

THE FRESH WATER AND TERRESTRIAL MOLLUSCA  
OF NORTHERN ASIA,

with notes on the Mollusca of Fennoscandia.

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## INTRODUCTION.

The following account deals with the systematics and distribution of the fresh water and terrestrial mollusca of Siberia and Northern Kazakstan. During the open seasons of the years 1932 and 1933, journeys were made through that country, and typical areas in several of the great natural regions were examined in some detail, and extensive collections were made. The object of this expedition was to obtain fresh and accurate information regarding the constitution and distribution of the molluscan fauna of this region. During the past one hundred years several scientific papers have appeared which deal more or less directly with the molluscs of this territory, but despite this the knowledge of this group of animals in northern Asia has remained in a very unsatisfactory state. This has been due to the collections in the past having been made incidently in the course of other work, and little or no attempt has been made to evaluate the fauna as a whole. The most thorough piece of investigation so far carried out in this region is that of Westerlund (1877)<sup>1</sup>; but this paper was published nearly sixty years ago, and the advances in the study of the mollusca since that time make it essential that some revision and extension of the work should be undertaken. The present paper is one contribution toward that end.

1. The dates refer to the Bibliography given at the end of this paper.

The Sub-Arctic Region, which for the present purpose may be defined as the territory lying between the fiftieth parallel of North Latitude and the Arctic Circle, offers a promising field for the study of numerous zoogeographical problems. For several years past a study has been made of the molluscan fauna of Canada, and in 1932 the scope of the work was extended to include the northern part of Asia. The greater part of this vast territory is still unknown from the standpoint of biology, and if a study of this kind is to have any value it must rest upon a sound systematic basis. Therefore in this paper only those species are included which have been examined by me and found to be distinct from all other members of the fauna<sup>1</sup>, and throughout the work it has been deemed advisable to distinguish between records based upon actual shells and those found in the papers of other workers. Naturally this has resulted in certain names of other authors being eliminated for the time being, but it has the advantage that every specific name used represents an actual animal which exists in nature in some numbers. Whatever advances are made in the study in the future, it should always be possible, with the aid of the descriptions and plates given here, to determine the identity or otherwise of the Siberian species noted with those from other parts of the world. After the publication

<sup>1</sup>. Excepting the case of certain members of the genus Pisidium q.v.

of this paper, which is based upon actual specimens in the hand, it is planned to consider the status of the various names of other authors, and to publish a Catalogue of the fresh water and terrestrial molluscs of this region. In the meantime it has been considered desirable to place on record some of the actual original work done as a result of this expedition.

The systematic account of the species is followed by a concise discussion of the principal types of situations in which molluscs are found in Siberia, together with remarks regarding the general geographical distribution of the members of the fauna. Both of these topics will be treated in greater detail in a later paper relating to the molluscs of the Sub-Arctic Region as a whole.

The account given here under each of the species is divided into sections as follows, first the location in the literature of the original description and the more important Siberian synonyms are stated, then a brief description of the shell is given, and it is especially to be noted that this refers to the Siberian shells in hand and not necessarily to specimens from the world at large. After this the geographical range, and the local distribution are summarized, and these are followed by notes on the habitat, measurements, and such general remarks as appear to be necessary. The whole scheme of presentation has been designed with a view to conciseness and clarity. The photographs reproduced

in the accompanying plates have been made under my direction by the photographer of the Smithsonian Institution. It may be of some importance to note that no attempt whatever has been made to retouch the photographs thus produced. Regarding the nomenclature adopted it may be well to point out that the generic names Lymnaea and Planorbis have been retained as indicating the general relationships of these animals.

This work was carried out under the grant of the Walter Rathbone Bacon Scholarship of the Smithsonian Institution, and I desire to express my thanks to the officers of the Institution for their very kind co-operation. In the Soviet Union I received the cordial assistance of many scientists and officials, and it was through their co-operation that I was able to travel so extensively in the more remote and less populated parts of the country. I should also like to express my thanks to Professor J.H. Ashworth, F.R.S. for his encouragement and advice, and for placing the facilities of the Department of Zoology at my disposal.

PREVIOUS INVESTIGATIONS OF THE MOLLUSCAN FAUNA  
OF NORTHERN ASIA.

The following is a résumé of the more important papers dealing with the molluscs of this region which have been published to date. Since it has been physically impossible to cover more than a small part of this vast territory in the course of the expedition of 1932-33, it has been considered desirable to give a summary of the results of other previous investigations, but it is obvious that in view of the advances which have been made in the study of the mollusca, especially during the past twenty-five years, many of the records quoted here must be regarded somewhat critically, and, as has already been pointed out, a distinction must be made between species which have been reported to occur in the region by other workers during the past one hundred and ten years, and those which have been actually examined in the course of this work.

Incidental references to Siberian molluscs are to be found in the works of Gmelin (1788) and Pallas (1789), but the first definite list of molluscs found in this region was that of Gebler (1829), who in 1829 reported the presence of twenty-five land and fresh water species at Barnaul. Somewhat later there were further notes by Siemaschko (1847) and Maack (1854), but the first really significant effort to study this fauna was that of Middendorff (1851) who recorded the discovery of thirty-three species from various

parts of Siberia, including the districts of Barnaul, Beresov, Tomsk, Irkutsk, Kirensk and Nertschinsk. These species are also listed, and their identity discussed in the paper by Westerlund noted below. L. Pfeiffer (1853) reported thirteen species from Siberia, but did not give precise localities. Gerstfeldt (1859) described five members of the endemic Baikal fauna, and at the same time recorded the presence of about thirty-five other species in Siberia and the region of the River Amur, and in 1867 E. von Schrenk listed several others from this territory. Some very interesting records were given by Friedrich Schmidt (1872) in the report of an expedition to the northern Yenissei and the surrounding country. "Pisidium fontinale" (= P. conventus, see Odhner (1923) below) was found by this expedition in a small lake on the Gyda tundra at about North Latitude 71°. Limax agrestis, Succinea putris, Valvata piscinalis, and Cyclas calyculata were found on Brekhovsky Island ("Brojohov-Inseln") at the mouth of the Yenissei in North Latitude 70° 30' to 71°. At Turukhansk, North Latitude 66°, Lymnaea stagnalis and Cyclas calyculata were collected, and at Dudino at about the same latitude, Helix schrenkii was found. Planorbis albus, Lymneus auricularius and Valvata cristata were found sub-fossil in material described as "löss" at Tolstoi Nos, but it is probable that this was a stream deposit, and the shells may have been carried down the river for some distance. Lymnaea stagnalis was found in "löss" at Plachino. In this connection it

may be of interest to note that Middendorf (l.c.) found Aplexa hypnorum on the Taimyr Peninsula in North Latitude  $73^{\circ} 30'$ . E. von Martens in 1874 reported fifty-six species in his report on the molluscs collected by the Fedchenko expedition, but a good many of these species are from more southerly localities than are included within the scope of this report.

The outstanding work on the Siberian mollusca was that of Westerlund (1877, 1885) who not only elaborated the material brought back by the Nordenskiöld Expedition of 1875 but gave a critical review of all the work done on the Siberian mollusca up to that time, and between the years 1874 and 1889 published several other papers dealing with the fauna of this region. In 1892 Michaelis gave a short account of some molluscs collected in Djungaria. Möllendorf in two papers published in 1899 and 1902 described several forms from Central Asia as well as from China. Simroth in 1901 reviewed the knowledge of the slugs of the Russian Empire. Commencing early in the present century Lindholm published numerous papers dealing with the molluscs of this region, but several of these pertain solely to the fauna of Lake Baikal, which is not strictly within the province of the present study. In recent years several short papers by other authors have appeared, the most important of which are those of Büttner and Ehrmann (1927) and Johansen (1934). The latter paper is in the nature of a preliminary list,

and the author very kindly handed his useful collection over to me for more detailed investigation. I have also examined a number of Westerlund's original specimens now in the possession of the United States National Museum. An interesting record of the occurrence of *Pisidium* in Novo Zemla was given by Odhner (1923). A list of the papers consulted in the preparation of this report is given in the bibliography at the end of this paper.

## SYSTEMATIC ACCOUNT.

Class Gastropoda

Order Pectinibranchiata

Family VIVIPARIDAE

Genus Viviparus Montford 1810.Viviparus fasciatus (Müller).

Plate 15, figures 1-4.

Nerita fasciata Müller, Verm. Hist. ii, p. 182. 1774.Viviparus contectus Johansen, Proc. Malac. Soc. London,  
p. 32. 1934.

DESCRIPTION. Shell of large size, length up to 40 mm., rather thinner than in most members of this genus; colour greenish-brown, with three dark brown (or slightly reddish) spiral revolving lines; surface generally smooth and glossy, growth lines for the most part fine and regular, crossed by widely spaced spiral lines; whorls six to seven, convex, inflated, regularly increasing in size; spire broadly acute, pointed, somewhat turreted in appearance; suture deeply impressed; aperture rather obliquely ovate, well rounded, parietal wall attached to the preceding whorl for about 4 mm. only; umbilicus open though not particularly broad, deep Operculum thin, light brown or red in colour.

GEOGRAPHICAL RANGE. Europe, northern Asia.

LOCAL DISTRIBUTION. New Record. River Anambinskaya, near Ekaterinoskovo, Tara area. Previous Record. Narim, north of Tomsk, Johansen (1934, p.32).

REMARKS. Prashad (1928) in his study of Recent and fossil Viviparidae, states that no members of this family are found in the whole of Central Asia, Mongolia, the greater part of China, and with the exception of the Amur Basin, the whole of Asiatic Russia. The present records, therefore, considerably extend the known distribution of Viviparidae. The precise locality for the Narim record is not given by Johansen, but it is probable that the specimens were from a small side stream and not from the River Ob, as the oxygen content of that stream, at least in the region further south, drops to a very low point during the winter months.

Johansen (1934, p. 32) tentatively reports the presence of Viviparus duboisianus in Siberia. Having seen the Tomsk University Museum collection in which a single specimen said to be of this species was found, I am of the opinion that there has been some mixing of shells or labels at the time of the recent unsettled conditions in this part of the world, during which period the collection was not always under the care of a qualified person, and hence the record must be accepted with reservation.

## MEASUREMENTS OF THE SHELLS OF

Viviparus fasciatus

from the River Anambinskaya  
near Ekaterinoskovo, Tara  
area, Siberia.

Length	Greater Diameter	Lesser Diameter	Aperature Length	Aperature Width
39.6 mm.	30.5 mm.	27.4 mm.	17.3 mm.	15.2 mm.
36.2	29.5	27.0	17.6	15.6
36.0	30.2	27.1	17.9	16.3
35.5	29.3	26.7	18.1	15.4
34.4	28.1	25.9	17.1	15.6
33.6	26.7	25.0	16.3	14.5
32.4	27.2	25.1	16.1	14.0
30.7	26.2	23.2	15.9	14.2
30.6	25.0	23.3	15.6	13.1
30.5	26.2	22.5	16.5	14.7
30.1	25.0	22.9	15.3	13.7
29.1	25.2	22.7	15.7	13.8
27.7	24.3	22.0	14.7	13.2
26.5	21.9	20.3	13.4	12.1
24.3	21.1	19.1	12.1	11.1
24.0	20.7	18.9	13.2	11.9
23.8	21.5	18.6	13.9	12.0
23.4	21.5	18.5	13.6	11.5

## Family PALUDESTRINIDAE

Genus Bithynia Leach 1818Bithynia tentaculata (Linnaeus)

Plate 16, figures 8-10.

Helix tentaculata Linnaeus, Syst. Nat., ed. X, p. 774,  
No. 616. 1758.

**DESCRIPTION.** Shell of moderate size, or rather small, length of largest specimen 11.5 mm., somewhat globose, relatively thick, colour dull green or brownish; surface usually dull, growth lines regular, minute, crossed by numerous fine impressed lines; whorls 5, rounded, enlarging regularly, but moderately rapidly; body whorl globose; spire broadly conical; sutures slightly impressed; aperture sub-orbiculate, but somewhat angular at the superior junction with the preceding whorl; peristome continuous, slightly thickened within; umbilical chink minute or absent.

**GEOGRAPHICAL RANGE.** Europe; northern Asia, Kashmir, Punjab, east of the River Indus, Annandale and Rao (1923); parts of North America, both living and in Pleistocene deposits Baker (1928).

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, ponds on the flood plain of the River Nura near Rojdestvensky; drift, River Nura; fossil deposits (Nos. 1, 2 and 4) near Rojdestvensky; Ashi Kum Kul; Kotur Kulb, near Borovoye.

Tara area, marshes along the River Anambinskaya. Omsk area, ponds and marshes on the flood plain of the River Irtish, near Omsk; Rivers Om, and Zamaraika, near Omsk; Nikolaevka; Alexandrovka. Intermittent stream on eastern shore of Lake Celeti-Denghiz. Barabinsk Steppe, River Chulim, north of Slavgorod; River Karat. Tomsk area, pond near the River Ob, 30 km. above the mouth of the River Ket.

Previous Record. Middendorf reported this species from Barnaoul.

HABITAT IN SIBERIA. The habitat of this species in Siberia is usually in ponds and marshy areas such as are found on the flood plains of the larger streams. The record from an intermittent stream refers to empty shells carried down from some other habitat. B. tentaculata does not occur in temporary ponds, and, judging from its local distribution, has a low tolerance of saline conditions in Siberia. Annandale and Rao (1923) however have reported the presence of dwarf specimens in the saline districts of the Punjab, though in precisely what type of habitat is not recorded.

## Measurements of the Shells of

Bithynia tentaculata

from several localities in  
Siberia and Kazakstan.

Length	Greater Diameter	Lesser Diameter	Aperature Length	Aperature Width	Locality
12.4 mm.	7.4 mm.	7.1 mm.	5.1 mm.	4.2 mm.	Alexandrovka nr. Omsk
11.6	7.0	6.4	5.0	3.7	River Zamaraika nr. Omsk
11.4	7.0	6.7	5.2	3.9	
11.2	7.3	6.8	5.4	4.0	River Nura, nr. Rojdestvensky
10.8	6.6	6.4	4.9	4.0	Zamaraika
10.7	6.4	6.3	4.9	3.6	
10.6	6.4	6.0	4.5	3.5	
10.4	7.0	6.6	4.6	3.5	Alexandrovka
10.4	6.9	6.5	4.9	4.0	Fossil deposit (2) nr. Roj- destvensky
10.3	6.3	5.9	4.6	3.2	River Chulim
10.1	6.5	6.1	4.7	3.4	River Anambin- skaya
9.8	6.3	5.8	4.6	3.4	Fossil, Roj- destvensky
9.1	5.6	5.4	4.5	3.1	
8.1	5.4	5.1	3.6	2.9	

Bithynia leachii inflata (Hansen)

Plate 16, figures 5-7.

Paludina inflata Hansen, Ofvers. k. Vet. Akad. Förhandl.  
Stockholm, II, p. 254. 1845.

ORIGINAL DESCRIPTION. "Paludina inflata n.s. P. testa globosoconcoidea, ventricosa, perforata, albido-lutescens, nitida; sutura profunda; anfractibus inflatis, peristomate reflectiusculo labiato; apertura ovali-rotunda. Longit. 8-11 millim; Latid. 5-7 millim. Anfr. 5."

Description of Siberian Shells. Shell of moderate size or small, length up to 11.1 mm., conical, thinner than that of B. tentaculata; colour greenish, surface as in B. tentaculata; whorls about five, gradually increasing in size, inflated; spire elevated; suture deeply impressed; apex sharp and pointed; aperture ovate, slightly angulated along the parietal wall; umbilicus small.

GEOGRAPHICAL RANGE. Europe; northern Asia.

LOCAL DISTRIBUTION. New Records. Akmolinsk area, abandoned channel of the River Nura near Rojdestvensky; Bouldi Kul; Ashi-Kum Kul; Djarla Kul; fossil deposit (No.2) near Rojdestvensky. Omsk area, flood plain of the River Irtysh near Omsk; Rivers Om and Zamaraika near Omsk. Teki-Celeti area, dry bed of intermittent stream on eastern shore of Lake Celeti-Denghoz. Djarla-Uli basin, River Chederti;

flooded area between the Rivers Chederti and Chaganak. Kulundinsk Steppe, side channel of the River Irtish sixteen kilometers below Pavlodar, and also in a similar situation on the flood plain of the Irtish eight kilometers below Chernoredsky. Aj-Bulat basin, Lakes Peschanaya and Homotenoye, the smaller Lake Topolnoye, and Lake Traynoye.

Previous Records. Westerlund has reported the presence of this species in the region of Tobolsk, near Tomsk, in the Altai, along the River Yenissei as far north as N. Lat. 60° 50', and in the vicinity of Irkutsk. Johansen has listed it from Omsk, Novo-Sibirsk, Tomsk and Narim.

**HABITAT IN SIBERIA.** In ponds and marshes on the flood plains of large streams, and in the larger lakes. This species appears to have a decidedly greater toleration of saline conditions than has B. tentaculata. It has not been found in any temporary pond.

**REMARKS:** While there is a certain amount of variation in the form of the shell of this species in Siberia, the group of variants is fairly compact, and it is therefore desirable to apply a single name to it. Some of the more extreme forms approach Bithynia leachii (Sheppard) and this species has been listed by Johansen (1934) as doubtfully occurring in Siberia. Having a moderately large series of specimens at hand, I am of the opinion that the name inflata (Hansen) covers all but a very few of the Siberian shells,

and the isolated specimens which are not typical inflata are probably extreme variants of that stock. To list them under the name leachii (Sheppard) would be to imply that the full series of variants of that species, including forms such as are described by Steenberg (1917), are found in Siberia. This is not the case, and since in any event there is gradual intergradation between these two forms, it is best to list only the varietal form B. leachii inflata (Hansen) about the locus of which the Siberian shells appear to vary.

## Measurements of the Shells of

Bithynia leachii inflata

from several localities in

Siberia and Kazakstan.

Length	Greater Diameter	Lesser Diameter	Aperature Length	Aperature Width	Locality
10.3 mm.	7.5 mm.	6.9 mm.	4.5 mm.	3.8 mm.	River Zamaraika nr. Omsk
9.6	6.8	6.3	3.9	3.6	Bouldi Kul
9.2	7.2	6.6	4.5	3.8	Zamaraika
9.2	6.9	6.3	4.5	3.4	
8.8	6.9	6.1	4.1	3.5	Bouldi Kul
8.8	6.6	6.2	4.1	3.4	
8.7	6.2	5.6	4.0	3.2	Ashi-Kum-Kul
8.0	5.6	5.4	3.5	2.8	Flooded area Chaganak- Chederti
7.5	5.9	5.3	3.4	2.9	
7.4	5.5	5.0	3.2	2.7	

Genus Paludestrina Orbigny 1840

Paludestrina ventrosa (Montagu).

? Turbo stagnalis Baster, Opusc. Subsec. II, p.77.  
1765 (See Kennard and Woodward, p.18).

Turbo ventrosus Montagu, Test. Brit., p. 317, 1803.

Cyclostoma acutum Draparnaud, Hist. Moll, France, p. 40.  
1805.

Hydrobia stagnalis Dollfus, Jour. de Conchyl. LIX, p. 238,  
1912.

DESCRIPTION. Shell small, length about 4.8 mm., elongated, conical, narrow at the base; whorls six, gradually increasing in size, convex and inflated, tapering acutely, tip of spire blunt; suture differing in various shells, always at least moderately impressed, and usually strongly so; aperture small relative to the size of the shell, gently rounded at the base, tapering to an angle of about  $80^{\circ}$  at the superior margin; lip continuous; umbilicus of moderate size.

GEOGRAPHICAL RANGE. Europe, including the British Isles (in brackish water); northern Africa; Central Asia, sub-fossil on the Deserts Kara-Kum and Kizil-Kum, north as far as Latitude  $53^{\circ} 40'$  N.

LOCAL DISTRIBUTION. New Records. Lake Teke, (N. Lat.  $53^{\circ} 40'$ , E. Long.  $73^{\circ}$ ); Lake Kizil-Kak (N. Lat.  $53^{\circ} 25'$ , E. Long.  $73^{\circ} 50'$ ).

**REMARKS.** In both the above situations the shells found were empty, bleached, and had obviously been lying near one of the old shore lines of these saline lakes for a moderately long period. In Continental Asia this is a species of definitely southern geographical distribution.

## Family VALVATIDAE.

As is to some extent true with the North American species, the Siberian members of this family present an almost perfect series of intergradations from one form to another, and while it is possible as a rule to place individual shells fairly definitely in one or other of the named groups (or species), in a series of any size the species and subspecies gradually merge into one another. As a result of this it might be possible from one point of view to include most of the Siberian Valvatidae under a single specific name. To do this, however, would be to disregard the real differences which exist in nature with some degree of constancy, even though they are obscured in the intermediate forms. Therefore, in the following account, forms which appear to be reasonably distinct have been described and named as species or subspecies, but it should be borne in mind that this is a variable group and the true status of the forms described here as species is not yet known. Nevertheless, each of the named forms represents a relatively distinct group of animals which as a rule are not found living together in the same situation, although they apparently do not occupy especially diverse types of habitat or geographical localities. At any rate they are not often found together. A practical though somewhat artificial key to the species known or likely to occur in Siberia is given below and may serve to supplement the descriptions and photographs.

Key to Valvatidae known or likely to  
occur in Siberia.

A. Top of Shell flat

1. Shell usually very small, greater diameter  
as a rule about 2 mm., never more than 4 mm.  
Valvata cristata

2. Shell of moderate size, greater diameter  
4-5 mm. V. siberica.

B. Spire slightly elevated, narrow along the base.

1. Aperture slightly depressed below the plane  
of the preceding whorls, greater diameter less  
than 4 mm. V. macrostoma.

2. Aperture considerably depressed below the  
plane of the preceding whorls, greater diameter  
5 mm. or more. V. baikalensis

C. Spire slightly elevated, broadly conical.

1. Body whorl only slightly inflated, and the  
whorls of the spire while convex, not standing  
out, but forming a low gently sloping spire. The  
aperture much depressed below the plane of the  
preceding whorls, giving the shell as a whole a  
somewhat oblique appearance. Suture moderately  
impressed. V. ambigua.

2. Spire definitely elevated or only slightly so,  
breadth not markedly greater than the height,  
body whorl much expanded, aperture depressed  
from the plane of the preceding whorls, but on  
account of the regular conical spire the shell  
as a whole has not the oblique appearance of the  
species above. V. aliena.

B. Spire considerably elevated.

1. Spire broadly conical, apex sharp or nearly so,  
V. piscinalis.

2. Spire broadly conical, apex blunt.  
V. antiqulina.

Genus Valvata Müller 1774.

Valvata piscinalis (Müller)

Plate 15, figure 6; Plate 16, figure 3.

Nerita piscinalis Müller, Verm. Hist., II, p. 172. 1774.

Valvata piscinalis (pars) Johansen, Proc. Malac. Soc.  
London p. 32. 1934.

**DESCRIPTION.** Shell of moderate size, length 6.4 mm. or less, thick; colour greenish; surface dull and rough, growth lines coarse, irregular, and widely spaced, spiral lines also present in some cases on the under side; whorls four to four and three-quarters, gradually increasing in size, convex and evenly rounded, without any tendency towards a carina; spire broadly conical, blunt; aperture sub-circular, only very slightly flattened and angulated along the peripheral wall; lip thin and sharp; umbilicus moderately deep.

**GEOGRAPHICAL RANGE.** Europe; Asia Minor, Kashmir, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Marshes near the River Anambinskaya, Tara area. Fossil Deposits (Nos. 1, 2 and 4) near Rojdestvensky, and ponds on the flood plain of the River Nura in the same locality. Borovoye. Pond near the River Ob, forty kilometers below the mouth of the River Tom.

**REMARKS.** Specimens from Lakes Topolnoye and Travnoye (Aj-Bulat basin) are intermediate between V. piscinalis and a new species, V. antiquilina Mozley.

Valvata antiquilina Mozley.

Plate 15, figure 5.

Plate 16, figure 4.

Valvata antiquilina Mozley, Smithsonian Misc. Coll.,  
Vol. 92, No.2, pp. 1-2.

**DESCRIPTION.** Shell of moderate size for members of this genus, length 6.4 mm., broadly conical; surface smooth, with minute crowded lines of growth; whorls four and seven-eighths, convex, very slightly flattened; aperture sub-circular, very slightly angulated along the superior margin, lip continuous, attached to the preceding whorl for about 0.6 mm. The dimensions of the type are as follows: Length 6.4 mm., greater diameter 5.9 mm, lesser diameter 5.2 mm, aperture length 3.1 mm, aperture width 2.5 mm.

**TYPE LOCALITY.** Lake Khomotenoye, Aj-Bulat drainage basin, approximately three hundred and seventy kilometers south-east of Omsk, Siberia. Type in the collection of the United States National Museum No. 469212.

**LOCAL DISTRIBUTION.** In addition to the type locality, this species was also found in the fossil deposits (Nos. 1 and 2) near Rojdestvensky, and in an old channel of the River Nura in the same vicinity. Specimens from Lakes Topolnoye and Trevnoye (Aj-Bulat basin) tend toward the piscinalis type of Valvata.

REMARKS. This species has some resemblance to both V. piscinalis (Muller), and V. antiqua Morris, and in many respects is intermediate between these two species. It differs from most forms of V. piscinalis in having the shell as a whole more solidly built, the spire more bluntly conical, and the whorls less broadly rounded, those in the new species being a little flattened, and turning sharply into the suture.

V. antiquilina differs from V. antiqua Morris (pl. I, fig. 5) in the proportions of the shell (see measurements below), the new form being slightly more broadly built, in having the suture a little deeper, and in the whorls being regularly rounded and slightly flattened, rather than rounded and projecting downward as in V. antiqua.

No living specimens were found, all the shells being empty and bleached. Apparently this species lived in Lake Khomotenoye at some former time when the water level stood considerably higher than in 1933.

## Measurements of the Shells of

Valvata antiquilina

from the shore of Lake Khomotenoye, Siberia.

No.	Whorls	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1.	4 3/4	6.4 mm.	6.0 mm.	5.5 mm.	2.7 mm.	2.5 mm.
2.	4 3/4	6.0	5.1	4.7	2.8	2.4
3.	4 5/8	5.7	4.8	4.6	2.3	2.1
4.	4 5/8	5.5	4.9	4.7	2.4	2.4
5.	4 1/2	5.6	5.4	4.8	2.5	2.4
6.	4 1/2	5.4	4.9	4.7	2.5	2.3
7.	4 1/2	5.3	4.8	4.5	2.7	2.1
8.	4 1/4	5.3	4.8	4.5	2.6	1.9
9.	4 1/4	4.7	4.5	4.1	1.9	1.8
10.	4 1/8	4.9	5.1	4.6	2.7	2.2

Measurements of the Shells of  
Valvata antiqua Morris  
 from Grays, Essex. (Type Locality).

No.	Whorls	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1.	4 $\frac{7}{8}$	7.3 mm.	6.1 mm.	5.3 mm.	2.8 mm.	2.6 mm.
2.	4 $\frac{7}{8}$	6.4	5.2	4.5	2.8	2.3
3.	4 $\frac{3}{4}$	6.3	5.5	5.0	2.8	2.3
4.	4 $\frac{5}{8}$	6.4	6.0	5.6	3.2	2.9
5.	4 $\frac{5}{8}$	6.3	5.2	4.9	2.4	2.3

Valvata aliena Westerlund

Valvata aliena Westerlund, Sv. Vet. Akad. Hand. b. 14,  
No. 12, p. 63. Also Bachrichtsbl. Deutsch.  
Malakozool, Ges. 1876. p. 102.

Valvata piscinalis Johansen, (pars) Proc. Malac. Soc. Lond.  
1934.

**DESCRIPTION.** Shell small, greater diameter usually about 4 mm. ("6½" Westerlund) broader than high; surface bright, growth lines coarse and regular; a few spiral lines present on the underside; whorls about three and a half in the specimens examined ("4½" Westerlund) rapidly increasing; body whorl much larger than those preceding it, somewhat inflated; spire slightly elevated; suture moderately impressed; aperture large, sub-circular or very slightly obtusely ovate; margin thin, sharp, not continuous; the upper part slightly angulated; umbilicus narrow and deep.

**GEOGRAPHICAL RANGE.** Northern Asia.

**LOCAL DISTRIBUTION.** New Records. River Om near Omsk. Tomsk (Johansen Coll.). The type locality was Nijni Inhatsk on the Yenissei (N. Lat. 63° 50').

**REMARKS.** The description given here is based upon specimens identified by Westerlund, which are in the United States National Museum, but does not agree exactly with that given in his "Palaarctische Binnen-Conchylien."

Valvata macrostoma (Steenbuch M.S.) Mörch.

Valvata pulchella Studer, in Coxe's Trav. in Switzerland, III, p. 391. 1789. Nom. nud.

Valvata macrostoma Steenbuch: Mörch. Synop. Moll. Daniae, p. 59. 1864.

**DESCRIPTION.** Shell small, greater diameter 5 mm. or less, moderately solid in build; surface bright, dark green in colour, whorls about three and a quarter, rounded, sub-circular in outline, gradually increasing in size; spire slightly elevated; body whorl very slightly dilated near the aperture; suture deeply impressed, but not to such an extent as in Valvata siberica; aperture nearly circular in outline, but very slightly angulated at the point of junction with the preceding whorl; umbilicus wide and deep.

The dimensions of a shell from Saiyan are as follows: Height, 2.9 mm., greater diameter, 4.8 mm., lesser diameter, 4.1 mm., aperture height, 1.8 mm., aperture width, 1.8 mm.

**GEOGRAPHICAL RANGE.** Europe, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Fossil deposits (Nos. 2 and 4) near Rojdestvensky, Akmolinsk area. Flood plain of the River Ket, four kilometers above the River Ob.

I have also examined a specimen labeled "Sajan, Hartung" in the United States National Museum. The locality is undoubtedly Saiyan, the mountain range on the frontier between the Soviet Union and the Tannu-Tuva Republic (Uran-hai). This specimen was identified by Westerlund.

Valvata siberica Middendorf.

Valvata cristata var. siberica Middendorf, Sibirische Reise, II, p. 297. 1851.

**DESCRIPTION.** Shell small, greater diameter less than 5 mm., much broader than high, usually neatly flat above, and with a deep cavity below; surface dull, growth lines coarse but regular, no spiral marking evident in the specimens examined; whorls about two and a half, specimens of the usual size, three in large specimens, rounded, rapidly increasing in size; the body whorl nearly circular in section, descending from the plane of the preceding whorls; suture deeply impressed; aperture thin, sharp, sub-circular, only very slightly angulated near the peripheral wall; umbilicus wide and deep.

**GEOGRAPHICAL RANGE.** Northern Asia. The variety frigida Westerlund occurs in northern Sweden, as well as on the River Yenissei (Westerlund's records).

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, fossil deposits (Nos. 1, 2 and 4) near Rojdestvensky. River Chederti, drift. Flood plain of River Irtish ten kilometers below Pavlodar. Ponds near the River Ket, eight and two hundred and ninety-four kilometers above the River Ob.

Previous Records. Middendorf gave Barnaoul, Beresov and Kamchatka as the localities of this species, and

Westerlund the region of the Yenissei, the Altai, and the Irkutsk-Baikal area. Lindholm (1919) has reported its occurrence near Obdorsk, and Johansen (1934) has given the following additional localities: Kisnetzk, Tomsk, Narim, and Bolotnaya.

Order Pulmonata

Family ELLOBIIDAE

Genus Carychium Müller 1774.

(Carychium minimum Müller)

Carychium minimum Muller, Verm. Hist., II. p. 125. 1774.

A species of Carychium was found fossil in a recent deposit along the River Nura, but has not been satisfactorily determined, and must for the present be left under the above name.

## Family LYMNAEIDAE.

The Lymnaeidae, as might be expected in this sub-arctic territory, occupy a commanding position in the Siberian mollusc fauna both as regards the number of species and individuals, and their occupation of nearly every available habitat. Twelve species and varieties of the genus Lymnaea have been collected in the course of this expedition and are described below. In addition to these, there is another subspecies, Lymnaea pereger geisericola Bk. which also is probably found in parts of Siberia, but as I have not been able to examine the specimens it is not included in this work.

Lymnaea

Genus Lamarck, 1799

Lymnaea stagnalis (Linné).

Plate 17, figures 1-12.

Plate 18, figures 1-16.

Plate 19, figures 3-12.

Helix stagnalis Linne, Syst. Nat. ed. X, p. 774, 1758.

**DESCRIPTION.** Shell of large size, up to fifty millimeters or slightly more in length; elongate, sometimes ovate; varying in thickness but usually moderately stout; horn-colored, sometimes dark brown or black; surface dull or shining, in some cases malleated; growth lines numerous and more or less elevated, crossed by spiral lines which are not always as numerous or as strongly impressed as in North American specimens; whorls six to seven, the first four only slightly convex, the last two much more so, the last whorl sometimes slightly shouldered, but as a rule not markedly so; spire varying in length in collections from different localities but usually about one-half of the length of the entire shell; suture distinct, sometimes impressed; aperture large, ovate, the outer periphery usually gently rounded, parietal wall with a wide callus; umbilical chink often completely closed, in some specimens slightly open; pillar of the columella forming an oblique ascending plait.

**GEOGRAPHICAL RANGE.** Lymnaea stagnalis with its varieties is found over a wide area, including the whole of Europe,

except Iceland; north Africa; northern Asia as well as Afganistan and Kashmir; and the greater part of North America to the north of Latitude 40° N.

LOCAL DISTRIBUTION. New Records. River Tobol at Chutovska. Akmolinsk area, ponds on flood plain of the River Ishim near Akmolinsk; pond on flood plain of River Nura near Rojdestvensky; Lakes Mai-Balik and Bouldi-Kul southeast of Akmolinsk; small lakes (Nos. 27, 30, 33) southwest of Rojdestvensky; Djarla-Kul; fossil deposits (Nos. 1 and 2) near Rojdestvensky. Borovoye; also near village Kotur-Kulb. Omsk area, marshes and ponds on flood plain of River Irtish near Omsk; near River Irtish at Nikolaevka and Alexandrovka; marsh near sanitorium "Karver", Omsk; marsh near station Moskalenka, Omsk Railway; River Zamaraika near Omsk near Anambins Kaya, and in the River Temshenyakova, Tara area. Teke-Celeti area, dry lake 10 km. southeast of Lake Ulkun Karoi; lake 30 km. south of Lake Kizil-Kak; pond (No. 4) east of Lake Celeti-Denghiz. Djarla-Uli Basin, small lakes (Nos. 4, 6 and 7) near Novo Troetskaya; drift along River Chaganak 35 km. above Lake Chaganak; flooded area between the Rivers Chaganak and Chederti. Kulundinsk Steppe, side waters of the River Irtish near Pavlodar; pond on flood plain of River Irtish 8 km. north of Chernoredsky; pond on steppe 50 km. north of Slavgorod. Aj-Bulat Basin, Lake Peschanaya; Lake Homotenaya; the smaller Lake Topolnoye; Lake Travnoye, Barabinsk Steppe,

pond (No. 2); Lake Sartlan; sub-fossil along shore of Lake Chani. Tomsk area, small lakes near the river Ket 100, and 294 km. above the River Ob; pond near the junction of the Rivers Issy-Kul area, near the village Klenayevka.

Previous Records. On account of its large size and wide local distribution, Lymnaea stagnalis has been included in the list of practically every writer on Siberian molluscs, and in contrast to the reported occurrences of many other species, the great majority of these records are doubtless based upon authentic specimens. This is the result of the fact that there are no other species or subspecies in this fauna which can be easily mistaken for L. stagnalis. Middendorf found this species at Barnaul, Beresov and Irkutsk. Gerstfeldt (1859) first reported it from the Tomsk district. Schmidt collected it at Turukhansk on the River Yenissei (N. Lat. 66°), while Westerlund recorded its occurrence in three localities in the far north of Siberia, namely, Dudino (N. Lat. 69° 15'); Lusino (N. Lat. 68° 40'); and Surgutskoye (N. Lat. 68° 50'). All of these are situated on or near the River Yenissei. Other localities given by Westerlund include the former Provinces of Iobolsk, Tomsk, Yenisseisk and Irkutsk, as well as the Altai and Far Eastern (Amur) regions. Maack collected at Nerschinsk and in Yakutia, and it also occurs in certain localities near Lake Baikal. Lindholm (1919) has reported it from two localities near Obdorsk, and Johansen (1934) has listed it from several localities in the region bounded by Omsk, Biisk, Minussinsk

and Tomsk. It is obvious, therefore, that in Siberia L. stagnalis has a wide geographical distribution, the local distribution, however, is more restricted, and while this species occurs in each of the great geographical sectors of Siberia, it is not as abundant as is the comparable form L. stagnalis jugularis in North America; that is to say, by no means every pond and lake in Siberia is inhabited by L. stagnalis. In Kazakstan it is less common than in Siberia.

HABITAT IN SIBERIA. Ponds and small lakes, particularly in marshy places. In the forested region Lymnaea stagnalis is found quite commonly in ponds and small lakes, which do not dry out during the summer. As a rule, these are found in the vicinity of the larger streams, and probably represent old cut-offs. On the steppe and forest-steppe it inhabits similar situations, and also in more or less isolated ponds and lakes on the steppe, away from the larger water-courses. Southward, however, it is found in a smaller proportion of these habitats, as the lakes become more saline and the ponds become more of the nature of temporary ponds filled by snow water for a short period in spring. As a rule, in Siberia the most favorable habitat of this species is in ponds and marshes on the flood plain of large streams, such as the Irtish, Ishim and Nura. In these situations it is often found in company with Planorbis corneus.

Lymnaea stagnalis has not been found in temporary ponds or intermittent streams, although it may sometimes survive in small shallow lakes on the steppe, which contain only a little water permanently. This species has no great toleration of saline conditions, and it has not been taken alive in any saline lake. In its resistance to conditions of this sort L. stagnalis stands in a position intermediate between L. palustris and Planorbis corneus.

Within the area examined the two most typical habitats of this species are the ponds on the flood plain of the River Nura, and Bouldi-Kul, a small shallow fresh water lake encircled by a broad zone of Phragmites communis, among which L. stagnalis and Planorbis corneus occur abundantly. Empty shells of L. stagnalis were very common in the bed of a lake 10 kilometers southeast of Lake Ulkun Karoi. This is a drained fresh water lake, L. stagnalis being a form characteristic of such situations. Occasionally, as in the case of Ashi-Kum-Kul, it is found in a "Drained and evaporated saline lake," but in such cases it occurs only around the edge of the lake, on the beaches laid down during the earlier, fresh water stages of the lake's history.

The geographical factors limiting the southward distribution of <sup>this</sup> species in this region are three in number, namely:

a. The increasing salinity of the lakes, with the attendant diminution of marsh development. Lymnaea stagnalis is not particularly tolerant of saline conditions, and finds its most suitable habitat in marshes.

b. The increasing proportion of ponds which do not contain water permanently, but merely have a short aquatic phase in the spring of each year. Lymnaea stagnalis is not able to endure a long period of desiccation.

c. The changing character of the rivers, which, as a result of the deficiency of precipitation, particularly of snow during the winter, become temporary drainage channels, without any pools containing water permanently.

It is likely that in the region of the Kirghiz Upland, the high inclination of the valleys and the presence of the bed rock at or near the surface also play a part in limiting the distribution of this mollusc by hindering the development of suitable habitats. Notwithstanding all of the above, L. stagnalis is a hardy and prolific species, and is found frequently and in large numbers wherever the geographical conditions permit of its existence. It may be well to note that from the standpoint of physiography, this species in common with many of its associates occupies very transient features of the landscape.

VARIATION. There is considerable variation in shells of specimens of Lymnaea stagnalis from Northern Asia, particularly in connection with the form of the spire and the

shape of the aperture. In some specimens the spire is long and narrow, as, for example, in a specimen from Tomsk (Plate 19, figure 3) in which the dimensions are as follows: Length 36.7.; greater diameter 15.8 mm.; lesser diameter 11.9 mm.; aperture length 17.9 mm.; aperture width 11.2 mm. Similar attenuated forms have been seen from the River Ket and from Kiev in European Russia. In other cases, the spire is much reduced in height, as in a specimen from a small lake east of Lake Celeti-Denghiz, with the following dimensions; Length 44.2 mm.; greater diameter 25.9 mm.; lesser diameter 20.0 mm.; aperture length 27.2 mm.; aperture width 18.4 mm.

No Siberian stagnalis has been seen with the spire very greatly reduced, as occurs in the well-marked lacustrine race of northern Europe, and in L. stagnalis sanctaemariae of North America, although this reduction sometimes occurs to a certain degree.

The shape of the aperture varies in Siberian shells from ovate (in some cases sub-circular) to elongate in outline, but no shells have been seen in which the outline of the periphery of the aperture is so nearly circular as in the North American L. stagnalis wasatchensis. Shouldering of the superior margin of the periphery of the aperture is a common but by no means universal feature of the Siberian shells; in some cases this is carried around the body whorl. The shells of many specimens have a maleated appearance, others are smooth. The

prominence of the lines of growth and the impressed spiral lines varies greatly. It is interesting to note, however, that the nearest approach to this form in any of the series collected in Siberia occurs in a non-lacustrine habitat, namely in a Phragmites marsh, which occupies an expansion of the River Burla about one kilometer above the village known as Ustianka (Aj-Bulat drainage basin). Several of these shells are shown in Plate 17, figs. 1-6) and it is significant that the series collected in this situation was moderately but not absolutely uniform, and that most, but not all, the specimens collected had a shorter spire than is usual in this species. Measurements of six shells from this habitat are given below.

Measurements of the Shells of

Lymnaea stagnalis

from the River Burla, 1 km. above Ustianka,  
northern Kazakstan.

The figure numbers refer to Plate 17.

Figure	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1	35.8 mm.	18.5 mm.	15.1 mm.	20.6 mm.	11.3 mm.
2	44.0	21.7	18.3	21.3	13.5
3	33.6	19.0	15.7	20.7	12.7
4.	44.1	24.6	19.2	26.9	17.1
5	39.6	24.0	17.8	24.5	18.0
6	42.8	23.7	19.0	23.8	16.2

Numerous so-called subspecies of L. stagnalis have been described from Europe, but with the material on hand it seems best to refer all the Siberian shells to typical stagnalis. In any moderately large series of shells from this region there appears to be fairly complete intergradation between the extreme forms, which taken alone might appear to be distinct and worthy of varietal names. Nevertheless, as is mentioned above, it is possible in some series to detect a tendency for shells of some particular form to occur more frequently than others. On the whole it seems that there are no varieties in Northern Asia comparable either in the stability of peculiar shell form, or degree of adaptation to a special type of habitat, with the four well-marked subspecies of Sub-Arctic America, viz. L. stagnalis jugularis, L. s. sanctaemariae, L. s. lillianae and L. s. wasatchensis, (see Mozley 1930a).

