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Biological activates and effect of some treatments on the infestation with wooden furniture beetle *Lyctus brunneus* (Coleoptera: Lyctidae) in Egypt

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Abstract

Powder post beetle, *Lyctus brunneus* Stephens (Coleoptera: Lyctidae) attacks the sapwood of certain hardwoods, either raw or working wood, of many wooden hosts, under suitable conditions of infestation causing destructive and reducing the infested wood to fine powder .The means of different oviposition periods were 2.4, 10.6 and 2.8 days for pre-oviposition, oviposition, and post-oviposition periods, respectively. The mean number of laid eggs/ females was about 21.4 eggs, the mean incubation period was 14.4 days. The larval stage duration ranged from 142 to 208 days according to different factors which govern brood growth (Such as the size of wood pores, starch and moisture contents, temperature, and relative humidity). The duration of the pupal stage ranged from 11-29 days, while the adult longevity ranged 10-22 days. The total life cycle of *L. brunneus* beetle rearing on an artificial diet varied from 170 to 280 days under laboratory conditions, ranging from 18-34 °C and 59-76% RH. The total duration for means of the different developmental stages was 218.5 days (About 7.28 months). The results showed a highly significant correlation between both starch and moisture contents and each number of emerged beetles and adult longevity on different wood species. The surface treatment of wood with Polyurethane Varnish, Nitrocellulose Sealer, Nitrocellulose Sealer and Alkyd Varnish, Saniton, Saniton and Wood putty, Oil paint (lacquer), and insecticide gave protection to intact wood from infestation, while these materials no prevent the beetle's emergence from infested wood except the insecticide with kerosene.

Introduction

All parts of trees in different growth stages are vulnerable to insect attacks. Lyctid beetles are known as powder post beetles because they reduce the wood to flour-like powder. The lyctidae are known as true powder post beetles in the United States (Ebeling, 1975). The most common lyctine found in binding wood is *L. brunneus* (Anon, 1935; Bootle, 1985; Creffield *et al*., 1995; Creffield, 1996 and Peters *et al*., 1996). Powder post beetles are pests of the sapwood of certain hardwood timber species. In Tasmania, *L. brunneus* is a very common species attacking drying hardwood timber (Gadgil *et al*., 1996). Lyctine beetles attack

only the sapwood and not softwood species found in Queensland, *L. brunneus* is the most destructive and common species (Peters *et al*., 1996).

The lyctid powder post beetles have been recognized as serious borers attacking wood products (either raw or working wood). In Egypt, the first record of any lyctid infestation is probably that of Zacher (1934), also, El-Zoheiry and Mohamed (1949) listed *L. brunneus* Stephens, *Lyctus cornifrons* Lesne and *Lyctus* linearis Goeze from Egypt. Some investigators carried out certain works on Lyctus beetles such as, Helal, 1981, a,b,c; 1984; Helal and El-Sebay, 1980, 1981 and 1985; El-Sebay and Helal, 1995; El-Sebay, 1995 ; Ali, 2013 and Batt and Ahmed, 2018, a and b.

This work was carried out during the different times of 2022 and 2023 seasons to study some items related to the furniture beetle, *L. brunneus* such as, some biological activities, the susceptibility of some wood species for infestation comprised different hosts, the influence of the percentage of each starch and moisture contents of wood, as well as the effect of some surface treatments of wood on the infestation with *L. brunneus* beetle.

Materials and methods

1. Laboratory culture of borer:

Samples of oak wood boards infested with *L. brunneus* beetles were collected from infested floor woods, besides, the emerged beetles collected from infested furniture wood at Giza governorate during the period from early August to the end of October 2022. A laboratory culture was established by rearing this species using the previous samples with some intact wood boards to obtain a permanent source of beetles, under natural conditions.

2. Biological activities:

To study some biological activities of *L.brunneus* beetles, an artificial diet was laboratory prepared to study the different stages.

2.1. Preparing the artificial diet:

The used diet consisted of a paste of white corn flour 75%, sawdust of oak wood 15%, dried yeast 5%, sugar 3.5% and Ascorbic acid 1.5%, these components were mixed and added hot distilled water until the paste was formed, then divided into small pieces (8x4x2cm) and dried for three days at 60°C in electric oven.

