

AN ECOLOGICAL STUDY OF THE FAUNA OF THE KHEWRA GORGE AND SOME OTHER SALT WATERS IN THE SALT RANGE, PUNJAB.

By HEM SINGH PRUTHI, *Zoological Survey of India.*

INTRODUCTORY.

The Khewra Gorge is a small stream which runs between low hills¹ near Khewra village (Jhelum district) in the Punjab. It is actually a stream only during and just after the rainy season; for the most part of the year it is a chain of pools, some of which are connected with one another by underground water channels. The water of this stream is absolutely fresh at a distance of about three miles from Khewra, and from there it is brought down by pipes for the use of the inhabitants of this and the neighbouring villages. As the stream approaches Khewra, it becomes gradually saline, its salinity near this village being more than twice that of the sea. Below this village it loses the form of a stream; its water spreads and falls into the Jhelum river, which runs at a distance of about three miles from Khewra.

Extensive literature exists on the fauna of the sea coasts of various parts of Europe². Blanchard and Richard (1892) and Roy and Gauthier (1927) described the Crustacean fauna (chiefly Copepods) of some salt water lakes of Algeria and Tunis (N. Africa). Sars (1903) gave an extensive account of the Crustacea of a large number of salt lakes in Central Asia, but unfortunately did not give any exact salinity data of the waters investigated. In India, Annandale (1907) and Kemp (1917) made several investigations on the brackish-water fauna of the Gangetic Delta and studied very exhaustively the fauna of the Chilka Lake in Orissa and the Talé Sap lake in Peninsular Siam³. Dr. S. L. Hora in 1922 made a collection of both terrestrial and aquatic fauna at several localities, including the Khewra Gorge, in the Salt Range, Punjab. The reports on this fauna were published in the *Records of the Indian Museum*, Vol. XXV, 1923. Dr. Hora examined the Khewra Gorge at one or two places only and did not study the chemical and physical condition of the water at the time of making collections. As the available literature shows, very few inland streams like the Khewra Gorge, in which the salinity varies greatly at different places at the same time of the year and in which it is not due to the addition of sea water, have been thoroughly investigated. It is fairly well known that, even though the salinity may be the same, the conditions of life in an inland water are quite different from those in the sea. Buxton (1926)

¹ The geological structure of the Salt Range is described by Sir H. Hayden in the Jhelum district Gazetteer as follows:—"The greater part of the district lies on the sandstones and conglomerates of the Sewalik Series (upper tertiary), etc. The lowest bed is the salt mark and rock salt which affords the material for extensive mining industry."

