Austromerope poultoni (Insecta, Mecoptera) in south-west Western Australia: occurrence, modelled geographical distribution, and phenology

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Abstract

Forest monitoring in the period 2001–2006, using pitfall and light trapping, resulted in the collection of 27 specimens of the endemic earwig fly *Austromerope poultoni*. These new locality records are combined with previously known records with precise locality data, and together with detailed vegetation maps available for the Regional Forest Agreement area, were used to model the potential distribution of the earwig fly in south-west Western Australia forests. This species is likely to occur widely in south-west forests and woodlands. Information collected from monitoring sites in Jarrah *Eucalyptus marginata* forest provides no strong indication that this species shows a preference for, or aversion to, a particular silvicultural treatment or period since the most recent fire.

Key words: *Austromerope poultoni* , modelled geographical distribution, phenology, south-west Western Australia

Introduction

Austromerope poultoni is an insect species (earwig fly) of scientific and conservation interest, being endemic at the generic level to south-west Western Australia (WA) and belonging to the primitive family (Meropeidae), which is unrepresented elsewhere in Australia (Riek 1954, Smithers 1987, Smithers 1988). Earwig flies are otherwise known only from eastern North America, represented by the extant species *Merope tuber* Newman, and from Siberia by fossils of the mid-Jurassic (Grimaldi and Engel 2005). Although first collected accidentally nearly 100 years ago, the subsequent collection history of *A. poultoni* is one of serendipity. This, its apparent absence from many well-collected sites (Abbott 1995), and its distribution as known in 2001 (when the present study commenced), are suggestive of a species that is rare and declining.

The remarkable characteristics of *A. poultoni* include (Fig. 1) the great length of the anal forceps of the male, the strong apical spine on its basal segment, the numerous veins of the wings (Byers 1991, Fig. 37.6A), and the dot-like thickenings on the margins of both pairs of wings. Its evolutionary significance rests on its presumed close relationship to the common ancestor of the insect orders Mecoptera and Siphonaptera (fleas) (Whiting 2002), and more distantly to the common ancestor of Diptera (flies), Lepidoptera (moths and butterflies) and Trichoptera (caddis flies) (Grimaldi & Engel 2005).

The circumstances of the discovery and subsequent collections of this species prior to our study provide important context for assessing its distribution and abundance. In 1914, the British Association for the Advancement of Science held its annual meeting for the first time in Australia (Howarth 1922, Gilbert 2001). An advance party of 70 scientists reached WA in July 1914. The zoologists present visited Mundaring Weir and the caves area near and south of Yallingup. One member of the party, the distinguished Oxford University entomologist Professor (later Sir) Edward Poulton, chanced to collect on July 31 an insect 'under log or stone, in bush' between Yallingup and Mammoth and Lake Caves west of Forest Grove. Apparently Poulton did not appreciate the specimen's significance, as he lodged it in the insect collection in the Oxford University Museum of Natural History, Oxford. There it lay for nearly 20 years until another entomologist, Frederick Killington, found it, realized its importance, erected a new genus, and named it as a new species (Killington 1933).

The following abridged account of subsequent collection history of the species has been updated from Faithfull *et al*. (1985). The second specimen of this species was collected, also by accident, in 1962 by an American entomologist, Edward Ross, on a granite outcrop in jarrah forest at or near Dalry Road, Darlington (the first female).

The next collection was made in 1974 by John Penniket of Curtin University near Manjimup (3 specimens, not traceable; collecting method and geocode(s) unknown). Several collections were made in 1976: in Jarrah forest in Plavins forest block near Dwellingup; and in Jarrah forest in Quilergup forest block east of Busselton. In 1978 the species was collected in Karri forest in Crowea forest block, south of Pemberton and again at Plavins. One specimen was pitfall-trapped by Jonathon Majer of Curtin University near Kojonup on 17 October 1976. This specimen could not be located and it cannot be ascertained at which of the 5 plots sampled it was collected (J. Majer, pers. comm.; this is indicated by ? in Fig. 2). The specimens from Plavins, Quilergup and Crowea forest blocks were collected by T. Burbidge.

Figure 1. *Austromerope poultoni* : Upper and middle photo: male (showing claspers), and lower photo: female, Boddington Gold Mine, Mt Saddleback 32° 58′ 00″S, 116° 27′ 00″E. [Photos courtesy of Dr Jan Taylor]. Body length: 5 mm (♂), 7.5–10 mm (♀); wing length 9 mm (♂), 10–14 mm (♀).

