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Sex determination in the Bulls Eye Borer *Phoracantha acanthocera* (Macleay) (Coleoptera: Cerambycidae)

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ABSTRACT

Phoracantha acanthocera (= *Tryphocaria acanthocera*) was studied using behaviour and external morphology to establish characters which could be reliably used to determine sex in live beetles. Elytral width was found to be the most reliable character with females having wider elytra than males.

INTRODUCTION

Phoracantha acanthocera (Macleay) (= *Tryphocaria acanthocera* (Macleay)) is recognized as a serious pest of living eucalypts throughout southern Australia (Wang 1995). In Western Australia (WA) this insect was first mentioned as attacking marri (*Corymbia calophylla* (Lindl.) K.D. Hill & L.A.S. Johnson = *Eucalyptus calophylla* Lindl.) in relation to investigations of kino production (Forests Department 1921-22). Similarly, Clark (1925) and Duffey (1963) refer to *P. acanthocera* as causing 'damage of considerable economic importance' despite not listing as hosts WA's two main timber species, jarrah (*E. marginata* Donn ex Smith) and karri (*E. diversicolor* Muell.). Currently in WA this insect is perceived as a problem in both karri (Newman and Marks 1976; Abbott *et al.* 1991) and jarrah (McKenzie and Donnelly 1993). A study on *P. acanthocera* in regrowth karri (Abbott *et al.* 1991) concluded that infestation rates were related to drought, proximity of coupes to old growth forest, tree age, and sites where karri was a minor component before felling. Recommendations from this work included the need for further investigations into the insect's ecology and oviposition preferences.

With this and the objective of future oviposition and sex recognition behavioural studies in mind it became apparent that there was a need to readily differentiate between the sexes of live beetles. Clarke (1925) reported males as smaller than females and with longer antennae, but otherwise having few differences. Antennal length extending beyond the abdomen and overall body size is appropriate to determine dead specimens, however, this is difficult to apply to live individuals, particularly when minimal handling and disruption are desirable. This study therefore aims to examine morphological features which facilitate the ready identification of live male and female beetles.

MATERIALS AND METHODS

Live adult beetles were captured using light traps located in karri inventory plots Crowea 728 (Lat 34°32'08" S, Long 166°03'46"E) and Warren 1 (Lat 34°31'50" S, Long 115°57'30"E). To ensure that insects were captured alive no killing agent was used in the traps. The traps used 8 watt 16 x 300 mm black light fluorescent tubes which were powered by 12V deep cycle truck batteries. Traps were visited daily from December 1994 to February 1995. Captured beetles were placed separately in ventilated glass containers and transported to the laboratory. Here they were maintained in individual rearing containers and fed a 15 per cent (by weight) honey solution prior to the behavioural study. Beetles were marked with white correction fluid so that individuals could be readily identified.

The behavioural study involved placing nine adult beetles together in a 17.5 cm diameter by 18 cm enclosed arena and noting behaviour against individual identification marks. The base of the arena was lined with paper towelling and two small diameter twigs (approximately 1 cm) were placed diagonally across to provide sites for beetle interactions. Behaviour was attributed as male when the beetle exhibited mounting behaviour, downward curvature of the abdomen and 'licking' as described by Kim *et al.* (1992) and Iwabuchi (1982). Gender was then attributed to individual beetles according to behaviour. The beetles were then examined for morphological features which could be used to easily distinguish the sex of live individuals. Following this gender was ascribed to all the beetles used in the behavioural study using the morphological features formerly deemed most appropriate. The adult beetles were then dissected from the dorsal position to verify the accuracy of sex determination. To verify the reliability of these characters in determining beetle sex, pinned beetle specimens were examined, sexed and the morphological characters of antennal length, elytra length and elytra width were measured. Elytral width was determined by individually measuring right and left elytra at the widest part between shoulder and apex and calculating the sum.

RESULTS AND DISCUSSION

Results of the behaviour, morphology and dissection tests are outlined in Table 1. The test demonstrated that the morphological features discussed below are reliable characters in determining the sex of individual beetles. Beetle number one's exhibition of female behaviour was recorded during a behavioural event with beetle five. Male cerambycid beetles behaving as females in male-male encounters has been recorded by Kim *et al.* (1992).