MEASUREMENTS OF SHELLS OF *LYMNAEA STAGNALIS*  
 from dry lake bed, 10 km. southeast of Lake Ulkun Karoi.  
 U. S. N. M. No. 570567.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1	58.8 mm.	28.9 mm.	25.0 mm.	31.5 mm.	17.5 mm.
2	55.9	28.8	23.9	32.8	16.4
3	52.8	27.5	23.3	31.9	18.9
4	51.2	26.2	21.5	29.5	16.6
5	50.6	25.6	19.9	27.5	17.0
6	50.0	26.0	20.6	29.2	17.2
7	49.7	23.5	20.8	25.5	13.4
8	49.2	26.7	21.4	27.9	18.6
9	48.9	25.6	18.9	28.9	18.8
10	48.8	24.7	19.0	27.6	17.3
11	48.0	23.6	18.0	25.3	17.4
12	47.8	25.0	19.4	26.4	18.9
13	47.4	25.0	19.0	26.7	16.4
14	47.0	25.3	20.3	28.4	17.2
15	46.9	25.2	18.6	26.2	17.2
16	46.7	25.0	20.3	26.6	17.6
17	46.7	24.2	20.0	28.1	17.3
18	46.5	26.5	19.8	27.6	20.8
19	46.5	24.5	19.4	27.3	17.1
20	46.4	25.9	19.7	29.1	19.7
21	46.4	24.9	19.1	17.3	18.9
22	46.2	24.0	18.6	25.4	16.4
23	45.5	24.8	19.8	26.1	16.4
24	45.5	23.6	18.0	25.3	17.4
25	45.2	25.7	20.1	27.0	19.3
26	44.2	23.0	19.0	25.4	17.8
27	44.0	23.8	18.7	25.8	16.4
28	44.0	23.3	18.0	26.6	16.4
29	43.9	23.0	17.8	24.1	15.7
30	43.9	20.8	16.9	22.7	15.5
31	43.7	26.9	21.2	27.9	18.7
32	43.4	24.2	19.3	26.9	15.4
33	43.4	23.1	18.0	25.0	16.3
34	43.2	23.2	17.5	25.1	16.8
35	43.0	27.5	22.3	28.3	19.3
36	42.3	22.7	18.4	25.3	15.5
37	41.7	22.5	17.4	24.1	16.1
38	41.5	21.8	17.8	24.7	14.9
39	41.2	21.9	17.6	23.3	15.2

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
40	41.1 mm.	22.5 mm.	23.4 mm.	22.9 mm.	16.0 mm.
41	41.1	22.6	17.5	23.9	15.5
42	40.6	20.2	16.2	22.1	13.9
43	40.5	21.4	16.9	22.5	15.8
44	40.3	21.2	17.1	23.6	14.1
45	40.1	22.5	17.2	24.3	17.0
46	39.8	23.4	17.3	24.7	16.0
47	39.7	17.8	15.2	19.0	11.4
48	38.6	22.9	16.8	23.6	16.6
49	36.4	19.1	14.4	19.9	12.5
50	34.0	18.0	13.8	19.6	11.8

MEASUREMENTS OF SHELLS OF LYMNAEA STAGNALIS  
from several localities in Siberia.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	U.S.N.M. No.	Locality
1	57.7 mm.	27.3 mm.	21.8 mm.	30.3 mm.	17.5 mm.		R. Babandaika Tomsk Johan- sen Coll.
2	54.0	25.3	20.8	28.6	16.1		Tomsk, Johan- sen Coll.
3	53.8	29.6	22.8	32.5	21.7	469431	R. Zamarai-Ka
4	52.0	28.8	21.6	30.9	19.5	470571	Bouldi-Kul.
5	51.0	27.4	21.4	30.9	17.7	470243	Novo-Troets- kaya.
6	48.4	23.9	18.9	27.2	16.5	470559	Nura Flood plain.
7	48.2	24.4	19.2	27.8	16.9	470559	"
8	47.2	26.9	21.5	30.0	20.4	470243	
9	46.6	26.1	20.8	27.0	18.5	470288	Borovoye.
10	45.9	24.9	19.4	27.0	17.4	470288	"
11	45.8	24.0	19.5	26.3	16.1	469479	Nikolaevsk.
12	45.7	22.3	18.3	24.3	14.4	469604	Pond nr. R. 30. km. above mouth of R. Ket.
13	45.3	23.2	19.9	26.9	15.0	470615	R. Chulim.
14	44.5	27.7	17.5	25.0	14.8	470559	
15	44.3	22.7	17.9	26.7	16.9	470325	Nr. Borovoye.
16	43.5	20.1	16.3	23.4	14.0	470559	
17	43.3	24.7	19.0	26.6	17.3	470288	
18	43.0	21.6	17.0	25.2	14.6	469806	Pond, R. Ket 294 km. above Ob.
19	42.9	23.5	18.7	25.8	15.2	469604	
20	42.9	22.2	18.7	10.7	14.7	470243	
21	42.8	21.9	17.6	23.7	14.6	470559	
22	42.7	24.6	19.6	26.6	18.5	470243	
23	42.7	24.1	19.4	25.3	15.8	470288	
24	42.6	20.3	17.0	22.5	13.8	469604	
25	42.4	21.3	17.4	24.8	13.4	469604	
26	42.0	22.9	18.0	25.1	14.3	470559	
27	41.7	19.5	16.2	21.9	13.9	470288	
28	41.6	19.4	15.5	21.7	13.3	470560	Mai Balik.
29	41.4	20.9	16.4	23.9	13.3	470559	
30	40.4	21.1	16.7	23.5	13.4	469806	
31	39.4	18.7	14.8	21.2	11.9	470560	
32	39.0	19.2	15.1	21.9	12.4	470559	
33	38.8	19.8	16.3	24.0	12.8	470559	
34	38.2	20.9	16.4	24.9	13.4	470571	

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	U.S.N.M. No.	Locality
35	38.2 mm.	19.3 mm.	15.7 mm.	22.2 mm.	12.6 mm.	469806	Pond. R. Oh, 31 km. above R. Ket.
36	38.0	17.3	14.4	18.7	10.3	469925	
37	37.9	15.9	15.8	21.7	10.5	470571	
38	37.6	19.1	15.7	21.7	13.6	470325	
39	36.6	22.9	18.0	23.4	15.5	470288	
40	36.5	16.8	14.6	19.4	10.3	470571	
41	36.2	18.9	16.0	21.2	12.2	470288	
42	34.4	19.1	14.8	20.7	12.5	470325	
43	33.1	18.3	15.0	19.9	12.4	470325	
44	33.0	17.6	14.4	19.7	11.9	470325	
45	30.0	13.7	11.5	16.9	9.3	470559	
46	28.7	13.1	10.7	16.4	8.7	470559	
47	28.4	13.8	10.6	15.8	9.1	470559	
48	27.9	12.1	10.3	14.7	7.8	470559	
49	27.0	12.8	10.4	15.0	8.2	470559	
50	25.9	12.6	10.4	14.3	8.4	470559	

Lymnaea (Radix) auricularia (Linne)

Plate 21, figures 12-14.

Helix auricularia Linne, Syst. Nat. ed. 10, p. 774, 1758.

**DESCRIPTION.** Shell large, length 30 mm. or more when mature, commonly about 28 mm., rounded, in some cases globose, thin, light horn-colored or brown; surface as a rule fairly smooth and shining, sometimes appearing malleated but not to such an extent as often occurs in L. palustris, growth lines distinct, in some shells sufficiently strong to give the last whorl a finely ribbed appearance, crossed by widely spaced, impressed, spiral lines which are distinct in some specimens, very faint or absent in others; whorls about  $4\frac{1}{2}$ , convex, all well rounded, the last much expanded, especially along the superior margin; spire very small in proportion to the shell as a whole, acute, pointed; sutures deeply impressed, especially around the body wall; aperture large, ovate to oval, often flaring, the outer edge in some cases carried out into a thin, nearly flat, plate; columella sub-sigmoid or gently curved, slightly twisted in some cases but generally flat or nearly so; umbilical chink minute in young specimens, usually large in mature shells.

**GEOGRAPHICAL RANGE.** Europe, as far south as Spain and Italy; northern Asia; Afghanistan; Kashmir.

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, ponds on the flood plain of the River Ishim near Akmolinsk; ponds

on the flood plain of the River Nura near Rojdestvensky; Lakes Mai Balik and Bouldi-Kul, south of Akmolinsk; small lake 15 km. southwest of Rojdestvensky. Near Borovoye, and also near the village Kotur-Kulb. Ponds on the flood plain of the River Irtish near Omsk and Nikolaevsk; River Zamaraika near Omsk. Sidewater of the River Irtish 8 km. north of Chernoredsky. Barabinsk Steppe, River Chulim north of Slavgorod; River Kargat near Nijni Kargat; Lake Chani, empty shells found on shore, no living specimens taken. Tomsk area, pond near the junction of the Rivers Ket and Eltiribi; pond near the River Ket 100 km. above the River Ob. Near the town Prosvet, 15 versts from Ust Talminskaya. Lake Nur, Island Olkonon, Lake Baikal.

Previous Records. Lymnaea auricularia is widely distributed in Siberia. Middendorf collected it at Beresov, Barnaoul, Tunguska, Kirensk, and Nertschinsk. Gerstfeldt reported its occurrence at Irkutsk, Tomsk, on the Vilui, and at Lucha and Olensk. Schmidt (1872) found it in sub-fossil condition on the Yenissei at North Latitude  $69^{\circ} 48'$ , but it is possible that the shells had been carried down the river for some distance before being deposited. West-erlund has reported it from Nijni Inbatsk (N. Lat.  $63^{\circ} 50'$ ), as well as from the provinces of Tobolsk, Tomsk, Yenisseisk, and Irkutsk, as well as the Altai and the Far Eastern (Amur) region. Johansen (1934) has recently listed it from several places in the Minussinsk-Novo Sibersk-Tomsk area. It is

noteworthy that L. auricularia was not found by the Kouznetzov Expedition to the tundra region near Obdorsk (see Lindholm, 1919). Johansen (1934) states that Middendorf found it in that region but I have not been able to find any published report of that fact, and since the later expedition failed to find it there (although twenty-five other species of molluscs were collected) it is safe to say that it does not occur so far north in that region.

**HABITAT IN SIBERIA.** This species is not one of the foremost immigrants to invade any new habitat. It is usually associated with the older and more luxuriant aquatic situations, and is never found in any of the border line habitats such as temporary ponds or saline lakes. The typical habitat is in quiet situations along the shores of slow-flowing streams, and in fresh water ponds and small lakes. Evidently it is quite intolerant of drought, or any considerable concentration of mineral salts in solution.

**VARIATION.** The shell of this species is moderately variable in form, but taking into consideration the wide variation which is generally to be found in a collection from one restricted habitat, and the great difference between young and mature shells, it appears to be best of all the specimens collected on this expedition under the typical form of auricularia.

Measurements of the Shells of  
Lymnaea auricularia  
 from several localities in  
 Siberia and Kazakstan

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	Locality
1	37.4 mm.	26.5 mm.	18.3 mm.	28.8 mm.	19.5 mm.	
2	33.4	26.1	17.4	27.3	18.9	15 km. south- west of Rojdestvensky
3	33.0	25.3	17.1	27.0	18.3	
4	30.9	26.5	16.5	26.1	21.2	
5	30.9	25.8	16.8	25.9	19.5	
6	28.9	24.3	15.6	25.5	17.6	Lake Tojanovo, nr. Tomsk Outskirts of Omsk
7	27.9	25.2	15.6	24.5	24.4	
8	27.3	21.5	13.5	23.2	15.5	
9	24.9	21.9	13.3	21.2	16.5	Lake Tojanovo, nr. Tomsk Nr. village Kotur-Kulb Borovoye area
10	24.6	18.9	13.0	20.2	14.6	
11	24.0	22.7	15.1	23.2	16.2	
12	15.8	13.4	10.2	13.2	9.2	

Lymnaea (Radix) pereger (Müller)

Plate 20, figures 10-14.

Buccinum peregrum Müller, Verm. Hist., ii, p. 130. 1774.

DESCRIPTION. Shell of moderate size, length about 25 mm., obliquely ovate, thin, light horn coloured; surface smooth, usually rather dull, with only moderately distinct lines of growth, in most cases crossed by widely spaced fine spiral impressed lines, in rare cases the upper part of the ultimate whorl has a malleated appearance; whorls about  $4\frac{1}{2}$ , nearly five in large specimens, convex, the last greatly expanded but not to such an extent as in L. auricularia, the body whorl sometimes very slightly shouldered on the left side, but usually gently sloping; spire short and relatively broad, in some cases forming about one third of the length of the shell, but as a rule less than one third; sutures moderately impressed; aperture ovate, varying in series from different localities but usually obliquely ovate; outer lip thickened, not flaring to any extent; columella slightly twisted or nearly flat; umbilical chink distinct, sometimes of large size.

GEOGRAPHICAL RANGE. Europe, including Iceland; northern Africa; northern Asia, Afghanistan, Kashmir.

LOCAL DISTRIBUTION. New Records. Ponds and marshes on the flood plain of the River Ishim near Akmolinsk; ponds on the

flood plain of the River Nura near Rojdestvensky; ponds on the steppe to the south and east of Rojdestvensky; small pond in the hills east of the River Nura 10 km. south of Rojdestvensky; pond in the valley tributary to the Nura 20 km. south of Bouldi Kul; Durt Sart; Djarla Kul; Kun Gul (Kumbi Kul); Ashi Kum Kul. Near Borovoye, and near the village Kotur Kulh. River Ishim near Petropavlovsk. Omsk, ponds and marshes on the flood plain of the River Irtish; River Om; marsh near Station Maoskalenka, Omsk Railway. Near Anambinskaya, and in the River Temshenyakova, Tara area. Teke-Celeti area, Lake Teke; intermittent stream on eastern shore of Lake Celeti-Denghiz; small lake near Celeti-Denghiz; Lake Ulkin-karoi; dry lake 10 km. south of Ulkun Karoi. Djarla Uli Basin, seven small lakes near Novotroetskaya; Rivers Chaganak and Chederti; flooded area between the above streams. Kulundinsk Steppe, sidewater of the River Irtish 10 km. below Pavlodar. Barabinsk Steppe, pond on the steppe 50 km. north of Slavgorod; Lakes Karachu and Sartlan. Aj-Bulat basin, sub-fossil in a former beach of Lake Topolnoye, living specimens in Lakes Peschanaya, Homontneye, the smaller Lake Topolnoye, and Lake Traynoye. Tomsl area, pond near the River Ob, 30 km. above the mouth of the Ket; ponds near the River Ket 30 and 294 km. above the Ob. Near the town Prosvet, 15 versts from Ust Talminskaya. River Maima near Ulala, Altai; River Balta 7 km. from Ulala.

Previous Records. The knowledge of the distribution of this species is somewhat obscured by the fact that it appears in the literature under several different names. Gerstfeldt reported it from Irkutsk, the Vilui, and Luncha. Westerlund gives three localities on the Yenissei at North Latitude  $60^{\circ} 50'$ ;  $62^{\circ} 50'$ ; and  $68^{\circ} 40'$ . That author also gives localities in the old provinces of Tobolsk (Obdorsk, N. Lat.  $66^{\circ} 32'$ ), Tomsk, Yenisseisk and Irkutsk, as well as in the Altai and Far Eastern (Amur) regions. Lindholm (1919) reports it from the neighbourhood of Obdorsk, and Johansen (1934) found it at Biisk, Kuznetzk and Tomsk.

**HABITAT IN SIBERIA.** Lymnaea pereger is a widely distributed and hardy species in Siberia. It is to be found in nearly all permanent ponds, marshy areas, sluggish streams and lakes in which the water is moderately fresh. It is abundant in the ponds and marshes on the flood plains of the larger streams and also occurs on the steppe away from the rivers valleys in most places where fresh water remains the year round. With one possible exception Lymnaea pereger has not been found in the temporary ponds of Siberia, although it is reported to inhabit such situations in Great Britain. It is likely however that in the latter country the drought is never so severe as on the northern Asiatic steppes. Likewise L. pereger has not been found in any of the saline lakes. Its tolerance of life conditions in these two types of habitat is decidedly less than that of L. palustris.

VARIATION. The generally prevailing race of L. pereger in Siberia is the typical form (Taylor, 1890, p.289), in which the shell is obliquely ovate, with a small but distinct spire which occupies about one quarter of the total length of the shell, and the aperture ovate rather than elongate, but not oval. In addition to this form there is one variety which is sufficiently distinct and constant to merit designation as subspecies. There is considerable variation in the shells of L. pereger collected in diverse localities, but none of these forms appear to be sufficiently constant in form either in one restricted habitat, or over the territory as a whole to be worthy of a distinct subspecific name. That is to say, the individual and geographical variation is so great that it is not possible to give a clear-cut description of many of the minor groups included under this specific name. Therefore in the absence of any detailed investigations over the whole of the range of this snail, and experimental breeding to ascertain the extent of variation in self fertilized series, it appears to be better not to give names to the minor varieties until their origin and status in classification are better understood.

## Measurements of the Shells of

Lymnaea pereger

From several localities in Siberia.

Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	Locality
27.4 mm.	20.4 mm.	15.7 mm.	20.7 mm.	14.9 mm.	Nikolaevsk
27.1	19.1	15.9	20.9	14.7	
22.8	16.9	12.3	17.5	11.7	Pond near River Ob 30 km. above R. Ket.
21.5	13.6	11.0	14.2	9.3	
20.6	15.3	12.4	16.0	10.4	Nikolaevsk
20.6	13.9	11.9	15.2	9.6	Borovoye
20.5	14.8	14.9	14.8	10.0	Pond near River Ob
19.4	14.3	11.4	14.6	9.6	
18.9	15.2	10.8	16.2	11.4	Omsk
18.8	12.5	9.9	13.0	8.9	Small lake (No. 2) nr. Novo Troetskaya
17.3	11.3	8.7	11.8	7.6	Pond near River Ob
16.4	12.0	9.1	12.1	8.4	nr. Novo Troetskaya
15.7	11.2	8.1	10.9	6.9	Pond near River Ob
16.4	12.0	9.1	12.1	8.4	nr. Novo Troetskaya
15.5	11.2	8.6	11.4	7.8	Borovoye
15.1	12.2	8.8	12.3	8.5	

Lymnaea (Radix) pereger ovata (Draparnaud).

Plate 20, figures 6-8.

Limneus ovatus Draparnaud, Hist. Moll. France, p. 50. 1805.

DESCRIPTION. Shell similar to that of Lymnaea pereger (Müll.) but usually thinner, and with the last whorl much larger in proportion to the preceding ones; aperture very large, length about four-fifths of that of the shell as a whole, and the spire correspondingly short.

GEOGRAPHICAL RANGE. Similar to that of L. pereger (Müll.)

LOCAL DISTRIBUTION. New Records. Borovoye; Omsk; Lake Lavrenyjevskoye, near Tomsk.

Previous Records. There are Siberian records in the literature but it is by no means certain that all of these refer to the same varietal form of L. pereger.

Lymnaea (Radix) zazurnensis. Mozley.

Plate 20, figure 9.

Lymnaea zazurnensis Mozley, Smithsonian Misc. Coll.,  
Vol. 92, No. 2, p. 6.

**DESCRIPTION.** Shell of fairly large size, length 18.5 mm., broad relative to the length, horn-colored; surface bright, glossy, crossed by many regularly spaced lines of growth which give the shell a slightly ribbed appearance, and by many microscopic spiral impressed lines; whorls five, convex, protruding and well rounded in all cases; the body whorl nearly semicircular in outline on the left side; having a slightly shouldered appearance at the junction with the preceding whorl, but actually having a small V-shaped depression intervening and continuing round the shell for at least one whorl above the aperture; aperture ovate-ellipsoidal; outer lip thin, sharp; inner lip gradually curving, columella nearly flat, not twisted, spreading out to some extent over the umbilical region, which is seen from side and below to be fairly widely open.

**TYPE LOCALITY.** Lake Zazurnia, a small mountain lake situated about fifteen miles east of Veedrina (eastern shore of Lake Baikal) in the mountain range known as the Khamar Daban. Type in the collection of the United States National Museum, No. 470709. L. zazurnensis is known only from the type locality.

HABITAT. Lymnaea zazurnensis was found living on stones and on the rocky shore of Lake Zazurnia, which occupies a narrow cleft about three miles long between two small but precipitous sub-ranges near the summit of the Khamar Daban. The habitat is typically lacustrine, there being no sign of marsh development. This small lake has been formed as a result of a great rock slide which has blocked the western end of this valley. The grayling (Thymallus bicalesnsis?) is common in this lake. The drainage is by a turbulent mountain stream into the River Snejnoya and thence into Lake Baikal. No molluscs were found in either of these small rivers, and in view of their montane character, it is unlikely that any exist there. Thus this habitat is an isolated one, and there is no connection, as far as the possible migration of snails is concerned, between Zazurnia and Lake Baikal.

REMARKS. This species is probably closely related to Lymnaea pereger, but is distinct from all described forms of that species, the nearest approach being L. pereger bakawskyana Clessin, a small species described from Plickow in Galicia. Nevertheless, it is quite different from all the common forms of pereger, and its peculiar characters appear to be sufficiently constant to merit its description as a distinct species.

Measurements of the Shells of  
Lymnaea zazurnensis from  
 Lake Zazurnia, Khamar Daban, Siberia.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
Type	18.9 mm.	12.5 mm.	11.0 mm.	11.9 mm.	7.9 mm.
	19.6	12.8	11.3	12.5	8.4
	18.8	13.3	11.2	11.7	7.8
	18.5	12.8	10.9	12.4	7.8
	18.2	12.4	11.1	12.2	7.7
	18.2	12.4	10.1	12.0	7.8
	17.2	12.1	10.3	11.1	7.7
	16.6	11.8	8.9	11.2	7.9
	15.9	11.1	9.9	11.7	7.9
	15.2	10.0	8.8	10.1	6.3

Lymnaea (Galba) palustris (Müller).

Plate 20, figure 5.

Buccinum palustre Müller, Verm. Hist. II, p. 131. 1774.

DESCRIPTION. Shell of moderate size or large, length up to 30 mm., usually about 20 mm., elongated, generally thick but very thin in some shells from the Taiga region, dark horn-coloured or brown; surface with many fine growth lines, crossed by crowded spiral impressed lines, surface with a malleated appearance in some shells; whorls 6 to 7, convex, gently curved, gradually increasing in size; spire long, broad at the base, gently tapering, and occupying more than one-half of the length of the shell; sutures not deeply impressed; aperture elongate-ovate, outer lip well rounded, not flaring; inner lip closely appressed to the parietal wall; columella gently curved, axis slightly twisted; umbilical chink narrow.

GEOGRAPHICAL RANGE. Europe; northern Africa; northern Asia; North America.

LOCAL DISTRIBUTION. New Records. Akmolinsk area, ponds on flood plain of River Ishim near Akmolinsk; ponds on flood plain of River Nura near Rojdestvensky; ponds on the steppe east and southwest of Rojdestvensk; ponds near intermittent stream 20 km. south of Bouldi Kul; Zum Kul; Ashi-Kum Kul; Kun Gul (Kumbi Kul), fossil deposits (Nos. 1

and 2) near Rojdestvensky. Borovoye, also near the village Kotur Kulb. Omsk area, marshes and ponds on flood plain of River Irtish near Omsk, also near Nikolaeoka; Rivers Om and Zamaraika near Omsk. Teke-Celeti area, Lake Ulkun Karoi; 6 km. of Kizel Kak; pond on steppe 8 km. east of Lake Celeti-Denghiz; intermittent stream on eastern shore of Lake Celeti-Denghiz; small lake 40 km. north of Novotroitskaya. Djarla-Uli Basin drift. Steppe Sari Dala, Aka Sor; Kulundinsk Steppe, ponds (Nos. 2 and 7); pond on flood plain of River Irtish near Pavlodar; also 8 km. north of Chernoredsky; lake east of Kara Bura; pond on steppe 50 km. north of Slavgorod. Aj-Bulat Basin. Lakes Horshoye, Peschanaya, Homotenoye, Travnoye. Barabinsk Steppe (ponds Nos. 2 and 15), Lake Sartland; River Kargat near Nijni Kargat; temporary pond near Zuza. Tomsk, drift on shore of River Ob 45 km. above the mouth of the Tom; ponds near the River Ket 35, 100 and 294 km. above the River Ob; pond near junction of Rivers Ket and Eltiribi.

Previous Records. Middendorf found this species at Barnaul and Irkutsk. Westerlund has reported its occurrence at Lusino on the River Yenissei (N. Lat. 68° 25') but applies the varietal name fusca of Pfeiffer to the specimens. He also states that it occurs in the old provinces of Tobolsk, Tomsk and Yenisseisk, as well as in the Altai and the Far Eastern (Amur) region. Some of these, however, may not be based on the typical palustris. Lindholm (1919) has reported on its occurrence in four localities

near Obdorsk, and Johansen (1934) gives several localities in the Biisk-Kuznetzk-Tomsk region. The record of L. palustris turricola Held from Novo Sibersk given by Johansen probably refers to one of the new subspecies described below; which from all the information at present available appears to be quite distinct from L. turricola Held.

**HABITAT IN SIBERIA.** As might be expected, Lymnaea palustris has a wide local distribution in Siberia. It is to be found in many of the fresh water lakes, in the more quietly flowing (or stagnant) rivers of the Steppe and Forest-Steppe, and in temporary ponds. It occurs in some of the lakes of the type designated as "drained saline lakes," but in those of the evaporated and ground water types palustris if present at all is usually represented by a turriculoid variety, such as L. palustris kazakensis.

It is not found in the mountain streams of Eastern Siberia although it is common enough on the Steppe and forest-steppe, sometimes in the streams themselves, and often in the ponds on the flood plains.

In collecting over an extensive area in Siberia and northern Kazakstan, one is impressed by the fact that this species is less common there than in the comparable regions of North America. In parts of Canada, Lymnaea palustris (or closely related and homologous forms whose systematic position is not yet clear) is extremely common and is to be found in abundance in almost any pond, small lake, and

marshy area. An examination of 314 ponds in the western part of Canada showed the presence of *Lymnaea* of the palustris group in 238 of them, and as many of these ponds were of a very temporary nature (and several of them contained no molluscs whatever), it is probable that this snail occurs in an even greater proportion of the aquatic situations of the region. This is not true in northern Asia, and even though to the casual observer conditions may appear to be very similar, the proportion of ponds and lakes which is populated by *Lymnaea palustris* is much smaller. It is estimated to be about one in four or five.

The geographical factors influencing the southward distribution of *Lymnaea palustris* in Siberia and northern Kazakstan are fairly clear cut. In the first place, although this species is able to withstand desiccation in temporary ponds for several months, the aquatic phase of such ponds grows shorter and shorter further south as a result of the somewhat higher temperatures and smaller snowfall, and obviously there must be a fairly definite requirement on the part of the aquatic inhabitants of such situations as to the minimum length of the active feeding period which will allow of survival from year to year. So that in common with the other species of molluscs which inhabit these situations, *Lymnaea palustris* while not uncommon in the temporary ponds of the steppe and forest steppe country, is much more rare in those on the steppe

desert. The increasing salinity of the lakes in the southern part of this country also plays a part. The typical form of Lymnaea palustris does not occur in the strongly saline waters of Siberia, and within this geographical area it is replaced in such situations by the subspecies saridalensis and kazakensis. These in turn become increasingly rare on the steppe desert where most of the lakes have an even higher salt content.

VARIATION. The shells of palustris f.t. from Siberia and Kazakstan closely agree with specimens from Europe, differing chiefly in length and the degree of expansion of the later whorls. The Siberian shells are invariably smaller than those from Europe, but retain the characteristic sub-triangular form of the shell as a whole. Some shells resemble the variety corvus Gmelin, which is common in parts of Europe.

In addition to the typical form of Lymnaea palustris, there are four distinct varieties in Siberia and Kazakstan. In any one locality these forms are as a rule distinct and constant, so that there is no difficulty whatever in distinguishing between them. However in a large collection from many different localities a good many more or less intermediate forms appear, but on the whole it appears to be worth while to describe these varieties as new subspecies.

Lymnaea (Galba) palustris saridalensis Mozley.

Plate 20, figure 3.

Lymnaea palustris saridalensis Mozley, Smithsonian Misc.  
Coll., Vol. 92. No. 2. pp. 2-3.

DESCRIPTION. Shell of moderate size, length 23.9 mm., elongate, and much narrower in proportion to the length than in the usual forms of palustris; light horn-colored, thin, surface smooth, minutely wrinkled, lines of growth not prominent, crossed by impressed spiral lines; whorls seven and one-half, regularly convex; spire long and narrow, more than half the length of the shell; suture moderately deep; aperture elongate-elliptical; outer lip gently rounded, periphery sharp and thin; columella somewhat twisted; umbilical chink a minute elongated slit.

A specimen 22.4 mm. in length had seven and three-quarters whorls.

TYPE LOCALITY. A small, somewhat saline lake on the Steppe Sari Dala 15 km. southwest of Pavlodar, northern Kazakstan. Type in the collection of the United States National Museum, No. 469734.

GEOGRAPHICAL RANGE. This species is known only from the type locality, which is about 400 kilometers southeast of Omsk, and 600 kilometers north of Lake Balkhash. Some idea of the geographical position may be given by stating that Pavlodar is situated approximately midway between Delhi, British India, and the Arctic Ocean.

Measurements of the Shells of  
Lymnaea palustris saridalensis  
 from the Steppe Sari-Dala  
 13 km. southwest of Pavlodar,  
 Kazakstan.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1.	25.7 mm.	9.5 mm.	9.0 mm.	10.7 mm.	5.4 mm.
2.	25.0	9.6	8.7	10.4	5.0
3.	24.9	9.9	9.1	10.8	5.9
4.	24.8	8.9	8.2	9.5	4.8
5.	24.7	9.4	8.6	10.3	5.5
6.	24.5	9.5	8.4	9.9	4.9
7.	24.2	9.5	8.8	10.0	5.6
8.	24.1	9.8	9.2	11.0	5.9
9.	23.9	9.7	8.8	10.4	5.8
10.	23.9	9.5	8.9	10.4	5.3
11.	23.9	9.5	8.8	10.2	5.5
12.	23.9	9.5	8.6	9.9	5.8
13.	23.8	9.4	8.3	10.5	5.6
14.	23.4	9.5	8.5	10.6	5.9
15.	23.3	9.0	8.4	9.6	5.2
16.	23.2	9.2	8.4	10.3	5.9
17.	23.1	9.7	8.7	10.5	5.3
18.	23.1	9.3	8.6	10.0	5.3
19.	23.0	9.9	9.0	11.0	6.0
20.	23.0	8.4	7.9	9.0	4.9
21.	22.9	9.2	8.5	9.1	5.4
22.	22.7	9.1	8.3	9.8	5.1
23.	22.7	9.0	8.4	9.7	5.2
24.	22.4	9.5	8.5	10.3	6.0
25.	22.4	8.8	7.9	8.9	4.7
26.	22.4	9.0	8.1	9.5	5.0
27.	22.3	9.1	8.3	9.4	5.1
28.	22.3	9.0	8.3	9.5	5.2
29.	22.3	8.5	7.7	9.5	5.0
30.	22.2	9.0	8.5	10.1	5.3
31.	22.1	9.0	8.1	9.5	5.1
32.	22.0	8.9	8.1	9.3	4.3
33.	22.0	8.8	8.0	9.3	5.0
34.	22.0	8.7	8.0	9.6	5.4
35.	21.9	9.0	8.0	9.8	4.9
36.	21.9	8.5	8.0	9.0	5.0
37.	21.8	8.8	8.2	9.7	5.2
38.	21.8	8.5	7.9	8.7	5.0
39.	21.8	8.1	7.7	8.7	4.4

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
40.	21.7 mm.	9.3 mm.	8.3 mm.	9.8 mm.	4.9 mm.
41.	21.7	8.3	7.4	9.4	4.3
42.	21.6	9.2	8.3	9.5	5.5
43.	21.6	8.9	8.1	9.7	5.2
44.	21.6	8.5	7.8	9.0	5.3
45.	21.6	8.4	7.5	8.8	4.4
46.	21.5	8.9	8.3	9.8	5.3
47.	21.5	8.2	7.5	9.2	5.0
48.	21.4	9.0	8.4	8.9	5.1
49.	21.4	8.8	8.1	9.3	5.1
50.	21.4	8.5	8.0	9.4	5.2
51.	21.3	9.1	8.4	9.2	5.5
52.	21.3	8.8	8.1	9.7	5.0
53.	21.3	8.5	7.9	9.1	5.0
54.	21.3	8.3	7.8	9.0	5.0
55.	21.2	9.0	8.2	9.6	5.2
56.	21.2	8.6	7.8	9.0	5.0
57.	21.2	8.5	8.2	8.9	4.5
58.	21.1	8.3	7.8	9.4	5.0
59.	21.1	8.0	7.4	8.5	4.9
60.	21.0	8.5	7.8	9.0	5.1
61.	21.0	7.9	7.4	8.7	5.1
62.	20.9	8.5	7.8	8.7	4.5
63.	20.9	8.1	7.2	8.7	4.7
64.	20.8	8.8	7.7	9.5	5.0
65.	20.7	8.7	8.1	8.9	5.1
66.	20.7	8.5	7.9	8.3	4.8
67.	20.6	9.2	8.4	9.6	5.0
68.	20.5	8.7	7.9	9.2	5.1
69.	20.4	9.0	7.8	9.2	5.1
70.	20.3	8.1	7.3	8.4	5.0
71.	20.3	8.8	7.9	9.2	5.1
72.	20.3	8.1	7.2	8.8	4.7
73.	20.2	8.4	7.8	8.8	4.6
74.	20.1	8.2	7.7	9.0	4.6
75.	19.9	7.8	7.2	8.2	4.5
76.	19.8	8.4	7.5	9.1	4.6
77.	19.7	8.4	7.6	8.8	4.7
78.	19.7	7.9	7.5	7.2	4.7
79.	19.6	8.6	7.9	9.1	5.0
80.	19.6	8.2	7.4	8.6	4.6
81.	19.6	7.9	7.5	8.6	4.7
82.	19.6	7.9	7.3	8.3	4.6
83.	19.5	8.0	7.3	8.1	4.8
84.	19.5	7.8	7.3	8.7	4.6
85.	19.4	7.5	7.0	8.0	4.7

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
86.	19.3 mm.	8.0 mm.	7.2 mm.	8.3 mm.	4.7 mm.
87.	19.1	7.7	7.1	8.3	4.7
88.	19.1	7.6	6.9	8.5	5.0
89.	19.0	7.8	7.2	8.3	4.7
90.	19.0	7.4	7.2	7.7	4.6
91.	18.9	7.7	7.2	8.2	4.2
92.	18.9	7.4	6.9	7.4	4.4
93.	18.9	7.3	6.7	7.5	4.6
94.	18.7	7.4	7.0	8.0	4.4
95.	18.7	7.3	6.6	7.7	4.0
96. <sup>2</sup> / <sub>8</sub>	18.3	7.4	6.7	8.3	4.6
97.	18.1	7.7	6.9	8.0	4.5
98.	18.1	7.5	6.8	7.6	4.7
99.	18.0	7.7	7.1	8.0	4.7
100.	17.7	7.2	6.7	7.2	4.1

Lymnaea (Galba) palustris kazakensis Mozley.

Plate 20, figure 1.

Lymnaea palustris kazakensis Mozley, Smithsonian, Misc. Coll.  
Vol. 92, No. 2, pp. 3-4.

**DESCRIPTION.** This subspecies resembles L. palustris saridalensis but has eight whorls, which are somewhat shouldered; the suture is very deeply impressed, the lower side of the whorls slopes into the suture in a plane not far from the vertical, the superior margin of each whorl, however, while at first gently curved, finally turns abruptly into the suture; the spire is very long, forming nearly three-fifths of the length of the shell as a whole, and has a somewhat turreted appearance.

A specimen 22.3 mm. in length had seven and seven eighths whorls.

**TYPE LOCALITY.** A small dry lake bottom six kilometers north of the village of Novo Troetskaya, northern Kazakstan. Type in the collection of the United States National Museum, No. 470457.

**GEOGRAPHICAL RANGE and LOCAL DISTRIBUTION.** L. palustris kazakensis was collected in the following places in addition to the type locality; two other small somewhat saline lakes near Novo Troetskaya; Durt Sart, a partly drained slightly saline lake situated 40 km. south west of Rojdestvensky,

in the Akmolinsk area; and in a small lake east of Kara Bura on the Kulundinsk Steppe.

This form of palustris is confined to saline lakes but in these situations it is sometimes found in very great numbers.

Measurements of the Shells of  
Lymnaea palustris kazakensis.

from near Novo Troetskaya, Kazazstan.

Type	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
	30.0 mm.	11.7 mm.	10.9 mm.	12.3 mm.	7.4 mm.
	26.5	10.9	10.4	11.3	6.3
	25.7	10.7	9.9	11.0	6.5
	25.1	9.9	10.0	11.3	6.6
	24.9	10.5	9.8	10.8	6.3
	24.8	10.2	9.5	10.5	5.7
	24.6	10.2	9.6	10.4	6.1
	23.8	9.9	9.0	10.4	5.9
	23.4	10.0	9.2	9.8	6.3
	21.2	8.9	8.5	8.9	5.3
	20.4	8.5	7.8	7.8	4.8

Lymnaea (Galba) palustris draverti Mozley.

Plate 20, figure 2.

Lymnaea palustris draverti Mozley, Smithsonian Misc. Coll.,  
Vol. 92, No. 2, p. 4.

**DESCRIPTION.** Shell somewhat resembling that of L. palustris kazakensis but having a more broadly conical spire; whorls seven and a half, convex, gently rounded, turning gradually into the suture, which is deep; aperture small and subovate, oval by comparison with that of kazakensis, columella not twisted, umbilical chink of large size.

**TYPE LOCALITY.** River Om, near Omsk. Collected by Professor Pierre Dravert. Type in the collection of the United States National Museum, No. 469681. Known only from the type locality, the specimens being collected in drift along the banks of the River Om.

## Measurements of the Shells of

Lymnaea palustris draverti.

from the River Om, near Omsk.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
Type	19.6 mm.	8.8 mm.	8.2 mm.	7.7 mm.	4.8 mm.
	19.2	9.1	8.7	8.9	5.4
	18.5	8.4	7.6	7.7	4.6
	17.9	9.2	8.1	8.3	5.5
	17.7	8.3	7.6	7.8	4.8
	16.3	7.9	7.1	7.3	4.4
	16.0	8.2	7.4	7.5	4.7
	15.8	7.8	7.2	7.2	4.7
	15.2	7.4	6.8	7.0	4.4
	14.1	7.0	6.4	6.2	3.7
	13.4	7.0	6.3	6.0	3.5

Lymnaea (Galba) palustris bolotensis Mozley.

Plate 20, figure 4.

Lymnaea palustris bolotensis Mozley, Smithsonian Misc.  
Coll. Vol. 92. No.2. p. 5.

DESCRIPTION. Shell somewhat smaller than in all the subspecies here described (length 22.7 mm) but of greater thickness; the general appearance somewhat barrel-shaped in comparison with kazakensis and the others, as a result of the shallowness of the suture, and the relatively large size of the last three whorls; the aperture is small and roundly auriform, the columella thin and only slightly twisted, and the outer lip thin, sharp and without any tendency toward flaring.

TYPE LOCALITY. The flooded area between the Rivers Chederti and Chaganak, northern Kazakstan. Type in the collection of the United States National Museum, No. 469821.

GEOGRAPHICAL RANGE and LOCAL DISTRIBUTION. In addition to the type locality this subspecies was also found in drift along the River Chaganak, and in a small lake near Novo Troetskaya. All these localities are in the isolated inland drainage basin of Djarla-Uli.

REMARKS. The four subspecies of Lymnaea palustris here described are all closely similar, but in any moderately

large series it is possible to distinguish the different forms without difficulty. Lymnaea palustris saridalensis is characterized by the tall spire, slightly convex whorls, and moderately impressed suture; kazakensis is distinguished by even higher spire, slightly convex whorls turning sharply into a deep suture; draverti by its shorter and broader, though still acute, spire, more convex whorls, and smaller subovate aperture and very gently curved columella; while bolotensis has a shorter spire with fat whorls, and shallower suture.

## Measurements of the Shells of

Lymnaea palustris bolotensis.

from several localities in Kazakstan.

Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	Locality
22.7 mm.	8.9 mm.	8.5 mm.	8.1 mm.	5.4 mm.	Flooded area between the Rivers Chaganak and Chederti.
21.4	9.1	8.7	9.3	6.8	
21.4	8.4	7.9	9.5	5.4	Drift, River Chaganak.
21.3	8.9	8.1	8.7	5.7	Small lake (No.6) near Novo Troetskaya.
21.1	8.4	8.3	8.4	5.3	
20.8	9.0	8.1	8.7	5.9	Chaganak
20.7	8.1	7.8	8.8	4.8	Novo Troetskaya
20.4	8.1	7.8	7.6	5.1	
20.4	8.1	7.5	8.6	5.3	Flooded area.
20.1	8.4	7.7	8.7	5.6	Chaganak
20.1	8.3	7.9	8.1	5.3	
19.5	8.0	7.4	8.2	5.3	
18.5	8.5	7.9	8.8	5.2	
17.6	7.6	7.1	8.7	4.8	Flooded area.
13.6	6.9	6.5	7.0	4.1	

Lymnaea (Galba) truncatula (Müller)

Buccinum truncatulum Müller, Verm. Hist. ii, p. 130. 1774.

**DESCRIPTION.** Shell small, length usually about 8 mm., elongate, light horn-coloured, surface smooth, growth lines minute, spiral sculpture consisting of widely spaces shallow impressed linesl whorls 5, convex, somewhate truncate; spire conic, turretted, tapering more abruptly than in most others members of the sub-genus Galba; sutures deeply impressed; aperture ovate in young specimens, ovate-elongate in older shells, outer lip thin, not reflected backwards, gently curving, the superior margin in most cases shouldered; inner lip regularly curved, not twisted, forming a broad plate covering the umbilicus, which when viewed from the side is a moderately large cavity.

**GEOGRAPHICAL RANGE.** Europe, including Iceland; northern Africa; northern Asia, Aghanistan, Kashmir, Alaska, Aleutian Islands, Yukon.

**LOCAL DISTRIBUTION.** New Records. A moderately large series of shells of this species was collected on the flood plain of the River Ket, about four kilometers above its mouth, but apart from this L. truncatula is rare in the collections of the expedition of 1932-33. Specimens which may belong to this species were collected in Lake Travnoye (Aj-Bulat basin), and on the flooded area between the Rivers

Chederti and Chaganak (Djarla-Uli basin).

Previous Records. Lymnaea truncatula was found by Middendorf at Barnaoul, Irkutsk, and Tomsk. It is listed by Gerstfeldt (1859) from Irkutsk, the Vilui and Luncha. Westerlund lists L. truncatula var. microstoma Drouët from two northern localities on the Yenissei at North Latitude  $63^{\circ} 30'$ , and  $63^{\circ} 50'$ . Lindholm (1919) reports that it occurs in northern part of the River Ob, and Johansen (1934) states that he found this species at Tobolsk and Narim, as well as on the Barabinsk Steppe.

Whether all of these previous records are based upon authentic specimens is open to question, but there is no doubt that L. truncatula does occur in Siberia.

Lymnaea (Leptolimnaea) glabra (Müller).

Plate 19, figures 1-2.

Buccinum glabrum Müller, Verm. Hist. ii, p. 135. 1774.

**DESCRIPTION.** Shell of moderate size, length about 12 mm., elongate, sub-cylindrical, thin, light horn-coloured, surface bright, glossy, crossed by fine line of growth and numerous minute spiral impressed lines; whorls about seven, closely coiled, slightly convex, gradually increasing in size, the last three whorls all of considerable height and breadth giving the shell a sub-cylindrical appearance, body whorl occupying about one half of the length of the shell; spire relatively blunt; sutures only moderately impressed; aperture small, ovate, well rounded and not pear-shaped; outer lip thin; inner lip forming a gently curving plate closing or nearly closing the umbilical cleft.

**GEOGRAPHICAL RANGE.** Europe, northern Africa, northern Asia.

**LOCAL DISTRIBUTION.** New Records. River Maima, near Ulala, Altai; River Balta, seven versts from Ulala.

Measurements of the Shells of  
Lymnaea glabra from Siberia.

Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	Locality
15.8 mm	5.2 mm	5.1 mm	5.7 mm	3.0 mm	River Balta
13.6	4.8	4.6	5.1	2.7	
12.9	4.8	4.6	5.0	2.6	
12.4	4.3	4.1	4.4	2.2	
12.3	4.3	4.2	5.0	2.2	
11.9	4.6	4.5	4.2	2.4	River Maima
10.0	4.0	3.7	3.9	2.0	
10.0	3.8	3.5	3.8	1.8	River Balta
9.2	3.8	3.7	3.7	2.1	

Genus Myxas (Leach MS.) Sowerby 1822.

Myxas glutinosa (Müller).

Buccinum glutinosum Müller, Verm. Hist., ii, p. 129. 1774.

DESCRIPTION. Shell of small size, thin, fragile and transparent; shape almost globicular; spire very small; aperture very large; oval. The mantle very much extended and covering the greater part of the shell.

GEOGRAPHICAL RANGE. Europe; northern Asia, Syria.

LOCAL DISTRIBUTION. Previous Record. Tomsk.

REMARKS. Mr Bodo Johansen states that he found his specimen near Tomsk. No example of this species was collected during the expedition of 1932-33, although many places were examined which are similar to its habitat in Europe. I have seen the specimen upon which this record is based, but have not had the opportunity of examining it critically. It is smaller than the prevailing form in Sweden and Finland.

## Family PLANORBIDAE

Genus Planorbis Geoffroy 1767.Planorbis (Planorbarius) corneus (Linné).

Plate 21, figures 1-6.

Helix corneus Linne, Syst. Nat., ed. X, p. 770, No. 587.  
1758.

**DESCRIPTION.** Shell of large size, greater diameter up to 32 mm., moderately thick, horn-coloured or reddish, surface often bright and glossy, sometimes malleated in appearance, lines of growth fine and regular, the first four whorls usually with heavy spiral lines which become fainter, more irregular, and almost disappear in the last whorl; whorls about 6, convex, not carinate but slightly inflated towards the superior periphery; sutures strongly impressed, breadth of the body whorl one-third of the breadth of the shell as a whole, aperture rounded, not angulated, inclined and oblique; outer lip sharp, thin.

**GEOGRAPHICAL RANGE.** Europe, northern Africa, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, ponds on the flood plain of the River Ishim near Akmolinsk; ponds on the flood plain of the River Nura, near Rojdestvensky; Bouldi Kul; Kun Gul (Kumbi Kul); pond on the steppe east of Rojdestvensky; fossil deposits 1 and 2, near Rojdestvensky. River Tobol near Chutovska. Omsk area, ponds

and marshes on the flood plain of the River Irtish near Omsk; Nikolaevsk; Rivers Om and Zamaraika. Tara area, marshes near Anambinskaya. Djarla-Uli basin, River Chaganak 35 km. above Lake Chaganak; flooded area between the Rivers Chaganak and Chederti. Kulindinsk Steppe, flood plain of the River Irtish below Pavlodar; side waters of the same stream 8 km. north of Chernoredsky; Aj-Bulat basin, Lakes Peschanaya and Travnoye. Barabinsk Steppe, River Chulim north of Slavgorod. Tomsk area, ponds near the River Ket near the junction of the Ket and Eltiribi, also in pond 30 km. above the River Ob.

Previous Records. Planorbis corneus was found by Middendorf at Barnaul and Beresov, Gerstfeldt (1859) reported its occurrence at Tomsk, and Westerlund stated that it occurs in the old provinces of Tobolsk (north as far as N. Lat.  $63^{\circ} 30'$ ), and Tomsk, as well as in the Altai. Lindholm (1919) found it in collections from Obdorsk. Johansen (1934) has recently collected it at Biisk, Kusnetzk, and Narim.

