THE MODE OF ATTACK AND TUNNELLING BY *CROSSOTARSUS RENGETENSIS* NIIJIMA ET MURAYAMA

BY

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(With 4 tables and 5 figures in text)

Of the 15 species[1] of the Formosan *Platypodidae*, *Crossotarsus rengetensis* does the greatest damage to forestry. By special experiment in Rengeti natural forest, the author was able to ascertain the trees attacked and the tunnelling system of this species. In this experiment, for the purpose of giving the insects free choice of trees under favourable conditions, 60 different trees shown in table I, were fallen down during February, 1922, in Rengeti forest and the logs set out in four places selected at equal distances from the forest boundary.

A. Open space in the neighbourhood of broad-leaved forest, the southern slope.
B. In the broad-leaved forest boundary in the vicinity of A, the southern slope.
C. Space in the broad-leaved forest, the eastern slope, neighboured by bamboo forest to the south.
D. In the broad-leaved forest, the eastern slope, neighboured by bamboo forest to the west.

TABLE I

SPECIES OF TREES TAKEN WITH FAMILIES OF INSECTS FOUND IN THEM

(B, *Buprestidae;* Bo, *Bostrichidae;* C, *Cerambycidae;* Cu, *Curculionidae;* Co, *Colydiidae;* I, *Ipidae;* L, *Lymexylonidae;* P, *Platypodidae;* W, *Without injury)*

No.	SPECIES OF TREES	PLACE			
		A	B	C	D
1	*Podocarpus macrophyllus* D.DON	W	W	—	—
2	*Castanopsis Kawakamii* HAYATA	C	C I	—	—
3	*C. cuspidata* SCHOTTSKY	—	P I	—	—
4	*C. Junghuhnii* HAYATA	—	I	—	—

(1) MURAYAMA, On the *Platypodidae* of Formosa, Jour. Col. Agr., Hokkaido Imp., Univ. Vol. XV, pt. 4, p. 199.

[Ins. Mats., Vol. III, Pt. 1, Oct., 1928]

No.	SPECIES OF TREES	PLACE			
		A	B	C	D
5	*Lithocarpus amygdalifolia* HAYATA	C	C I	—	—
6	*L. brevicaudata* HAYATA	—	C I	—	—
7	*L. ternaticupula* HAYATA	—	—	C	C I
8	*Quercus Konishii* HAYATA	C	I P	—	—
9	*Q. tomentosicupula* HAYATA	C	I	—	—
10	*Engelhartia formosana* HAYATA	C	C	—	—
11	*Trema orientalis* BLUME	—	—	C	C I
12	*Ficus nervosa* HEYNE	—	—	C Cu I	C I
13	*Morus acidosa* GRIFFITH	—	—	C I	I
14	*Daphniphyllum Roxburghii* BAILLON	—	—	C	C
15	*Glochidion Fortunei* HANCE	—	—	C I	—
16	*Mallotus cochinchinensis* LOUREIRO	—	—	C I	C I
17	*Sapium discolor* MUELLER-ARG.	—	—	C	Cu I P
18	*Actinodaphne citrata* HAYATA	—	—	—	C L
19	*Cinnamomum Camphora* NEES et EBELMAIRE	—	—	P	C Cu I L P
20	*C. micranthum* HAYATA	—	—	P	I L P
21	*C. randaiense* HAYATA	I L	W	—	—
22	*Cryptocarya chinensis* HEMSLEY	Cu P	Bo	—	—
23	*Litsea dolichocarpa* HAYATA	W	—	—	—
24	*Machilus longipaniculata* HAYATA	P	—	—	—
25	*M. Thunbergii* S. et Z.	C I	C I	—	—
26	*Tetradenia Konishii* HAYATA	C L	P	—	—
27	*Ehretia longiflora* CHAMPION	—	—	W	I
28	*Fraxinus formosana* HAYATA	—	—	—	C I
29	*Alniphyllum pterospermum* MATSUMURA	—	—	C I	I L
30	*Styrax formosanum* MATSUMURA	—	—	W	I L P
31	*Symprocos Laurina* WALLICH	—	—	Cu	Cu I
32	*Diospyros eriantha* CHAMPION	—	—	C	C I
33	*D. Lotus* LINNAEUS	Bo	I L	—	—
34	*Ardisia Sieboldii* MIQUEL	—	—	C	I L
35	*Diplospora viridiflora* A. P. de CANDOLLE	C I	Co I P	—	—
36	*Psychotria elliptica* KER.	I	I	—	—
37	*Cornus taiwanensis* KANEHIRA	—	—	W	W
38	*Aralia chinensis* LINNAEUS	—	—	C Cu I	C I
39	*Agalma lutchuense* NAKAI	W	W	—	—
40	*Casearina Merrilli* HAYATA	—	—	—	Cu I
41	*Lagerstroemia subcostata* KOEHNE	—	Bo C I P	C	W
42	*Eugenia acutisepala* HAYATA	—	L	L	—
43	*E. sinenis* HAMSLEY	Cu I	C	—	—
44	*Prunus punctata* HOOKER f.	—	—	C I	—
45	*Malus formosana* KAWAKAMI	—	—	W	C I

