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Comparative Biology of some Australian Hemerobiidae

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Abstract

Aspects of the field ecology of the two common Hemerobiidae in southern Australia *(Micromus tasmaniae* WALKER, *Drepanacra binocula* (NEWMAN)) are compared from data from three years sampling near Melbourne. *M. tasmaniae* occurs in a range of habitats, is polyphagous and is found throughout much of the year. *D. binocula* is more closely associated with acacias, feeds particularly on *Acacia* Psyllidae and is strictly seasonal. The developmental biology and aspects of feeding activity of these 'relative generalist' and 'relative specialist' species are compared in the laboratory at a range of temperatures and on two prey species with the aim of assessing their potential for biocontrol of Psyllidae.

Introduction

About 20 species of brown lacewings, Hemerobiidae, are known from Australia. Most of these are uncommon and represented by few individuals in collections, and only two can be considered common in south eastern Australia. One of these, *Micromus tasmaniae* WALKER, represents a widely distributed genus and is abundant on a range of vegetation types. The other, *Drepanacra binocula* (NEWMAN), represents a monotypic genus from Australia and New Zealand and is more particularly associated with native shrubs and trees – in Australia, perhaps especially with acacias. These species are the only Hemerobiidae found on *Acacia* during a three year survey of arboreal insect predators on several *Acacia* species around Melbourne, Victoria, and some aspects of their life-histories and feeding biology are compared in this paper. Both species are amongst predators being considered for use in biological control of Psyllidae on acacias in other parts of the world and the data given (the first comparative data for naturally coexisting Hemerobiidae) may aid in assessing their relative potential in such situations.

Hemerobiidae are well-known as predators of small soft-bodied arthropods (NEUENSCHWANDER et al. 1975, NEW 1975a), and both larvae and adults are predatory. Little information has been published on the biology of Australian species, but the bulk of this is limited to the two species studied here. CARTER (1949) outlined the biology of *Drepanacra* in association with *Powellia vitreoradiata* MASKELL (Psyllidae) in New Zealand, and its early stages were described by NEW (1975b). *M. tasmaniae* was implicated as an important predator of the rose aphid *(Macrosiphum rosae* (L.)) in South Australia by MAELZER (1977), and aspects of its developmental biology were discussed by SAMSON and BLOOD (1979).

Methods

Hemerobiidae (larvae and adults) were collected by beating from four species of *Acacia* MILLER (*A. baileyana* F. VON MUELLER, *A. decurrens* (J. WENDL.) WILLD., *A. dealbata* LINK and *A. pravissima* F. VON MUELLER) on the La Trobe University campus at weekly intervals throughout 1974–76, and by sweeping nearby herbage and open grassland at similar intervals. The trees were planted as seedlings in 1967 and were thus mature at the commencement of this work. Details of the beating sampling programme, and a fuller description of the study site are given by NEW (1979). Sporadic pyrethrin knockdown samples were

taken from trees not included in the regular sampling schedule. Suction trap catches at La Trobe (1972–74) and Warrandyte (an abandoned pear orchard, some 15 km from La Trobe University (1972, 73) made in a 45 cm diameter propellor-type suction trap operating 1 m above ground level at each site were sorted for adult Hemerobiidae.

Larvae from the vegetation samples were retained in the laboratory to detect parasitism and to form the foundation of laboratory stocks for use in feeding experiments. They were maintained individually in two dram clear glass vials stoppered with cotton and kept at 25° C, >70% rh and 16:8 hours L:D photoperiod. Fresh food was provided daily. For experimental rearings, F_1-F_3 larvae were kept under similar conditions, but at one of several constant temperatures (10, 15, 23, 25° C, all ±ca. 0,5° C) and known numbers of prey (either *Psylla acaciae-baileyanae* FROGGATT from fresh collections or *Brevicoryne brassicae* (L.) from laboratory cultures on cabbage seedlings) provided daily or at other stated intervals: on each occasion, untouched prey were replaced with fresh individuals. For all feeding trials, third instar prey were used. Mortality and development of predator larvae were assessed daily. For studies of reproductive performance, pairs of adults were kept in plastic "cylinder" cages (40 cm high x 15 cm diameter) and provided with a surfeit of prey and cotton pads of honey and water.

Fresh and dry weights were taken with a torsion balance reading to 0,005 mg. Analysis of temperature effects follows NEUENSCHWANDER (1975).

Results

Field data

a) Suction traps

More than 4000 Hemerobiidae were captured during the five trap-years examined (Table 1), and all but seven were *Micromus* or *Drepanacra*. The catch thus reflects the apparent rarity of other species of Hemerobiidae in Victoria, but the few other specimens represent species which have been collected in very small numbers from low vegetation: nothing is known of their biology.

