

2. Adult beetles were also captured at Ôkura-chô lumberyard, Machida, on 9 July 1992 to supply them for the observation of mating and other adult behavior in the laboratory. A pair of adults was released into an empty plastic box (about 32 cm × 25 cm × 10 cm high) in two replications (Pair I: body length of 21 mm in ♂, 28 mm in ♀; Pair II: body length of 27 mm in ♂, 26 mm in ♀), while 2 males (32 mm, 18 mm) and one female (24 mm) were also grouped and released into an identical box to observe the pairing (Pair III). The sequences of their behavior were recorded as above for 120 min, with the room temperature being recorded as well.

Results and Discussion

Host plants

The following plant genera have been listed by KOJIMA and NAKAMURA (1986) as *R. batesi* host trees: *Salix*, *Juglans*, *Pterocarya*, *Betula*, *Carpinus*, *Fagus*, *Ulmus*, *Magnolia*, *Cercidiphyllum*, *Acer*, *Hovenia*, and *Styrax*. Here, in accordance with the above-stated direct observations of ours at Yaita and Machida, we add to them *Aesculus turbinata* and *Zelkova serrata*. *R. batesi* can thus be categorized as a "semi-omnivorous" cerambycid, but the host plant is limited to deciduous broad-leaved trees.

Larval boring and distribution within logs

The *R. batesi*-infested *Aesculus* logs in the building at Yaita were completely devoid of, and the *R. batesi*-infested *Fagus* logs from Minakami were partly devoid of, the bark, with the surfaces of cambium of both showing no larval gallery carvings or entrance holes at all. HAYAKAWA and HORI (1971) stated that young larvae of *R. batesi* bore underneath the bark of cuttings of *Juglans mandshurica* ssp. *sieboldiana*. However, if boring took place in the inner bark at a very early stage of the larva, the grown larva had to move from the inner bark to the xylem by consecutive boring, which led to formation of a hole or a carving on the cambial surface of the xylem. Also, female beetles are more often observed to oviposit directly on exposed xylem surface than on logs with intact bark. Despite HAYAKAWA and HORI's (1971) statement, newly hatched young larvae of *R. batesi* are thought to immediately enter into xylem in most cases.

In *R. batesi*-infested *Fagus* logs from Minakami, 14 cm in diameter, the larval boring galleries were rather concentrated to the center of the xylem, and most of the larval galleries ran very irregularly, and some longitudinally, as seen in consecutive cross sections (Fig. 7). This indicates that *R. batesi* larvae do not exclusively bore in the outer portion of xylem in logs, at least those with a small diameter.

Figure 8 shows the result of m-m analysis on the longitudinal distribution of adult emergence holes on the air-dried *Aesculus* logs perpendicularly installed in the building at Yaita, where each log represents one data set. The result is presented in two different quadrat sizes, showing different tendencies (IWA0, 1972): (a) 100 cm long cylinder (namely, each log divided into 3 quadrats); and (b) 10 cm long cylinder (namely, each log divided into 30 quadrats). The holes in each of the logs, as seen roughly (a), are distributed randomly ($\beta \approx 1$),

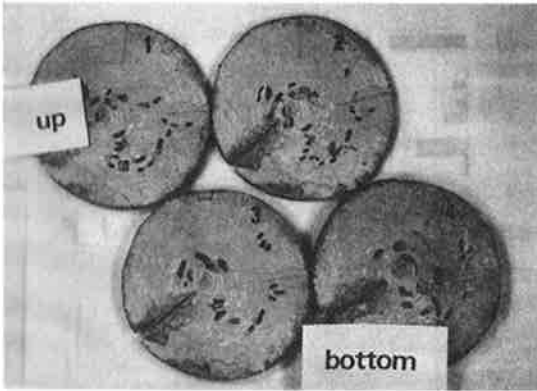


Fig. 7 Consecutive cross sections (Nos. 1-4) of a *R. batesi*-infested *Fagus crenata* log from Minakami, 14 cm in diameter, showing distribution of larval boring galleries (reproduced from AOKI *et al.*, 1992). Most of the galleries were exposed by removing the frass inside.

suggesting that each part of the log is homogeneous along its longitudinal axis in regard to *R. batesi* larvae's nutritional requirements. On the other hand, the holes, as seen precisely (b), are distributed in slight aggregation ($\beta > 1$), suggesting either that each log is heterogeneous along its longitudinal axis, or that the oviposition did not take place randomly

throughout the whole log.

The correlation between the pupal chamber depth (D) and the opening area of adult emergence hole (δ), and that between the former (D) and the hole position (h) are shown in Figs. 9 and 10, respectively. The depth was little correlated to the opening area and the hole position. These indicate that the position of the pupa in the radial direction, as supposed to reflect the larval position within the log, was not influenced by the degree of development at the final stage of the larva. One of the three logs at Yaita had a large cross-cut plane surface of a major branch, and some adult emergence holes were also seen on it, suggesting the larvae's indifference to wood tissue direction in constructing their pupal chambers.