2.2. Laboratory rearing of *Lyctus brunneus* beetle:

Thirty plastic boxes (12cm x 6cm x 5cm), each contained on one piece of artificial diet (8 cm x4 cm x2cm) with one couple (♀, ♂) of newly emerged beetles from previously collected samples and covered with muslin. Continue observation and daily inspection until a new generation of beetle's emergence.

3. The susceptibility of some wood species for infestation with *Lyctus brunneus* beetle:

The susceptibility of some wood species used in buildings, floors, ceilings, furniture, agricultural tools and ordinary lifeworks was investigated. Three variables determine the susceptibility of sapwood to lyctine attack: pore size, starch content and moisture content (Cymorek, 1966), so, some of these variables were determined in some wood species to detect the susceptibility range of tested wood to infestation with *L.brunneus* beetle. The tested woods are *Poinciana regia, Acacia Arabica, Dalbergia sisso, Albizzia lebbek, Morus alba, Eucalyptus rostrata, Bambosa arundinacea, Casuarina equistifolia* and *Quercus* sp.

Twenty pieces (20 cm long x 3 cm diameter) from each host were placed separately in glass Jars (31.5cm X16.2cm X14.5 cm), 5 couples of beetles from the laboratory culture of *L.brunneus* were released in each Jar and covered with a muslin cloth. Daily observations were carried

out to determine the adult longevity, number of emerged beetles (Progeny / female) and length of emergence period which are affected by moisture content and starch amount.

3.1. Determination of wood moisture content:

Samples of tested wood were weighed and dried up in an air oven regulated at 135°C (± 2°C) for 2hrs. The samples were transferred to cool down and weighed, this process was repeated until the nearly constant weight of the wood. The percentage of moisture content could be determined, as follows:

$$\text{Moisture content \%} = \frac{\text{Sample weight before drying} - \text{Dry sample weight.}}{\text{Weight the sample before drying.}} \times 100$$

3.2. Determination of wood starch content:

The percentages of starch content in tested wood species are estimated by the Laboratory of Plant Physiology Department, Faculty of Agriculture, Menoufia University, according to methods of AOAC 996.11 and 76.13 (Vasanthan *et al*., 2005 and Megazyme, 2009).

4. Influence of different surface treatments:

To determine the effect of surface treatments of certain materials on the infestation of different types of wood with *L. brunneus* beetles, the intact and infested oak wood pieces (Measured 23cm x7cm x 1.5 cm) were prepared. Each five pieces (Intact and infested) were treated with one of the tested materials: Polyurethane Varnish, Nitrocellulose Sealer, Alkyd Varnish, Saniton, Wood putty, Oil paint (Lacquer), and the insecticide (Ranous) (Table 1).

Table (1): List of tested materials used to control *Lyctus brunneus* beetles.

No.	Name	Dilution	Application
1	**Polyurethane Varnish**	20-30% thinner	2 layers with spray gun
2	**Nitrocellulose Surfacer Sealer**	20-30% thinner	2 layers by using cotton
3	**Alkyd Varnish**	10-15% White spirit	2 layers with brush
4	**Saniton**	10-15% White spirit	2 layers with brush
5	**Wood putty (Animal glue +Boiled Linseed Oil +Zinc oxide + Spedage)**	(1Kg Animal glue :0.5 Boiled Linseed Oil Kg :2Kg: Zinc oxide 6 Kg Spedage)	2 layers with putty knife
6	**Lacquer**	10-15% White spirit	2 layers with brush
7	**Ranous (Bifenthrin)**	$3cm^3$/L white kerosene	1 layer with brush

The treatments carried out by the paint of the surface of wood with previous materials, in groups as follows:

- Surface treatment from all sides for infested wood.
- Surface treatment of one side face for infested wood.
- Surface treatment from all sides for intact wood.
- Surface treatment of one side face for intact wood.
- Infested wood without treatment.
- Intact wood without treatment.

The intact oak wood pieces (Treated and untreated) were liable to infestation by newly emerged beetles. Treated and untreated pieces were left until the beetle's emergence. The results were recorded.

5. Statistically analysis:

The obtained data were statistically analyzed using SAS program (2003).

Results and discussions

1. Some biological activities for *Lyctus brunneus*:

1.1. Egg stage:

After emergence, the mature beetle mate and egg-laying begin, oviposition begins 2 or 3 days later with a mean of 2.4 ± 0.49 days, Table (2). The oviposition period ranged 7-15 days, with a mean of 10.6 ± 2.73 days, while the duration of post-oviposition period ranged from 2-4 days, with a mean of 2.8 ± 0.79 days (Table 2).