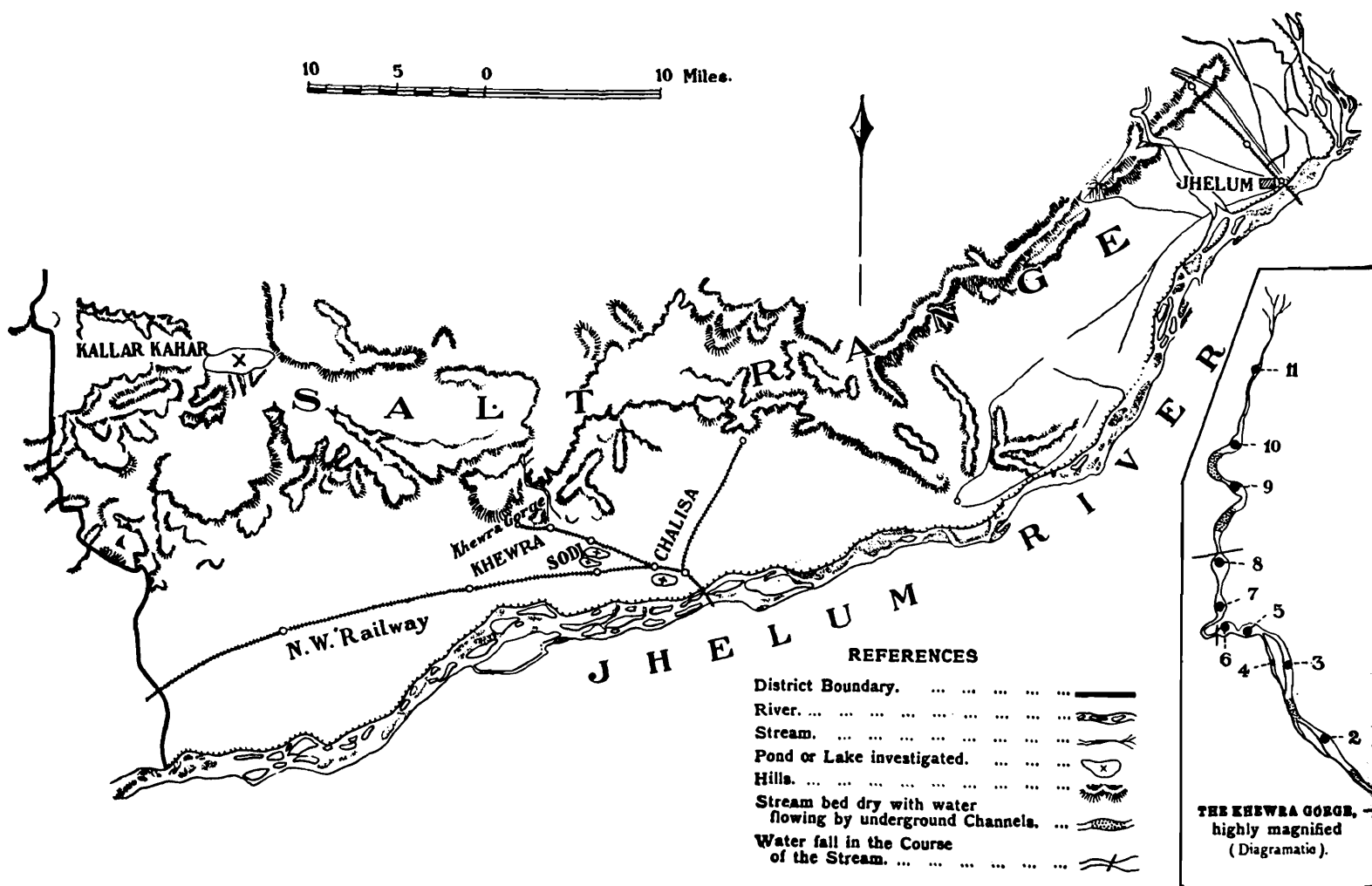
² H. v. Lengerken (*Die Tier Welt d. Nord U. Ostsee*, Teil XIe, Lief. 16, 1929) gives a complete list of these works.

³ Systematic reports on the fauna of these two areas were made by numerous workers and were published in the *Memoirs of the Indian Museum*, Vol. V, 1915-1924 and *Mem. Asiat. Soc. Beng.*, VI, 1916-1925, respectively.

gave instances of several animals which can tolerate inland waters of very high salinities but cannot apparently live in the sea. It was, therefore, considered desirable to make an intensive study of the fauna of the Khewra Gorge in special reference to the nature of its water.

The fauna of this stream was collected in the autumn of 1930 and the spring of 1931. On both occasions the stream was in the form of a series of pools. The salinity was found to be higher on the latter occasion. Between the two periods of making collections there had been no intervention of a rainy season, which lasts from July to September. During and just after this season the stream is continuous and flows very rapidly and there is consequently a thorough mixing of the fauna of its different parts. To study the changes in the fauna after the intervention of a rainy season and thus complete the investigation, I intended to pay another visit to the locality in September, 1931, but in view of the financial stringency the project had to be abandoned. As the financial conditions are not likely to improve in the near future, it has been thought advisable to publish the results of the investigations made on the two occasions mentioned above.

In addition to the Khewra Gorge, the fauna of the salt water lake near Kallar Kahar and of a series of pools at Chalisa and Sodi were also investigated. On the occasion of my second visit I examined also the San Sakesar Lake near the village Uhhali at the base of the Sakesar hills in the Salt Range. In the map of the Salt Range given below the various waters investigated, except the San Sakesar Lake, are indicated. This lake lies about 60 miles west of Kallar Kahar.