In general, the nutrients in wood tissue are distributed quite unevenly as seen in cross section (MERRILL and COWLING, 1966), as well as the moisture in a dead tree trunk (TABLOKOFF, 1953). And yet, the larval development here seems quite independent of the unevenness of these factors within the wood tissue.

These observations of ours, that mature

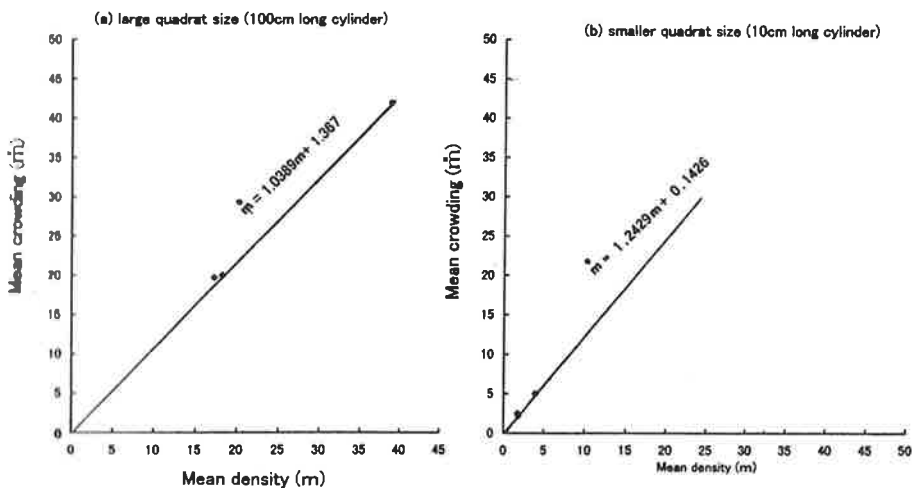


Fig. 8 The m-m analysis (IWAO, 1968) of adult emergence holes of *R. batesi* on three *Aesculus turbinata* logs, 3 m in length, at Yaita, with two different quadrat sizes.

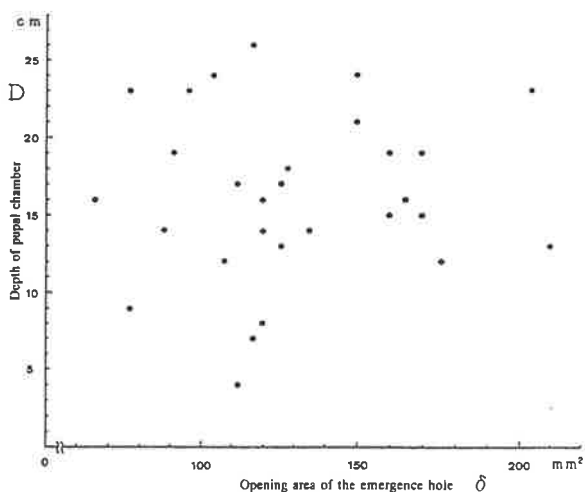


Fig. 9 The relationship between the opening area of the emergence hole (δ) and the depth of pupal chamber (D) of *R. batesi* in the logs at Yaita, showing little correlation between the two parameters ($r = 0.058$).

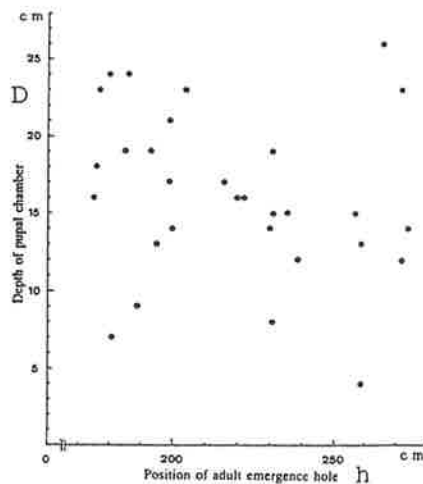


Fig. 10 The relationship between the position of adult emergence hole (height above the floor, h) and the pupal chamber depth (D) of *R. batesi* in the logs at Yaita, showing little correlation between the two parameters ($r = -0.198$).

larvae can survive in air-dried wood to some degree, that larvae do not bore along the cambium, the most nutritionally rich portion of tree trunk, and that a log is attacked homogeneously in terms of larval development both longitudinally and radially, but the central portion may be preferred for boring in a smaller log, together suggest that *R. batesi* larvae digest the wood substance using a complete set of cellulases, which are independent of wood-rotting fungi. This has been first suggested in *Hesperophanes campestris* (FALDERMANN) (Cerambycidae; Cerambycinae), a species with a durability in and a preference for drier wood (IWATA and YAMADA, 1990), but unlike *R. batesi*, *H. campestris* attacks only the outermost portion of sapwood. Meanwhile, a recent investigation on adults and larvae of *Psacothea hilaris* (PASCOE) (Cerambycidae; Lamiinae), a borer of living mulberry trees, has found that they have various endogenous carbohydrate-degrading enzymes including cellulases (SCRIVENER *et al.*, 1997). Since drywood

borers are expected to have more endogenous and fewer exogenous enzymes than living-tree-borers, this finding is also applicable to *R. batesi*.