Micromus was by far the most abundant hemerobiid captured and its seasonal entry pattern (Fig. 1) showed that, although it was present throughout the year, greatest numbers were trapped throughout spring and early summer and few were taken during winter. The entry pattern of *Drepanacra* (Fig. 2) was similar but more clearly defined, and only occasional specimens were captured from January to July in any trap year. It thus appears that the two species may have grossly similar adult dispersal patterns in that both actively disperse during the spring and summer.

Over the period of this survey, the mean catch of 68 Hemerobiidae per trapmonth is considerably greater than that of ca. 5 per trap month captured in Britain (NEW 1967). The British catches, which were made over parts of the summers of five years, comprised only 505 specimens of Hemerobiidae and represented 13 of the 29 species then recorded from Britain. They were not as clearly dominated by a few species; although *Wesmaelius subnebulosus* (STEPHENS) – the only species found also in Australia – was the most abundant species caught, only five yielded less than 10 individuals.

b) Vegetation

The preponderance of *Micromus* shown in the suction trap catches is not reflected in the samples from *Acacia*, on which *Drepanacra* was by far the more common species (Table 2), and may reflect the greater habitat spectrum of *Micromus*. The period of incidence of *Drepanacra* (Fig. 3) coincided closely with that of the *Acacia* Psyllidae. Only on *A. baileyana* was *Drepanacra* common, and it is notable that the other three *Acacia* species sampled did not develop large psyllid populations during the survey period. *Micromus* occurred also at times when psyllids were scarce or absent but was also most abundant on *baileyana*. On low vegeta-

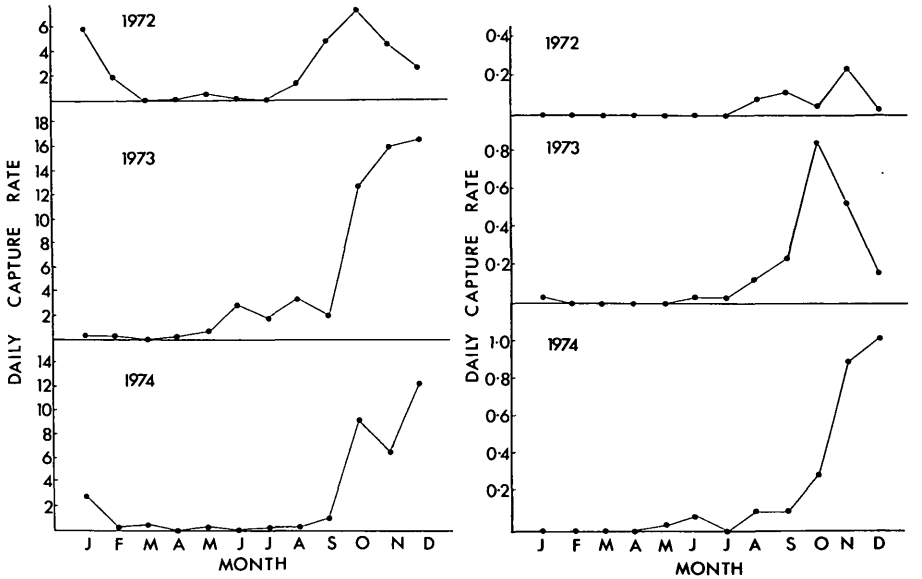

Fig. 1: Seasonal entry pattern of *Micromus tasmaniae* captured in a suction trap (45 cm diameter, 1 m above ground) at La Trobe University, Victoria, 1972–1974.

Fig. 2: Seasonal entry pattern of *Drepanacra binocula* captured in a suction trap (45 cm diameter, 1 m above ground) at La Trobe University, Victoria, 1972–1974.

tion (Table 2) *Drepanacra* was scarce, and *Micromus* considerably more common than on acacias.

In New Zealand, CARTER (1949) found *Drepanacra* to occur for much of the year on *Pittosporum,* on which its psyllid prey were also present over a long period. The broader habitat range of *Micromus* suggested by this survey implies that it may exploit a wider range of prey than does *Drepanacra:* it may be a "relative generalist" and *Drepanacra,* a "relative" specialist, and the laboratory programme discussed below was undertaken to indicate whether such may be reflected in aspects of the feeding ecology of the two species. *Drepanacra* has not been found commonly in other habitats in Victoria, and the possibility of an egg diapause through winter cannot be ruled out: a few eggs have been found on *A. baileyana* at that time. *Micromus* appears to breed throughout the year. Field parasitism of larvae of the two species was low (a maximum of about 15 per cent) and was by two species of Anacharitinae (Hymenoptera, Figitidae), namely *Anacharis zealandica* ASHMEAD and *Xyalaspis victoriensis* NEW.