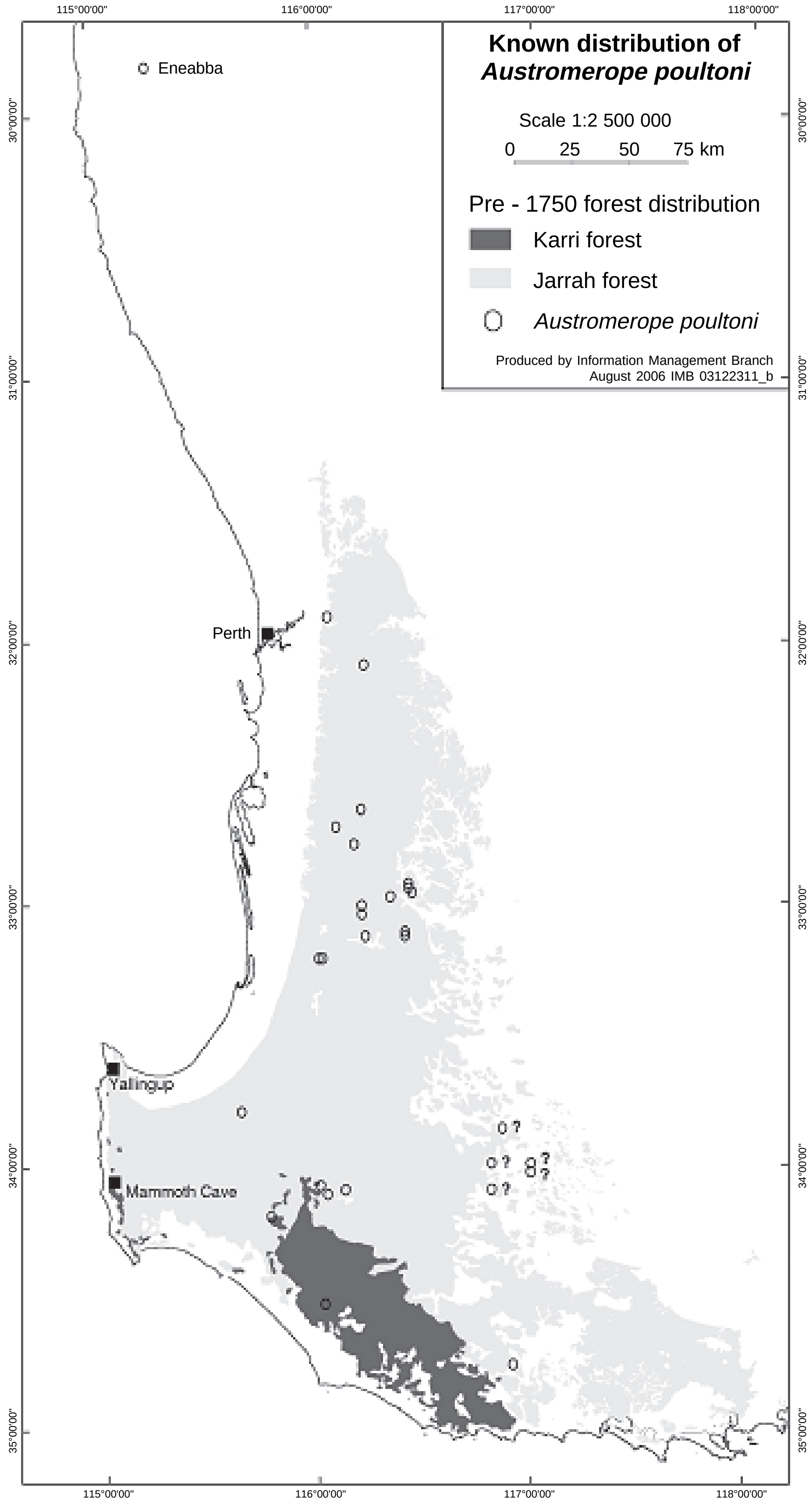

Figure 2. Map of south-west Western Australia showing localities from which *Austromerope poultoni* has so far been recorded. ? = occurrence of specimen in the correct locality (of the 5 localities depicted) cannot be ascertained (see text and Table 1).

