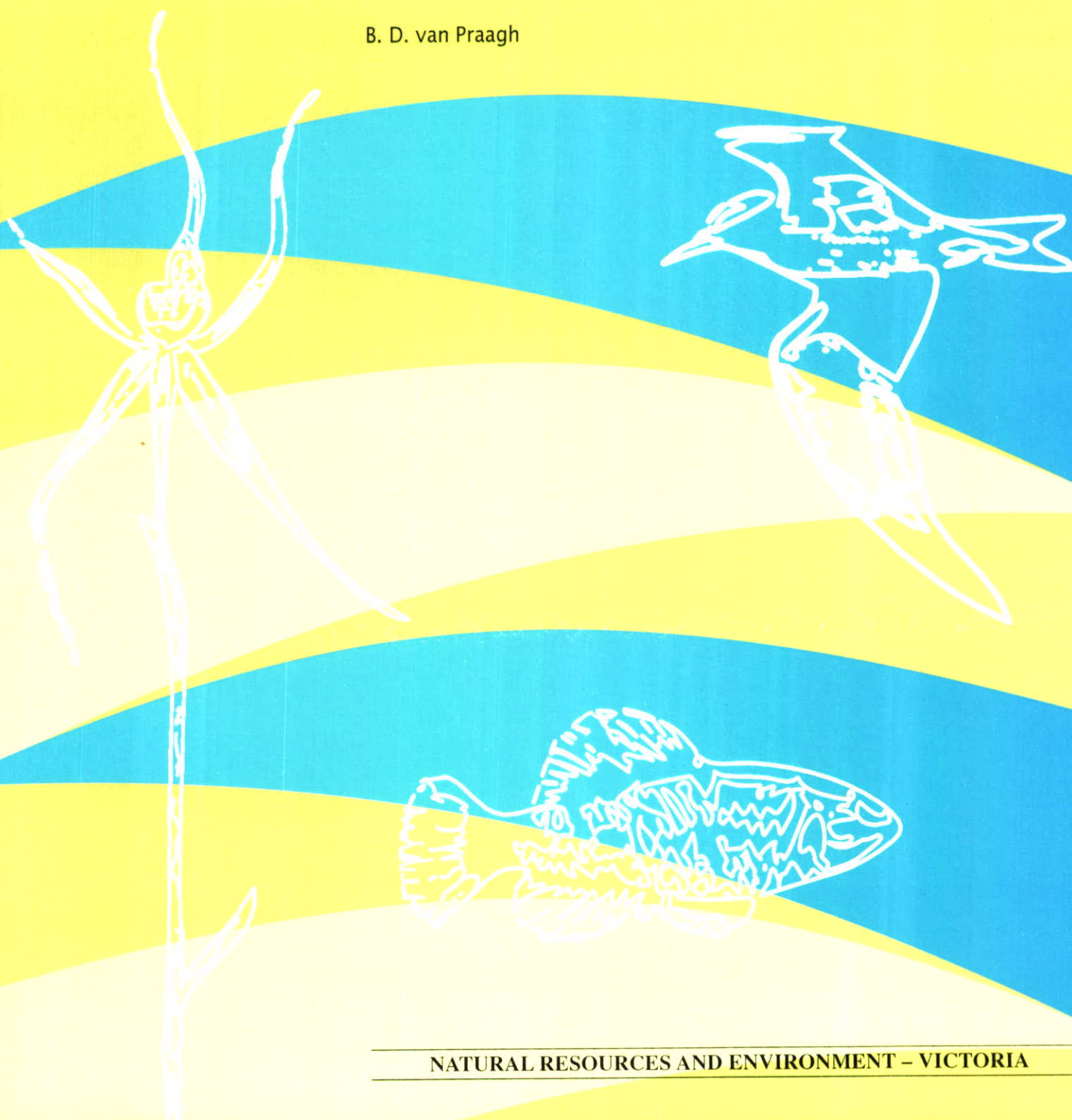


Adult and larval counts of the  
Eltham Copper Butterfly, *Paralucia*  
*pyrodiscus lucida* Crosby, 1993–1995

B. D. van Praagh



**ADULT AND LARVAL COUNTS OF THE  
ELTHAM COPPER BUTTERFLY,  
*PARALUCIA PYRODISCUS LUCIDA* CROSBY,  
1993–1995**

---

**B. D. van Praagh**

Invertebrate Survey Section, Museum of Victoria, 71 Victoria Crescent, Abbotsford 3067

Department of Natural Resources and Environment  
September 1996

ISSN 1326–6446

© Crown (State of Victoria) 1996

Published by the Department of Natural Resources and Environment  
240 Victoria Parade, East Melbourne 3002

This publication is copyright. Apart from any fair dealing for private study, research, criticism or review allowed under the Copyright Act 1968, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying or other, without the prior permission of the copyright holder.

Citation

Van Praagh, B.D. (1996) Adult and larval counts of the Eltham Copper Butterfly, *Paralucia pyrodiscus lucida* Crosby, 1993–1995. Flora and Fauna Technical Report No. 144. Department of Natural Resources and Environment: Melbourne.

Cover design by Marius Foley Graphic Design, Port Melbourne

Designed, edited and produced by the Arthur Rylah Institute for Environmental Research  
123 Brown Street, Heidelberg, Victoria 3084

Printed on recycled paper to help conserve our natural environment

# CONTENTS

SUMMARY.....	iv
1 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Aims of the study .....	3
2 MATERIALS AND METHODS.....	4
2.1 Study Sites .....	4
2.1.1 Kiata .....	4
2.1.2 Salisbury Reserve .....	5
2.1.3 Castlemaine Botanic Gardens.....	5
2.1.4 Eltham .....	5
2.2 General Methods.....	7
2.2.1 Adult counts.....	7
2.2.2 Larval counts.....	7
2.2.3 Adult butterfly count 1993–94.....	8
2.2.4 Adult butterfly count 1994–95.....	8
2.2.5 Larval count.....	8
3 RESULTS.....	9
3.1 Adult butterfly count 1993–94 .....	9
3.1.1 Numbers of Eltham Copper Butterflies observed .....	9
3.1.2 Assessment of adult counting protocol .....	11
3.2 Butterfly count 1994–95.....	12
3.3 Larval counts during 1994.....	16
3.3.1 Larval numbers .....	16
3.3.2 Larval and plant sizes .....	18
4 DISCUSSION .....	20
4.1 Adult butterfly count 1993–94 .....	20
4.2 Adult butterfly count 1994–95 .....	21
4.3 Larval counts .....	22
4.3.1 Limitations of methods.....	23
4.3.2 Predictive value of larval counts.....	23
4.4 Overview of survey results.....	24
5 RECOMMENDATIONS .....	25
5.1 Standardisation of protocol.....	25
5.2 Continuation of monitoring .....	25
5.3 Suggestions to improve future larval counts .....	26
6 ACKNOWLEDGEMENTS.....	27
7 REFERENCES.....	28
Appendix 1: List of Lepidoptera species observed at each site .....	29
Appendix 2: Plants species recorded with Eltham Copper Butterflies on them.....	29
Appendix 3: Protocols for monitoring populations of Eltham Copper Butterfly .....	30

## SUMMARY

Surveys to estimate adult and larval populations of the Eltham Copper Butterfly (*Paralucia pyrodiscus lucida* Crosby) were conducted over several seasons at Kiata, Salisbury, Castlemaine and three sites at Eltham, as part of the implementation of the management plan and Flora and Fauna Guarantee Action Statement prepared for the species. Survey results were compared with population estimates derived from previous counts. A set of standardised protocols, developed by the Eltham Copper Butterfly Coordinating Group for monitoring population numbers, were adopted and refined in this study. Butterflies were found to be most active within the temperature range of 25–35°C and activity varied during the day. Overall numbers of butterflies at all sites examined tended to be lower than previous estimates. At Eltham, the Pauline Toner Reserve consistently had the lowest number of butterflies. Population estimates at Castlemaine, Kiata and Salisbury were particularly low for both seasons surveyed. Drought appeared to have a severe effect on the life cycle of the butterfly, especially in the drier areas of central and western Victoria. Low numbers of larvae and adults were encountered during the season of the drought and many food plants of Sweet Bursaria (*Bursaria spinosa* Cav.) appeared dead and lacked foliage. Very few plants flowered during summer, some plants flowering much later than usual. More information on larval habits is needed before useful conclusions can be drawn from larval counts. It is recommended that monitoring of population trends be continued in the long-term, to assess whether the low population estimates observed in this study are a true indication of population decline.

# 1 INTRODUCTION

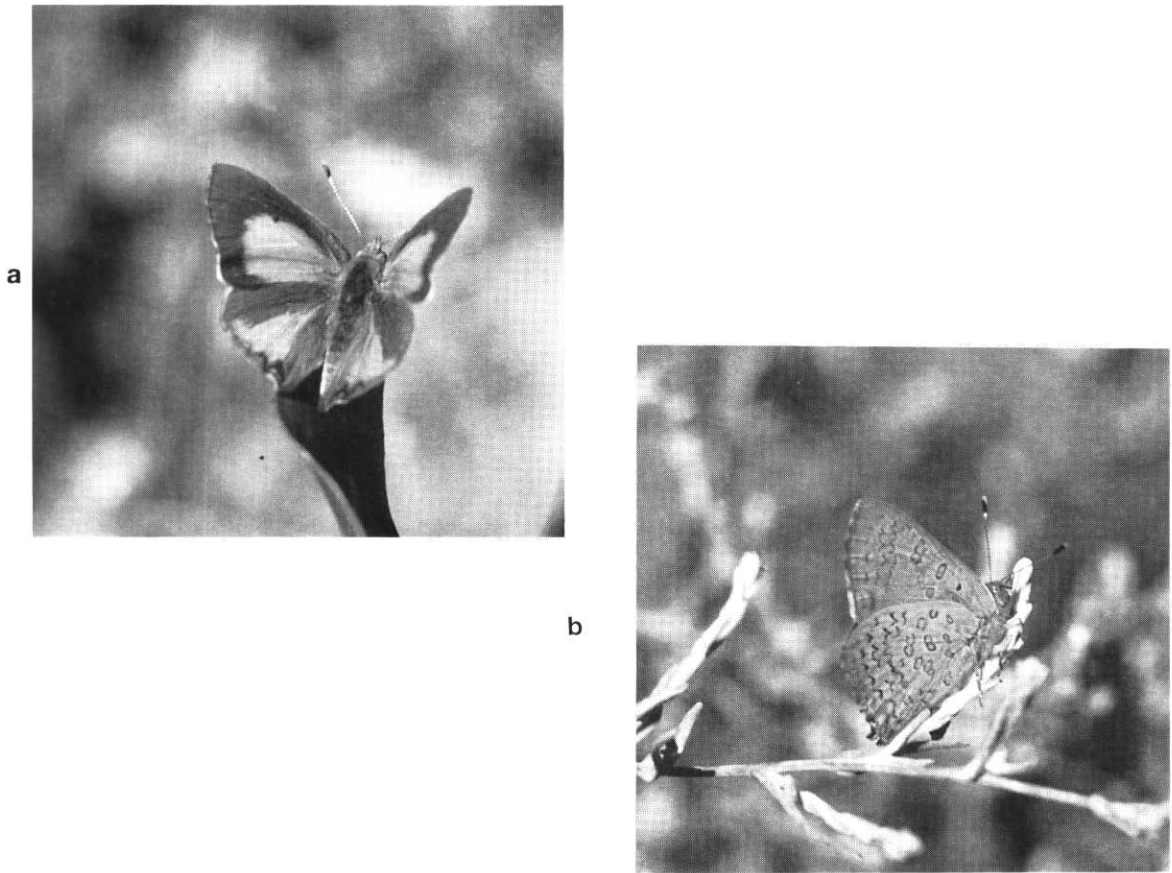
## 1.1 BACKGROUND

The Eltham Copper Butterfly (*Paralucia pyrodiscus lucida* Crosby) (Lepidoptera: Lycaenidae) (Plate 1) is well known in Victoria for its role as a 'flagship' taxon in helping to promote the acceptance of butterfly conservation in Australia (New 1990). It was described as a subspecies of the Dull Copper (*P. pyrodiscus* Rosenstock) by Crosby (1951). The Dull Copper has a much wider distribution and occurs from Expedition Range in Queensland to western Victoria (Crosby 1987). However, the distinctiveness of the Eltham form of *P. pyrodiscus* is still debatable (Yen *et al.* 1990).

Specimens of the butterfly were collected from the Eltham area from around 1923–1956 (Crosby 1987), but no records were made after this time. The butterfly was thought to be locally extinct until a population was found at Eltham in 1987 (Braby 1987, 1990) on land threatened by the development of a housing estate. Detailed searches for other colonies by Crosby (1987) and Vaughan (1987, 1988) identified three disjunct populations (Figure 1). The butterfly is now known from 10 localities in the Eltham-Greensborough area, one at Castlemaine in central Victoria, five at Kiata and one at Salisbury in the Wimmera. The long-term viability of the populations at these sites is uncertain. At present, the Kiata site, situated on land gazetted as a Flora and Fauna Reserve, and three sites at Eltham (the Diosma Road eastern and western colonies and the Eucalyptus Road Pauline Toner Reserve), are considered to have the highest potential for long term viability of the butterfly populations, given proper management (Vaughan 1988). The major cause of butterfly decline has been loss of habitat due to agricultural and urban expansion (Vaughan 1988). Other factors identified as posing a threat to existing populations include degradation of habitat by adverse human impacts, weed invasion and wildfires (Webster 1993).