It is worth noting again that the ability to survive within drywood is found only in the species of the subfamily Cerambycinae, to which this species belongs: most of the drywood-boring cerambycids belong to this subfamily (IWATA, 1997).

Daily and seasonal activities of adults

During our observation at Ôkura-chô, Machida, in 1992 summer, *R. batesi* adult beetles were found on *Zelkova* logs and on weed leaves around them, and the adult emergence holes were also found exclusively on half-decayed *Zelkova* logs.

Half-day observations on the daily activity pattern of adult beetles were done on 5 days, namely 3, 9, 11, 14, and 21 July 1992, at the lumberyard of Ôkura-chô, Machida. The results are presented in Fig. 11. In the morning a small number of beetles appeared, mostly

being motionless, until 9:00-10:00, when the temperature rose up to a point high enough to allow more beetles to appear and to be more active. The temperature was significantly positively correlated with both the number of all the adult beetles appearing and that of adult beetles

showing activity other than resting on 3 July ($\tau = 0.77$, $P < 0.001$ and $\tau = 0.81$, $P < 0.001$, respectively), on 9 July ($\tau = 0.55$, $P < 0.01$ and $\tau = 0.63$, $P < 0.01$, respectively) and on 11 July ($\tau = 0.47$, $P < 0.05$ and $\tau = 0.69$, $P < 0.001$, respectively), but on 14 and 21 July these

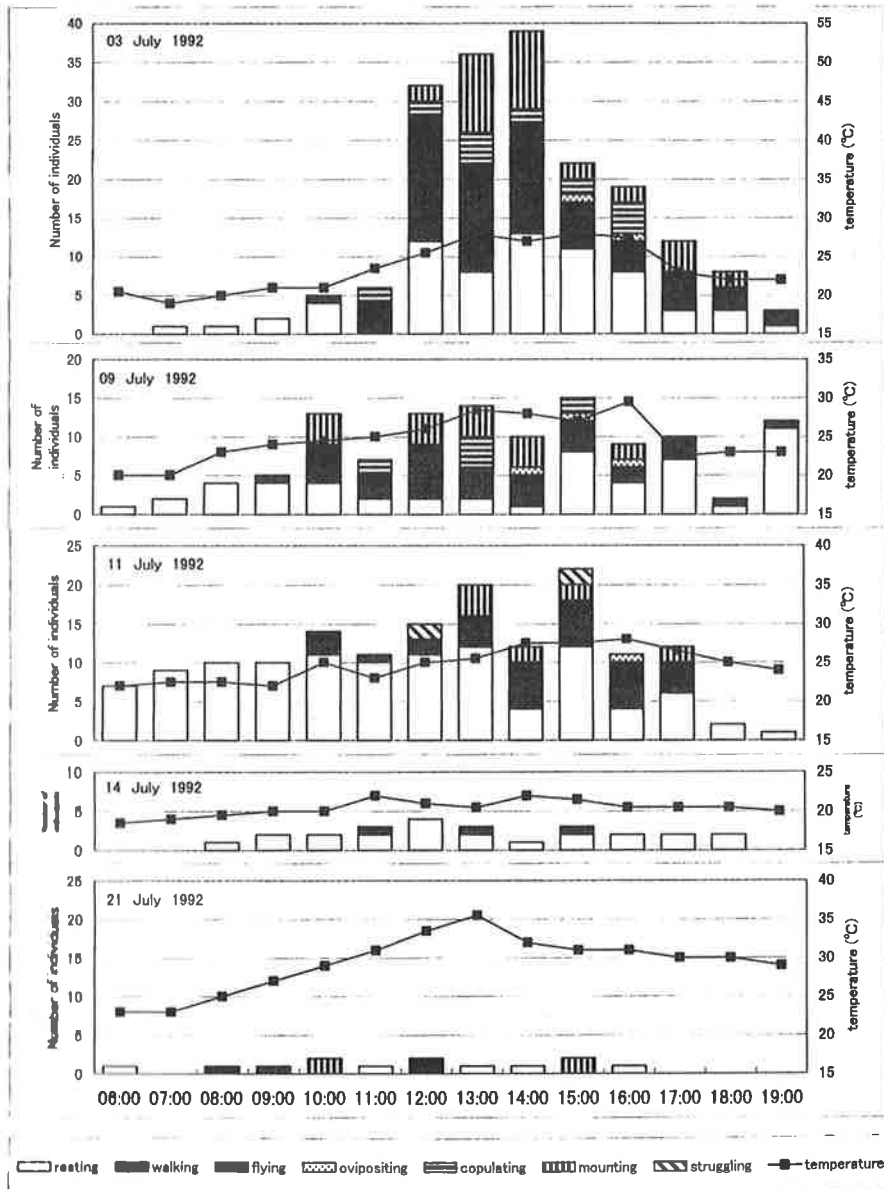


Fig. 11 Daily activity pattern of adult beetles of *R. batesi*, observed on 3, 9, 11, 14 and 21 July 1992, at the lumberyard in Ôkura-chô, Machida.

