EFFECT OF TEMPERATURE AND SALINITY ON SURVIVAL AND REPRODUCTION IN BALTIC POPULATIONS OF *SPHAEROMA HOOKERI* LEACH, 1814 AND *S. RUGICAUDA* LEACH, 1814 (ISOPODA)

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ABSTRACT

Populations of *Sphaeroma hookeri* from Copenhagen Harbour (Sydhavn) and *S. rugicauda* from Selsø (about 40 km west of Copenhagen) were studied during the summer of 1969. Tests were carried out at 5, 15, and 25 °C, at salinities from 0 to 60 ‰; a greater percentage of adults of *S. hookeri* survived longer at lower salinities (0, 2, 5 ‰) at the three temperatures; at these lower salinities females of *S. hookeri* produced more young which survived longer. The depressing effect of low salinities on reproduction in *S. rugicauda* is considered to be a significant factor limiting the distribution and abundance of this species in the Baltic.

INTRODUCTION

Although some confusion has existed, arising from incorrect identification, the distributions of *Sphaeroma rugicauda* and *S. hookeri* in the Baltic are now well known. The species are readily distinguishable by morphological differences in the pleotelson, especially in males (Forsman 1952; Kinne 1954a; Grüner 1965); males and females of both species are figured here to help in identification (Figs 1, 2).

Breeding characteristics of species-populations of *S. hookeri* at Kiel and Copenhagen were described by Kinne (1954a) and Jensen (1955) respectively, in situations in which this species is successful and abundant, although *S. rugicauda* has not been similarly studied.

The species distributions overlap widely, but *S. hookeri* occurs commonly and in considerable numbers where the salinity is as low as 2‰, whereas *S. rugicauda* occurred in only 2 out of 8 stations with salinities ranging from 0.3 to 7‰, examined by Messner & Wohlrab (1959); further, in these 2 stations there were respectively only 24 and 2 specimens of *S. rugicauda* compared with 103 and 80 of *S. hookeri*.

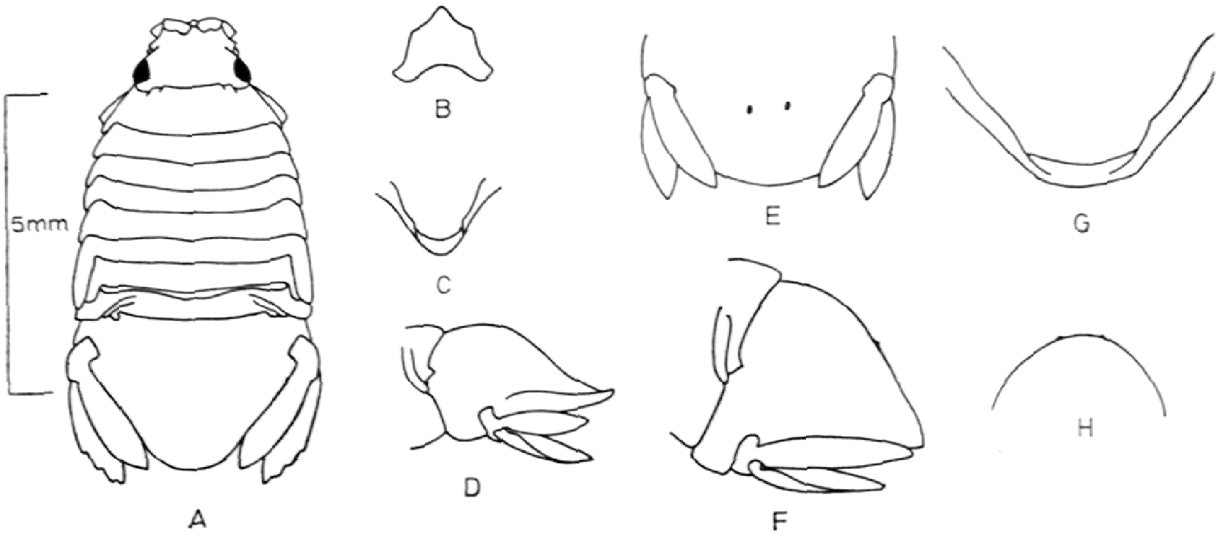

FIG. 1. *Sphaeroma rugicauda*. A-D, male: A, entire animal, dorsal aspect, appendages omitted; B, epistome; C, pleotelson apex, ventral aspect; D, pleotelson, lateral aspect; E-H, female pleotelson: E, dorsal; F, lateral; G, ventral; H, posterior aspects.

