CXLII. THE CHEMICAL ASPECT OF THE DESTRUCTION OF OAK WOOD BY POWDER POST AND DEATH WATCH BEETLES— *LYCTUS* SPP. AND *XESTOBIUM* SP.

BY WILLIAM GEORGE CAMPBELL.

*From the Chemistry Section, Forest Products Research Laboratory,
Princes Risborough.*

(Received November 6th, 1929.)

INTRODUCTION.

In considering the extensively destructive activities of the larvae of wood-boring beetles, and granting that during boring operations wood is pulverised and passed through the alimentary canals of the organisms, the important question arises as to whether wood substance, in part or in whole, is utilised as food. In the study of wood-boring organisms such as white ants, it has been proved by comparing analyses of sound wood and borings respectively that in virtue of the symbiotic activity of intestinal micro-organisms the larvae concerned actually digest a portion of the carbohydrate components of the wood in which they bore [Schorger, 1926, pp. 503-4; Hawley and Wise, 1926, pp. 302-3]. These conclusions have been arrived at by comparing the carbohydrate-lignin ratio in sound wood and borings respectively. In the case of the white ants this ratio was found to be lower in the borings than in sound wood, hence the deduction that carbohydrate material was removed. Moreover, by assuming that lignin was not attacked, and remained constant throughout, it was possible to calculate the actual percentage of such material digested.

With regard to the feeding habits of wood-boring insects in general, there is some doubt from the entomological standpoint as to whether they invariably feed on wood substance. Indeed Uvarov [1928] has summarised the position as follows: "There is, however, no evidence at all as to what substances they do in fact feed on; these may be particles of wood partially digested by micro-organisms, or their secretions, or their excretions, or even the micro-organisms themselves. In other words wood-eating insects must be classified as insects of absolutely unknown feeding habits."

In the present investigation an attempt has been made to determine the chemical effect, if any, (1) of the larva of a species of powder post beetle on oak sapwood, and (2) of the larva of the death watch beetle on oak heartwood.

EXPERIMENTAL.

Series I. The material used was *Lyctus* frass or borings collected from a number of samples of infected English oak sapwood. For the purposes of comparison a sample of sound sapwood was obtained from a disc of English oak cut at about 20 ft. from the ground.

Comparative analyses of frass and sound wood were carried out according to the methods recommended by Schorger [1926, pp. 505-6] and Hawley and Wise [1926, pp. 129-72], the percentages of the main constituents only being determined. In screening the frass, prior to analysis, it was found that the material was of a texture fine enough to permit of its passage through a 120 mesh screen. Since standard wood analyses are as a rule carried out on 80-100 mesh material, the composition of the sample of sound English oak sapwood was first determined on material of this particle size. It can be seen from the following tables that particle size has a marked influence on analytical results, since in the 120 mesh material the hot water- and alkali-soluble contents respectively are higher, and the cellulose, lignin, and pentosan contents are lower than those in the 80-100 mesh material prepared from the same sample of sound sapwood. These discrepancies are no doubt explained by the fact that in grinding the wood to fine particle size, greatly increased surface area is exposed to analytical reagents. A true comparison between the respective compositions of sound wood and frass, taken from the same species of wood, is thus afforded in Table II.

Results are expressed throughout as percentages by weight of oven-dry material.

Table I. *Analysis of sound English oak sapwood of 80-100 mesh.*

				%
Hot water-soluble	...	...	...	9.9
Alkali-soluble	...	...	...	22.6
Cellulose...	...	...	...	55.0
Lignin	...	...	...	22.4
Total pentosans	...	...	...	25.1

Table II. *Comparative analyses of Lyctus frass from English oak sapwood and sound English oak sapwood of same particle size.*

Material	Hot water-soluble	Alkali-soluble	Cellulose	Lignin	Total pentosans
Sound English oak sapwood, 120 mesh	10.4	24.2	52.9	21.8	24.3
<i>Lyctus</i> frass, 120 mesh	11.5	23.0	52.8	21.1	25.4

Series II. The material used was *Xestobium* frass collected from a badly infected sample of English oak heartwood. The frass was in the form of small pellets which crumbled very easily to a fine dark brown powder. Light grinding in a mortar was sufficient to reduce the whole sample to a powder which passed a 120 mesh screen. The composition of this material is given in Table III.