HABITAT. Planorbis corneus is a common species in Siberia, but is found only where there is fresh water permanently. It is usually abundant in the ponds and marshes on the flood plain of the larger streams, and in the moderate-sized fresh water lakes on the steppe, particularly in those which are surrounded or filled with a thick growth of Phragmites communis. It has not been found in any temporary pond,

nor in anybody of saline water. Its distribution in the Djarla-Uli system, one of the isolated inland drainage basins, is of some interest. In this drainage basin P. corneus is to be found only in the strictly fresh water part of the system, namely, in the upper parts of the River Chaganak, and the River Chederti. The ultimate reservoir of the basin, Lake Djarla-Uli is too saline to permit of any molluscan life at the present time, but in the small lakes above it, there are several species of gastropods. P. corneus, however, appears for the first time at a point thirty-five kilometers above Lake Chaganak, and is not to be found in any abundance until the flooded area between the Rivers Chaganak and Chederti is reached. In this area it is found in some abundance, particularly in the larger ponds and marshes in which there is a moderately close growth of Phragmites communis.

It is a noteworthy fact that although the habitat requirements of this species coincide in a general way with those of Lymnaea stagnalis, the latter species occurs much more frequently in Siberia than does P. corneus.

This species is nearly always accompanied in its habitat by L. stagnalis, but it is only in a small proportion of the habitats of L. stagnalis that P. corneus is to be found, so that while the coefficient of association of P. corneus with L. stagnalis is high, the reciprocal coefficient of L. stagnalis with P. corneus is low. It is probable that the

explanation lies in the fact that P. corneus, as has been pointed out by Webster (1919), is very sensitive to injury, and if the shell is cracked, death usually results. It is reasonable to suppose that in this lies the explanation of the absence of P. corneus in even slightly wave-washed habitats in Siberia, in which L. stagnalis often occurs. Nevertheless where it does occur, in quiet marshy situations, P. corneus is found in some abundance, and is almost invariably accompanied by L. stagnalis.

## Measurements of the Shells of

Planorbis corneus

from several localities in

Siberia and northern Kazakstan.

Height	Greater Diameter	Lesser Diameter	Aperture Height	Aperture Width	Locality
12.3 mm.	32.8 mm.	26.0 mm.	11.3 mm.	11.8 mm.	Bouldi Kul
11.2	31.6	24.6	9.5	12.6	
11.4	28.3	23.1	10.6	11.2	
11.7	28.3	22.2	11.1	11.1	
11.8	28.2	22.1	10.6	11.7	30 km. S.W. of Rojdestvensky
11.7	27.9	22.3	10.8	11.7	
10.5	27.5	22.1	9.5	10.6	Bouldi Kul
11.1	25.6	20.4	10.2	9.0	Omsk
10.4	24.9	19.6	9.9	10.8	30 km. S.W. of Rojdestvensky
10.5	24.1	19.6	9.7	9.4	Omsk
10.2	23.8	18.7	9.7	9.3	

Planorbis (Gyraulus) acronicus Ferussac

Planorbis acronicus Ferussac, Essai Method. Conchyl.  
p. 105. 1807.

Planorbis strömi Westerlund, Öfers. k. Vet. Akad.  
Förhandl. Stockholm, XXXVIII,  
No. 4, p. 63. 1881.

Planorbis gredleri var. strömi Johansen, Proc. Malac. Soc.  
London, p. 32. 1934.

**DESCRIPTION.** Shell of rather small size, greater diameter 6.4 mm. or less, somewhat discoid, slightly rounded above, more flattened above, although biconvex, depressed in the center on both sides; light horn-coloured; surface rather dull but shining, crossed by many microscopic regularly spaced transverse ridges, faint spiral lines visible on the upper side; whorls four, at first rapidly increasing in size, the last whorl with a rather rough periostracal keel at the periphery; aperture sub-circular, oblique and inclined, margin not continuous.

**GEOGRAPHICAL RANGE.** Europe, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Pond on the steppe northwest of Rojvensky, Akmolinsk area; Kulundinsk steppe, on beach of Lake Topolnoye; Tomsk area, pond near the River Ket, one hundred kilometers above the River Ob.

Planorbis (Gyraulus) borealis Lovén.

Planorbis borealis Loven in Westerlund, Malakozool.  
Blätt., XXII, p. 7 and 112. 1875.

**DESCRIPTION.** Shell of moderate size, greater diameter about 7.8 mm., colour greenish and light horn-coloured; surface nearly smooth, with minute lines of growth, but without evident spiral marking; concave above, flat below; depressed at the center on both sides; whorls about four and a quarter, regularly rounded, moderately rapidly increasing in size, the body whorl in some cases descending from the plane of the previous whorls; aperture of large size, oblique and inclined, sub-ovate, gently curving; suture deeply impressed.

**GEOGRAPHICAL RANGE.** Northern Europe, northern Asia.

**LOCAL DISTRIBUTION.** New Record. Lake Lazurnia, Khamar Daban, eastern shore of Lake Baikal.

Previous Records. Westerlund reported this species from several places on the Yenissei, as follows: Dudino (N. Lat. 69° 15'); Kolmogorowa (N. Lat. 59° 30'); Krasnogarsk (N. Lat. 56°) and Lusino (N. Lat. 68° 40'). That author also stated that it occurred in the old province of Tobolsk and in the Far Eastern (Amur) region. Lindholm (1919) listed it from thirty-one different localities in the vicinity of Obdorsk.

REMARKS. There is a specimen in the United States National Museum identified by Westerlund as Planorbis borealis var. frigidus Westerlund from "Sajan" (= Saiyan). There are also somewhat similar though not identical specimens from Popoff Island, Shumagins, Alaska, which were identified by Dall as Planorbis deflectus Say, but are not referable to that species as at present understood.

There is some doubt as to whether borealis should be given specific rank, or be treated as a variety of P. acronicus (see Odhner, 1929.)

Planorbis (Gyraulus) crista (Linné).

Nautilus crista Linnaeus, Syst. Nat., ed. X. p. 709,  
No. 234. 1758.

**DESCRIPTION.** Shell very small (greater diameter about 1.5 mm.), slightly translucent, of a faint horn-colour, which is more pronounced in the first few whorls; somewhat flattened above, rounded below; surface crossed by a great many minute, gently curved, lines of growth, and by more prominent slightly elevated parallel ridges running from the lamellae across the whorl; whorls about three, rapidly increasing in size, convex dorsally, ventral side convex for about the first whorl, then becoming more flattened; periphery of the body whorl rather sharp, but not so much so as to be keeled, with a number of comparatively large crescentic flanges projecting from it, one at the end of each of the parallel ridges mentioned above; the projections are nearly as broad as high and are concave toward the aperture; aperture semicircular in outline when viewed from the plane of the previous whorls, sub-oval when viewed at right angles to that plane; ventral margin nearly flat, ventral margin gently curved, inclined, oblique, descending from the plant of the previous whorls.

**GEOGRAPHICAL RANGE.** Europe, northern Africa, northern Asia.

**LOCAL DISTRIBUTION.** New Record. Kulindinsk Steppe, sub-fossil in one of the former beaches of Lake Topolnoye.

Previous Record. This species is listed by Johansen (1934) from the Barabinsk Steppe without a definite locality, but apart from this has not been previously reported from Siberia.

Planorbis (Spiralina) spirorbis (Linné).

Helix spirorbis Linnaeus, Syst. Nat., ed. X, p. 770,  
No. 588. 1758.

? Planorbis leucostoma Johansen (pars) Proc. Malac. Soc.  
London, p. 31. 1934.

DESCRIPTION. Shell small, greater diameter about 5.6 mm., moderately thick, light horn-coloured; surface nearly smooth, glossy, shining, lines of growth almost microscopical; whorls about five and a half, gradually increasing in size but more rapidly than in P. leucostoma, rounded, not angulated, somewhat flattened above and below but not markedly so; suture deeply impressed; aperture inclined, not oblique, in outline obliquely ovate, lip thin and sharp.

GEOGRAPHICAL RANGE. Europe; northern Africa, northern Asia.

LOCAL DISTRIBUTION. New Records. Akmolinsk area, River Nura, near Rojdestvensky, drift; six ponds on the steppe to the east of Rojdestvensky; fossil deposit (No. 1) near Rojdestvensky. Pond on the outskirts of Omsk.

Planorbis spirorbis has not been previously reported from Siberia, although it may have been erroneously recorded under other names.

HABITAT IN SIBERIA. This species is sometimes to be found in marshy habitats, but is more characteristic of temporary ponds in which it sometimes occurs in great abundance.

REMARKS. The somewhat angulated forms which sometimes occur in European series labeled "spirorbis" have not been observed in the Siberian collections.

Planorbis (Spiralina) leucostoma Millet.

Planorbis leucostoma Millet, Moll. Maine et Loire, p. 16  
1813.

Planorbis leucostomus f. major Westerlund.

? Planorbis leucostomus Johansen (pars) Proc. Malac. Soc.  
London, p. 31. 1934.

DESCRIPTION. Shell similar to that of P. spirorbis but with the shell flatter, the whorls more tightly wound and more gradually increasing in size; the aperture while moderately sharp, has the lip thickened by a relatively heavy internal rib which in many cases is white in colour.

GEOGRAPHICAL RANGE. Europe, including Iceland; northern Asia.

LOCAL DISTRIBUTION. New Records. Akmolinsk Area, River Nura, drift; two small lakes to the southwest of Rojdestvensky, fossil deposit (No. 2) near Rojdestvensky. Borovoye, and near Kotur Kulb. Flood plain of the River Irtish on the outskirts of Omsk. Teke-Celeti area, sub-fossil on the shore of Lake Teke; pond to the south of Lake Kizil-Kak; intermittent stream on the eastern shore of Lake Celeti-Denghiz. Djarla-Uli drainage basin, small lake near Novo Troetskaya; Rivers Chaganak and Chederti; flooded area between the above streams. Two ponds on the Kulundinsk Steppe south of Slavgorod. Pond ten kilometers north of Cherno Kurea. Barabinsk Steppe, River Chulim, north of

Slavgorod; Lake Sartlan. Tomsk area, drift of River Ob, forty kilometers below the mouth of the River Tom; flood plain of the River Ket, four kilometers above the River Ob (with Lymnaea truncatula); ponds near the River Ket, two hundred, and also two hundred and ninety-four kilometers above the Ob.

Previous Records. Middendorf collected this species at Barnaul and Gerstfeldt (1859) stated that it was found at Irkutsk. Westerlund does not mention this species in his original lists of Siberian molluscs, although it may appear under another name, now difficult to trace. Lindholm (1919) states that it occurs near Obdorsk, and some of the records given by Johansen (1934) may refer to this species.

REMARKS. A specimen in the collection of the United States National Museum labeled "Planorbis (Gyraulus) leucostoma Müll. forma major Westerlund," from the flats at the village Pjanovo, Angara valley (identified by Westerlund) is a shell of leucostoma somewhat smaller than the prevailing Siberian type, but larger than many specimens from Europe. Specimens from Yakutsk (Maack) in the same collection are very small, the greater diameter being 4.3 mm. in a specimen with nearly five whorls.

Planorbis (Spiralina) compressus Michaud.

Planorbis compressus Michaud, Complem. Hist. Nat. Moll.  
France, Draparnaud, p. 81, 1831.

Planorbis vortex var. compressus Westerlund, Kongl. Sv.  
Vet. Akad. Hand. Bd. 14, No. 12. 1877.

Planorbis vortex Johansen (pars), Proc. Malac. Soc. London,  
p. 31. 1934.

Planorbis vorticulus Johansen (pars) Ibid. p. 31. 1934.

DESCRIPTION. Shell of moderate size, greater diameter about 8.2 mm., discoidal, thin, horn-coloured; surface rather dull; growth lines minute and regular; little or no spiral marking; whorls about five and three-quarters, convex above and below; aperture inclined, obliquely heart-shaped; lip thin and sharp.

GEOGRAPHICAL RANGE. Europe; northern Asia.

LOCAL DISTRIBUTION. New Records. Pond on the flood plain of the River Nura, near Rojdestvensky, Akmolinsk area.  
River Zamaraika, near Omsk.

Previous Records. Westerlund reported this species from Krasnoyarsk and Tomsk. An examination of Johansen's collection shows that this species has been confused with P. vortex and P. vorticulus. This has probably been the case with the others records of these two species from Siberia as in the collections made on this expedition no shells have been found which resemble the vortex or

vorticulus of Europe. The nature of the relationship of P. compressus to P. vortex and P. johanseni is not yet understood, but these three may prove to be varieties of one single species.

Planorbis (Spiralina) johanseni Mozley.

Planorbis vortex Johansen (pars) Proc. Malac. Soc., London,  
p. 31. 1934.

Planorbis vorticulus Johansen (pars) loc. cit. p. 31.

Planorbis johanseni Mozley, Smithsonian Misc. Coll.,  
Vol. 92, No. 2, pp. 6-7.

DESCRIPTION. Shell of moderate size, greater diameter 7.5 mm., discoidal, very thin (height 1.2 mm) slightly concave above and below, closely resembling P. compressus; surface bright and shining, with many fine but distinct lines of growth; whorls five and a quarter, gradually increasing in size, carinate on the upper side; the upper side of the carina of all or nearly all the whorls being visible on the dorsal side of the shell; aperture inclined and oblique, ellipsoidal; lip sharp and thin.

TYPE LOCALITY. River Om, near Omsk. Type in the collection of the United States National Museum, No. 469658.

GEOGRAPHICAL RANGE. The Steppe, Forest-Steppe, and Taiga (forest) regions of Siberia.

LOCAL DISTRIBUTION. Akmolinsk area, ponds on flood plain of River Nura near Rojdestvensky; fossil deposits (Nos. 1 and 2) near Rojdestvensky, Borovoye, also near the village Kotur Kulb. Omsk area, ponds and marshes on flood plain of River Irtish near Omsk; Nikolaevka; Alexandrovka; River

Om near Omsk, Djarla-Uli Basin, Drift on the River Chederti. Kuleindinsk Steppe, ponds on flood plain of River Irtysh near Pavlodar. Aj-Bulat Basin, Lakes Little Topolnoye, and Travnoye. Barabinsk Steppe, River Chulim, north of Slavgorod. Tomsk pond near River Ob, 30 km., below the mouth of the River Tom.

HABITAT IN SIBERIA. The most favourable habitat for this species in Siberia is in ponds and marshes on the flood plain of the larger streams. In these situations it is often found in abundance on the under side of water lily leaves and on the submerged stems of Phragmites communis. In general, it appears to prefer, and to reach its greatest size, in the deeper ponds, although it is sometimes found in ponds frequently flooded during the freshets. Planorbis johanseni is rare in lakes, ponds and marshes situated at some considerable distance from the larger streams; it has not been found in any temporary pond, nor in any lake which is at all saline. In the two largest island basins examined, those of Djarla-Uli and Aj-Bulat, it is noteworthy that this species was found only in the upper waters, namely, in the River Chederti of the former basin, and the smaller Lake Topolnoye and Travnoye in the latter. In general this may be regarded as a species which is moderately sensitive to the conditions accompanying desiccation.

REMARKS. Planorbis johanseni is the predominant Siberian manifestation of the group of snails represented in Europe by P. vortex and P. compressus. An examination of a moderately large series of European shells, including the Jefferys' Collection, has failed to bring to light anything resembling this new species.

The following dimensions of P. johanseni may be useful to other workers.

Locality	Omsk	Kotur Kulb	Nikolaevsk
Greater Diameter	10.3 mm.	6.6 mm.	8.1 mm.
Number of Whorls	6 $\frac{1}{4}$	5	5 $\frac{1}{2}$

Planorbis (Bathyomphalus) contortus (Linné)

Helix contortus Linnaeus, Syst. Nat., ed. X, p. 770,  
No. 589. 1758,

**DESCRIPTION.** Shell small, greater diameter generally about 4.7 mm., maximum 6.0 mm., moderately thick for its size, horn-coloured, somewhat flattened above, but with a depression in the middle, deeply concave below; surface usually dull; growth lines minute, regular; little or no spiral marking; whorls 8, convex, very tightly coiled, compact, slowly increasing in size, sharply rounded below, but not angulate; aperture oblique, inclined, sub-crescentic in outline, especially in young shells, lip thin, sharp.

**GEOGRAPHICAL RANGE.** Europe, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, drift, River Nura near Rojdestvensky; fossil deposits (Nos. 1 and 4) near Rojdestvensky; Bouldi Kul; Durt Sart; Kun Gul (Kumbi Kul); ponds on the steppe southwest of Rojdestvensky. Tara area, marshes along the River Temshenyakova. Omsk area, ponds and marshes on the flood plain of the River Irtish near Omsk; River Zamaraika. Teke-Celeti area, near Lake Teke, Lake Kizil-Kak. Kulundinsk Steppe, flood plain of the River Irtish 10 km. below Pavlodar. Aj-Bulat basin, Lakes Peschanaya, Homotenoye, Travnoye. Lake Karachu. Tomsk area, drift of River Ob 40 km. above the mouth of

Ket; pond near the junction of the Rivers Ket and Eltiribi. Ulala, Altai.

Previous Records. Middendorft collected this species at Barnaul, Beresov and Irkutsk, and Gerstfeldt (1859) gives the Vilui, in addition to Irkutsk. Westerlund (1885) states that it was found by the Nordenskiöld expedition at three points on the River Yenissei, namely at Worogowa Selo (N. Lat. 60° 50'); Surgutshoye (N. Lat. 62° 50'); and Lusino (N. Lat. 68° 24'). That author also stated that it occurred in the former provinces of Tobolsk, Tomsk, Yenisseisk, and Irkutsk, as well as in the Altai and Far Eastern (Amur) regions. Johansen (1934) has collected it at Biisk, Tobolsk and Narim.

**HABITAT IN SIBERIA.** Planorbis contortus has a wide local distribution in Siberia. The most typical habitat is in small ponds both on the steppe, and in the taiga, including those ponds which are purely temporary and contain water for only two months or even less during the spring and early summer of each year. It is often to be found in the ponds and marshes on the flood plains of the larger rivers, but is not characteristic of such situations as the species mentioned above. (Lymnaea stagnalis, P. compressus, etc.). Planorbis contortus was not found in any saline body of water. It seems to be one of the species which disappear soon after the advent of saline conditions.

Genus Segmentina, Fleming 1818.

Segmentina nitida (Müller)

Planorbis nitidus Müller, Verm. Hist., II, p. 163. 1774.

**DESCRIPTION.** Shell of small size, greater diameter of largest specimen 4.9 mm., lenticular, thin, light brown or yellowish in colour; surface smooth, glossy, shining; whorls about four, flattened above, well rounded below; spire sunk below the level of the body whorl; body whorl large, expanded, periphery sharply rounded, not angulated; the interior with about three sets of large curved lamellae which are visible through the shell; aperture oblique and inclined, somewhat narrowly heart-shaped; lip sharp, thin, gently curved.

**GEOGRAPHICAL RANGE.** Europe and northern Asia.

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, four temporary ponds in the immediate vicinity of Rojdestvensky; temporary ponds 4, 5 and 24 km. east of Rojdestvensky; dry bed of a small lake 10 km. southwest of Rojdestvensky; Durt Sart. Omsk Area, small ponds and shallow marshy areas on the flood plain of the River Irtysh near Omsk; River Om near Omsk; Ponds on outskirts of Omsk. Teke-Celeti area, ponds south of Kizel Kak. Tomsk area, ponds near the River Ket, 30 and 100 km. above the Ob. Baikal area, Lake Dukovoye.

Previous Record. Segmentina nitida was collected by Siemaschko (see Middendorf (1856) at Irkutsk, but Westerland apparently regarded this record as being somewhat doubtful. It may be that records of Planorbis (Hippentis) complanatus (Linné) from Siberia are based upon this species. No specimens of complanatus were collected during this expedition.

HABITAT IN SIBERIA. In this region S. nitida is usually found in temporary ponds, although it sometimes occurs in permanent ponds, marshy areas and small lakes.

## Family ANCYLIDAE.

Genus Ancylus Geoffroy 1767.Ancylus lacustris (Linne).Patella lacustris Linnaeus, Syst. Nat., ed. X, p. 783,  
No. 672. 1758.

DESCRIPTION. Shell ovate-oblong, thin, conical, pointed, the apex pointed and inclined to the left, length about 6 mm., surface with fine regular lines of growth, lip sharp,

GEOGRAPHICAL RANGE. Europe; north Africa, northern Asia.

LOCAL DISTRIBUTION. New Records. Ponds on the flood plain of the River Nura near Rojdestvensky; fossil deposit (No.1) near Rojdestvensky. Lake Dukovoye, near the Gulf of Barguzine, Baikal area.

Previous Record. Johansen (1934) collected this species at Biisk and Tomsk.

HABITAT IN SIBERIA. The living specimens were in most cases found crawling about on the underside of water lily leaves, and on the stalks of reeds. It is noteworthy that the ponds in which A. lacustris was found are situated at some distance from the main channel of the River Nura, and so are somewhat less disturbed at times of flood than the general run of ponds on the flood plain.

## Family PHYSIDAE.

Genus Physa, Draparnaud 1801.Physa fontinalis (Linnaeus).Bulla fontinalis Linnaeus, Syst. Nat., ed. X, p. 727,  
No. 340. 1758.

**DESCRIPTION.** Shell rather small in size, usually less than 10 mm. in length, thin, fragile, surface shining, glossy, growth lines minute, crossed by regular spiral impressed lines; whorls about four and a half, all but the last very small; the body whorl rapidly increasing and of large size; suture slightly impressed; aperture elongate-ovate, length about three-quarters of the length of the shell as a whole; outer lip sharp, thin; inner lip broadly spread over the preceding whorl; columella with a distinct fold.

**GEOGRAPHICAL RANGE.** Europe, northern Asia.

**LOCAL DISTRIBUTION.** New Records. Akmolinsk area, dry bed of a small lake 10 km. southwest of Rojdestvensky; Kun Gul; Ashi Kum Kul. Kotur Kulb near Borovoye. Omsk area, River Om; marsh near station Moskalenka, Omsk Railway. Ulkum Karoi. Djarla Uli basin, River Chaganak; flooded area between the Rivers Chederti and Chaganak. Kulundinsk Steppe, pond on the flood plain of the River Irtish north of Pavlodar. Aj-Bulat basin, Lake Horoshoye; one mile east of

Ustianka. Barabinsk Steppe, Lake Karachu; River Chulim north of Slavgorod. Baikal Region, Lake Nur, Island Olkhon, Baikal.

Previous Record. Westerlund listed this species from Worogowa Selo on the Yenissei (N. Lat. 60° 50') and also stated that it was found in the old provinces of Tobolsk, Tomsk and Yenisseisk (N. Lat. 60° 50'), as well as in the Far Eastern (Amur) region. Lindholm (1919) found it in collections from Obdorsk, and Johansen (1934) collected it at Biisk, Kuznetzk, Tomsk, Narim, and Tobolsk.

HABITAT IN SIBERIA. Physa fontinalis inhabits small lakes, including drained saline lakes; ponds which contain water permanently, including some of those found on the flood plains of the large rivers, and the more stagnant streams, i.e. especially those of western Siberia. It appears to be somewhat sporadic in its local distribution, and it is almost impossible when approaching a lake or pond for the first time to predict whether or not P. fontinalis will be found there.

## Measurements of the Shells of

Physa fontinalis

from several localities in

Europe and Asia.

Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width	Locality
9.9 mm.	5.7 mm.	4.6 mm.	7.7 mm.	3.6 mm.	Tomsk, Siberia
9.6	6.2	5.3	7.4	3.7	Scarborough, England.
8.6	6.2	4.7	6.4	3.8	Cardiff, Wales.
8.6	6.1	4.8	6.7	3.4	
8.5	4.8	4.0	6.2	2.6	Lk. Horoshoye, Siberia.
8.3	5.9	4.9	6.9	3.2	nr. Lyons, France.
8.3	5.3	4.4	6.4	3.2	Scarborough
7.8	4.5	3.6	6.0	2.9	River Om, Siberia.
7.1	4.5	3.5	4.8	3.5	Kotur Kulh, Siberia
6.9	4.3	3.7	5.0	2.2	10 km.W. of Ulkun Karei, Kazakstan.

Physa sartlandinensis Mozley.

Plate 21, figure 11.

Physa sartlandinensis Mozley, Smithsonian Misc. Coll.,  
Vol. 92, No.2, p.7.

DESCRIPTION. Shell resembling that of Physa fontinalis but of larger size, length 12.6 mm.; the aperture shorter than in that species and the spire much higher and more conspicuous; the suture more deeply impressed; whorls four and three-quarters, surface smooth, lines of growth microscopic, crossed by larger, regular, impressed spiral lines. In this new species the length of the aperture is approximately two-thirds of the length of the entire shell, while in P. fontinalis it is three-quarters of the shell length.

TYPE LOCALITY. Lake Sartlan, Barabinsk Steppe, Siberia. Type in the collection of the United States National Museum, No. 469614. Known only from the type of locality.

## Measurements of the shells of

Physa sartlandinensis.

from Lake Sartlan, Siberia.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
Type	12.6 mm.	7.1 mm.	5.7 mm.	8.7 mm.	4.1 mm.
	11.4	6.2	5.2	8.0	3.4
	10.6	6.0	4.8	7.4	3.1
	10.3	5.4	4.6	6.4	2.9
	10.2	5.3	4.6	6.6	3.2
	9.7	5.3	4.6	6.4.	3.0
	9.5	4.9	4.1	5.6	2.3
	9.3	5.4	5.7	5.9	2.8
	9.2	5.7	4.4	6.0	3.2
	9.1	5.3	4.0	6.1	3.0

Genus Aplexa Fleming 1820

Aplexa hypnorum (Linnaeus).

Plate 21, figures 7-10.

Bulla hypnorum Linnaeus, Syst, Nat., ed. X, p. 727,  
No. 341. 1758.

DESCRIPTION. Shell of moderate size, length about 16 mm., largest specimen 18.8 mm., elongate, thin, brittle, surface bright and very glossy; line of growth very small, scarcely visible under low powers of the microscope, spiral marking sparse when present, minute, and irregular; extremely minute longitudinal or spiral linear marking probably present as the surface of the shell in some cases acts as a refraction grating; whorls about six, somewhat convex; spire elongate, about half the total length of the shell, or slightly less; sutures slightly impressed; aperture lanceolate-ovate, outer lip thin, sharp; inner lip spread over the preceding whorl; columella slightly twisted; no indication of umbilical chink.

GEOGRAPHICAL RANGE. Europe; northern Asia, including the Taimyr Peninsula at N. Lat.  $73^{\circ} 30'$ ; northern North America.

LOCAL DISTRIBUTION. New Record. Akmolinsk area, ponds in the vicinity of Rojdestvensky. Ponds near Omsk. Djarla Uli basin, River Chaganak; flooded area between the Rivers Chaganak and Chederti. Aj-Bulat basin, Lake Peschanaya.

Barabinsk Steppe, near Dologoorurnia; River Chulim north of Slavgorod, Tomsk area, pond near River Ket near the junction of the Rivers Ket and Eltiribi; pond near River Ket 60 km. above the River Ob.

Measurements of the Shells of  
Aplexa hypnorum  
 from pond near the junction of the  
 Rivers Ket and Eltiribi,  
 north of Tomsk Siberia.

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
1.	18.8 mm.	7.6 mm.	6.7 mm.	9.7 mm.	4.3 mm.
2.	18.5	7.4	6.6	9.0	3.7
3.	17.9	7.3	6.5	8.9	3.9
4.	17.9	7.2	6.4	8.6	4.0
5.	17.8	7.3	6.5	8.9	4.1
6.	17.8	7.1	6.6	8.7	4.3
7.	17.6	7.2	6.4	8.9	3.7
8.	17.5	7.5	6.8	8.8	3.9
9.	17.5	7.3	6.6	8.8	4.0
10.	17.5	7.0	6.3	8.4	3.6
11.	17.4	7.5	6.5	8.8	4.0
12.	17.4	7.2	6.7	8.9	3.8
13.	17.4	7.0	6.3	8.7	3.7
14.	17.3	7.4	6.5	8.9	4.2
15.	17.3	7.4	6.5	8.4	4.0
16.	17.2	7.4	6.3	8.9	4.1
17.	17.2	7.2	6.3	8.8	3.7
18.	17.1	7.3	6.7	9.1	3.8
19.	17.1	7.1	6.4	8.5	3.6
20.	17.1	7.0	6.4	8.4	3.9
21.	17.0	6.9	6.2	8.2	3.9
22.	17.0	6.8	6.3	8.3	3.6
23.	17.0	6.8	6.3	8.1	3.7
24.	17.0	6.7	6.2	8.4	3.5
25.	16.9	7.4	6.4	9.5	4.2
26.	16.8	7.0	6.5	8.7	3.6
27.	16.8	7.0	6.5	8.4	3.6
28.	16.7	7.2	6.6	8.4	3.6
29.	16.7	7.0	6.4	8.6	3.8
30.	16.7	6.9	6.2	7.5	3.5

	Length	Greater Diameter	Lesser Diameter	Aperture Length	Aperture Width
31.	16.6 mm.	7.4 mm.	6.6 mm.	8.6 mm.	4.1 mm.
32.	16.6	7.0	6.2	8.8	3.8
33.	16.6	6.7	6.3	7.8	3.7
34.	16.5	6.8	6.2	8.3	3.5
35.	16.5	6.8	6.2	8.2	3.5
36.	16.4	7.1	6.4	8.5	3.8
37.	16.4	7.0	6.4	8.2	3.6
38.	16.4	6.9	6.5	8.6	3.6
39.	16.4	6.7	6.1	8.3	3.4
40.	16.3	7.4	6.6	8.5	3.8
41.	16.1	6.6	5.8	8.4	3.4
42.	15.9	6.3	5.8	7.7	3.0
43.	15.8	6.7	5.9	8.0	3.6
44.	15.7	6.8	6.1	7.8	3.9
45.	15.7	6.8	6.0	8.0	3.8
46.	15.5	6.6	6.0	8.3	3.4
47.	15.3	6.3	5.8	7.5	3.3
48.	15.2	6.7	6.0	8.1	3.6
49.	15.1	6.6	6.7	7.8	3.6
50.	14.9	6.0	5.5	7.4	3.1

## Family PUPILLIDAE.

Genus Pupilla Leach. 1819.Pupilla muscorum (Linne)

Plate 22, figure 10.

Turbo muscorum Linnaeus, Syst. Nat., ed. X, p. 767.  
No. 568. 1758.

DESCRIPTION. Shell small, length about 3.8 mm., cylindrical, with rounded ends, brown in colour; surface crossed by fine oblique lines; whorls six and a half, convex; spire blunt; suture slightly impressed, in some cases more so than in others, the last whorl rising to the aperture, behind which there is a strong white crest; the aperture somewhat obliquely oval, well rounded, facing slightly downward, angulate at each margin, with one small tooth on the parietal wall, peristome slightly flaring and with a strong callus; umbilicus minute, barely visible to the naked eye.

GEOGRAPHICAL RANGE. Europe, including Iceland; northern Africa; northern and central Asia, south as far as Persia; northern North America, Alaska, Canada generally, southward in the Rocky Mountain region as far as Colorado, and in the eastern part of the continent to New Jersey.

LOCAL DISTRIBUTION. New Records. Teke-Celeti Region, near Lakes Teke, Ulkun-karoi, and Celeti-Denghiz. Bed of intermittent stream on eastern shore of Lake Celeti-Denghiz.

River Chederti, drift. Baikal area, 4 km. N.W. of Listvinichnoye near Kurma, in the vicinity of Sarma.

Previous Records. Middendorf reported this species from Barnaul, and Gerstfeldt added, Irkutsk, Baikal and Viluisk. Westerlund has listed it from the Tomsk region, the Altai, and the Baikal region.

REMARKS. Two old and worn specimens from the River Chederti possess two small teeth on the parietal wall of the aperture, but in the absence of fresh specimens, it is difficult to judge what is their true status. In any case, they are quite distinct from P. bidentata C. Pfeiffer. A specimen in the United States National Museum from "Lake Baikal" is labeled "V. muscorum bigranata" (Westerlund's identification), but this shell resembles the common muscorum more closely than the true Pupilla bigranata (Rossm.).

Pupilla muscorum lundströmi (Westerlund)

Pupa muscorum var. lundstromi Westerlund, Kongl. Sv. Vet.  
Akad. Hand. Bd. 14, No. 12, p. 41. 1877.

ORIGINAL DESCRIPTION. Testa ovato-cylindrica, obtusa, nitida, brunnea, laevigata; anfractus 7 convexi, sat angusti, lente accrescentes, ultimus penultimo paullulum altior sed brevior, antice valde ascendens, pone apertura intransversim (sic) anguste elevatus (non albo-callosus), deinde peristoma versus forte declivus; sutura sat profunda, ad apertura alte ascendens et stricta; apertura ovato-rotunda, intus rufa, margine exteriori supra medium parietis affixo, superne forte sed breviter arcuato, deinde regulariter curvato, margine columellari superne strictiusculo, pariete edentulo vel denticulo minimo; peristoma levissime reflexum.

GEOGRAPHICAL DISTRIBUTION. Northern Europe and Asia.

LOCAL DISTRIBUTION. New Records. River Yenissei at Dudino (N. lat. 69° 15'); Pupkovsky (N. Lat. 64° 42'); Tunguska (N. Lat. 61°) - Westerlund. Near the River Kurma, vicinity of Sarma, Baikal area.

REMARKS. I have examined specimens collected by Maack at "Lake Baikal", which were identified by Westerlund. The shell is similar to that of P. muscorum but is without the white callus behind the aperture, or at most has it very

slightly developed. In addition, the outer margin of the aperture is inserted definitely above the middle of the penultimate whorl. Westerlund, in his "Palaeartic Fauna," lists this form from the Lofoten Islands, off the coast of Norway at about N. Lat.  $68^{\circ}$ , but Luther (1901) does not include it in the fauna of Finland and Esthonia.

Family VERTIGINIDAE

Genus Vertigo Müller 1774.

(Vertigo sp.)

At least one species of Vertigo occurs in the collections from several places in Siberia but has not yet been completely identified.

## Family VALLONIIDAE

Genus Acanthinula Beck 1847Acanthinula harpa (Say).

Plate 22, figure 11.

Helix harpa Say, Longs Exped., II, p. 256. 1824.

DESCRIPTION. Shell small, length 3.4 mm., greater diameter 2.7 mm. (specimen from near Listvinichnoye, Baikal area), turbinate; brown in colour; surface dull, minutely wrinkled, crossed by small oblique ridges and also by large projecting costae which are visible to the naked eye; whorls four and one-eighth (in Baikal specimen above), convex, body whorl rounded and of large size; spire bluntly conical on a broad base; suture fairly deeply impressed; spire whorls of moderately large size; aperture ovate-circular, gently rounded, not angulated, inclined, thin, sharp, not continuous; inner lip slightly reflected over the umbilical region but leaving an umbilicus of considerable size.

GEOGRAPHICAL RANGE. Northern Europe (in part); northern Asia; North America, Alaska, Canada, part of the extreme northern United States.

LOCAL DISTRIBUTION. New Records. Tomsk area, mixed forest of poplar and pine near the River Ket, two hundred and ten kilometers above the River Ob. Baikal area several localities in the vicinity of the village of Listvinichnoye,

Lake Baikal, in a mixed forest of birch, pine and alder; eastern shore of Lake Baikal 25 km. north-east of the mouth of the River Selenga; near Lake Dukovoye, Gulf of Barguzine, Baikal. This species has been previously reported from Siberia (see Mozley, 1934).

**REMARKS.** As in North America, this species is extremely locally, and seemingly erratic in its local distribution. This doubtless accounts for the fact that it has not previously been found in Siberia. When a steady and systematic search is made for it, this species will doubtless be found living in more or less isolated colonies throughout the forested region of Northern Asia, but it is a species which often eludes the casual collector.

Genus Vallonia Risso 1826.

Vallonia costata (Müller)

Plate 22, figure 7-9.

Helix costata Müller, Verm. Hist. ii, p. 31. 1774.

**DESCRIPTION.** Shell small, greater diameter about 2.3 mm., of moderate thickness, greyish-white in colour, growth line microscopic but distinct and regular, surface crossed by numerous large, thin, oblique and projecting costae; whorls about three and a half, well rounded; spire only slightly elevated; suture deeply impressed; aperture sub-circular, inclined and oblique; lip much thickened; umbilicus broad and deep.

**GEOGRAPHICAL RANGE.** Europe; northern Africa; northern Asia; North America.

**LOCAL DISTRIBUTION.** New Records. Forest Steppe near Omsk; River Temshenyakova, Tara area (in marl). Taiga along the River Ket, north of Tomsk. Near the River Kurma, vicinity of Sarma, Baikal.

Previous Records. Gerstfeldt (1859) reported the occurrence of this species at Irkutsk. Westerlund gave the locality "Jarzowa Selo" on the Yenissei at North Latitude  $60^{\circ} 10'$ , and also reported its presence in the old provinces of Tobolsk and Yenisseisk. It is undoubtedly a widely distributed species, although somewhat localized

in any given area, and is less common than V. pulchella.

The name of the locality on the Yenissei given by Westerlund has been transliterated from the Russian characters in diverse ways, which are not always readily recognizable as referring to the same Russian name.

REMARKS. Included among the Vallonia from the forest-steppe near Omsk is a slightly thinner form which is similar to costata, but with the costae and thickening of the lip less developed. This may be the result of the specimens being somewhat immature.

Vallonia pulchella (Müller).

Helix pulchella Müller, Verm. Hist. ii, p. 30. 1774.

DESCRIPTION. Shell small, greater diameter about 2.3 mm., thickness about the average for members of this genus; surface nearly smooth, growth lines minute, regular; whorls about three and one-third, gradually increasing, the last of large size; aperture sub-circular, inclined, not markedly descending from the plane of the previous whorls; peristome abruptly everted; lip thickened; umbilicus broad and deep.

GEOGRAPHICAL RANGE. Europe; northern Africa; the Azores and Madeira; northern Asia; North America.

LOCAL DISTRIBUTION. New Records. Abandoned channel of the River Nura near Rojdestvensky, Akmolinsk area. Fossil deposits (Nos. 2 and 4) near Rojdestvensky. River Temshenyakova, Tara area (in marl). Flood plain of the River Irtysh near Omsk. Sub-fossil on the shores of Lakes Kizil-Kak and Celeti-Denghiz, south of Omsk. In the dry bed of an intermittent stream on the eastern shore of Lake Celeti-Denghiz. River Chederti, drift. Tomsk area, near the River Ob, forty kilometers below the mouth of the River Tom. River Ket, several localities between the junction with the River Ob, and "Tresto" (three hundred kilometers above the Ob).

Previous Records. This species was listed by Gerstfeldt (1859) from Irkutsk and Westerlund reported it from "Jarzowa Selo" on the Yenissei at North Latitude 60° 10'. That author also states that it is found in the provinces of Yenisseisk and Irkutsk (?) (sic), as well as in the Far Eastern (Amur) region. It was not found in the collections from Obdorsk examined by Lindholm (1919) although other species such as Gonyodiscus ruderata and Euconulus fulvus, which are sometimes associates of V. pulchella and V. costata, were included in the collections.

Vallonia tenuilabris (Braun).

Valle tenuilabris A. Braun, Deutsch Naturf. Ver. Main, 1843, p. 143.

Helix tenuilabris Westerlund, Fauna Paläarktische Region, I, p. 15. 1886.

DESCRIPTION. "Shell with umbilicus open, and rapidly widening at the aperture, depressed convex, with prominent, almost papilliform apex, with fine acute, crowded ribs, grayish horn-coloured; whorls 4-4½, somewhat convex, the last somewhat expanding in front, gradually deep descending; suture rather impressed; aperture very oblique, little crescentic, transversely oval, rounded with the margins much approximate; peristome widened, thin lipped, yellowish horn coloured, inferior margin reflexed. Size 3 : 2 ¾ - 2 mm." Translation of Westerlund's description.

This description is not altogether satisfactory so that the following description, based upon shells from the vicinity of Irkutsk which were identified by Westerlund, may be of use to other workers.

Shell small, greater diameter about 1.9 mm., thin, grayish or very light horn coloured; growth line microscopic, surface crossed by regularly placed, large, oblique ribs similar to those of V. costata but somewhat less prominent than in that species, and also a little closer together, and so slightly more numerous; whorls 3 to 3½, well rounded and rapidly increasing in size, slightly more so than in

V. costata, very sharply curved on the underside at the edge of the umbilicus; spire slightly elevated, and appearing as a rounded, button-shaped projection arising from the moderately deep suture; aperture thin, sharp, inclined, slightly deflected, roughly oval in shape, and somewhat diminished by the encroachment of the preceding whorl; umbilicus broad and deep, exhibiting all the volutions, but rather steeply sided.

GEOGRAPHICAL RANGE. Siberia; "Fossil in southern Germany," Pilsbry.

LOCAL DISTRIBUTION. New Record (based on Westerlund's shells in the United States National Museum.) Irkutsk.

Previous Records. "Jarzowa, Siberia" (=Jarzewo, on the Yenissei, N. Lat. 60° 10'); "Werschininsky, Siberia"(=?).

REMARKS. In the collection of the United States National Museum there are specimens of Vallonia asiatica Nev. identified by Möllendorf, with locality as follows: "South side of Mountains of South Kukunoz, 12500 feet. Under stones on the ground in valleys, April 13, 1884. Prejevsky coll." This is a large, minutely costate form, with a small but distinct lip and appears to be different from all the other species mentioned here. The locality is near the boundary of Mongolia with China and Tibet.

## Family COCHLICOPIDAE.

Genus Cochlicopa Ferussac 1821.Cochlicopa lubrica (Müller)Helix lubrica Müller, Verm. Hist., ii, p. 104. 1774.

DESCRIPTION. Shell small, average dimensions of Siberian shells as follows: Length 5.5 mm., greater diameter 2.5 mm. (River Ob, near mouth of the Tom); 1. 5.8 mm., g.d. 2.4 mm. (Forest-Steppe near Omsk); 1. 5.5 mm., g.d. 2.3 mm. (Ulala, Altae) cylindric-oblong, surface smooth, shining, glossy, semi-transparent, horn coloured, surface showing the lines of growth in some places; whorls about five and a half, slightly convex; spire broad, rounded at the top, approximately equal in length to the body whorl, suture moderately impressed, without any impressed spiral revolving line beneath it, although an internal sutural line can often be seen through the shell; aperture somewhat acutely pyriform, the lower part rounded in some specimens, but frequently having a slight angle at each extremity; imperforate.

GEOGRAPHICAL RANGE. Europe; northern Africa; Asia Minor; northern Asia; North America.

LOCAL DISTRIBUTION. New Records. River Temshenyakova, Tara area (in marl); birch groves of the Forest Steppe near Omsk; empty shells found on the shore of Lake Kizil Kak; Tomsk area, River Ob, 40 km. below the mouth of the River Tom. Ulala, Altai.

Previous Records. This species was collected by Middendorf at Barnaul, and Westerlund listed it from three localities along the River Yenissei situated at North Latitude  $60^{\circ} 10'$ ;  $61^{\circ}$ ; and  $62^{\circ} 50'$ . That author also states that it was found in the old provinces of Tomsk, Yenisseisk, and Irkutsk, as well as in the Altai and in the Far Eastern (Amur) regions. Lindholm (1919) does not list it from the vicinity of Obdorsk.

Family ENDODONTIDAE

Genus Punctum Morse 1864.

(Punctum pygmaeum (Draparnaud))

Helix pygmaea Draparnaud, Tabl. Moll. France, p. 93. 1801.

A species belonging to this genus was collected in several places but has not yet been satisfactorily determined, and must for the present be left under the above name.

Genus Gonyodiscus Fitzinger 1833.

Gonyodiscus angulosus Mousson

Patula ruderata var. angulosa Mousson, Jour. de Conch.,  
XXV, p. 13. 1887.

DESCRIPTION. Shell of moderate size, greater diameter up to 6.4 mm., discoidal by comparison with the other species of this genus; colour reddish brown; incremental striae large and regular, seven to nine to each millimeter of the upper side of the last whorl just behind the aperture, giving the shell a costulate appearance; whorls four to four and a quarter ("4½" -Gould). convex above and below, the last sub-angulate at the periphery, and descending from the plane of the preceding whorls; aperture subovate with a tendency toward angulation at the periphery, somewhat flattened above, convex below; umbilicus broad and deep.

GEOGRAPHICAL RANGE. Northern Asia, Siberia and the basin of the River Amur.

LOCAL DISTRIBUTION. New Records. Near the R. Ket, 105 km. above the Ob. Baikal area, several localities near Listvinichnoye; near Goloustnaya; near Lake Dukoyoye, near mouth of the River Dukovoye.

Previous Records. This species has been reported from the Amur Province.

Gonyodiscus ruderatus (Studer MS. Ferussac)

Helix ruderata Studer: Ferussac, Tabl. syst. Limacons, Jan. ed. p. 44. 1821.

DESCRIPTION. Shell of moderate size, (greater diameter 5.3 mm.), differeng from G. angulosa in having a higher spire; the whorls rounded, not angulated, and the aperture regularly curved, not flattened, or angulate. Differing from European specimens of G. ruderatus in having a more elevated spire, and narrower umbilicus. Suture deeply impressed.

REMARKS. This description applies to a single shell in the United States National Museum labeled, "Sajan, Hartung" (=Saiyan), and identified by Westerlund. It is distinct from the European ruderata but since there is only a single specimen its designation as a new subspeices would hardly be justified.

## Family ZONITIDAE.

Genus Zonitoides Lehmann 1862Zonitoides nitidus (Müller).Helix nitida Müller, Verm. Hist., II, p. 32. 1774.

