Steel, R. G. D. & Torrie, J. H., 1960. **Principles and Procedures of Statistics with special reference to the biological sciences.** McGraw-Hill Book Co. Inc., New York.

Timofeef-Ressovsky, N. W., 1940, Zur Analyse des Polymorphismus bei **Adalia bipunctata** L. **Biol. Zbl.** 60:130-137.

Weaver, C. R. & King, D. R., 1954. Meadow Spittlebug. **Bull. Ohio Agric. Exp. Stat.** 741:1-99.

Weaver, C. R. & Whitney, D. R., 1956, A proportion method for sampling spittlebug populations. **Ohio J. Sci.** 56:237-244.

Wiegert, R. G., 1964, Population energetics of meadow spittlebugs (**Philaenus spumarius** L.) as affected by migration and habitat. **Ecol. Mon.** 34:217-241.

MOISTURE AND FAT CONTENT DURING THE ADULT LIFE OF THE AMBROSIA BEETLE, *TRYPODENDRON LINEATUM* (OLIV.)

By W. W. NIJHOLT[1]

ABSTRACT

Depletion of fat deposits during the long hibernation period of the adult ambrosia beetle, **Trypodendron lineatum** (Oliv.), amounts to about one quarter of the original fat content. The fat loss during flight activity appears to be also about one quarter of the amount present at the start of hibernation.

Experiments with beetles stored at different temperatures indicate that during a long cool spring the rate of fat loss increases, probably affecting the vigor of the population during subsequent flight and brood establishment.

INTRODUCTION

Many insects derive energy for metabolic activity from stored lipids (Fast, 1964), supplies of which are likely to vary during adult life. To understand individual behaviour patterns, a knowledge is required of the relationship between the fat content of the insect and its behaviour. Atkins (1966) demonstrated such a relationship in a scolytid, and stressed the need for studies that penetrate to the physiological basis of behavioural variation.

The ambrosia beetle, *Trypondendron lineatum* (Oliv.), spends a major part of its adult life in hibernation. Climatic conditions influence the length of the hibernation period and thus affect the utilization of stored lipids which in turn affects the subsequent flight and attack activities. This investigation was undertaken to learn more about the depletion of fat during hibernation and the flight period that follows.

METHODS AND MATERIALS

The data were obtained from beetles collected from duff or bark in standing timber around logging areas near Lake Cowichan, B.C., between August 1965 and July 1966 (Dyer and Kinghorn, 1961). The heated pan method described by Hadorn (1933) and Kinghorn and Chapman (1959) was used for recovering the beetles. Moisture and fat were determined by drying in an oven and extracting with petroleum ether in a Soxhlet unit (Nijholt, 1965). In this presentation, values for fat, or lipids, represent substances extractable in petroleum ether.

To check the speed and efficiency of the extraction, groups of 25 beetles were dried, weighed, and extracted for various lengths of time up to six hours. The amount of fat loss

[1] Department of Forestry and Rural Development, Forest Research Laboratory, Victoria, B.C.

