SALINITY RANGE AND OSMOREGULATORY ABILITY OF CORIXIDS ((HEMIPTERA : HETEROPTERA) IN SOUTH-EAST AUSTRALIAN INLAND WATERS

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Abstract

The distribution of corixids in Victoria was investigated with respect to salinity. None was found above 13·4‰. Osmoregulatory studies on the two most saline-tolerant species, *Sigara australis* and *Agraptocorixa hirtifrons*, indicated that both can weakly hypo-osmoregulate near upper lethal salinity values.

I. INTRODUCTION

A number of authors have recorded corixids at high salinities (up to 80‰) in inland saline waters outside Australia (e.g. Hutchinson 1931; Bond 1935; Baid 1968; Green 1968; Howmiller 1969; Scudder 1969). Indeed Macan (1963), summarizing early records, noted corixids as one of the characteristic faunal constituents of saline lakes. In Australia, however, where occur a very large number of such lakes over a wide range of salinity (Bayly and Williams 1966, 1973; Williams 1967), corixids are not common in saline waters. This situation is of considerable interest in view of the widespread and abundant occurrence of saline waters in Australia. The present paper is based on an attempt to document this phenomenon more precisely in south-eastern Australia. Two directions have been followed: a large number of inland water bodies over a wide salinity range in Victoria was sampled for corixids; and the osmoregulatory abilities of two of the more saline-tolerant species were investigated in the laboratory.

II. SALINITY RANGE

Methods and Results

Collections of corixids were obtained from the littoral areas of water bodies using a hand net of mesh size 1 mm. Specimens were preserved in 70% ethanol. Water samples were obtained contemporaneously and preserved in polyethylene bottles for transport to the laboratory, where salinities were derived by using a conductivity meter and applying the formula of Williams (1966). In all, 72 localities throughout Victoria were investigated during the period April to October 1971. Corixids were obtained from 36 of these. In general type, localities ranged from small ponds and dams to large impoundments and natural lakes. Only lentic localities

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were investigated. The total range of salinity over which collections were attempted was from <0·1 to 336‰. Results are tabulated in summarized form in Table 1. This table, it should be noted, includes records of co-existing species.

TABLE 1

SALINITY RANGE OF CORIXIDS AND DISTRIBUTION WITH RESPECT TO SALINITY OF LOCALITIES INVESTIGATED*

Except for last column and line, data in body of table refer to numbers of localities

Species	Salinity ranges (‰)							
	<0·5	0·5–3·0	3–10	10–15	15–50	50–100	100–336	Total
Agraptocorixa eurynome	1	4	3	0	0	0	0	0·4–7·3
A. hirtifrons	0	1	2	0	0	0	0	1·0–7·8
A. parvipunctata	0	1	0	0	0	0	0	1·0
Micronecta annae	2	0	1	0	0	0	0	0·1–9·3
M. gracilis	1	0	1	0	0	0	0	0·1–4·3
M. robusta	11	8	6	0	0	0	0	<0·1–7·8
Sigara australis	1	4	6	1	0	0	0	0·4–13·4
S. sublaevifrons	2	1	0	0	0	0	0	0·4–1·0
Corixids not recorded	2	3	4	3	11	6	7	
Total of localities investigated	16	13	15	4	11	6	7	
Percentage localities with corixids	87·5	77	73	25	0	0	0	

* Full details of the data on which this table is based are given in Knowles (1971).

Discussion

The results indicate that corixids do not occur in Victorian waters of salinity greater than 15‰. This stands in sharp contrast to the situation in many regions outside Australia where corixids may penetrate into waters considerably more saline than 15‰. It also contrasts with the two isolated records of Ettershank *et al.* (1966) who recorded *Agraptocorixa* sp. near *eurynome* and *Micronecta gracilis* at a salinity of 36‰, and the same species of *Agraptocorixa* at 53‰ in New South Wales. Both records relate to man-made impoundments (a bore dam and a homestead tank). Although localities of this sort are sometimes saline, they are usually fresh (to serve pastoral needs), and the records are viewed with suspicion by the present authors. Even if valid, it seems unlikely that they could have applied to permanent breeding populations; they may relate to transient, non-breeding individuals whose presence was atypical and temporary.