DESCRIPTION. Shell of moderate size, greater diameter up to 6.2 mm. (generally 5.0 to 5.5 mm.), thin, rather dark horn coloured; surface bright, shining, with indistinct rib-like markings across the whorls, but without spiral marking; the shell as a whole convex above, but having a flattened appearance below; spire somewhat elevated, to about the same extent as in western European specimens; whorls about four and a half, slightly convex; suture moderately impressed; aperture ovate, a little compressed, very slightly descending from the general plane of the whorl just before the aperture; lip sharp, thin umbilicus moderately broad and deep.

GEOGRAPHICAL RANGE. Europe; northern Africa; northern Asia, Japan; North America.

LOCAL DISTRIBUTION. New Records. Kotur Kulb near Borovoye, Kazakstan; near River Ob, 40 km. north of the mouth of the River Tom; near River Balata, Ulala area, Altai.

Previous Records. This species was found by the "Vega" expedition on the River Yenissei at Latitude 62° 50' N.

Genus Retinella (Shuttleworth MS.) Fischer

Retinella radiatula (Alder)

Helix radiatula Alder, Trans. Nat. Hist. Northumb.  
I, p. 38. 1830.

**DESCRIPTION.** Shell of rather small size, greater diameter about 3.5 mm., sub-ovoid, surface shining, somewhat hyaline, with minute rugae which have the appearance of radiating from a center; whorls about 4, slightly flattened at the junction with the previous whorl, the last of relatively large size and well rounded; suture shallow; aperture sub-ovate, almost oval; umbilicus broad and deep.

**GEOGRAPHICAL RANGE.** Europe, northern Asia, North America.

**LOCAL DISTRIBUTION.** New Records. Several localities near the River Ket to the north of Tomsk, as far east as 288 km. above the Ob; Baikal area, near Listvinichnoye, near Goloustnoya.

Previous Records. Westerlund (1877) reported this species from Tomsk, Krasnoyarsk, and Nijni Inbatsk (N. Lat. 63° 50').

Genus Euconulus Reinhardt 1883.

Euconulus fulvus (Müller)

Helix fulva Müller, Verm. Hist., II, p. 56, 1774.

DESCRIPTION. Shell small, greater diameter about 2.7 mm., broadly conical; thin; light horn-coloured; surface minutely costulate, glossy, shining; whorls  $5\frac{1}{2}$  or less, convex, gradually increasing in size; suture somewhat impressed; aperture subovate; minutely perforate.

GEOGRAPHICAL RANGE. Europe, including Iceland; North America, including Greenland; northern Asia.

LOCAL DISTRIBUTION. New Records. Frequent in mixed forests along the River Ket, north of Tomsk; Baikal area, near Listvinichnoye, also near the Bay Babuska.

Previous Records. Gerstfeldt (1859) reported this species from Irkutsk, and Westerlund (1877) noted its presence in a number of different localities on the River Yenissei, viz. Dudino (N. Lat.  $69^{\circ} 15'$ ); Werschinsky (N. Lat.  $68^{\circ} 55'$ ), Baklanowski (N. Lat.  $64^{\circ} 25'$ ), Pupkowsky (N. Lat.  $64^{\circ} 42'$ ), Nijni Inbatsk (N. Lat.  $63^{\circ} 50'$ ), Aniskoj (N. Lat.  $63^{\circ} 30'$ ), Worogowa (N. Lat.  $60^{\circ} 55'$ ), 6 mil. (= 60 km.) South of Podk. Tunguska N. Lat.  $61^{\circ}$ , Intsarewo (N. Lat.  $60^{\circ} 55'$ ), Krasnoyarsk (N. Lat.  $56^{\circ}$ ), Lindholm (1919) has reported it from the Obdorsk region.

## Family VITRINIDAE.

Genus Vitrina Draparnaud 1801.(Vitrina sp.)

A species of Vitrina was found to be fairly common in the forested region of Siberia, and has been examined in conjunction with collections from Kamchatka and Alaska in the United States National Museum, but the species have not yet been satisfactorily determined.

## Family LIMACIDAE

Genus Agriolimax Mörch 1865(Agriolimax sp.)

A species belonging to this genus has been collected but not identified.

## Family EULOTIDAE

Genus Eulota Hartmann 1842.Eulota schrenkii (Middendorf)

Plate 22, figures 3-6.

Helix schrenkii Middendorf, Reise in den Russ. Norden und Osten Sibiriens, Bd. II, Th. I, p. 302, St. Petersburg, 1847 (February 1848).

DESCRIPTION. Shell of rather large size, greater diameter up to 18.5 mm. (23 mm., Schrenk), thin, light brown in colour, white in old specimens, with a single revolving chestnut coloured band just above the suture and near the distal part of the body whorl; whorls about six, rather narrowly convex, the last not descending and markedly less inflated than in E. fruticum Müll; umbilicus narrower than in that species; aperture sub-elliptical, but diminished by the intrusion of the preceding whorl, lip thin and sharp, extremities not approaching.

GEOGRAPHICAL RANGE. Siberia, Russia in Europe. As far north as the mouth of the River Yenissei.

LOCAL DISTRIBUTION. New records. Near River Ket 230 km. above the Ob; Altai Region, near the Rivers Maima, and Balta, and also on the mountains near the Chemansky Track, Ulala area. Zaisky Peregza, 30 km. from Ust Talmins Kaya. Near the village Cherni Anui, Biisk area. Baikal Region,

near Listvinichnoye; small valley tributary to the River Goloustnaya, 8 km. east of Lake Baikal; Peschanaya Bay, western shore of Baikal; shore of Lake Nur, Island Olkhan, Baikal; in the Mountains Khamar Daban, 23 versts above Veedrina, eastern shore of Baikal.

Previous Records. Middendorf has reported this species from the River Tunguska, Barnaul, Irkutsk, and Transbaikalia, and Westerlund states that it occurs near Krasnoyarsk. Schmidt (1772) found it at "Dudino" on the Yenissei, N. Lat. 66°. It is also reported to occur in Yakutia.

HABITAT. The distribution of this species is somewhat localized, and as a rule it is not particularly abundant in any one locality. It seems to prefer mixed forests of conifers with a few birch and alder, in which situations there is often a rather meagre undergrowth of grasses and herbs. It also occurs in some places under pure stands of Populus tremula.

REMARKS. In addition to the new localities noted above, specimens have been examined from "Nishujaja, River Tunguska, up stream from Troinsky", and the River Amur. These specimens (identified by Westerlund) are in the collection of the United States National Museum.

Specimens collected in a moist poplar forest on the River Ket, 230 kilometers above the River Ob as well as

several from the Altai, resemble E. fruticum (Müll) rather than E. schrenkii, at least as far as shell characters are concerned, but are definitely smaller than European specimens of E. fruticum (Müll).

Eulota nordenskiöldi (Westerlund)

Plate 22, figures 1-2.

Helix nordenskiöldi Westerlund, Sib. Land- och Sötvatten-  
Moll. p. 32. 1877.

DESCRIPTION. Shell of rather small size, greater diameter up to 14.3 mm. (14 mm., Westerlund), yellowish brown in colour, surface bright and shining, not smooth but minutely costulate, the little ribs being closely crowded, regular, and slightly oblique, they are visible individually to the naked eye; some specimens (less than 5% of the collection) are rather sparsely covered with short hairs; there is a revolving white line just below the distal part of the whorl, which in most specimens coincides with the position of the suture; whorls about six, convex, spire only slightly elevated, the last whorl not descending in front; periphery subangulate, especially in young shells; aperture forming an oblique obscure crescent; lip thin and sharp; rather widely umbilicate.

GEOGRAPHICAL RANGE. Siberia, the Altai, and Yenissei regions north to Latitude  $68^{\circ} 5'$  (Chantajskoj Westerlund Chantaiskoye )

LOCAL DISTRIBUTION. New Records. Altai Region, Ulala, near the Rivers Maima, Balta, Banan and Oblin.

Previous Records. Westerlund records this species from Tunguska (N. Lat.  $61^{\circ}$ ), Krasnoyarsk and Tomsk. Schrenk states that it occurs along the Amur, but I have seen no specimens from that part of the country.

## Family HELICIDAE

Genus Fruticicola Held 1837.Fruticicola bicallosa Frivaldsky.

Helix bicallosa Frivaldsky mss. Pfeiffer, Monog. Hel.  
Suppl. p. 638 (See Pfeiffer, 1853,  
p. 189).

DESCRIPTION. Shell of moderate or rather small size, length about 6 mm. or slightly more, greater diameter 7.0 mm., broadly conical with the sides of the spire somewhat convex; dark horn-coloured; surface bright with small, indistinct transverse ridges; whorls seven to seven and a half, convex, very slowly increasing in size, the last subangulate and with a broad white band on the periphery; aperture semi-ovate in outline with two ridge-like teeth in the interior, the distal one being more than twice the size of the proximal, the baso-proximal part of the lip slightly reflected; umbilicus minute.

GEOGRAPHICAL RANGE. Siberia.

LOCAL DISTRIBUTION. New Records. Near the Rivers Maima and Balta, Ulala area, Altai.

Previous Records. It appears that the only other known locality of this species is at Buchtarminsk, Altai.

REMARKS. Specimens collected somewhat further to the east, near Lake Baikal, do not conform exactly with the description given, but as the museum collections at hand contain very little material for comparison, it seems to be better for the present not to describe them as new.

## Family SUCCINEIDAE

Genus Succinea Draparnaud, 1801.Succinea pfeifferi Rossmässler.

Plate 22, figure 12.

Succinea pfeifferi Rossmassler, Icon. I, p. 92. 1835.

DESCRIPTION. Shell of large size, length up to 19.6 mm.; elongated and slender; horn-coloured; surface appearing nearly smooth to the naked eye, and rather coarsely ribbed under the low power of the microscope; whorls about three and a half, and a half, slightly convex, rapidly increasing in size, spire somewhat produced and relatively slender; aperture of very large size, rounded below, rising to an acute angle.

GEOGRAPHICAL RANGE. Europe including Iceland; northern Africa; northern Asia.

LOCAL DISTRIBUTION. New Records. Akmolinsk area, near ponds on the flood plain of the River Nura, near Rojdestvensky; drift, in the same stream; fossil deposits (Nos. 1 and 2) near Rojdestvensky; Buldi Kul; near Zum Gul. Kotur Kulb and Borovoye. In the marshes on the flood plain of the River Irtish near Rojdestvensky; Nikolavesk; marsh near station Moskalenka, Omsk Railway; near River Om in the vicinity of Omsk. Near the River Temshenyakova, Tara area. Teke-Celeti area, sub-fossil on the shore of Lake

Ulkum, Karoi; dry bed of an intermittent stream on the eastern shore of Lake Celeti-Denghiz. Djarala-Uli basin, near the Rivers Chaganak and Cherderti, flooded area between the above two streams. Near ponds on the flood plain of the River Irtish, below Pavlodar. Aj-Bulat basin, near the Lakes Peschanaya, Homotenoye, Little Topolnoye and Travnoye. Also in marshy area two kilometers above the village Ustianka. Barabinsk Steppe, near Dologozurnia, near the River Kargat in the vicinity of Nijni-Kargat. Tomsk area, near the River Ket at points situated ten, forty, two hundred and two hundred and ninety-four kilometers above the River Ob. Near Ulala. Altai.

Previous Records. Middendorf reported this species from Irkutsk, Barnaul, Kirensk and Beresov, and Westerland added the locality Nijni Inbatsk (N. Lat.  $63^{\circ} 50'$ ) on the Yenissei. Lindholm (1919) reported it from the vicinity of Obdorsk, and Johansen (1934) found it at Biisk, Kusnetzk, and Tomsk.

**HABITAT.** Usually in the immediate vicinity of lakes, ponds or streams.

Succinea putris (Linne')

Plate 22, figure 13.

Helix putris Linnaeus, Syst. Nat., ed. X, p. 774,  
No. 614. 1758.

DESCRIPTION. Shell of large size but usually smaller than in S. pfeifferi, length up to 19.0 mm., horn- or amber-coloured, finely striated, surface glossy and shining; whorls about three and a half, rapidly increasing, and of large size, the last considerably swollen; spire short and pointed; aperture sub-ovate, broadly rounded below, rising to an angle much less acute than in the preceding species.

GEOGRAPHICAL RANGE. Europe; northern Asia.

LOCAL DISTRIBUTION. New Records. Borovoye; near the River Irtisch, ten kilometers below Pavlodar; near the River Ob, forty kilometers below the mouth of the River Tom; near the town Spolokh and also near Berusinsky Zavod, Taishet district; near the Rivers Maima and Balka, Ulala area, Altai. Two localities near Listvinichnoye; near Lake Dukovoye, Baikal area.

Previous Records. Middendorf listed this species from Irkutsk, Barnaul, Kirensk, and Beresov, Westerlund added the following localities on the Yenissei: Potapowsky (N. Lat. 68° 25'); Lusino (N. Lat. 68° 40'); Briokowsky (N. Lat. 70° 39'); Tunguska (N. Lat. 61°); Baklanowsky

(N. Lat. 64° 25'). That author also stated that it was found in the former provinces of Tobolsk, Tomsk, Yenisseisk and Irkutsk, as well as in the Altai and Far Eastern (Amur) regions. Lindholm (1919) reported it from the Obdorsk region and Johansen (1934) found it near Tomsk.

HABITAT. In moist places generally, except in the steppe region, where it is rare.

Class Pelecypoda

## Order Eulamellibranchia.

## Family UNIONIDAE.

Of the family Unioniidae only two species, Anodonta cygnea and A. anatina, are described in this report. There is no doubt that other members of this family occur in Siberia, in fact a species of the genus Unio was collected in the River Tom during this expedition, but, unfortunately, the specimens were stolen by some hungry native while they were being brought out of Tomsk. As no specimens are on hand, they are not included in this paper, but it may be well to point out that species of this genus do occur in the region at the present time. Records of several species of Unio have appeared in publications by other authors, and will be discussed in a later paper, as only species of which actual shells have been examined are included in this report.

Genus Anodonta Lamarck, 1799.

Anodonta cygnea (Linné).

Mytilus cygneus Linnaeus, Syst. Nat., ed. X, p. 706,  
No. 218. 1758.

Anodonta piscinalis (pars), Nilsson, Hist. Moll. Svec.,  
p. 116. 1822 (1823).

DESCRIPTION. Shell of moderate size, length up to 65 mm., usually about 70 mm., elongate, thin, only slightly swollen (breadth 23.4 mm. in a pair of valves 85.2 mm. in length); colour yellowish or light brown; outer surface of the shell smooth and glossy, but with small wrinkles about the growth lines; umbo above the middle of the anterior half of the shell; beak sculpture consisting of about nine small concentric wrinkles, usually fairly regular; the dorsal part of the shell usually quite straight for 20 mm. or slightly more; the interior of the shell light blue in colour, and irridescent; muscle scars very indistinct; the anterior adductor muscle scar not very closely approaching the anterior margin of the shell; the posterior adductor muscle scar somewhat bluntly arrow-shaped, with the long narrow scar of the posterior retractor pedis muscle projecting upward from it; protractor pedis scar elongated or crescentic in shape.

GEOGRAPHICAL RANGE. Europe; northern Asia.

LOCAL DISTRIBUTION. New Records. Lake Mai Balik, south-east of Akmolinsk; ponds on the flooded plain of the River Nura, near Rojdestvensky; River Om, near Omsk; Lakes Khoro-shoye, Peschanaya and Travnoye, Aj-Bulat basin.

Anodonta anatina (Linné)

Mytilus anatinus Linnaeus, Syst. Nat., ed. X, p. 706.  
No. 219. 1758.

Anodonta piscinalis Nilsson (pars), Hist. Moll. Svec.,  
p. 116. 1822 (1823).

DESCRIPTION. Shell similar in a general way to that of Anodonta cygnea, but in the specimens to hand tending to be a little larger (length up to 90 mm., and commonly about 75 mm.) and also a little broader (breadth 29.6 mm. in a pair of valves 88.7 mm. in length); colour often darker than in A. cygnea, varying from horn-coloured to brown; surface a little more rough than in A. cygnea; umbo situated a little nearer the middle of the upper margin of the shell than in that species; the beak sculpture consisting of nine, more or less concentric, small, slightly irregular wavy ridges; the interior of the shell similar to that of A. cygnea but a little darker in colour; the dorsal part of the shell gently curving, and the shell increasing in thickness towards the edges; muscle scars

moderately distinct, markedly so in some cases; the anterior adductor muscle scar situated close to the anterior edge of the shell; the posterior adductor muscle scar rounded in shape, with the scar of the posterior retractor pedis muscle short, and usually broader than long; the scar of the protractor pedis muscle of irregular shape, sub-triangular or quadrangular, not approaching the crescentic form.

GEOGRAPHICAL RANGE. Europe; northern Asia.

LOCAL DISTRIBUTION. New Records. Ponds on the flood plain of the River Nura, near Rojdestvensky; River Om, near Omsk; sidewater of River Irtish, north of Pavlodar; Lakes Khoroshoye and Travnoye, Aj-Bulat basin; River Chulim, north of Slavgorod; River Kargat, near Nijni Kargat; River Barguzine, four kilometers above Ust Barguzine, Baikal area.

## Family SPHAERIIDAE.

Genus Sphaerium Scopoli, 1777.Sphaerium corneum (Linne)Tellina cornea Linnaeus, Syst. Nat., ed. X, p. 678,  
No. 57. 1758.

DESCRIPTION. Shell of rather small size, length up to 12 mm.; sub-orbicular in shape, nearly equilateral, but not absolutely so; moderately thick; colour yellowish, gray or brown; surface glossy and shining, crossed by many coarse lines of growth; ligament very small; the interior light blue in colour; cardinal teeth minute but distinct, one in the right valve, two in the left, in general a little stronger in Siberian shells than in those from Europe; lateral teeth short and strong, two in the left valve, four in the right valve, sub-triangular in shape, especially in the left valve; muscle scars faint.

GEOGRAPHICAL RANGE. Europe; northern Asia,

LOCAL DISTRIBUTION. New Records. River Nura near Rojdestvensky, also in an abandoned channel of the same stream; fossil deposits (Nos. 1, 2 and 4) near Rojdestvensky. Borovoye; Kotur Kulb. River Anambinskaya, Tara area. Side channel River Irtish, two kilometers above Pavlodar. Nikolaevka, and the Rivers Zamaraika and Om near Omsk. Pond near the River Ket, ten kilometers above the Ob, north of Tomsk

HABITAT. In lakes and streams, usually in clean fresh water, never in saline lakes or temporary ponds.

Genus Musculium Link 1907Musculium lacustre (Müller)

Tellina lacustris Müller, Verm. Hist., II, p. 204. 1774.

DESCRIPTION. Shell of moderate size, length up to 8.8 mm., very thin, shape rhombic-orbicular, not equilateral; surface glossy, shining, apparently smooth but evidently minutely striate since it is sometimes irridescent; the valves somewhat compressed; nearly the whole of the periphery gently, though not regularly rounded; beaks central, long and prominent, broadly spaced, calyculate; hinge thin, lateral teeth strong but delivate in form and gently curved; cardinal teeth minute, nearly straight; cavity of the beaks moderately deep.

GEOGRAPHICAL RANGE. Europe; northern Africa; northern Asia.

LOCAL DISTRIBUTION. New Records. Six temporary ponds near Rojdestvensky, Akmolinsk area; River Om, near Omsk; pond 6 km. south of Lake Ulkun Karoi; dry lake 10 km. west of Ulkum Karoi; two woodland temporary ponds in the taiga near the River Ket, north of Tomsk.

Previous Records. Middendorf found this species at Barnaul, Beresov and Kirensk and Gerstfeldt (1859) added the localities of Tomsk, Vilui and Luncha. Schmidt collected it at Turukhansk on the Yenissei at North Latitude 66°. Westerlund gave the locality Jarzowa Selo on the same stream,

in North Latitude  $60^{\circ} 10'$ , but referred the specimens to the variety septentrionalis Clessin. Westerlund also stated that it was found in the old provinces of Tobolsk, Tomsk, Yenisseisk, and Irkutsk, as well as in the Altai, Yakutia, and the Far Eastern (Amur) region. Johansen (1934) has recently reported it from the Barabinsk steppe, but did not give the precise locality.

**HABITAT.** Musculium lacustre is found in lakes, streams and ponds, but is especially characteristic of small ponds which contain water for only a short period in each year. Jeffreys (1862, p. 13) says of this species, "I have found it alive in the hardened mud of a pond which had been drained and its bed so completely dried up by the sun as scarcely to show the marks of any footsteps on it."

Genus Pisidium C. Pfeiffer 1821.

The small bivalves of the genus Pisidium have long been known to be a group of great diversity and complexity, and the true status of many of the variant forms is far from being understood, even at the present time. With certain exceptions, the writer does not consider himself to be competent to give a critical review of the Pisidia collected on this expedition, and it is probable that nearly all of the previous work on the Siberian members of this genus

contains a large proportion of "paper names" which, considering the variation that exists in this group, can never have very much significance. Nevertheless, a part of the Siberian fauna has been recently revised by Woodward (1913), an ~~undoubted~~ authority on the group, in the course of other work. This author's critical remarks on the Siberian fauna, however, are hidden away in somewhat obscure corners of his Catalogue of the British species and do not appear to have come to the attention of many of the workers in the general field. In addition to this, a very important zoo-geographical fact has been overlooked even in the work of Woodward. This pertains to the so-called "Baikal" *Pisidium* fauna. A considerable number of specimens of this genus have been found in the neighbourhood of Lake Baikal (see Lindholm 1909) and either the collectors or the specialists who elaborated the material have fallen into error in giving the localith as "Lake Baikal". If such statements were to be accepted, it would appear that Lake Baikal possesses a typically Sub-Arctic *Pisidium* fauna. This is not necessarily the case, since although *Pisidia* do occur in the Baikal proper, they have as yet been very little studied. The Sub-Arctic species already referred to are found for the most part in certain shallow-water areas adjacent to the Lake Baikal but faunistically utterly distinct from it. The true endemic Baikal fauna is quite distinct from the shallow-water Sub-Arctic fauna, which is

to be found in certain more or less isolated localities adjacent to the Baikal but not part of it, and on the whole there is surprisingly little overlapping of the faunas. In view of all this, it appears that a resume of whatever reliable information is available, presented in such a manner as to bring out certain zoogeographical facts which have been neglected, or buried, hitherto, would be worthy of inclusion in this paper even though many of the observations are not original.

Pisidium amnicum (Müller)

Tellina amnicum Müller, Verm. Hist., ii, p. 205. 1774.

Pisidium baicalense Dybowski Nachrichtbl. Deutsch. Malak. Ges., XXXIV. p. 93. 1902.

Pisidium subkilestriatum Lindholm, in Korotneff, Wissensch. Ergebn. Zool. Exped. nach Baikal-See, IV, p. 84. 1909.

DESCRIPTION. Shell of very large size for members of this genus (dimensions of average Siberian specimen, length 10 mm., height 7.4 mm., breadth 6.0 mm.); sub-triangular in shape, rounded at the base of the triangle, rising a moderately acute apex, but with the umbo rounded; somewhat swollen, moderately thick; surface light to dark brown in colour, glossy and crossed by heavy lines of growth; anterior end somewhat abruptly rounded; posterior end produced.

The hinge in Siberian specimens agrees fairly well with the description given by Woodward (1913 pp. 17-18).

**GEOGRAPHICAL RANGE.** Europe, Great Britain generally, Ireland, (Pliocene to Recent). Europe as far south as Italy, North Africa?; northern Asia.

**LOCAL DISTRIBUTION.** New Records. Rivers Irtysh and Om, near Omsk.

Previous Records. Specimens from Tomsk (Johansen Coll.) have been examined. This author also records it from Biisk and Narim. Westerlund also reported its presence in the Tomsk Province, but not elsewhere, though it probably occurs.

Dybovski's records of "P. baicalense" are from the Rivers Selenga, Snejnoya and "Palawinnaja" (=?). The specimens from the Snejnoya probably come from the lower part of the stream near Lake Baikal. Lindholm's specimens came from Possolsky Sor nor far from the mouth of the Selenga, which, while situated close to Lake Baikal, contains a Sub-Arctic rather than a Baikal fauna.

Pisidium astartoides Sandberger

Pisidium antiquum, Martens, Zeitschr. Deutsch. Geol. Ges.  
XVI, p. 349. 1864 (Non Braun 1851).

Pisidium astartoides, Sandberger, Palaeontographica. N.F.  
VII, p. 96. 1880.

GEOGRAPHICAL RANGE. Pleistocene deposits in the southeast of England, Denmark, and Germany; Upper Pliocene (Cromerian) in Suffolk; and both upper and lower Pliocene in Norfolk.

LOCAL DISTRIBUTION. Deposits (age?) on the bank of the River Irtysh near Omsk (von Martens).

Pisidium casertanum (Poli).

Cardium casertanum Poli Test. utr. Siciliae, i, ord. II,  
p. 65. 1791.

Pisidium nordenskioli Clessin, in Westerlund, Nachrichtsbl.  
Deutsch. Malak. Ges. viii, p. 103. 1876.

Pisidium sibiricum Clessin, ibid. p. 103. 1876.

Pisidium boreale Clessin, ibid. p. 103. 1876.

Pisidium maculatum Dybowski. Nach. Deutsch. Malak. Ges.  
XXXIV, p. 94. 1902.

Pisidium trigonides Dybowski, ibid. p. 95. 1902.

Pisidium dubium Lindholm, in Korotneff. Wissensch Ergeb.  
Zool. Expo. Baikal-See iv, p. 85. 1909.

GEOGRAPHICAL RANGE. England, Wales, Scotland and Ireland (upper Pliocene to Recent), Iceland, Lappland. Northern Asia.

LOCAL DISTRIBUTION. River Yenissei at Worogowa (N. Lat. 60° 50'); Surgutskoj (N. Lat. 62° 50'); and Dudino (N. Lat. 69° 15'). -Glessin. Lake Baikal, 20-60 meters - Dybovsky. Near Possolsk, Baikal area, Lindholm.

Pisidium nitidum Jenyns.

Pisidium nitidum Jenyns, Trans. Camb. Phil. Soc. iv, p. 304. 1832.

Pisidium granum Lindholm, in Korotneff, Wissensch. Ergebn. Zool. Exped. Baikal-See. IV, p. 87. 1909.

GEOGRAPHICAL RANGE. Europe, England, Wales, Southern Scotland. Ireland (Upper Pliocene to Recent). Scandinavia. France, Italy, Transylvania, Russia in Europe. Northern Asia.

LOCAL DISTRIBUTION. Waters near Lake Baikal.

Pisidium subtruncatum Malm

Pisidium subtruncatum Malm. Götheborgs K. Vet. & Vitt. Samh. Handl. iii, p. 92. 1855.

GEOGRAPHICAL RANGE. Europe, England, Wales, Scotland and Ireland (Upper Pliocene to Recent). Scandinavia, France, Transylvania, Russia in Europe, Northern Asia.

LOCAL DISTRIBUTION. "Lake Baikal", Woodward. These specimens probably came from one of the waters adjacent to Lake Baikal.

Pisidium henslowanum (Sheppard)

Tellina henslowana Leach MS. Sheppard Trans. Linn. Soc.  
XIV, p. 150. 1825.

GEOGRAPHICAL RANGE. Europe, England, Wales and Ireland.  
(Upper Pliocene to Recent). Scandinavia, France and Ger-  
many. Russia in Europe. Northern Asia.

LOCAL DISTRIBUTION. "Lake Baikal", Woodward. As in the  
other similar cases, it is likely that the specimens came  
from some body of water near the Baikal rather than from  
the lake itself.

Pisidium supinum A. Schmidt.

Pisidium supinum Schmidt, Leitschr. f. Malakozool. VII,  
p. 119. 1850.

GEOGRAPHICAL RANGE. Europe, England (Lower Pliocene to  
Recent). France, Germany, Scandinavia. Russia in Europe.  
Northern Asia.

LOCAL DISTRIBUTION. Lake Baikal (60 fath.) -Woodward.

Pisidium parvulum Clessin

Pisidium parvulum Clessin in Westerlund Fauna Moll. Svec.  
Norv. et Daniae, p. 553. 1873.

GEOGRAPHICAL RANGE. Sweden, Denmark, Northern Asia.

LOCAL DISTRIBUTION. "Lake Baikal," Woodward. Probably from some habitat near the Baikal.

Pisidium steenbuchii (Möller)

Cyclas steenbuchii Möller, Index Moll. Groenlandiae, p. 20, 1842.

Pisidium korotnevi Lindholm, in Korotneff, Wissensch. Ergebn. Zool. Exped. Baikal-See. iv, p. 85. 1909.

GEOGRAPHICAL RANGE. Greenland and Iceland. Europe, parts of England and Ireland (Recent only). Scandinavia, Germany. Northern Asia.

LOCAL DISTRIBUTION. "R. Schrachutschia, Eastern Siberia.... and from Lake Baikal," Woodward. Kobylja Golowa (=?); Listwenitschenoje (=Listvenichnoye) Dredge, Lindholm.

The first locality given by Lindholm is not known to me, but it may be that the local geographical names have changed somewhat in the past thirty years. There is a "Horses Head" situated at the south end of the Island Olkhon, in a situation in which one might expect to find Pisidium, there is also a point known as the "Head of the Czar Alexander" at the north end of Olkhon, but this is a typical Baikal habitat. It is not certain from what locality came the specimens examined by Woodward, but if they were from Listvinichnoye there is no doubt of their inhabiting a true, though not extreme, Baikal type of habitat. That the specimens examined by Woodward actually did come from this

locality, however, it is not by any means certain.

Pisidium lilljeborgii Clessin

Pisidium lilljeborgii Clessin in Esmark & Hoyer, Malak.  
Blatt. N. F. VIII, p. 119. 1886.

Pisidium nordenskiöldi var. semenkevitschi Lindholm in  
Korotneff. Wissensch. Ergebn. Zool.  
Exped. Baikal-See, IV, p. 86. 1909.

GEOGRAPHICAL RANGE. Europe. Iceland; Great Britain and Ireland generally in restricted localities. Shetland Islands (Upper Pliocene to Recent); Scandinavia; Switzerland; northern Asia.

LOCAL DISTRIBUTION. Angarsky Sor, and Bogutschanskaya Bay near Lake Baikal. Lindholm.

THE LOCAL AND GEOGRAPHICAL DISTRIBUTION OF  
NORTHERN ASIATIC MOLLUSCA.

The fresh water and terrestrial mollusca of the Sub-Arctic Region are eminently fitted for distributional studies, both within closely delimited localities and over broad geographical areas, because of their wide range of occurrence, specificity of habitat, sensitiveness to external conditions, presence in large numbers of individuals, and tendency towards variation. The shells of these molluscs are in themselves a record of the growth-history of the individuals, and are readily measured. In addition, their small size and relative ease of capture are factors of importance on an extended expedition through wild country.

As has been mentioned in the introduction, this work on the Siberian fauna forms a part of a general study of the molluscs of the Sub-Arctic Region and the principal geographical and evolutionary conclusions must await the completion of the work now in progress in North America and Europe. The present account is concerned more with the facts of distribution, but nevertheless certain general tendencies in the fauna stand out clearly and are stated below.

From the standpoint of phylogeny, the molluscs which inhabit Siberia are drawn from a wide variety of sources, and in a sense the fauna can be said to be made up of especially hardy representatives of most of the different

groups of fresh water and terrestrial molluscs which inhabit the more favourable parts of the Palaearctic Region. As regards local distribution the situation is similarly diverse, these molluscs being found in a wide range of different freshwater and terrestrial habitats. In general however there is a high degree of specificity in the habitat requirements of each of the species.

In the following account the distribution of the mollusca is discussed from four points of view, namely:

- (1) The types of habitat available for settlement by molluscs.
- (2) Typical (or representative) molluscan habitats
- (3) The geographical affinities of the fauna and the faunal regions.

## TYPES OF AQUATIC HABITATS IN NORTHERN ASIA.

From the standpoint of the fauna in addition to general geographical conditions, the aquatic situations of Siberia and northern Kazakstan may be most conveniently treated under the seven headings listed below:

- (a) Temporary ponds
- (b) Permanent ponds, small and shallow freshwater lakes
- (c) Large lakes having outlet streams
- (d) Lakes without a direct outlet stream
- (e) Intermittent streams
- (f) Permanent Streams of the forest and steppe regions
- (g) Streams of the mountainous region

It is worthy of note that the three types of streams probably have more in common, as far as life conditions are concerned, with the first three types of still-water habitats respectively than they have with one another. Thus the intermittent streams are closely akin to the temporary ponds, and in certain cases these two types merge into one another. Likewise there is a similarity between the more sluggish permanent streams with their side and back waters and the small and shallow lakes; while in certain respects the mountain streams somewhat resemble the larger fresh water lakes.

Each of these types may now be described in greater detail, but before doing so it may be mentioned that the mollusca in many cases form useful indices of preceding



Plate 1, fig. 1. A temporary pond on the steppe near Rojdestvensky.



Plate 1, fig. 2. A temporary pond in the taiga (forested region) north of Tomsk.

conditions, and while they must be taken in conjunction with geographical factors, the resulting bio-geographical classification of habitats has reality in nature in so far as it marks clear cut stages in the development of the landscape.

(a) Temporary Ponds.

Natural ponds which contain water for only a short time, either periodically or at irregular intervals, occur quite commonly in the region examined in the course of this expedition. From the standpoint of their mode of formation three fairly well-marked types are met with namely :

Temporary ponds formed by rain.

Temporary ponds formed by the overflowing of streams.

Temporary ponds formed in spring by the melting of the snow which accumulates during the winter.

The first two of these are of relatively little significance in the present connection. Ponds formed during rainstorms are usually of such an ephemeral nature that the majority of aquatic organisms are unable to exist in them. A few cyclops and algae are all that occur in such ponds and quite often they are barren. The short period of the aquatic phase and the irregularity of its occurrence together with the recurrent prolonged droughts preclude the existence of aquatic molluscs in such ponds in Siberia and Kazakstan. With this type of pond belong those which result from isolated occasional snow flurries and snowstorms,

especially those which occur just before the onset of winter. Temporary ponds formed by the overflowing of rivers are also of little importance in Siberia from the standpoint of the mollusca. The tremendous flow of water through them in times of flood and their short duration afterwards precludes development of a permanently resident mollusc fauna, and with the exception of a few doomed stragglers they do not occur in these situations.

Temporary ponds formed in the spring by the melting of the snow accumulated during the winter, by reason of their regularity of occurrence and persistence for a reasonably long period each year, often support a varied and abundant fauna. Such ponds are formed during the month of April and contain water for a month or more, but as a rule all of them are dry by the beginning of June, and remain so for the rest of the year. They are characterized, therefore, by having a relatively short period of submersion followed by progressively drier conditions, and in addition are subject to low temperature during the winter.

The most characteristic of the animals found in ponds of this type are phyllopod crustacea of the genera Branchi-pus and Apus, but several species of molluscs occur quite commonly. These are the following: Lymnaea palustris Planorbis leucostoma, Segmentina nitida, and Aplexa hypnorum. It is interesting to find that these species are able to withstand the rigorous conditions of existence in habitats of this sort, in which following the drying of the pond,

they are subjected to severe desiccation and high temperature for several months, and subsequently are exposed to very low temperature during the winter.

(b) Permanent Ponds and Small Lakes.

Over the greater part of the forest and steppe regions of Siberia the larger permanent ponds are practically indistinguishable from small lakes. They are therefore treated together. They may be divided into two types on the basis of their topographical situation, as to whether or not they are situated in the immediate vicinity of large streams. The ponds or small lakes situated on the flood plains of rivers are especially numerous and important from the standpoint of the mollusca. As a rule they are small and relatively shallow bodies of water which are formed as a result of the meandering of the stream. During the early spring they are often subject to severe flooding, but at that period the life in them is dormant and as they lie at or near the level of the ground water, they contain water throughout the summer. In comparison with the temporary ponds, therefore, the conditions of life are favourable. Ponds of this type frequently support an abundant growth of aquatic plants, especially species of Potamogeton and Utricularia. In some of the deeper ponds there are water lilies (Nymphaea spp.) while the more shallow bodies of water, where they are situated slightly off the main course of the spring freshet, tend to become filled by marsh



Plate 2, fig. 1. A permanent pond near the River Ket,  
200 km. above the Ob.



Plate 2, fig. 2. The River Ket, 100 km. above the Ob

plants such as Phragmites communis. The invertebrate fauna of situations of this sort is abundant and varied, and certain molluscs especially, appear to find there almost ideal conditions of life,

The principal species found in this type of habitat in the course of the expedition of 1932-33 were as follows :  
Lymnaea stagnalis, L. auricularia, L. pereger, L. palustris,  
L. truncatula, Planorbis corneus, P. planorbis, P. compressus,  
P. johanseni, P. sp (like arcticus), Ancylus lacustris, Physa fontinalis, Bithynia tentaculata, Bithynia leachii inflata  
Anodonta cygnea Anodonta<sup>o</sup> anatina. Not all of these species are to be found in any one pond. Frequently one or more species will be found in a pond in large numbers, while in a neighbouring pond they may be replaced by others which occur in similar abundance.

Ponds and small lakes situated at some distance from streams of any size present conditions of life which are very different from those mentioned above.

Ponds situated on flood plains are periodically flushed by the overflow from the parent stream, but in isolated ponds on the treeless area they must be a considerable fresh water run-off in the spring to carry away the mineral salts which accumulate during the warmer months as a result of evaporation. In the forested area this condition does not arise as the soils of that region contain very little water-soluble mineral matter. On the steppe, and steppe-desert

and also to some extent on the forest steppe there is a tendency toward the accumulation of mineral salts such as magnesium sulphate, sodium sulphate, and sodium chloride and these, when present in sufficiently high concentration, have an injurious effect upon the mollusc fauna. In addition to this direct effect, compounds of this sort exert an injurious influence upon the fauna of molluscs and other invertebrates through their being inimical to the aquatic and semi-aquatic vegetation upon which these animals are dependent for food. In addition to these saline ponds are a certain number which contain relatively fresh water. In the forested region ponds and small lakes tend to become choked with vegetation, but on the treeless steppes this process is held in check and such bodies of water are not uncommon. As a rule they are surrounded, and in some cases nearly filled by a growth of Scirpus and Phragmites, and their molluscan fauna resembles that of marshes in which those plants predominate, On the whole however as a result of the conditions referred to above, their fauna is somewhat less rich than that of the marshes and ponds on the flood plains.

Ponds of this type commonly have a molluscan fauna consisting of the following species, Lymnaea stagnalis, L. pereger, L. palustris, Planorbis planorbis, P. sp. (like arcticus and Musculium lacustre).



Plate 3, fig. 1. The western shore of Lake Baikal,  
near Listvinichnoye.



Plate 3, fig. 2. The western shore of Lake Baikal south  
of Peschanaya Bay.

To sum up therefore, it may be said that there are two general types of permanent pond - small lake habitat in Siberia, the primary distinction being the existence of some means of flushing or draining the body of water. This takes place regularly in ponds on the flood plain of the larger streams, or in cases where there is an outlet stream. Fifteen or more species of fresh water molluscs may be found in these situations. Contrasted with these are ponds and small lakes which are more or less isolated and have little or no drainage connection. In the forested region these are filled by vegetation, but on the treeless areas they persist, but on account of the increasing concentration of mineral salts and the periodic droughts their molluscan fauna is not rich.

(c) Large Lakes.

Conditions in Northern Asia are not favourable for the development of a widespread specifically lacustrine mollusc fauna. Lakes of considerable size occur only in widely separated areas, and under special circumstances which are sometimes inimical to molluscan life. Several of the large lakes of this region, including the Aral Sea and Lake Balkhash, as well as other smaller, though still large bodies of water, are saline. Others while having an extensive surface area, are very shallow, and are therefore more of the nature of very large ponds, than true lakes. On the other hand at least one body of water, Lake Baikal,



Plate 4, fig. 1. The shoreline of Lake Baikal between Koti and Listvinichnoye.



Plate 4, fig. 2. Wind-swept hillside leading down to the shore of Baikal near Kurma.

is of such profound depth, and is subject to such severe storms, that none of the common Sub-Arctic genera of pulmonate molluscs are able to live in it. Some of the lakes in the mountainous region of eastern Siberia are relatively isolated bodies of water and many species of fresh water molluscs appear to have difficulty in migrating into them.

Over the greater part of the country however, large lakes do not occur, and the explanation of this lies in the recent history of the country, there having been relatively little glaciation in this sector of the Sub-Arctic Region.

The only species of mollusc in western Siberia which can be regarded as being in any sense a lacustrine form is Paludestrina ventrosa, which formerly inhabited some of the large saline lakes. This species however was not collected in the living condition in the course of the expedition and it appears to be probable that it no longer exists within this area. Further to the east there is a rich fauna of molluscs in Lake Baikal, a description of which is given elsewhere in this paper (See page 182). While this fauna is of very great interest in itself, it is so specialized and of such localized occurrence, that it is not of very great significance in connection with the present phase of this study, which centres about the pulmonate forms, such as Lymnaea, and Planorbis, and some of their associates including Bithynia, Anodonta, Sphaerium, etc. It is characteristic of the Baikal fauna that none of these forms occur in that lake.

In Lake Zazurnia, a moderate-sized body of water situated in the mountains near the Baikal known as Khamar-Daban, there is a strictly lacustrine type of habitat, and two species of molluscs, Lymnaea zazurnensis and Planorbis borealis live on the stones and smooth rock surfaces which form the shores of the lake. Lymnaea zazurnensis is endemic to Lake Zazurnia, and appears to be one of the few cases in this territory of a local race especially adapted to lacustrine conditions,

(d) Lakes without Direct Outlet Streams.

In the southern part of Siberia, and in Kazakstan there are many saline lakes and ponds. The primary cause of the saline conditions lies in the climatic changes which have taken place since the last period of glaciation, but the immediate cause of the accumulation of salts is the loss of the outlet stream, coincident with a drop in the level of the lake or pond.

A wide range of conditions is presented in habitats of this kind. Not only does the content of dissolved mineral salts such as magnesium sulphate, sodium sulphate, and sodium chloride, vary greatly but the extent of the development of the emergent marsh vegetation, which is a valuable source of food for molluscs, also varies from lake to lake. The suitability of such a body of water for fresh water mollusca is dependent to a great extent upon the nature of the substratum on which the lake or pond rests. If this

is water-permeable there is an outlet for the accumulating salt, and in all probability the lake will continue to be a more or less suitable habitat for molluscs until the water finally disappears. Under these conditions sub-fossil shells are often found on the mud flat exposed after the water has gone, as well as around the shores. Should the lake-bottom be impermeable the salts accumulate, after a time the solution becomes saturated, and as this evaporates, a salt flat is formed which is usually covered by a thick layer of salt crystals. Under these conditions the molluscs do not long survive, and while in a few cases shells may be found in the highest of the old shorelines around such a lake, they do not occur on the salt flat.

It is difficult to generalize regarding the mollusc fauna of these situations, since to an even greater extent than elsewhere the fauna is a reflection of local conditions. Certain general conclusions stand out however. The most hardy species in this region as far as these conditions are concerned are Lymnaea palustris kazakensis, L. palustris saridalensis and Planorbis planorbis, while the least so are Bithynia tentaculata, B. leachii inflata and Planorbis corneus. The majority of the common fresh water pulmonates are able to withstand a considerable concentration of mineral salts but after the marsh vegetation in a lake has been destroyed, most of the molluscs also disappear. This subject has been discussed more fully in another part of this paper. (p. 212).

(e) Intermittent Streams.

Streams which contain water only intermittently are not particularly important as habitats for molluscs, but as they form one of the striking features of the landscape in parts of the country they are mentioned here. Conditions in habitats of this type are usually quite unsuitable for the maintenance of a molluscan fauna, the great force of the flood in spring carrying off any immigrants, and the long dry period making it difficult for any individuals to survive in pools in the stream bed. In the forested region there may be a few intermittent streams, analogous to those in Canada, in which a few temporary pond species have gained a foothold, but none have been found in the course of this expedition. In the steppe-country the majority of the intermittent streams are dry channels for more than eleven months in each year and are exposed to the full heat of the sun during the drought period in summer. Hence the conditions are not suitable for aquatic mollusca. Nevertheless in a few cases ponds may be found in the bed of intermittent streams in which a few individuals of Lymnaea palustris manage to survive.

(f) Permanent Streams of the Forest and Steppe Regions.

The Rivers Ob, Yenissei and Lena are the three largest streams of the northern part of Asia but the actual channels of these rivers do not appear to be of great interest from the standpoint of the mollusca. There are, however, numerous

smaller, though still large streams which are of some importance in this connection. They are especially numerous in the forested region where in addition to the marsh and flood-plain associations mentioned above a certain number of molluscs are to be found living in the rivers, these include Anodonta cygnea (Linne), Anodonta anatina, Viviparus fasciatus, and Sphaerium corneum. The steppe region is subject to severe drought each year, so that only the very largest streams contain water during the latter part of the year and there are no permanent brooks. They are moreover subject to very severe floods and the two extremes of very high and very low water react unfavourably upon the mollusca. As a rule the fauna of these streams is meagre, and it is made up of scattered individuals of the three pelecypod species noted above. The truly aquatic animals pass the winter in the deeper holes in the bed of the stream. In general the river fauna of molluscs in Siberia is a poor one and is to a great extent lacking in positive characteristics.

(g) Mountain Streams.

For the most part the mountains of Siberia do not attain a great altitude. Usually the peaks are not much more than two thousand metres above sea level. To the east of the River Yenissei is a rugged upland about one thousand metres in altitude which is crossed by rocky ridges and hills with steep sided valleys. In this region the streams are of a somewhat montane character. This is also the case to a



Plate 5, fig. 1. The River Snejnoya, Baikal area, at moderately low water.