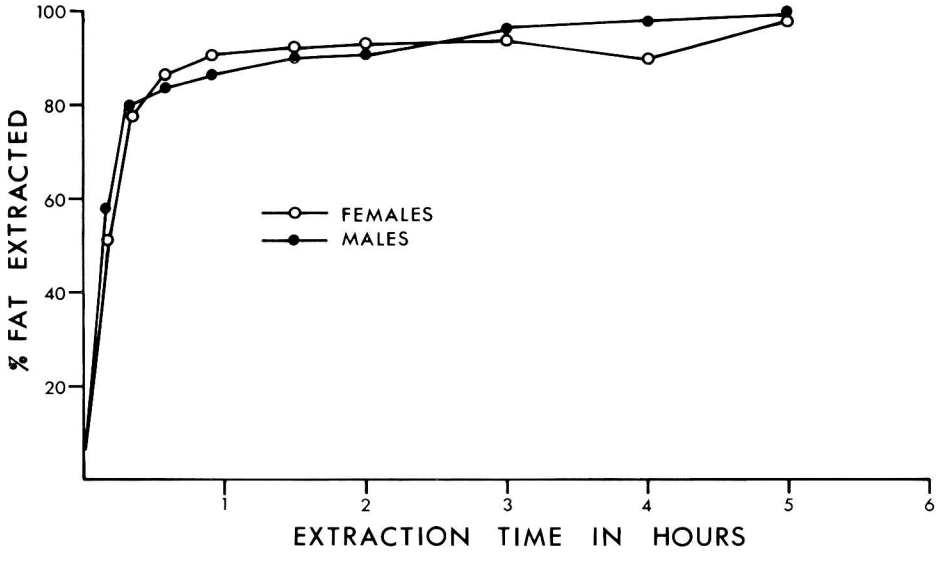

Fig. 1. Fat extracted in petroleum ether from male and female adult ambrosia beetles, **Trypodendron lineatum**, in groups of 25.

was determined for all the groups, which were then extracted again for the time required to bring the total extraction period to six hours.

Fig. 1 shows that more than half of the total fat was removed within the first 10 minutes, and that more than 99% was extracted in five hours. Six hours was therefore considered to be sufficient to extract all the fat.

During the period of hibernation of the ambrosia beetle, samples were taken at intervals from the same forest margin to determine the reduction of stored fat deposits. Samples of beetles in flight or crawling near attractive logs were taken during the subsequent flight period. All samples were kept at 0°C after collection and were processed as soon as possible, so that the results closely represent the condition of the beetles at the time and place of sampling. Unless otherwise indicated, water and fat determinations were made for individual beetles, to provide a measure of the variability within the samples. The weights were determined to within 0.01 mg.

Samples of flying beetles were obtained by "live - trapping", using a glass-barrier flight trap, with a trough leading to a slit in a horizontally placed metal cylinder with clear vinyl plastic ends. The beetles crawled toward the light at the ends of the cylinder. Little mortality occurred when the beetles were collected regularly. The traps were set up in forest stands near sources of attractive log odour.

The fat content decreased gradually during hibernation (Fig. 2), while the fat free extracted weight remained at the same level indicating that lipids were utilized. This was accompanied by an increase in moisture content. The beetles caught during the flight period cannot be considered as members of the above population since they were captured several miles from the site of overwintering. Nothing is known of where the flying beetles came from or how long they had flown. The results indicate that the beetles use up about one quarter of their stored fat during hibernation and a similar amount during post hibernation dispersal. Consequently, the beetles arrive at

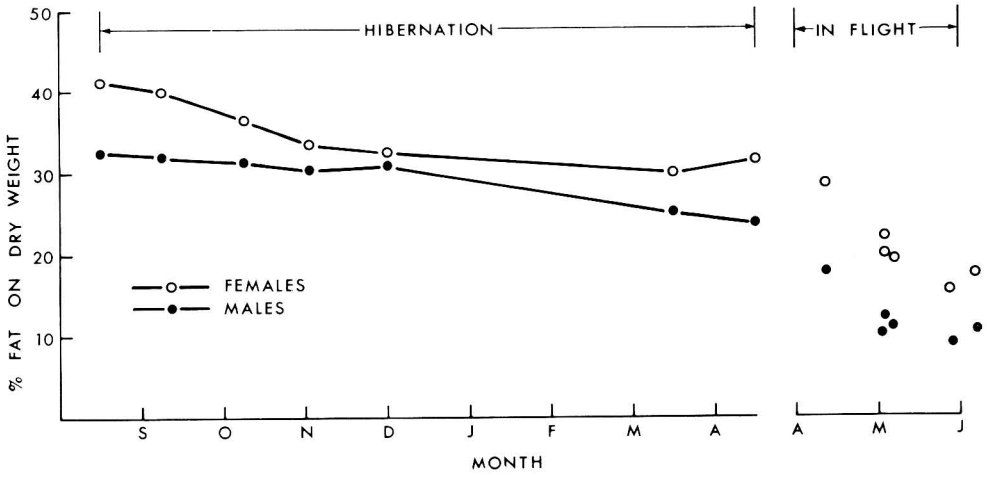

Fig. 2. Percentage of fat of dry weight of **Trypodendron lineatum** (Oliv.) during hibernation and flight period.

their new brood site with about one half of their original fat reserves.