No.	SPECIES OF TREES	PLACE			
		A	B	C	D
46	*Erythrophloem Fordii* OLIVER	—	—	—	I
47	*Ormosia formosana* KANEHIRA	C	C Cu I L	—	—
48	*Meliosoma rhoifolia* MAXIMOWICZ	—	—	Cu L I	W
49	*Ilex formosana* MAXIMOWICZ	C Cu L	C	—	—
50	*Melia Azedarach* LINNAEUS	—	—	Cu	I P
51	*Evodia meliaefolia* BENTHAM	—	—	W	I L
52	*Fagara ailanthoides* ENGLER	—	—	C	C I
53	*Adinandra formosana* HAYATA	B C	C	—	—
54	*Gordonia axillaris* DIETRIG	W	P	—	—
55	*Saurauja tristyla* DC. var. *Oldhami* FINET & GAGNEPAINE	—	—	—	W
56	*Schima kankaoensis* HAYATA	—	—	Cu I	C I I
57	*Ternstroemia japonica* THUNBERG	—	C I P	—	—
58	*Thea sinensis* LINNAEUS	—	C	—	—
59	*Illicium arborescens* HAYATA	W	I L	—	—
60	*Michelia compressa* MAXIMOWICZ	W	W	W	I L
	Total (in each place)	23	28	28	30

N.B. In addition to the above mentioned trees, there were 9 more undetermined species infested by insects belonging to *Ipidae*, *Buprestidae*, *Cerambycidae* and *Lymexylonidae*.

The logs were placed in close contact with each other on long sleepers. In January, 1923, the author examined them and obtained two hundred individuals of *Crossotarsus rengetensis* from the nine species of trees given in the following table.

TABLE II

TREES ATTACKED BY *CROSSOTARSUS RENGETENSIS* NIIJIMA ET MURAYAMA

No.	TREES ATTACKED	Sex of Insects	PLACE				REMARKS
			A	B	C	D	
1	*Castanopsis cuspidata* (= *Passania cuspidata*)	♂ ♀		1			With a few larvae and imagines of insects of other families
2	*Cinnamomum Camphora*	♂ ♀			1		This species only
3	*C. micranthum*	♂ ♀			11 17 (1)	28 14 (7)	In the case of C, with two larvae of *Cerambycidae* and one imago of *Ipidae*. In the case of D, with many larvae of *Lymexylonidae* and a few imagines of *Ipidae*.

No.	TREES ATTACKED	Sex of Insects	PLACE A	B	C	D	REMARKS
4	*Machilus longipaniculata*	♂	8				With a few imagines of *Xyleborus*
		♀	7				and a few larvae of *Cerambycidae*
5	*Tetradenia Konishii*	♂					With many imagines of *Ipidae*
		♀		2			
6	*Cryptocarya chinensis*	♂					This species only
		♀	1				
7	*Melia Azedarach*	♂				(1) 2	With a few imagines of *Ipidae*
		♀				3	
8	*Gordonia axillaris*	♂		11			With many imagines of *Xyleborus*
		♀		10			and a few larvae of *Cerambycidae*
9	*Ternstroemia japonica*	♂		34			With many larvae of *Cerambycidae*
	(= *Taonabo japonica*)	♀		50			and one imago of *Xyleborus*
	Total	♂	8	46	12	31	97 } 200
		♀	8	62	17	16	103

N.B. The underline shows the place in which the logs were set out and the figures in brackets give the larvae obtained.