Since these small numbers of *S. rugicauda* can obviously survive at low salinities, it appears that some other effect of salinity, or some factor other than salinity, may limit population growth. It seemed worthwhile to compare the effects of different temperatures and salinities on survival and reproduction in the two species; the results of this investigation are presented here.

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MATERIALS AND METHODS

Three sets of artificial sea-water were prepared in concentrations of 0, 2, 5, 15, 30, 45, and 60‰; 250 ml of each concentration was placed in a container to which a loose cover was fitted to reduce evaporation and to allow free air circulation. Each set of solutions was brought to the experimental temperature before the samples were introduced; constant salinity was maintained by transferring the solutions to a measuring cylinder and replacing evaporation losses with distilled water twice daily. Temperatures were constant within $\pm$ 1°C. Since shallow containers were used no problems with respect to oxygen deficiency occurred. A small amount of *Ulva* was added daily to prevent possible starvation effects. The salinity of each solution was checked with a refractometer at the beginning

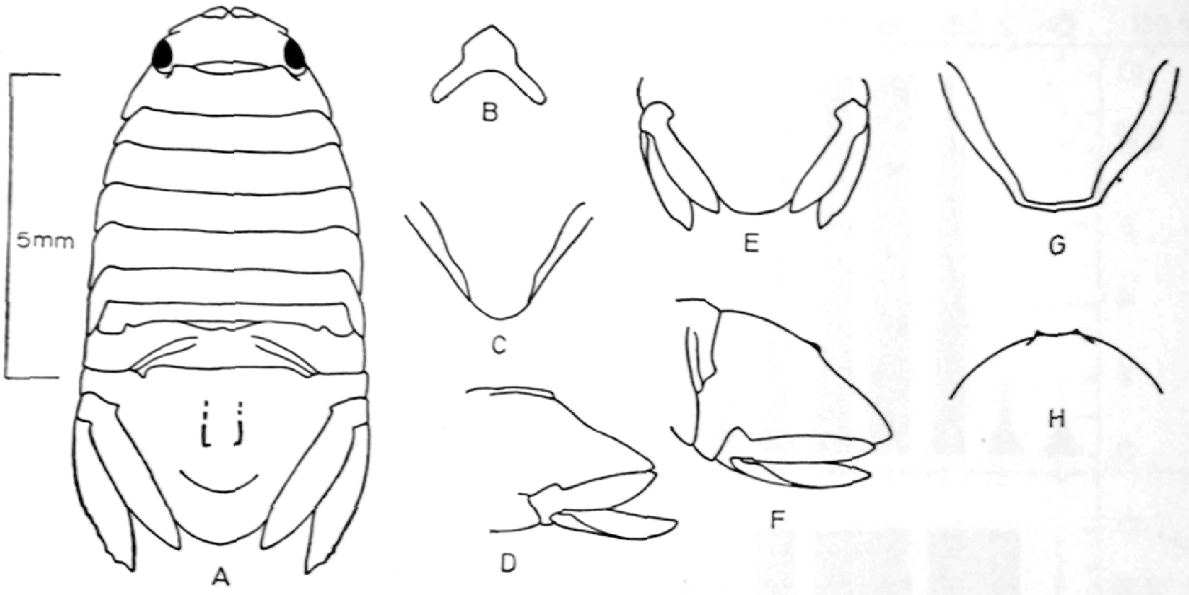

FIG. 2. *Sphaeroma hookeri*. A-D, male: A, entire animal, dorsal aspect, appendages omitted; B, epistome; C, pleotelson apex, ventral aspect; D, pleotelson, lateral aspect; E-H, female pleotelson: E, dorsal; F, lateral; G, ventral: H, posterior aspects.

and end of the experiment; all solutions remained within $\pm$ 0.5‰ of the original salinity. The samples were maintained in water from their respective habitats at the experimental temperature for 12 hours before beginning the tests to avoid additional stress from a sudden change in temperature. Only healthy active females from 4 to 7 mm in length were used to obviate unknown factors as far as possible.