Histograms of the distribution of individual beetles into classes of different fat content at different times show that the number of lean beetles increased during the first part of the collection period and then declined (Fig. 3), suggesting that some of the weaker beetles did not survive the hibernation period and therefore the population quality would be altered to some extent. It is not known how many non-survivors were old adults, going through a second hibernation.

To determine the fat content of beetles during their flight period, the possibility of using "wet-trap" catches, as described by Chapman and Kinghorn (1955, 1958) was considered, but results from these samples were not considered reliable.

A study was made of changes in fat content during laboratory storage of beetles at 4°C for several months. The beetles do not walk or fly at 4°C, but some of the stored fat is consumed by metabolic activity. A sample of beetles collected in April 1966 was sorted into groups of approximately 80 individuals and these were stored in plastic bags of bark flakes in a darkroom at 4°C. A control sample was stored similarly at 0°C. At monthly intervals for three months the dry weight, moisture content and fat content were determined. One group was kept stored for an additional three months. The results are presented in Table 1 with data from samples of beetles collected in the spring of 1965 and stored for six months at 0° C.

Table 1 shows that considerably more fat is utilized at 4° C than at 0° C. At 4° C conditions simulate a prolonged, cool spring during which the beetles could conceivably lose some vigor, while awaiting sufficiently warm weather for flight and attack. The relationships between the amount of fat remaining after overwintering, and the flight and brood production remain to be established.

These studies indicate no more than quantitative changes in fat. The qualitative aspects of the lipid metabolism of the insect during its long adult life await further study and should provide some insight into the relationship between the various aspects of behaviour and stored energy.