A few years later further specimens were collected during a major pitfall trapping program run by J. Majer for Worsley Alumina (Worsley Alumina Pty Ltd 1985): in Saddleback forest block, south of Boddington (in heathland in July and October 1980; in Jarrah woodland October 1980; in heath and Jarrah forest July 1982; and in Wandoo woodland October 1982) and in Hamilton forest block, northwest of Collie (in October 1982 in Jarrah forest). More than 40 specimens had been collected in a period of 8 years. Although Poulton's original specimen came from either Jarrah woodland or Karri forest, subsequent collections were from a greater variety of habitat types, including Jarrah forest, Karri forest, Wandoo woodland and heath.

A significant extension of 240 km to the known geographical range of *A. poultoni* was made in August 1998, when R.P. McMillan and P. West collected a female in a pitfall trap near Eneabba. This specimen is lodged in the collection of the Western Australian Museum.

Between 2001 and 2006 the Department of Conservation and Land Management implemented a structured monitoring program in Jarrah forest, termed FORESTCHECK. FORESTCHECK is an integrated monitoring system that is intended to provide relevant information to forest managers in south-west WA about any changes and trends in key elements of forest biodiversity associated with forest management activities (Abbott & Burrows 2004). Its initial focus is logging activities undertaken since 1995, particularly release of existing regeneration by the creation of gaps, and the establishment of regeneration by shelterwood (These terms are defined below). We were involved in the planning and field sampling of the terrestrial invertebrate component of this program. An unexpected consequence was the collection of further specimens of *A. poultoni.*

The objectives of this paper are to:

1. Assemble and assess all records of *Austromerope poultoni,* and collate information about the phenology of, and optimal method of capture for, the species;
2. Map the occurrence of all specimens;
3. Produce a preliminary pictorial model of potential geographical distribution within the forested south-west, based on the vegetation complexes present in 1750 and mapped for the Regional Forest Agreement (RFA); and
4. Examine the occurrence of the species in relation to forest basal area, time since the most recent logging, and time since the most recent fire.

Materials and methods

We located and reviewed all literature relating to *A. poultoni*, as already indicated in the historical outline provided above. We attempted to clarify for each specimen the actual place of location (geocode), the method of collection, and the number and sex of specimens collected (Table 1). For the specimens collected as part of FORESTCHECK, we also determined stand basal area, the type of logging most recently applied, the period since the last logging, and the period since the last fire (Table 2).

The major logging treatments sampled in the FORESTCHECK program are: Gap Release (removal of

Table 1

Collection data for *Austromerope poultoni,* 1914–1980, and for 1998–2006 (excluding FORESTCHECK, for which see Table 2).

Locality	Latitude (° ' " S)	Longitude (° ' " E)	Most recent fire before collection if known	No. collected, sex, and collection method if known
1914–1980				
Between Yallingup and Forest Grove				1♂, by hand, Jul 1914
Dalry Lodge	31.55.00	116.04.56		1♀, pitfall trap, Sep 1962
Quilergup forest block	33.48.05	115.39.20	Spring 1973	1♀, pitfall trap; 2♀, light trap, Jul 1976
Plavins forest block	32.47.34	116.11.40	Spring 1973	1♂, 2♀, pitfall trap, Jul 1976; 1♂, Jul 1978
Mininup, Kojonup	34.06.00	116.49.00	1966/1967?	1, Berlese extractor, Oct 1976*
Narlingup Tank, Kojonup	33.52.00	116.52.00	1966/1967?	
Mettabinup, Kojonup	34.00.00	116.49.00	1966/1967?	
Jowerlup, Kojonup	34.00.00	117.00.00	1966/1967?	
Towerlup Creek	34.02.00	117.00.00	Autumn & spring 1977	
Crowea forest block	34.32.00	116.02.00	Spring 1975	2, light trap, Nov 1978
Boddington gold mine	32.58.00	116.27.00		2♂, 2♀, photographs
Saddleback PIL H	32.56.21	116.26.65	Spring 1979	1♂, pitfall trap, Oct 1980
Saddleback PIL I	32.57.14	116.26.12	Spring 1979	1, pitfall trap, Oct 1982
Hamilton R15Y	33.13.11	116.01.16	Spring 1980**	45+, pitfall trap, 1982***
Hamilton R16J	33.13.11	116.02.44	Spring 1980**	Pitfall trap, 1982
Hamilton R17B	33.13.26	116.02.32	Spring 1980**	Pitfall trap, 1982
Hamilton R18J	33.13.09	116.02.48	Spring 1980**	Pitfall trap, 1982
1998–2006				
RGC Sand mine, Eneabba	29.49.18	115.16.10		1♀, Aug 1998
London forest block	34.46.40	116.55.34	Spring 2002	1♀, Dec 2004

* It cannot now be established from which of these 5 plots the specimen was collected.
** Prescribed burn over that part of the forest block.
*** Collected over entire area. It cannot be determined from which plot(s) specimens were collected.