The samples were inspected every 24 hours and the dead specimens removed to avoid contamination. Death was judged to have occurred when the animals failed to move in response to mechanical stimulation – absence of pleopod movement alone is no sure indication of death in Sphaeromatidae, particularly at low temperatures in which they remain motionless for considerable periods. Further, the dead specimens were inspected after about 30 minutes to ensure that revival had not occurred. No such revival did in fact occur.

At the same time the numbers of live and dead young were recorded. Finally the females were examined to determine how many in each container had produced young. The total young in each container was then reduced to the number per female. This is at best an approximation, but the differences are so great that a valid comparison can be made.

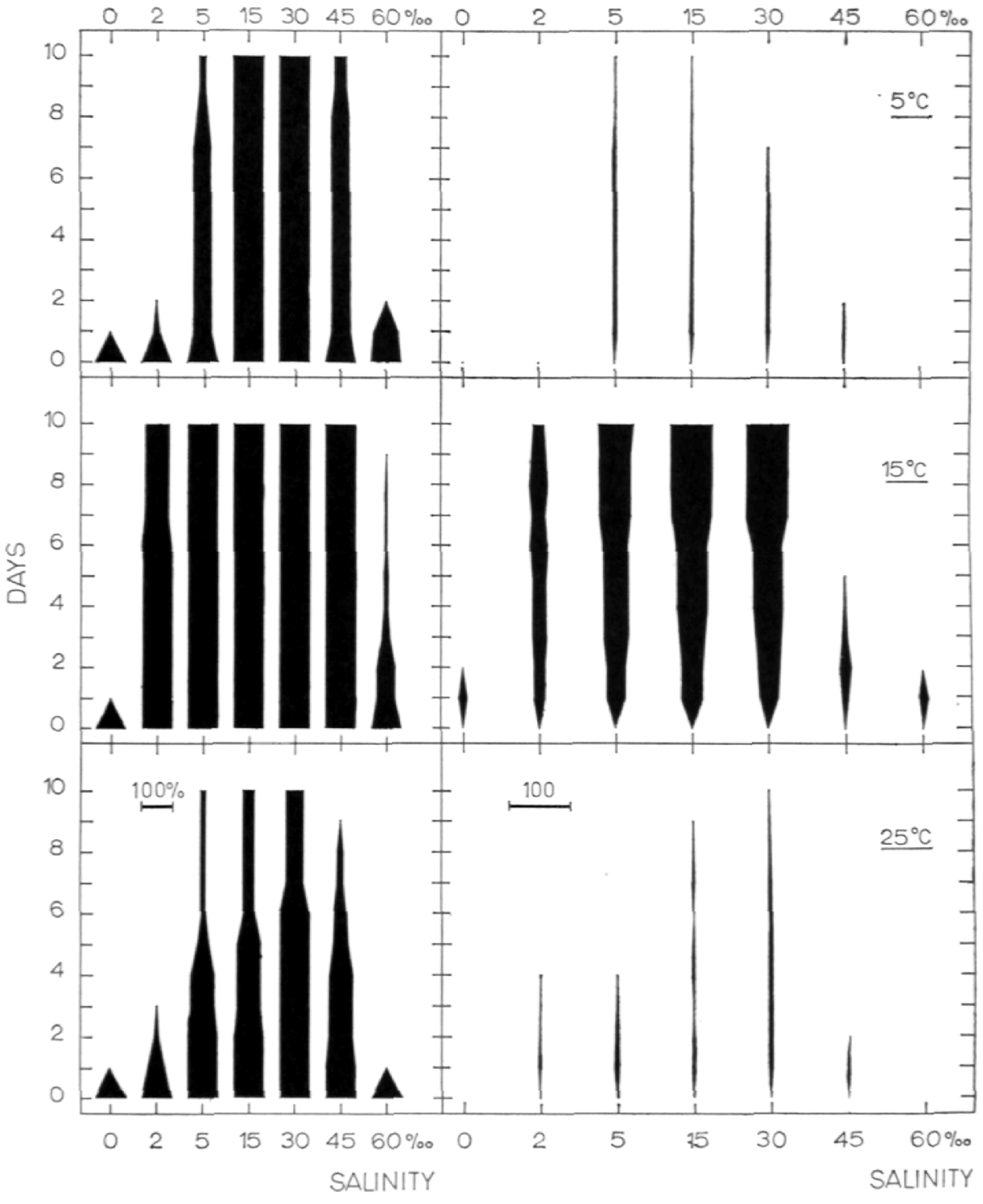

FIG. 3. *Sphaeroma rugicauda*. Effect of temperature and salinity on adult survival and the production of young; left, adult survivors, %; right, numbers of live young

