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A regional study on the environmental requirements of *Gammarus lacustris* G.O. Sars (Crustacea, Amphipoda) in Jotunheimen, Southern Norway

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This paper presents data on the distribution of *G. lacustris* in Lom municipality, Oppland County, southern Norway. The species has been recorded at 20 different localities.

The occurrence of *G. lacustris* in the studied area seems mainly to be affected by the hydrogen ion concentration and total hardness of the water. Fish predation pressure may also influence the occurrence and abundance of this crustacean.

G. lacustris survived a water level fluctuation of 7.3 m (range 3.7 m — 11.8 m) in the Tesse hydro-electric reservoir, during a period of 20 years, but not the more recent annual changes in water level of 12.2 m.

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INTRODUCTION

The freshwater amphipod *Gammarus lacustris* G.O. Sars survived the last Ice Age in refuges on the west and north coast of the Scandinavian peninsula, and spread from these areas far into the interior (Segerstråle 1954).

G. lacustris is probably one of the most important fish food organisms for brown trout *Salmo trutta* L. in Norway (Berg 1951, Sømme 1954).

Økland (1969a, 1980) concluded, after outlining the distribution of *G. lacustris* in Norway, that the distribution of this species was affected mainly by hydrographical and geological factors. Hynes (1960) stressed the significance of dissolved salts for freshwater Crustacea.

Fish predation has also been discussed in relation to the distribution and abundance of *G. lacustris* (Klemetsen 1966, Økland 1969a, 1980). The influence of this factor seems to vary, however, depending on the locality.

This paper considers the distribution and ecological requirements of *G. lacustris* within the limited geographical area of Lom municipality in Oppland Country, Southern Norway.

THE STUDY AREA

Lom municipality is situated in North-Gudbrandsdalen in Oppland County (62°N, 9°E) and includes most of the central regions of Jotunheimen.

About 90 % of the area concerned (1951 km^2) is situated > 900 m above sea level, and consists mainly of glaciers, bare rocks and bogs.

With few exceptions, brown trout is the only fish species in the municipality.

METHODS

The distribution of *G. lacustris* was mapped by examining fish stomach contents, and by using a rod sieve to collect samples along the shores of lakes and small ponds.

One water sample was collected at the outlet of each lake, mainly in July. Hydrogen-ion concentration (pH) was measured electrometrically. Total hardness, given in German degrees of hardness (1°dH = 10 mg «CaO»/l), was measured by an atomic absorption spectrophotometer. Values of pH and °dH for lakes at Memurutunga were compared with those earlier found by J.A. Eie (pers. comm.) and showed very good agreement.

RESULTS

Distribution

The only previous records of *G. lacustris* in Lom municipality have been from the lakes Tesse and

Table 1. Localities inhabited by *G. lacustris* in Lom municipality, with hydrochemical data.

Locality	pH	Total hardness (°dH)	Altitude (m)		Position (UTM)
Høydalsvatn	6.8	0,35	906	32V-MV	5337
Nedre Bakkebergtj.	7.4	2,25	994	«	5436
Leiråstjern	7.3	2,25	939	«	5941
Øvretjern	6.8	0,45	1451	«	7415
Trygvetjern	7.0	0,40	1357	«	7516
Lågtungtjern	6.7	0,47	1341	«	7516
Øvre Hesttjern	6.7	0,20	1560	«	7719
Nedre Hesttjern	6.7	0,20	1472	«	7919
Grønbutjern	6.7	0,25	1299	«	8638
Nautgardtjern	6.8	0,40	1230	«	8837
Nedre Ringtjern	6.5	0,75	1295	«	9241
Smådalsvatna	6.8	0,50	1076	«	8742
Sylvetjern	6.6	0,30	1401	«	9448
Dågåtjern	6.9	0,78	857	«	9746
Tesse	6.8	0,43	851	«	9847
Ostjern	6.9	0,38	851	«	9753
Søre Kopptjern	7.1	0,50	1140	«	9153
Krosstjern	7.0	0,45	1076	«	8756
Ausa	6.8	0,58	1002	«	8156
Årsjø (Kjørri)	6.7	1,63	362	«	7856

Sylvetjern (Segerstråle 1954), Årsjø (Økland 1969b, 1979), Høydalsvatn (Fiskerikonsulenten for Øst-Norge 1974) and Smådalsvatna (Borgstrøm & Saltveit 1975). This paper presents data from an additional 15 localities (Table 1).

Except for Årsjø (altitude 362 m), the localities are all situated in the subalpine and alpine region, between 851—1560 m above sea level.