With regard to species differences in salinity preferenda, the paucity of data precludes any definitive statements. In general, it appears that most species can tolerate waters of salinity <10‰, but with the possible exception of *Sigara australis* (and perhaps *Agraptocorixa hirtifrons*) most prefer waters <3‰ salinity. *Sigara australis* was found at the highest salinity, 13·4‰, at which corixids were collected. This salinity occurred at Lake Rosine, western Victoria; at a later date and a slightly higher salinity, 15·8‰, no corixids were found in this lake.

III. Osmoregulatory Abilities

Methods and Results

The two apparently most saline-tolerant species were selected for study: *Sigara australis* and *Agraptocorixa hirtifrons*. The osmoregulatory ability of these was studied by estimating the body fluid concentration of experimental animals in a series of media over a range of salinity. Experimental animals were placed directly after capture into various concentrations of natural lake water (from Lake Coragulac, where both species occur naturally) or sea-water. They were allowed 3 days for acclimation, a period in line with that used and found satisfactory by Claus (1937) and Scudder (1971) in similar experiments on other corixid species. They were not fed during this period. Experimental media were aerated and maintained at 20°C, the mean summer temperature of lakes in western Victoria (Hussainy 1969).

Table 2

OSMOREGULATION: RESULTS OF FREEZING POINT DEPRESSION DETERMINATIONS

Δ_i, depression of freezing point of internal medium (= body fluid); Δ_e, depression of freezing point of external medium

External medium			Body fluid					
			Agraptocorixa hirtifrons			*Sigara australis*		
Salinity (‰)	No. of determinations	$\Delta_e \pm$ SE (°C)	No. of specimens	No. of determinations	$\Delta_i \pm$ SE (°C)	No. of specimens	No. of determinations	$\Delta_i \pm$ SE (°C)
			Lake Coragulac Water Dilutions					
2·6	3	0·11±0·03	3♂, 1♀	6	0·45±0·04	1♂, 3♀	6	0·55±0·04
3·2	4	0·14±0·04	3♂, 1♀	5	0·46±0·04	2♂, 2♀	7	0·57±0·04
9·5	5	0·48±0·03	2♂, 3♀	8	0·56±0·07	2♂, 3♀	5	0·60±0·03
11·2	5	0·54±0·03	1♂, 2♀	5	0·57±0·05	4♂, 1♀	8	0·63±0·06
16·4	4	0·81±0·02	1♂, 2♀	3	0·70±0·05	2♂, 2♀	6	0·92±0·06
19·4	4	0·96±0·02	no survivors			2♂, 1♀	5	0·95±0·03
			Sea Water Dilutions					
5·8	5	0·31±0·05	5♂, 2♀	10	0·68±0·06	3♂, 2♀	7	0·55±0·05
9·9	5	0·52±0·02	4♂, 1♀	7	0·70±0·05	2♂, 3♀	9	0·60±0·08
12·4	4	0·76±0·03	2♂, 2♀	6	0·75±0·07	1♂, 3♀	7	0·84±0·06
16·8	5	0·90±0·02	3♂, 4♀	8	0·80±0·09	2♂, 3♀	9	0·93±0·07
21·2	5	1·12±0·01	1♂, 1♀	4	0·84±0·04			
22·1	4	1·19±0·04				2♂	5	1·07±0·04
26·3	5	1·42±0·01	no survivors			1♂	3	1·25±0·02

Body fluid concentrations were estimated by determining freezing point depressions; for comparison, similar determinations of the appropriate medium were also made. In an actual body fluid determination, an experimental animal was removed from its medium, washed with deionized water, and dried. A small volume of haemolymph was then withdrawn with a micropipette of 100–150 μm external diameter inserted along the mid-dorsal line of the first abdominal segment. Gut contamination was avoided. The fluid was withdrawn, sandwiched between two layers of liquid paraffin, and its freezing point depression was immediately determined using a Kalber Biological Cryoscope.

Detailed results are given in Table 2, and a summary of them in graphical form for ease of assessment in Figure 1.

Discussion

As is indicated most clearly by Figure 1, both species hyperosmoregulate in media of low salinity, like almost all freshwater invertebrates. Both, however, unlike most freshwater invertebrates (e.g. Beadle 1959), are also capable of a limited amount of hypo-osmoregulation at higher salinities. It is this latter ability perhaps which permits their occurrence in waters which, whilst not highly saline with regard to the total range of salinity displayed by inland waters, are nevertheless rather too saline to accommodate most invertebrates that are typically freshwater in occurrence.