Like many butterflies belonging to the Lycaenidae, the Eltham Copper Butterfly has an intricate tripartite relationship between the caterpillar, foodplant and ant (New 1987). The larvae of the Eltham Copper Butterfly have an obligatory association with ants of the genus *Notoncus*. The ant species involved are *Notoncus capitatus* Forel (previously placed under *N. enormis*) and *Notoncus ectatommoides*, in the Eltham-Greensborough and Kiata areas, respectively (Yugovic *et al.* 1990). The larvae feed on a dwarf or stunted form of Sweet Bursaria, *Bursaria spinosa* ssp. *spinosa* Cav. (nomenclature of Cayzer and Crisp, in press). The plants comprise juvenile foliage only and generally have a full compliment of thorns. It is not clear whether the small or stunted plants comprise young individuals or are 'stunted' by larval grazing and maintained in the juvenile condition and/or by the effects of the ant nest at the base of the plant (Braby, in press). The larvae are nocturnal, living in the ants' nest at the bottom of the *Bursaria* plant during the day and emerging at night to feed on the foliage, where they are constantly attended by ants (Vaughan 1988).

Although the exact nature of the relationship is not clear, it appears that the ants guard the larvae, as they move from the nest to the plant, and help prevent predation. The ants feed on a secretion of sugar and amino acids from the dorsal organ of the larvae. This may also help to keep the larvae free from fungal and bacterial disease (Vaughan 1988). Five larval instars have been observed by Braby, with the final instar exhibiting rapid growth (Vaughan 1988). Larvae pupate in the ants' nests and, although the length of the pupal stage in the field is unknown, in captivity it is 24 to 33 days (from Vaughan 1988).



**Plate 1** Eltham Copper Butterfly: (a) upperside of wings and (b) underside of wings.



**Figure 1** Location of the three main populations of the Eltham Copper Butterfly in Victoria.

The Eltham Copper Butterfly is considered 'vulnerable' (CNR 1995) and is now a protected species following its listing under the *Flora and Fauna Guarantee Act* 1988 (SAC 1991). A detailed management plan for the conservation of the butterfly was formulated to ensure the protection and conservation of existing populations (Crosby 1987, Vaughan 1988). A Flora and Fauna Guarantee Action Statement for the species has been published (Webster 1993). As part of the implementation of the management plan and the Action Statement, it was recommended that population numbers at known localities be assessed in order to monitor general population trends and to detect threats to long-term survival. Monitoring of long-term population trends is necessary to determine if Eltham Copper Butterfly numbers are declining at any of the known locations, such that appropriate management strategies can then be considered.

Previous estimates of adult populations from counts have been made at several sites at Eltham by Vaughan in the summer of 1987 and 1988, and by the Friends of the Eltham Copper Butterfly Group in the summers of 1991–93, and 1995. Estimates of adult butterfly numbers at Castlemaine were made in 1987 by David Crosby and, for Kiata, by Keith Hatley (Vaughan 1988).

Estimates of larval numbers at Eltham/Greensborough were made by Crosby, in April 1987. A total of seven colonies were found, with an estimated total population of more than 1000 larvae (Crosby 1987). A total of 16 larval colonies throughout the range of the Eltham Copper Butterfly were examined by Michael Braby and David Crosby in the spring of 1988 and yielded an estimated total population size of 2600 (Braby and Crosby unpublished data). However, the subdivision of land for housing development in 1988–89 severely reduced the available population habitat of the largest colony in Eltham, which comprised an estimated 38% of the total population and over half of the population in the Eltham district (Braby and Crosby unpublished data). No follow-up monitoring of larval populations has occurred and no information is available regarding the relationship between larval numbers and adults both within the same site and between sites.

Up until recently, a standardised protocol for adult and larval Eltham Copper Butterfly counts was not available. During 1992 to 1993, the Eltham Copper Butterfly Co-ordinating Group (with representatives from Department of Conservation and Natural Resources, Museum of Victoria, City of Banyule, Shire of Nillumbik, La Trobe University and local naturalist interests) developed a set of standardised counting techniques for monitoring both larval and adult populations of the Eltham Copper Butterfly. This protocol served as a model which was further developed and refined in the present study (see Appendix 3).

## 1.2 AIMS OF THE STUDY

The aims of the present study were:

- To examine the methods of estimating numbers of adult Eltham Copper Butterflies by rigorous counts at three sites at Eltham in order to assess and refine a standardised protocol;
- To assess and compare adult Eltham Copper Butterfly numbers at the major population sites including Eltham, Castlemaine and Kiata over several years (1993 to 1995) and to compare current butterfly counts with those from previous counts (such as those of Vaughan 1988 and Friends of the Eltham Copper Butterfly Butterfly Group 1991–93, 1995);
- To conduct larval counts at Kiata, Salisbury, Castlemaine and three sites at Eltham, and assess and refine a standardised protocol for estimation of larval numbers;
- To investigate the potential of larval numbers as an early indicator of population development and as a relative means of comparison between Eltham Copper Butterfly colonies prior to adult emergence. Where possible, to compare larval counts with those of Braby and Crosby from 1988.



## 2 MATERIALS AND METHODS

### 2.1 STUDY SITES

#### 2.1.1 Kiata (90 ha)

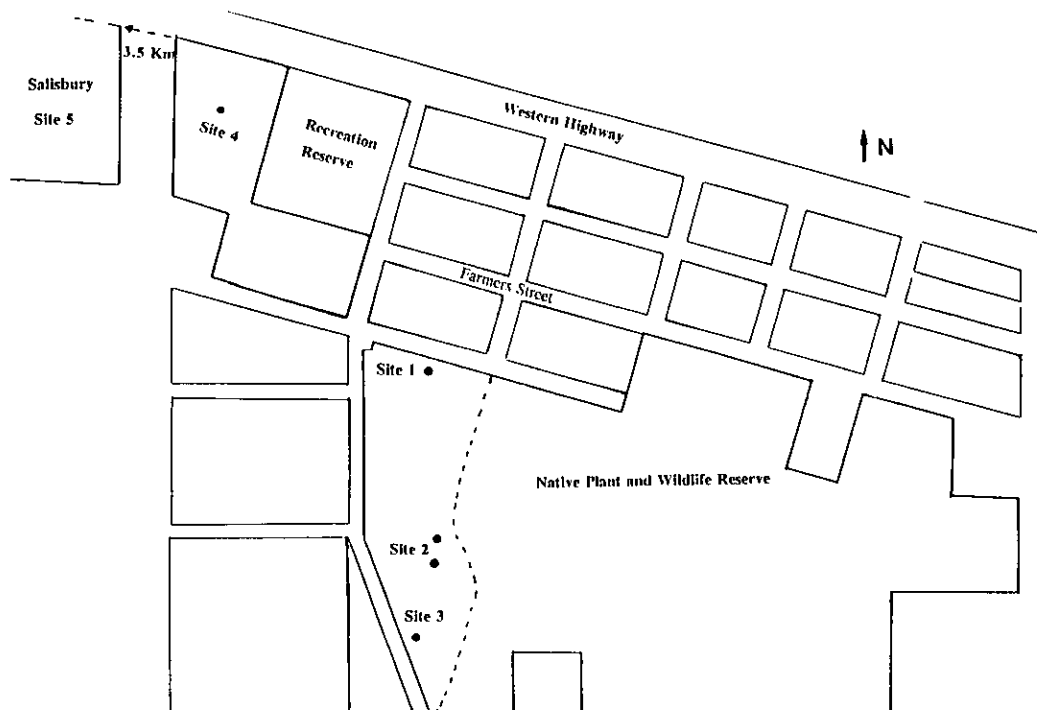
*Approximately 12 km east of Nhill. Sites 1–4 (Figure 2)*

**Site 1** (36°21'58"S, 141°47'14"E) Located on the Native Plant and Wildlife Reserve. Small patch of Sweet Bursaria (*Bursaria spinosa*) approximately 10 m in diameter. Includes several tall Sweet Bursaria bushes approximately 2 m high, together with a few scattered dwarf plants of the same species.

**Site 2** (36°22'12"S, 141°47'13"E) Consists of two large Sweet Bursaria patches approximately 100 m west of the track in Native Plant and Wildlife Reserve. Patch 1: Sweet Bursaria ranging from 30 cm to 1.5–2 m in height (mostly small). The patch is approximately 30–40 m in circumference. Patch 2: Tallish, thick patch, 25 m long x 3 m wide, with scattered smaller bushes.

**Site 3** (36°22'12"S, 141°47'79"E) Located on the Native Plant and Wildlife Reserve about 30 m in from track (Fig 2). Tall thicket of Sweet Bursaria, 2.5–3 m high, area approx 3.4 m wide x 8 m long.

**Site 4** (36°21'44"S, 141°47'04"E) Located on public land, including a strip parallel to the Western Highway and an area to the west of the football oval (Recreation Reserve) (Fig 2). The site consists of about eight scattered patches of Sweet Bursaria.



**Figure 2** Eltham Copper Butterfly sites at Kiata and Salisbury.

### 2.1.2 Salisbury Reserve (12 ha)

Approximately 3.5 km west of Kiata. Site 5 only (Figure 2).

**Site 5** (36°21'14"S, 141°45'08"E). Site is located on public land and consists of very scattered patches of Sweet Bursaria.

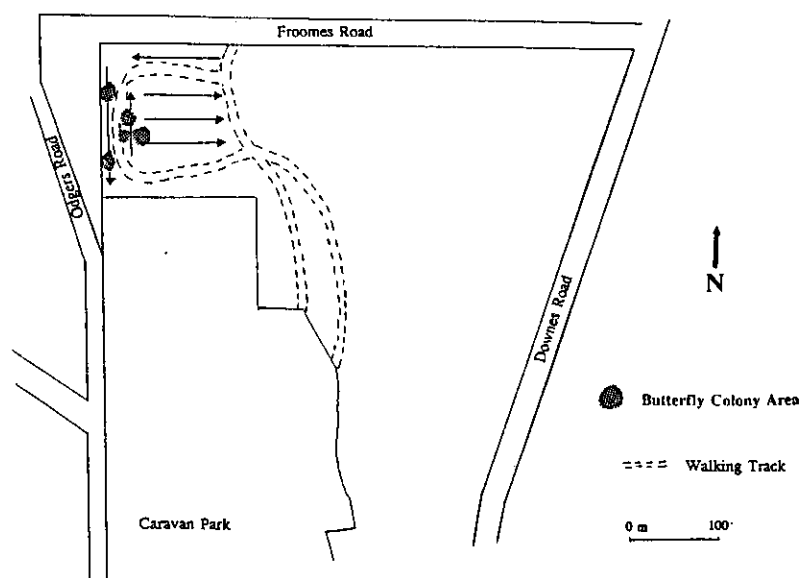
Other areas near Kiata, categorised by Vaughan (1989) as 'potential sites' were checked for Eltham Copper Butterfly colonies. These areas included:

- 1 West Rail Reserve. (36°26'12"S, 142°02'25"E). Inspected 28 November 1993.
- 2 Gerang Gerung Reserve (36°22'07"S, 141°52'45"E). On the Gerang-Glenlee Road, 700m north from the Angle Road intersection. Inspected on 26 November 1993.
- 3 Wail Reserve on Nursery Road (36°29'49"S, 142°04'06"E). Inspected 28 November 1993.
- 4 Various scattered roadside Sweet Bursaria patches along the Western Highway, just east of Kiata. Inspected 26–28 November 1993.

### 2.1.3 Castlemaine Botanic Gardens (3 ha)

One site only (Figure 3).

(37°03'S, 144°12'E). The site consists of remnant bushland within the Botanic Gardens. A colony exists in the north-western corner of this area.



**Figure 3** Eltham Copper Butterfly sites and transects at Castlemaine Botanic Gardens.

### 2.1.4 Eltham

Pauline Toner Reserve (Eucalyptus Road) (2.5 ha.) (Figure 4): 37°42'S, 145°09'E.