TEXT-FIG. 1.—Map of the Salt Range (part), Punjab, showing all the waters investigated except the San Sakesar Lake

I determined the PH value (Colorimetric method), the temperature and the oxygen content (Winkler's method) of the water at the side of the stream at the time of making collections. The salinity was roughly measured in the Dak Bungalow at Khewra on the same day on which the water samples were collected. But since, as was shown by Bert (1883), Varigny (1883), Plateau (1883), Pantin (1931), etc., salinity changes alone hardly give an accurate index to the suitability of a water as a habitat for different animals, and ions like sodium, potassium, calcium, etc., play an important role in this connection, it was proposed to have all the water samples completely analysed. Dr. A. N. Puri, D.Sc. (Lond.), of the Irrigation Research Laboratory, Lahore, carried out the chemical analyses including salinity determinations soon after the collection of the samples. Col. R. B. Seymour Sewell made accurate salinity determinations (by titration method as recommended by the Conseil Permanent pour l'Exploration de la Mer) in Calcutta after the expiry of one year, when the water samples were received back from Dr. Puri. The samples had been stored in spring-stoppered glass bottles provided with good rubber washers. The salinities mentioned in the following pages were calculated from Col. Sewell's figures of halogen contents.

The credit for starting this research is mainly due to my colleague and friend Dr. S. L. Hora, who as above mentioned had toured in the Salt Range in 1922 and who not only drew my attention to the stream but accompanied me to Khewra on the occasion of my first visit, *viz.*, October 1930. My best thanks are also due to Col. R. B. Seymour Sewell, Director, Zoological Survey of India, who took keen interest in the investigations and afforded facilities for carrying out the same, and to Dr. Bains Prashad for going through the manuscript and making some useful suggestions.

Naturally I had to seek the help of many specialists both in India and abroad for naming the various groups of animals collected and I take this opportunity of expressing my indebtedness to them. I give below the list of such workers. The orders and families of insects, which are not mentioned below but are dealt with in the report, have been named by myself with the help of my Assistant, Mr. S. Ribeiro.

| | |
|---------------------------------|--|
| Pisces | Mr. D. D. Mukerji, Indian Museum, Calcutta. |
| Amphibia and Mollusca | Mr. J. L. Bhaduri, Indian Museum, Calcutta. |
| Crustacea | Mr. K. N. Das, Indian Museum, Calcutta. |
| Insects. | |
| Coleoptera | Prof. Dr. Heinrich Kuntzen (Berlin). Dr. A. d'Orohyont (Brussels). Dr. M. Cameron (London). Mr. H. E. Andrewes (London). Mr. S. Maulik (London). M. E. Fleutiaux (Paris). |
| Rhynchota (part) | Dr. G. E. Hutchinson (Yale). Dr. O. Lundblad (Stockholm). |
| Odonota | Lt.-Col. F. C. Fraser. |
| Ephemeroptera | Dr. B. N. Chopra, Indian Museum, Calcutta. |
| Diptera | Mr. F. W. Edwards (London). |
| Algae | Dr. S. L. Ghosh, Government College, Lahore. |

The fauna of the Khewra Gorge and the condition of its water at the time of making collections.

At the beginning of the investigation, the salinity of the stream was roughly measured at several places, and eleven stations were selected for intensive work. In this chapter these stations are described in detail, the physical and chemical analyses of the water at each station are appended and the animals collected at the stations are enumerated. In the analyses the values are expressed as grams per litre except when otherwise stated. The salinity was calculated from the halogen content by the following formula of Knudsen :— $\text{Sal.} = 0.03 + 1.805 \times \text{cl}$, where cl is equal to the halogen content.

Sta. 1.

Near the first dam across the stream, about one furlong from Khewra. Water shallow, clear, with long tufts of filamentous algae. Bottom rocky, covered with fine, dark mud with a coating of reddish coarse sediment.

Date and time of collection.—11th October, 1930. 3-15—10-30 a.m.