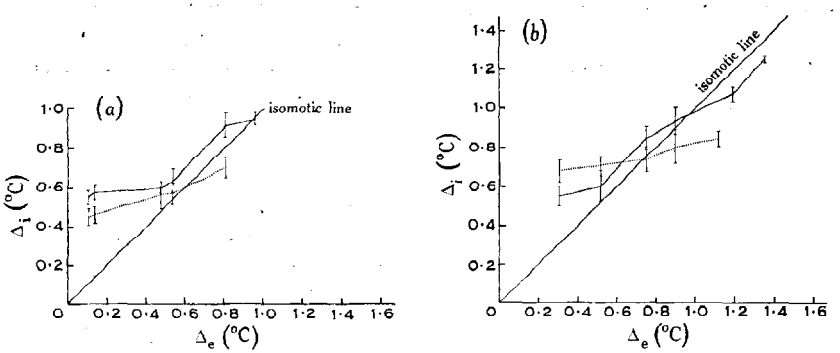

Fig. 1.—(*a*) Osmoregulation in Lake Coragulac media; (*b*) osmoregulation in sea-water media. Solid line, *Sigara australis*; dotted line, *Agraptocorixa hirtifrons*. Vertical bars indicate standard errors. Δ_i, concentration of haemolymph as freezing point depression (°C); Δ_e, concentration of external medium as freezing point depression (°C).

In the experimental media, mortalities were low at salinities <18‰, but became much higher at salinities above this value. There were no survivors of *A. hirtifrons* in media of salinity >16·4‰ (Coragulac media) or >21·2‰ (sea-water media), and none of *S. australis* beyond 19·4‰ (Coragulac media) or 26·3‰ (sea-water media). Although no animals were found in the field at salinities quite as high as these values, it should be noted that the laboratory animals at the high salinities represented merely the *survivors* of bigger groups of experimental animals. In any event, the upper salinities at which corixids survived in the laboratory are sufficiently close to the highest salinities at which corixids were found in the field to suggest that salinity *per se* is an important limiting factor in corixid distribution in Victoria. A similar conclusion was arrived at by Scudder (1971) in his study of two corixids occurring in saline lakes in British Columbia. The results of this author closely parallel ours, although the species involved were different (*Cenocorixa bifida*, *C. expleta*), as was also the ionic composition of the waters.

Considering the differences between the four graphs of Figure 1, it may firstly be noted that, although there is no apparent difference between the results for *S. australis* acclimated in Lake Coragulac media and in seawater media, this is not the case for *A. hirtifrons*. In this species, it seems, the chemical composition of the external medium does have an effect on the concentration of the body fluid and consequently on osmoregulation. Thus, it may be hypothesized, the distribution of *S. australis* in the field with respect to salinity may be independent of the chemical

composition of the waters involved, whereas that may not be the case with *A. hirtifrons*.

Secondly, it may be noted that by and large—and certainly at all higher concentrations of experimental media—the body fluid concentration of *S. australis* in the various media was greater than that of *A. hirtifrons*. This finding is in accord with the general range of salinity tolerated by these two species in the field, with *S. australis* apparently the most tolerant. Scudder's (1971) results with *Cenocorixa bifida* and *C. expleta* were similar.

IV. Conclusion

Despite the occurrence of corixids in highly saline waters outside Australia, and two isolated records of their occurrence in such waters within Australia, the present study indicates that, at least typically, corixids do not occur in highly saline waters in south-eastern Australia (Victoria). The highest salinity at which a corixid was found in this area was 13·4‰, a value not greatly below that at which the two apparently most saline-tolerant species were found to survive in the laboratory. The ability of at least these two species to survive in salinities of this order is probably related to the fact that both can weakly hypo-osmoregulate, for although corixids have waxed cuticles and rely on atmospheric oxygen for respiration, cuticular permeability is definitely higher in these insects than it is in terrestrial insects (Holdgate 1956; Staddon 1963, 1964). Whether those corixids occurring in much more saline waters (outside Australia) are strong hypo-osmoregulators remains to be seen.

V. Acknowledgment

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