RESULTS

The results are given in Tables 1 and 2, and Figs 3 and 4. The numbers of dead young were recorded to give some indication of comparative survival, but are not reliable because of cannibalisation of sick and moribund specimens by adults. More adults of *S. hookeri* survived for longer at the lower salinities (0-5‰) at

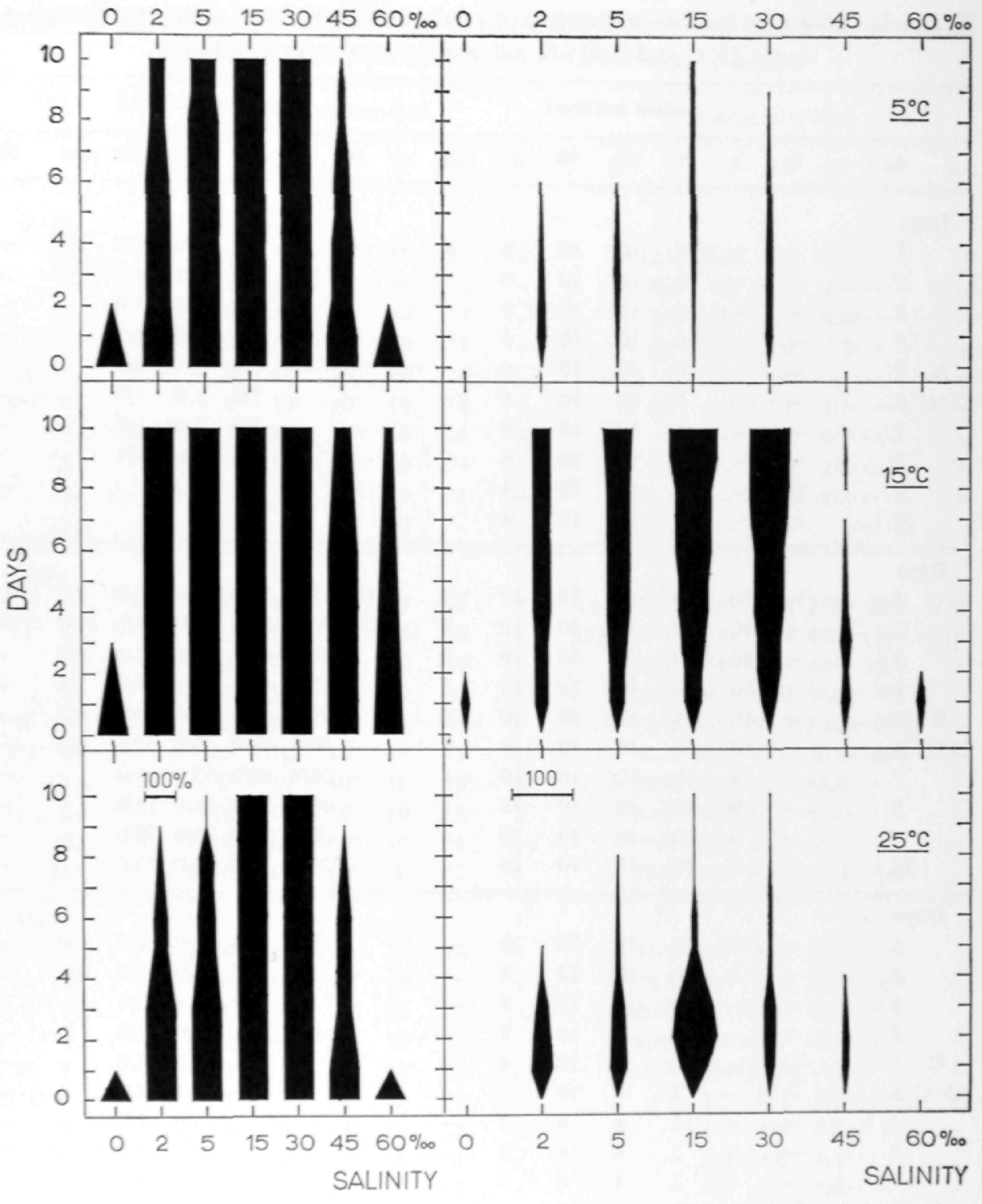

FIG. 4. *Sphaeroma hookeri*. Effect of temperature and salinity on adult survival and the production of young; left, adult survivors, %; right, numbers, of live young.