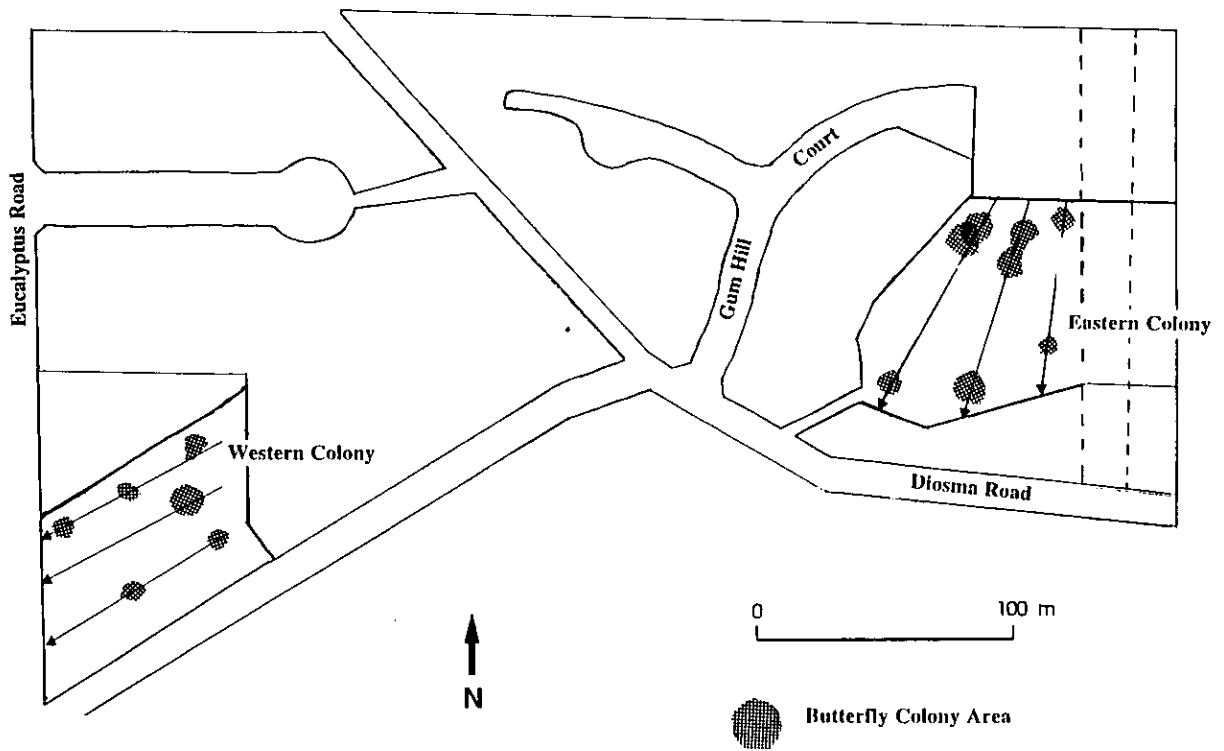
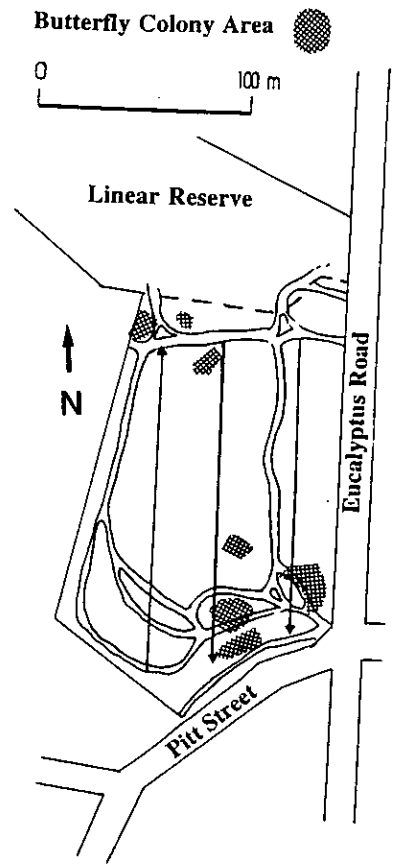
Diosma Road western colony (1.6 ha.) (Figure 5): 37°42'S, 145°10'E.

Diosma Road eastern colony (1.47 ha) (Figure 5): 37°42'S, 145°10'E.

Three other sites near Eltham were briefly examined for adult Eltham Copper Butterflies during the 1994 adult counts: Currawong Bush Park, Reynolds Rd, Warrandyte; Wildflower Reserve, Tindals Rd, Warrandyte; and Yandells Reserve, Greensborough (not sampled due to bad weather).

The above sites occur in mixed eucalypt open forest and woodland. Vaughan (1988) and Webster (1992) give detailed site descriptions, including plant composition and structure.

**Figure 4** Eltham Copper Butterfly sites and transects at the Pauline Toner Reserve, Eltham.



**Figure 5** Eltham Copper Butterfly sites and transects at the Diosma Road, eastern and western colonies.

## 2.2 GENERAL METHODS

### 2.2.1 Adult Counts

Two principal methods were used for adult counts, reflecting differences in the dispersion of *Bursaria* at different sites. These were (1) circle count, and (2) transect count.

#### Circle count

At all sites where Sweet *Bursaria* was found in large discrete patches (Kiata and Salisbury) it was not appropriate to use transects for estimating butterfly numbers, so circle counts were carried out.

Two people were positioned around (or either side of) the patch of Sweet *Bursaria* being examined. All butterflies in front or to the sides of each observer were recorded. Counters kept in verbal contact with each other to reduce the chances of double counting. In smaller patches, one counter was used. Bushes were tapped with a stick to disturb any resting butterflies. The bush was then watched for several minutes and the total number of butterflies recorded.

#### Transect count

Transect counts were based on standard techniques developed in Britain for comparing butterfly numbers between sites (Pollard and Yates 1993). They were used at Castlemaine and Eltham, where Sweet *Bursaria* plants were more scattered. Transects were walked slowly, with the counter using a stick to lightly tap branches or the bases of bushes to flush resting butterflies. Butterflies up to 10 m either side of the transect line were counted. If a Sweet *Bursaria* patch was observed within this area, but not directly in line with the transect, the counter went over to the bush to tap it with the stick. The length of the transects were determined by the size of the site, although most were around 100 to 150 metres.

### 2.2.2 Larval Counts

Each site was examined in daylight to identify the major Sweet *Bursaria* patches and to search them for signs of grazing, while also gaining an orientation of the area. Counts began at each site around 1900 hrs, depending on light levels. Basic environmental conditions such as temperature, level of moonlight and general weather conditions were recorded at each site.

Each site was divided into areas based on the occurrence of the highest densities of Sweet *Bursaria* bushes. Counts at each site were carried out with 3 to 5 people walking along transects within each area. Each Sweet *Bursaria* bush encountered was carefully searched with a spot-light or strong torch, starting at the base of the plant and moving up and out along the branches. Once a larva was observed, its size was determined using a small flexible ruler, and the number of ants tending the larva, the height of the bush and time were recorded. Temperature readings were taken at varying intervals throughout the count. Care was taken during counts to try to avoid trampling the ground flora or damaging Sweet *Bursaria* bushes.

It was noted that the bright lights used during counting caused the ants to move off the larvae and the larvae to retreat back down the plant toward the base. To reduce the impact of light on the larvae, a spotlight was covered with red cellophane. This was found to disturb the ants and larvae to a lesser degree than the bright light, however it made observations difficult. It was found best to use two observers when larvae were located on a bush so that larval and plant measurements could be taken as quickly and efficiently as possible while one person held the light source on the plant when necessary.

### **2.2.3 Adult Butterfly Count 1993–94**

#### **Sampling Regime**

Adult counts were carried out at Kiata, Salisbury, Castlemaine and Eltham, between November 1993 and February 1994.

**Kiata** The circle method was used at all four sites at Kiata and at the site at Salisbury between 25 November 1993 and 28 November 1993.

**Castlemaine** Five transects were chosen (see Figure 3) and each walked once per sampling day (17 December 1993 and 7 January 1994), to estimate butterfly numbers.

**Eltham** Since a major objective of the 1993/94 count was to assess and refine the counting protocol for estimating adult numbers, a more rigorous counting regime was adopted at three sites at Eltham (Pauline Toner Reserve, eastern and western colony). This information was used to determine whether marked fluctuations in butterfly activity occurred throughout the day and whether activity was affected by weather conditions and temperature. The three sites chosen were those believed to have butterfly populations with the best prospects of long-term viability (Vaughan 1988).

Three transects per site were used on each count. The locations of these transects were the same as those used by the Eltham Copper Butterfly Friends Group (Steve Anderson, pers. comm.; 1993) and were used at each count. Counts were made three times a day for three separate days over a five day period in late December 1993. This process was repeated in early and late January 1994 and again in early February 1994. This regime was interrupted due to rain and bad weather on several occasions (See Table 3). One count was made in late February, in order to check if adults were still flying. Counts were generally from 1100-1200, 1200-1300 and 1400-1500 hrs. It took approximately 1 hr to complete one count at each of the three sites. All times are given in Eastern Standard Summer time.

### **2.2.4 Adult Butterfly Count 1994–95**

#### **Sampling Regime**

Counts of adult Eltham Copper Butterflies were carried out in 1994/1995 at Kiata, Salisbury, Castlemaine and Eltham, following the standard methods developed for the 1993/1994 counts. Information gained from the 1993/1994 counts regarding temperature and general weather conditions was used, where possible, to determine when to carry out butterfly counts at each site. For example, counts were generally carried out within the temperature range of 25-30°C, as adults were found to be most active at these temperatures (see section 3.1.2.1). However, this was not always possible. For example, on one occasion, at Castlemaine, an unexpected high temperature of 35°C was recorded at 1030 hr. Counts were carried out between 1100 and 1500 hrs at Eltham and Castlemaine, while at Kiata and Salisbury counts were run at 0900, 1100 and 1700 hrs (due to the very high temperatures encountered).

Currawong Bush Park, and the Wildflower Reserve, Warrandyte, were briefly examined for adults in early February.

### **2.2.5 Larval Count**

#### **Sampling Regime**

Colonies of the Eltham Copper Butterfly identified during the 1993/1994 adult counts were examined for larval numbers in September and October 1994. This included colonies at Kiata, Salisbury, Castlemaine, and three sites at Eltham (Pauline Toner Reserve, eastern and western colonies). Two separate counts were made at Kiata, Salisbury, Castlemaine and the Pauline Toner Reserve while only one count was made at the eastern and western Colonies, Eltham.

### 3 RESULTS

#### 3.1 ADULT BUTTERFLY COUNT 1993–94

##### 3.1.1 Numbers of Eltham Copper Butterflies Observed

###### Kiata

Estimates of adult numbers varied between the sites and within the sites over different counts (times) and ranged from no butterflies to a maximum of 47 at Site 2 (Table 1). In general, Site 4 had the most frequently high numbers of butterflies, followed by Site 2.

Only a small number of Eltham Copper Butterflies were observed at Salisbury, with a maximum of four at a single count. On each count, this colony was found in the same area, near the south west corner of Salisbury South Road (see Figure 2). This particular area consisted of a patch of 12 Sweet Bursaria bushes within a 20m radius.

No previous rigorous counts have been made at Kiata. However, Keith Hatley estimated two thousand butterflies to have resulted from two emergences beginning in early November, 1987 (Vaughan 1988). Despite fairly extensive searches, no butterflies were found at West Rail Reserve, Gerang Gerung Reserve, Wail Reserve, or any of the roadside Sweet Bursaria patches checked along the Western Highway. *Notoncus* ants were not found on the Sweet Bursaria bushes at any of these sites (although the investigation for ants was not thorough).

**Table 1** Population size of Eltham Copper Butterflies at Kiata and Salisbury during November 1993. Estimates are based on adult counts using the circle method. Sites were not sampled in the order presented.

25 Nov 1993 Count 3 = 1730–1830 hrs

26 Nov 1993 Count 1 = 0920–1100 Count 2 = 1317–1435 Count 3 = 1645–1810

27 Nov 1993 Count 1 = 0900–1000 Count 2 = 1100–1215 Count 3 = 1630–1730

28 Nov 1993 Count 1 = 0830–0940 Count 2 = 1150–1250

Date	Site 1			Site 2			Site 3			Site 4			Site 5*		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
25 Nov. 93	–	–	–	–	–	–	–	–	3	–	–	5	–	–	0
26 Nov. 93	6	0	0	30	9	4	4	2	1	34	17	4	0	2	0
27 Nov. 93	3	6	0	9	47	15	4	6	1	9	36	27	0	1	0
28 Nov. 93	0	8	–	0	21	–	0	6	–	3	35	–	1	4	–

\* Salisbury

###### Castlemaine

Low numbers of butterflies (the maximum count being nine) were recorded from the two counts made at Castlemaine (Table 2). These were mainly found at two areas, one at the base of a north-facing slope and one at the top of a ridge. One butterfly was also found in a Sweet Bursaria patch adjacent to the one at the base of the north-facing slope (see Figure

Figure 2). On 11 January 1994, approximately 30 newly-emerged butterflies were counted (Gary Sobey, pers. comm.; 1994).

These estimates are very low compared to the observation made by David Crosby, on 12 December 1987, when he observed about 100 butterflies on the wing. However, no butterflies were observed by Crosby on 8 January 1988 or 8 February 1988 (Vaughan 1988), in contrast to the observations made by Gary Sobey of butterflies on the wing as late as 11 January 1994.

**Table 2** Population size of Eltham Copper Butterflies at Castlemaine Botanic Gardens during 1993–94. Estimates are based on transect counts of adults.

Date	Count
17 Dec. 93	9
07 Jan. 94	3
11 Jan. 94	about 30*

\* G. Sobey, pers. comm. 1994

### Eltham

The first adult Eltham Copper Butterflies of the season were noted at Eltham on 10 December 1993 (Cam Beardsell, pers. comm.). Highest numbers of butterflies were observed at the Diosma Road eastern colony, where a maximum of 58 butterflies was counted (Table 3). This is consistent with the observations of Vaughan (1989) (Table 4) but not with those of the Eltham Copper Butterfly Friends Group counts (S. Anderson, pers. comm.), where higher numbers of butterflies were observed at the Pauline Toner Reserve and western colony sites (Table 5). In the present study, the lowest numbers of Eltham Copper Butterflies were observed at the Pauline Toner Reserve, where a maximum of 21 was recorded. This is considerably lower than that observed by Vaughan (1989) at the same site over a similar time period, where a maximum of 60 adults was counted (see Table 5).