The female beetle deposited about 17-32 eggs, with a mean of 21.4 ± 5.32 eggs (Table 2), at the rate of about 1to 3eggs in each hole. The egg is about 0.5-1 mm long, with a mean of 0.62 ± 0.16 mm, translucent white, and cylindrical, with rounded ends, and bears a thread like process on the anterior end. The incubation period ranged from 1 to 3 weeks, with a mean of 14.4 ± 3.75 days (Table 3).

The longest incubation period for *L.africanus* eggs was 13 days at 20°C combined with 75% RH, while the shortest one (2.6 days) was at 35°C and 45% RH. (Helal, 1981 b). Batt and Ramadan (2018) recorded that the highest incubation period for *L. linearis* ranged from 8-12, days at 16.9 °C and 54.6% RH., while the lowest incubation period ranged from 4 -7 days at 32.2 °C and 44.6% RH.

1.2. Larval stage:

The larva is typically lyctidae. On hatching, larvae are about 0.5-0.7mm long, with a mean 0.53 ± 0.06 mm, (Table 3), pale cream-colored with a brown head and bears three pairs of small, jointed legs, larva is white has darker spots (Breathing pores) on either side near rear of body, straight bodied, and bears a pair of small spines at the rear. After the first molt, the larva assumes a curved from c shaped. A mature larva is white, about 5-7 mm. long, with a mean of 6 ± 0.63mm. (Table 3), curved and enlarged at the thorax, its antennae are 3-segmented and have an accessory appendage. The abdomen bears 8 spiracles; the legs are small, distinct, 3-segmented, and unclawed. The estimated period of larval development varied from 142-208 days with a mean of 171 ± 21.4 days, Table (3), depending on temperature and humidity. The larvae are found all year round in an infested host. Gerberg (1957), found that the life cycle may take from 30-48 months or longer, under adverse conditions.

The larval duration of *L. africanus* beetles ranged from 18 -96 days, during different generations, Helal (1981c). While the larval duration recorded 28-108 days of *L. linearis* reared on royal Poinciana wood (Mohamed, 2013). Whereas, Batt and Ramadan (2018) found that the longest larval duration for *L.linearis*, lasted 74-79 days, at 17.3°C and 57.7% RH., while the shortest duration of the larva ranged from 17-21 days, , at 31.4 °C and 45.9 % RH.

1.3. Pupal stage:

The mature fully grown larva bores to a point near the surface and excavates a small oval cell (Pupal chamber). Inside the pupal chamber the fully grown larva enters into prepupa form, lasting 2-5 days, then metamorphoses to pupa. The duration of the pupal stage is variable, but it usually lasts from 11days to 29 days, with a mean of 19 ± 5.50 days, (Table 3). The longest pupal duration of *L. africanus* beetle (44.3 days) occurred at 20°C and 75% RH and the shortest duration (7.4 days) occurred at 35°C and 45% RH., Helal (1981b). Whereas Haggag and Batt (2000) found that the pupal stage of *L. impressus* beetle ranged from 5 to 18 days. Also, Batt and Ramadan (2018) reported that the longest pupal duration for *L. linearis* recorded at 9-14 days, with an at 22.5 °C and 59.1% RH., while the shortest one was ranged from 5 -8 days, at an average of 34.6 °C and 50.6% RH.

1.4. Adult stage:

The adult beetle is 4-7 mm. long, with a mean of 6.1 ± 0.94 mm. (Table 3), flattened,

elongated with roughly parallel sides. The beetles have a prominent distinct head not covered by the prothorax; the two terminal segments of the antennae are enlarged to form a compacted club. The thorax, which is as long as it is broad, has a shallow depression along its mid-line. The parallel sided elytra (Wing cases) have regular longitudinal rows of punetures; the tibiae with distinct spurs. The color is reddish brown to black, shiny; the prothorax is wider in front than behind. The hairs on the wing cases have no definite arrangement. The adult longevity ranged from 10-22 days, with a mean of 14.1 ± 3.93-day (Table 3).

