



CANOPY FOGGING IN THE VALDIVIAN FORESTS OF SOUTHERN CHILE PRODUCES STONEFLIES (PLECOPTERA)

William D. Shepard¹ and Richard W. Baumann²

¹ Essig Museum of Entomology, University of California, Berkeley, CA, U.S.A. 94720
E-mail: william.shepard@csus.edu

² Department of Biology and Monte L. Bean Life Science Museum,
Brigham Young University, Provo, UT, U.S.A. 84602
E-mail: richard_baumann@byu.edu

ABSTRACT

Canopy fogging in the Valdivian forests of southern Chile unexpectedly produced many Plecoptera throughout the austral summer. Females outnumbered males, with many females being full of eggs. It is proposed that the trees were used as environmental markers for mate location.

Keywords: Plecoptera, canopy fogging, Valdivian forest, Chile

INTRODUCTION

In 2007 and 2008, the senior author worked on a project examining arthropod diversity in tree canopies in the Valdivian temperate forests of southern Chile (Fig. 1). The Valdivian forests have long been recognized as a unique biological unit (Wilcox 1966; Kuschel 1960; Darlington 1965; Peña G. 1966), filled with many taxa having Gondwanan connections (Arias et al. 2008). Currently, these forests are under severe pressure as logging interests cut native forests and replace them with more fast-growing eucalyptus and Monterey pine. The project examined what canopy arthropods might be lost as the native forests were cut. The arthropods collected were expected to be mainly, if not entirely, terrestrial insects. It was quite surprising that many adults of aquatic insects were collected, examples being mayflies, stoneflies and caddis flies. The stonefly collections are described here.

METHODS

Fogging was accomplished with a standard, hand-

held, agricultural fogger using diesel fuel mixed with a pyrethroid insecticide (Fig. 2). Each tree was fogged for approximately 10 minutes. Arthropods affected by the insecticide dropped out of the canopies onto sheets placed around the base of the tree (Fig. 3). After an hour the arthropods were collected and preserved in 95% ethanol. The trees fogged included one species of Gymnospermopsida, *Araucania araucana*, and 16 species of Angiospermopsida (Table 1). These trees were chosen for their species and the ease of working around them. No consideration was given for proximity to streams or rivers. Fogging was done during the months of November through March, which is the summer season in the southern hemisphere. Field samples were returned to various museums in Chile and the USA for sorting and identification to convenient taxa that could then be made available to specialists for study. Most unstudied sample residues are stored at the University of California, Berkeley or the California Academy of Sciences. Unstudied samples from 2005 and 2006 have not yet been relocated, having been

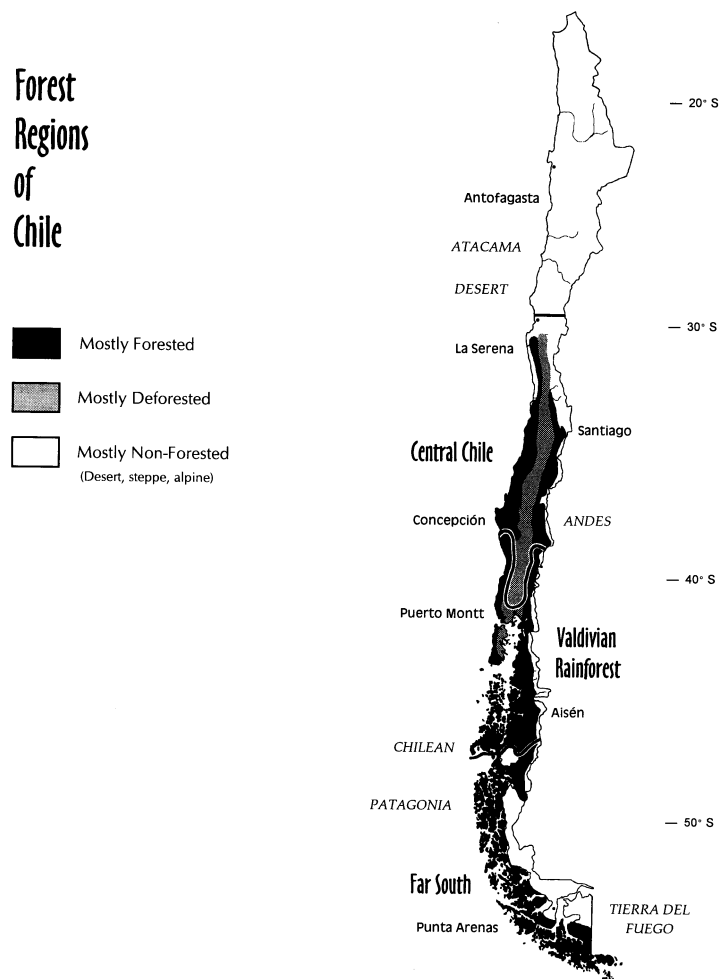


Fig. 1. Map of Chile with the Valdivian Forests indicated. From Wilcox 1996.

stored in Chile. This fogging project began in 2001 and ended in 2008 (Table 3). This work was part of a larger study of arthropods in canopies of the Valdivian forests of southern Chile (see Acknowledgments) conducted by University of California, Berkeley personnel.

The stoneflies recovered from the unstudied arthropods were identified to the family level and the genders determined. Specimens from the 2007 samples were further identified to the generic or, where possible, species level.

RESULTS

Of the 17 species of trees that were fogged

through the course of the study, only 7 species had stoneflies. However, not every tree species with stoneflies had stoneflies in every individual tree fogged. There was no discernable pattern in which trees had, or did not have, stoneflies present. Unfortunately the tree's proximity to flowing water was not recorded so nothing can be said in that regard.