correlations became insignificant. Oviposition took place only when the temperature rose to the highest point of the day (13:00-16:00). Bad weather kept beetles from being active. The results for the last day with good weather (21 July) represents a situation in the end of the adult flight season. Although Fig. 11 may indicate the adult beetles of *R. batesi* are diurnal, as is the case with the other *Rosalia* species including *R. coelestis* SEMENOV-TJANSHANSKI (TSSHEREPANOV, 1981), the capture record of *R. batesi* adult beetles at a light in Machida (SHIBATA, 1997) claims further observation.

From 26 May to 29 July 1993, with a much smaller number of logs remaining in the lumberyard, a further census was done. Adult beetles were not found until 20 June and after 16 July. Two individuals were found on 24 June (24.0 °C; cloudy), five on 27 June (31.0 °C; fine), none on 30 June (21.0 °C; rainy) and 4 July

(31.5 °C; fine, then cloudy), one on 8 July (23.0 °C; cloudy, then fine), none on 11 July (25.0 °C; cloudy), one on 12 July (25.0 °C; rainy, then cloudy), and finally one on 14 July (26.5 °C; cloudy): the adult beetles' appearance period lasts only three weeks.

Adult biometry

The relationship between the body length and the antennal length of available male and female adult beetle specimens is shown in Fig. 12, and that between the body length and mesothoracal body thickness in Fig. 13.

Figure 12 indicates that the ratio of the antennal length to the body length can be an obvious sex character, and that a few males exceed all the females in body length ("macho individuals") though this is not the case in most of the cerambycid species. This also indicates that the adult body length, as a parameter of the degree of development of larva

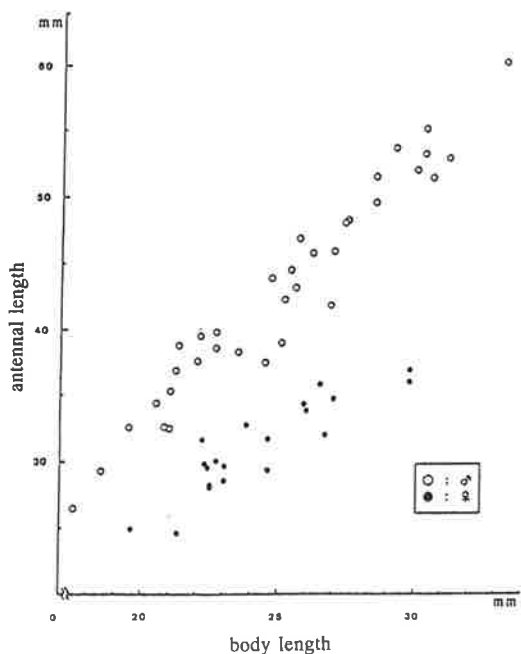


Fig. 12 The relationship between the body length and the antennal length of available male and female adult beetle specimens of *R. batesi* (male, $r = 0.970$; female, $r = 0.894$) (modified from AOKI *et al.*, 1992).

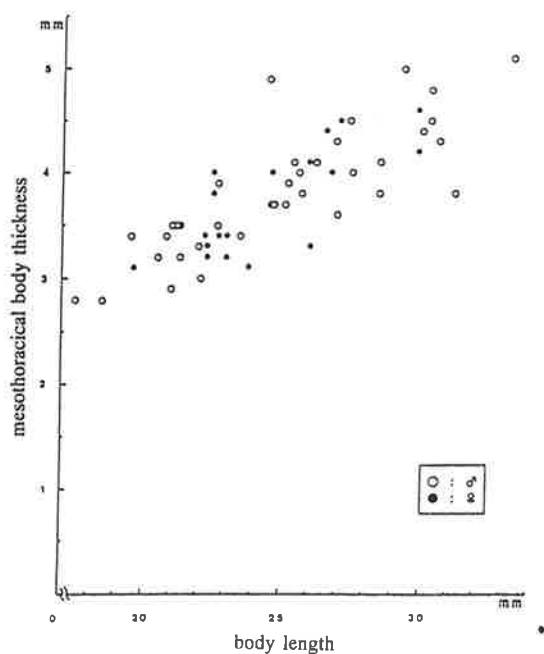


Fig. 13 The relationship between the body length and the mesothoracal body thickness of available male and female adult beetle specimens of *R. batesi* (male, $r = 0.864$; female, $r = 0.776$).

or prepupa, varies considerably. We have shown above that wood are attacked by *R. batesi* larvae rather evenly in terms of nutrition, and the nutritional variation of the wood the larvae bore must not be its cause. The cause of the marked variation of the individual development is thus uncertain.