the three experimental temperatures, but especially at 5 and 25°C. At 5°C females of *S. hookeri* produced small numbers of young from 2 to 30‰S whereas *S. rugicauda* females produced similar small numbers from 5 to 45‰S. At 15°C females of both species released a small number of young at 0‰S, all of which died within 2 days; at 2‰S, however, although approximately equal numbers of young ap-

TABLE 1. *Sphaeroma rugicauda*. Survival of adults and numbers of young per female at 5, 15, 25°C and 0-60‰S. All series started with 10 adults.

		adult survival							young, live/dead						
	‰ S	0	2	5	15	30	35	60	0	2	5	15	30	45	60
	Days														
	1....	–	1	10	10	10	9	8	–	–	6/0	6/0	4/0	1/0	–
	2....	–	–	6	10	10	6	–	–	–	6/0	5/1	4/0	0/1	–
	3....	–	–	6	10	10	6	–	–	–	6/0	5/0	4/0	–	–
	4....	–	–	6	10	10	6	–	–	–	6/0	5/0	4/0	–	–
A	5....	–	–	6	10	10	6	–	–	–	5/1	3/1	3/1	–	–
5°C	6....	–	–	6	10	10	6	–	–	–	5/0	3/0	3/0	–	–
	7....	–	–	6	10	10	6	–	–	–	5/0	3/0	1/2	–	–
	8....	–	–	4	10	10	6	–	–	–	3/2	3/0	0/1	–	–
	9....	–	–	2	10	10	4	–	–	–	3/0	1/2	–	–	–
	10....	–	–	1	10	10	4	–							
	Days														
	1....	–	10	10	10	10	10	7	14/0	18/0	30/0	35/0	30/0	9/5	15/0
	2....	–	10	10	10	10	10	7	/14	20/0	30/0	35/0	35/0	17/4	0/15
	3....	–	10	10	10	10	10	3	–	25/0	40/0	40/0	45/0	9/7	–
	4....	–	10	10	10	10	10	3	–	25/0	40/0	50/0	50/0	2/6	–
B	5....	–	10	10	10	10	10	2	–	25/4	40/0	50/0	50/0	4/2	–
15°C	6....	–	10	10	10	10	10	1	–	30/0	40/0	50/0	50/0	0/4	–
	7....	–	9	10	10	10	10	1	–	26/4	50/0	65/0	65/0	–	–
	8....	–	9	10	10	10	10	1	–	28/0	50/0	68/0	65/0	–	–
	9....	–	9	10	10	10	10	–	–	26/2	50/0	70/0	70/0	–	–
	10....	–	9	10	10	10	10	–	–	20/6	55/0	70/0	70/0	–	–
	Days														
	1....	–	6	10	10	10	10	–	–	3/2	5/3	5/0	6/3	6/0	–
	2....	–	2	10	10	10	8	–	–	2/1	3/2	5/0	3/2	0/6	–
	3....	–	–	8	8	10	8	–	–	1/1	1/2	1/4	2/1	–	–
	4....	–	–	8	8	10	8	–	–	0/1	0/1	2/0	3/0	–	–
C	5....	–	–	4	8	10	4	–	–	–	–	2/0	4/0	–	–
25°C	6....	–	–	2	4	10	4	–	–	–	–	1/1	4/0	–	–
	7....	–	–	2	4	6	2	–	–	–	–	3/0	2/2	–	–
	8....	–	–	2	4	6	2	–	–	–	–	1/1	2/0	–	–
	9....	–	–	2	4	6	–	–	–	–	–	0/1	1/1	–	–
	10....	–	–	2	4	6	–	–	–	–	–	–	1/0	–	–

TABLE 2. *Sphaeroma hookeri*. Survival of adults and numbers of young per female at 5, 15, 25°C and 0-60‰S. All series started with 10 adults.