Plate 5, fig. 2. The River Snejnoya, the results of the spring flood.

greater degree along the frontier with Mongolia, Tannu-Tuvia, and Dzungaria, and in the country near Lake Baikal. There are extensive uplands with many rocky peaks of eight hundred metres or more, on the Kirghiz Steppes between Akmolinks and Lake Balkhash, but the climate in this section of the country is so dry that there are no permanent streams.

In the Yenissei-Baikal area however, as well as along the southern frontier mentioned, there is an abundance of water, and many mountain streams. Practically none of these contain molluscs. The reason for this lies not so much in any special character of the streams, apart from their swiftness and the relatively low temperature of the water, but more in the fact that the molluscs which inhabit this geographical area and particularly the pulmonate forms, are not suited to life in a torrential habitat. The molluscs which inhabit Siberia are for the most part species and genera which thrive in quiet water, and in this region there appears to have been little or no attempt on their part to migrate into other types of habitat, although considering the degree of adaptation in other parts of the world (e.g. in Lymnaea hedleyi, in Canada) given the right material, the difficulties would not seem to be insuperable. In the eastern part of Siberia the fact that many of the streams freeze solid during the winter may be an unfavourable influence. The fact remains however that apart from the Baikal fauna most of the Siberian fresh water molluscs are pond and marsh-loving forms.

## REPRESENTATIVE MOLLUSCAN HABITATS.

Generally speaking, there are two methods of approach to the detailed study of the problems of distribution. The first of these, which is greatly in vogue in the United States, consists of the special study of a single or limited number of localities. A second possible method is geographical in scope and involves the study of series of representative and comparable habitats over a wide area. This second method was adapted to the conditions under which the expedition of 1932-33 was made, the route being through moderately wild country in which it was not always possible to remain in one locality for a long period. Therefore in addition to discussing in a general way the principal types of habitats occupied by molluscs, it appears to be desirable briefly to describe the fauna of certain specific localities which appear to be reasonably representative of the territory examined in the course of this expedition. The habitats described here are not necessarily typical, but taken as a whole are fairly representative of the territory examined.

Lists of the species of molluscs collected in certain fairly typical and circumscribed habitats are given below and these may prove to be of use in comparative work. In this connection it is a noteworthy fact that during the course of this work no two ponds or lakes have been found to have exactly the same fauna and from one geographical area to another there are often significant differences in distribution and relative abundance.

## AQUATIC HABITATS.

(a) Temporary Ponds.

1. A small rather dry pond, situated 20 kilometers south of Bouldi Kul, Akmonlinsk region.  
Lymnaea palustris, Segmentina nitida, Planorbis leucostoma.
2. Small pond near Bolshoi Luke, Barabinsk Forest-Steppe.  
Lymnaea palustris Aplexa hypnorum.
3. Grass-covered pond in the centre of a large birch grove, 6 kilometers west of the village Topolnoye, Barabinsk Forest-Steppe.  
Lymnaea palustris Planorbis leucostoma.
4. Small, very shallow pond in a birch grove near Zuza, Barabinsk Forest-Steppe.  
Planorbis leucostoma.
5. Small pond in the centre of the bed of a marshy lake which was dry at the time of the examination.  
Aplexa hypnorum
6. Small pond in a poplar forest near the River Ket, 100 kilometers above the River Ob.  
Lymnaea palustris.

(b) Permanent Ponds and Small Lakes.A. Ponds situated on the flood plain of streams.

1. Pond near the River Nura,  $\frac{1}{2}$  kilometer north east of Rojdestvensky. A small pond, about three by two metres and thirty centimeters in greatest depth. Partly overgrown by small Salix, Scirpus and Phragmites and containing a rather sparse growth of Potamogeton, Utricularia and Chara. Bottom of sand, covered by a thin layer of organic detritus on which the young snails appear to feed.

Lymnaea stagnalis      Planorbis sp. (like arcticus)  
L. pereger              Ancylus lacustris.

2. Pond near the River Ishim at Akmolinsk. Similar to ponds along the Nura.

Lymnaea stagnalis      Planorbis corneus  
L. pereger              P. compressus  
L. palustris            Bithynia leachii inflata  
L.auricularia

3. Pond near the River Irtish at Omsk (Novo-Omsk). An extensive marshy area partly overgrown by Phragmites communis

Lymnaea stagnalis      Planorbis corneus  
L. pereger              P. johanseni  
L. auricularia        P. contortus  
L. palustris            Sphaerium corneum

Bithynia tentaculataB. leachii inflata

4. Pond near the River Irtish, 20 kilometers below Pavlodar.

Lymnaea stagnalisPlanorbis corneusP. cristaP. sp.Physa fontinalisBithynia tentaculata

5. Pond near the River Ket, 30 Kilometers above the River Ob.

Lymnaea palustrisL. peregerAplexa hypnorumPlanorbis johanseniP. planorbisBithynia tentaculata

6. Pond near the River Ket, 285 kilometers above the Ob.

Lymnaea truncatulaPlanorbis leucostoma

7. Pond near the River Ket, 295 kilometers above the Ob.

Lymnaea stagnalisL. peregerPhysa fontinalisPlanorbis planorbisP. leucostomaValvata piscinalis

B. Ponds and small lakes situated at some distance from large streams.

1. Bouldi Kul, a large marshy area almost completely overgrown by Phragmites communis. The water is only

very slightly saline.

(i) Found among Phragmites communis.

Lymnaea stagnalis

Planorbis planorbis

Planorbis corneus

Bithynia leachii inflata

(ii) Found in a shallow pond of open water at the northern end of the lake

Lymnaea auricularia.

2. Kun Gul (Kumbi Kul) a lake several kilometers in length situated about 60 km. south west of Rojdestvensky, Akmolinsk area.

Lymnaea stagnalis

Planorbis corneus

L. palustris

P. planorbis

L. pereger

P. contortus

Bithynia leachii inflata

Segmentina nitida

Pisidium spp.

Sphaerium corneum

3. A large pond on the steppe 2 kilometers east of Rojdestvensky.

Lymnaea stagnalis

Planorbis corneus

L. palustris

P. sp. (like arcticus)

L. pereger

Musculium lacustre

Pisidium sp.

4. A moderate-sized pond situated on the floor of a broad valley, 20 kilometers east of Rojdesvensky. Circular in shape, occupying a shallow depression 200 metres in diameter. Filled with a thick growth of

Scirpus and Carex. Water slightly salt but potable. The field notes include the remarks "A typical permanent pond of the steppe, very similar to many in Canada."

Lymnaea palustris

Planorbis planorbis

L. pereger

P. sp. (like arcticus)

Aplexa hypnorum

Musculium lacustre

Note. Lymnaea stagnalis was not found in this pond, but did occur in a similar pond one kilometer distant, in which Aplexa hypnorum was absent. In all probability this means that the pond described (No. 4) was somewhat more subject to drought than the other.

5. Pond 20 kilometers south of Bouldi Kul. In years of "normal" precipitation evidently containing water throughout the summer, but dry in July 1932.

Shells of the following species were found on the dry bottom:

Lymnaea stagnalis

Segmentina nitida

L. palustris

Aplexa hypnorum

L. pereger

Musculium lacustre

Pisidium sp.

6. Small circular lake, 1 kilometer in diameter situated 6 kilometers south of Lake Kizil-Kak. Nearly filled by a thick growth of Phragmites communis, but with several open ponds

Lymnaea stagnalis

Planorbis contortus

Planorbis planorbis

Segmentina nitida.

7. Small unnamed lake 2 kilometers south of the River Chulim, below Lake Sorgul, Barabinsk Forest-Steppe.

Lymnaea stagnalis

L. palustris

Planorbis planorbis

8. Small lake near Ust Tandovskaya, Barabinsk Forest-Steppe. Maximum depth about .5 metres.

Lymnaea palustris

Planorbis planorbis

9. A small shallow and somewhat saline lake on the Steppe Sari-Dala, 15 kilometers south west of Pavlodar. Without marsh or submerged vegetation. Water barely potable.

Lymnaea palustris saridalensis.

(c) Large Lakes.

1. Lake Zazurnia, Khamar Daban, Baikal area. This is a moderate-sized lake situated in a ruggedly mountainous area. Only two species were collected, namely,  
Lymnaea zazurnensis.  
Planorbis borealis.
2. Lake Chani, Barabinsk Forest-Steppe. Although this lake has a very considerable surface area, and on the map appears to be an important and fairly typical lake, it proved on examination to be a somewhat saline lake (in 1933) which at some former period, at least in some places, had a mollusc fauna of the marsh-small lake type, rather than of a true lacustrine type.
3. Lake Sartlan, Barabinsk Forest-Steppe. This lake was not at all extensively examined, but a species of Physa (P. sartlandinensis) was collected which appears to be endemic to that body of water. The habitat of this form was not satisfactorily determined but it is possible that it occupies some strictly lacustrine station.
4. Lake Baikal.  
The fauna of Lake Baikal is a special study in itself, and is not strictly speaking within the province of this report, but the following notes may serve to indicate the general nature of the molluscan fauna.

Lindholm (35) identified the collections made by the Korotnev Expedition of 1900-02 and his paper has been the standard work on the molluscs of this area. Recent investigations made under the direction of Dr G. U. Vereschagin have brought to light a wealth of new material and the molluscs are now being revised by Professor Kojov of Irkutsk whose monograph on the subject will be published within a few years. Certain fundamental facts however stand out at the present time. As is the case with many other groups of animals in this lake, there is a high degree of endemism among the Baikal molluscs, not only among the species and genera, but also in the larger groups, two families the Baicalidae<sup>1</sup> and Benedictidae being essentially confined to this lake. These are Pectinibranchs and are allied to Amnicola and Bithynia. The principal genera are Baicalia, Benedictia, and Kobel tocochlea. Choan-omphalus also occurs. At least one species of Benedictia and one or two species of Baicalia are to be found for some distance down the River Angara, but this is also true of several amphipods and the Baikal Grayling (Thymallus baikalensis). In general the conditions in the upper part of the River Angara, have greater resemblance to Baikal than to the Sub-Arctic type of lakes and streams nearby. One (endemic) species of Kobetocochlea is found in Kosso-Gol a large lake in nearby Mongolia. The typical sub-arctic molluscan fauna

1. Some authorities do not rank these groups as families.

is almost completely lacking in the waters of Baikal. Species of Lymnaea, Planorbis and Physa which predominate in the rest of Siberia, do not occur in the lake proper, although they may be found in a few scattered marshy areas nearby. One (endemic) species of Valvata occurs in considerable numbers in about twenty metres of water, & there are apparently present several species of Pisidium which are not endemic, Starostin (1928) has recorded the presence of "Planorbis (Tropiduscus) marginatus Drap." from Lake Baikal near Uskani Island in ten metres of water. Although I have never been on to Uskani Island I have seen enough of the surrounding district to be utterly incredulous regarding this record and believe that it must have resulted from some mixing of shells. Anodonta is sometimes to be found in shallow water in the Gulf of Barguzine within one kilometer of the mouth of the River Barguzine (in which it occurs in numbers) but on this expedition although some dredging was done in this vicinity none were found.

The report of a nudibranch mollusc Ancylodoris from the Baikal is erroneous.

(d) Lakes without direct outlet streams.

Dissolved mineral salts are constantly being carried into bodies of water of this kind by their tributary streams, and since there is little or no outflow the salt concentration in the lake water continually increases. As a result of this the fauna is often very meagre, and for the most part the molluscs of these situations are the most hardy species inhabiting the region. A more detailed account of the lakes of this type is given in another section of this paper.

1. **Tuz Sol**, a large saline lake near Rojdestvensky, Akmolinsk region.

The water is saturated with salt, no evidence of the present or former existence of molluscs.

2. **Teke**, a large basin, situated 125 kilometers to the south of Omsk, which has evidently been saline from a remote period. No fresh water molluscs were found, but the empty shells of one brackish-water species occurred on one of the former shore lines, namely, Paludestrina ventrosa.

3. **Kizil Kak**, a basin similar to Teke, situated 165 kilometers south of Omsk. There are no molluscs living in the lake at the present time, but empty shells occur along the shore, these include both Paludestrina

ventrosa and typically fresh water molluscs such as Lymnaea and Planorbis. It is not certain however that these two groups of species were contemporaneous in the lake.

4. Lake Topolnoye, near Aj Bulat, Siberia. A very saline lake, in which there are no living molluscs at the present time. In two of the uppermost old shorelines fragments of shells are numerous. The species represented include Planorbis planorbis, Lymnaea sp. and Anodonta sp. No shells of Paludestrina were observed anywhere about the lake.

5. Ashi-Kum-Kul. This basin which is situated forty nine kilometers south west of Rojdestvensky, is now completely dry. What was formerly the bottom of the lake is now a great mud flat, but in contrast to similar situations in other lake beds in this region this mud flat bears the empty and bleached shells of molluscs in considerable abundance. The following species were collected, Lymnaea palustris, Planorbis planorbis, Physa fontinalis, Bithynia leachii inflata, Pisidium spp.

It is to be noted, however, that none of these species was found alive.

6. A large rather saline pond near Novo Troetskaya, Djarla Vli Basin, Kazakstan. Two species found in moderately large numbers, namely,

Lymnaea palustris      Planorbis planorbis.

7.      Kun Gul (Kumbi Kul).

A slightly saline lake situated sixty kilometers south west of Rojdestvensky.

Lymnaea stagnalis      Planorbis corneus

L. palustris      P. planorbis

P. contortus

L. pereger      P. sp. (like arcticus)

Bithynia leachii inflata      Segmentina nitida

Sphaerium corneum

Pisidium spp.

(e) Intermittent Streams.

It has been mentioned in the preceding section that as a rule fresh water molluscs do not occur in the intermittent streams of Siberia and Kazakstan. In one case however, three species were found in a permanent pond in the bed of an intermittent stream which had been isolated by the undercutting of the stream bed in another place, thus diverting the full force of the freshet away from the pond, which was then fed by the normal drainage in spring, instead of by the concentrated freshet. This pond was situated near the eastern shore of Lake Celeti Dengehiz and the species represented were Lymnaea stagnalis, Planorbis planorbis and P. leucostoma.

(f) Permanent Streams of the Forest and Steppe Regions.

1. River Chulim, Kulundinsk Steppe. A small sluggish stream north of Slavgorod.

Lymnaea stagnalis      Planorbis corneus

L. pereger

Physa fontinalis      P. planorbis

P. johanseni

Bithynia tentaculata      Anodonta anatina

Sphaerium corneum      Pisidium spp.

2. River Baganeok, 3 kilometers north of the village Bolshoi Luke, Barabinsk Forest-Steppe. A broad marshy area occupying a shallow valley. Nearly filled with Phragmites communis.

Lymnaea stagnalis      Planorbis corneus

L. palustris

L. pereger

3. River Kargat 6 kilometers above Nijne Kargat Barabinsk Forest-Steppe.

A small stream with very little current, width 15 metres depth about 2 m. Nymphaea, Potamogeton and Scirpus abundant.

Lymnaea stagnalis      Bithynia tentaculata

L. pereger      Sphaerium corneum

L. auricularia      Pisidium spp.

Anodonta anatina.

4. River Chebanik, near the village Gramatina, Barabinsk Forest-Steppe. A stream about 15 metres in width.

Lymnaea stagnalis

Planorbis corneus

L. palustris

P. planorbis

L. pereger

P. johanseni

Bithynia leachii inflata

5. R. Karasuk, Barabinsk Forest-Steppe.

A small slow-flowing stream, the snails being found on the bottom and in little pools among Scirpus along the edge

Lymnaea stagnalis

L. auricularia

Planorbis corneus.



Plate 6, fig. 1. Dry forest near Lake Baikal, land molluscs are rare in forests of this kind.



Plate 6, fig. 2. Moist scrub-forest on the hills west of Lake Baikal. Land molluscs are moderately common around the bases of the birch clumps.

## TERRESTRIAL HABITATS.

1. A birch grove on the Forest-Steppe near Omsk.

Vallonia costata

Cochlicopa lubrica.

2. Groves of birch and willow near the mouth of the River Dukovoye, Gulf of Barguzine, Lake Baikal.

Gonyodiscus angulosus

Euconulus fulvus

Succinea putris

3. Forest of Populus tremula on the shore of Lake Dukovoye, Baikal region.

Gonyodiscus angulosus

Euconulus fulvus

Acanthinula harpa

4. Under birch and willow<sup>w</sup> in the bed of a small stream near the River Kurma, north of Sarma, western shore of Lake Baikal.

Vallonia costata

Gonyodiscus angulosus

Pupilla muscorum

P. muscorum lundstromi

It is to be noted that the place in which these shells were found is protected from the very high winds known as the Gornaya (or locally as the Sarma).

5. Poplar forest with a few scattered birch, pine, and spruce, four kilometers north-west of Listvinichnoye, Baikal region.

Gonyodiscus angulosus

Pupilla muscorum

Vitрина pellucida

Succinea putris

6. Forest of birch and alder in a small valley 2 kilometers north of Listvinichnoye.

Eulota schrenkii

Gonyodiscus angulosus

Cochlicopa lubrica

Vitрина pellucida

Succinea putris

7. Mixed forest of poplar, birch and pine, near the River Ket, 105 kilometers above the River Ob, and to the north of Tomsk.

Vallonia costata

Acanthinula harpa

Gonyodiscus angulosus

Cochlicopa lubrica

Euconulus fulvus

Vitрина pellucida

8. Forest of larch, pine, poplar, and birch near the Bay Buchentriva, Gulf of Barguzine, Lake Baikal.

Vallonia costata

Acanthinula harpa

Gonyodiscus angulosus

Cochlicopa lubrica

Euconulus fulvus

Retinella radiatula

Vitrina pellucida

THE GEOGRAPHICAL AFFINITIES OF THE MOLLUSCAN  
FAUNA OF NORTHERN ASIA.

One of the objects of the work in Siberia was to ascertain, as far as possible, the general faunistic relationships of the molluscs inhabiting this part of the Sub-Arctic Region. From the previous investigations carried out in the northern part of Asia, it is difficult to judge the extent to which misidentifications, superfluous names, and sporadic collecting have influenced the knowledge of this fauna. During the past thirty-five years, since the publication of Kobelt's "Mollusken der Palaearktischen Region" there has been a considerable advance in the knowledge of the mollusca, and a certain shifting of emphasis in the subject as a whole. It is therefore desirable that this matter should be reconsidered, even though the conclusions in this preliminary paper must be somewhat tentative.

From the point of view of their geographical distribution the freshwater and terrestrial molluscs of Siberia may be divided into several groups as described below.

I. Circumboreal Species.

There are about twenty species in the Siberian mollusc fauna which are circumboreal in their distribution. They are found in Europe, northern Asia, and North America, and some of them also occur in Iceland and Greenland. It is interesting to note that many of these species are not only found over a broad geographical area, but also have a wide

local distribution, i.e. they occupy a wide range of types of habitat in any one region. The members of this group of species are as follows :-

Aquatic Species.

Lymnaea stagnalis.

L. palustris.

Planorbis crista

P. albus

Aplexa hypnorum

Bithynia tentaculata

Terrestrial Species.

Vallonia costata

V. pulchella

Acanthinula harpa

Cochlicopa lubrica

Euconulus fulvus

Pupilla muscorum

Vertigo modesta

Retinella radiatula

Punctum pygmaeum

Zonitoides nitidus.

Regarding Planorbis albus there is still some doubt as to whether the Eurasian and North American forms are identical, but it appears that they are at least very closely allied. The case of Bithynia tentaculata is somewhat peculiar, since although it is widely distributed in Europe and Asia, it is much more restricted in its range in North America (see Baker 1928). It has not yet been found in the western part of Canada, although conditions there are very similar to those in Siberia.

## 2. Eurasian Species.

For the most part the species noted in the list below are found quite commonly in northern Europe, and some of them also in Africa north of the Sahara. From their abundance and wide local distribution in that region they may be taken to be the most hardy species in the European fauna, and hence this element in the Siberian fauna may be regarded as a selection of the most hardy species in the northern European fauna. This group is made up of the following species :-

Bithynia leachii inflata

Valvata piscinalis

Lymnaea auricularia

L. truncatula

Planorbis planorbis

P. laevis

P. spirorbis

P. compressus

Segmentina nitida

Ancylus lacustris

Physa fontinalis

Sphaerium corneum

Pisidium amnicum

P. casertanum

P. subtruncatum

P. supinum

V. cristata.

L. pereger

L. glabra

P. corneus

P. acronicus

P. leucostoma

P. contortus

P. astartoides.

P. nitidum

P. henslowanum

P. parvulum

P. steenbuchiiP. lilljeborgiiAnodonta cygneaA. anatinaUnio pictorumGonyodiscus ruderatusColumella edentulaVitрина pellucidaEulota fruticumSuccinea putrisS. pfeifferiAgriolimax laevisA. agrestis

2a. European species having a restricted distribution in northern Asia.

The two species referred to below cannot be regarded as altogether hardy forms, and are more of the nature of species specially adapted to particular habitat conditions, and they are therefore placed in a separate sub-group in this account.

Hydrobia ventrosa is a small gastropod which lives in brackish water and is common around the coast of the British Isles and Europe generally. Apparently it occurs also in the saline belt of Central Asia, and in the course of the expedition of 1932-33 it was found in two localities in Kazakstan, to the north of latitude 52° North, viz: Lakes Teke and Kizil-Kak. In continental Asia this is a southern species which finds suitable conditions only along the extreme southern boundary of the Sub Arctic Region.

Viviparus fasciatus is a moderately common species in European rivers, but in the northern part of Asia it appears to be much less widely distributed and so far has been found only in two relatively isolated localities. It is quite possible that the Siberian rivers are not favourable habitats for this species and its immediate relatives on account of a shortage of oxygen during the winter months, a condition which is known to occur in at least certain parts of the River Ob. An alternative explanation may lie in the ice action in the spring, which severely erodes the shores of all the larger streams.

### 3. North American and Asiatic Species.

In 1930 the Russian geologist S. V. Obrutschev collected several species of molluscs in an interglacial deposit near the River Kolyma, in far north-eastern Siberia. These were identified by Lindholm (1932) and among several common Palaeartic and circumboreal forms were found shells of a North American mollusc, Planorbis trivolvis. Lindholm compared these shells with specimens from North America, and named them as a new subspecies, P. trivolvis kolymense. P. trivolvis is common in North America, but had never before been found on the Asiatic continent. The locality was on the right bank of the River Kolyma, near the mouth of the River Omolon, at north latitude  $68^{\circ} 42' 5.8''$  and east longitude  $158^{\circ} 42' 29''$ . The lower layers of the deposit contained the remains of mammoth, elk, reindeer, bison, and

horse, and associated with Planorbis trivolvis were nine other species of molluscs, viz:- "Anodonta cygnea morpha anatina", Sphaerium corneum, two species of Pisidium, Valvata macrostoma, Bithynia leachii, var., Lymnaea stagnalis, L. ovata, and L. auricularia morpha lagotis. This region has been visited by other Russian naturalists since this discovery was made but no living specimens of Planorbis trivolvis have come to light.

#### 4. Endemic Siberian Species.

At the present time, while vast tracts of Siberia are still unexplored, and certain of the older species are not adequately understood, it is difficult to make a critical estimate of the endemic element in the mollusc fauna of this territory. Nevertheless enough is known to justify the enumeration and the tentative classification of these forms.

It is possible to distinguish four moderately distinct groups among these endemic molluscs, viz:-

(i) The greater part of the molluscan fauna of Lake Baikal, which has already been mentioned, is utterly distinct from the fauna of the surrounding country and the rest of northern Asia, with the possible exception of Lake Kossogol, in far northern Outer Mongolia.

(ii) A group of peculiar forms inhabiting the Far Eastern (Amur and Ussuri) Regions, many of the forms of which are distinctly Chinese or Manchurian in their affinities, and are probably not strictly endemic to Siberia.

These are listed in the section of this paper dealing with the Faunal Regions.

(iii) A group of local species and varieties found in certain circumscribed localities which are often isolated, or are of a peculiar character, including the following:-

Lymnaea palustris bolotensis

L. palustris kazakensis

L. palustris draverti

L. zazurnensis

Valvata antiquilina

V. baicalensis

(iv) Endemic Siberian forms which have a wide distribution over the whole or the greater part of the country.

Gonyodiscus angulosa

Eulota schrenkii

Planorbis johanseni

With these may possibly be grouped Eulota nordenskioldi which is more or less confined to the region of the Altai, but is found in many localities there. It is probably also found in Djungaria and Tannu-Tuvia.

Most of the members of the third and fourth groups are closely related to European species.

## THE FAUNAL REGIONS.

From the account given above it follows that, on the basis of the freshwater and terrestrial molluscs, there are four moderately well characterized faunal regions, viz:-

## 1. The Great Siberian Region.

This is the Asiatic portion of the Palaearctic Region, and includes the greater part of the country. As far as molluscs are concerned it has a fauna which is definitely European in its affinities, many of the species are identical in both regions, and such endemic forms as do occur in Siberia are for the most part closely allied to European species. In all probability this part of Siberia has been populated by migration from Europe. A number of the predominating species are circumboreal in their distribution.

## 2. The Baikal Region.

This region, consisting of Lake Baikal, and possibly certain neighbouring waters, is characterized by a high degree of endemism in the genera and species inhabiting it. The majority of the molluscs, including Baikalia and Benedictia are probably of ancient freshwater origin in this basin, but certain species, e.g. Valvata baikalensis, are endemic forms belonging to well-known genera which are widely distributed in the Sub-Arctic Region. A few species of molluscs, including as far as is known at present, only a few species of Pisidium may occur in this lake and also have a wide distribution in Siberia and Europe.

### 3. The Far Eastern Region.

From the point of view of faunistics, the region of the Rivers Amur and Ussuri is markedly distinct from the remainder of Siberia. This area was not included within the area examined during 1931-32, and although many of the species have been examined, the series in all cases were small. The following is a list of the species which characterize this faunal region:-

Eulota selskii

E. cincto-inflata

E. maackii

E. middendorffii

Fruticicola diekmani

Euconulus fulvus infrazonatus

Bithynia ussuriensis

Vivipera ussuriensis

V. praerosa

Anodonta herculea

### 4. The Chuckchee-Kamchatka Region.

The fauna of the region to the north of the sea of Okhotsk is almost unknown, but enough material is on hand to indicate that this region, with Kamchatka, has a fauna composed of both Siberian and Alasko-Canadian elements. The species which are definitely known to occur on both sides of the Bering Strait are as follows:-

Gonyodiscus pauper

Punctum conspectum

Vitrina exilis

Succinea chrysis

Planorbis trivolvis

Anodonta beringiana

The Planorbis is known on the Asiatic side only in the fossil condition.

THE DISTRIBUTION OF THE NORTHERN ASIATIC MOLLUSCA  
IN RELATION TO THE NATURAL REGIONS.

It is a striking fact that in northern Asia it is possible to distinguish several well defined types of landscape which have a wide range of occurrence, and are comparable to those in Sub-Arctic Canada. They are so strongly characterized from diverse points of view that they may be regarded as major natural regions. A general account of these is in course of preparation, and the purpose of this section is to briefly outline some of the facts pertaining to the distribution of the mollusca in relation to them. Seven major natural regions may be distinguished in this part of Asia, viz. the Tundra, Taiga, Forest-Steppe, Steppe Steppe-Desert, and Desert.

The term Tundra is applied to the narrow treeless belt along the Arctic coastline. It is a region with small relief, and is covered by a low growth of vegetation, which in dry places is characterized by Empetrum nigrum, and small Salix, or Cladonia, and in wet places by mosses such as Polytrichum and Sphagnum. The soils have developed under conditions of plentiful moisture and low temperature, and there is usually a considerable amount of plant material which shows few signs of decomposition. Gleevo-podsols occur in some of the drier situations. The climate of the region is moderately severe, the mean annual temperature being about - 7.2° C., and that of the warmest month



Plate 7, fig. 1. The River Ket, 250 km. above the Ob.

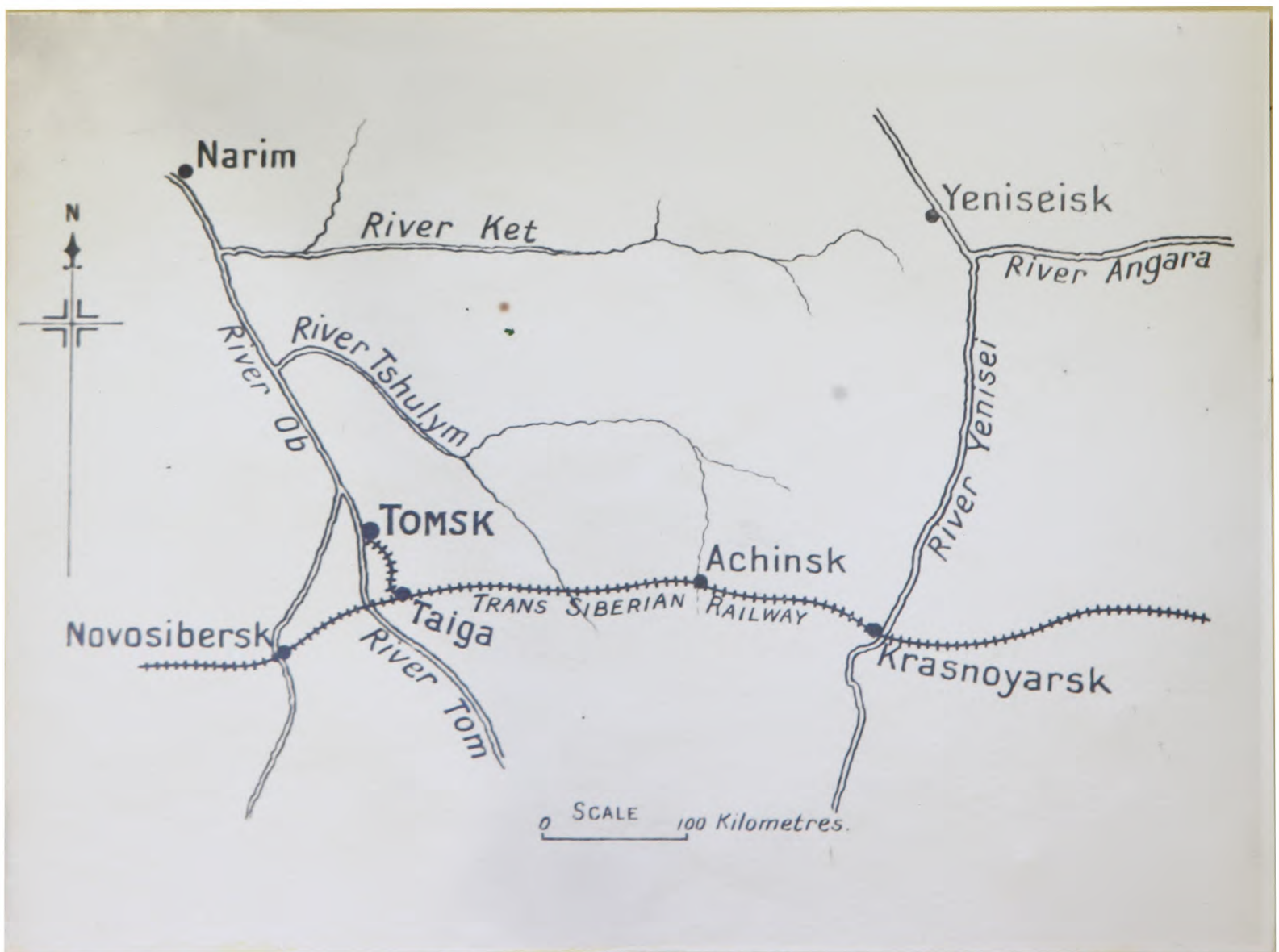


Plate 7, fig. 2. Sketch map of the region between Novosibirsk and Yeniseisk.

(July)  $5.3^{\circ}$  C. The absolute minimum temperature is about  $-42^{\circ}$ C. and the absolute maximum  $23^{\circ}$ C. The length of the frost free season is approximately 85 days. The mean annual precipitation is in the neighbourhood of 450 mm., and the minimum in any one year is 300 mm. There are many ponds and small lakes, but the molluscan fauna is meagre. The principal aquatic species are Lymnaea palustris, Planorbis borealis, and Pisidium. Aplexa hypnorum has been found in ponds on the Taimyr Peninsula. The terrestrial snails, Euconulus fulvus and Gonyodiscus ruderatus also occur but are not common.

The forested region, which in Siberia is universally referred to as the Taiga, forms a broad band to the south of the tundra, stretching across the whole continent from the Ural highland to the Sea of Okhotsk. The region to the west of the River Yenissei is a great plain, but the country to the east of that stream is broken by numerous ridges which may reach an altitude of one thousand meters above the sea. The region of the Altai and Saigan mountains is very rugged, and there are numerous small mountain chains in the territory between Lake Baikal and the mouth of the Lena and Kolyma. For the most part the forest is made of five trees, viz. Pinus sylvestris, P. cembra, Picea obovata, Abies siberica, and either Larix siberica or L. dahurica. In the southern part of the forested area Betula and Populus are not uncommon, and occasionally form

pure stands. Bogs are numerous, and are frequently of considerable extent. The soils of this region are mainly podsols, which have developed under conditions of moderate moisture, and their characteristic feature is the prevalence of leaching in the upper layers due to the considerable rainfall. The mean annual temperature of this region is about  $-1.0^{\circ}\text{C}$ ., and that of the warmest month is  $18.0^{\circ}\text{C}$ .. The absolute minimum temperature is  $-52^{\circ}\text{C}$ . over the greater part of the territory, and the absolute maximum  $35^{\circ}\text{C}$ .. Under the special conditions existing near Verkhoyansk a temperature of  $-69.8^{\circ}\text{C}$ . has been recorded. The length of the frost free season is approximately 115 days. The mean annual precipitation is about 500 mm., and the minimum recorded in any one year is 325 mm. A large part of this region is underlaid by permanently frozen ground. There are many large and small streams, most of which contain water the year round. Many of those in the eastern part of the area, and especially in Transbaikalia freeze solid during the winter. For the most part ponds and small lakes are not numerous, but what large lakes there are contain fresh water, are moderately deep, and the waters have a relatively low temperature during the summer. Aquatic molluscs are fairly numerous, the most common species being, Lymnaea pereger, and Planorbis acronicus. Land molluscs are to be found in large numbers in suitable situations in this region, and in the southern part of the territory they are more abundant than in any of the other natural regions. The

commonest species are Cochlicopa lubrica, Retinella radiatula, Euconulus fulvus, and Gonyodiscus angulosus. Less universally distributed but common in certain restricted localities are Acanthinula harpa and Eulota schrenkii.

Along the southern border of the taiga, and more particularly in Western Siberia, there is a region of mixed forest and grassland which is known to the local inhabitants as the Forest-Steppe. This is a belt of groves composed largely of Betula, in some cases of Populus, with intervening grassy glades. In northern Outer Mongolia a similar landscape occurs in which Larix is the tree which predominates. It is particularly to be noted that the grasses and other herbs of the glades form a continuous turf. The soils of this region are mainly chernozems which have been formed under conditions of slightly deficient moisture such as exist in the area at the present time. There are also two types of alkali soils which are not uncommon in the forest-steppe, and in the regions adjoining it on the south. These are the solonetzki or alkali soils with a definite structure, and the solontschaki or alkali soils without pronounced structure. In the northern and eastern part of the Forest-Steppe in Western Siberia, there are also meadow soils. The mean annual temperature of the greater part of the Forest-Steppe has a mean annual temperature in the neighbourhood of 0.0°C., while that of the warmest month is 19° C. The absolute minimum temperature is -48°C., and

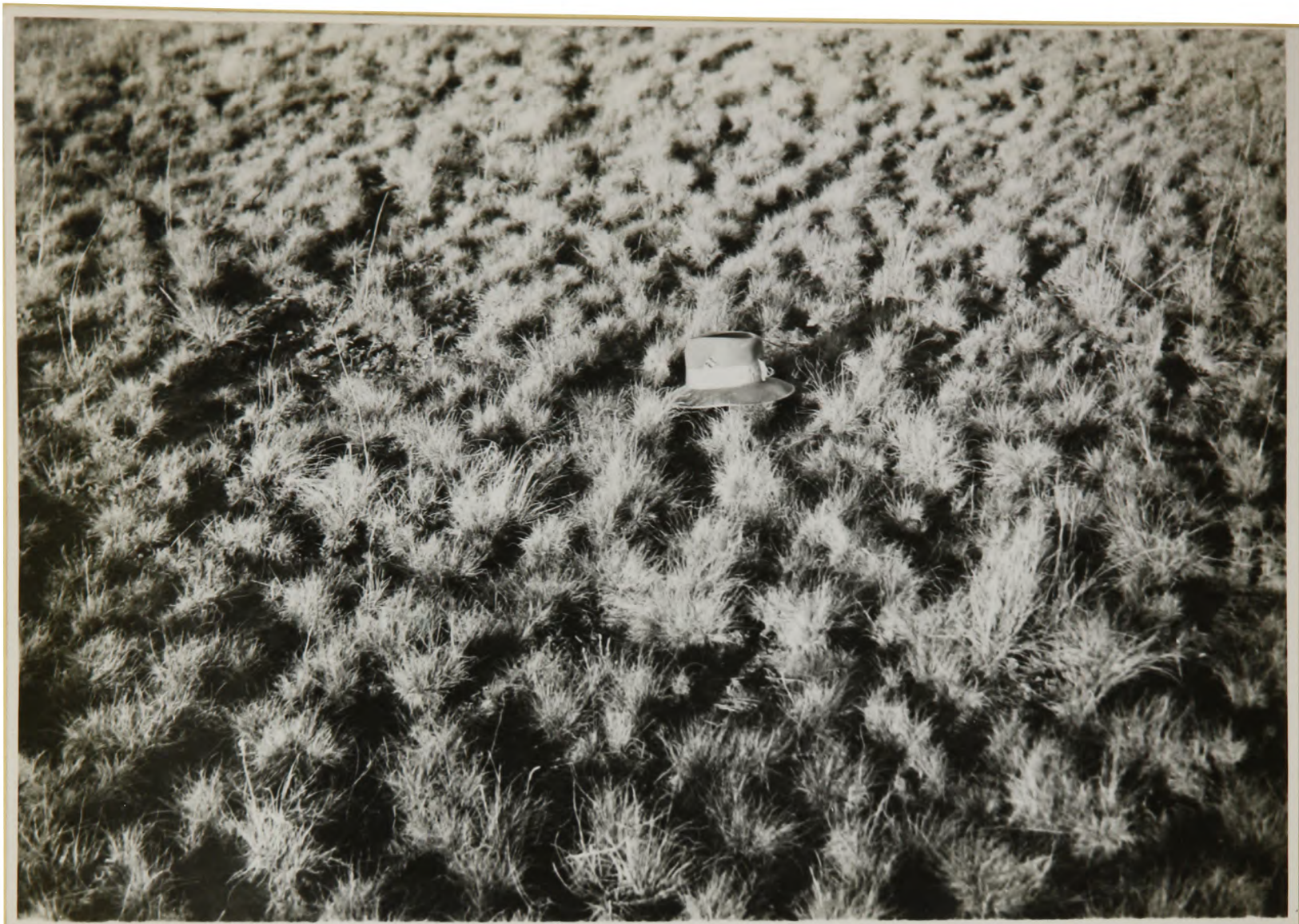


Plate 8, fig. 1. A typical view the steppe vegetation near the border with the steppe desert.

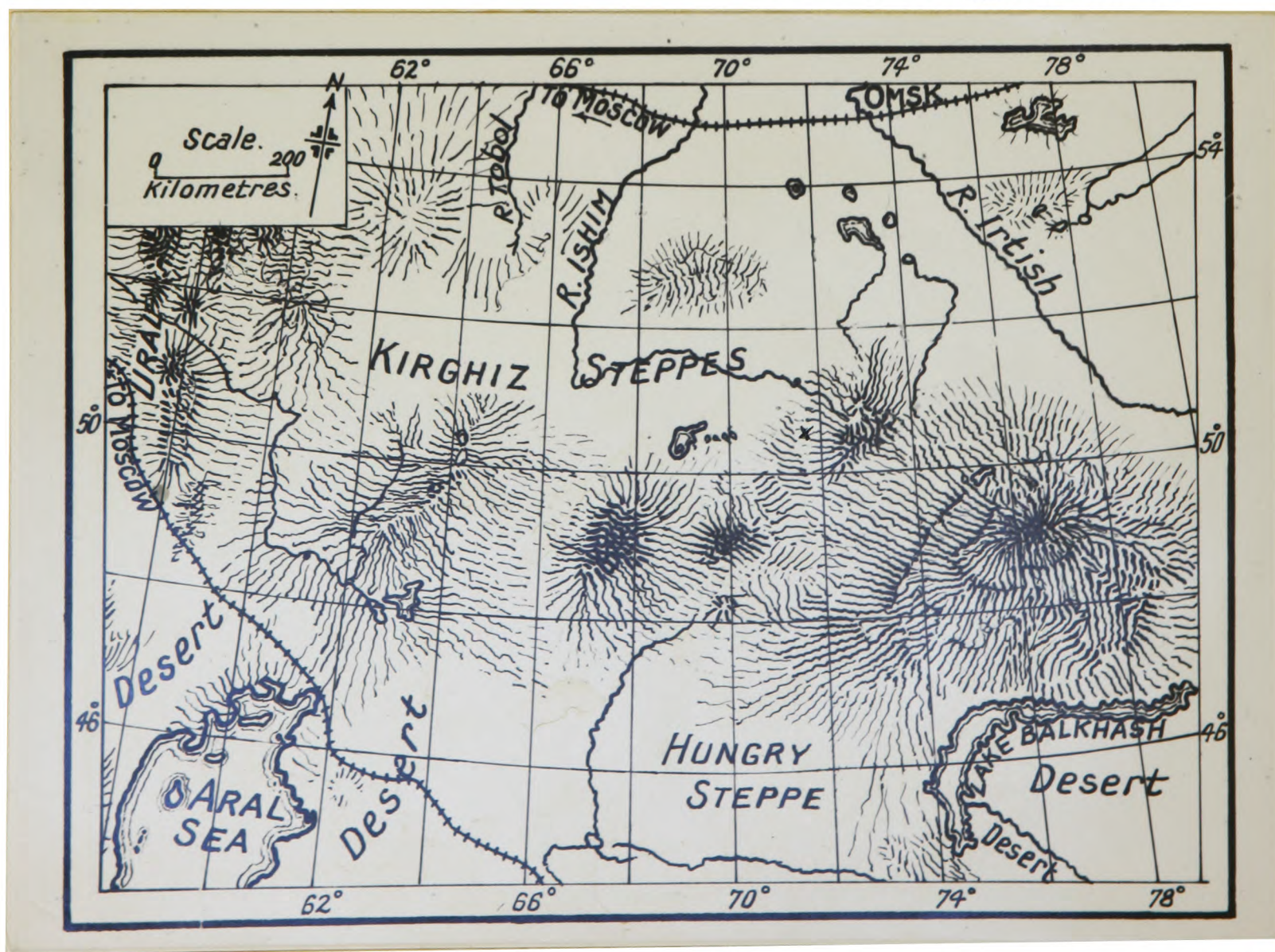


Plate 8, fig. 2. Sketch map showing the general position of the Kirghiz Steppe. The cross marks location of fig. 1.

the absolute maximum recorded is 38°C. The frost free season is 125 days in length, and the mean annual precipitation is 370 mm., while the minimum recorded is 225 mm. Ponds and lakes are numerous in this region, and there are many sluggish meandering streams in which fresh water animals of many sorts are abundant, in which aquatic molluscs thrive. The aquatic molluscs thrive better in the Forest-Steppe than in any of the other natural regions, and although no great number of species is represented, those which are present frequently occur in enormous numbers of individuals. The most common species are Lymnaea stagnalis, L. pereger, Planorbis planorbis, and Planorbis corneus. For the land snails conditions in this region are not so favourable as in the taiga, and the reason for this doubtless lies in the less abundant water supply, and high evaporation. The species which occur most frequently are Vallonia costata, and Cochlicopa lubrica.

The Steppe is a belt of treeless, flat or rolling country which in Western Siberia adjoins the Forest-Steppe at about north latitude 54°, and which also occurs in Outer Mongolia and Djungaria. For the most part it is treeless, but tiny colonies of Populus nigra occur in certain localities, e.g. six kilometers south east of Rodjestvensky, near Teretki Tul, and near Ulkun Karoi. These trees are of very small size, most of them being about 80 cm. in height. Shrubby willows occur in many of the river valleys.

The predominant vegetation however consists of grasses and small herbs, and except in saline places they form a continuous turf. In the northern part of the Steppe the soils are mainly chernozems, but towards the south they give place to chestnut coloured soils. Solonetz and solontschaki are common. The mean annual temperature is  $1.4^{\circ}\text{C}$ ., and that of the warmest month  $20^{\circ}\text{C}$ .. The absolute minimum temperature is  $-45^{\circ}\text{C}$ ., while the maximum is  $39^{\circ}\text{C}$ .. The length of the frost free season is 130 days. The mean annual precipitation is 300 mm., while the minimum quantity recorded in any one year is about 200 mm. Ponds and lakes are numerous, but many of them are somewhat saline. The smaller streams in most cases contain water only during the early part of the summer. Aquatic molluscs while less abundant than on the Forest-Steppe, are found in moderate numbers, the most common species being Lymnaea stagnalis, L. pereger, Planorbis contortus, P. spirorbis, and P. leucostoma. Terrestrial molluscs are rare, but Vallonia costata is to be found in some places in moderate numbers.