Figure 13 indicates that the ratio of body thickness to the body length is not a sex character, and varies considerably among individuals. This may suggest the importance of antennae, which show a greater correlation coefficient against the body length in both sexes than this does: antennae must vary proportionately among individuals of each sex.

Mating behavior and struggle between males

In general observation, a male violently fought against an equivalent one by biting with his mandibles the opposite's antennal bases and

forelegs in many cases (data not shown). A struggle between a large male and a small one usually resulted in the large one expelling the small one by antennal whipping and stridulating sound. An observation with a very large male (32 mm in body length), a very small male (18 mm) and a female (24 mm) from the Machida population, however, presented a single example where the small male did not move at all while the other two were mating.

An outline of adult beetles' mating behavior and struggle between male beetles were given by observing individuals from the Minakami population in a tall petri dish and those from the Machida population in a plastic box. The results are shown in Table 1 and Fig. 14.

A male, after perceiving the existence of a conspecific female by directly touching her with his antennae, immediately tried to mount her

Table 1 Copulation durations and frequencies of *Rosalia batesi* adults from Minakami population within 30 min of observation

Pair No.	Onset ^{a)}	No. of copulations	Duration of each copulation	Average duration
1	0'13"	4	3'11", 0'31", 0'32", 3'30"	1'56"
2	0'22"	1	3'58"	3'58"
3	0'04"	2	4'45", 5'03"	4'56"
4	0'09"	3	4'42", 5'14", 5'04"	5'00"
5	0'06"	3	2'16", 3'52", 1'21"	2'30"
6	0'33"	1	3'40"	3'40"
7	0'02"	2	2'49", 5'07"	2'13"
8	0'08"	2	4'03", 4'54"	4'59"
9	0'03"	2	5'09", 2'52"	4'00"
10	0'06"	4	3'34", 2'12", 3'18", 0'45"	2'27"
11	0'10"	2	2'35", 0'43"	1'37"
12	0'02"	3	3'12", 3'07", 3'01"	3'07"
13	0'06"	3	3'10", 4'55", 1'24"	3'10"
14	0'47"	3	3'13", 1'04", 0'56"	1'45"
15	0'08"	1	5'28"	5'28"
16	0'12"	2	3'42", 3'58"	3'50"
17	0'04"	3	0'19", 3'14", 2'43"	2'05"
18	0'09"	2	2'41", 3'15"	2'58"
19	0'08"	3	4'30", 5'06", 5'13"	4'56"
Average	0'11"	2.4	3'14"	

^{a)} The time required from the beginning of mounting to the first copulation.