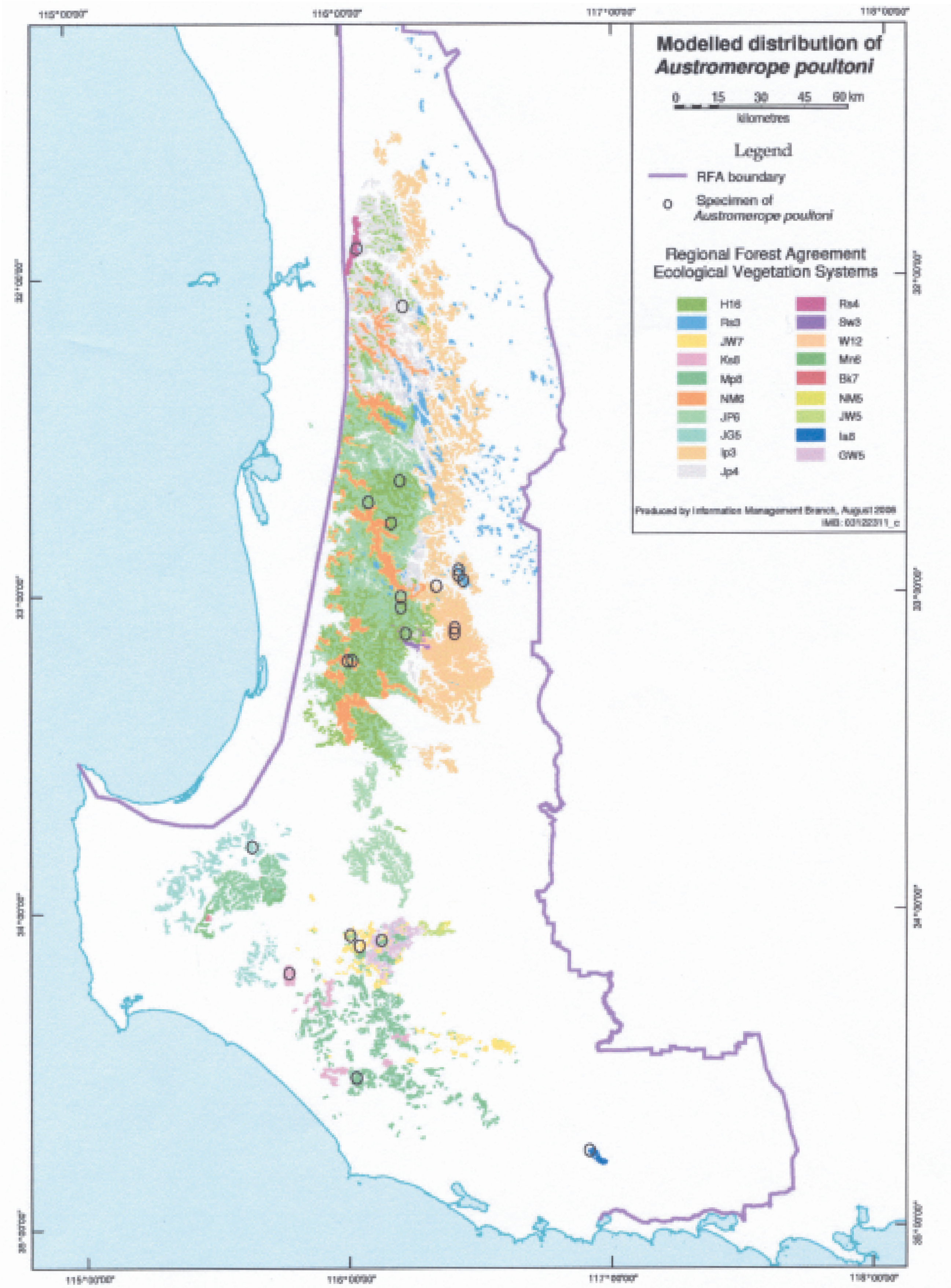

Figure 3. Map of lower south-west Western Australia showing the modelled distribution of *Austromerope poultoni,* based on the occurrence of vegetation complexes from which it has been collected.