**Table 3** Population size of Eltham Copper Butterflies at three sites at Eltham during 1993–94. Estimates are based on transect counts of adults. Count 1 approx. 1100–1200 hrs; Count 2 approx. 1200–1300 hrs; Count 3 approx. 1400–1500 hrs. nc= No count due to rain.

Date	Pauline Toner Reserve			Diosma Rd Western Colony			Diosma Rd Eastern Colony		
	1	2	3	1	2	3	1	2	3
Late December									
20 Dec. 93	6	14	0	22	20	9	35	48	34
21 Dec. 93	8	14	10	29	24	10	21	58	31
Mid January									
11 Jan. 94	12	19	21	17	22	23	14	17	31
12 Jan. 94	12	14	8	26	31	18	38	35	22
14 Jan. 94	1	0	nc	0	0	nc	15	40	nc
31 Jan. 94	1	13	14	16	16	8	16	16	1
Early February									
01 Feb. 94	nc	3	3	nc	7	2	nc	15	12
02 Feb. 94	1	0	7	1	2	6	0	2	11
Late February									
23 Feb. 94	–	7	–	–	1?	–	–	0	–

**Table 4** Population size of Eltham Copper Butterflies determined by P. Vaughan at three sites at Eltham during 1987–88. Estimates are based on transect counts of adults (from Vaughan 1988).

Date		Pauline Toner Reserve	Diosma Rd Western Colony	Diosma Rd Eastern Colony
Early December	07 Dec. 87	3	0	0
	08 Dec. 87	20	4	0
Mid December	11 Dec. 87	24	20	0
	16 Dec. 87	18	40	5
	19 Dec. 87	60	30	20
Late December	27 Dec. 87	30	10	80
Early January	6–7 Jan. 88	40	100+	50
Mid January	19 Jan. 88	10	20	52
Late January	29 Jan. 88	0	0	10
Early February	2 Feb. 88	0	0	0
Mid February	11 Feb. 88	0	0	0
Late February	23 Feb. 88	0	0	0

**Table 5** Population size of Eltham Copper Butterflies determined by the Eltham Copper Butterfly Friends Group at three sites at Eltham from 1991 to 1995. Estimates are based on transect counts of adults. Counts were made from approximately 1030–1200 hrs.

Date	Eucalyptus Rd Pauline Toner Res.	Diosma Rd Western Colony	Diosma Rd Eastern Colony	Max. Temp. (°C)
20 Jan. 91	10	27	24	29
19 Jan. 92	38	32	17	33
24 Jan. 93	35	47	22	22
12 Feb. 95	6	24	11	36

Although Vaughan's (1988) counts were not carried out using the transect method and may have involved some double counting, they still represent approximate numbers of butterflies seen on the day of the count and are therefore roughly comparable to the counts in the present study (P. Vaughan, pers. comm.). Counts made by the Friends Group at this site also showed higher numbers ranging between 10 and 38 (Table 4). The high numbers of 100 and 200 observed by Vaughan in 1988 at the Diosma Road eastern and western colonies during early January were not encountered during this study. However, the eastern colony site was much larger during Vaughan's 1987/88 counts, at which time development had not yet destroyed butterfly habitat in the northern and southern parts of the reserve.

### 3.1.2 Assessment of Adult Counting Protocol

#### Butterfly Numbers in Relation to Temperature, Time of Day and Weather Conditions

There is clearly a relationship between butterfly activity, temperature and time of day, however it is difficult to separate the effects of temperature from time of day (although these are probably related), due to the time limitations involved in sampling and lack of controls.



Most butterfly activity was observed between 25°C and 35°C and little activity was observed below 20°C (Figure 6). Butterfly activity also tended to be less at temperatures above about 30°C. This is particularly evident at Kiata sites 2 and 4 (Figure 7). The number of Eltham Copper Butterflies observed over the three counts at each site varied greatly (e.g. 14 to 31, 21 to 58) (Figure 8). Numbers were generally lower at the first morning count, possibly because temperatures were lower. The highest numbers of butterflies were generally observed in the middle count (1200–1300 hrs), though this varied between sites and dates, with some counts highest in the afternoon (1400–1500 hrs).

Butterflies were observed flying under both sunny and overcast conditions, depending on the temperature. For example, the maximum number of butterflies at Diosma Road eastern colony, was observed on a warm day (30°C) with 100% cloud cover. However, on overcast days when the temperature was cooler, lower numbers of butterflies were observed. On 14 January 1994, for example, temperature ranged from 18.5 to 20°C (See Table 3). However, on this same day, during a 5 minute burst of sunshine while sampling the Diosma Rd eastern colony, the number of butterflies observed increased from 1 to 40 (See Table 3). A change in weather conditions during the day resulted in large differences in the number of butterflies observed between counts. For example, on 31 January 1994, the day started sunny and reasonable butterfly numbers were observed but, by the third count, there was a drop in temperature of 7.5°C, cloud-cover of 100% and stormy conditions. At Diosma Rd. eastern colony, butterfly numbers dropped from 16, at the second count, to one, at the third. Butterflies were also observed under windy conditions, though this made counting somewhat more difficult.

Lists of other butterfly species observed at each site and the plant species upon which Eltham Copper Butterflies were observed are provided in Appendices 1 and 2, respectively. The subject butterflies were very territorial and were often observed chasing other butterflies, particularly the Common Brown (*Heteronympha merope merope*).

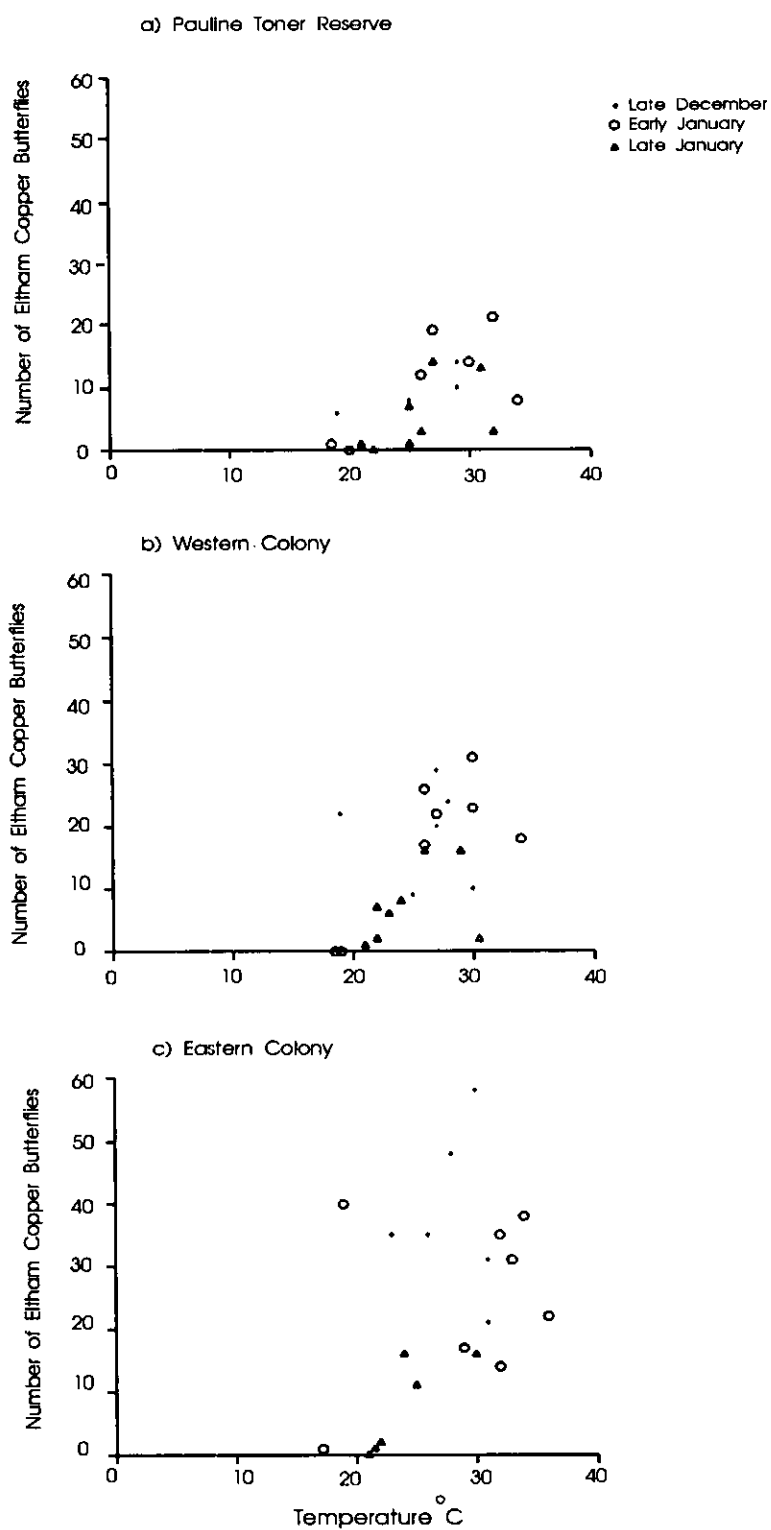
On one occasion a Robberfly (Diptera:Asilidae) was observed taking and eating an Eltham Copper Butterfly at the eastern colony site (Plate 2).

### 3.2 ADULT BUTTERFLY COUNT 1994–95

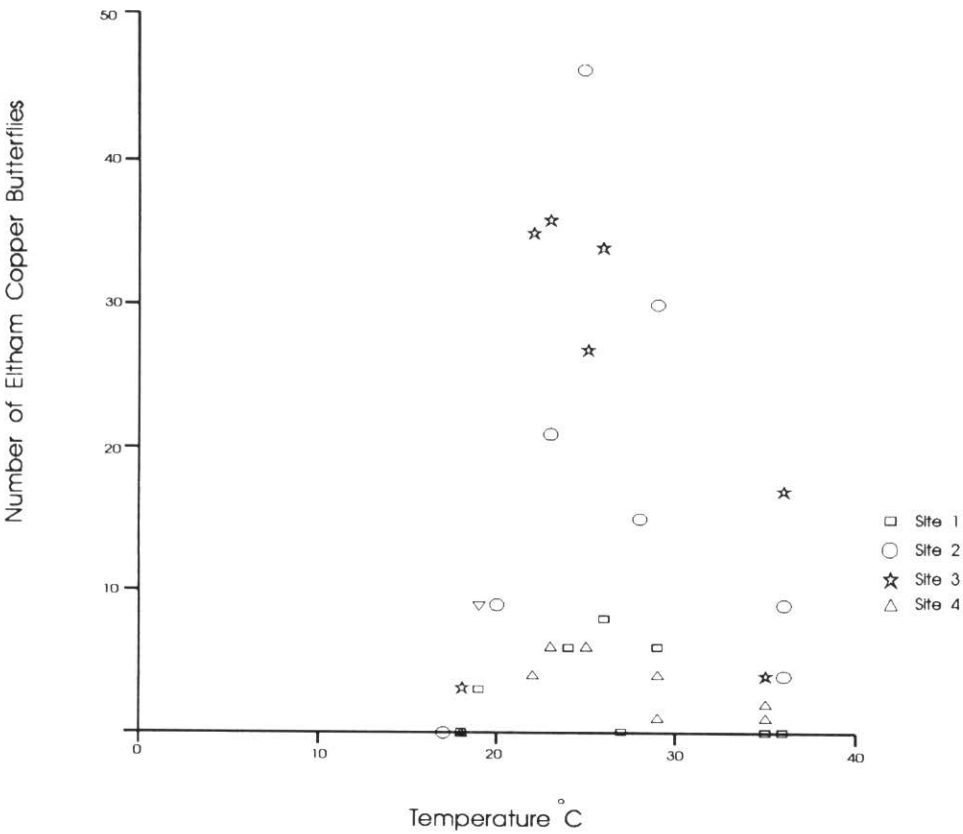
Eltham Copper Butterflies were recorded from only two of the four sites at Kiata (Sites 2 and 4) and numbers were very low, with a maximum number of 15 recorded at site 4 (Table 6). No Eltham Copper Butterflies were counted at Salisbury (Site 5). Numbers of butterflies recorded at Castlemaine were also low, with a maximum of seven recorded in late December (Table 7).

At Eltham, highest numbers of butterflies were recorded at Diosma Road western colony, where a maximum of 52 butterflies was counted in mid-January (Table 8).