The previous results indicated that the total life cycle for *L. brunneus* rearing on an artificial diet ranged from 170-280 days (About 5.7-9.3 months), the total duration of the developmental stages was 218.5 days (About 7.28 months).

Table (2): Ovipositional periods of *Lyctus brunneus* female beetles rearing on artificial diet under lab. Cond. of 18-34°C and 59-76% RH.

Items	Duration of Ovipositional periods (In days)			Number of laid eggs/ female beetle
	Pre- Oviposition	Oviposition	Post- Oviposition	
M ± S.d.	2.4 ± 0.49	10.6 ± 2.73	2.8 ± 0.79	21.4 ± 5.32
Range	2 - 3	7 - 15	2 - 4	17 – 32

Table (3): Biological activities of developmental stages of *Lyctus brunneus* beetle under lab. Cond. of 18-34°C and 59-76% RH.

Stage	Measurements (mm)		Duration (in days)	
	M. ± s.d	Range	M. ± s.d	Range
Egg	0.62 ± 0.16	0.5 – 1	14.4 ± 3.75	7 – 21
Hatching Larvae	0.53 ± 0.06	0.5 – 0.7	171 ± 21.49	142 – 208
Mature larvae	6 ± 0.63	5 – 7		
Pupa	5.30 ± 0.62	4 – 6	19.0 ± 5.50	11 – 29
Adult ♀	6.1 ± 0.94	4 – 7	14.1 ± 3.93	10 – 22
Adult ♂	5.8 ± 0.87	5 - 7		
Total	--	--	218.5	170 – 280

2. The susceptibility of some wood species for infestation with *Lyctus brunneus* beetle

2.1. Hosts:

This beetle infested *Acacia Arabica* Willd (*Egyptian acacia*), *Eucalyptus* sp. (*Eucalypt rostrata*), *Ulmus* sp. (Elm), *Morus* sp. (Mulberry), *Bambusa arundinacea* willd (Bamboo), *Dalbergia sisso* Roxb. (Sisso), *Casuarina equistifolia* (Casuarina), *Poinciana regia* (Poinciana), *Albizzia lebbeck* (Lebbek) and *Quercus* sp. (Oak). Lyctid powder post beetles attack only the sapwood of hardwoods (Peters *et al.*,1996).

In this respect, El-Zoheiry and Mohamed (1949) and Nour (1963a) recorded that the beetles of this borer were collected from acacia, bamboo, sisso, beech, mango, poinciana and oak. Also, Alfieri (1976) recorded that *L. brunneus* emerged from dry bamboo, lebbek, dry timber and oak flooring. Whereas Shi and Tan (1987) stated that these beetles attacked Chinese hardwood.

2.2. Effect of starch and moisture contents of different wooden hosts of *Lyctus brunneus* beetle on each of adult longevity and number of emerged beetles:

Data on the percentages of both starch and moisture contents and their influence on a number of emerged beetles and adult longevity are illustrated in Table (4).

2.2.1. Influence of starch content:

Obtained data in Table 4 detected that the percentages of starch content for tested hosts showed that the Poinciana wood had the largest content of starch (12.9%) and resulted in the highest number of emerged *L. brunneus* beetles (16.2 beetles/ female), which lived of about 24.5 days, while the

smallness starch content found in casuarina wood (3%) and gave the least number of emerged beetles (3.2 beetles/ female), while lived the shortest time (4.6 days). The other hosts appeared with various results ranging between 5.9% (Lebbek) to 3.2% (Mulberry) for starch content, while showed 9.3 beetles/ female (Lebbek) and 4.3 beetles/ female (Mulberry) for adult emergence whereas detected at 17.1 days (Lebbek) -5.2 days (Kafour) for adult longevity.

The recorded data in Table (5), showed a highly significant positive correlation between starch content with both numbers of emerged beetles (r= 0.96) and adult longevity (r= 0.79) (Table 5).

2.2.2. Influence of moisture content:

According to data illustrated in Table (4), the highest percentage of moisture content was (12.8%) recorded for poinciana wood resulting in 16.2 beetles/ female, these lived for about 24.5 days, while the lowest percentage was (8.2%) recorded for casuarina wood and gave 3.2 beetles/ female, which lived of about 4.6 days. The other remaining data detected differences between the obtained values of each moisture content, a number of emerged beetles and adult longevity, the ranges of these values varied from 11.7% (Lebbek) to 8.3% (Oak) for moisture content; 9.2 beetles/ female (Lebbek) to 4.3 beetles/ female (Mulberry) for beetles emergence and 17.1 days (Lebbek) to 5.2 days (Kafour) for adult longevity. The relation between the moisture content of wood and each number of emerged beetles and the longevity of adults showed a highly significant correlation (r=0.80) for beetles emergence and a moderate correlation (r=0.59) for adults, Table (5). The previous results reflect the influence of starch and moisture contents on *L. brunneus* life within their different wooden hosts.