	TRAP AND YEAR					
	LA TROBE			WARRANDYTE		
Species	1972	1973	1974	1972	1973	Total
Micromus tasmaniae	694	1597	996	237	323	3847
Drepanacra binocula	15	59	75	39	38	226
Drepanomina sp.	–	–	1	–	–	1
Carobius sp.	–	–	–	1	–	1
Wesmaelius sp.	–	3	2	–	–	5

Tab. 1: Numbers of Hemerobiidae captured in suction traps in Victoria, 1972–1974.

	Micromus		*Drepanacra*	
	Larvae	Adults	Larvae	Adults
Low vegetation	146	103	0	3
Acacia				
baileyana	164	49	317	111
decurrens	7	11	39	26
dealbata	0	8	52	14
pravissima	0	8	10	7

Tab. 2: Numbers of *Micromus* and *Drepanacra* captured on vegetation by sweeping and beating, 1974–1976, La Trobe University campus.

Laboratory biology

a) Developmental rates and temperature

As with the North American *Hemerobius pacificus* (NEUENSCHWANDER 1975), the field activity patterns imply active spring development, and the consequent likelihood of relatively low developmental threshold temperatures. Larval and later developmental relationships with temperature are indicated in Table 3.

Thresholds for larvae and pupae (plus prepupae) of *Drepanacra* are higher than of *Micromus,* but values for both species are relatively low. However, although *Drepanacra* may not be able to develop during much of winter, equivalent values for several Chrysopidae found around Melbourne are rather higher (9 to 11° C) (NEW, unpublished data), and *Drepanacra* thus has the potential to be more active earlier in the spring than are these. Figures for *Micromus* are somewhat higher than those given by SAMSON and BLOOD (1979) for a Queensland stock but, in common with their results, when additional data from attempted rearings at 30°C were also included, calculated threshold temperatures were unusually low (below zero) and, as in NEUENSCHWANDER's (1975) data, mortality was also very high.

The greater size of *Drepanacra* larvae is reflected in the higher larval "K". Fresh weights of fully-grown *Drepanacra* larvae usually fall within the range 5 to 8,5 mg. In contrast, *Micromus* larvae often weigh less than 4,5 mg at cessation of feeding. Smallest prepupae of each species that successfully developed to adults are 2,75 mg and 1,17 mg, respectively.

b) Larval feeding biology

The following data indicate the relative voracity of *Drepanacra* and *Micromus* larvae as predators of *Psylla* and *Brevicoryne* in confined laboratory situations.

I. Capture success

The tests undertaken were modelled on those of BROWN (1972), who investigated the predatory behaviour of several species of Coccinellidae against wheat aphids *(Schizaphis graminum* (RONDANI)) and of DIXON and RUSSEL (1972). By testing the three larval instars of each hemerobiid separately against each of several active size classes of each prey species, any difficulty experienced by the predators in capturing a particular size of prey may be revealed. The data obtained (Fig. 4) show that all instars of both hemerobiids had a high capture success when presented with various stages of *Brevicoryne*. Success with *Psylla* was also high, but first instar *Micromus* were often unsuccessful in capturing larger psyllids, suggesting that they may be predominantly limited to feeding on the younger stages. A complementary inference is that the larger size of first instar *Drepanacra* may enable them to capture larger psyllids more successfully. "Preferred" attack sites do not differ greatly between the two species; in both, most successful captures resulted from initial contact with the body of the prey rather than with its appendages (Table 4). Neither prey species showed any elaborate defence, although some aphids dropped when touched by the predator, and some psyllids moved off in short jerky runs.

	Drepanacra		*Micromus*	
	Larvae[1]	Pupae[2]	Larvae[1]	Pupae[2]
y = a+b T	y = −0.0002+0.0029T	y = −0.0247+0.0056T	y = −0.0115+0.0036T	y = 0.0124+0.0045T
r^2	.942	.965	.900	.986
t∓SE(°C)	6.9∓0.85	3.80∓0.65	3.19∓1.35	2.75∓0.40
K∓SE(°d)	344.8∓5.6	153∓4.3	77.78∓7.3	222.2∓11.8

1. From eclosion to cocoon formation
2. From cocoon formation to adult emergence
y = rate of development (l/time, in days), T = temperature in °C
t = threshold temperature
K = thermal constant

Tab. 3: Developmental relationship with temperature for larvae and pupae of *Drepanacra* and *Micromus* (N = 25 of each species reared at each of 10, 15, 20, 23 and 25°C).