Table 2

FORESTCHECK sample sites, recent logging and burning history, trapping method, and locations and numbers of *Austromerope poultoni* specimens collected. Blank entries in the column headed Collection date indicate that no specimens were captured.

Forest block	Plot No.	Latitude (° ' " S)	Longitude (° ' " E)	Silvicultural treatment (year)	Most recent fire (year)	Stand basal area (m^2ha^{-1})	Collection date	Pitfall spring (♂ or ♀)	Pitfall autumn (♂ or ♀)	Light spring (♂ or ♀)	Light autumn (♂ or ♀)
Winnejup	1	34.04.03	116.19.34	External reference	1986 Autumn	20.9					
Kingston	2	34.04.59	116.21.29	Gap Release (1996)	1996 Spring	34.9					
Kingston	3	34.05.20	116.22.00	Shelterwood (1996)	1996 Spring	18.0					
Kingston	4	34.05.20	116.21.36	Coupe Buffer	1996 Spring	81.6					
Yornup	5	34.06.24	116.08.33	External Reference	1996 Spring	71.6	30.11.01	11 (4♂+7♀)			
Thornton	6	34.07.17	116.03.31	Gap Release (1991)	1992 Autumn	17.3	30.11.01	1 (♀)			
Thornton	7	34.07.17	116.03.26	Coupe Buffer	1996 Spring	34.1	30.11.01, 18.12.01	2 (♀)		1 (♂)	
Carter	8	34.05.27	116.01.46	Gap Release (1999)	1999 Spring	10.3					
Carter	9	34.05.30	116.01.50	Coupe Buffer	1999 Spring	41.9	30.11.01	1 (♀)			
Easter	10	34.12.43	115.47.49	External Reference (oldgrowth)	1995 Spring	66.4	21.11.01			1 (♀)	
Edward	11	33.11.20	116.10.22	Gap Release (1994)	1995 Spring	10.5					
Ross	12	33.07.33	116.13.49	Gap Release (1992)	1991 Spring	10.0					
Ross	13	33.07.34	116.14.12	Shelterwood (1992)	1991 Spring	15.7					
Surface	14	33.08.49	116.14.24	Gap Release (1997)	1998 Spring	52.1	5.11.02			1 (♀)	
Surface	15	33.08.55	116.14.28	Shelterwood (1997)	1998 Spring	7.2					
Yourdamung	16	33.13.38	116.13.27	External Reference (oldgrowth)	1995 Spring	41.6					
Surface	17	33.07.22	116.15.49	External Reference (oldgrowth)	1998 Spring	33.3					
Chalk	18	33.03.13	116.13.01	Shelterwood (1992)	1993 Spring	13.8	15.11.02	1 (♀)			
Tumlo	19	33.01.03	116.13.03	External Reference (oldgrowth)	1997 Autumn	42.6	15.11.02	1 (♀)			
Holyoake	20	32.42.16	116.06.43	Shelterwood (1995)	2001 Spring	45.2					
Holyoake	21	32.43.19	116.16.51	External Reference	1998 Spring	18.3					
Kennedy	22	32.39.19	116.13.49	Gap Release (1998)	1990 Spring	16.9	11.11.03	1 (♂)			
Cameron	23	32.43.08	116.06.41	Shelterwood (1989)	1983 Spring	32.3	14.11.03			1 (♀)	
Kennedy	24	32.37.21	116.14.09	External Reference	1988 Spring	37.0					
Lesley	25	32.10.51	116.15.17	Gap Release (1998)	1994 Spring	7.8					
Lesley	26	32.09.05	116.13.07	Shelterwood (1997)	1993 Spring	28.6					
Occidental	27	32.06.53	116.14.12	External Reference	1983 Spring	34.6	21.11.03			1 (♀)	
Nalyerin	28	33.12.15	116.23.21	External Reference (oldgrowth)	1987–8	56.6					