Tesse is used as a hydroelectric reservoir. During the period 1943—1963, the water level fluctuation exceeded 6.5 m in 15 years (Fig. 1), with a yearly mean of 7.3 m (range 3.7 m — 11.8 m). During this period, *G. lacustris* still occurred frequently in the reservoir. In 1963 the Veo river was diverted into Tesse, and the water amplitude changed to 12.2 m annually. Since then *G. lacustris* has not been registered in this reservoir.

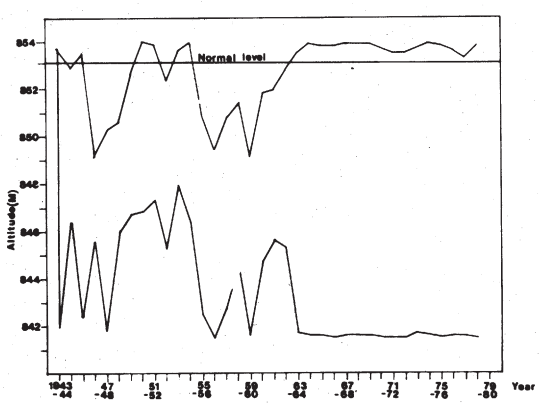

Fig. 1. Water level fluctuation in the hydroelectric reservoir Tesse during the period 1943—1979.

The fact that the water level in Tesse was only slightly increased artificially during the period 1943—1963, implies less damage to the habitat of *G. lacustris*.

The channelling of the turbid Veo river into the Tesse reservoir has reduced the Secchi disc transparency, Z_{SD}, from 8—10 m (Huitfeldt-Kaas 1906) to 4 m measured in 1979. This can have reduced primary production in the reservoir, but its effect on the population of *G. lacustris* is unknown.

Previous studies have shown that when water level changes in hydroelectric reservoirs exceed 6 m, *G. lacustris* populations either disappear or become too reduced to be of importance as fish food (Grimås 1962, Aass 1969).

G. lacustris, however, occurs in Dågåtjern, close to Tesse. One specimen of *G. lacustris* was found in Tesse in 1979 near the outlet of Dågåtjern Creek. It was decided that it had been displaced from its original habitat into Tesse.

In Ostjern, at the original outlet of Tesse, *G. lacustris* still occurs. Tesse flows into this pond only at high water level.

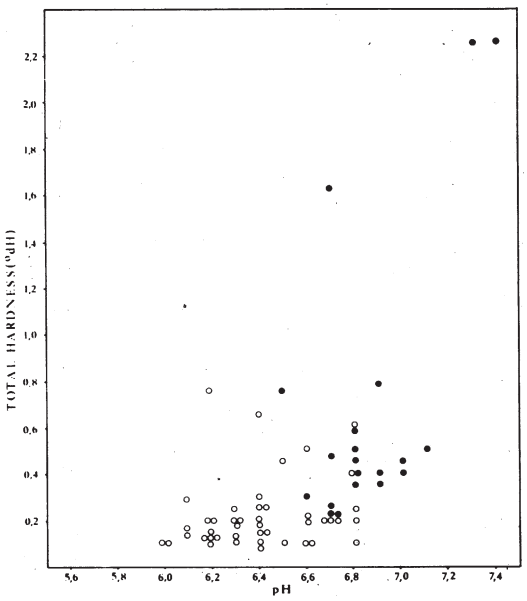

Fig. 2. Total hardness (°dH) and pH values from 20 localities containing *G. lacustris* (solid marks) and that from 44 localities where the species has not been detected (open marks).

Hydrochemical factors

Fig. 2 shows pH and total hardness for the localities inhabited by *G. lacustris*. Corresponding values from 44 other localities where the species has not been detected are shown on the same figure.

The lowest value from localities of the first category was pH = 6.5 (range 6.5—7.3) and total hardness = 0.2°dH (range 0.2—2.25). Corresponding values from the areas not supporting populations of *G. lacustris* were 6.0 (range 6.0—6.8) and 0.1 (0.1—0.76) respectively.

DISCUSSION

Most of the lakes and tarns in Lom Statsalmenning, which represents the main part of the localities containing fish populations in Lom municipality, have been investigated. Some locations inhabited by *G. lacustris* in Lom municipality may have been overlooked, particularly where the species is scarce.

Downward migration of parts of the population of *G. lacustris* in July (Bjerknes 1974) may reduce the chance of detecting the species when using a rod sieve along the shore-line.