II) Numbers of prey eaten

Several sets of feeding trials were undertaken, to determine the maximum number of prey that would be killed/eaten, the minimum number necessary for development, and the effect of the amount of food eaten on the rate of development. The minimum food requirement is not often measured in biocontrol contexts, but may be of considerable importance in predicting the survival of predators at low prey densities, and the difference between "minimum" and maximum" consumption may be an indication of the ability of a predator to "control" rapid increases in its prey population by increasing consumption in response to greater food abundance. The numer of prey killed does not necessarily bear any relationship to meal size – some may not be consumed at all and others may continue to lose weight after partial consumption by the predator. However, in enclosed, limited-prey situations (such as in the present tests), the larvae commonly utilised their prey thoroughly, and the number of prey killed is considered to be adequate as an index to compare consumption by the two species. The large numbers of tests undertaken also tend to validate such a comparison, but the amounts of prey actually eaten may be slightly overestimated.

Numbers of prey "eaten", developmental time (at 25° C) and survival of the hemerobiid larvae are shown in Table 5. For both species on *Brevicoryne,* five prey per day throughout

		Percent initial contacts with			
	N	Appendage	Head	Thorax	Abdomen
a) Attacks					
M-P	983	11	17	29	43
M-B	1155	18	26	23	33
D-P	1017	15	30	25	30
D-B	1144	16	18	29	37
b) Captures					
M-P	671	8	21	25	46
M-B	976	16	30	18	36
D-P	893	11	40	16	33
D-B	1055	8	14	29	49

Tab. 4: Sites of initial contact with prey (a, all attacks, b, all captures; *Micromus, Drepanacra, Psylla, Brevicoryne* denoted by their initial letter; data rounded to nearest whole per cent).

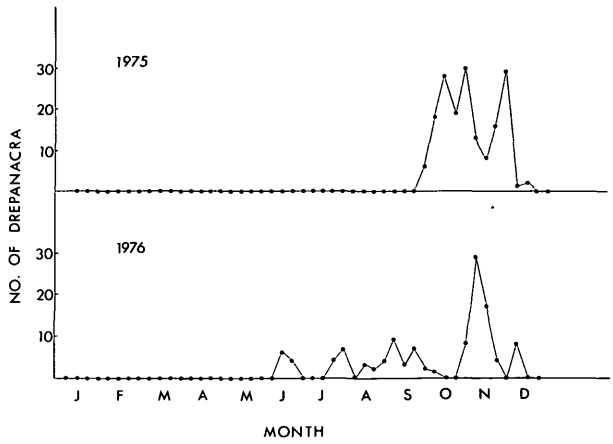

Fig. 3: Numbers (larvae and adults) of *Drepanacra binocula* captured on *Acacia baileyana* at La Trobe University, Victoria, 1975–1976.

development was clearly in excess of requirements: such permitted developmental time and prepupal size almost identical to those of larvae fed *ad lib.*, 100% survival, and the surfeit of prey present under this regime was shown by the almost invariable survival of some prey between feeding intervals. With *Drepanacra* (Table 5), reduction of this numer to two/d increased both developmental time and mortality. All larvae died under the more extreme regime of one prey/d. *Micromus* under these regimes had higher survival rate at two prey/d, but its developmental period was considerably longer than at five/d. A few individuals still completed development at one/d. Under these conditions, therefore, *Drepanacra* successfully completed development on 25 to 28, *Brevicoryne* and *Micromus* on 9 to 36 *Brevicoryne* – the majority at below 20 prey.

Table 6 shows data obtained from providing the different predator instars with different numbers of prey. For *Drepanacra,* it is shown that one *Brevicoryne*/d is ample for instar I, two/d for instar II and at least four (preferably five)/d for instar III is necessary to ensure a survival rate of 80% or over. The prey "thresholds" for later instars of *Micromus* were rather less for equivalent survival rates.

A comparable set of trials with *Psylla* as prey (Tables 5,6) showed that *Micromus* could still – although rarely-develop under a regime of one prey/d, whereas *Drepanacra* needed at least three/d. Relative sizes (dry weights) of the two prey organisms *(Brevicoryne: Psylla,* N=20 of each weighed) are 1:0,83 and (although this is total weight rather than ingestible weight), this difference reflects the larger number of *Psylla* needed for development, although this difference is usually small.

The above tests represent regular feeding regimes. Resistance to starvation (the survival period possible without food, and ability to recover after resumption of feeding) was also estimated. Series of larvae fed at known rates until a moult were then starved for successive two/d intervals before being returned to a regular regime of two/d (II) or five/d (III), and development to adult was recorded as "survival" (Table 7). Unfed first instars mainly survived for only 2 to 4 d, with a maximum of eight d in one *Drepanacra,* second instars rather longer and previously adequately-fed third instars starved for up to 16 or 18 d without apparent damage. Fresh weight loss over such periods was of the order of 20 to 30 per cent, but prepupation weight of such individuals was generally within the range of normally-fed larvae. The two species appeared similar in their ability to resist starvation.