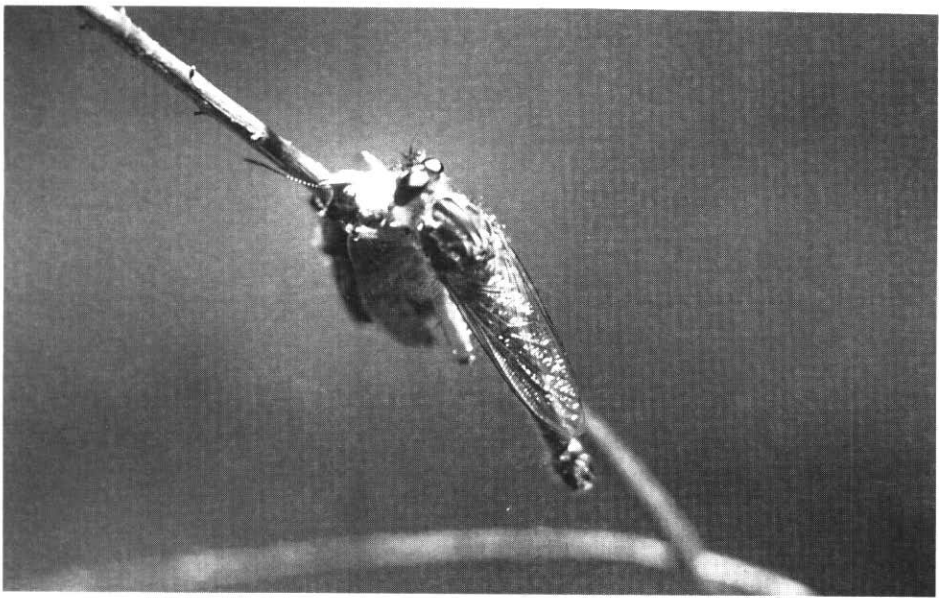
No adults were observed at Currawong Bush Park or the Tindalls Road Wildflower Reserve. Although the ant species *Notoncus enormis* was found on Sweet Bursaria plants at Currawong Bush Park (Miller 1993), the Sweet Bursaria plants examined did not appear to be suitable for Eltham Copper Butterflies as the plants were very large and not the dwarf form usually associated with the butterfly. More suitable dwarf Sweet Bursaria plants were found at the Wildflower Reserve; however species of *Notoncus* ants were not found at this site when examined by Miller (1993).



**Figure 6** Number of adult Eltham Copper Butterflies observed in relation to temperature at three sites at Eltham, 1993–94. (Note: time of day is not constant.)

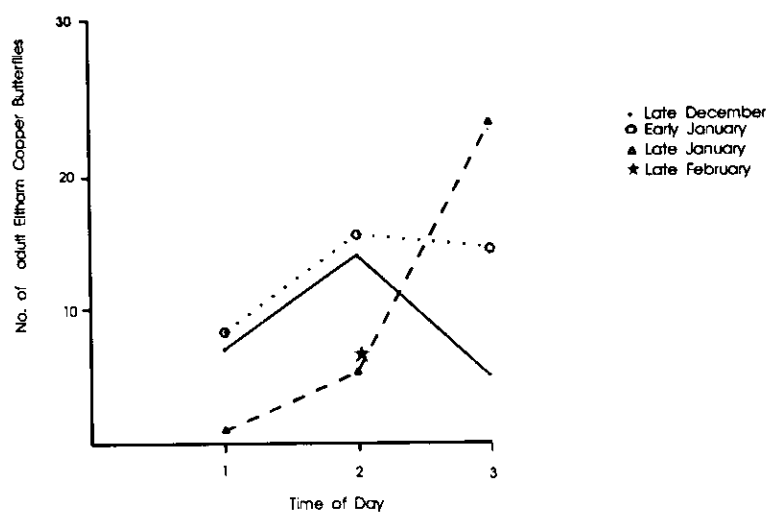


**Figure 7** Number of adult Eltham Copper Butterflies observed in relation to temperature at Kiata 1993/1994 (Note time of day is not constant).

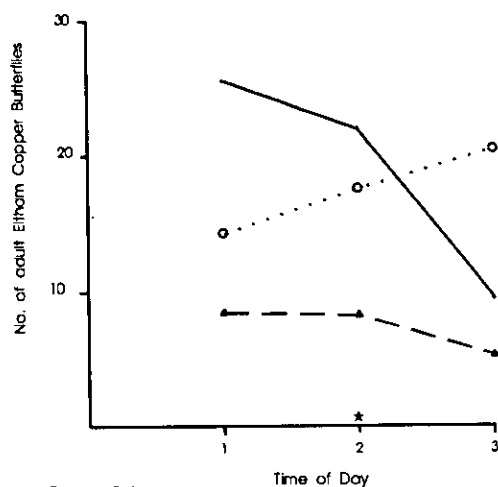


**Plate 2** Robberfly (Asilidae) eating an Eltham Copper Butterfly at Eltham.

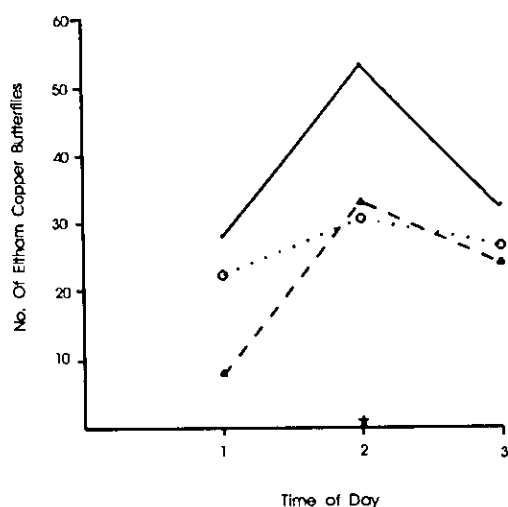
a) Pauline Toner Reserve



b) Western Colony



c) Eastern Colony



**Figure 8** Mean number of adult Eltham Copper Butterflies counted at Eltham (December 1993 – February 1994). On the horizontal axis, 1 = 1100–1200 hrs, 2 = 1200–1300, and 3 = 1400 – 1500 (except early January count where count 1 = 1000–1100).

**Table 6** Population size of Eltham Copper Butterflies at each site at Kiata and Salisbury during 1994–95 (– = not surveyed). Estimates are based on adult counts using the circle method.

Date	1			2			3			4			5*			Temp. (°C)
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
26 Nov. 94	0	0	0	6	1	3	0	0	0	9	1	6	0	0	0	27–36
27 Nov. 94	0	–	–	0	–	–	0	–	–	3	–	–	0	–	–	21–23
29 Nov. 94	0	–	–	3	–	–	0	–	–	15	–	–	0	–	–	25
16 Dec. 94	–	–	–	7	–	–	1	–	–	9	–	–	–	–	–	28–32
16 Jan. 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21–24

\* Salisbury

**Table 7** Population size of Eltham Copper Butterflies at Castlemaine Botanic Gardens during 1994–95. Estimates are based on transect counts of adults.

Date	Count	Temp. (°C)
21 Dec. 94	7	25
13 Jan. 95	4	35

**Table 8** Population sizes of Eltham Copper Butterflies at three sites at Eltham during 1994–95. Estimates are based on transect counts of adults.

Date	Pauline Toner Reserve	Diosma Rd Western Colony	Diosma Rd Eastern Colony	Temp. (°C)
30 Dec. 94	13	27	30	24.5
12 Jan. 95	19	52	26	29
24 Jan. 95	12	39	11	28

### 3.3 LARVAL COUNTS DURING 1994

#### 3.3.1 Larval numbers

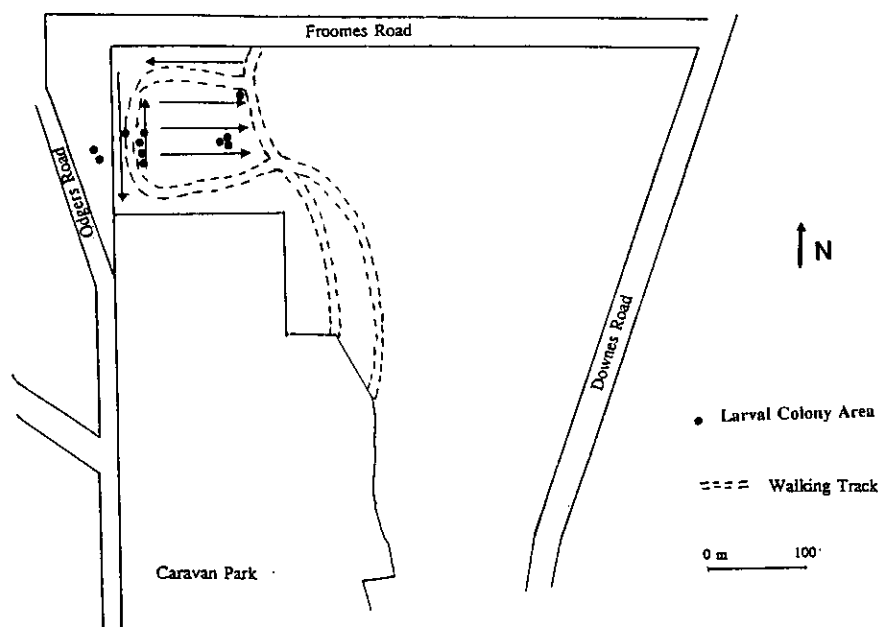
Larval numbers varied at each site, with the highest count of 150 larvae recorded at the Diosma Road eastern colony. Kiata had the lowest counts, with a total of 28 larvae recorded on the first count and only 4 on the second (Table 9). Larvae were only found at three sites at Kiata, with sites 2, 4 and 1 having 17, 10 and one larvae, respectively. On the second count at Kiata, temperatures were very low and there was light rain which probably explains the low count, larvae being found only at site 2 and 4. No larvae were recorded at Salisbury.

Two counts were carried out at Castlemaine, the first count yielding 24 larvae and the second, 79. Lower numbers on the first count may be due to the timing of emergence of the larvae. This may not have been completed by mid-September (when the first count was made), as emergence appears to be staggered. The major colonies were concentrated at the western end of the site, parallel to Odgers Road, while others were scattered along the easterly slope (Figure 9). The colony clearly appeared to extend into the freehold land adjacent, as evidenced by Sweet Bursaria bushes close to the fence.

Of the Eltham sites, the larval numbers at the Pauline Toner Reserve were the lowest with 55 larvae recorded (early October). The larvae were found on a total of only 16 plants, distributed in three main patches (Figure 10). The largest patch was made up of 11 plants, supporting 41 larvae. One small plant (70 cm) within this patch supported 13 larvae and was totally defoliated. This particular plant had been a larger bush which, at some stage, was either cut back or broken, as it had a 3.5 cm diameter stump at the base from which two branches supporting the larvae protruded. A second count at this reserve was made three weeks later and a similar total of 64 larvae recorded. However, the distribution of the larvae was quite different, with the 64 larvae being found over 31 plants. Twelve of the sixteen plants that were recorded with larvae from the first count were recorded as having larvae on the second count but a total of only 23 larvae were found within the main colony site, compared with 41 at the first count.

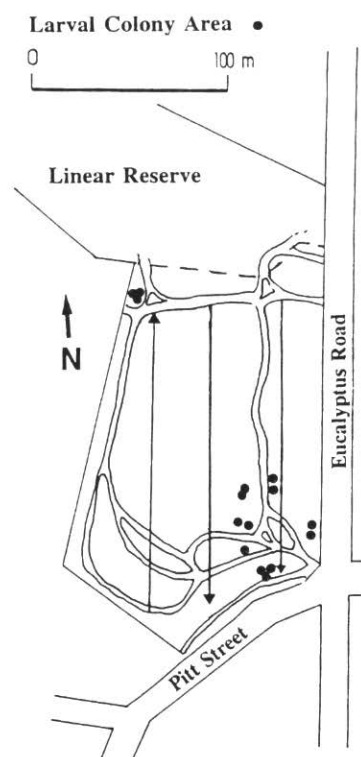
**Table 9** Population size and food plant size (mean and range) for Kiata, Salisbury, Castlemaine and Eltham during 1994. Estimates are based on larval counts. All five sites at Kiata are pooled.

Site	Date	Total No. Larvae	Larval size (mean±SD) (mm)	Mean No. Ants	Total plants with larvae	Mean plant size (cm)	Temp. range during count (°C)
Kiata/Salisbury	13–14 Sep. 94	28	11.0±3.4	–	11	60 (20–110)	12–9
	26–27 Sep. 94	4	13.0±1.9	5	3	93 (60–150)	10–4
Castlemaine	22 Sep. 94	24	14.0±1.2	5	13	86 (50–150)	17–10
	12 Oct. 94	79	15.0±2.4	4	45	86 (45–180)	13–6
Eltham							
Toner Res.	3 Oct. 94	56	13.5±2.2	4	16	60 (30–120)	16
	23 Oct. 94	63	15.0±3.7	4	31	59 (15–90)	20–17
Western Colony	6 Oct. 94	81	14.0±1.6	4	34	51 (30–120)	20
Eastern Colony	10 Oct. 94	150	14.0±0.2	3	63	48 (10–120)	17–14



**Figure 9** Eltham Copper Butterfly larval sites at the Castlemaine Botanic Gardens (1994).

**Figure 10** Eltham Copper Butterfly larval sites at Pauline Toner Reserve, Eltham (1994).



Mean larval size varied between the two counts at the Pauline Toner Reserve, with the larvae being significantly larger at the second count ( $t = -2.58$ ,  $p = 0.012$ ), although the variation in larval sizes was greater at the second count.