For the purpose of comparison a standard wood analysis was carried out on a sample of 80–100 mesh well-seasoned English oak heartwood taken 20 ft. from the ground (Table III).

Table III. *Analysis of Xestobium frass from English oak heartwood and of 80–100 mesh English oak heartwood.*

	<i>Xestobium</i> frass	Oak heartwood
Hot water-soluble	13.6	13.0
1 % alkali-soluble	57.3	24.5
Cellulose	39.0	53.2
Lignin	32.1	26.5
Total pentosans	16.5	21.7

DISCUSSION.

Series I. The analytical data show clearly that *Lyctus* frass taken from the sapwood of English oak sapwood is of the same general composition as sound English oak sapwood of the same particle size. The agreement of the data is close considering that the sound wood and frass, although obtained from the same species of wood, were none the less obtained from different trees.

Since the carbohydrate-lignin ratio in *Lyctus* frass is of the same order as that in sound wood, it would appear that the larva does not feed on any particular wood constituent, for in the light of previous work, if any of the main components were interfered with during larval activity the carbohydrate-lignin ratio in the frass would betray the fact. Since the composition of the actual wood from which the frass was obtained could not be determined, it was thus impossible to determine any loss in weight which might have been sustained as a result of attack. There remains the open possibility therefore, that if a loss in weight were sustained, part of the wood substance might have been consumed *in toto*. That lignin could be utilised by the larva as food, however, seems highly unlikely, and since cellulose and pentosans appear on analysis to be in no sense depleted, the conclusion that the *Lyctus* larva does not feed on the wood in which it bores seems justified. Moreover, having regard to the remarks by Uvarov [1928] previously quoted, it would appear that among all the possible sources of food available to the larvae, "micro-organisms themselves or cell contents are most likely to be used." Thus the larvae must feed directly on some cell contents of sapwood or else on some micro-organisms which feed on cell contents, for comparative analysis shows that the main constituents of wood cell-wall substance are not affected by larval activity.

Series II. With regard to the effect of the death watch beetle on the heartwood of oak, the experimental data in Table III show clearly that, in view of the low cellulose and pentosan contents of the frass, part of these components in the original wood must have been consumed during larval activity. The high alkali-solubility of the frass is further evidence that some radical change has taken place in the wood substance during attack.

Since the composition of the original wood, and the loss in weight after attack could not be determined, it is impossible definitely to establish the true

extent of depletion in each component, but comparison of the carbohydrate-lignin ratios is conclusive evidence of attack on the carbohydrates of the original wood.

The experimental procedure adopted in the above studies of the feeding habits of two wood-boring beetles is admittedly of limited application since it can only be used within broad limits to indicate whether part of the skeletal substance of wood can be used as food by the larvae in question. None the less, as a preliminary to further and more detailed study of the biology of wood-boring organisms it is of unquestioned value. For instance, with regard to the powder post beetles the analytical results point to the fact that the source of larval nourishment is within the cells of the sapwood of oak and not in the cell-wall substance.

Treatment of death watch beetle frass by the same technique discloses the fact that the larva in this case attacks the carbohydrates of wood substance. The indication here is therefore that intestinal micro-organisms play a prominent part in the biology of the larva. When it is possible to feed the larvae of wood-boring insects on weighed samples of wood of known composition, so that the losses in weight due to attack can be determined, the full effectiveness of the application of chemical analysis to the elucidation of feeding habits will be realised, since it is obvious that accurate information on this subject must lead to more efficient methods in wood preservation.

I wish to express my indebtedness to Prof. F. Soddy for facilities afforded in the Old Chemistry Department, University of Oxford, to Sir James Irvine and Dr J. W. Munro, for helpful criticisms and advice, and to Mr R. S. Pearson, Director of Research, Forest Products Research Laboratory, Princes Risborough, Bucks., for permission to publish these results.

REFERENCES.

- Hawley and Wise (1926). Chemistry of wood.
Schorger (1926). Chemistry of cellulose and wood.
Uvarov (1928). *Trans. Ent. Soc. Lond.* December 31st.