By comparing the number of species of trees in Table II and these of the same family used in the experiment, the following table was obtained.

TABLE III

NUMBER OF TREES USED IN THE EXPERIMENT AND PERCENTAGE OF SPECIES ATTACKED BY *CROSSOTARSUS RENGETENSIS* NIIJIMA ET MURAYAMA

FAMILY	I Number of species used in this experiment	II Number of species attacked	III % attacked	IV % of total attacked
Fagaceae	7	1	12.5	11.1
Lauraceae	9	5	55.6	55.6
Meliaceae	1	1	100.0	11.1
Theaceae	6	2	33.3	22.2
Total	24	9	37.5	100.0

With the exception of *Meliaceae* of which one species only was used, *Fagaceae* gave the lowest percentage in both III and IV, *Theaceae* came next in order, and *Lauraceae* showed the highest percentage. Therefore, the conclusion comes to us that the trees specially selected by *C. rengetensis* belong to *Lauraceae* and *Theaceae*. This result is interesting, that *Crossotarsi* in Kyushiu chiefly attack trees belonging to *Fagaceae*.

Table II also shows that, the species of trees and other conditions being the same, the *C. rengetensis* selects those logs set out in the forest in preference to those in open spaces. In Nos. 5, 7 and 8 this insect attacked exclusively the logs in the forest. The only exception was in the case of *Cryptocarya chinensis* HEMSLEY. In the logs of *Cinnamomum micranthum* HAYATA the number of insects obtained and the degree of damage done were about equal in both inner and outer parts of the forest. This clearly proves that its preference is for *Cinnamomum micranthum* HAYATA.

By comparing the spaces A and C, more insects were obtained and greater damage to trees discovered in C than in A. The difference between A and C lies in the greater breadth of A and in its southern slope, as compared with the narrower breadth and the eastern slope of C. This accounts for the difference in the periods and intensity of sunshine experienced by them, and naturally for the different degree of dryness of the logs. STEBBING[1] noted in the *Platypi* and *Crossotarsi* of India that "the insects would appear to infest only the timber of freshly fallen or of dying trees in the forest. They will not attack dry timber. This is understandable if it is remembered that the larvae require walls of the egg-tunnel made by the beetle to be sappy, and thus affording them the sustenance they require." This is also acceptable in the case of *C. rengetensis* and appears still more so when their system of tunnelling is considered.

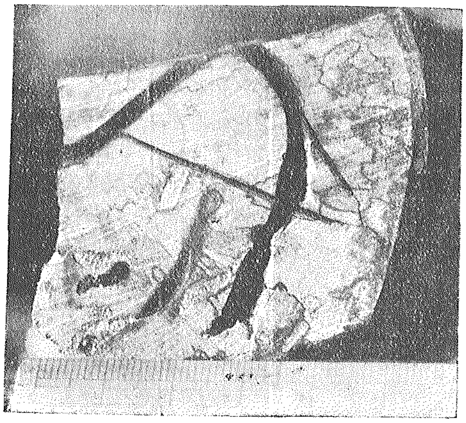


Fig. 1.

Crossection of a timber of *Ternstroemia japonica* infested by *Crossotarsus rengetensis* showing the mother-tunnel and entrances to the perpendicular tunnels (natural size).

Fig. 1 shows a cross section of the timber of *Ternstroemia japonica* infested by *C. rengetensis*. As shown in this figure the mother-tunnel comes straight down from the upper part of laid timber in the direction of the medullary ray, cutting the wood fibres perpendicularly, passing through the pith and nearly reaching the rotten part in contact with the sleepers, where it turns aside and follows the annual ring. The tunnel is black throughout and has a diameter of 3 mm. Throughout the entire length of the tunnel, 5 holes are noticeable at intervals of 12–20 mm. Three more holes are seen tunnelled in the opposite side.

(1.) STEBBING, Indian Forest Insects, p. 612 (1914).

These holes are the entrances to the longitudinal branches running paralled to the wood fibres. The entrances, in agreement with the description given by STROHMEYER(1) of the *Platypus cylindrus* var? *cylindriformis* REITTER, have a rounded side in the direction through which the female beetle enters. The opposite side is sharp. This form of entrance is also found in the secondary and tertiary branchings of the tunnel.