G. lacustris was found in lakes over a wide vertical range, indicating that this species is a eurytherm organism. Øvre Hesttjern (altitude 1560 m) is probably the highest known locality inhabited by *G. lacustris* in Norway. As evidence of this wide temperature tolerance of *G. lacustris*, Segerstråle (1954) states that the descendants of glacial refuge stocks also tolerate fairly warm water.

G. lacustris was registered throughout the municipality, also in high mountain lakes in geographic isolated areas. Insufficient dispersal apparently is not the main reason for the absence of this species in some areas. As a consequence of immigration history and the fact that dispersal is mainly brought about through the intermediation of water fowl, *G. lacustris* is especially widespread in Norway (Segerstråle 1954).

The distribution of *G. lacustris* in Lom indicates that the species is limited by hydrochemical factors. The species was never found at locations with a pH below 6.5 and total hardness below 0.2°dH. Økland (1980) documented a synergistic relation between these two parameters. In mountain areas the species can tolerate lower values of pH and hardness, and local adaptions do also exist (Økland op.cit.).

G. lacustris has not yet been registered in the north-eastern region of the municipality (Hesthagen 1979a). The baserock in this area consists entirely of gneiss, as opposed to eruptive species of rock in other parts of the municipality (Holtedahl & Dons 1960). The range of the pH in the lakes of this area was 6.1—6.4 and total hardness 0.13—0.3°dH. This indicates that the distribution of *G. lacustris* is closely linked to the more productive species of rocks, and agrees with the results found by Økland (1969a, 1980) on the distribution of this species in Norway.

Of 15 different lakes of the plateau Memurutunga, 13 lack natural spawning areas for fish populations. Therefore these lakes are being stocked with fingerlings of brown trout. Neither different stocking density (0.20—0.30 fish/km^2) nor catch of older fish per standard gill net series in different lakes can explain why *G. lacustris* has been detected in only two of them, Lågtungtjern and Øvretjern (Table 2). Stocking density for the other lakes in the area is unknown. Trygvetjern in the same area was empty of fish in 1976 when *G. lacustris* was registered. Moreover, pH and total hardness in all the lakes of Memurutunga seem favourable for *Gammarus* with values between 6.7—7.1 and 0.33—0.56 °dH, respectively, table 2. The absence of *G. lacustris* in most of the lakes in this area can there-

Table 2. Occurrence of *G. lacustris* in different lakes at Memurutunga with data on hydrochemistry, stocking density until 1976 and catch of trout per standard gill net series.

Locality	Altitude (m)	pH	°dH	Occurrence of *G. lacustris* (x)	Size (ha)	No. stocked (Year)	Stocking density (No/ha)	Year of gill netting	No. of trout caught per standard gill net series
Grunnevatn	1366	6.9	0.34		3.5	100 — 100 — 150 — (1968) (1974) (1976)	100.0	1973	19
Hindåtetjern	1546	6.8	0.31		180.0	3600 (1966)	20.0	1973	1.5
Kjuklingtjern	1450	6.7	0.41		2.5	30 — 46 — 50 — (1967) (1973) (1976)	50.4	1972	0
Langtjern	1243	7.1	0.56		13.5	Natural reproduction	—	1973	61
Lågtungtjern	1341	6.9	0.46	x	13.5	375 — 250 — 700 — (1967) (1974) (1976)	98.2	1972	15
Sjugurdstindtjern	1500	6.9	0.33		5.0	150 — 90 — 150 — (1969) (1974) (1976)	78.0	1973	42
Trygvetjern	1397	7.0	0.40	x	0.5	75 (1976)	150.0	—	—
Øvretjern	1451	6.9	0.45	x	7.0	200 — 60 — 150 (1967) (1974) (1976)	58.6	1972	16
Ånde	1284	6.8	0.35		2.0	60 (1967)	30.0	1971	5

fore not be explained by insufficient water quality. Neither can different stocking density nor catch of older fish be related to the occurrence of *G. lacustris* in these lakes. Unfortunately, data on the eventual occurrence of *G. lacustris* in these lakes before they were stocked with brown trout are not available.

Økland (1969a, 1980) showed that *G. lacustris* occurred frequently at depths were macrovegetation grows, i.e. mainly in the littoral zone. Dahl (1915) also pointed out that the abundance of *G. lacustris* in a lake is dependent on the depth conditions. Thus different amounts of macrovegetation and cover, providing varying degrees of protection against predation, may explain why the species is absent in most of the lakes on Memurutunga.