Larval counts at the eastern and western colonies yielded numbers of 150 and 81 respectively (Table 6). At both sites the larvae tended to be more scattered over the site (Figure 11) than at the Pauline Toner Reserve and were found most consistently on the smaller Sweet Bursaria plants, with a mean height of 48 and 51 cm respectively.

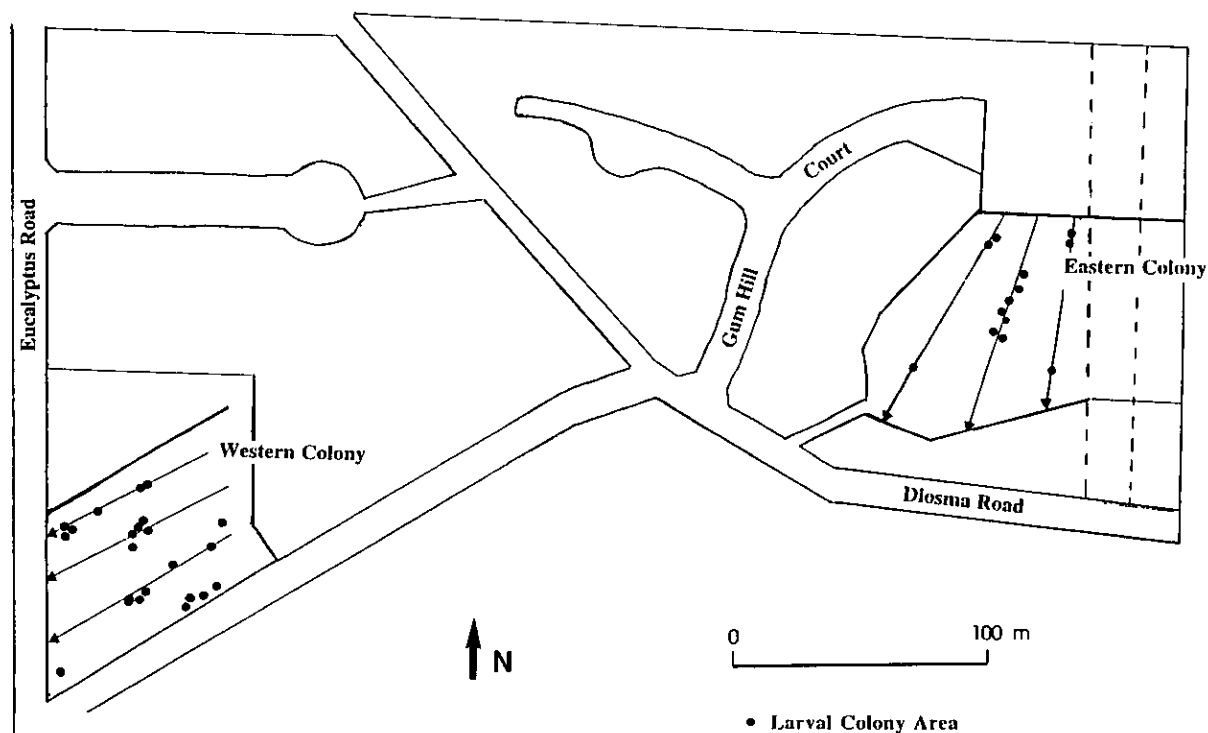
### 3.3.2 Larval and Plant Sizes

Larvae were most commonly found on the smaller, often isolated Sweet Bursaria bushes (<1 m) and were rarely found on plants above 1m. It was often possible to predict whether a Sweet Bursaria plant was supporting larvae by the plant's small size and characteristic defoliated appearance, particularly toward the top of the plant (Plate 3). Many of the smaller Sweet Bursaria bushes were completely defoliated by the larvae. Numbers of larvae on each Sweet Bursaria plant varied from 1 to 13 and did not appear to be related to the size of the plant. Larvae on a single plant were often of several different sizes. Larval sizes varied from 6 to 25 mm with mean size range (reflecting different larval instar stages) from 11 to 15 mm at Kiata and the Pauline Toner Reserve, respectively (Table 9).



**Plate 3** Typical appearance of Sweet Bursaria defoliated by Eltham Copper Butterfly larvae.

Larval activity appeared to be very dependent on weather conditions. Larvae did not venture out of the ant nest to feed when temperatures were less than 6–8°C. Larval counting usually began at around 1900 to 2000 hrs and continued to around 2200–2230 hrs, depending on temperature. Because the temperature usually dropped as the night progressed, it is unlikely that the larvae were out feeding much after 2230 hrs (unless it was a particularly mild night). Larvae were almost always tended by ants while feeding, with numbers varying from 1 to 8 ants per individual (Table 9).



**Figure 11** Eltham Copper Butterfly larval sites at Diosma Road eastern and western colonies at Eltham (1994).



## 4 DISCUSSION

### 4.1 ADULT BUTTERFLY COUNT 1993–94

Similar methods to those used previously for estimation of adult Eltham Copper Butterflies by Vaughan (1988), and by the Friends Group during 1991–93 (S. Anderson, pers. comm.), were adopted for this study. It was found that transect counts were the most appropriate method at sites where Sweet Bursaria bushes were spread or scattered throughout the site, such as at Eltham. In contrast, the circle method was most appropriate where known butterfly colonies occurred on clumped Sweet Bursaria bushes, such as at Kiata and Salisbury. Using a stick to lightly tap branches along transects or in circle counts was useful to disturb butterflies into flight, generally making them more visible.

Rigorous counting at three sites at Eltham yielded useful information on butterfly activity in relation to time of day, temperature and weather conditions. The variation observed between counts at the same site, on a single day, probably depends primarily upon weather conditions (temperature), which may vary throughout the day. Most butterfly activity was observed between 25°C to 30°C under either sunny or overcast conditions. This indicates that a single count on any one day, depending on the weather, may give a misleading estimate of butterfly numbers. However, one count under optimum conditions (e.g. between 25 and 30°C, in the middle of the day) may be more accurate. At Eltham, butterfly numbers overall were highest in the early December 1993 and early January 1994 counts, with numbers dropping off by late January 1994. A total of seven butterflies were still found at the Pauline Toner Reserve on February 23 (all under a stand of Monterey Pines *Pinus radiata*), whereas there was only one possible sighting at the western colony and none at the eastern colony. If only one count per flight season were to be made at Eltham, this would best be done during the peak season of late December to early January.

Overall numbers encountered at all sites tended to be lower than those previously recorded by others. Of the three sites sampled at Eltham, the Pauline Toner Reserve consistently yielded the lowest number of butterflies. Very low numbers of butterflies were observed at Castlemaine, although a count (by local naturalist Gary Sobey) of 30 butterflies in mid-January is higher than that by the author yet still much lower than the 100 estimated by David Crosby in 1987. It is difficult to tell whether the lower numbers observed at most sites during 1993–94 are due to differences in methodology, observer awareness or seasonality, or whether they reflect a true drop in population numbers.

Only two counts were made at Castlemaine. The data may therefore give a misleading estimation of butterfly numbers, particularly since the temperature was around only 20°C for both counts. Also, it is likely that adults first emerge in late November or early December at Castlemaine. Therefore, low numbers counted may reflect an early emergence, such that the counts were made toward the end of the flight season. However this explanation does not account for the increase in numbers from the author's count of three butterflies on 7 January 1994 to 30 butterflies observed by Gary Sobey on 11 January 1994.

## 4.2 ADULT BUTTERFLY COUNT 1994–95

Adult butterfly numbers are comparable to those recorded the previous year at Castlemaine and Eltham although the eastern colony numbers at Eltham appear slightly lower (Table 6).

Numbers at Kiata are alarmingly low compared to last year where the total number recorded at all sites during one count was 100 adult butterflies (see table 1) compared with a total of 15 this year. This was also reflected in the very low larva count recorded (24 larvae).

Overall trends indicate that butterfly numbers have decreased dramatically compared to relative population trends inferred from earlier estimates (Table 11). This is probably the result of a number of factors including reduced availability of suitable habitat, particularly in the Eltham area, because of housing development and, more immediately, environmental stress caused by severe drought.

The drought appears to have severely affected the life cycle of the butterfly, particularly in the drier areas of central and western Victoria where the rainfall recorded for 1994 was almost half that for 1993 (Figure 12). The lack of rain has had a dramatic impact on the condition of the Sweet Bursaria plants: very little green foliage was available during the larval feeding period, and few plants flowered during the adult flight period. Moreover, those that did flower appeared to do so later than usual. Flowering also occurred later than usual at Eltham.

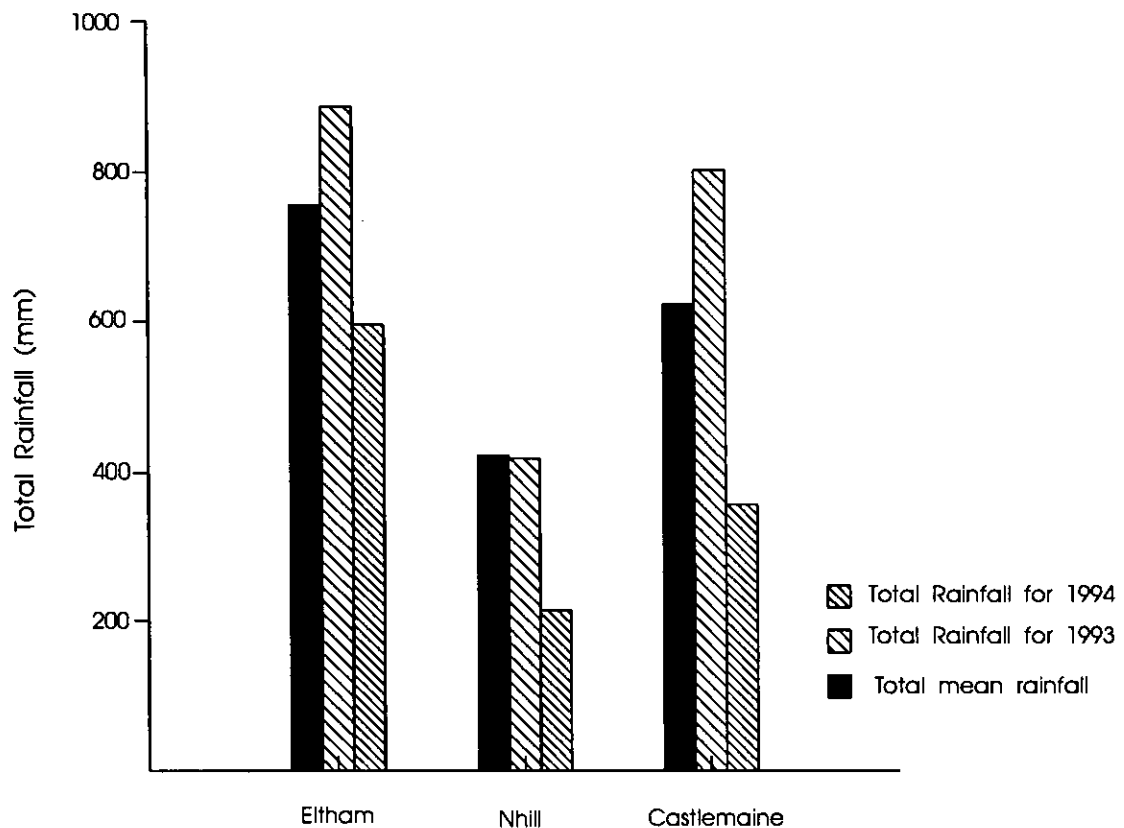
The drought also affected many other plants at each site, such that there were few other food plants available for butterflies to feed on. It is not known how the poor condition of the Sweet Bursaria bushes affected the larvae, but it may have restricted the amount of food available to them prior to pupation.

The effects of the drought on the Sweet Bursaria plants at Kiata were compounded at some sites (particularly site 2) due to the presence of the introduced Brown Hare (*Lepus capensis*), which severely ringbarked plants. About 70% of plants were affected. This should be dealt with immediately by erecting hare-proof fencing around the affected site.

**Table 11** Summary of maximum number of adult Eltham Copper Butterflies counted between 1987 and 1995 by different sources at various sites. The counts are not necessarily quantitatively comparable because of differences in methodology, time of year, weather, etc., but they do provide a historical record of relative numbers of butterflies at particular sites.

Source and Date	Kiata	Salisbury	Cas'maine	Pauline Toner Res.	Diosma Rd (Western)	Diosma Rd (Eastern)
K. Hatley 1987	2000*	—	—	—	—	—
D. Crosby 1987	—	—	100	—	—	—
P. Vaughan 1987	—	—	—	60	100+	80
ECB Friends						
1991	—	—	—	10	27	24
1992	—	—	—	38	32	17
1993	—	—	—	35	47	22
G. Sobey 1993–94	—	—	30	—	—	—
B. Van Praagh						
1993–94	95	4	9	21	31	58
1994–95	18	0	7	19	52	26
ECB Friends 1995	—	—	—	6	24	11

\* estimated



**Figure 12** Total rainfall recorded for 1993 and 1994, and long-term mean rainfall, for Eltham, Nhill and Castlemaine (Source: Bureau of Meteorology, Melbourne).

### 4.3 LARVAL COUNTS

Crosby (1987) estimated larval numbers of 50, 200–300 and 300–500 at the Pauline Toner Reserve, and Diosma Road eastern and western colonies, respectively. Except for the Pauline Toner Reserve, these estimates are much higher than those encountered in the present survey at Eltham.