	adult survival							young, live/dead						
‰ S	0	2	5	15	30	45	60	0	2	5	15	30	45	60
Days														
1....	5	10	10	10	10	10	6	–	12/6	6/1	5/1	13/3	–	–
2....	–	8	10	10	10	7	–	–	6/6	5/1	5/0	9/4	–	–
3....	–	8	10	10	10	7	–	–	7/0	8/0	3/2	9/0	–	–
4....	–	8	10	10	10	7	–	–	2/5	4/4	3/0	7/2	–	–
A 5....	–	8	10	10	10	6	–	–	1/1	2/2	8/0	6/1	–	–
5°C 6....	–	8	10	10	10	6	–	–	0/1	0/2	7/1	3/3	–	–
7....	–	7	10	10	10	4	–	–	–	–	5/2	0/3	–	–
8....	–	6	10	10	10	4	–	–	–	–	5/0	2/0	–	–
9....	–	6	9	10	10	2	–	–	–	–	5/0	0/2	–	–
10....	–	6	9	10	10	–	–	–	–	–	5/0	–	–	–
Days														
1....	7	10	10	10	10	10	9	14/0	20/0	25/0	30/0	25/0	16/0	16/0
2....	2	10	10	10	10	10	9	0/14	20/0	25/0	30/0	40/0	9/4	0/16
3....	–	10	10	10	10	10	9	–	20/0	35/0	40/0	40/0	19/0	–
4....	–	10	10	10	10	9	8	–	25/0	40/0	50/0	50/0	9/8	–
B 5....	–	10	10	10	10	9	6	–	25/0	40/0	50/0	50/0	3/6	–
15°C 6....	–	10	10	10	10	9	5	–	30/0	40/0	60/0	50/0	2/0	–
7....	–	10	10	10	10	8	3	–	30/0	40/0	60/0	60/0	–	–
8....	–	10	10	10	10	8	3	–	30/0	40/0	60/0	60/0	–	–
9....	–	10	10	10	10	8	2	–	25/0	45/0	80/0	65/0	–	–
10....	–	10	10	10	10	7	1	–	28/0	45/0	80/0	65/0	1/0	–
Days														
1....	–	10	10	10	10	10	–	–	35/5	30/5	50/0	15/0	7/0	–
2....	–	10	10	10	10	8	–	–	30/5	25/5	75/0	20/0	10/0	–
3....	–	10	10	10	10	5	–	–	20/10	20/5	65/10	18/2	5/5	–
4....	–	8	8	10	10	5	–	–	4/16	9/10	36/27	12/6	0/5	–
C 5....	–	5	7	10	10	5	–	–	0/4	5/4	11/25	5/12	–	–
25°C 6....	–	5	7	10	10	5	–	–	–	2/3	8/3	5/0	–	–
7....	–	4	6	10	10	3	–	–	–	2/0	3/5	5/0	–	–
8....	–	2	6	10	10	2	–	–	–	2/0	3/0	1/4	–	–
9....	–	–	2	10	10	2	–	–	–	0/2	2/1	1/0	–	–
10....	–	–	2	10	10	–	–	–	–	–	2/0	1/0	–	–

peared in both species, there were no deaths in *S. hookeri,* but in *S. rugicauda,* the numbers fluctuated as individuals born earlier died and were replaced by later births. At 25°C the young of both species appeared in the same salinity range, 2-45‰S, but the numbers were greater in *S. hookeri,* and in 5‰S the young lived for 8 days compared with 4 days in *S. rugicauda.* In both species the greatest numbers of young appeared at 15°C and in the salinity range 15-30‰S, in which the adults survived best at the three experimental temperatures.

DISCUSSION

Three conclusions may be drawn from these results. Firstly, both species are better adapted for both survival and reproduction in a higher range of salinity (15-30‰) than they encounter in southern parts of the Baltic where they are often abundant. The same situation was described in the *Jaera albifrons* group by Sjöberg (1967).

Secondly, the ability of both species to survive at low salinities is reduced at high and low temperatures within the range occurring in their habitat (see also Kinne, 1954b), but the reduction is greater in *S. rugicauda* than in *S. hookeri.* Thus the less frequent occurrence and smaller numbers of *S. rugicauda* in regions of lower salinity is at least partly explained.

Thirdly, the reduced production and shorter survival of young of *S. rugicauda* at the lower salinities at the three experimental temperatures appears to explain the failure of this species to establish healthy growing populations in situations to which numbers of individuals may be accidentally distributed, and in which they may survive.

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