The Steppe-Desert, which bounds the last mentioned region along the south, is an area in which the life conditions approach the extreme limits of tolerance of most plants and animals. The vegetation consists of grasses and low-growing herbs, but these no longer form a continuous turf, and for the most part they occur in small clumps:

with bare spaces intervening. There is no clear cut line of demarkation between the Steppe and the Steppe-Desert, as several factors such as elevation, slope and exposure influence the occurrence of plants in the area of transition. Grey soils predominate in this region, although in the northern part of the Steppe-Desert chestnut coloured soils occur. There are also considerable areas of bare rock and alkali soils. The mean annual temperature of this region is  $4^{\circ}\text{C}$ ., and that of the warmest month  $24^{\circ}\text{C}$ ., The absolute minimum temperature is  $-40^{\circ}\text{C}$ ., and the absolute maximum  $40^{\circ}\text{C}$ .. The length of the frost free season is 150 days. The mean annual precipitation is 230 mm., and the minimum recorded is 180 mm. Ponds are uncommon, while the lakes are almost invariably saline, and frequently contain water which is saturated with mineral salts. There are very few permanent streams. Terrestrial molluscs are almost completely absent, while aquatic species are rare, it appears that the most common species are Planorbis planorbis and P. leucostoma.

The Desert, which is situated still further to the south is an even more unfavourable region for molluscs. The vegetation is extremely scanty, and the soils, which are usually sandy, or are merely desert crusts, contain very little organic matter. The mean annual temperature is between  $8^{\circ}$  and  $12^{\circ}\text{C}$ ., and that of the warmest month is  $26^{\circ}\text{C}$ .. The absolute minimum temperature is  $-30^{\circ}\text{C}$ ., and the

maximum over 40°C. The length of the frost free period is 170 days. The mean annual precipitation is 125 mm., and the minimum recorded is practically nil. The lakes of this region are saline. Very little is known about the molluscan fauna of this region but it appears that there are probably deposits containing sub-fossil molluscs dating from some recent pluvial period.

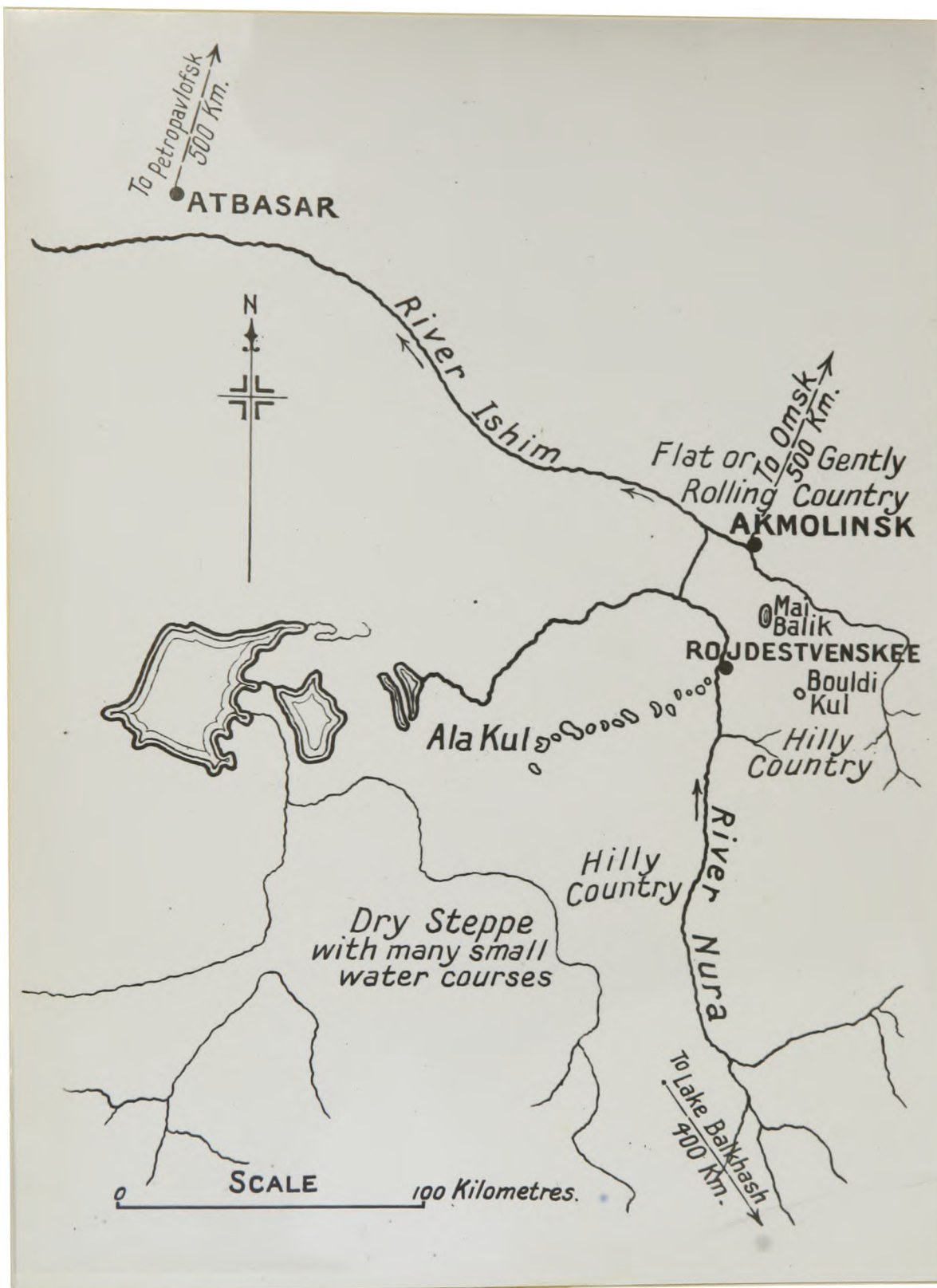


Plate 9.

Sketch map of the country lying to the south and west of Akmolinsk.

OBSERVATIONS ON SALINE LAKES IN NORTHERN ASIA  
AND THEIR MOLLUSCA.

It is well-known that there are many isolated inland drainage basins in the northern part of Asia, but so far they have been little studied, and such accounts of them as do occur in scientific literature are with rare exceptions in the Russian language. The object of this section is to discuss some of the biological and geographical characteristics of these inland basins. The work is based upon original observations made in the course of the expedition of 1932-33. The area in which these investigations were made lies in southern Siberia and northern Kazakstan, between the meridians  $60^{\circ}$  and  $80^{\circ}$  east of Greenwich. Casual observations were made on a large number of lakes, but particular attention was paid to certain bodies of water, which it appeared would most profitably repay more careful examination. The names of these are as follows :

Ala Kul, Kun Gul (Kumbi Kul), Ashi-Kum Kul,  
Zum Kul, Kara Sol, Djarla Kul, Durt Sart,  
Teretki Kul, Uzum Sor, Tuz Sol, Mai Balik,  
Bouldi Kul, Ulkun-Karoi, Teke, Kizil-Kak,  
Celeti-Denghiz, Djala-Uli, Urpek, Tuz,  
Chaganak, Djaman Tuz, Aj-Bulat, Osolodchnoye  
Topolnoye, Khoroshoye, Peschanaya, Khomotenoye,  
and Burlenskoye.



Plate 10, fig. 1. Ashi-Kum-Kul.

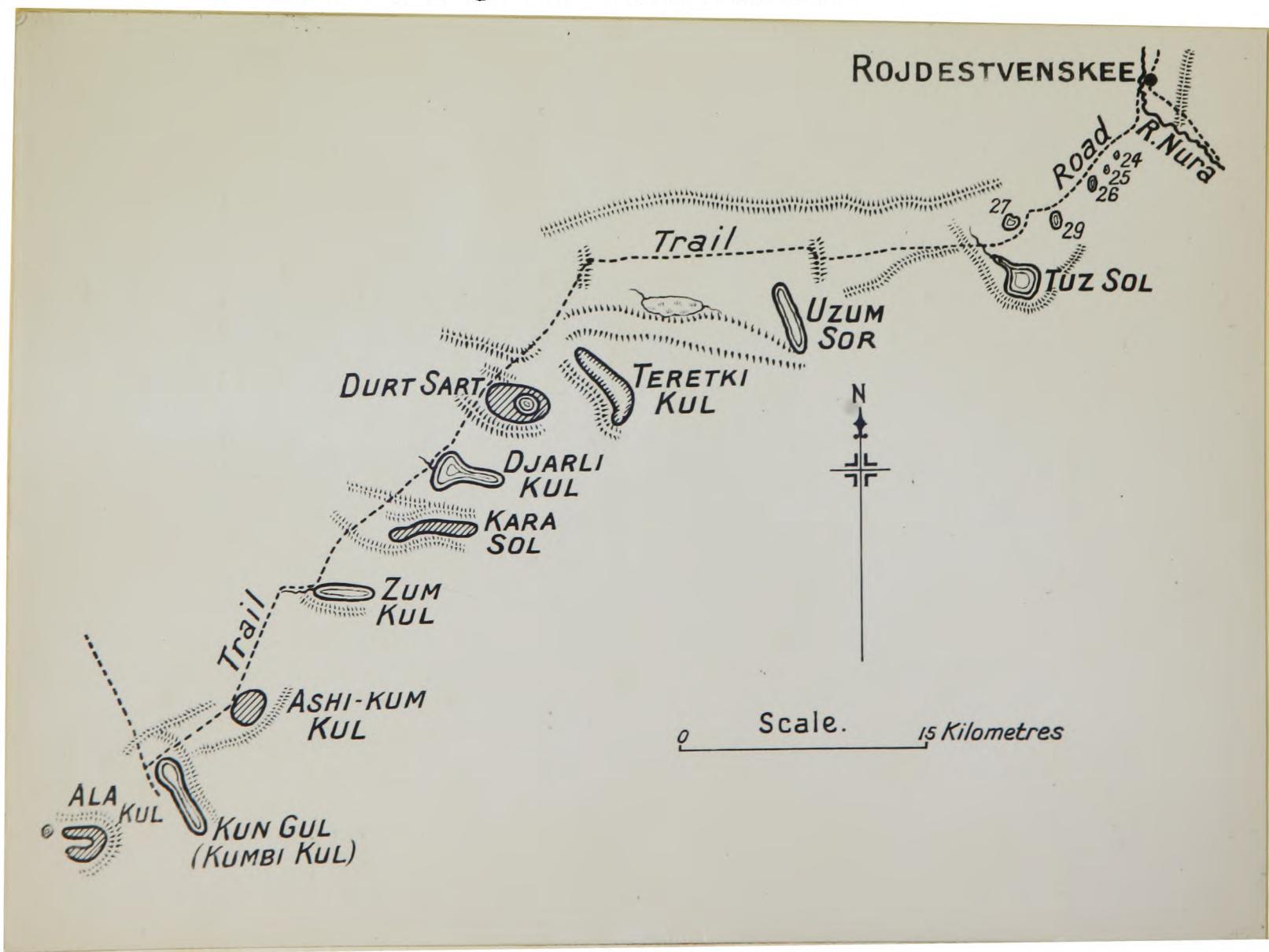


Plate 10, fig. 2. Sketch map showing the location of the lakes lying to the south-west of Rojdestvensky.

The work is intended to be complementary to similar investigations carried on in Sub-Arctic America. The conditions of travel in the northern part of Asia at the time that these observations were made did not permit of many chemical analyses of the lake waters being obtained, and in addition to this the conditions of life were often such that it was necessary to leave a given district before the observations were complete. Therefore the results given below are largely of a general nature, but they may nevertheless have some value, especially in conjunction with the more detailed work carried out in Canada, an account of which will be published shortly.

The characteristic feature of lakes of this type is the high concentration in their waters of mineral salts such as sodium chloride, sodium sulphate, and magnesium sulphate. This has come about as a result of the level of the lake falling below that of the outlet stream. Following that, since there has been no flow through the lake, there is a gradual increase in the salt content of the water, culminating in a saturated solution, and after the evaporation of this in a salt flat covered by a deep layer of salt crystals.

The essential characteristic of such a lake therefore is that it lacks an outlet, and the explanation of the loss of this doubtless lies in the climatic changes which have taken place throughout the Sub-Arctic Region since the last period of glaciation.

As a rule a lake of this kind on the Steppes of Siberia and northern Kazakstan has a characteristic appearance. The immediate shores are low and gently sloping, usually almost barren of vegetation (except for a few Salicornia and stunted Phragmites), and in many cases are covered by a thick deposit of small salt crystals which have crystallized out of the solution in the lake. Obviously these conditions are not very favourable for living organisms, and the biota is meagre in the extreme. The process however is a gradual one and in its earlier stages it is possible to discover many diverse plants and animals living in these lakes. In addition there are often evidences of a former freshwater fauna in the old beaches which have been left behind as the water receded. The shells of molluscs are sometimes to be found in these former shorelines in considerable abundance. It is important to note that one reason for the paucity of emergent vegetation in these lakes, quite apart from the physiological effects of the salts in solution, may be that the relatively frequent fluctuations of level give very little opportunity of any permanent colonies of such plants as Phragmites, as in one year the water may be at a low level and in the next or succeeding years at a higher one so that any invading plant colonies are destroyed by the ice, while colonies formed at high water are left high and dry for the greater part of the time. Thus the wide fluctuations in level

particularly in lakes belonging to a series such as that of Aj-Bulat or Djali-Uli must in themselves have an unfavourable influence, and when acting simultaneously with other factors such as salinity, which reduces the vigor of the growth, are often sufficient to debar the entry into a lake of certain types of plant associations and of course thereby also prevent the incursion of many of the animals, such as molluscs, usually accompanying these plant associations.

In the following account a brief description of some of the diverse types of saline lakes is given, and this is followed by a brief summary and discussion of some of the main points which have come to light in the course of these investigations. It will be noted that the lakes described fall into two major groups, depending upon whether they are isolated individual lakes, or members of a series, forming a larger inland drainage basin.

#### Ulkun-Karoi.

This name is applied to a large saline basin one hundred and forty kilometers south west of Omsk, which was formerly occupied by a single body of water, but in which now occur many smaller lakes and ponds, the number of which varies from year to year depending upon climatic conditions. The form of the basin indicates that Ulkun-Karoi in ancient times was roughly circular in outline, with a shallow area

in the center which later formed an island or peninsula, surrounded by somewhat deeper places particularly to the north and east, which now form separate lakes. One of these, occupying what is now the northern lobe of the basin, is about ten kilometers in length and from three to four in width. It is obviously shallow and the water saline though not a saturated solution. The River Djarli flows into this lake from the north. This is a stream of some size, its valley at a point two miles above the mouth being one hundred meters in width, and thirty in depth. The actual stream at this point on April 30th, 1933, was three meters in width, and the flow was quite considerable, but it is probable that later in the year the flow ceases altogether leaving a series of more or less permanent ponds in the bed of the stream. Near its mouth the River Djarli has the form and character usually found in the larger tributaries of saline lakes, there being a considerable body of relatively stagnant water which is less saline than that of the lake and acts as a reservoir for the survival of aquatic species in times of great drought.

No living molluscs were observed in this northern member of the Ulkun-Karoi complex and no empty shells could be found on the mud in the immediate vicinity of the present shoreline, which is moderately conclusive evidence that none exist in the lake at the present time, but the presence of shells on the mud of the old lake bottom, which was

exposed as the water receded, up to within thirty meters of the shoreline at the present time, and also their occurrence in the beaches which mark former shorelines indicates that molluscs inhabited this lake during a period of high water in comparatively recent times. A section as taken through the beaches on the northern shore and revealed the presence of four well defined zones, as follows :

- A. Within thirty meters of the waters edge. Bare mud without any evidence of molluscs.
- B. From thirty to two hundred and thirty meters of the shore (in 1933). Bare mud with many bleached and empty shells of Planorbis planorbis (Linne). Two hundred and thirty meters from the waters edge there is a small but clearly defined old shoreline, thirty centimeters in height which is built up of broken pieces of Phragmites and the shells of molluscs as well as mud and sand.
- C. From two hundred and thirty to two hundred and sixty meters from the present shore. Mud and sand partly overgrown with Phragmites communis and terminating in a well-marked beach of sand one meter in height and containing many shells.
- D. From two hundred and sixty to three hundred and sixty meters from the shore. An area more or

less overgrown with steppe plants, and obviously not flooded for a considerable time past. Three hundred and sixty meters from the shore is an ill-defined and relatively ancient sandy beach which contains shell fragments in abundance.

The following species were recognized:

Planorbis planorbis.

Planorbis sp.

Lymnaea truncatula.

L. sp. (palustris?)

No Pisidia were found.

Beyond this is level steppe, but the general configuration of the country indicates that during some former pluvial period it formed part of the lake bottom. An examination of the northern shore of the dry basin in the vicinity of the narrows, four kilometers east of the mouth of the River Djarli, revealed the presence of a great beach 3.4 meters in height apart from smaller shorelines standing below it which have a total elevation of 1.9 meters about <sup>ve</sup> the dry bed of the narrows. It is likely that this beach was formed during the period of the submergence of the beach three kilometers west of the River Djarli as already noted.

In addition to these observations on the lake found in the northern part of the old Ulkun-Karoi, the shoreline of the separate and distinct lake in the south-eastern part of

the basin was also examined. No evidence was found of the existence of molluscs in this lake at the present time, and no remains were to be found in the mud along the present shoreline, but many shells occur in the four small shorelines recently abandoned.

Shoreline of Lake Ulkun-Karoi.

	Elevation above 1933 shoreline.	Distance from 1933 shoreline.	Shells.
Shoreline of 1933	-	-	none.
Algal Mats	.5m	100m	none.
Shoreline A	.8	132	abundant.
" B	1.1	167	"
" C	1.6	181	"
" D	3.6	202	"

The species collected were as follows : L. stagnalis, L. pereger, L. palustris, Planorbis planorbis, Physa fontinalis.

It is interesting to see that these shorelines agree in a general way with those observed on the shores of the lake situated in the northern part of the basin, in spite of the fact that these two bodies of water are entirely separate, have different tributaries, and their drainage basins lie in diverse regions. Obviously therefore the fact that the history of the two lakes since their separation has been similar lends some support to the view that these old shorelines definitely record stages in the climatic cycles, and are not merely the result of local conditions.

The River Djarli runs into the large northern component of Ulkun-Karoi, while the southern member is fed by the River Kara-Su. Similarly there is a tendency for each of the little intermittent streams which run down from the surrounding hills to have its own individual reservoir.

This can be seen in many places in northern Kazakstan, in fact it can be taken as a general principle of the local physiography. This condition has arisen from the climatic conditions acting in conjunction with the somewhat unusual topography. The relief of the floor of the Ulkun-Karoi basin is slight, and the flow of water is confined to a short period in the spring at which time the whole region is more or less inundated. The excess after running down the hillside into the old lake basin collects in the ponds but since the old lake bottom is almost a plane surface there is little or no tendency for drainage channels to be formed connecting one pond with another. The water therefore remains in these small basins indefinitely being subject only to evaporation.

#### Teke.

Lake Teke is a large roughly circular body of water situated one hundred and twenty-five kilometers to the south of Omsk, and forty-five kilometers east of Ulkun-Karoi. The diameter of the lake is about eighteen kilometers but at the present time, as a result of the drop in level the diameter of the actual water surface is fifteen kilometers

or less. The area is about two hundred square kilometers. As in the case of Ulkun-Karoi the lake in addition to the barren sandy flats of the recently exposed lake bottom is surrounded by a gently sloping saline plain six kilometers or so in diameter, from which steep hills arise leading to the rolling table lands above the lake. On the plain between the hills and the lake shore there are innumerable ponds which are fed during the early spring by small intermittent streams. These minor drainage basins carry much of the water which flows down from the hills so that a considerable proportion of the run-off never reaches the main lake, but is retained in small basins nearby. Obviously this results in a maximum of evaporation. In addition to the little channels which run into these ponds, there are ten or more large intermittent streams whose channels run through the plain to the lake, but with the possible exception of Ak-mui-sai and Taldi Sai the period during which they carry water to the lake is very short. The main body of the lake is extremely saline, and particularly along the south-eastern shore there are large flats covered with a white crystalline deposit. No molluscs exist in the lake at the present time, and no shells were found on the lake bottom which has been recently exposed. Likewise nearly all the ponds on the plain near the lake were too salt for molluscs. There is a well-marked sand beach rising one and a half to two meters above the present level of the lake, and at the base of this many empty and bleached shells

of Paludestrina ventrosa were found. This species is commonly found in brackish water near estuaries in Europe, including the British Isles. The whole of the plain referred to, which was at one time undoubtedly lake bottom, is impregnated with salt. From these facts it is clear that Teke has been a saline lake, and an unsuitable situation for molluscs from a remote period.

#### Kizil Kak.

This is a body of saline water situated one hundred and sixty-five kilometers to the south of Omsk and about one hundred kilometers west of the River Irtysh. It is somewhat circular in shape the diameter being in the neighbourhood of twelve kilometers and the total area one hundred and fifty square kilometers. The maximum depth is one and a half meters. Like its neighbours Teke and Ulkun-Karoi it is situated in a deep depression, and steep hills lead down from the surrounding elevated steppe onto a gently sloping plain which surrounds the lake as is the case near Teke, and on this there are many large ponds but in contrast to those found near Teke the water in many of these ponds is fresh. Kizil-Kak is a saline lake, and molluscs do not inhabit its waters at the present time, but empty shells including those of Paludestrina ventrosa occur in an old shoreline marked by drift half a kilometer behind the present shoreline and about sixty centimeters above it. There

are also two well defined beaches besides this one, the first being 1.35 meters and the other 2.70 meters above the present (1933) level of the lake. No shells were found in either of these beaches.

#### Celeti-Denghiz.

This is a large lake situated one hundred and seventy-five kilometers south of Omsk and thirty-five kilometers south of Lake Teke. Its length is nearly sixty kilometers and greatest width about twenty kilometers. The area of its surface is about nine hundred and sixty-five square kilometers. One of the great rivers of the Kirghiz Steppes, the Celeti, empties into this lake at the southern end, but apart from this the tributaries are small and not important in this connection. At the present time Celeti-Denghiz is a saline lake, but it appears that from time to time in the past during wet years the solution there has been diluted so that there have been periods when the conditions of life in the lake have been much more favourable than formerly. This is indicated by the fact that while no molluscs live in the lake at present, shells of Planorbis planorbis are to be found in the former shorelines. A section was taken across the old shorelines on the eastern shore of the lake fifteen kilometers above the mouth of the River Celeti. There are two fairly recent shorelines marked by dry mats of filamentous algae stretching continuously along the sandy mud parallel to the present

shoreline, and two beaches of sand situated behind and above these. The older of these two appears to have been eroded in places by a subsequent rise in level at the time when one of the lower beaches was formed so that in many places it is difficult to find the full series of beaches. In at least one place however all four beaches are to be distinguished.

Shorelines of Lake Geleti-Denghiz.

Shoreline.	Distance from 1933 shoreline.	Elevation above 1933 shoreline.	Character.
A	200 meters.	60 cm.	Dried mats of filamentous algae, no molluscs.
B	425 m.	1.m.	Dried mats of filamentous algae, a few shells.
C	429 m.	1.80 m.	Sand Beach, shell fragments.
D	440 m.	2.95 m.	Sand Beach.

Djaman Tuz.

This lake, which is situated on the Steppe Sari-Dala eighty kilometers southwest of Pavlodar, contains water which is a saturated solution of mineral salts. There are numerous intermittent channels leading into the lake, but no tributaries which contain water permanently. The drainage basin is small, probably about one hundred square kilometers in area. No clearly defined old beaches of this

lake were found but it is obvious that in former times the level stood higher than at present. The shores are without any emergent vegetation and for the most part are covered with a layer of salt crystals. No shells of molluscs were found in or about the lake. It is evident that this has been a saline lake from a remote period.

#### Lake Burlenskoye.

This is a moderate-sized, roughly circular lake about eight kilometers in diameter, situated fifteen kilometers north-west of Slavgorod. The water is saturated with salt. There are two recent beaches on the sandy shore, thirty and sixty kilometers above the level of the water in 1933 as well as an older one standing considerably behind these and rising two and a half meters above that level. The shores are barren, without emergent vegetation, and there is no sign of aquatic life of any kind. No shells were found in any of the beaches.

#### Tuz Sol.

This is a relatively large body of saline water situated about twenty kilometers south-west of the village of Rojdestvenskye, to the south of Akmolinsk. Its shape is nearly rectangular, and the dimensions approximately two by three kilometers. At the time of examination in July 1932 the water of this lake was saturated with mineral salts

and crystal deposition was taking place along the shores. The bottom near shore is composed of finely-divided stinking black mud in which there are no Chiromomidae and there is no emergent vegetation. The conditions of existence were obviously impossible for fresh water molluscs, and no living specimens or empty shells were found in or about this lake. Likewise there was no evidence of the existence of a mollusc fauna in the lake in former times in the form of shells in the sand of an old beach which occurs on the northern shore of the lake approximately thirty-three meters beyond the water's edge (in 1932) and slightly over a meter above it.

#### Uzum Sor.

This lake, situated twenty-five kilometers southwest of Rojdestvensky, is a considerable body of water, its length being seven kilometers while the width is one kilometer. The salt content of the water is less than that of Tuz Sol. Chironomid and other dipterous larvae were extremely abundant. Only the northern end of this lake was examined, but no molluscs were observed, nor were any empty shells found in the vicinity.

#### Terekti Sor.

This lake, which is about thirty kilometers southwest of Rojdestvensky, is comparable in size and shape with the preceding, and appears to be of considerable interest.

The water in July 1932 had receded to a point approximately one hundred meters from a recent shore-line. (1931?) and in doing so had fallen one meter, the old shoreline being marked by dried mats of filamentous algae. A former, but relatively recent shoreline occurs six feet above the present (1932) level of the water. There is a well-marked zonation along the southern shore. A zone of small Phragmites communis borders the strictly terrestrial vegetation along the shore. Further out and towards the center of the lake there is a wide band of Salicornia, and then there is bare mud, more or less incrustated with a brownish deposit of crystals, and then comes the open water of the lake. A careful search was made in the first three of these zones in several different situations, along the shore of the lake but no evidence of the present or past existence of fresh water molluscs was to be found. In this respect Terekti Kul differs very much from Ashi-Kum Kul. (see below).

Terekti Kul is notable for its very rich bird fauna, and also for there being a small group of dwarfed poplar (Populus tremula) on the southern shore. These trees are approximately three feet in height and occur on a steep bank facing directly north, in such a situation that they are protected from the full force of the sun's rays during the greater part of the day and also to some extent against the hot southerly winds which sometimes occur in this region. This is the most southerly point at which trees were observed.

Durt Sart.

This lake which is situated thirty-eight kilometers southwest of Rojdestvensky, is of considerable interest. The area now occupied by water is much less than was formerly the case, but in contrast to the other lakes of this series, the former lake bottom now exposed is not merely a mud flat devoid of vegetation, but is occupied by a luxuriant growth of Phragmites communis. In company with this plant and on the surrounding area the empty shells of molluscs are to be found in great abundance. Molluscs still live in Durt Sart, but the lake as a whole is not now nearly such a favourable habitat as formerly since the water is now restricted to an area of about two square kilometers at the southern end of the basin. The species collected here were: Lymnaea stagnalis, L. palustris, Planorbis planorbis, Bithynia leachii inflata.

Kara Sol.

In the month of July 1932, Kara Sol, which is situated forty-four kilometers southwest of Rojdestvensky, was almost completely dry. The length of the lake within recent years has apparently been in the neighbourhood of six kilometers, but on July 18th 1932, only half a dozen pools, each a few meters in length, remained of the waters of the lake. The remainder of the bottom was a great barren mud flat. Around the edges of this, at the foot of the hills

which surround the lake, is a well-marked old beach of the lake. No molluscs have been observed in or on this beach, on the mud flat, or in any of the ponds mentioned. There is little or no emergent vegetation about the lake.

#### Djarla Kul.

Djarla Kul is situated forty-two kilometers southwest of Rojdestvensky and is a very much less saline body of water than any of those described above. It is a moderately large lake being approximately seven kilometers in length and from two to four in width. The northern shores are of sand or sandy mud and the shallower parts are occupied by large species of Potamogeton growing in great luxuriance. Many living molluscs and empty shells are to be found in the drift cast up on the shore by the waves. Pisidium is especially abundant in this situation. In this respect Djarla Kul resembles Beaverhills Lakes near Tofield, Alberta, Canada, in fact there is a marked similarity between these two lakes in their general appearance, and character of the shores, bottom, and water as well as in the major features of their biota. In the fishes however, the place of Catostomus in Beaverhills Lake is taken in Djarla Kul by Carassius carassius. The following molluscs have been found in this lake: Lymnaea stagnalis, L. palustris, L. pereger, Planorbis planorbis, P. sp., Bithynia leachii inflata, and Pisidium spp.

Ashi-Kum Kul.

This basin, which is situated forty-nine kilometers southwest of Rojdestvensky, is now completely dry. What was formerly the bottom of the lake is now a great mud flat, but in contrast to similar situations in other lake beds in the vicinity this mud flat bears the empty and bleached shells of molluscs in great abundance.

Along the borders of the basin, in the region which was occasionally flooded in former times during periods of extremely high water, there is a zone in which the steppe grasses are mingled with a few very small Phragmites communis. In this belt the empty shells of four species of aquatic molluscs are to be found, ~~three of~~ these species occur here in great abundance, Lymnaea palustris, Planorbis planorbis, Physa fontinalis, Bithynia leachii inflata and Pisidium spp. Beyond these zones, and occupying the whole of the center of the basin is a large flat, roughly circular in shape, with a diameter of from two to three kilometers, this is the old lake bottom. The empty shells of all of the above mentioned species of molluscs are found in this area, either on the surface or embedded in the first few centimeters of the somewhat saline greyish or black soil. The shells of gastropods are not as abundant here as in the preceding zones, and it is evident that during the final stages before the complete disappearance of the water, this lake did not afford such favourable conditions

for molluscs as previously. The species represented on this large mud flat are the same as those found on the higher shorelines but their number is very much reduced except in the case of the Pisidia which occur in great abundance.

In Ashi-Kum Kul therefore, there are three well-defined zones marking levels of the lake at different times.

- a. An area submerged only at times of extremely high water.
- b. An area marked by a belt of emergent vegetation which formed the most favourable habitat for the gastropod mollusca.
- c. The old lake bottom, which toward the end of the life of the lake was not a particularly favourable situation for molluscs in general and was inhabited chiefly by species of Pisidium.

It should be pointed out however, that these shorelines are of recent origin and not comparable in age with the higher shorelines of many of the other lakes examined. In all probability these shorelines of Ashi-Kum Kul have been occupied within the past twenty years, although with a climate such as that of Kazakhstan it is difficult to make an estimate of the age of the sub-fossil deposits.

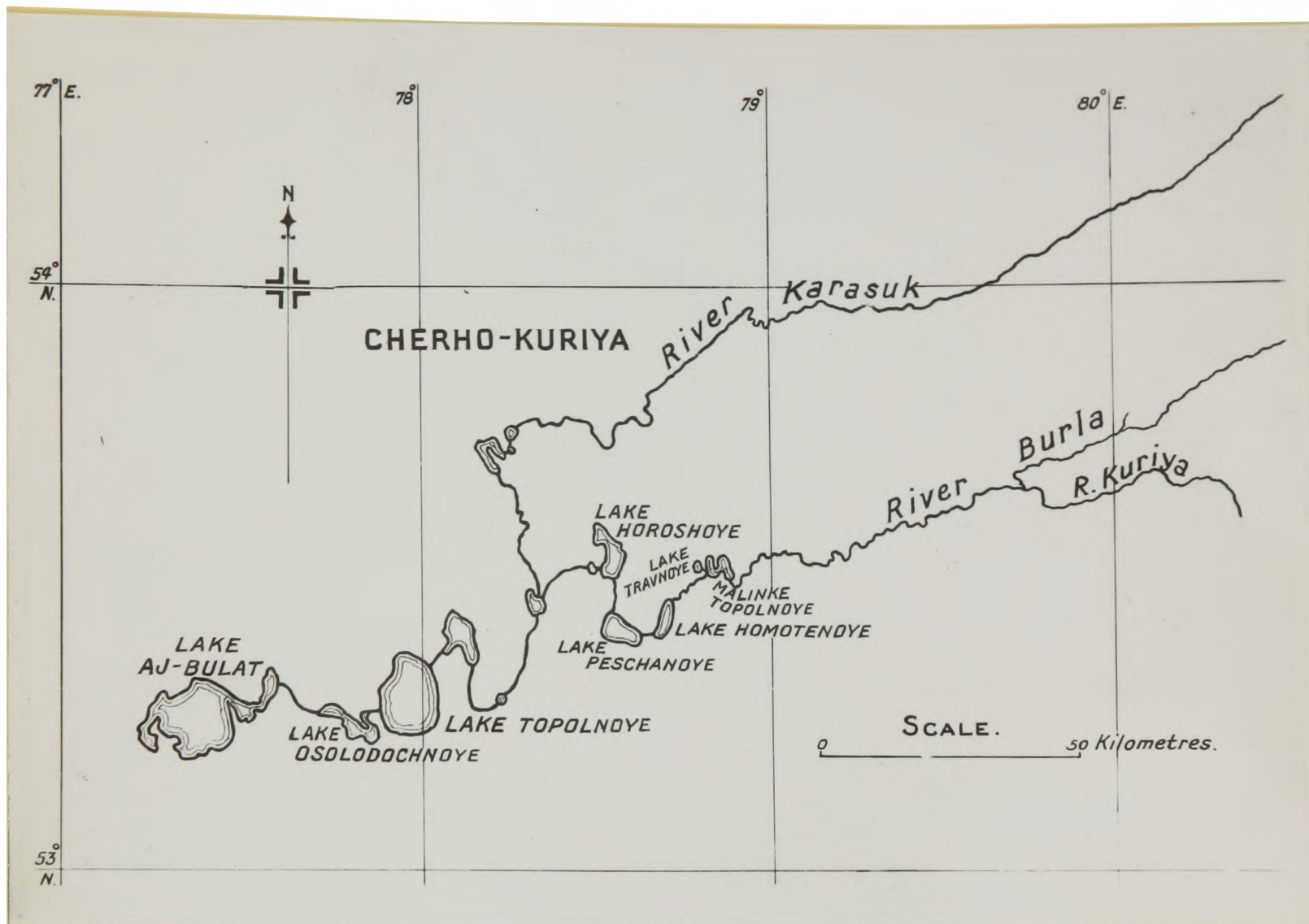


Plate 11.

Sketch map of the Aj-Bulat drainage basin.

The Aj-Bulat Basin.

Aj-Bulat, a lake which forms the center of a large inland drainage basin is situated three hundred and ten kilometers southeast of Omsk and three hundred and seventy-five kilometers north of Semipalatinsk. It is a large, more or less circular lake about fifteen kilometers in diameter. The water is saturated with mineral salts, and around the edge there is a white incrustation of salt about half a kilometer in width. Along the southern and eastern shores an old shoreline one meter in height occurs at a point one half kilometer behind the present one and a second one hundred meters behind this one and a half meters in height. In the succeeding four hundred meters (i.e. between six hundred and a thousand meters from the present shoreline) there are five small but moderately distinct former levels marked in the sand, the total elevation being one and a half meters. Approximately one hundred meters beyond these again there is a strongly marked beach which along the southern shore is one meter in height but this increases along the eastern shore to two and a half meters. No molluscs live in the lake at present and none were found in any of the beaches mentioned.

A stream ten kilometers in length (in which there was no water in 1933) runs into Aj-Bulat from Lake Osolodochoye the next lake of the series. The water of this lake is not so saline as that of Aj-Bulat but it is likewise

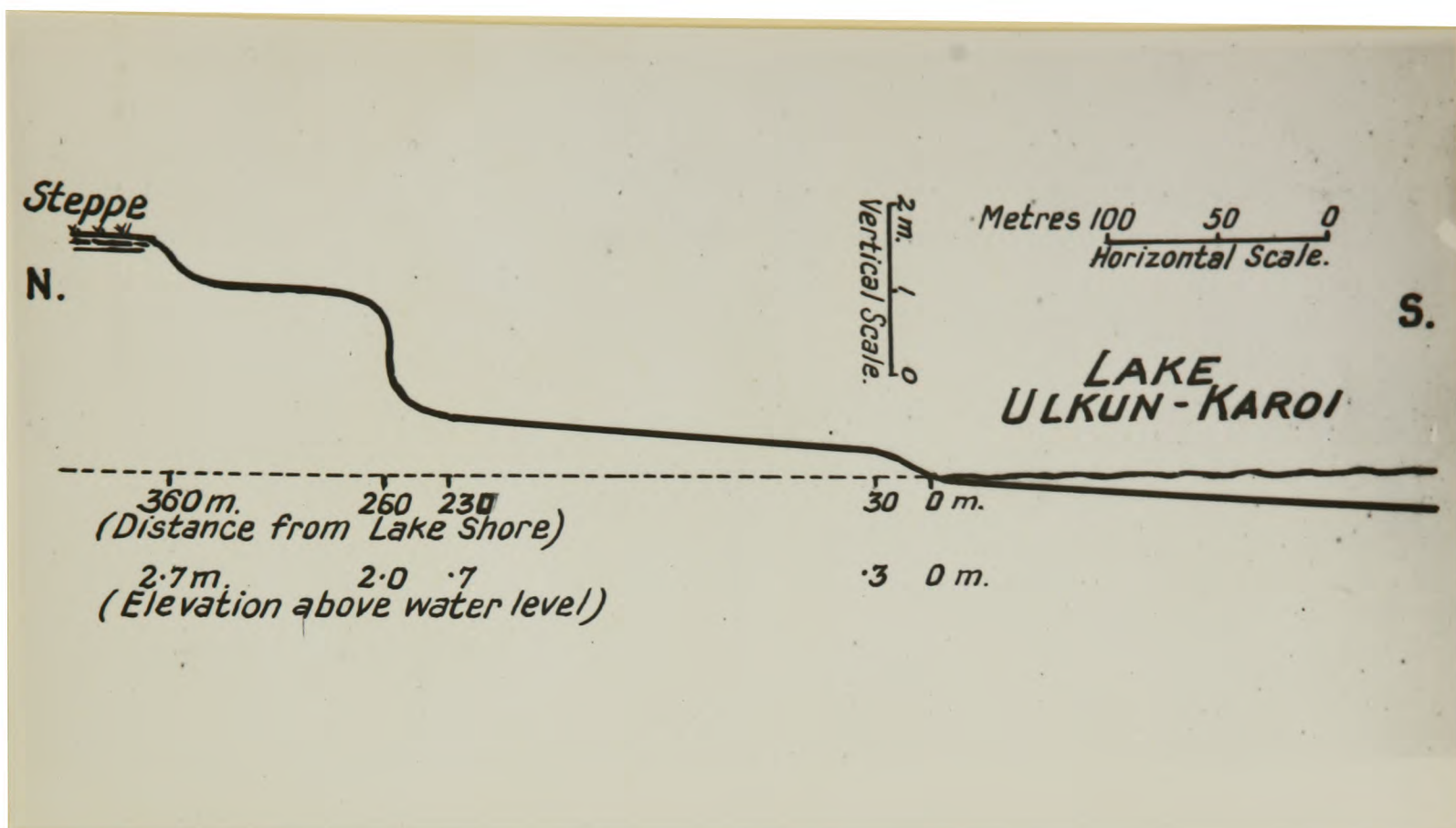


Plate 12, fig. 1. Diagrammatic cross section of the shorelines of Lake Ulkun-Karoi.

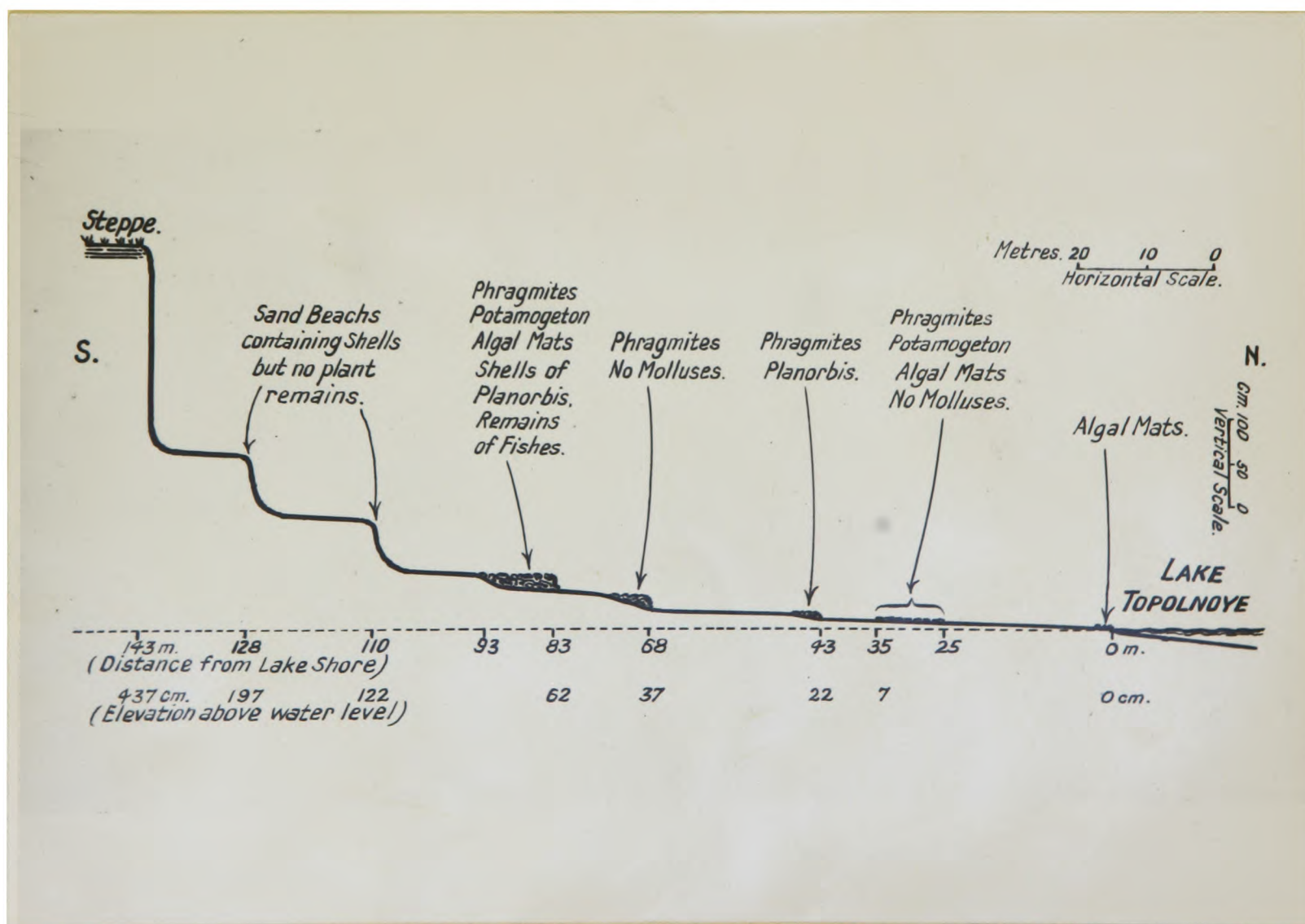


Plate 12, fig. 2. Diagrammatic cross section of the shorelines of the larger Lake Topolnoye.

surrounded by a saline deposit, although it is not as heavy as that in the lower lake. Four well-marked old shorelines can be seen along the southern end of the lake, the highest being about five meters above the present level. No molluscs were found either living in the lake or as fossils in the old shorelines.

Three kilometers above Lake Osolodochnoye there lies Lake Topolnoye which is roughly fifteen kilometers in length and ten in width. In times of high water a stream runs from Topolonoye into Osolodochnoye but not at the time of this expedition. The water in Lake Topolnoye is saline, but less so than in Osolodochnoye. No evidence was found of the existence of molluscs living in this lake at the present time, but there were a few shells in a former shoreline forty-three meters behind that occupied at present and in other higher shorelines they occur in abundance. In former times, apparently, the lake contained water less saline than at present and molluscs flourished in it. While this may have been true of Aj-Bulat and Osolodochnoye at one time it must obviously have been at a much more remote period, since no fossils are to be found in their old shorelines.

The shorelines discovered in this lake were as follows :-

- A. The present shoreline. Mats of filamentous algae and Potamogeton being washed upon the shore. No evidence of the occurrence of molluscs.

- B. A recently abandoned shoreline ten meters in width marked by old and dried mats of algae together with the dried leaves and stems of Potamogeton. No shells.
- C. A poorly defined shoreline composed of small pieces of Phragmites. Empty and bleached shells of Planorbis planorbis occur rarely.
- D. A small beach somewhat indefinitely marked by drift. Made up of small pieces of Phragmites, no shells.
- E. A strongly marked shoreline, ten meters in width built up of dried remains of Phragmites, Potamogeton and dried algal mats. Shells of Planorbis and the remains of thousands of small fishes (Carassius ?) were found here.
- F. A well-marked beach of sand. Many shells of Planorbis planorbis, Lymnaea, sp. and a Naiad (Anodonta sp). No evidence of aquatic plants.
- G. Another beach similar to "E" and containing Planorbis planorbis, fragments of Anodonta and Lymnaea sp. No plant remains.
- H. A beach or erosion-scarp, two meters in height leading to the steppe. Without fossils.