In Leiråstjern *G. lacustris* occurs frequently in spite of a dense population of brown trout. The occurrence of macrovegetation in this lake is thought to provide sufficient protection against fish predation.

Sylvetjern was stocked with brown trout for the first time in 1935. In the 1950's *G. lacustris* was still very abundant in this lake. (T. Holø pers.comm.). The stocking of this lake continued, and the trout population is still sustaining a high yield (Hesthagen 1979b). In spite of repeated investigations I have never found *G. lacustris* in Sylvetjern. A high predation pressure of the trout population through many years may explain why the species has not been detected in recent years.

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REFERENCES

Aass, P. 1969. Crustacea, especially *Lepidurus arcticus* Pallas, as brown trout food in Norwegian mountain reservoirs. *Rep.Inst.Freshw.Res. Drottningholm 49,* 183—202.

Berg, M. 1951. Om kostholdet hos auren i Espedalsvatnet og Sjusjøen. *Nytt Mag. Naturvid. 88,* 165—205.

Bjerknes, V. 1974. Life cycle and reproduction of *Gammarus lacustris* G.O. Sars (Amphipoda) in a lake at Hardangervidda, western Norway. *Norw.J.Zool. 22,* 39—43.

Borgstrøm, R. & S.J. Saltveit 1976. Bunndyr og fiskebestander i Øvre og Nedre Smådalsvatn. *Lab. for ferskvannsøkologi og innlandsfiske, Zoologisk Museum, Universitetet i Oslo, Rapport nr. 28,* 77—104.

Dahl, K. 1915. En studie over Grundaatens eller Marfloens *(Gammarus pulex)* biologi og utbredelse i Norge. *Norsk Jæg. og Fisk. Foren. Tidsskr. 44,* 323—352.

Fiskerikonsulenten for Øst-Norge, 1974. *Fiskeribiologiske undersøkelser i Otta-Lågenvassdraget 1969—1973.* 129 pp.

Grimås, U. 1962. The effect of increased water level fluctuations upon the bottom fauna in Lake Blåsjön, Northern Sweden. *Rep.Inst.Freshw.Res. Drottningholm 44,* 14—41.

Hesthagen, T. 1979 a. *Fiskeribiologiske undersøkelser i Finndalen Statsalmenning i Oppland i 1978.* Unpubl. report. 69 pp.

Hesthagen, T. 1979 b. Growth and yield of an alpine population of brown trout, *Salmo trutta L.,* in Eastern Norway. *Rep.Inst.Freshw.Res. Drottningholm 58,* 34—40.

Holtedahl, O. & J.A. Dons 1960. *Geologisk kart over Norge. Berggrunnkart.* Norges Geol. Unders. No. 208.

Huitfeldt-Kaas, H. 1906. *Planktonundersøgelser i norske vande.* Nationaltrykkeriet, Christiania. 199 pp.

Hynes, H.B.H. 1960. *The biology of polluted waters.* Liverpool University Press. Liverpool. 202 pp.

Klemetsen, A. 1966. *Ørret i Jølstervann. Ernæring, vekst og beskatning.* Unpubl. thesis, Univ. Oslo. 74 pp.

Økland, K.A. 1969 a. On the distribution and ecology of *Gammarus lacustris* G.O. Sars in Norway with notes on its morphology and biology. *Nytt Mag.Zool. 17,* 111—152.

Økland, K.A. 1969 b. List of localities with *Gammarus lacustris* G.O. Sars in Norway, with references and notes. Supplement to *Contribution No. 89, Zool.Mus., Univ. Oslo.* 36 pp.

Økland, K.A. 1979. Localities with *Asellus aquaticus* (L.) and *Gammarus lacustris* G.O. Sars in Norway, and a revised system of faunistic regions. *SNSF-project, TN 49/70,* Oslo-Ås, Norway. 64 pp.

Økland, K.A. 1980. Økologi og utbredelse til *Gammarus lacustris* G.O. Sars i Norge, med vekt på forsuringsproblemer. *SNSF-project, IR 67/80,* Oslo-Ås, Norway. 87 pp.

Segerstråle, S.G. 1954. The freshwater Amphipods *Gammarus pulex* (L) and *Gammarus lacustris* G.O. Sars, in Denmark and Fennoscandia — a contribution to the late and post-glacial immigration history of the aquatic fauna of northern Europe. *Commentat.biol. 15* (1), 1—91.

Sømme, I.D. 1954. *Ørretboka.* Handbok i ferskvannsfiske og fiskekultur 4. utgave, Oslo, Jacob Dybwads forlag. 617 pp.