Godfrey	29	33.16.22	116.26.16	Coupe Buffer	2002–3	30.5		
Godfrey	30	33.16.02	116.25.25	Shelterwood (2000)	2002–3	25.7		
Godfrey	31	33.16.52	116.25.51	Gap Release (2000)	2002–3	21.6		
Stockyard	32	33.08.21	116.24.55	External Reference (oldgrowth)	1998–9	12.9		
Stockyard	33	33.07.53	116.25.44	Shelterwood (1998)	1998–9	20.9	19.11.04	1 (♀)
Stockyard	34	33.08.21	116.25.44	Gap Release (1998)	1998–9	31.9	19.11.04	1 (♂)
Bell	35	32.59.39	116.21.34	External Reference (oldgrowth)	1997–8	25.8		
Bell	36	32.59.53	116.21.18	Shelterwood (1996)	1997–8	19.7	19.11.04	1 (♂)
Bell	37	32.59.51	116.21.32	Gap Release (1996)	1997–8	18.3	19.11.04	1 (♂)
Barrabup	38	33.57.16	115.42.15	External Reference (oldgrowth)	2002 Spring	63.1		
St John	39	33.55.11	115.39.52	External Reference (oldgrowth)	1992 Spring	39.6		
Layman	40	34.01.21	115.29.48	External Reference (oldgrowth)	1997 Spring	50.9		
Barrabup	41	33.56.40	115.44.06	Shelterwood (2002)	2002 Spring	43.8		
Cambray	42	33.54.15	115.41.38	Shelterwood (1995)	1995 Spring	22.2		
Barrabup	43	33.56.10	115.44.10	Selective (2002)	2002 Spring	21.8		
Cambray	44	33.53.60	115.42.27	Selective (1995)	1996 Spring	40.0		
Butler	45	34.00.25	115.29.10	Selective (1998)	1995 Spring	31.2		
Barrabup	46	33.56.49	115.44.14	Gap Release (2002)	2002 Spring	11.4		
Cambray	47	33.55.01	115.43.56	Gap Release (1996)	1996 Spring	49.1		
Butler	48	33.57.48	115.31.08	Gap Release (1998)	2001 Spring	27.8		

competing overstorey to encourage the development of existing advance growth); Shelterwood (reduction of competing overstorey but retention of sufficient overstorey to provide a seed source and other forest values); Coupe Buffer (areas left unlogged between adjacent gaps or shelterwood forest); and External Reference (forest nearby that has not been recently logged).

Details and photographs of all 48 plots (each of 2 ha), as well as the data collected twice each year (from spring 2001 until autumn 2006), are available at URL: *http://www.naturebase.net/content/view/2388/482* Invertebrates were sampled in spring and autumn by active, ground-based habitat searching, beating and sweeping, pitfall trapping, and light trapping. As *A. poultoni* was captured only by the last two methods, only these will be briefly described here. Ten pitfall traps (clear plastic drink cups 85 mm in diameter and inserted into permanently located PVC sleeves; each partially filled with 60 ml of ethylene glycol) per grid were left open for 10 days in November and March 2001–2006. Light traps are standard Australian Entomological Supplies 8 Watt bucket UV light traps with a timer mechanism (details as at *http://www.entosupplies.com.au/?path=1_2_2_20*). One light trap was operated, at 0.5 m above ground level, at each grid for three nights from dusk until dawn during the same months (one night per week, one week apart, and avoiding the full moon). A maximum-minimum thermometer was used to measure nocturnal temperature. Wind speed was not assessed. Any failure in a light trap in the first night of trapping resulted in the trapping being repeated (most light trap failures occur within the first night of setup).

All specimens are held in the Department of Environment and Conservation terrestrial invertebrate collection at its Manjimup Research Centre. Representative specimens will be lodged at the conclusion of the FORESTCHECK program with the WA Museum.

Six vegetation complex maps produced for the Regional Forest Agreement area were used to model the potential distribution of *A. poultoni* in the RFA area (Commonwealth and Western Australian Regional Forest Agreement Steering Committee 1998). This approach was previously used successfully by Abbott (2001). These maps, prepared at a scale of 1: 250 000, are based on dominant overstorey and understorey species, and represent the most accurate vegetation mapping of pre-1750 distribution of forest in south-west WA (as 312 vegetation complexes). Accurately-determined geocodes were used to identify the vegetation complex. Each of these complexes was then mapped to demonstrate the potential occurrence of the species within the RFA area. We could not model the potential distribution of *A. poultoni* outside the RFA area because the vegetation maps available are based on much broader categories.