The total elevation from beaches "A" to "G" is two and a quarter meters. It is evident from the fossils found in beaches "F" and "G" that at one time Lake Topolnoye contained a definitely fresh water fauna at some remote period. Since that time the level of the lake has fallen and the

water has become increasingly saline, with occasional intervals of relatively fresh water as evidenced by the remains found in shoreline "E".

The next lake of this series to be examined was Lake Khoroshoye, situated thirty-five kilometers north-west of Lake Topolnoye. Its length is eleven kilometers and its width three kilometers. The maximum depth is said to be about three meters. The water is somewhat saline but is used for drinking purposes by the inhabitants of the surrounding district. The shores are of sandy or sandy mud and are barren of emergent vegetation. Lake Khoroshoye is chiefly remarkable for the large number of fresh water mussels, Anodonta cygnea (Linne) and A. Anatina (Linne) which are found in it. During every storm hundreds of these mussels are washed up on the shores. Nowhere else in the drainage basin is this species so prevalent. Empty shells of gastropods occur in moderate numbers around the edge of the lake, the species represented being as follows: Lymnaea stagnalis, L. palustris, L. pereger, Planorbis corneus, Planorbis planorbis, Physa fontinalis, and Bithynia leachii inflata. Fish are common in the lake, there being ~~four~~ <sup>three</sup> species namely, Esox lucius, Carassius carassius, and Perca sp.

At high water a stream connects this lake by a tortuous channel with Lake Topolnoye, and at such times there is also a stream entering Lake Khoroshoye from the next one above it in the series, namely Lake Peschanaya.

Lake Peschanaya is a small body of water in comparison with some of the lower lakes being only three by seven kilometers. As a general rule the lakes in a system of this kind decrease in size upstream from the ultimate reservoir. The shores of Pershanaya are low and gently curving. Four distinct old shorelines can be made out above the present one, but according to the local inhabitants all of these have been occupied in recent times. The crest of the highest of these beaches stands three and a half meters above the present (1933) level of the lake, while that of the lower ones stand respectively one meter forty centimeters, and seventy-five centimeters, above it. No molluscan fossils are found in these beaches although living specimens occur in the lake at the present time. The specimens collected being as follows: Lymnaea stagnalis, L. pereger, L. palustris, Planorbis corneus, P. planorbis, P. sp., Bithynia leachii inflata, Anodonta sp.

Lake Khomotenoye, the next lake in the series, lies two kilometers above Lake Peschanaya and is connected with it by a small stream in which there was no water flowing when it was examined in June 1933. This lake is similar to the one below it except in that there is rather more emergent vegetation. Three old shorelines can be found, situated respectively fifteen centimeters, ninety centimeters, and two meters forty centimeters above the 1933 level. Shells of a mollusc (Planorbis planorbis Linne)

are found on the surface of the middle one of these (90 cm above 1933 level) but a careful search has failed to reveal any shells actually embedded in the sand of this beach so that it appears that the shells were deposited on the top of this moderately old beach during a period of high water in relatively recent times. Valvata antiquilina Mozley is also found on this shoreline. Just as the water of Lake Peschanaya is slightly less saline than that of Khoroshoye that of Lake Khomotenoye appears to carry less mineral salts than Peschanaya, but the difference is small. Fresh water molluscs are common in Khomotenoye although the fauna is not very varied. As far as the observations go, the fauna is the same as in Lake Peschanaya.

Two kilometers above Lake Khomotenoye the River Burla flows through a marshy area overgrown by Phragmites communis. It appears that there is usually a slight flow through this section of the stream and at any rate the evaporation is not sufficient to give rise to severely saline conditions. This is probably the result because of the relatively fresh water flowing into this little basin. Lymnaea stagnalis and Planorbis corneus occur here in considerable abundance, but during a short examination no other species was collected.

Nine kilometers north of the upper end of Lake Khomotenoye and connected with it by the small stream mentioned, there lies another small lake called Topolnoye

which is quite distinct from the other lake of that name already described. The water in this lake is slightly fresher than that of Khomotenoye. Two distinct old beaches can be made out on the shore standing fifty centimeters and one meter twenty centimeters respectively above the present (1933) level. No shells were found in these beaches, but the following species were collected in the lake : L. stagnalis, L. pereger, L. palustris, Planorbis planorbis, P. johanseni, Bithynia leachii inflata, Valvata piscinalis.

Beyond this Lake Topolnoye the River Burla continues for one hundred and forty kilometers to the north-east, its source being only twenty-five kilometers from the River Ob at Krutikha, but there are no lakes of any size further up the course of the stream. There is, however, an interesting body of water which is tributary to the upper Lake Topolnoye. This is Lake Travnoye a small body of water circular in shape and two kilometers in diameter, situated one kilometer to the west of Lake Topolnoye with which it is connected by a small stream. All the lakes of this basin which have been described so far have been in the main course of the River Burla as will be seen by reference to the accompanying map. It is obvious that a stream such as the Burla the waters of which flow by a much convoluted channel through more or less saline soils will pick up on its way downstream, a considerable amount of mineral matter, so that when it reaches the upper Lake Topolnoye

the river water will be by no means fresh. Below this point it passes at times of flood gradually downstream from lake to lake, but its progress is slow and there is a considerable loss by evaporation, the salinity increases downstream in each succeeding lake until in the lower Topolnoye it is sufficient to preclude altogether the existence of molluscs in the lake. In all these lakes the water is more or less saline quite without regard to local conditions. Lake Travnoye stands in marked contrast to this. The lake is a separate entity which is tributary to the Burla, and the waters of that stream do not flow through this lake on their way downstream, and as a result the salt content of the Travnoye water is a reflection of purely local conditions and not those of the whole territory stretching for one hundred and fifty kilometers to the north-east. As a result of this Lake Travnoye has water which is only very slightly saline, and the molluscan fauna is rich in point of individuals and as varied as the geographical conditions permit. The following species were collected: Lymnaea stagnalis, L. palustris, L. pereger, Planorbis corneus, P. planorbis, P. johanseni, P. leucostoma, P. sp., Segmentina nitida, Valvata piscinalis, Bithynia leachii inflata, Anodonta cygnea, Anodonta anatina.



Plate 13, fig. 1. A typical intermittent stream on the Steppe 20 km, south of Mai Balik.

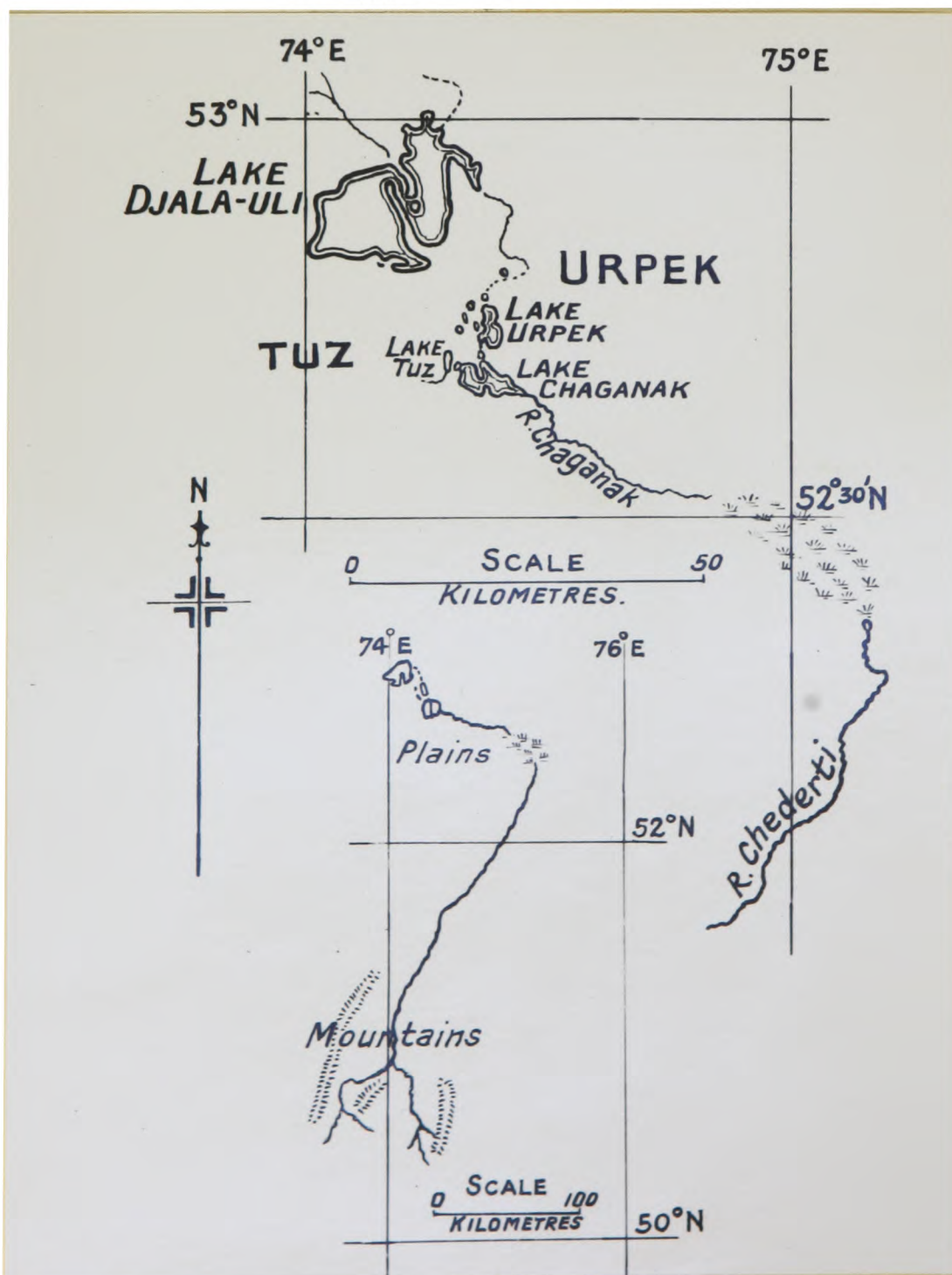


Plate 13, fig. 2. Sketch maps of the Djarla-uli drainage basin.

The Djala-Uli Basin.

Lake Djala-Uli, situated two hundred and thirty kilometers to the south of Omsk and thirty-two kilometers south-east of the mouth of the River Celeti is the ultimate reservoir of an extensive drainage system. To the north of the lake the basin does not reach very far, there being only one or two intermittent tributaries running from this area into the lake, but to the south and east parts of the country up to a distance of two hundred and fifty kilometers are tributary to Djala-Uli. In spite of the extensiveness of the basin the drainage channels are so inefficient under present climatic conditions that by far the greater part of the run-off never reaches the ultimate reservoir, but is trapped in secondary basins and evaporates from them. The principal and only large tributary of Djala-Uli is the River Chaganak, which throughout the upper part of its course is known as the River Chederti. This stream rises in the mountains called Byeli-Agach, Niyaz, and Kotur-Kizil-Taw at about North Latitude  $50^{\circ}$ , East Longitude  $74^{\circ}$ , and runs north-eastward leaving the mountains at about North Latitude  $52^{\circ}$ . About eighty kilometers beyond this point it becomes involved in a large area of marsh and morass in which it is difficult to follow the main channel. The general course turns north westward, and at about North Latitude  $52^{\circ} 30'$ , East Longitude  $74^{\circ} 40'$  there is once more a well defined channel

ten meters wide, in which at the middle of the month of May 1933, was a stream five meters in width and thirty centimeters in depth. Below this point the stream flows through saline country and Lake Chaganak, into which it flows, is at times a moderately saline Lake. In the year 1933 there was no outflow from Lake Chaganak into Lake Urpek and thence into Djala-Uli, but in years of high water an outflow regularly occurs. There are three poorly defined old shorelines above the present one in Djala-Uli, each about sixty centimeters in height. No molluscs live in the lake at the present time and none were found in the beaches mentioned. However, in most of the smaller lakes situated from ten to twenty kilometers above Djala-Uli and including Lakes Urpek and Chaganak, aquatic molluscs do occur although not in any great variety. An exception to this is the saline Lake Tuz which it appears has not for a long period been in the course of flow downstream from one lake to another. In the marshy area situated thirty kilometers and more above Lake Chaganak, molluscs occur in great abundance and some variety. Above this point they are found here and there but apart from members of the Sphaeriidae the life conditions in this part of the stream are not especially favourable for molluscan life.

The fauna in most cases is made up of Lymnae stagnalis, L. pereger, L. Palustris, and Planorbis planorbis. In one saline pond L. palustris kazakensis Mozley was found alone.

A good many shells are to be found along the shores of Lake Chaganak, particularly at its upper end, in the vicinity of the mouth of the River Chaganak, but it is difficult to judge whether any of them were actually inhabitants of the lake, None were alive there in 1933.

Above Lake Chaganak the water is decidedly fresher, and at a distance of about forty kilometers from the lake there is a large marshy area overgrown with Phragmites communis, and in this vicinity molluscs are very numerous. The principal species are: L. stagnalis, L. palustris bolotensis, Planorbis corneus, P. johanseni, P. leucostoma, Physa fontinalis, Aplexa hypnorum, Bithynia leachii inflata.

## SUMMARY AND DISCUSSION.

Certain general conclusions stand out from the above account, and may be summarized as follows :

1. In the northern part of Kazakstan and southern Siberia between East Longitude  $60^{\circ}$  and  $80^{\circ}$  there are numerous isolated inland drainage basins which, as a result of changes in climate no longer have functioning outlets, and so have no connection with the usual channels of drainage. Subsequent to the loss of their outlets these lakes have become increasingly saline.
2. It is evident from the old shorelines, which almost without exception are found encircling these lakes, that there are both long-period and short-period cycles in the climate of this region and that both within recent years, and from a remote period the general tendency in the climate has been toward increasing desiccation.
3. The increasing dryness has resulted in a considerable retrogressive<sup>1</sup> rearrangement of the channels of drainage within these isolated basins. As a result of this there are now a great many small lakes and ponds, situated in what was formerly the basin of a single large lake, and each of these bodies of water is fed by a single stream. The commencement of this process

<sup>1</sup> Retrogressive from the standpoint of the development of the landscape.

is marked by the loss of the outlet of the ultimate reservoir of the basin; this is followed by a similar isolation of the tributary lakes; after which numerous small separate basins form on the floor and sides of each of the lakes. Each of these miniature reservoirs has a single inlet stream. The ultimate fate of such small basins, as the country becomes drier depends upon the nature of the substratum upon which the lake rests. If this is impermeable the floor of the lake or pond becomes a salt flat, covered by salt crystals and barren of vegetation, if it is permeable the site is occupied by herbs and grasses.

4. The events following the isolation of a lake basin in this region have an unfavourable effect upon the fauna of aquatic molluscs. The usual fauna of small fresh water lakes in this region is made up of such species as Lymnaea stagnalis, L. palustris, L. pereger, Planorbis corneus, P. planorbis, P. compressus, P. contortus, Bithynia tentaculata, B. leachii inflata, Physa fontinalis.

As might be expected, the branchiate snails (Bithynia) are the first to be eliminated from the fauna after the advent of increasing salinity. Of the pulmonate species the least tolerant of saline conditions is Planorbis corneus, while those having the greatest resistance are Planorbis planorbis and two subspecies

of Lymnaea palustris (viz. L. palustris saridalensis Mozley, and L. palustris kazakensis Mozley).

The remaining species (L. stagnalis etc.) react more or less as a group, although Physa fontinalis appears to have slightly less ability to withstand an increase in salinity than the other species mentioned.

It is evident that in lakes of this kind the saline conditions may effect the mollusc fauna in two ways. First in a direct physiological manner, and second by bringing about the destruction of the aquatic and marsh vegetation upon which these animals are dependent for food and shelter. It is suggested that the first of these is the explanation of the early disappearance of Planorbis corneus from lakes of this kind, as this species is eliminated from the fauna previous to the marshy areas being destroyed. Whereas it seems probable that the group species headed by Lymnaea stagnalis disappears from the fauna at the same time or soon after that has taken place so that it is reasonable to suppose that the two groups are correlated in the food chain as suggested above. Planorbis planorbis, Lymnaea palustris saridalensis, and Lymnaea palustris kazakensis sometimes survive in these saline lakes for a considerable time after other species have disappeared.

ANALYSIS OF WATER FROM LAKES IN NORTHERN KAZAKSTAN, JULY 1932.

Nos. 1 and 2 collected by Alan Mozley, Nos. 3 and 4  
by the Hydrological Institute of Leningrad.

Analysis by the Hydrological Institute. Published by permission of the Director.

No.	Name	milligrams per litre				Mg.	
		Cl.	SO <sub>4</sub>	H <sub>2</sub> CO <sub>3</sub> --CO <sub>3</sub>	K & Na		Ca
1.	Tuz Sol	189,696.0	28,751.25	5088.0	96688.0	843.70	25,788.3
2.	Durt Sart	3,145.65	647.66	603.0	1922.25	184.82	315.52
3.	Bouldi Kul	164.82	142.99	328.25	238.25	60.08	5.70
4.	Mai Balik	868.32	167.13	318.0	540.0	67.56	99.6

THE FRESH WATER MOLLUSCA INHABITING  
TEMPORARY PONDS IN CANADA AND SIBERIA.

As has already been mentioned in a preceding section, there is in parts of the Sub-Arctic Region a particular type of temporary pond, formed in spring by the melting of the accumulated winter's snow, (See also p.163) which is of great interest from the standpoints of biology and geography. These ponds are formed by the snow-water collecting in small depressions, in which it remains for a period of a month or more before evaporating or being absorbed by the soil. As a rule ponds of this kind are periodical features of the landscape, being formed regularly each year, and hence, in spite of the long dry period lasting for ten months or more, it is possible for a considerable number of aquatic invertebrates to maintain themselves. The most characteristic of these animals are phyllopod crustacea of the genera Branchipus, Apus, and Lepidurus. Quite common, but less characteristic are species of Limnetus and Estheria. In addition to these there are a large number of other animals. An account of the fauna of a pond of this type in Canada has already been published (Mozley, 1932) and since that work was done observations have been made on a large number of other ponds in that region. During the years 1932 and 1933 several similar habitats in Siberia were examined, and it may be of interest to give a brief account of

the mollusca found living in this rather peculiar type of habitat in North America and northern Asia. The landscape types and faunal regions of the northern part of these two continents are comparable, so that it is highly desirable that a more precise comparison of the prevailing habitat types and their fauna should be undertaken, and this is one contribution to that end.

Temporary ponds of the type mentioned are very similar in Canada and Siberia. As a rule they consist of small shallow depressions which are overgrown by grasses and herbs. Further southward, in the steppe region of both continents the temporary ponds become increasingly saline, and under these conditions the vegetation on the bottom of the pond-sites gradually disappears, so that there is little food for any animals which might be able to endure the saline conditions.

The annual history of a pond of this type is somewhat as follows: in the latter part of the month of March, or more commonly early in April, there occur a series of warm days during which a considerable part of the winters accumulation of snow melts, and the water runs into shallow depressions on the surface of the soil. It is characteristic of the climate of these regions that the first spring thaw is often followed by a return of winter weather, but as a rule by early April many ponds are being formed. The length of time that the water remains in the ponds varies with the climate from year to year, and also with the situation,

depth, and drainage area of the ponds. The shortest period appears to be about one month, and the longest about two and one half months. During this period the various aquatic animals must complete their life cycle. The snails pass the winter in a more or less adult condition, mate early in the spring, and lay eggs shortly thereafter, so that the new generation is relatively mature by the time the pond is dry. The water disappears from the pond by evaporation, and absorption into the soil, at a fairly gradual rate, and when this happens the molluscs crawl into crevices and aestivate until the following year. The months of July and August are usually hot and dry and at this time the pond sites are subject to severe desiccation. The autumn in both Canada and Siberia is cold, and the precipitation during the latter part of this season is commonly in the form of snow. In some years there may be considerable rainfall during September and October, but this is never sufficient to fill the temporary ponds. The winter in both these regions is a season of great cold, and temperatures of  $-40^{\circ}\text{C}$ . are by no means unknown. Temperatures below  $-30^{\circ}\text{C}$ . occur commonly each winter. In many cases the dormant organisms are protected to some extent by a blanket of snow over the surface of the ground, but as the frost penetrates the soil to a depth of two meters or more, it is obvious that they must be exposed to moderately low temperatures.

At least in some respects the mollusca often occupy a predominant position in the fauna of these ponds, both in Canada and Siberia, and it has been observed that there is considerable diversity in the species found in different ponds and in their relative abundance. It is probable that the gross differences in the life-conditions which are readily observed in the ponds, favour some species more than others. Thus, as has been described in the previous paper (Mozley 1932 p. 247), there may be considerable differences in the fauna of two separate parts of a single pond. There are four general conditions, however, which appear to be essential to the existence of mollusca in ponds of this kind, namely :

- (i) the periodical occurrence of the aquatic phase of the pond.
- (ii) the persistence of water in the pond for a reasonable time after it has once formed.
- (iii) the continuance of fresh water conditions.
- (iv) the presence of a fairly rich growth of terrestrial plants on the site of the pond to serve as food for the animals during the aquatic phase.

To these may be added one other condition which is applicable only in certain special cases, viz.

- (v) the periodical occurrence of a period of desiccation.

It is hardly necessary to point out that, in any one year, all of these conditions must be fulfilled at least to the extent of the minimum requirement of each species if they are to survive and be permanent inhabitants of the pond, and when the variation in the climate from year to year is borne in mind, it is somewhat remarkable that these ponds have at all a varied fauna. All of the conditions mentioned above are to some extent affected by the general geographical conditions of the country as a whole, in fact the presence of this particular type of pond is often a trustworthy indication of a certain combination of climatic conditions. These will be discussed in another paper, the present note being more concerned with the molluscan fauna.

It has been pointed out in the previous paper (Mozley, l.c.) that many of the organisms make their appearance very soon after these ponds are formed each spring, and that many snails are to be found active on the first day that such a pond contains water, while there is still a great deal of snow and ice in the immediate vicinity. The time factor is extremely important in habitats of this kind, and often determines whether or not a species is to complete its life cycle in any one year, and thus that it is to continue to be a member of the pond fauna. The temperature of the water in the pond is therefore of primary importance

to many of the aquatic organisms. Practically nothing is known about temperature conditions in ponds of this kind, and it therefore appeared to be desirable to obtain precise observations in the field. Two series of temperatures extending over full twenty-four hour periods are given in the accompanying tables. The series in the pond near Alexandrovka was taken early in the season (April 26) at which time there was a large snowdrift, one and half meters in height, in the center of the pond. The series from Kara Bedank was taken toward the end of the period of the existence of temporary ponds (May 26), and just before the commencement of the hot weather. The highest temperature found in any temporary pond in the course of this expedition, was 29.8°C., observed in a temporary pond near the eastern end of Lake Chaganak, at 1.30 P.M. on May, 19, 1932, the air temperature at that time being 26.5°C. The significant fact brought out by these observations is that the temperature of the water is relatively high very early in the season while there is still snow in these ponds, this is also the case during the cold nights later in the season. This makes it possible for the animals to develop rapidly, and thus there is a greater chance of their completing their life cycle before the disappearance of water from the pond.

An intermittent stream which runs into Lake Celeti-Denghiz about fifteen kilometers north of the mouth of the River Celeti affords an instructive example of the course

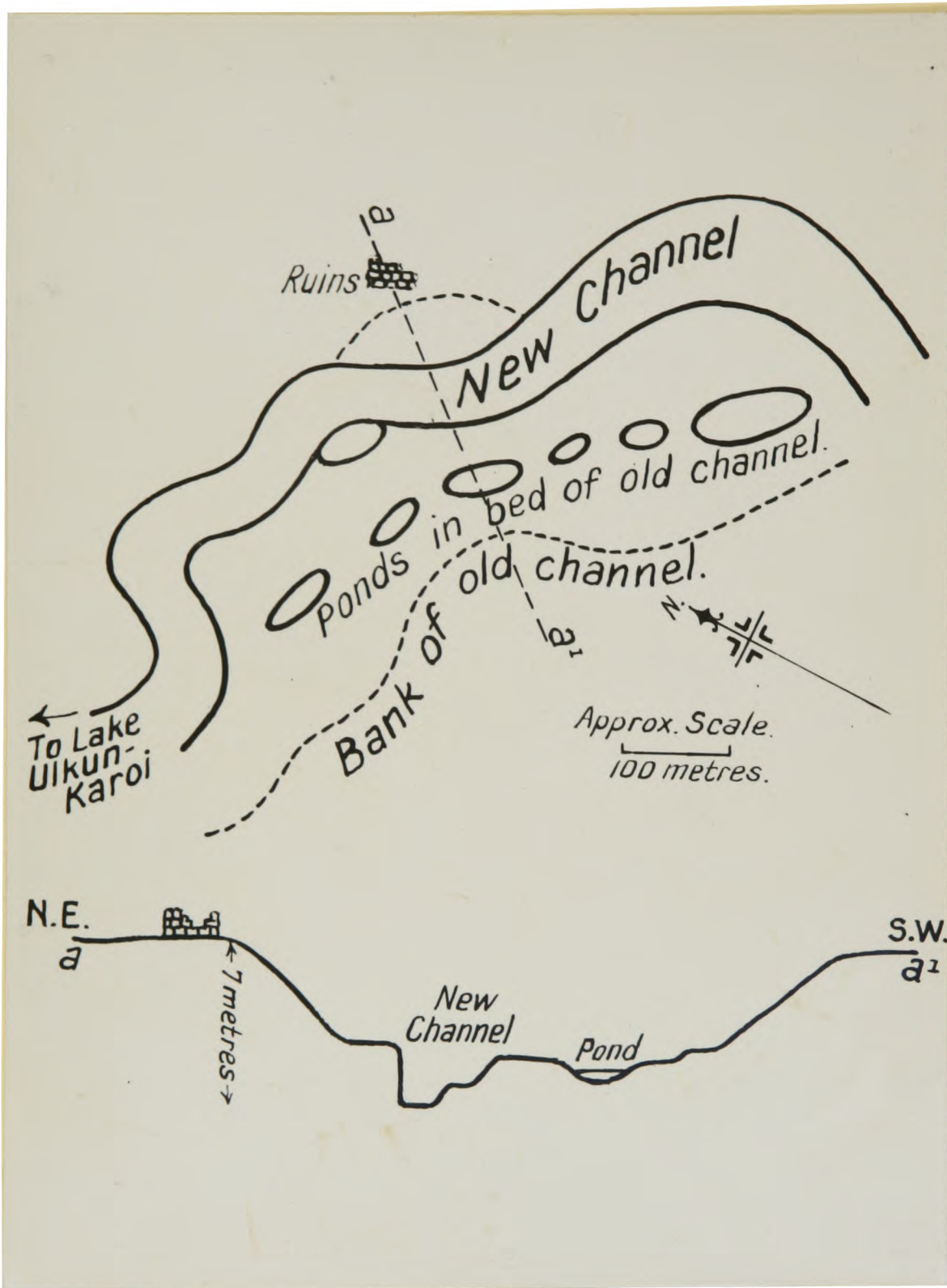


Plate 14.

Sketch map of the intermittent stream bed 8 km. east of Lake Celeti-Denghiz.

of development of this type of stream in relation to the development of temporary ponds and their molluscan fauna. In former times, when the level of the lake was considerably higher than at present a stream of moderate size with a shallow valley about one hundred and thirty meters in width flowed down from the hilly country which lies to the east. After the level of Celeti-Denghiz had fallen approximately to its present low level this stream commenced to cut a new channel through its bed at a lower level in conformity with the new conditions existing in the lake, commencing at the mouth and continuing gradually upstream year by year. As the flow of water in this stream is confined to a short period in the spring of each year, however, the process of cutting the new channel takes place slowly. Twelve kilometers from the lake this stream enters the hilly country, and while the old bed of the stream consists of a wide depression with gently sloping sides, the new channel is cut in the bottom of this, as a narrow ravine with steep and often perpendicular walls.

In the bed of the old stream there are many ponds which have been scoured out by the force of the current. These ponds contain water for a considerable time after the freshet, and are inhabited by the characteristic temporary pond animals including molluscs. At a point approximately eight kilometers from the shores of Celeti-Denghiz the new channel of the stream has been cut through the bed of the older one in such a way that the essential features of both the new

and old stream bed are retained intact for a distance of about half a kilometer. This condition is shown in the accompanying figure . The freshly cut channel, on the northern part of the channel is completely barren, while a few meters to the south there is a series of ponds formerly in the old stream bed which is now isolated by the change in level. In the early part of the year these ponds are swarming with invertebrate life of the characteristic temporary pond type (see Mozley, l.c.) The new stream bed on the other hand is not at all a suitable situation for these animals. It consists of bare clay and silt without any organic matter which might serve as food, and while during the early spring there is water in abundance as well as a very swift current, after a very short period the bed is dry. It is therefore, an altogether unsuitable place for molluscs and the majority of other aquatic animals, as regards food, force of the current, and duration of the aquatic phase. A few empty shells with the whole of the periostracum worn off were found in the bottom in one or two places but these had obviously been carried in from some habitat upstream.

In the western part of Canada east of the Rocky Mountains, the following species of molluscs have been found in temporary ponds formed by melting snow:

Lymnaea palustris Müller

Lymnaea caperata Say

Planorbis umbilicatellus Cockerell

Planorbis exacuous Say

Planorbula crassilabris Walker

Planorbula campestris Dawson

Aplexa hypnorum Linne

Sphaerium occidentale Prime

With the exception of Planorbula crassilabris Walker, and Sphaerium occidentale Prime, all of these are of moderately common occurrence in the temporary ponds of the area. P. crassilabris was found only on one occasion, but as the specimens concerned were identified by Walker himself there appears to be no valid reason for discarding the record. In 1927 Sphaerium occidentale Prime was found in what appeared to be a temporary pond near Mile 17, Hudson Bay Railway, Manitoba, but although this species is reported to be common in "swales" (ponds or marshy areas which become dry in the summer) in the north-central part of the United States, it is very uncommon in the temporary ponds of Western Canada. In 1929, 1930, and 1931 an intensive study was made of ponds of this type in the steppe and forest-steppe regions of Manitoba, Saskatchewan, and Alberta. Three hundred and fourteen ponds were examined and Sphaerium occidentale was found in five of them, or in less than two percent of the ponds. These two species may therefore be regarded merely as stragglers or occasional immigrants into the temporary ponds of this area. It is noteworthy that Planorbula campestris Dawson (of which P. christyi Dall is a synonym) has never been found in any other type of habitat.

In Siberia and the northern part of Kazakstan the molluscan fauna of temporary ponds includes the following species:

Lymnaea palustris(Müller)

Planorbis leucostoma(Millet)

Segmentina nitida (Müller)

Aplexa hypnorum (Linne)

Musculium lacustre (Müller)

All of these are of reasonably frequent occurrence, but Aplexa hypnorum is found less often than the other species. It is possible that Planorbis contortus (Linne) may also occur in these habitats in Siberia, but during the expedition of 1931-32 no really reliable instance of this was found.

The mollusc fauna of such ponds in western Canada therefore, consists of eight species, of which two are probably stragglers, while in northern Asia there are five species, with the possible addition of one other. It is interesting to compare these from the standpoint of their local and geographical distribution. It will be seen that two species, Lymnaea palustris and Aplexa hypnorum are common to such situations in North America and northern Asia. Both of these are hardy species of wide local distribution. There are also several other species occurring in temporary ponds, which while they are more or less indigenous to North America, or Eurasia as the case may be, have a distribution within those areas equally as wide as that of the two circumboreal species noted above. These are Lymnaea caperata and Planorbis exacuus in North America, and Planorbis leucostoma,

Segmentina nitida, and Musculium lacustre in Siberia and Kazakstan. Standing in marked contrast to these there are two species in the Canadian temporary ponds, namely Planorbis umbilicatellus Cockerell and Planorbula campestris Dawson, which have a restricted distribution, and so far as is known at present, are found only in ponds which are dry during the summer. These are therefore specialized species, which are adapted to life in temporary ponds, and in this respect they are to some extent comparable with certain of the phyllopod crustacea (Eubranchipus, Lepidurus, etc.) with which they are associated.

It may be noted in passing that these are strongly characterized species, which are not likely to be confused with any other forms. It appears that a similarly sharp division into hardy forms of wide distribution and especially adapted forms with a limited geographical range, exists in many of other members of the temporary pond fauna. The distribution of Planorbis umbilicatellus more or less coincides with that of the steppe and forest-steppe regions, although there is one record (Brereton,) from the forested region on the edge of the Canadian Shield in the eastern part of Manitoba. Plaorbula campestris is a more northern species, and has only been found a few times in the United States, and then only in North and South Dakota. In the western part of Canada east of the Rocky Mountains it is common, so that it would appear that the more severe climate, or more probably

the more stable climate without winter thaws, or considerable autumn rains, acts as a favourable influence for this species.

Regarding the extent of adaptation to these special conditions on the two continents, it may be said that although temporary ponds formed by melting snow are equally common in the northern part of Asia, as in Western Canada, and have an equally rich fauna, barring the doubtful case of Planorbis leucostoma, there has not been any special adaptation on the part of the mollusca in Northern Asia to life in ponds of this kind. While it is difficult to make valid general statements at this stage in the work, it may well be typical of northern Asiatic mollusc fauna that no specially adapted endemic species have arisen to meet the peculiar conditions which occur in temporary ponds which are comparable to those in North America. In this connection it should be pointed out that while Planorbis umbilicatellus and Planorbula campestris are very distinct species they have moderately close relatives in the other members of the fauna of the region.

Pond near the village Alexandrovka,  
60 kilometers south-west of Omsk, Siberia.

Date	Hour	t° Air	t° Water Edge of Pond.	t° Water Center of Pond (at 10 cm.)	Remarks.	
April 25, 1933 26	19	13.7°C.	12.1°C.	10°C.	Calm	
	5	2.6	5.3	2.6	Calm	
	6	3.3	4.1	1.9	Sunrise at 5.15, Breeze	
	7	5.1	4.8	2.2	Sun on Pond	
	8	7.5	6.1	3.4	Bright	
	9	8.6	8.0	4.9	Bright	
	10	11.0	10.7	6.5	Bright	
	11	11.1	11.6	7.2	Dull	
	12	11.6	10.5	7.9	Dull	
	13	10.8	11.1	8.4	Dull	
	14	10.5	10.4	8.6	Dull	
	15	11.8	11.4	8.6	Dull	
	16	11.0	11.5	9.4	Dull	
	17	9.7	10.6	8.8	Dull	
	18	9.1	10.0	8.6	Light Rain	
	19	9.4	9.4	7.8	Rain	
	20	8.0	8.7	8.1	Rain	
	April 27	7	2.0	2.8	1.9	Calm, Dull
		8	3.4	3.9	2.2	Calm, Dull
		9	6.1	5.9	3.0	Calm, Bright
10		8.0	7.9	4.5	Calm, Bright	

Note. There was a large snowdrift in the center of this pond.

Pond near Kara Bedank, 390 kilometers  
south of Omsk.

Date	Hour	t° Air	t° Water Edge of Pond.	t° Water Center of Pond (at 10 cm.)	Remarks	
Day, 25, 1933. 26	20 <sup>30</sup>	11° C.	13.8° C.	14.2° C.	Clear, Calm Sunrise, 5 <sup>05</sup>	
	4 <sup>50</sup>	-1.7	4.3	10.2		
	6	-0.5	4.9	10.0	Sun on surface of pond.	
	7	2.4	5.4	9.9		
	8	6.4	8.8	10.4		
	9	9.2	11.8	11.3		
	10	11.4	15.4	12.3	A clear, calm day.	
	11	12.5	19.4	13.5		
	12	12.9	22.3	14.4		
	13	13.3	24.1	15.6		
	14	13.6	25.6	16.7		
	15	14.1	26.0	17.7	Warm afternoon.	
	16	15.0	25.2	18.6		
	17	16.0	23.3	18.7		
	18	14.6	20.5	18.6		
	19	13.9	16.7	17.8		
	20	13.0	14.3	16.9		
	20 <sup>30</sup>	11.9	12.7	16.4	Sunset about 21.15	
	27	5 <sup>45</sup>	4.5	5.2	11.8	Sun just on pond.

Note. The apparent discrepancy in the times of sunrise results from the fact that for considerable periods there was no opportunity of checking the observers watch.

## SUMMARY.

Temporary ponds formed by melting snow occur in different parts of the Sub-Arctic Region, and are common in Canada and Siberia. The most characteristic of the animals found in these situations are phyllopod crustacea such as Branchipus and Lepidurus, while molluscs are of frequent occurrence. The conditions of existence in ponds of this type are somewhat severe, and in order to support a mollusc fauna it is essential that a pond be periodical in its occurrence, and that it should contain fresh water for at least one month each year, and that it should have a vigorous growth of land plants to serve as food. A regular period of dessication may also be necessary (Planorbula campestris). The saline conditions which are met with in the neighbourhood of North Latitude 50° in both continents have an unfavourable influence upon the mollusc fauna.

Eight species are known to occur in these ponds in the western part of Canada, while the total for northern Asia is five. There appears to have been a considerably greater degree of adaptation to meet the special conditions of temporary ponds in North America than in northern Asia.

SUMMARY.

The area covered in this investigation includes the greater part of continental Asia to the north of latitude 50°, but does not include Outer Mongolia and Manchuria. Within this area sixty seven species and subspecies have been examined in detail, and are considered definitely to represent distinct forms. In addition to this there are several other species which have not yet been satisfactorily determined. This number does not include the members of the highly specialized and distinct Baikal fauna, which is not properly within the scope of this paper, nor does it include the single record of a North American gastropod (Planorbis trivolvis Say) in the Chuckchee Peninsula, nor the Chinese and Manchurian forms which are found in certain parts of the Far Eastern Province. In addition to the sixty seven forms above mentioned, there occur in the literature of the past hundred years, a multitude of records that are undoubtedly based upon incorrect identifications, or references to specific names that are no longer valid. These have been considered in this account only in so far as the actual specimens have been available for personal examination. The distinct and valid forms include fifty aquatic and seventeen terrestrial representatives, which fall under the following genera :

AQUATIC GENERA.

<u>Viviparus</u>	1 sp.	<u>Bithynia</u>	1 sp.
<u>Paludestrina</u>	1 sp.	<u>Valvata</u>	5 spp.
<u>Lymnaea</u>	12 spp.	<u>Myxas</u>	1 sp.
<u>Planorbis</u>	9 spp.	<u>Segmentina</u>	1 sp.
<u>Ancylus</u>	1 sp.	<u>Physa</u>	2 spp.
<u>Aplexa</u>	1 sp.		
<u>Anodonta</u>	2 spp.	<u>Sphaerium</u>	1 sp.
<u>Musculium</u>	1 sp.	<u>Pisidium</u>	10 spp.

TERRESTRIAL GENERA.

<u>Pupilla</u>	2 spp.	<u>Acánthinula</u>	1 sp.
<u>Vallonia</u>	3 spp.	<u>Cochlicopa</u>	1 sp.
<u>Gonyodiscus</u>	2 spp.	<u>Zonitoides</u>	1 sp.
<u>Eulota</u>	2 spp.	<u>Euconulus</u>	1 sp.
<u>Succinea</u>	2 spp.	<u>Retinella</u>	1 sp.
		<u>Fruticicola</u>	1 sp.

During the course of the work, the following genera, each represented by a single species so far as can be ascertained at present, have been collected, but the difficulties of determination render it desirable to postpone final identification: Unio, Carychium, Fruticicola, Vertigo, Agriolimax, Punctum, Vitrina.

The habitats available for settlement by the aquatic forms are divisible into three general types, namely, ponds, lakes and streams. The ponds and pond-like lakes are the only bodies of water which have an abundant molluscan fauna, and for the most part these are inhabited by a selection of the most hardy northern European species. Large lakes are not common and where they do occur usually present some special condition such as salinity, or the isolation of the habitat, which have an unfavourable influence upon the molluscan fauna. The streams are subject to wide fluctuations of level, and for the most part have a relatively low temperature. Those in the southern part of the area are frequently dry during the summer, while many of those in the eastern region are frozen solid during the winter (pp. 160-193).

Four elements may be distinguished in the molluscan fauna of this region when viewed from the standpoint of their geographical affinities; viz. a small group of circumboreal species, a large number of Eurasian species, a few which are common to North America and north-eastern Asia, and several endemic forms. On the basis of these groups northern Asia may be divided into four faunal regions, namely, the Great Siberian Region, the Baikal Region, the Far Eastern Region, and the Chuckchee-Kamchatka Region (pp. 194-203).

In a general way the distribution of the mollusca conforms to that of the major natural regions (pp. 204-211).

In the northern part of Kazakstan and southern Siberia there are numerous isolated inland drainage basins in which the reservoirs are saline to a varying degree. About thirty such lakes were examined and the presence of old shorelines around many of them indicates their greater extent during previous pluvial periods. Fossil molluscs were found in certain of these old shoreline deposits. In some instances the number of species decreases in the descending series of beaches, thus giving evidence of a progressive impoverishment of the molluscan fauna. The main salts in solution in these waters are chlorides and sulphates of sodium, and magnesium. Their presence is detrimental to the molluscs, both directly and indirectly. In respect to these conditions the most tolerant species of molluscs are Planorbis planorbis (Linne), Lymnaeapalustris saridalensis Mozley, and L. palustris kazakensis Mozley, (pp. 212-246).

Another type of habitat characteristic of the steppe and forest-steppe regions in both Canada and Siberia is the temporary pond formed by melting snow in spring. As a result of the shortness of the annual aquatic phase of these ponds, which is succeeded by severe drought, and

by low temperatures during the winter, conditions of life are severe. Nevertheless, a considerable number of invertebrates belonging to different groups manage to exist in them (Mozley, 1932). Eight species of molluscs occur in ponds of this type in the western part of Canada, and five in northern Asia. There appears to be a considerably greater degree of adaptation to meet the special conditions of temporary ponds in North America than in northern Asia (pp. 247-259).

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NOTES ON THE MOLLUSCAN FAUNA  
OF FENNOSCANDIA.

The original plan for the summer of 1934 was to continue the work in Siberia, and to examine the northern forested region of Yakutia, and also the tundra. The Soviet authorities however, refused to allow me to enter Siberia a third time, so that it was necessary to find another region in which to study the northerly distribution of these molluscs. The most promising field appeared to be Finland, Sweden, and Norway, which may be collectively termed Fennoscandia. The better facilities for travel, and the helpful companionship of Doctor Nils Hj. Odhner during a part of the journey, made it feasible to cover much more ground than would have been possible under the more severe conditions of Siberia. The following is a preliminary account of some of the results of this expedition. These notes are given under several headings viz.

The types of country examined, and the general nature of the molluscan fauna.

Preliminary list of the species collected.

Notes on the local and geographical distribution of certain of the species.

The distribution of molluscs on the Baltic coast near Hango, Finland.

The Types of Country Examined, and the General  
Distribution of the Mollusca.

Three moderately distinct types of country are included in the territory covered during this expedition, namely,

- (i) The forested region, which extends northward to about latitude  $69^{\circ} 30'$ . This area is one of only moderate relief, and the prevailing type of landscape is a gently rolling country covered with a forest of coniferous trees, with numerous lakes and boggy areas, and traversed by a few large streams with a moderate current.
- (ii) To the north of this there lies the tundra, which is devoid of trees, and is hilly in places.
- (iii) In the north-western part of Sweden, near the Norwegian frontier there is a considerable area of mountainous country, nearly all of which is occupied by alpine tundra or semi-tundra. Lakes occur in some places, and on account of the configuration of the country the boggy areas are more localized than in the two areas noted above.

Lakes, while moderately numerous in all three of these regions, are as a rule not so common as in the comparable regions of Canada. The south-eastern part of Finland is an exception to this, but even there the lacustrine mollusc fauna is not well developed. Ponds, such as provide

important habitats for molluscs in the regions further south are quite rare in Finland and northern Sweden, and it appears that this is the result of Sphagnum and other plants invading and rapidly filling any small depressions in the soil or bed rock. Roughly speaking the lakes may be divided into two classes, viz. small and shallow lakes, and those which have a considerable surface area and are relatively deep. In this region the lakes of the first type usually have a very meagre mollusc fauna. The small lakes as a rule are invaded by Sphagnum and this appears to have a very unfavourable influence upon the mollusca, and unless there is an outlet a few Pisidium are all that are usually found in these lakes.

A precisely similar condition was found to exist in the smaller lakes of the northern forested region of Siberia and Canada. Cases in point from these areas are Lake Badbalnoeya which is situated 2 kilometers north of the River Ket and a point 260 km. east of the River Ob, and the unnamed lake at Mile 55 on the main line of the Canadian National Railways between Winnipeg, Manitoba and Reddit, Ontario, Canada. In Lake Padbalnoeyo only a few Pisidium sp. were found, while in the Canadian lake mentioned Esisium sp. and Planorbis antrosus striatus Baker, were collected.

The larger lakes in Finland and northern Sweden often have rocky shores, but there are also many with shores of sand and stones. The molluscan fauna of these lakes is

not remarkable for its variety, but is often characterized by a considerable abundance of the species which do occur. The most common of these species are Lymnaea pereger and Planorbis acronicus, and these forms are not only the predominant molluscs in the southern part of the territory examined, at about north latitude 65<sup>o</sup>, but further north they are actually the only molluscs which are found in certain lakes, as for example is the case in Abiskojaure,

The only other association of aquatic molluscs which is of much significance in this region is that found along the margin of the larger streams. Provided that the shores are suitable and that they are not subject to very severe erosion by ice in the spring, there may be a rich molluscan fauna, as far as the number of individuals is concerned. The most common species is usually Lymnaea stagnalis, and in some cases L. pereger ovata is also common. Lymnaea palustris, Planorbis acronicus and Valvata sp. may also occur but as a rule these are not so abundant as the two species first mentioned.