TABLE 1

Gender determination of *Phoracantha acanthocera* using behavioural, morphological observations and dissection for male (M) and female (F) beetles.

BEETLE	BEHAVIOURAL OBSERVATIONS	MORPHOLOGICAL OBSERVATIONS	DISSECTION
1	M, F	M	M
2	F	F	F
3	F	F	F
4	M, M	M	M
5	M	M	M
6	M	M	M
7	F, F	F	F
8	F	F	F
9	M	M	M

Morphological observations showed that the posterior elytral margins of females (Fig. 1) were more obtuse than those of males (Fig. 2). Elytral spines at apex initially appeared longer for females compared with those of males, however, on closer inspection no difference was found. In live beetles the female abdomen (Fig. 3) does not closely follow the elytral margins and apices compared with those of the male whose abdomen is closely aligned with its elytral margins (Fig. 4). The outer elytral margins of males were more parallel as the insect visually appeared more streamlined. In many instances the terminal abdominal segment of the male may protrude from the base of the elytra, but this was not consistent between specimens. Comparison of the fifth visible sternites showed no easily recognizable differences between sexes.

Beetle dissection verified that elytra shape was the most reliable character to distinguish gender. Sex determination using this character was consistent with dissection results (Table 1).

Measurement of the pinned specimens (Table 2) demonstrated that although males had significantly longer

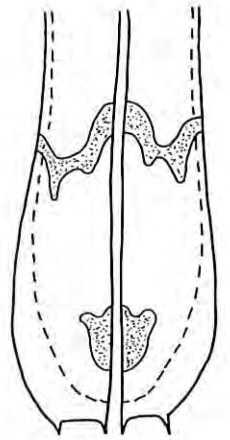

Figure 1. Dorsal view of female elytra. Broken line indicates position of abdominal wall.

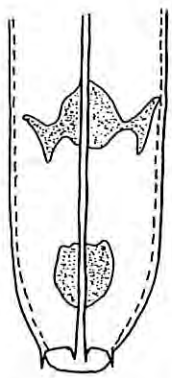

Figure 2. Dorsal view of male elytra. Broken line indicates position of abdominal wall.

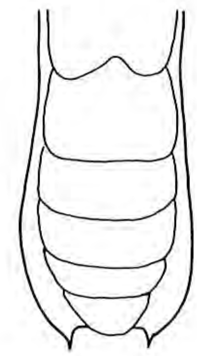

Figure 3. Ventral view of female abdomen and elytral margin.

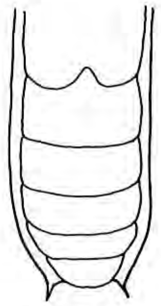

Figure 4. Ventral view of male abdomen and elytral margin.

antennae and shorter elytra, some overlap in these characters between the sexes did exist, particularly for antennal length. The greatest difference between males and females was in elytral width, with a t value of 8.04. Clear differentiation between the sexes was achieved using simple relationships between elytral length, width and antennal length (Table 3). However, these relationships are more applicable to preserved rather than to live beetles, particularly in respect to antennal length.

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TABLE 2

Comparison of means for Antennal length, Elytral length and Elytral width using t tests for independent samples.

	MEAN	RANGE	N	SE	DF	t^a	P
Antennal length (mm)							
Male	40.05	36.32 - 43.83	7	1.24	16	-2.98	0.009
Female	35.69	31.90 - 40.00	11	0.87			
Elytral length (mm)							
Male	19.96	18.47 - 21.91	7	0.52	16	5.988	0
Female	25.36	21.54 - 29.00	11	0.64			
Elytral width (mm)							
Male	8.58	8.01 - 9.33	7	0.16	16	8.043	0
Female	11.58	10.12 - 13.14	11	0.28			

[a] statistic for pooled variances

Critical $t_{0.05\,(16)} = 2.120$

TABLE 3

Differentiation between male and female beetles using relationships between Antennal length (Ant len), Elytral length (Ely len) and Elytral width (Ely wid), expressed as a range.

	Ely len x Ely wid	Ant len/Ely wid	Ant len/(Ely len x Ely wid)
Male	158.12 - 203.86	4.30 - 4.94	0.21 - 0.26
Female	217.98 - 367.66	2.93 - 3.25	0.11 - 0.15