Fig. 2 shows the two split surfaces along the line connecting the centres of the first and fourth entrances of the female tunnel in Fig. 1. The fourth entrance leads to a hole 10 mm. deep. This hole exactly corresponds to the pupal cradle and is found at the termination of each branch tunnel. The longitudinal branch tunnel from the first entrance continues unbroken for 5 mm., then branches out again at every 10 or 20 mm. Each branching continues obliquely for 20 mm., then turns in a direction parallel with the wood fibres, divergeing again in the same way, and finally ending in two pupal cradles. The whole shape resembles the pendent branches of the weeping willow. According to STROHMEYER(2) this shape also appears in the tunnels of *Crossotarsus Leconti* CHAPPUIS in *Gyrocarpus Jacquini* ROXBURG from the Philippines and is the special form of tunnelling of *Platypodidae*. EGGERS(3) also noted that this form is seen in the holes of *Xyleborus Pfeili* RATZEBURG, though the life history of these two species differs. The author also recognized the some form of holes made by *Platypus lepidus* CHAPPUIS subsp. *formosanus* NIIJIMA et MURAYAMA in the timber of *Lagerstroemia subcostata* KOEHNE in the same place (c) as the *Ternstroemia japonica* THUNBERG and by *Xyleborus* sp? in a trunk of *Cinnamomum Camphora* NEES et EBELMAIRE var. *nominale* HAYATA from Kuraru (a district in the southern part of Formosa).

Fig. 2.

Longitudinal section of the same piece of timber given in Fig. 1. showing the perpendicular tunnels and pupal cradles

Though the timber tunnelled by *Crossotarsus rengetensis* is often inhabited by insects of other families, I found no other insect in the holes made by *Cros-*

(1) STROHMEYER, Neue Untersuchungen über Biologie, Schädlichkeit und Vorkommen des Eichenkernkäfers, *Platypus cylindrus* var? *cylindriformis* REITTER, Naturw. Zeitschr. für Land- und Forstw. 4 Jahrg. 10 Heft, p. 419 (1906).

(2) STROHMEYER, *Platypodidae* (in Genera Insectorum), p. 10 (1914). Kleine Beobachtungen über verschiedene Forstshädlinge, Ent. Bl. p. 251 (1912).

(3) EGGERS, Zur Gangform und Lebensweise von *Xyleborus Pheili* RATZ., Ent. Bl. 4 Jahrg. pp. 4-7 (1908).

sotarsus rengetensis. This fact, combined with the special system of tunnelling, shows that these holes are exclusively tunnelled by this species, and if some fungi do exist in these holes they certainly do not come from the holes of other insect species in the same trunk. The determination of the food of this insect in its natural state is of a great importance to the forestry of Formosa. Therefore, the testing of the substances found in its holes and comparison of the results with the contents of the intestinal canals of the insect is of an atmost importance.

The black substance covering the surface of the holes consists of two layers. The outer layer is formed of a very crumbly material which seems quite to coincide with the description of the original "ambrosia", the inner layer is composed of numbers of mycelia tangled together (Fig. 3). These mycelia propagate in the wood, especially in the ducts, trachides and medullary rays, and

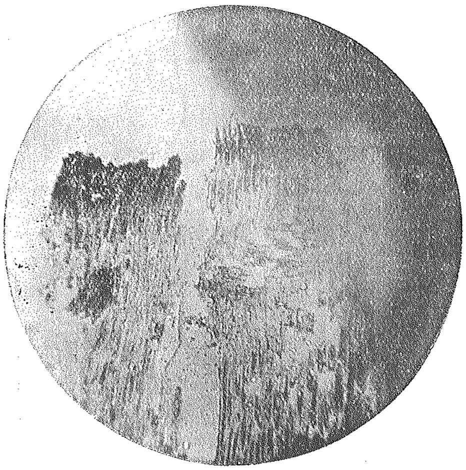


Fig. 3.

Longitudinal section of the same through the mothertunnel of *Crossotarsus rengetensis* showing the layer of ambrosia and mycelia.