Preliminary List of the Species of Mollusca  
Collected in Finland and Northern Sweden.

Aquatic Species.

<u>Viviparus fasciatus</u>	(Müller)	<u>Bithynia tentaculata</u>	(Linne)
<u>Valvata piscinalis</u>	(Müller)	<u>Valvata macrostoma</u>	(Linne)
<u>Lymnaea stagnalis</u>	(Linne)	<u>L. auricularia</u>	(Linne)
<u>L. pereger</u>	(Müller)	<u>L. pereger ovata</u>	(Draparnaud)
<u>L. palustris</u>	(Müller)	<u>L. palustris corvus</u>	(Gmelin)
<u>L. truncatula</u>	(Müller)		
<u>Myxas glutinosa</u>	(Müller)		
<u>Planorbis planorbis</u>	(Linne)	<u>P. carinatus</u>	(Müller)
<u>P. acronicus</u>	(Müller)	<u>P. borealis</u>	Loven.
<u>P. vortex</u>	(Linne)	<u>P. vortex</u> var	
<u>P. contortus</u>	(Linne)		
<u>Physa fontinalis</u>	(Linne)	<u>Aplexa hypnorum</u>	(Linne)
<u>Sphaerium corneum</u>	(Linne)	<u>Musculium lacustre</u>	(Müller)
<u>Pisidium amnicum</u>	(Müller)	<u>P. cinereum</u>	Alder
<u>P. personatum</u>	Malm.	<u>P. conventus</u>	Clessin
<u>P. spp.</u>			
<u>Anodonta cygnea</u>	(Linne)	<u>A. anatina</u>	(Linne)

Terrestrial Species.

<u>Acanthinula harpa</u>	(Say)	<u>Vallonia costata</u>	(Müller)
<u>Vallonia pulchella</u>	(Müller)	<u>Cochlicopa lubrica</u>	(Müller)
<u>Gonyodiscus ruderatus</u>	(Ferussac)	<u>Euconulus fulvus</u>	(Müller)
<u>Retinella radiatula</u>	(Alder)	<u>Vitrina pellucida</u>	(Müller)
<u>Eulota fruticum</u>	(Müller)	<u>Clausilia</u> sp.	
<u>Agriolimax</u> sp.		<u>Succinea pfeifferi</u>	Rossmässler
<u>Succinea putris</u>	(Linne).		

Notes on the Local and Geographical  
Distribution of Certain of the Species  
Collected.

In the course of the work in the field during the summer of 1934, full notes were taken regarding the habitats of the species collected. A short account of the observations on certain species is given below, but only a few of the more striking facts are included. Further comparative studies, especially on material in museums are necessary before a full account of the observations can be prepared.

Although Lymnaea stagnalis is one of the most common Sub-Arctic molluscs, little attention has been paid, up to the present, to the varietal forms of this species in relation to local and geographical distribution. It is known that a well marked "lacustrine" races of this species, with a short spire, and large aperture, is to be found in some bodies of water, but little is known of the variation of this form. One of the objects of the work in Fenno-scandia was to obtain large series of this and other varieties, in order to ascertain whether or not this "lacustrine" form is a true subspecies. Large collections of L. stagnalis were made, but it will be some considerable time before the measurements will be complete. Nevertheless it appears that several different types of "lacustrine" stag-nalis occur in this region, and also that the tendency

towards the production of shells having a short spire is not confined to wave-washed shores. Moreover there appears to be some tendency in habitats of that kind, for the shells to vary in the opposite direction, so that they are of relatively gigantic size, with a long spire. If this is true an interesting case is presented of parallelism to the Lymnaea stagnalis of North America. These conclusions must of course, be regarded as tentative, and are subject to later revision.

A species which has a more limited distribution in this country is Lymnaea auricularia. In Finland it is known to occur as far north as Koulajarvi (north latitude  $67^{\circ}$ ), but up to the present it has been found only as far north as Dalarna (north latitude  $60^{\circ}$ - $62^{\circ}$ ). In 1934 Doctor Odhner and I found it in a small lake 4 km. north of Nedder Kalix, Norbotten, Sweden. This locality is situated at about north latitude  $65^{\circ} 50'$ , and with the Finnish locality already noted probably constitutes the northernmost range of this species.

Lymnaea palustris has a wide distribution throughout this area, but is frequently difficult to find in any one locality. L. palustris corvus was collected in a marsh near Sortavala, Finland (North latitude  $61^{\circ} 40'$ ), where it was very common, and was found in company with the following species; Lymnaea stagnalis, L. pereger, Myxas glutinosa, Planorbis planorbis, P. corneus, P. vortex, P. contortus, Vivipora fasciatus, Bithynia tentaculata, and Musculium lacustre.

No other habitat was found in either Sweden or Finland which was comparable to this in the abundance and variety of the mollusc fauna. Most of these species are found at least for some distance, further to the north, but as far as these observations go, they do not occur all together in one habitat, anywhere to the north of this point. In the far north, at about north latitude  $68^{\circ} 40'$  Lymnaea stagnalis, L. pereger, and L. palustris were found living together in one lake (Tsharmijarvi) but there is seldom any larger number of species to be found associated in one habitat. On the tundra at Linhamari, Finland (north Latitude  $69^{\circ} 40'$ ) Lymnaea pereger, Planorbis acronicus and Pisidium sp. were found in a large pond, while further to the west in Abiskojaure (north latitude  $68^{\circ} 20'$ ) near the Swedish-Norwegian frontier, L. pereger and Planorbis acronicus were found to occur in abundance. This fauna is comparable with that which occurs on the tundra of North America. In the district round about, Fort Churchill, Manitoba (north latitude  $58^{\circ} 20'$ ) Lymnaea vahllei, Planorbis arcticus, and Physa gyrina were found in tundra ponds.

Lymnaea truncatula was found in a small temporary pond at an altitude of 975 meters in the mountains twentyfive kilometers west of Abisko, Sweden (north latitude  $68^{\circ} 25'$ ). This pond was situated on the shoulder of a mountain ridge at the mouth of a hanging valley, and there were large

snowdrifts in the vicinity.

Aplexa hypnorum was found by Middendorf in tundra ponds on the Taimyr Peninsula, Siberia (north latitude  $71^{\circ} 30'$ ), and it<sup>is</sup> also found moderately far north in North America, although the actual records are not to hand at the moment. In Fennoscandia the northward distribution of this species is much more restricted. Luther (1901) has reported its presence in fourteen different localities, the northernmost being Jorois, at about north latitude  $62^{\circ} 20'$ . In Sweden it was formerly thought that this species did not occur to the north of Dalarna (north latitude  $60^{\circ}$ - $62^{\circ}$ ), but several years ago Doctor Odhner found it in Jämtland at Strömsund (north latitude  $63^{\circ} 45'$ ). At that time the habitat was believed to be a small stream, which was examined in a year of high water, but if this was true habitat of Aplexa it was difficult to understand why it did not occur in other small brooks in the vicinity, and further to the north. The matter was therefore looked into rather more carefully in 1934, which was a year of low water. The streams in which Odhner had found this species several years before, was very carefully examined but no Aplexa were to be found in it. Other streams, and also ponds and marshes in this district were inspected, but no specimens of Aplexa were obtained. A careful re-examination of the vicinity of the stream near Strömsund, revealed their presence in a small temporary pond near the brook

but separated from it. This pond which was about one meter in diameter, was dry in August, 1934, but was doubtless the source of the population which Odhner found in the stream. The explanation of the absence of this species in the territory to the north lies in the fact that temporary ponds of the type in which it occurs in North America and northern Asia, do not occur to the north of Stromsund, nor in northern Finland.

Regarding the terrestrial species, the condition near Lohja (north latitude  $60^{\circ} 9'$ , east longitude  $24^{\circ}$ ) is apparently typical of southern and central Finland. Land molluscs are not particularly common, but in a forest of birch, poplar, and alder, three species were found, namely, Cochlicopa lubrica, Retinella radiatula, and Vittrina pellucida. In another spot, under large pine and spruce trees, in places where the forest floor was moderately moist and was covered by the mosses Dicranum scoparium, Hylocomium splendens, and Hypnum schreberi, there were few shells of Euconulus fulvus, Gonyodiscus ruderatus, and Retinella radiatula. While in a pure stand of pine, with Calluna vulgaris and Arctostaphylos UVA-URSAI on the forest floor, no molluscs were to be found. In a general way the condition just described is paralleled in the forested regions of Canada and Siberia. In the analogous pine of those regions molluscs are usually rare or absent altogether. In the mixed forests

of birch, poplar, and alder in northern Asia and North America land snails are as a rule much more common than in the analogous habitats in Finland. Professor Alexander Luther of Helsingfors is inclined to attribute this local scarcity of land species in Finland to the absence of limestone over a large part of the country, and it is a striking fact that in certain restricted localities near Tvärminne, southern Finland, where there are small outcrops of Pre-Cambrian limestone, terrestrial molluscs are much more abundant than anywhere else in the neighbourhood.

In the northern part of Finland, and also to some extent in Sweden the land snails become increasingly sporadic in their occurrence, and over the greater part of the country it is difficult to find any but isolated individual specimens in any one locality. This is essentially the condition which exists in the comparable regions of Canada and Siberia. Here and there in northern Finland, especially around the base of clumps of small birches, it is sometimes possible to find a moderate number of shells belonging to several different species. In the vicinity of Pithä Lompolo (north latitude  $68^{\circ} 47'$ , east longitude  $28^{\circ} 5'$ ) the following molluscs were found in one situation of this kind, Cochlicopa lubrica, Gonyodiscus ruderatus, Euconulus fulvus, Retinella radiatula. The explanation of the greater abundance of these animals in situations of this kind lies in the fact that they are slightly elevated above the general

level of the forest floor, and as a result of this they are less waterlogged, and have a higher temperature during the summer, also, the decaying birch leaves and twigs provide a more suitable source of food for the snails than does the scanty herbaceous vegetation which grows under the pure stands of evergreen trees. The alpine tundra, at an altitude of 300 meters, was examined on a range of hills in the neighbourhood of north latitude  $68^{\circ} 30'$ , east longitude  $27^{\circ}$ ). No land shells were found, and this is probably accounted for by extreme dryness of the whole of the higher ground in this neighbourhood at the time of this examination.

The Baltic Coast near Hango, Finland.

The region along the northern shore of the Gulf of Finland is of considerable interest, as in this region there is a good deal of intermingling of fresh water and terrestrial species of mollusca. The coastline of this region is very irregular in outline and there are numerous small fjords and a great many islands. These islands, and also the shore of the mainland are for the most part composed of Pre-Cambrian rocks worn smooth by the action of glaciers, but the configuration of the shoreline is so irregular that in spite of the nature of the shores there are many places which are completely protected from the severe storm which occur in the more open parts of the Baltic Sea. In the region of the islands at the mouth of the fjords the salinity of the water varies between 5. and 6.8, but varies from place to place and is subject in any one place to considerable fluctuations from time to time. The aquatic flora is a mixture of fresh water and marine elements. In the channels between the islands, and at the mouth of the fjords the predominating species is Fucus vesiculosus, and in the small bays of the islands, and along the shores of the fjords there is frequently a moderately vigorous growth of Phragmites communis. In some places in the neighbourhood of the islands, and also in the fresher water of the fjords there are two species

of Potamogeton (P. perfoliatus and P. pectinatus) and Ranunculus Caudotii maritima. They may be found in company with, or immediately adjacent to beds of the Fucus. Typha angustifolia and Utricularia are found in certain places in the middle or upper parts of the fjord, but do not occur in the lower part nor near the mouths, where the Fucus grows.

The principal marine molluscs of this region are Cardium edule, Tellina Caltica, Mya arenaria, and Mytilus edulis. These species are represented in this area by small forms. As far as the present observations go it appears that the Cardium, Tellina, and Mya occur only in the moderately salt water in the region of the islands near the mouth of the fjords, but they occur in habitats which directly adjoin those of the forms of Lymnaea stagnalis, L. parlustriis and L. ovata mentioned below. In addition to these there are the common European estuarine species, Neritina fluviatilia, and at least one species of Hydrobia, viz. Hulvae with the doubtfully distinct H. baltica. The Neritina is very widely distributed in this region. As far as these observations go Hydrobia appears to have an equally wide distribution, but was not collected as many times, although in some places it may have been overlooked. Professor Luther states that no species of Hydrobia other than those mentioned, occur in this region.

With regard to the local fauna of fresh water molluscs, one of the most striking facts is that the luxuriant association of pulmonate species which commonly occurs in beds of Phragmites communis in other parts of the Sub Arctic Region, is almost completely absent. A few Lymnaea stagnalis and L. palustris are usually all that are to be found in such situations. The species of fresh water molluscs collected in this vicinity are as follows: Lymnaea stanalis var., L. ovata, L. palustris, Planorbis corneus, P. vortex, P. vortex discus, Physa fontinalis, Valvata piscinalis, Ancylus lacustris and Anodonta sp. The most hardy of these species in this region appears to be Lymnaea stagnalis, and the least so Planorbis corneus. It is interesting to note that on the Kirghiz Steppe in Northern Asia, Planorbis corneus was observed to be the species most susceptible to increasing salinity, while the most hardy species in that region were found to be Lymnaea palustris and Planorbis planorbis. For some reason not understood, Planorbis planorbis does not occur in the Hango region, but L. palustris on the Siberian steppe is a much more hardy species than L. stagnalis, but in this part of Finland the local form of L. stagnalis is slightly more widely distributed and more abundant in the exposed habitats than is L. palustris. In this connection, it should be borne in mind that in the region to the north-east of Hango there are two chief unfavourable conditions with which the molluscs have to

contend, namely increasing salinity and increasing exposure to wave action, towards the outer islands and open Baltic. In the southern part of Siberia, and northern Kazakstan however, the principal unfavourable conditions for these species in extending their distribution southward toward the desert country, are salinity and drought, and under this combination of conditions, Lymnaea palustris, which is a species highly resistant of drought, is much more hardy than L. stagnalis, and is the predominating species.

In the middle or upper part of a fjord situated near Tvärminne, to the north-east of Hango, and in the immediate vicinity known as Bagby there is a narrow inlet in which the succession of the habitats of the species of molluscs in relation to increased protection from wave-action and the decreasing salinity towards the further end of the inlet, is well marked. On the open, unprotected rocky shores at the mouth of the inlet Neritina fluviatilis occurs in large numbers and with it are associated a few individuals of Lymnaea stagnalis and L. ovata, while in the deeper water a few meters from the shore, there are many Anodonta. On the rocky shores which are slightly protected from wave-action by a narrow belt of Phragmites communis the Neritina are not so common and the Lymnaea mentioned are present in greater numbers, and in addition a small form of Lymnaea palustris is present, especially in little indentations in the shorelines and in places where there are stones. The

The mouth of the inlet is overgrown with a thick stand of Phragmites communis which continues for about one kilometer above the mouth of the inlet. In this marsh there are at least two open pools around which Typha angustifolia is found, and which have Nymphaea candida and Nuphar listium growing in them. One of these pools was examined, and the following species were collected :

Lymnaea stagnalis

L. palustris

L. ovata

Planorbis corneus

Planorbis vortex

Physa fontinalis

Bithynia tentaculata.

This pond, which contains the freshest water at any point examined in this fjord, has a mollusc fauna which approaches, in the variety and abundance of the different species, the fauna of Phragmites -- Typha -- Nymphaea habitats in other parts of the Sub Arctic Region. It is a noteworthy fact that the amount of dead and decaying plant material in this pond, available for use as food by molluscs, was much greater than in the open fjord.

Two other molluscan habitats in this neighbourhood deserve brief mention. The first of these, a small pond on an almost barren rocky island south-west of Tvärminne, contained a single species of mollusc Lymnaea palustris

in considerable numbers, and it is noteworthy that specimens from this pond in which there was an abundance of organic matter centering about a tiny *Carex* marsh, were of much larger size than those from among the Fucus in the adjoining channels of "Baltic" water between the islands. The second habitat is a small and exceptionally well protected inlet in an island situated about eight kilometers south of Lappvik. Apparently as a result of the absence of any wave-action, this inlet contained a mollusc fauna composed of not only Neritina, Lymnaea stagnalis, and L. palustris, but an additional form, Planorbis vortex discus also occurred. All three of the pulmonate species were common on the beds of Fucus vesiculosus, but the Planorbis was found to be especially numerous on stones in shallow water along the shore.

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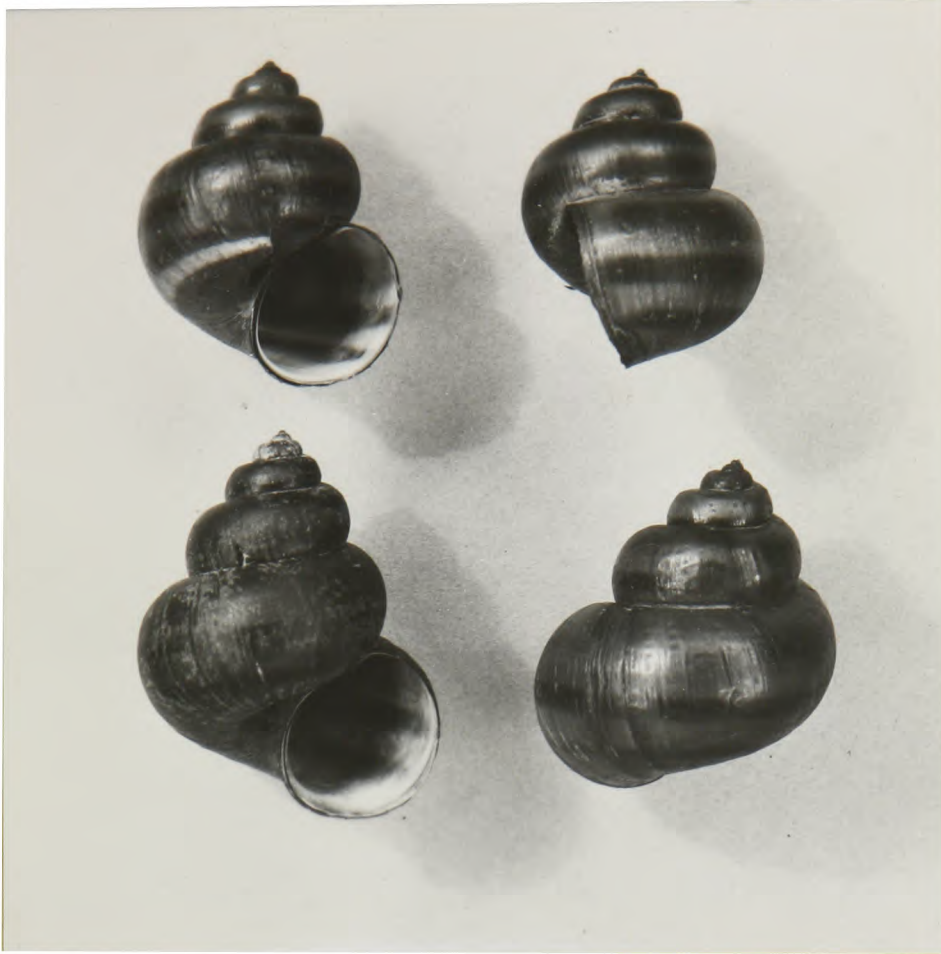
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Plate 15.

figures 1-4. Viviparus fasciatus (Müller) X /  
River Anambinskaya, Tara area. X

figure 5. Valvata antinquilina Mozley. X 5  
Lake Khomotenoye, Aj-Bulat. basin.

6. Valvata piscinalis (Müller) X 5  
Marseille, France.



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Plate 16.

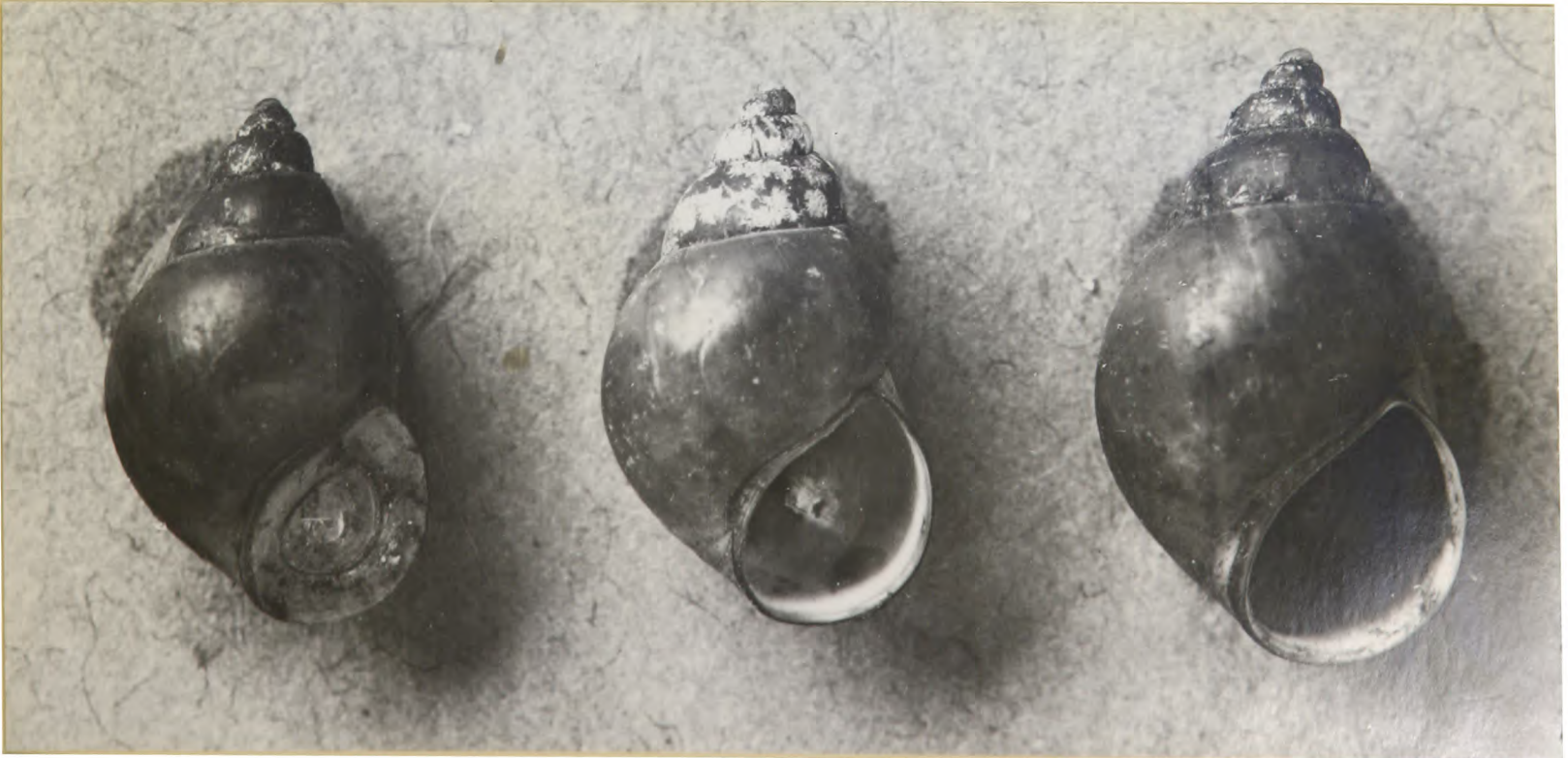
figures 1-2. Valvata antiqua Morris Grays, Essex. X 5

3. V. piscinalis (Müller). East coast of  
Scotland. X 5

4. V. antiquilina Mozley. Lake Khomotenoye,  
Siberia. X 5

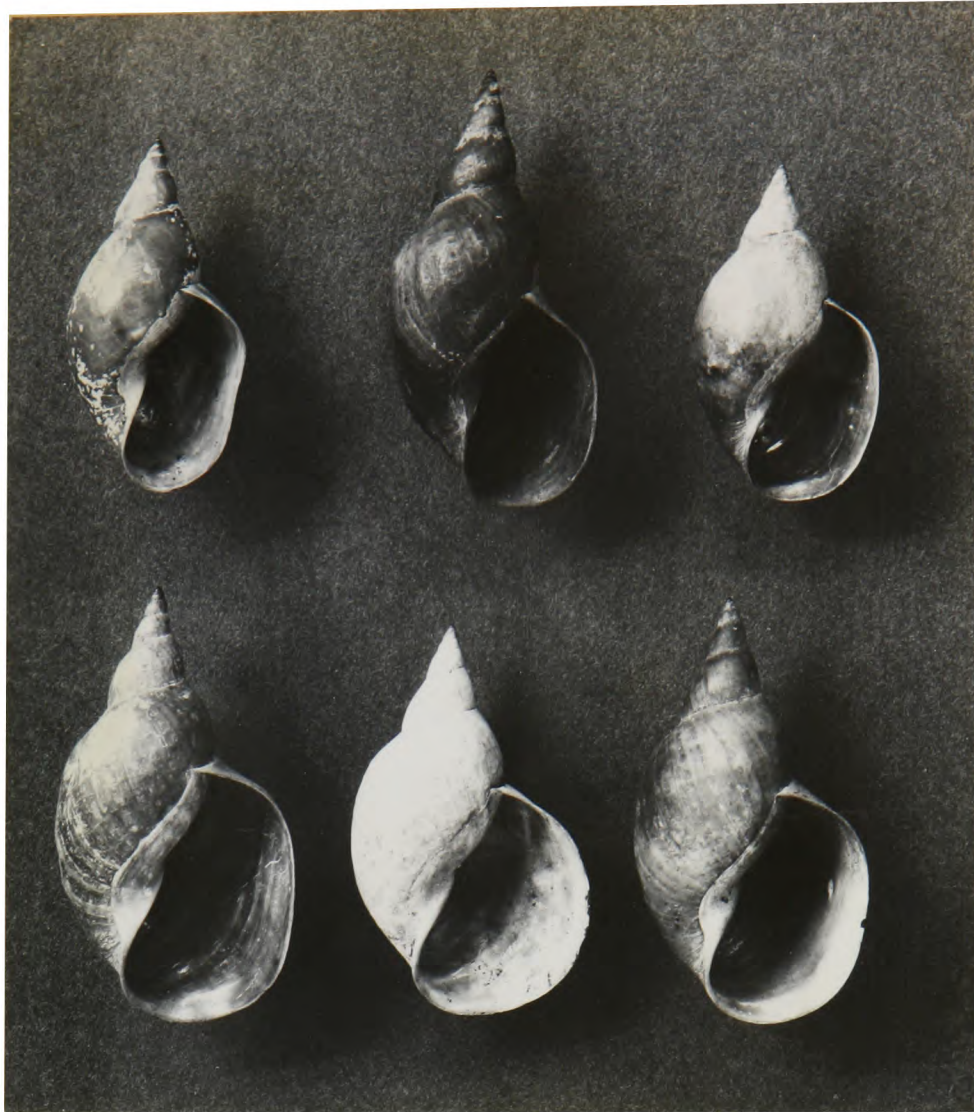
5-7. Bithynia leachii inflata (Hansen). Flood  
plain of River Irtish, near Omsk. X 5

8-10. Bithynia tentaculata (Linnaeus). Kotur  
Kulb, Borovoye. X 5



Platell7.  
Lymnaea stagnalis (Linne). X /

- figures 1-6. Phragmites marsh, 1 km. above Ustianka,  
Aj Bulat basin.
7. Pond east of Lake Celeti-Denghiz.
  8. River Chulim, Kulundinsk Steppe.
  9. Borovoye, Kazakstan.
  10. Bouldi Kul, Akmolinsk Region.
  11. Woolar Lake, Kashmir.
  12. River Zamaraika, near Omsk.



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Plate 18.

A series of shell of Lymnaea stagnalis  
(Linne) from the dry bed of a lake 10 km.  
South-East of Lake Ulkhun Karoi.

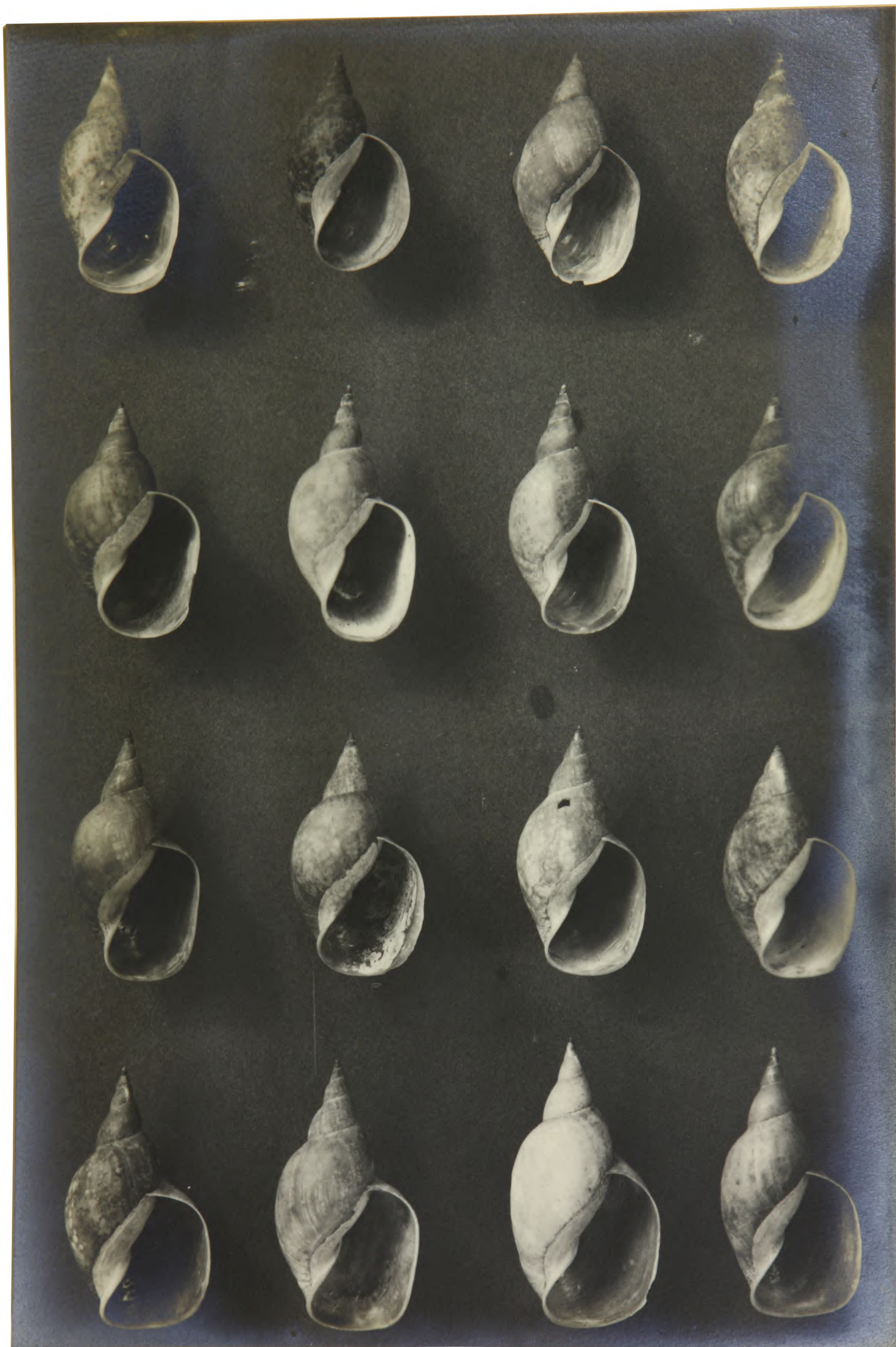


Plate 19.

figures 1-2. Lymnaea glabra (Müller) X2  
River Balta, near Ulala, Altai.

figure 3. Lymnaea stagnalis (Linne) X/  
Tomsk.

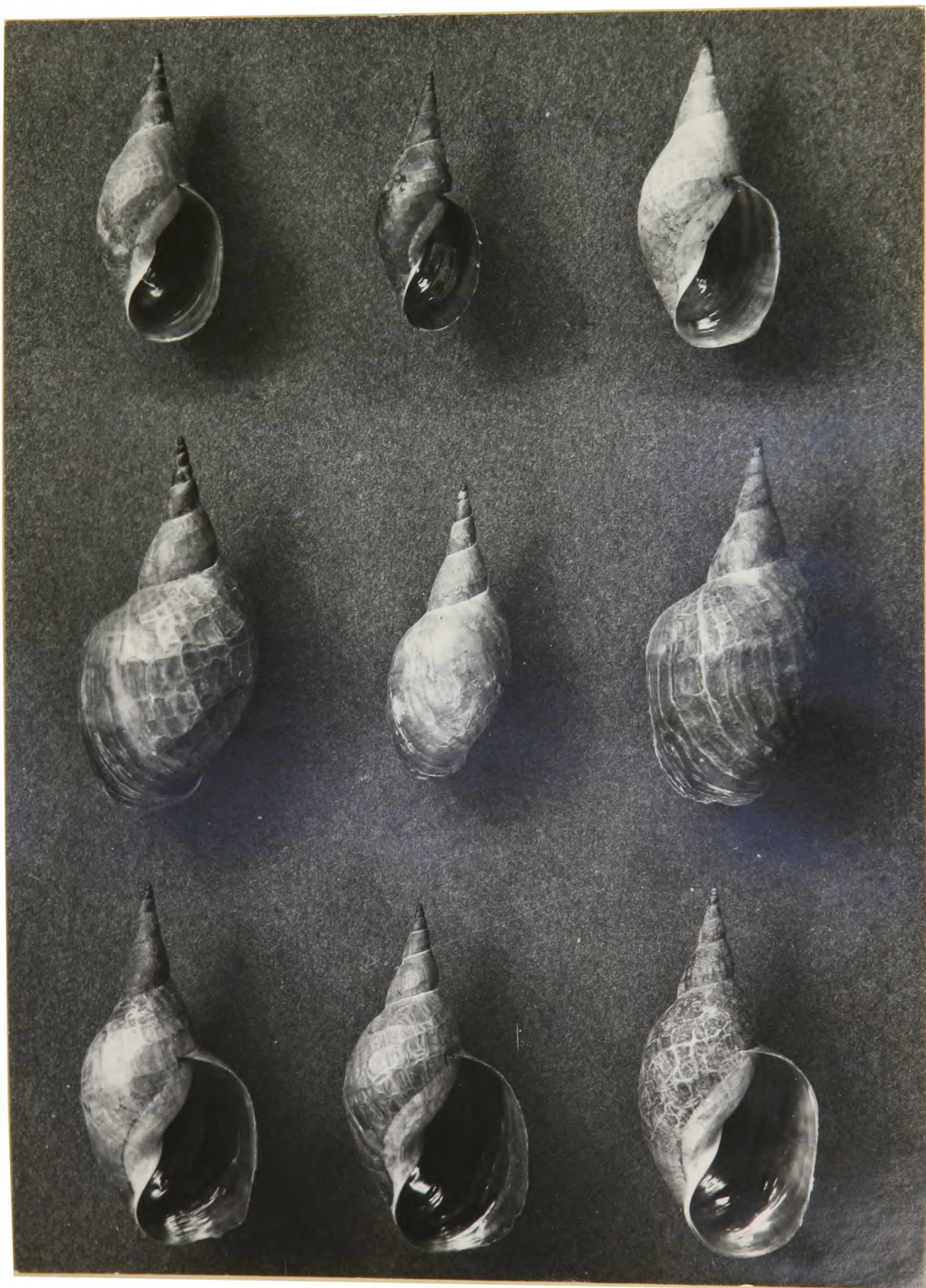
figures 4-12. Lymnaea stagnalis (Linne) X/  
Pond on flood plain of River Nura,  
near Rojdestvensky.



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Plate 20.

- figure 1. Lymnaea palustris kazakensis Mozley. X2  
Novo Troetskaya.
2. Lymnaea palustris draverti Mozley. X2  
River Om, near Omsk.
3. Lymnaea palustris saridalensis Mozley. X2  
Steppe Sari Dala.
4. Lymnaea palustris bolotensis Mozley. X2  
Rivers Chaganak-Chederti.
5. Lymnaea palustris (Müller) X2  
near Rojdestvensky.
- 6-8. Lymnaea pereger ovata (Draparnaud) X1  
Tomsk.
9. Lymnaea zazurnensis Mozley X2  
Lake Zazurnia, Baikal area.
10. Lymnaea pereger (Müller) X2  
Novo Troetskaya.
11. Lymnaea pereger (Müller) X2  
Ulala, Altai.
12. Lymnaea pereger (Müller) X2  
Borovoye.
13. Lymnaea pereger (Müller) X2  
Nikolaevka.
14. Lymnaea pereger (Müller) X2  
Novo Troetskaya.



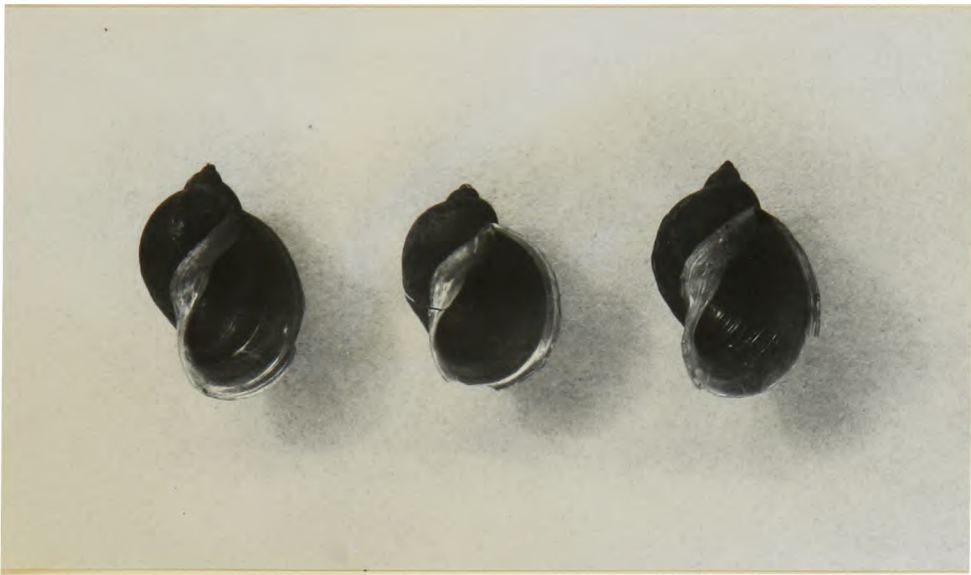
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Plate 21.

figures 1, 2, 4, and 5. Planorbis corneus (Linné) x /  
Borovoye.

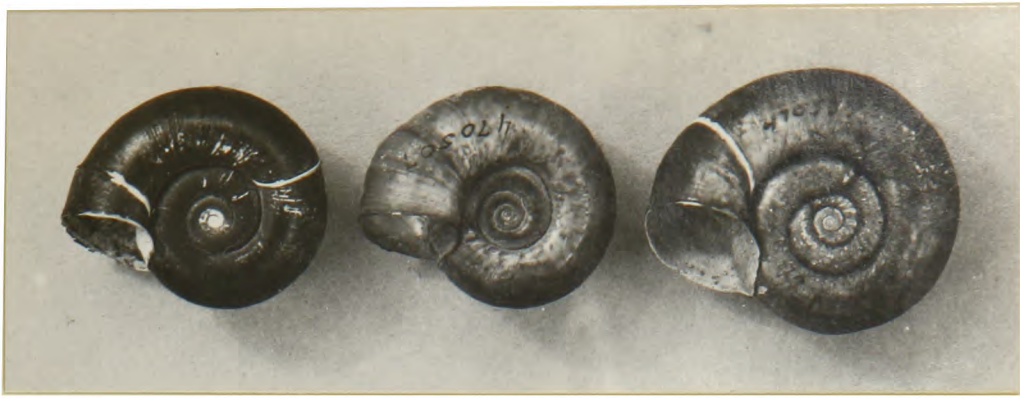
3, and 6. Planorbis corneus (Linné) x /  
Bouldi Kul.

7-10. Aplexa hypnorum (Linné) x /  
Pond on Barabinsk Steppe, north of  
Dologozurnia.

11. Physa sartlandinensis Mozley. X 5  
Lake Sartlan, Barabinsk Steppe.

12, and 14 Lymnaea auricularia (Linné). X /  
near London, England.

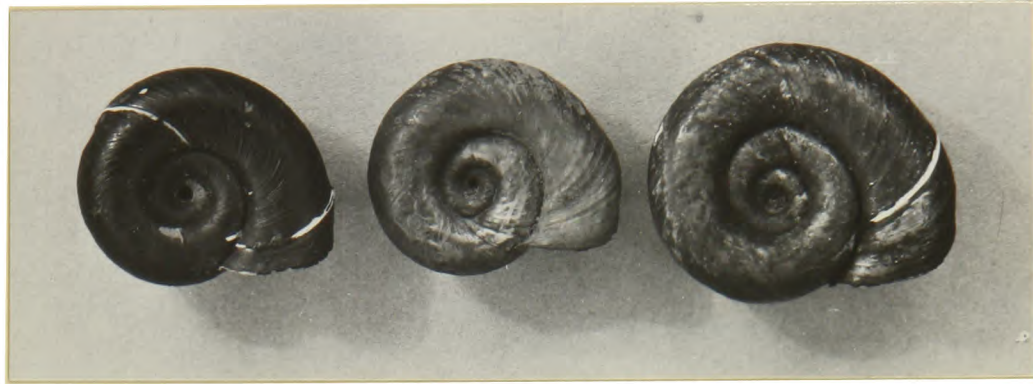
13. Lymnaea auricularia (Linné). X /  
Lob Nor, Central Asia.



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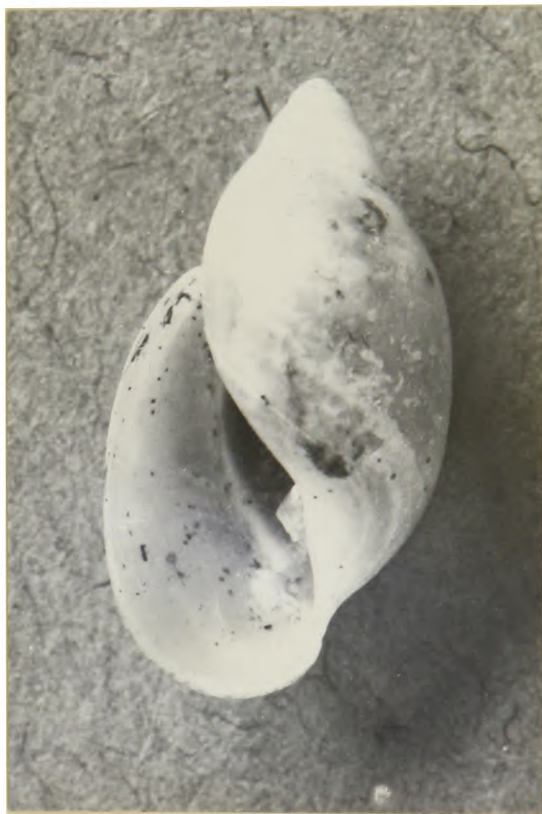
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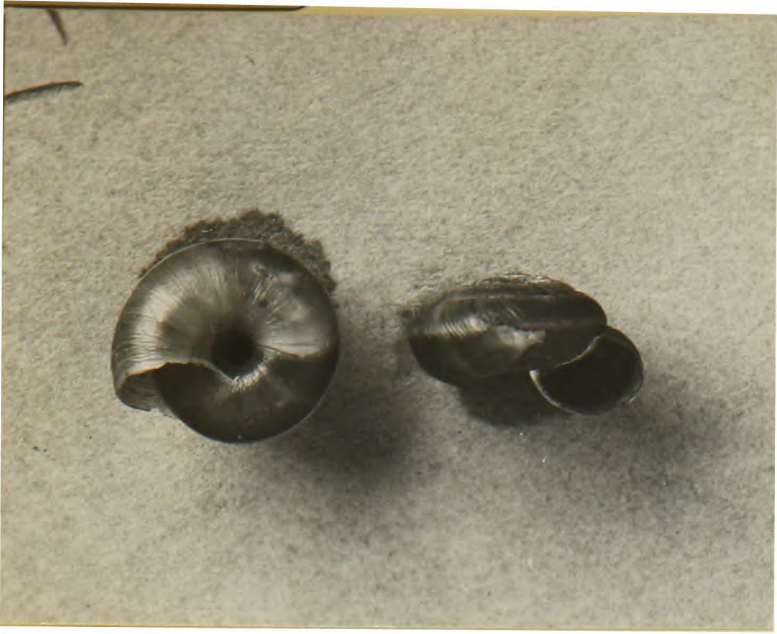
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Plate 22.

- figures 1-2. Eulota nordenskiöldi (Westerlund). X /  
near River Bana, Ulala region, Altai.
3. Eulota schrenkii (Middendorff). X /  
Cherni Anui, Biisk area.
- 4-6. Eulota schrenkii (Middendorff). X /  
near River Balta, Ulala region, Altai.
- 7-9. Vallonia costata (Müller). X 5<sup>-</sup>  
Omsk Forest-Steppe.
10. Pupilla muscorum (Linne). X 5<sup>-</sup>  
near Lake Celeti-Denghiz.
11. Acanthinula harpa (Say) X 5<sup>-</sup>  
near River Ket, 210 km. above the Ob.
12. Succinea pfeifferi Rossmässler. X 5<sup>-</sup>  
Taishet.
13. Succinea putris (Linne). X 5<sup>-</sup>  
Nikolaevka.



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