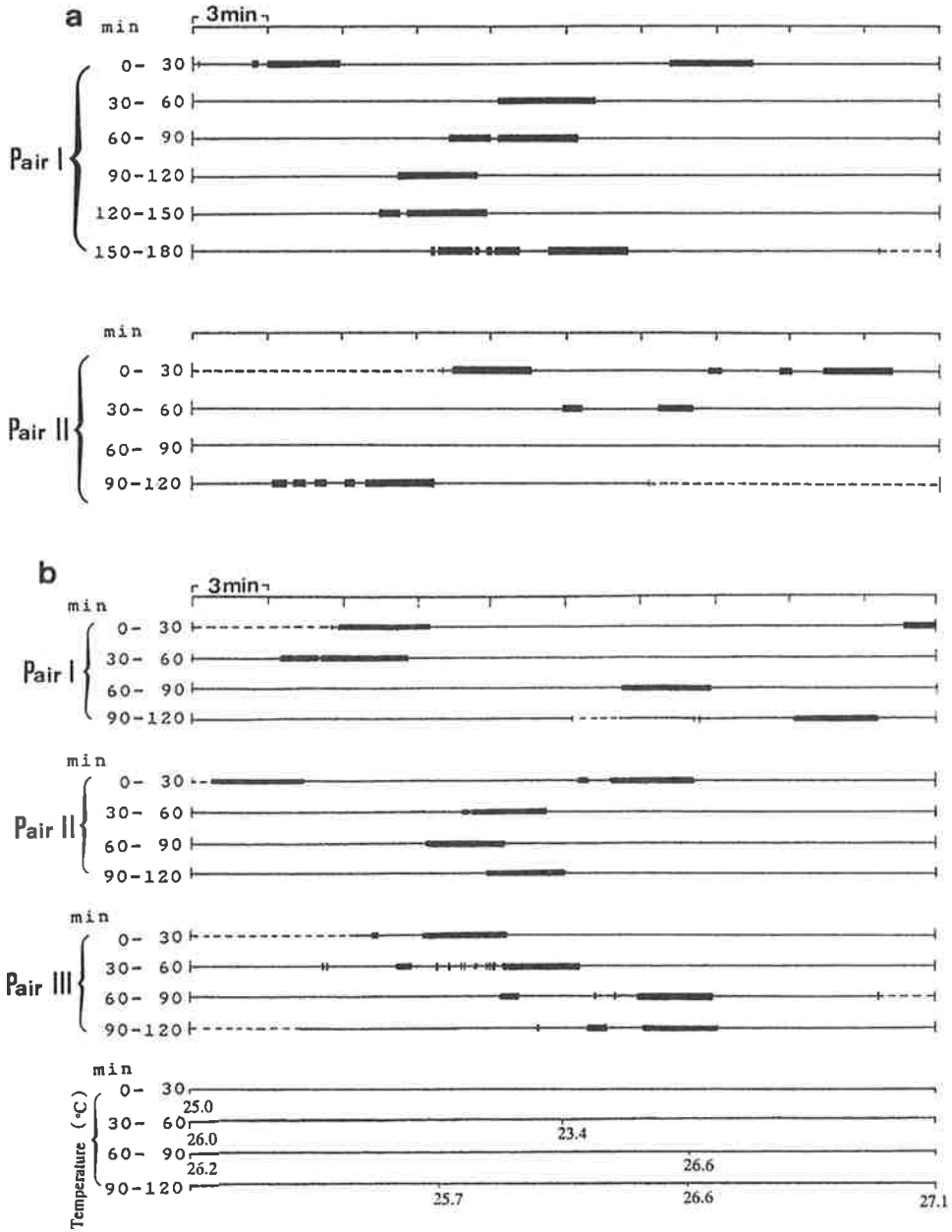


Fig. 14 Long-term sequences of the mating behavior of adult beetles of *R. batesi*, from the Minakami population observed in a tall petri dish (a), and from the Machida population observed in a plastic box (b). Thick line represents aedeagus insertion (copulation), fine line represents mounting, and broken line represents no contact between the pair.

from her back, and copulated with her within 1 minute (0'11" in average) (Table 1). Insertion of the aedeagus took place intermittently in

some cases. The mounting posture, either resting or moving, always lasted for more than 30 minutes; it lasted as long as 177'23" and

96'15'' in the long observation with the Minakami population (Fig. 14a), and 99'42'', more than 120', and 81'6'' with the Machida population (Fig. 14b). The frequency of aedeagus insertion (copulation) within 30 minutes' mounting averaged 2.4 times with 19 insertions, with each insertion lasting 3'14'' in average (Table 1). While mounting on the female, either copulating or non-copulating, the male palpated the female's pronotum disc and scutellum, and no antennal contact was observed between the two. A subtle change of temperature (23.4-27.1 °C) did not influence the mating behavior (Fig. 14b).

Prolonged pair-bonding in cerambycid adult beetles has been first pointed out in *Monochamus scutellatus* (SAY), a North American laminae, where a male does not readily quit the mounting posture with his mate after copulation (HUGHES, 1979). Lengthy non-copulating mounting in *R. batesi* may be of the same nature as this, and it is the case with most of the cerambycids, ensuring the male will copulate with his mate multiple times.

Adults' feeding behavior

While the adult of an allied species, *R. coelestis*, does not visit flowers (TSHERPANOV, 1991), *R. batesi* does: the senior author (R. I.) had opportunities to observe *R. batesi* adults' flower-visiting behavior in some places, including Mt. Comadan, Wakayama Pref. Further, *R. batesi* adults seem to have a habit of licking sap flowing from oak tree trunks (FUJITA, 1997). Our additional observation that *R. batesi* adults from Minakami logs suck sugar solution in a cotton-ball, to which was added benzyl acetate as a flower scent, also supports the idea that *R. batesi* adults have a regular habit of visiting flowers. The genus *Rosalia* may vary in regard to flower-visiting habit among species.

Occurrences in urban areas

Among the species of the genus, *R. alpina* L.,

a southern European species, inhabits protected forest of *Fagus*, and has long been protected by law (DEMELT, 1956). *Rosalia coelestis*, a Far-East Continental species, occurs on dead standing trees only, and not on felled or fallen trees (TSHERPANOV, 1981). *Rosalia funebris* MOTSCHULSKY, a North American species, is seen on newly felled trees, and was observed in an urban area to be attracted to paint as a pheromone mimic (LINSLEY, 1995). Reviewing these, occurrences of *R. batesi* in urban areas and on felled trees are not unique but rather specific characters of the species within the genus. In fact, *R. batesi* is expanding its distribution area toward Tokyo from Tama Kyūryō (SHIKADO, 1995; TAKAKUWA, 1997; SHIBATA, 1997).

In wood-boring beetles in general, adaptation of a certain species to man-made (that is, urban and/or indoor) environments is mostly associated with its adaptation to dryness (IWATA, 1997). The infested *Zelkova* logs at Machida lumberyard (about 70 cm in average diameter) had the average moisture content of 17.0% (min. 5.5%; max. 25.0%) as measured at the cross-cut surfaces. The wood within this range of moisture content is well defined as air-dried. In due consideration of the instance of indoor occurrence at Yaita as well, we may conclude that *R. batesi* may well be defined as a drywood borer.