Among the stoneflies there were representatives of all 6 Neotropical families. The families with the most individuals present were: Gripopterygidae (367), Austroperlidae (242) and Notonemouridae (147) (Table 2). The families Diamphipnoidae, Eustheniidae and Perlidae were represented by only



Fig. 3. Cloth sheets used to collect fallen arthropods while fogging tree canopies in Chile.

Fig. 2. Fogging tree canopies in Chile.



Table 1. Chilean Valdivian forest trees fogged for canopy arthropods, 2001-2008 combined. (+ = presence of stoneflies; common names: E=English; Sp=Spanish)

- + *Araucaria araucana* – monkey puzzle tree (E)
- + *Aextoxicum punctatum* – olivillo (Sp)
- Amomyrtus luma* – luma (Sp)
- Dasyophillum diacantiodes*
- Drymus winteri* – canelo (Sp)
- Gevuina avellana* – avellano (Sp)
- Lacurelopsis filipiana*
- + *Laurelia sempervirens* – laurel (E)
- + *Nothofagus dombeyi* – coihue (coigüe) (Sp)
- + *Nothofagus nitida*
- + *Nothofagus oblique* – roble (Sp)
- Nothofagus pumilio*
- Promnopytis andina* – llenga (Sp)
- Pseudalopex culpaeu* – tepa (Sp)
- Pseudopanax laetevirens* – sauco del diablo (Sp)
- Sauco pseudoranax*
- + *Saxegothaea conspicua* – short-leaved mañío (E and Sp)

Table 2. Numbers of specimens and families of Plecoptera collected by canopy fogging, in the Chilean Valdivian forests, 2001-2008. (-- = missing collections)

Families	2001	2003	2004	2005	2006	2007	2008	Σ %
Gripopterygidae	43	314	7	--	--	2	1	367 48.2
Austroperlidae	2	4	--	--	--	236	0	242 31.8
Notonemouridae	0	77	6	--	--	64	0	147 19.3
Diamphipnoidae	0	0	1	--	--	1	0	2 0.3
Eustheniidae	0	1	0	--	--	1	0	2 0.3
Perlidae	0	2	0	--	--	0	0	2 0.3
Σ	45	398	14	--	--	304	1	762 100.2

2 specimens each, and they were considered to be accidental collections. Stonefly numbers were low in November and increased through January and then fell precipitously afterward (Table 4). January was the month with the most stoneflies collected. All months for which samples have been studied had stoneflies represented. Each month usually

had both males and females present, but almost always there were more females than males. Many of the females had the abdomen packed full of eggs; only a few had a small number of eggs in the abdomen. In the 2007 stonefly sample there were 14 species present, 6 of which are undescribed species (Table 5).

Table 3. Canopy fogging periods, Chilean Valdivian forests, 2001-2008.

	November	December	January	February	March	
2001	XXXXXX	XXXXXX				2002
2002			XXXXXX			2003
2003	XXXXXX	XXXXXX	XXXXXX			2004
2004	XXXXXX				XXXXXX	2005
2005			XXXXXX			2006
2006			XXXXXX			2007
2007				XXXXXX		2008

Table 4. Monthly distribution of numbers and genders of stoneflies collected by fogging, in the Chilean Valdivian forests, 2001-2008 combined. Gender was not determined for all specimens collected. The March collections have not yet been relocated.

Month	November		December		January		February	
Genders	♂	♀	♂	♀	♂	♀	♂	♀
# per Gender	14	11	16	29	217	265	0	1
Gender ratio	1:0.79		1:1.81		1:1.22		--	
Σ (% of Σ)	25 (4.5%)		45 (8.0%)		482 (87.3%)		1 (0.1%)	

Table 5. Species list of stoneflies collected in 2007 by canopy fogging.

Gripopterygidae – 9 species

Alfonsoperla flinti
Antarctoperla michaelsoni
Aubertoperla illiesi
Aubertoperla kuscheli
Limnoperla jaffueli
Teutoerla new species A
Teutoerla new species B
Teutoerla new species C
Teutoerla new species D

Austroperlidae – 1 species

Penturoperla barbata

Notonemouridae – 4 species

Austronemoura new species A
Austronemoura new species B
Neonemoura barrosi
Neonemoura sp.

Diamphipnoidae – 1 species

Diamphipnopsis beschi

Eustheniidae – 1 species

Undetermined species

DISCUSSION

Presence of stoneflies in the canopy raises the question of what were they doing there. Given the presence of high numbers, including both genders, it is likely that they were using the trees as mating

locations, much as many beetles, wasps and flies use “hill-topping” to bring together both genders (Shields 1967; Parker 1978; Stewart 1994). This idea is also supported by so many females having their abdomen packed with eggs. Given the lack of a

pattern of what trees were used, probably the trees merely represented an obvious environmental marker. Ureta R. (1935) briefly mentioned finding Chilean perlids in trees. Many Australian stoneflies are also found in the tops of tall trees and tree ferns (Hynes 1974).

This is the first time that hill-topping (using trees) has been demonstrated for South American stoneflies. The only other report of stoneflies having been found in tree canopies using fogging is from Japan (Watanabe 1997), but the number of specimens was not cited. Future studies of a similar nature will indicate whether or not this phenomenon is more widespread than occurred in Chile. Perhaps re-examination of stored samples from other fogging projects will reveal the presence of stoneflies in canopies in other geographical areas. Such samples are present in the Smithsonian Institution, Washington, D.C., and other national collections.

The high percentage of undescribed species in the 2007 sample (6 of 14 species) suggests that forest canopies might represent an untapped pool of "rare" and undescribed taxa awaiting further study (Stark 2008).

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