Direct comparison between the present larval counts at Eltham and those by Crosby (1987) and Braby and Crosby (1988, unpublished data) cannot be made as the size of the habitat area surveyed has been dramatically reduced, due to housing development. According to Braby and Crosby (1988, unpublished data), these sites have been reduced to 30% of their original size. Also, slight differences in sampling procedure occurred. For example, some of the survey work of Braby and Crosby was carried out over several nights at the one site, an approach which may yield higher numbers compared with only a single count at one site. A total larval population size of approximately 2000 larvae for the Eltham district was estimated by Braby and Crosby, with 1249 (62%) occurring in the Pauline Toner Reserve (eastern and western colonies) in spring 1988. These three sites yielded a maximum population estimate of only 342 larvae in the present study. This indicates that the present combined population within the Pauline Toner Reserve and the Diosma Road eastern and western colonies may have been reduced by as much as two thirds of the original population size prior to the housing development.

Plants that supported Eltham Copper Butterfly larvae were often severely defoliated and it was noted during the adult counts in the following December (1994) and January (1995) that most of these plants had still regained little, if any, foliage (that is, had not been able to recover). At Eltham a few of the defoliated plants had just begun new growth in late January, 1995.

**Table 10** Population sizes for Eltham, Castlemaine and Kiata/Salisbury, based on larval counts by Braby and Crosby during September and October 1988 (unpublished data).

Locality	Site	Estimated population
Eltham	Pauline Toner Reserve	259
	Diosma Road (Western and Eastern Colonies)	900
	All other sites in Eltham combined	748
	Total for Eltham district	1997
Castlemaine	Botanic Gardens	157
Kiata	six sites	470

#### 4.3.1 Limitations of Methods

Larval counts are very labour intensive and generally take around three hours at each site with a minimum of three to five people needed for counting. The concentration span of the counter is limited to about three hours so it is recommended that a minimum of five people be involved in the larval counts to obtain the greatest accuracy and productivity. If time or personnel is limited, it is possible to reduce the search time by concentrating the search effort on characteristic defoliated or partially-defoliated, small Sweet Bursaria bushes.

The variation in larval numbers between counts at the same site (such as was observed for sites at Pauline Toner Reserve and Castlemaine), and the variability of larval numbers on individual plants at the same site, indicate the difficulties in count accuracy. It is doubtful that all larvae come out at the same time during the night. Rather, it seems likely that this activity is staggered between about 1915 hrs and 2200 hrs, thus making consistency of counting difficult. It also appears that not all larvae on each bush come out at the same time. For example, at Pauline Toner Reserve, one plant was checked at 1920 hrs and one larva was present. At 2030 hrs, no larvae were found on this same plant but, at 2200 hrs, there were three larvae present. It appears that counts probably represent a conservative estimate of population numbers.

Taking into consideration the difficulties involved in larval monitoring, the data is not particularly meaningful unless it is followed up by monitoring over a long period (5–10 years), to determine the impact of environmental factors (such as weather patterns of the previous year) on larval and adult numbers.

#### 4.3.2 Predictive Value of Larval Counts

The predictive value of larval counts in relation to adult population numbers cannot be adequately assessed until further population monitoring occurs. The low larval counts recorded at Kiata were, indeed, reflected by low adult counts. However, the consequent expectation that high larval counts might be followed by high adult counts was not supported by the result from Castlemaine. The fact that the 1994 adult counts at Castlemaine were similar to those in 1993 may indicate that there is high larval and/or pupal mortality. Again, the true picture can only be determined by long-term monitoring. It is possible that severe environmental stress may cause the pupae not to hatch but to remain within the ants' nest and hatch only when conditions become favourable, such as in the following summer. The larval counts reflected trends in adult population numbers to some extent, as the lowest number of larvae were recorded at the Pauline Toner Reserve, which also had the lowest adult count. However, this did not apply to results from the Diosma Road eastern and western colony counts. This may be due to the inadequacies of a single sample count, which may not be sufficient to give an accurate estimation of population numbers.

#### **4.4 OVERVIEW OF SURVEY RESULTS**

Estimates of butterfly numbers at all sites surveyed appear to be low compared to previous estimates. The particularly low count at the Pauline Toner Reserve during both surveys and low numbers, made worse by the drought at Kiata, Salisbury (4 butterflies in 1993 and no butterflies in 1994) and Castlemaine, bring into question the long-term viability of the populations at these sites. This is also reflected in the comparatively low numbers of larvae recorded at all sites. Vaughan (1988) points out the problems of reduced genetic diversity of the population, if numbers become too low. This is compounded by the apparent lack of opportunities for dispersal between colonies, particularly at Eltham, where there is no continuity of habitat between the sites (Braby and Crosby, unpublished data; Vaughan 1988). Further monitoring of sites over the next few years is needed to determine whether there is any real trend of declining butterfly numbers or whether there are seasonal or yearly fluctuations in population numbers.

If the current protocol is adopted for all adult counts, useful comparative information on population numbers can be obtained. This may reveal important information on the ability of the butterfly to recover from environmental stress and heavy population reduction caused by low rainfall. This may also provide useful information in predicting the butterfly's potential to recover in other situations which reduce numbers. Larval counts may be a valuable tool in determining early population development only if more information is obtained on larval behaviour.

If the trend towards low numbers continues, serious consideration should be given to the recovery options proposed in the Victorian management plan for the subspecies (Vaughan 1988) including, in particular, introduction of butterflies or larvae from better populated sites, and captive breeding. These options should be considered in conjunction with continued local education, and habitat management and protection, as outlined by Vaughan (1988).

## 5 RECOMMENDATIONS

### 5.1 STANDARDISATION OF PROTOCOL

From this study, the following protocol for counting of adult Eltham Copper Butterflies is suggested.

- 1 A standardised method of butterfly counts should be used when monitoring all populations, using either circle counts or permanent transect counts, depending on vegetation type. It is recommended that the use of the method documented (with some modification) is continued (see Appendix 3).
- 2 To ensure that counting takes place when butterflies are most active (and thus to maximise the numbers of butterflies seen), counting should occur when temperatures are between 25–30°C, such that the butterflies are most active (under either sunny or overcast conditions). Depending on temperature, counts are probably best made between 1100 and 1500 hrs at Castlemaine and Eltham. Counts at Kiata and Salisbury may be over an extended time period (e.g. later in the day up to 1700 hrs) due to the warmer weather conditions. Counting at temperatures above 30°C should be avoided. This may frequently exclude counts in the mid-afternoon period at Kiata and Salisbury.
- 3 Temperature and general weather conditions should always be recorded, for any counts. Monitoring at all three sites at Eltham should continue with one count in late December, two in January (early and late) and one in early to mid February. Similar counts should be made at Castlemaine in November and December. One or two counting days during the peak period at Kiata and Salisbury (e.g. November) should be sufficient for butterfly estimates, if the emergence time is known.

### 5.2 CONTINUATION OF MONITORING

- 1 It is critical that the monitoring of both larval and adult populations be continued at least into 1995/1996. This information may help clarify the understanding of the biology of the butterfly and its ability to cope with environmental stress and low numbers. Before larval monitoring can be used as an indicator of adult populations, further investigation into methods to improve estimate accuracy is needed.
- 2 Specific issues relating to the effects of rainfall, and the influence of growth and flowering of Sweet Bursaria, should be investigated. This may include pruning of Sweet Bursaria plants to encourage green growth and flowering.

### **5.3 SUGGESTIONS TO IMPROVE FUTURE LARVAL COUNTS**

Further investigation of nocturnal larval activity is needed, to clarify activity patterns and thereby enhance count accuracy. Some guiding questions would be:

- Do all larvae come out of the nest at the same time on the same night?
- Once they have defoliated the host plant, do larvae move on to another plant?
- For how long do larvae feed?
- What is the mortality rate from larval stage to adult stage?

Investigating these questions would require the monitoring of specific *Sweet Bursaria* plants for several hours over several nights. Ideally, this could be followed up by excavation of one or more of the nests, to enable the larvae residing within the nest to be counted. Further research should include investigation into the larval response to drought conditions. For example, are the larvae able to go into diapause and halt development until the following year if weather conditions become more suitable?

## 6 ACKNOWLEDGEMENTS

Many people have contributed to this project in terms of financial assistance, guidance and field assistance. Financial support is gratefully acknowledged from the former Department of Conservation and Natural Resources under the guidance of the Eltham Copper Butterfly Co-ordinating Group (Leigh Ahern, Stephen Anderson, Rick Brown, David Crosby, Neil Murray, Tim New, Rob Price, Pat Vaughan, David Venn, Alan Webster, Alan Yen). The Museum of Victoria provided facilities and supervised the project. In particular, I would like to thank Dr Alan Yen for his support and guidance.

The field work could not have been carried out without the dedicated assistance of Colin Knight, Steve Anderson, Peter Lillywhite, Rob Price and David Venn. Valuable help in the field was also provided by Melanie Archer, Pam Clunie, Amanda Kobelt,, Anna Richtarik, Evan Schmidt and Gary Sobey.

Comments on the manuscript by Leigh Ahern, Peter Lillywhite, Tim New and Alan Yen are much appreciated. Leigh Ahern also assisted with technical editing. Thanks also to David Meagher (NRE) for assistance with the publication of the report.

Photographs were taken by A. L Yen and Department of Conservation and Natural Resources.

I am grateful to M. Braby and D. Crosby, and to The Eltham Copper Butterfly Friends Group, for access to unpublished data.



## 7 REFERENCES

- Braby, M.F. (1987). The Eltham Copper: a butterfly with a special appeal. *Habitat Australia* 15(6): 16–18.
- Braby, M.F. (1990). The life history and biology of *Paralucia pyrodiscus lucida* Crosby (Lepidoptera: Lycaenidae). *Journal of Australian Entomological Society* 29: 41–50.
- Braby, M.F., Van Praagh, B.D. and New, T.R. (in press). The Dull Copper, *Paralucia pyrodiscus* (Lycaenidae). In Kitching, R.L., Pierce, N.E. and Jones, R.E. (eds) *Biology of Australian Butterflies*. Monographs of Australian Lepidoptera, Volume 5. CSIRO: Melbourne.
- Cayzer, L. and Crisp, M. (in press) A morphometric analysis and revision of *Bursaria* (Pittosporaceae). *Systematic Botany*.
- Crosby, D.F. (1987). The conservation status of the Eltham Copper Butterfly *Paralucia pyrodiscus lucida* Crosby (Lepidoptera: Lycaenidae). A report for the National Parks and Wildlife Division, Department of Conservation, Forests and Lands: Melbourne.
- CNR (1995). Threatened fauna in Victoria — 1995. Department of Conservation and Natural Resources: Melbourne.
- Miller, L. (1993). Eltham Copper Butterfly (*Paralucia pyrodiscus lucida* Crosby) (Lepidoptera Lycaenidae). Monitoring and survey project for the 1992/3 flight season. Unpublished report to the Department of Conservation and Natural Resources: Melbourne.
- New, T.R. (1987). Butterfly conservation. Entomological Society of Victoria: Melbourne.
- New, T.R. (1990). Conservation of butterflies in Australia. *Journal of Research on the Lepidoptera* 29(4): 237–253.
- Pollard, E. and Yates, T.S. (1993). Monitoring butterflies for ecology and conservation. Chapman & Hall: London.
- SAC (1991). Final recommendation on a nomination for listing: *Paralucia pyrodiscus lucida* - Eltham Copper Butterfly (Nomination No. 112). Scientific Advisory Committee. Department of Conservation and Natural Resources: Melbourne.
- Vaughan, P.J. (1987). The Eltham Copper Butterfly draft management plan. ARI Technical Report Series No. 57, Department of Conservation Forests and Lands: Melbourne.
- Vaughan, P.J. (1988). Management plan for the Eltham Copper Butterfly. ARI Technical Report Series No. 79, Department of Conservation Forests and Lands: Melbourne.
- Webster, A. (1993). Eltham Copper Butterfly *Paralucia pyrodiscus lucida*. Action Statement No. 39. Department of Conservation and Natural Resources: Melbourne.
- Yen A.L., New T. R., Van Praagh B.D. and Vaughan P.J. (1990). Invertebrate conservation: three case-studies in south-eastern Australia. In: T. Clark and J.H. Seebeck (eds), pp. 207–224. *Management and Conservation of Small Populations*. Brookfield, Illinois.
- Yugovic, J.V., Crosby, D.F., Ebert, K. Lillywhite, P., Saddler, S.R., Schulz, M., Vaughan, P.J., Westerway, J. and Yen, A.L. (1990). Flora and Fauna of the Koonung and Mullum Valleys (Proposed Eastern Arterial Road and Ringwood Bypass), Victoria. Ecological Survey Report No. 38. Department of Conservation and Natural Resources: Melbourne.