Results

Collation of all geocoded specimens indicates that *Austromerope poultoni* has a broad distribution in south-west WA, from latitude 30 to 35°S, and from longitude 115 to 117 °E, and is not restricted to the forests and associated habitats in the lower south-west (Fig. 2). The occurrences near Eneabba and Kojonup indicate that the species has been able to persist under a low average annual rainfall (median = 487, 519 mm respectively). Extrapolation from accurately known occurrence at localities, based on vegetation complexes, indicates that the species is likely to occur widely within its known geographical range (Fig. 3).

Previous to the FORESTCHECK program, the limited data available (Table 1) indicated that *A. poultoni* had been collected 2–10 years after fire (mode = 2 years, median = 2.5 years). The FORESTCHECK program was designed to assess the impact of a more intensive logging process, which commenced in Jarrah forest in 1989. *A. poultoni* was collected on four of the 15 External Reference sites (27%), five of the 14 Gap release sites (36%), two of the four Coupe Buffer sites (50%), four of the 12 Shelterwood sites (33%), and on none of the three Selective sites (Table 2). Ten of the 15 External Reference sites were oldgrowth (never logged) and on only one of these plots was *A. poultoni* collected. The number of specimens collected by treatment was as follows: External Reference (14), Gap Release (5), Coupe Buffer (4) and Shelterwood (4). Although the number of specimens captured is small, there is no strong indication that the species is showing a preference for, or aversion to, a particular silvicultural treatment or fire history (Table 2, Fig. 4).

Our studies at FORESTCHECK sites found that pitfall traps were more effective than light traps as a passive means of collecting *A. poultoni* (22 vs 5 specimens), although light traps ran for only 30% of the nocturnal trap hours that pitfall traps were open. Specimens were trapped at 15 of the 48 plots sampled and all were captured in spring. All dated specimens were captured between July and December (Tables 1, 2). There was an excess of females captured (67%).

Discussion

The history of collections documented in the introductory section is instructive in that it shows that primitive invertebrate species do not necessarily have small geographical ranges and narrow habitat preferences. A flexible attitude needs to be maintained about their distribution and niche, and it should not be presumed that 'primitive' or 'Pangean origin' necessarily implies that such a species is not sufficiently resilient to withstand ecological changes, or should be restricted to relatively undisturbed refugia such as unlogged or infrequently burned forests. *A. poultoni* has been collected from a range of vegetation types, a variety of disturbance (logging and burning) regimes, and a broad range of mean annual rainfall zones (500–1400 mm). Evidently the life history of the species has enabled it to persist with the annual low rainfall summer period that is characteristic of a Mediterranean climate.

It is important not to prejudge the rarity of invertebrate species without first having searched for them thoroughly with appropriate sampling methods. *A. poultoni* was evidently not further collected for 60 years after its discovery because it is cryptic and lives in leaf litter and possibly incorrect collection methods were used in attempts to find it or it was thought to be too 'rare' to be found again.