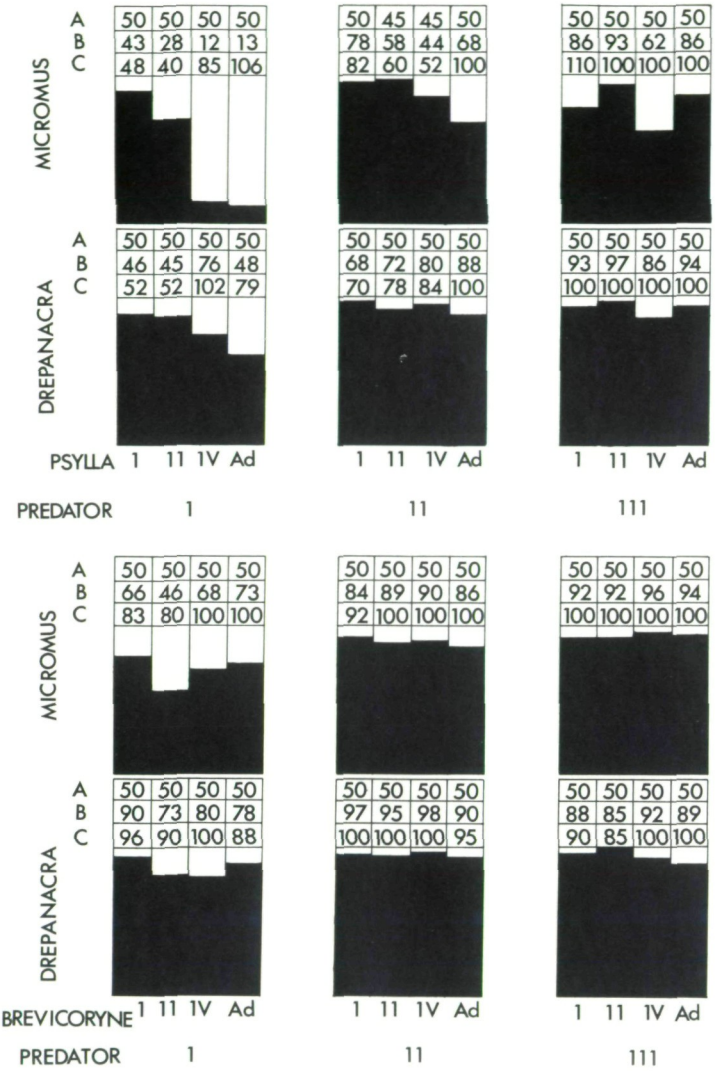

Fig. 4: Capture success (per cent) of each instar of *Micromus* and *Drepanacra* in laboratory tests against various stages of (a) *Psylla* and (b) *Brevicoryne*.
(A = no. of predators used, B = no. of captures observed, C = no. of encounters observed, histogram = B/C×100).

III) Efficiency of food utilisation

A further aspect of prey utilisation, possibly mirrored in the above results, is the efficiency with which food is converted into body tissue. A prospective source of error for such estimates in lacewings is the lack of faecal production during larval life: food is selectively removed from the gut solely by absorption, and the remaining waste material retained in the gut until after cessation of feeding. For the work summarised in Table 8, the faecal component from prepupae was weighed, and it is assumed that the proportioning of this between each instar directly reflects the amount of food ingested by each instar: this component is subtrac-

	No prey offered/d	No prey eaten	Larval development (d)	Survival (%)
Drepanacra Brevicoryne	Unlimited	?	9–11	100
	5	26–28	9–10	100
	2	25	15	4
	1	–	–	0
Psylla	Unlimited	?	9–12	100
	5	24–38	9–12	96
	3	30–36	10–14	16
	2	–	–	0
	1	–	–	0
Micromus Brevicoryne	Unlimited	?	6–12	100
	5	13–31	6–11	92
	2	25–36	14–21	28
	1	9–16	10–16	8
Psylla	Unlimited	?	7–10	100
	5	18–29	6–12	100
	3	14–23	7–12	100
	2	18–30	14–16	56
	1	15	18	4

Tab. 5: Numbers of prey consumed, duration of development, and survival of larvae of *Drepanacra* and *Micromus* when provided with known constant numbers of potential prey (25°C, 70% rh, 16:8 L:D, prey are instar 3, counted and changed daily, N=25 at start of each trial).

ted from the total dry weight of (larvae + faeces) and the resultant is shown in the Table. A greater difficulty for study of sucking predators is accurate estimation of the amount of food ingested, and the method used here is essentially that of GLEN (1973). For the limited number of predators used, the prey remaining each day were dried to constant weight and this weight compared to aliquot prey kept in predator-free vials over the same period. The different gives an estimate of dry weight ingested over the period, and the small error due to "leakage" from partially-consumed prey was assumed to be negligible.