## APPENDIX 1

### List of Lepidoptera species observed at each site during the study

Species	Kiata	Salisbury	Cas'maine	Eucalyptus Road	Diosma Rd (west)	Diosma Rd (east)
<i>Dispar compacta</i> Dispar Skipper				+	+	
<i>Anaphaeis java teutonia</i> Caper White	+			+		
<i>Pieris rapae</i> Cabbage White	+		+		+	+
<i>Geitoneura acantha acantha</i> Eastern Ringed Xenica				+	+	+
<i>Geitoneura klugii klugii</i> Klugs Xenica	+			+	+	+
<i>Heteronympha merope merope</i> Common Brown	+	+	+	+	+	+
<i>Vanessa kershawi</i> Painted Lady	+	+	+			
<i>Paralucia pyrodiscus lucida</i> Eltham Copper	+	+	+	+	+	+
<i>Jalmenus evagoras evagoras</i> Imperial Blue			+		+	+
<i>Lampides boeticus</i> Pea Blue					+	
<i>Zizina</i> sp. Grass Blue	+			+	+	+
<i>Agrotis infusa</i> Bogong Moth				+		
<i>Synemon plana</i> Golden Sun Moth		+				

## APPENDIX 2

### Plants species upon which Eltham Copper Butterflies were recorded during the study

<i>Acacia</i> sp.	Wattle
<i>Bursaria spinosa</i>	Sweet Bursaria
<i>Clematis microphylla</i> <sup>f</sup>	Small-leaved Clematis
<i>Eucalyptus leucoxylon</i>	Yellow Gum
<i>Exocarpus cupressiformis</i>	Cherry Ballart
<i>Pinus radiata</i>	Monterey Pine
<i>Themeda triandra</i>	Kangaroo Grass

f = feeding

## APPENDIX 3

### Protocols for monitoring populations of the Eltham Copper Butterfly

#### Background

The Eltham Copper Butterfly Co-ordinating Group (ECBCG) was established in 1992, following a decision by the Department of Conservation and Natural Resources (CNR) that improved co-ordination of relevant agencies and other interested parties was needed for successful implementation of the Eltham Copper Butterfly management plan (Vaughan 1988). The role of the Co-ordinating Group was subsequently confirmed by CNR and the Flora and Fauna Guarantee Scientific Advisory Committee in approving, for publication, the FFG Action Statement for Eltham Copper Butterfly (Webster 1993).

During 1993, the ECBCG developed a set of standardised techniques (protocols) for monitoring both larval and adult populations of the Eltham Copper Butterfly across all sites of its occurrence in Victoria. This action accords with the role of the Co-ordinating Group as set out in the Action Statement and with management requirements specified by Vaughan (1988).

In addition to the population estimates derived from counts undertaken in the past by Crosby (1987), Vaughan (1988) and Braby & Crosby (in prep.), a number of less scientifically-rigorous surveys of adults on the wing have been routinely undertaken at the three main Eltham sites by the Friends of Eltham Copper Butterfly Group, using simple transect counts. Keith Hately, of Kiata, has also undertaken adult counts of the Kiata population in some past years (Vaughan 1988).

The Co-ordinating Group believes that butterfly population numbers at all sites should be assessed regularly, in order to monitor general population trends at these sites, and to detect (and hopefully remove or ameliorate) threats to the long-term survival of these populations. It is also clear that, without regular population assessment, other prospective work towards conservation of the butterfly (e.g. genetic investigation, translocation, and research into fire ecology) has no firm basis.

General requirements for monitoring Eltham Copper Butterfly populations:

- 1 Statewide consistency, through standardised techniques applied at all sites;
- 2 Information upon which to determine population trends (preferably, initial total site counts based on high-quality data);
- 3 Incorporation of Eltham Copper Butterfly monitoring as a regular component of CNR regional management programs;
- 4 Minimum disturbance to ground flora, ants and associated biota;
- 5 Close liaison with the Eltham Copper Butterfly Friends Group to ensure adoption of standardised techniques in any ancillary monitoring activity undertaken by the Group.

#### Larval count protocol

Larval counts are desirable and useful, as an early indicator of population development and (potentially) as a relative means of comparison between Eltham Copper Butterfly colonies prior to adult emergence. However, the precise value of these counts will not be clear until a better understanding is gained of factors influencing larval behaviour.

- Counts should be performed once each year at each site, preferably on a warm night with temperature in excess of 8°C. Each individual plant of Sweet Bursaria (*Bursaria spinosa*) should be carefully searched for larvae.
- Counts should be carried out before mid-October near Melbourne, 3-4 weeks earlier at Kiata, and sometime in between at Castlemaine. Determination of the precise time will require careful observation of the state of development of larvae. Once significant numbers of larvae commence pupation, the value of the larval count as a population indicator reduces dramatically.

- Each site should be examined in daylight to identify the main patches of Sweet Bursaria and to search them for signs of grazing by larvae. These sites can be marked to help gain an orientation of the area at night.
- Intensive searching must not be permitted to cause trampling of flora or ants, or such other disturbance as might cause ants or larvae to retreat underground.
- Three to five people should ideally be used to count larvae at a site.
- Counts should begin at around 1900 hrs, the precise timing depending upon light levels. Basic environmental conditions (temperature; level of moonlight, cloud, wind, and moisture) applying on each survey night must be recorded.
- Each site should be divided into areas based on the occurrence of the highest densities of Sweet Bursaria bushes. Rough transects within each area should be walked and each Sweet Bursaria bush encountered should be carefully searched with a spotlight or strong torch, starting at the base of the plant and moving up and out along the branches.
- Larval lengths must be measured, and records made of the number of ants tending the larva and the height of the host plant. Larval plants should be identified to avoid double counting, and to permit daylight relocation. It is best to use two observers when larvae are located, to enable measurements to be taken as quickly as possible, with minimal disturbance of ants or larvae due to the torchlight.
- General activity levels or particular activity patterns of attendant ants should be noted.
- For the initial count on each site, total site coverage should be attempted. (However, where only a quick estimate of larval numbers is desired, it may suffice to restrict search effort to the small, obviously-grazed Sweet Bursaria plants.)
- As a "once-only" exercise, it is desirable that a single survey evening be held at Eltham (early to mid-January) to investigate whether a second generation of larvae is being produced during a single season. The three "strongest" colonies should be examined for this purpose. The exercise would simply aim to ascertain presence or absence, rather than to quantify abundance.
- The scope for sample stratification should also be investigated, to determine from initial data the feasibility of using follow-up "sub-set" counts which may still permit extrapolation of overall trends in larval population size at each site, but which may be less exhaustive and intrusive.

### Adult count protocol

In both of the following count options, the presence of an independent count recorder will aid count accuracy. Double counting should be carefully avoided.

#### *Count Option 1*

*Circle count (used in areas where Sweet Bursaria plants are clumped rather than scattered)*

A circular survey area of 10-30m radius (depending upon the size of the Sweet Bursaria clump) is carefully pegged out, with minimum disturbance. Butterfly counters (at least two people) are positioned around (or either side of) the subject patch. In smaller patches, only one counter is needed, and may be positioned at a permanent central marker (red peg). All butterflies observed within the circle (margins identified by white pegs) over a 5 or 10-minute period are recorded. It may be necessary for the counter to gently tap each of the bushes with a stick to disturb any resting butterflies. This method varies in effectiveness depending upon site visibility, bush density and disturbance.

#### *Count Option 2*

*Line transect count (used in areas where Sweet Bursaria bushes are scattered over the site)*

Permanent transects are laid out with tags or pegs, then walked *very* slowly and steadily. (Transects should preferably be located along existing tracks to reduce disturbance to habitat.) Butterflies observed within 5–10 m on either side of the transect line are counted. If a Sweet Bursaria patch is observed within this area, but not directly in line with the transect, the counter may go over and tap the bushes with a stick.

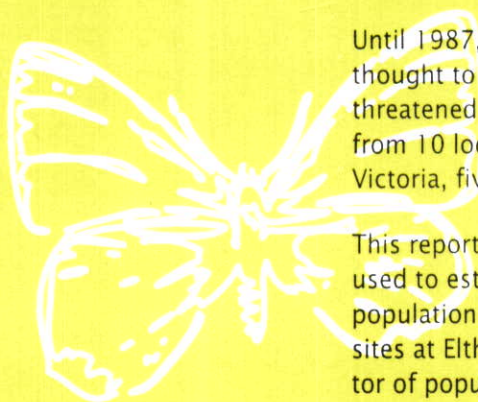
- 1 Absolute counts, whilst ideal, are not critical; the main aim being to obtain relative counts for comparative purposes.
- 2 Counts at Eltham should be performed in mid-December, early January and late January; counts should be performed at Castlemaine approximately two weeks earlier and, at Kiata, three to four weeks earlier than at Eltham.
- 3 For intensive estimates, counts at each site should be performed three times per day on three consecutive days, and always between 1000 h and 1400 h (Eastern Summer Time). Where counts on consecutive days are unachievable (for example, during unsettled weather conditions), three counts should be performed within (at most) a 5-day period. Mid-afternoon counts at Kiata should be avoided, due to the likelihood of encountering high temperatures.
- 4 As far as possible, a still, sunny day should be chosen for counts. Temperature at time of count should be recorded and any aberrant environmental factors on the day should be carefully documented. Counts should be carried out within the temperature range of 25–30°C. If less intensive counts are desired, one count at each site in mid-December, a second in early January and a third in late January should suffice, provided count conditions are optimum (sunny day, temperature 25–30°C).
- 5 In a particular year, it may not be logistically possible to arrange for more than one count sequence (that is, three discrete counts within a 5-day period) to be performed at either Kiata or Castlemaine. Under this constraint, the main objective should be to obtain three discrete count sequences (around mid-December, early January and late January) for Eltham sites.

### References

- Crosby, D.F. (1987). The conservation status of the Eltham Copper Butterfly (*Paralucia pyrodiscus lucida* Crosby) (Lepidoptera: Lycaenidae). ARI Technical Report Series No. 81, Department of Conservation, Forests and Lands: Melbourne.
- Vaughan, P.J. (1988). Management plan for the Eltham Copper Butterfly (*Paralucia pyrodiscus lucida* Crosby). ARI Technical Report Series No. 79, Department of Conservation, Forests and Lands: Melbourne.
- Webster, A. (1993). Eltham Copper Butterfly *Paralucia pyrodiscus lucida*. Action Statement No. 39. Department of Conservation and Natural Resources: Melbourne.

*Compiled by L. Ahern and A. Webster for ECBCG in December 1993, with revisions by B. Van Praagh in August 1995*

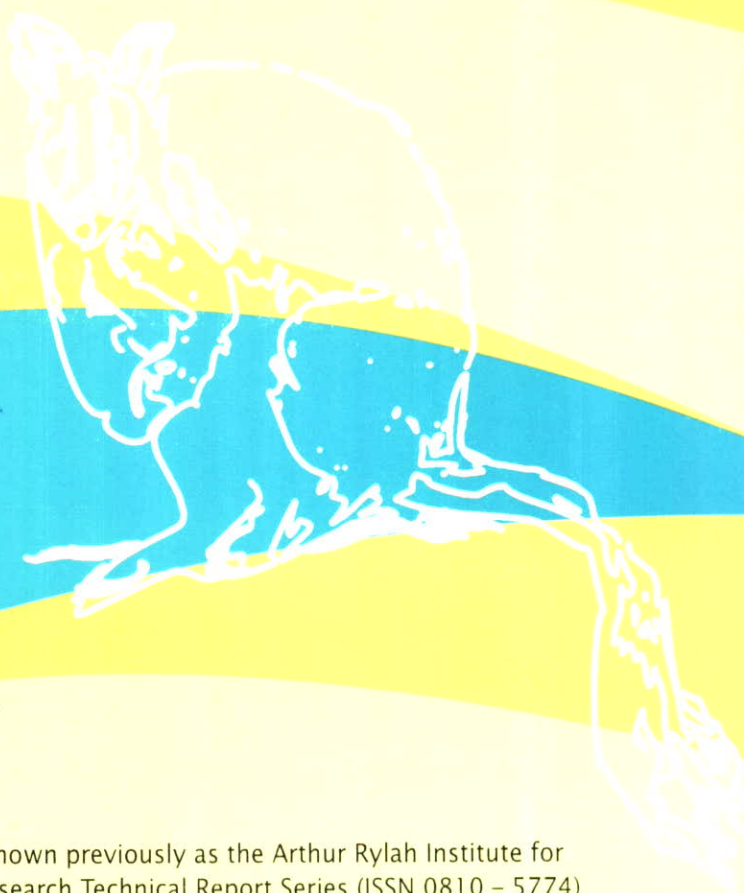
## Adult and larval counts of the Eltham Copper Butterfly, 1993–1995



Until 1987, the Eltham Copper Butterfly, *Paralucia pyrodiscus lucida* Crosby, was thought to be extinct. In that year a population was found at Eltham on land threatened by the development of a housing estate. The butterfly is now known from 10 localities in the Eltham–Greensborough area, one at Castlemaine in central Victoria, five at Kiata and one at Salisbury in the Wimmera.

This report presents the results of a study which aimed to examine the methods used to estimate populations, assess and compare adult numbers at the major population sites, conduct larval counts at Kiata, Salisbury, Castlemaine and three sites at Eltham, and investigate the potential of larval numbers as an early indicator of population development and as a means of comparing colonies before emergence.

The results have important implications for the future monitoring and management of this threatened butterfly.



ISSN 1326 – 6446

This series was known previously as the Arthur Rylah Institute for Environmental Research Technical Report Series (ISSN 0810 – 5774)