Ali (2013) found that the longevity of *L. africanus* beetle varied on the different tested hosts, the longest longevity occurred on poinciana wood (16 days, range 4-30 days), while the shortest one recorded on casuarina wood (3.3 days, ranged 3-5 days).

Table (4): Effect of starch and moisture contents of different hosts for *Lyctus brunneus* beetle on each of emergence and longevity of beetles.

Host wood		Starch content %	Moisture content %	Number of emerged beetles/ females	Adult longevity
Scientific name	common name				
Acacia Arabica	Acacia	5.6	11.5	7.1	16.1
Albizzia lebbek	Lebbek	5.9	11.7	9.3	17.1
Bambosa arundinacea	Bamboo	3.9	9.8	5.1	15.1
Casuarina equistifolia	Casuarina	3.0	8.2	3.2	4.6
Dalbergia sisso	Sisso	4.7	11.3	6.2	13.9
Eucalyptus rostrata	Kafour	4.8	10.1	4.4	5.2
Morus alba	Mulberry	3.2	10.8	4.3	6.3
Poinciana regia	Poinciana	12.9	12.8	16.2	24.5
***Quercus* sp.**	Oak	4.9	8.3	4.6	15.7

Table (5): Effect Starch and Moisture contents on emergence and longevity of *Lyctus brunneus* beetles estimated by simple correlation (r) and simple regression (b).

Factors / Variables	Starch		Moisture	
	simple correlation (r)	Simple regression (b)	simple correlation (r)	Simple regression (b)
Emergence	0.96	1.30	0.80	2.07
Longevity	0.79	1.75	0.59	2.51

3. Effect of some wood surface treatments to protection wooden furniture from lyctus infestation:

According to Table (6), *L.brunneus* beetles emerged from infested wood which superficially treated by each Polyurethane Varnish, Nitrocellulose Sealer and Alkyd Varnish, Saniton, Saniton and Wood putty and Oil paint (Lacquer), while the beetles not emerged from the others treated with insecticide additive to kerosene at a rate 0.3% ($3cm^3$ insecticide / 1litre kerosene). To the point, the surface treatments for intact wood before exposure to the beetles do not show any infestation in treated wood with all different foregoing materials. While the beetles emerged from the infested untreated wood, the intact untreated wood gave a distinguished infestation appearance of lyctus beetle, when they were subjected to beetle's attack.

Previous results indicated that surface treatments for all exposed surfaces protect treated intact wood with each Polyurethane Varnish, Nitrocellulose Sealer and Alkyd Varnish, Saniton, Saniton and Wood putty and Oil paint (Lacquer), where the wood pores are plugged by previous paints to prevent eggs laid, however these treatments no prevent beetles emergence from the infested wood before treatment, while the insecticide gave protection to intact wood and remedy the infested wood.

In Egypt, Helal and El-Sebay (1981) reported that the recommended insecticides for control *L.africanus* are cidial-L 50% EC at 0.3% which gave protection for 24-40 months, Meral 50% EC at 0.3% (16-40 months) and Xylophene 94% at 25% concentration (Over 40 monthly).

Table (6): Effect of some surface treatments of wood on the infestation by *Lyctus brunneus* beetle.

Treatment	Emergence beetles					
	Infested wood			Intact wood		
	Treated		Untreated	Treated		Untreated
	All face	One face		All face	One face	
Polyurethane Varnish	+	+	+	*	●	● & +
Nitrocellulose Sealer	+	+	+	*	●	● & +
Nitrocellulose Sealer And Alkyd Varnish	+	+	+	*	●	● & +
Saniton	+	+	+	*	●	● & +
Saniton, Wood putty and lacquer	+	+	+	*	●	● & +
Insecticide	-	-	+	*	*	● & +
Keys	+ = Emergence			* = No infested		
	- = No emergence			● = Infested		

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