As: Growth efficiency = $\frac{\text{Increase in dry weight in predator x 100,}}{\text{dry weight of prey consumed}}$ series of predators towards the end of each instar (before moulting) were weighed alive, then oven dried and their proportional dry weight calculated. The relevant gravimetric data, and calculated growth efficiencies are shown in Table 8. Dry weight increase in each instar of *Drepanacra* and *Micromus* fed on either prey showed no major difference due to prey type, and conversion efficiencies also overlapped considerably. First instars of both species had rather higher growth efficiency on *Psylla* than on *Brevicoryne*, but the difference was only marginally significant ($P.<0,1>0,05$). Growth efficiency of *Micromus* III was greater on *Brevicoryne* than on *Psylla* ($t = 2,7$, $P<0,002$).

IV) Choice between prey species

The following tests were undertaken to determine whether the implied specialisation of *Drepanacra* is reflected in any tendency to select *Psylla* rather than *Brevicoryne* if both prey

	No prey offered/d to I	II	III	No prey eaten	Larval development (d)	Survival (%)
Drepanacra						
Brevicoryne	1	2	3	24–27	12–14	60
	1	2	4	25–30	10–13	80
	1	2	4	23–28	13–17	16
	1	1	5	20–26	10–11	96
Psylla	1	2	3	26–33	10–16	48
	2	2	3	28–35	11–14	56
	2	3	3	24–29	10–14	44
	2	3	4	26–30	11–13	92
	2	3	5	28–35	9–12	88
Micromus						
Brevicoryne	1	2	3	11–15	8–13	80
	1	2	4	9–15	7–12	92
	1	1	3	12–25	10–12	56
	1	1	4	18–26	8–13	84
Psylla	1	2	2	18–24	12–15	44
	1	2	3	15–20	10–15	80
	1	2	4	16–23	10–15	96
	2	2	4	16–27	7–12	100
	2	2	5	20–32	8–12	96

Tab. 6: Numbers of prey consumed, duration of development, and survival of larvae of *Drepanacra* when provided with known constant numbers of potential prey, but with feeding regime changed for different instars (regime and N as Table 5).

species are available. Experimental conditions were as in the above trials, but five individuals of each prey species were supplied daily for each predator, namely enough to satisfy its usual food requirements on either prey species alone. Earlier data (Fig. 4) imply that both prey species could be easily captured by third instar predators, and that prey defence should not be a factor in selection of either prey species. In all tests (Table 9), *Micromus* larvae took similar numbers of each prey species, and the small variations appeared to be due to sequence of encounter rather than actual choice. The same was so for *Drepanacra,* but there was a slight tendency (P slightly >0,10) for more *Psylla* to be taken, and a majority of individual predators tested ate more psyllids than aphids.

c) Reproductive biology

Although there are departures from a uniform sex ratio in the suction trap catches (Table 10), examination of reared and other captured adults indicated that both *Drepanacra* and *Micromus* have sex ratios of near unity. Fecundity, adult longevity and oviposition rate were measured for adults reared separately on *Brevicoryne* and *Psylla*. The data summarised in Table 11 are for adults maintained at 25° C and 16:8 hours L:D photoperiod.

The results are very variable and differences between species are obscured because of this range of variation, but some tentative trends are apparent:

I) The preoviposition period of *Drepanacra* is usually greater than that of *Micromus* (difference not significant), and is sometimes shorter when fed on *Psylla* than on *Brevicoryne* (difference not significant).

		Per cent survival after interval:									
		1	2	3	4	5	6	7	8	9	10
Drepanacra	I	92	80	20	4	0	0	–	–	–	–
	IIB	96	92	92	28	0	8	8	0	–	0
	IIP	96	92	88	56	20	4	0	4	0	0
	IIIB	100	100	96	92	76	64	60	48	8	0
	IIIP	100	100	100	100	56	68	36	40	0	0
Micromus	I	100	48	8	0	0	0	–	–	–	–
	IIB	100	100	48	20	8	16	0	0	–	–
	IIP	100	92	100	56	36	0	0	–	–	–
	IIIB	92	96	80	80	–	–	16	0	–	–
	IIIP	100	92	88	64	16	–	20	0	0	0

Tab. 7: Survival of larvae of *Drepanacra* and *Micromus* starved for known periods after controlled feeding up until the start of an instar and returned to a regular feeding regime after successive 2d intervals. (Regular feeding regimes (pre and post-testing) are 2 (I and II) and 5 (III) prey/d.; not all food was necessarily eaten by the larvae before or after tests; N = 25, B = *Brevicoryne*, P = *Psylla*).