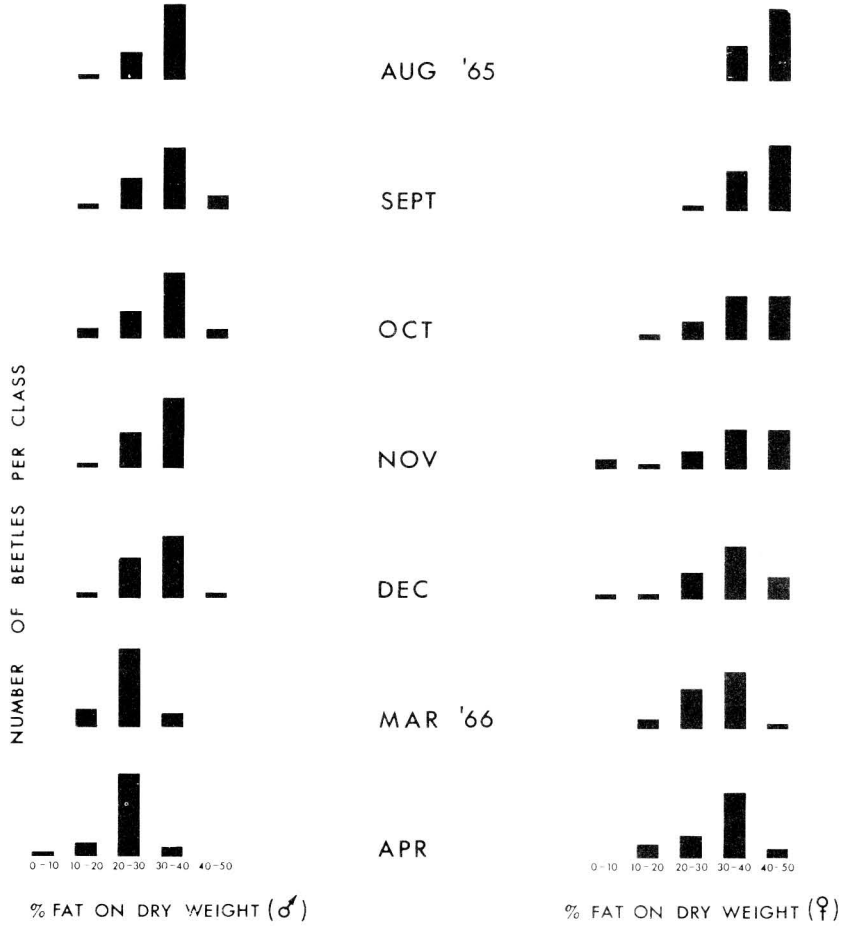

Fig. 3. Histogram of percentage of fat of dry weight of **Trypodendron lineatum** (Oliv.) during hibernation.

TABLE 1—Average values in mg of moisture, dry weight and fat, with percentage fat of groups of 25 ambrosia beetles, **Trypodendron lineatum**, stored for periods up to six months at 0° or 4°C.

Time stored, days	Weight of moisture	Fat free weight	Weight of fat	Fat % of dry weight
Females				
0	2.09	1.28	0.52	28.3
30	2.14	1.15	0.54	30.7
60	2.06	1.12	0.35	21.8
90	2.14	1.10	0.36	22.7
180	2.28	1.15	0.26	17.5
180[1]	2.34	1.15	0.45	27.3
180[2]	2.16	1.10	0.37	22.7
Males				
0	1.89	1.09	0.33	22.6
30	1.88	1.01	0.31	22.1
60	1.84	0.84	0.15	11.9
90	2.04	1.03	0.18	14.4
180	2.03	1.03	0.08	7.1
180[1]	2.05	0.98	0.24	18.6
180[2]	1.95	1.06	0.27	19.7

[1]Control sample stored at 0°C.
[2]Sample collected in the spring of 1965 and stored at 0°C.

Acknowledgements

Co-operation of the Gordon River Division of Western Forest Industries Ltd. in locating insect sampling areas is gratefully acknowledged. Thanks are extended to Dr. J. A. Chapman for suggesting the problem and advice during the study and preparation of this publication and to M. D. Atkins and E. D. A. Dyer for reviewing the manuscript.

References

Atkins, M. D. 1966. Laboratory studies of the behaviour of the Douglas-fir Beetle, **Dendroctonus pseudotsugae** Hopkins. Can. Entomol. 98:953-991.

Chapman, J. A., and J. M. Kinghorn. 1955. Window flight traps for insects. Can. Entomol. 87: 46-47.

Chapman, J. A., and J. M. Kinghorn. 1958. Studies of flight and attack activity of the ambrosia beetle, **Trypodendron lineatum** (Oliv.) and other scolytids. Can. Entomol. 90:362-372.

Dyer, E. D. A., and J. M. Kinghorn. 1961. Factors influencing the distribution of overwintering ambrosia beetles, **Trypodendron lineatum** (Oliv.). Can. Entomol. 93: 746-759.

Fast, P. G. 1964. Insect lipids: A review. Memoirs of the Entomol. Soc. of Canada, No. 37.

Hadorn, C. 1933. Recherches sur la morphologie, les stades evolutifs et l'hivernage du bostryche lisere (**Xyloterus lineatus** Oliv.). Suppl. aux. org. de la Soc. forest. Suisse No. 11. Buchler and Co., Bern.

Kinghorn, J. M., and J. A. Chapman. 1959. The overwintering of the ambrosia beetle **Trypodendron lineatum** (Oliv.). Forest Sci. 5:81-92.

Nijholt, W. W. 1965. Moisture and fat content in the ambrosia beetle **Trypodendron lineatum** (Oliv.). Proc. Entomol. Soc. Brit. Columbia 62:16-18.