Gross life history

For the gross life history, we present 3 examples of laboratory rearing record with 3 half-decayed *F. crenata* logs from Minakami: the first (about 14 cm in diameter), felled and harvested on 1 May 1990, yielded 1 female adult emerging on 21 Jun 1990, some mature larvae taken out in Nov 1990, and 2 male adults emerging on 20 May 1991. The second log (about 10 cm in diameter), harvested in early Nov 1990, yielded 1 female adult emerging on 27 Apr 1991, and from the third log, harvested on 5 Aug

1991, we took out 3 mature larvae on 20 May 1992. The larvae were identified as that of the genus *Rosalia* using ŠVÁCHA and DANILEVSKY'S (1988) key. Since no other *Rosalia* spp. are found in Japan proper, we regarded them as *R. batesi* larvae. The data from the first and third logs, at least, indicate that one generation can take multiple years, and that *R. batesi* may hibernate in its larval stage. The adult emergence takes place in early summer.

The *R. batesi* beetle occurrence from Japanese horse-chestnut logs at Yaita, however, is an odd case. In 1981, one log had been installed indoors, and the other two semi-outdoors, and the mass occurrence of the beetles was noticed 5-7 years later (1986-1988). In this place, beetles' invasion and oviposition onto the indoor-installed log in 1982-1985 is quite unlikely. These facts collectively suggest that the occurrence is possibly ascribed to female beetles' oviposition at the lumberyard in Kuriyama in 1980. This inference naturally leads to two alternative hypotheses: one is that *R. batesi* mature larvae can survive and further develop within drywood by prolonging larval duration up to 8 years (!), but successive generations never occur, probably due to young larvae's susceptibility to dryness; the other is that *R. batesi* can occur on barkless drywood throughout successive generations. We need to clarify which is the case.

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References

- AOKI, M., R. IWATA, Y. YOKOMIZO and F. YAMADA (1992) Bionomics of a hardwood log borer, *Rosalia batesi* HAROLD (Coleoptera: Cerambycidae) (preliminary report). *Trans. 43rd Annual Mtg. Kanto Branch, Jpn. For. Soc.* : 111-114. (in Japanese with English title)
- DEMELT, C. (1956) Beobachtungen und Bemerkungen über *Rosalia alpina alpina* L. *Entomol. Blätt. Biol. Syst. Käfer*, 52 : 170-175.
- FUJITA, H. (1997) *Rosalia batesi* HAROLD (Coleoptera : Cerambycidae) attracted to sap flow. *Kanagawa-Chūhō, Odawara*, (118) : 38. (in Japanese)
- HAYAKAYA, H. and K. HORI (1971) Food habit and bionomics of cerambycid larvae in Nagano Prefecture, Japan (Notes on Cerambycidae of Nagano Prefecture. 3). *Matsumoto Mushi no Kai Nenpo (Annu. Rep. Matsumoto Entom. Soc.)*, Naganō, 8 : 68-96. (in Japanese)
- HUGHES, A. L. (1979) Reproductive behavior and sexual dimorphism in the white-spotted sawyer *Monochamus scutellatus* (Say). *Coleopt. Bull.*, 33 (1) : 45-47.
- IABLOKOFF, A. Kh. (1953) Le rôle hygrométrique des arbres morts dans l'équilibre thermodynamique des forêts. *Rev. Forest. Fr.*, 5 (1) : 17-28.
- IWAO, S. (1968) A new regression method for analyzing the aggregation pattern of animal populations. *Res. Popul. Ecol.*, 10 : 1-20.
- IWAO, S. (1972) Application of the m-m method to the analysis of spatial patterns by changing the quadrat size. *Res. Popul. Ecol.*, 14 : 97-128.
- IWATA, R. (1997) Drywood pest insects. In *Wood Science Series. Vol.12. Preservation and Durability* (YAGA, S. *et al.*, eds.). Kaiseisha,

- Otsu, 224 pp. : 87-94.
- IWATA, R. and F. YAMADA (1990) Notes on the biology of *Hesperophanes campestris* (FALDERMANN) (Col., Cerambycidae), a drywood borer in Japan. *Mater. u. Organ., Berlin*, 25 : 305-313.
- KOJIMA, K. and S. NAKAMURA (1986) Food plants of cerambycid beetles (Cerambycidae, Coleoptera) in Japan. Hiba Society of Natural History, Shōbara, 11 + 336 pp. (in Japanese)
- LIMBLEY, E. G. (1995) The banded alder beetle in natural and urban environments (Coleoptera : Cerambycidae). *Pan-Pac. Ento-mol.*, 71 : 133-134.
- MERRILL, W. and E. B. COWLING (1966) Role of nitrogen in wood deterioration : Amounts and distribution of nitrogen in tree stems. *Can. J. Bot.*, 44 : 1555-1580.
- MURATA, Y. (1997) The longicorn beetles of Machida City, Tokyo (Insecta, Coleoptera). *Annual Bull. Nichidai Sanko, Machida*, (30) : 21-45. (in Japanese)
- SHIKADO, K. (1995) Capturing *Rosalia batesi* HAROLD (Coleoptera: Cerambycidae) at Hachiōji, Tokyo Prefecture. *Gekkan-Mushi, Tokyo*, (291) : 37. (in Japanese)
- SCRIVENER, A.M., H. WATANABE and N. NODA (1997) Diet and carbohydrate digestion in the yellow-spotted longicorn beetle *Psacotheta hilaris*. *J. Insect Physiol.*, 43 : 1039-1052.
- ŠVÁCHA, P. and M. L. DANILEVSKY (1988) Cerambycoid larvae of Europe and Soviet Union (Coleoptera, Cerambycoidea). Part II. *Acta Univ. Carolinae, Biol., Praha*, 31 : 121-284.
- TAKAKUWA, M. (1997) *Rosalia batesi* HAROLD (Coleoptera: Cerambycidae) inexplicably expanding its distribution range. *Kanagawa-Chūhō, Odawara*, (120) : 0. (in Japanese)
- TSSHEREPANOV, A. I. (1981) Longhorn beetles of North Asia [vol. 2] (Cerambycinae). Nauka, Novosibirsk, 216 pp. (in Russian)