	Dry Weight increase (mg)	Dry Weight (% Wet Weight)	Dry Weight consumed (mg)	Growth Efficiency
Drepanacra Brevicoryne				
I	0.21∓0.06	39.6∓3.2	0.51∓0.09	38∓3.8
II	0.58∓0.14	32.0∓4.3	1.20∓0.25	43∓1.4
III	1.95∓0.41	32.6∓6.1	4.80∓0.12	41∓2.6
Psylla				
I	0.18∓0.04	34.8∓3.3	0.48∓0.11	46∓4.4
II	0.63∓0.10	33.2∓1.9	1.35∓0.16	41∓3.6
III	2.13∓0.29	35.0∓4.0	4.48∓0.18	43∓1.5
Micromus Brevicoryne				
I	0.14∓0.03	38.0∓4.3	0.30∓0.04	44∓4.6
II	0.37∓0.09	42.6∓3.0	0.74∓0.10	46∓5.7
III	1.24∓0.18	40.3∓4.8	2.80∓0.05	42∓3.9
Psylla				
I	0.12∓0.03	36.8∓3.7	0.26∓0.03	53∓4.9
II	0.44∓0.06	39.6∓2.8	0.81∓0.04	47∓2.8
III	1.19∓0.11	43.0∓5.2	3.70∓0.08	34∓5.1

Tab. 8: Dry weight measurements of growth increments, food ingested and growth efficiency of larve of *Drepanacra* and *Micromus* (means ±S.D.; Growth efficiency to nearest integer; N = 20 of each instar of each species fed on each of *Brevicoryne* and *Psylla;* gut contents omitted (see text).

II) Fecundity and fertility of *Micromus* are similar on the two prey. Fecundity of *Drepanacra* is slightly greater on *Psylla* than on *Brevicoryne* (t=1,8,P<0,10>0,05).
III) In general, fecundity of *Drepanacra* is lower than that of *Micromus*. (*Brevicoryne* t=2,6,P<0,01, *Psylla* t=1,9,P<0,10>0,05).

Predator	N	Total prey eaten *Brevicoryne*	*Psylla*	x^2	P	No. eating more *Psylla*
Drepanacra	20	50	76	2.683	NS (>0.10)	12
Micromus	20	45	52	0.253	NS (>0.50)	8

Tab. 10: Sex ratios (male: female) of *Micromus tasmaniae* and *Drepanacra binocula* captured in suction traps in Victoria, 1972–1974. (one 45 m diameter trap at each site, operating ca 1 m above ground level).

	TRAP SITE AND YEAR				
	LA TROBE			WARRANDYTE	
	1972	1973	1974	1972	1973
M. tasmaniae	1.20:1	1.16:1	1.14:1	0.76:1	0.82:1
D. binocula	0.08:1	0.18:1	0.05:1	0.12:1	0.15:1

Tab. 9: Choice between two prey species by third instar larvae of *Drepanacra* and *Micromus*.

	Micromus		*Drepanacra*	
	B	P	B	P
Preoviposition period (d)	2-5 (3.8)	2-6 (4.0)	4-8 (6.0)	3-6 (4.5)
Oviposition period (d)*	11-23 (16.0)	10-19 (14.5)	9-47 (24.6)	12-31 (19.3)
Postoviposition period (d)	2-8 (5.5)	3-10 (6.2)	1-15 (8.4)	2-11 (7.0)
Longevity●	16-34 (25.2)	17-32 (22.0)	25-58 (33.8)	19-43 (29.3)
Fecundity: Eggs/♀°	116-583 (280)	84-431 (252)	92-286 (154)	188-364 (206)
Fertility: %	92-100 (96.0)	89-96 (93.6)	87-98 (95.0)	76-100 (86.4)

* measured only for females that subsequently survived for a day without laying eggs: all females were dissected at death, and those with well-developed (chorionated) egg-rudiments in ovarioles omitted from the above table. Three *Micromus* (B), one *Micromus* (P) and three *Drepanacra* (P) died within a week of commencing oviposition and are also omitted.

● see above. N for this line = (MB) 15, (MP) 18, (DP) 16; ♀ longevity only included.

° measured only for females that completed their oviposition period; see above.

Tab. 11: Reproductive biology of *Drepanacra* and *Micromus* reared on *Brevicoryne* (B) or *Psylla* (P) and fed on the same prey (N= 20 pairs of each predator-prey combination; range and mean given).

IV) Both species are relatively long-lived , with some *Drepanacra* surviving longer than all *Micromus*. In both, the post-oviposition period is relatively short, and oviposition may occur over a period of several weeks. The oviposition period of *Drepanacra* is often longer than that of *Micromus* (difference of means not significant).