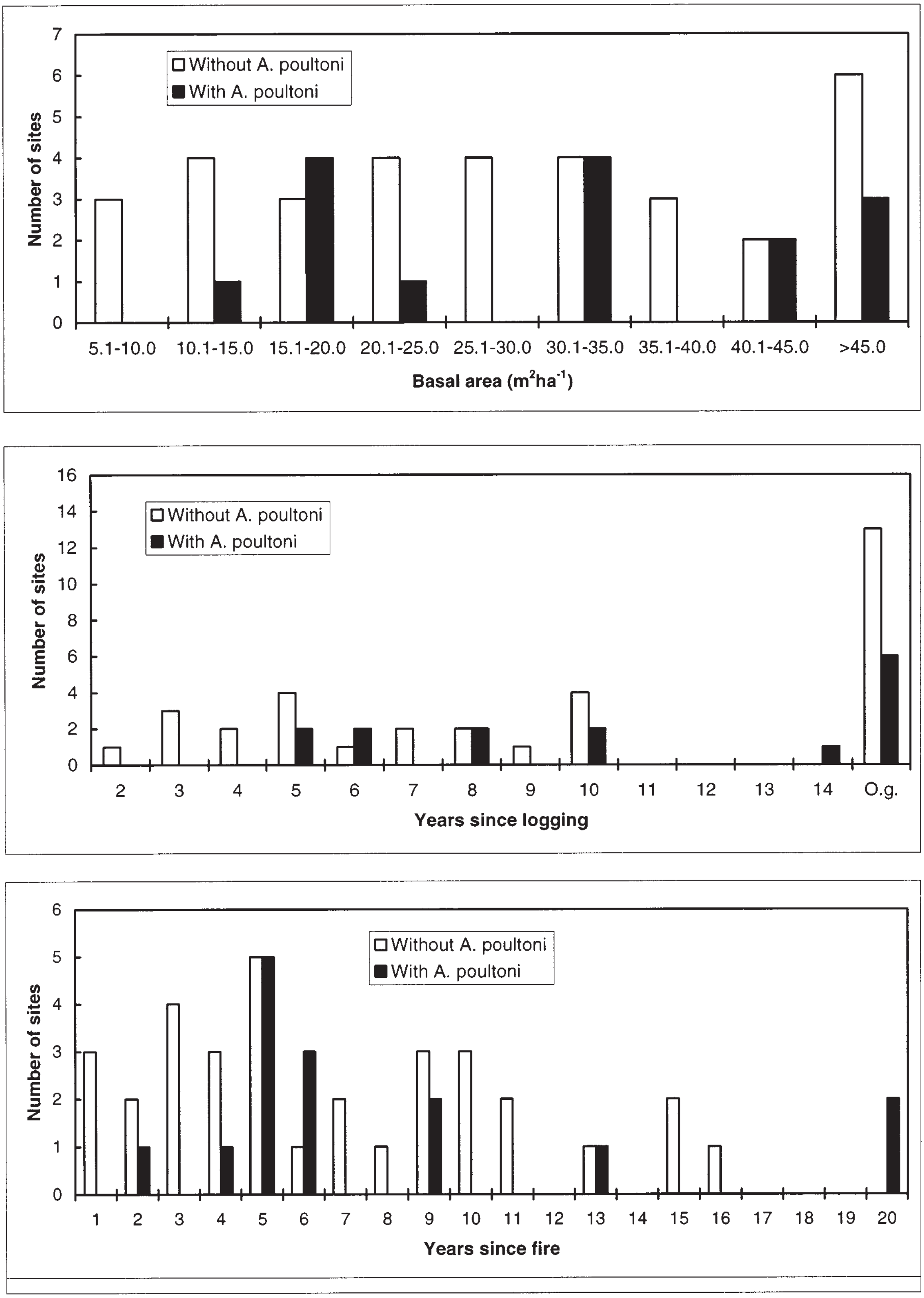

Figure 4. Number of FORESTCHECK sites with or without *Austromerope poultoni* in relation to stand basal area (m^2ha^{-1}), period since the most recent logging, and period since the most recent fire. O.g. = oldgrowth (unlogged) forest.

Collection effort, in terms of amount and distribution, constrains the known range of many invertebrate species in south-west Western Australia, and the FORESTCHECK collection has revealed range extensions for other species. For example, two or three specimens of the distinctive grasshopper *Ecphantus quadrilobus*, widespread throughout Australia but formerly not known from Jarrah forest (Rentz *et al.* 2003), and one specimen of the distinctive weevil *Cucullothorax horridus* previously known from Mt Barker and Mt Madden in WA (Zimmerman 1993), have been recovered from FORESTCHECK samples.

It is also pertinent to note that increased survey effort using appropriate trapping methods in North America has extended the range of *Merope tuber* to Florida (Dunford *et al.* 2007). All specimens were taken in flight intercept traps. Pitfall traps and funnel traps were ineffective. Females predominated in these samples (60%). With *Austromerope poultoni*, females are also more often captured (69%, based on data for 58 sexed specimens presented in Table 1; 67%, based on data for 27 sexed specimens presented in Table 2.)

Despite the extensive ranges of *A. poultoni* in south-west Western Australia and *Merope tuber* in eastern North America and the representation of adult specimens in collections, almost nothing is known of the life history and juvenile stages of the Meropeidae. Larval stages have either never been collected or remain unrecognized as such in collections. Research into the life history of these species would help to elucidate the reasons for their survival in the variety of habitat types and the ability of *A. poultoni* to survive annual summer drought.

It would also be worthwhile assessing cryptic variation that may exist in *A. poultoni*, using DNA analysis. Pitfall specimens have been collected in ethylene glycol and then preserved in 70% alcohol, and thus should be suitable for investigating the phylochronology and phylogeography of this species.

Finally, further collection in national parks and nature reserves in low rainfall areas (*i.e.*, outside the RFA area), between Eneabba and Kojonup, may result in the discovery of hitherto unknown populations. It would then be appropriate to predictively model geographical range with climatic data.

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