ヒラタキクイムシ食害材から検出される アコースティック・エミッション (AE) について

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Acoustic Emission (AE) Detected from Wood Attacked by Powder-post Beetles, *Lyctus brunneus* STEPHENS. Yuji IMAMURA¹⁾, Akio ADACHI¹⁾, and Yoshihisa FUJII²⁾ (1) Wood Research Institute, Kyoto University, Uji, 611-0011, Japan. (2) Division of Forest and Biomaterials Science, Graduate School of Agriculture, Kyoto University, Kyoto, 606-8502, Japan). *Jpn. J. Environ. Entomol. Zool.* 9 : 98-100 (1998)

Acoustic emissions (AE) of the burst type were detected from the air-dried sapwood of *Parashorea* sp., which were inoculated with larvae of the powder-post beetle, *Lyctus brunneus* STEPHENS. Piezoelectric sensors of resonant frequency of 150 kHz were attached to the specimen. More AEs were detected from the specimens with more larvae inoculated. AE generation stopped upon tapping the specimen with a finger, and started again in one to 24 hours after the tapping was stopped. The three phases of the AE generation were confirmed, the first term up to 200 hours when the AE events increased rapidly, the second one up to 500 hours of less increasing of AEs and the last 100 hours of rapid increase, respectively. These phases could be associated with the three growing stages of larva, pupae, and adults, respectively.

Key Words : Acoustic emission (AE), Powder-post Beetle, *Lyctus brunneus*

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はじめに

シロアリの職蟻等が、その口器で木材を加害する際には、木材の微小な破壊が発生し、それに伴い微弱な弾性波であるアコースティック・エミッション (AE) が発生する。著者らはこのことをこれまで間接的および直接的な方法で確認し、AEモニタリングがシロアリの非破壊的検出や生態解析の一手法となりうることを明らかにしてきた (FUJII *et al.*, 1990a ; IMAMURA *et al.*, 1991 ; NOGUCHI *et al.*, 1991 ; MATSUOKA *et al.*, 1996)。また本手法は、シロアリと同様の食害作用をもつ木材加害昆虫にも適用できると考えられる。本研究では、ヒラタキクイムシの幼虫をホワイトセラヤ辺材に接種し、接種後成虫が脱出するまでの期間AE計測を行い、接種条件とAEの消長との関係を考察した。

試料

ホワイトセラヤ (*Parashorea* sp.) の気乾辺材 (断面約50 mm角, 長さ100 mm) のまき目面に1つの穴 (直径約2.5 mm, 深さ15 mm) をあけ、穴の底にヒラタキクイムシ, *Lyctus brunneus* STEPHENS の幼虫を1, 3あるいは5頭接種した。幼虫は接種3ヶ月前にふ化し、飼育室で育てたものを用いた。接種に際しては幼虫が定着するまでの餌として、セルロース粉末50, 小麦粉30, イースト20の重量比で混合したものも穴に少量入れ、ビニールテープで封じた。接種後の材は透明プラスチックケースに入れ、温度26°C, 相対湿度70%の恒温恒湿室に設置した。

なおヒラタキクイムシの幼虫の取扱いは難しいため、予備実験において予め断面約50 mm角, 長さ100 mmまたは200 mmの試料を22個用意し、接種位置や接種方法と幼虫の生存率や成虫脱出までの時間との関係を検討したうえで、AE計測用の試料 (前述の幼虫を1, 3あるいは5頭接種した試料および対照試料の計4個) を作製した。今回の条件では概ね接種後20日で成虫の脱出が始まり、25日でほとんどの試料からの脱出が完了した。また脱出位置や時期への材の大きさや接種位置の影響は明かではなかった。

AE計測方法

AE計測には圧電型AEセンサ (株) エヌエフ回路設計ブロック社製, AE-901U, 共振周波数150 kHz) お