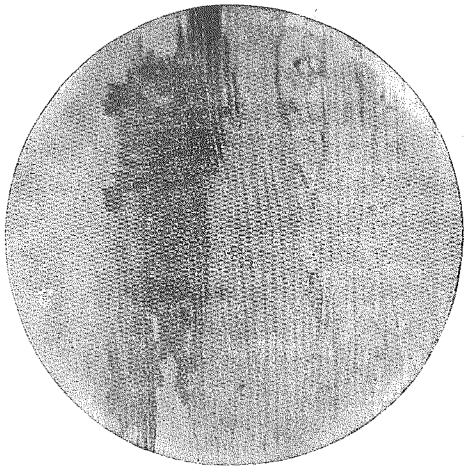


Fig. 4.

Longitudinal section of the same showing the tangled masses of mycelia in ducts, medullary rays etc.

may also be found in the macroscopically healthy part of the wood (Fig. 4). The insects of this species have no appendages or bristles on the front as a means of transporting fungi as in the cases described by STROHMEYER[1], on the contrary, their upper surfaces are smooth and shining. Therefore, whether the fungi in the holes were imported by the insects or invade their way through

(1) STROHMEYER, Die biologische Bedeutung sekunderer Geschrechtscharaktere am Kopfe weiblicher *Protypodiden.* Ent. Bl. Vol. VII, pp. 103-107 (1911).

the ducts, etc., can not easily be determined. Laying aside the testing of the fungi, many characteristics go to show that this insect is probably an "ambrosia beetle", such as the bristles on the inside edges of its maxillae, the structure of the chitinous part of the proventriculus, and the system of tunnelled holes closely resembling that of *Saetiaentatae* of HAGEDORN[1], especially that of *Xyleborous*, the fact that they live together in the same trunk, their omnivorous nature, and their preference for moist parts of the wood as the place for deposting their eggs. According to R. KLEINE[2] these features have a special bearing on their easy distribution in tropical and subtropical districts.

The determination of the species of fungi in the holes, generally, is very difficult and uncertain. In spite of many experiments in the pure culture of ambrosia fungi, NEGER[3] and SCHNEIDEK-ORELLI[4] were unable to obtain enough clear results by which to determine definitely the species of the fungi. Unfortunately the author's material from Formosa is too old and has been too badly mishandled to be placed in the hands of specialists for the purpose of artificial culture.

To determine the inner substances of the intestinal canals, especially those of the oesophagi and proventriculi, I used the imagines of this species from the wood of three species of trees in table II and obtained the following results:

TABLE IV

CONTENTS OF INTESTINES OF IMAGINES OF *CROSSOTARSUS RENGETENSIS* NIIJIMA ET MURAYAMA

Trees attacked	Place	Sex of insects	Number of specimens used	Condition of intestines	
				Empty	With contents
Cinnamomum micranthum	D	♂	21	17	4
		♀	5	5	0
Goldonia axillaris	B	♂	7	6	1
		♀	4	3	1
Ternstroemia japonica	B	♂	2	3	0
		♀	3	1	1
Total		♂	30 } 42	26 } 35	5 } 7
		♀	12	9	2

(1) HAGEDORN, Zur System der Borkenkäfer. Ent. Bl. Vol. 5. No. 7/8 pp. 134-141 (1909).

(2) R. KLEINE, Die geographische Verbreitung der Ipiden. Ent Bl. Vol. 8. No. 6/7, pp. 160-161(1912).

(3) NEGER, Biologie der Pflanzen. pp. 503-511 (1912), Ambrosiapilze II, IV, Berichte d. deutsch. Botan. Gesellschaft. Bd. XXVII (1909), XXIX (1911).

(4) SCHNEIDER-ORELLI, Die Uebertragung und Keimung des Ambrosiapilze von *X. dispar*. Naturw. Zeitschr. f. Forst-u. Landwirt. (1911).