As CANARD (1970) showed for *Chrysopa perla* (L.), larval feeding regimes or food spectrum may have greater effects on subsequent adult performance than on larval developmental rate or size, but most implications of difference listed above are statistically unjustified (t test), and it is unwise (in view of the large variations recorded) to emphasise any of the above impressions.

Discussion

The two hemerobiids are active predators but, although both are found on acacias, their major habitats imply that they predominantly feed on different prey organisms. This study has attempted to determine whether or not they are "preadapted" to particular prey, by comparing aspects of their larval feeding – and the subsequent effects on adult reproduction – when fed on what may be considered a "normal" prey for each species (namely *Brevicoryne* for *Micromus, Psylla* for *Drepanacra)* and the converse "unusual" prey for each species. Few comparable data on hemerobiid biology are available, although the developmental biology of two European species was separately studied by LAFFRANQUE and CANARD (1975: *Boriomyia subnebulosa* (STEPHENS) and by MIERMONT and CANARD (1975: *Micromus angulatus* (STEPHENS)). Both of these species frequent a wide range of vegetational strata, but, *M. angulatus* is particularly characteristic of low vegetation, and both are considered to be relatively generalist predators. NEUENSCHWANDER (1975, 1976) studied the biology of the North American *Hemerobius pacificus* BANKS, larvae of which fed readily on both aphids and psyllids, and two species of *Micromus* were compared as predators of citrus aphids in Florida by SELHIME and KANAVEL (1968). *M. posticus* (WALKER) was considerably more common than *M. subanticus* (WALKER). The fragmentary literature available on biology of the two Australian species was noted earlier, and the accounts of other species noted above have an emphasis different from the work reported here.

Drepanacra, because of its more limited habitat and consequent more limited prey spectrum than *Micromus,* may be considered a "relative specialist" and its regular occurrence in acssociation with psyllids on *Acacia* implies that it should be well-adapted to utilising these as prey. This is clearly so, and "performance" (as evidenced by developmental rate and effect on reproduction) is often slightly better on *Psylla* than on *Brevicoryne. Micromus* does comparably well on both prey species, and a feature of such "relative generalist" predators may be their ability to exploit any one of a range of prey species to a similarly adequate extent. But full assessment of the food requirements of predators is difficult, even neglecting nutritional differences between prey, and many supposedly generalist feeders may prove to have some specific food requirements – or more limited prey spectrum – than is generally thought. Both ANDERSON (1962) and RUSSEL (1970), for example, have indicated that such situations occur in Anthocoridae. Some anthocorids reared on clearly unnatural prey (namely, species not usually encountered or utilised in field situations) had a higher growth rate and lower mortality rate than other anthocorids reared on the same prey species as "natural" prey. Likewise, the growth rate and survival of different anthocorid species on the same natural prey species differed. Comparative assessment of the suitability of particular prey species for particular predator species is therefore complex and, although the differences noted in this work can be interpreted as confirming that *Drepanacra* is more specialised than *Micromus,* such a conclusion may be premature.

However, assessment of such parameters as larval food utilisation and its effect on reproduction are perhaps fundamental to understanding the action of predators and does provide some rational basis for their comparison in laboratory situations: criteria for selection of predators against insect pests have not been formalised to the extent that selection of insect control agents for plant weeds has been (for example, by HARRIS 1973). Clearly, the criteria emphasised by VAN EMDEN (1966) are fundamental. The voracity of the predators is affected by their appetite, activity, abundance in relation to prey, efficiency of searching for prey, defence by prey, relative specificity and rate of multiplication. Even (unrealistically) neglecting the areas of prey reproduction and synchronisation between predator and prey (as appears to be a regular association with such apparently specific predators as *Drepanacra)*, ranking can perhaps be made only the most general terms.

"Generalist" predators, however, are likely to be present in most prey associations, and introduction of predators to other areas should probably be limited to the use of "relative

specialists". Ideally, these should (1) remain in association with the target prey (2) eat or kill large numers of it, preferably of all growth stages (3) be able to survive at low prey densities, and utilise other less-preferred prey at such times (4) actively prefer the target prey over others available and (5) withstand the full range of climatic variation of the area. The work described in this paper is an initial step in suggesting that *Drepanacra* may be more suitable than *Micromus* as a potential control agent for *Acacia* Psyllidae outside Australia. Even without evidence that the above criteria are partially fulfilled, the larger size and greater appetite of *Drepanacra* could intuitively suggest its preference over *Micromus*. But, as FRAZER and GILBERT (1976) have so forcibly shown, any isolated laboratory study of a predator-prey interaction is unreliable because "some vital aspect of the true i. e. the field relationship may be completely overlooked in the laboratory."

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