As shown in this table, the intestines with contents were very few in number and the components of the contents, though very carefully microscopically and otherwise analysed, still remain undetermined. From this, I deduce that the imagines of this species require but little nourishment. On the other hand, the intestinal canals of the larvae were filled, from mouth to anus, with a thick black substance. Whether this substance is the same with the ambrosia in the holes or not could not be determined with any certainty by mere observation under the microscope. As the larvae have soft white skins and very weak legs, they show themselves inhabitants of the innermost holes, and so naturally feed upon the milky sap of the tree, on the mucus of ambrosia fungus, or on the fungus itself. They do not bore holes, except pupal cradles, on attaining full growth, and have strong mandibles with two or three sharply dentated inside edges. This part of the mouth is not necessary if life is nourished only by sap or mucus, but suitable for crumbling the ambrosia and cutting the mycelia. The fact that I found a quantity of mycelia in the oesophagi of larvae sufficiently proves that they feed upon the ambrosia fungi(Fig. 5).

Recognition of these considerations and experiments are of much importance in combating the wood pests resulting from these insects.

Keeping the logs in a condition to prevent the development of fungus growth, is an important factor in the protection of timber from the insect pest. In boring their holes, the imagines prefer wet or moist timber and deposit their eggs in these parts; the larvae feed upon the fungi growing in them or probably upon the tree sap, and the fungi seem to be transported from one to other timber. These facts show that the most successful method of avoiding diminution in value of the timber lies in the earliest possible transportation of the logs from the forests and storage of them to dry sunny places, or preserving them in water. The abundant sunshine and water of Formosa are an everlasting and merciful provision of nature for this purpose. Stripping the bark, which is the usual method in the temperate zone, is of no use for preventing these insects from boring, because their progress in boring holes is quicker than the progress made in the natural dry-

Fig. 5.

Contents of oesophagus of a larva of *Crossotersus rengetensis*. The scattered minute parallel lines are mycelia.

drying of the timber in the forests or in their immediate neighbourhood.

摘　　要

レンゲチナガキクヒムシ *Crossotarsus rengetensis* は臺灣の此屬中最大被害をなすものなるが、其被害樹種と狀況さを知る爲めに蓮華池森林に於て六十種の樹種を用ひて試驗を行ひたり。其結果は樟科と山茶科のもの最も多くして同屬の虫が九州にて主さして被害を及ぼす山毛欅科に最少なるは奇さ云べし。場所に關してば開放地よりは林内を好む、即ち陽光の強くして樹幹の乾燥し易きときは穿孔するこさ少なきが如し。此虫の穿孔の形は先づ髓線の方向に進みそれより水平に曲り更に垂直に纖維の方向に柳の垂技の如き狀態をなして分技す。穿孔の內面は黑色をなす。此部は二層より成り、外層は所謂「アムブロシヤ」菌にして、內層は其菌糸の集合せるものなり。幼虫の食道は全く黑色の物質にて充たさる。之は生活の時に採りたる「アムブロシヤ」さ其菌糸に由るものなり。故に此虫の被害を防がんとせば伐採せる木材を可及的速かに乾燥して材中の水分を除き、「アムブロシヤ」菌の繁殖を防止するを一良法さす。

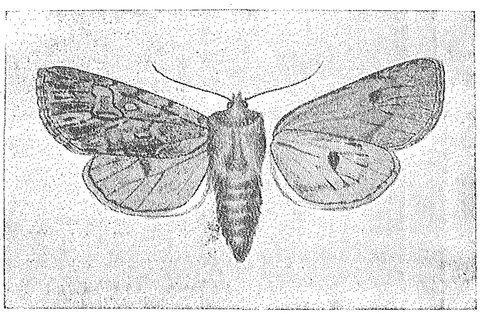
A NEW MOTH FROM HOKKAIDO

By

PROF. DR. S. MATSUMURA

Brachionycha nebeculosa jezoensis n. subsp.

♀. From the typical *B. nebeculosa* ESP. differs in the following points: Upperside—Primaries at the base with an excurved black subbasal line; antemedial line serrated, defined by whity gray at the innerside; claviform at the outer end with a whity speck; dorsum in the middle broadly infuscated; orbicular smaller; reniform larger, at its base with a downwardly curved black arc; interspaces 2, 4 and 6 filled in with each a black patch, leaving the ground colour at the termen.



Brachionycha nebeculosa jezoensis MATS.

♂. Paler in colour and the marking in the interspaces being smaller.

Exp.—♂ 52–♀ 54 mm.

Hab.—Hokkaido (Sapporo); 3 (1 ♂, 2 ♀) specimens were collected on the 2nd of May, 1927, at the park MARUYAMA by T. UCHIDA.