Physical and Chemical condition of the water.—Temp. 27°C; PH 8.0; Alkali reserve 0.0038N; Oxygen 4.14 cc. per litre. Total solids 75.96 gm. per litre; Ca 1.748; Mg 0.252; K 0.142; Na 27.691; SO₄ 1.799; HCO₃ 0.0114; NO₃ 0.0124; Conductivity 13.98. Halogen content 43.49; Salinity 78.529.

Na & Cl constituted the major portion (36.46 per cent. and 58.33 per cent. respectively) of the total solids; Ca 2.3 per cent. (Tables I and II).

Fauna.—No animal life except insects.

Coleoptera.

| | | | |
|---------------|---|----------|--------------|
| Hydrophilidae | . 1. <i>Octhebius</i> sp. | (Adult). | Very common. |
| | 2. <i>Berosus punctulatus</i> f. col. <i>immaculicollis</i> Fairm. sensu Knisch | „ | Common. |

Ephemeroptera.

| | | | |
|----------|---------------------|-----------|-------------------|
| Baetidae | . <i>Cloëon</i> sp. | (Larvae). | Extremely common. |
|----------|---------------------|-----------|-------------------|

Diptera.

| | | | |
|--------------|-------------------------|-----------|--------|
| Chironomidae | . <i>Culicoides</i> sp. | (Larvae). | Some. |
| „ | . Gen. and sp. ? | „ | „ |
| Tabanidae | . <i>Tabanus</i> sp. | „ | A few. |

Under stones on the sides of the water channel an earwig, *Labidura* sp. and a spider, *Lycosa* sp. were fairly common.

Date and time of collection.—27th March, 1931. 8—10 a.m.

Physical and Chemical condition of the water.—Temp. 21.0°C; PH 7.85; Oxygen 3.02 cc. per litre; Halogen content 92.42; Salinity 166.830.

Fauna.—The *Berosus* beetle, may-fly and chironomid larvae obtained in October, 1930 were absent. In addition to the other species obtained in October, 1930, the following were collected :—

Coleoptera.

| | | | |
|---------------|----------------------------------|-------------|--------|
| Hydrophilidae | Probably <i>Berosus</i> sp. | . (Larvae). | Some. |
| Chrysomelidae | <i>Psylliodes tenebrosus</i> * | | |
| | Jac. | . (Adult). | „ |
| Elateridae | <i>Drasterius collaris</i> Cand. | „ | A few. |

Rhynchota.

| | | | |
|---------------|-----------------------|------------|--------|
| Hydrometridae | <i>Hydrometra</i> sp. | . (Adult). | A few. |
|---------------|-----------------------|------------|--------|

Diptera.

| | | | |
|-------------|----------------|-------------|-------|
| Sciomyzidae | Gen. and sp. ? | . (Larvae). | Some. |
|-------------|----------------|-------------|-------|

Sta. 2.

About $\frac{1}{4}$ mile beyond Sta. 1. High red rocks on both sides of the stream. Water shallow, laden with red sediment. Some algae present, chiefly *Chaetomorpha* sp., near *herbipolensis* Lag.

Date and time of collection.—12th October, 1930. 7-30—10-30 a.m.

Physical and Chemical condition of the water.—Temp. 26.4°C ; Oxygen 3.35 cc. per litre ; PH 7.95 ; Alkali reserve 0.0044 N. Total solids 87.536 gm. per litre ; Ca 1.888 ; Mg 0.231 ; K 0.089 ; Na 33.047 ; SO₄ 1.530 ; HCO₃ 0.0126 ; NO₃ 0.0093 ; Conductivity 15.65 ; Halogen content 50.55 ; Salinity 91.273.

Na and Cl constituted the major portion (37.76 per cent. and 57.97 per cent.) of the total solids. Ca 2.16 per cent. only (Tables I and II).

Fauna.—No animal life except insects.

Coleoptera.

| | | | |
|---------------|---|-------------|-------------------|
| Hydrophilidae | <i>Octhebius</i> sp. | . (Adult). | Extremely common. |
| „ | <i>Berosus punctulatus</i> f. col. <i>immaculicollis</i> Fairm. sensu Knisch. | „ | Common. |
| „ | <i>Enochrus</i> sp. | „ | A few. |
| „ | <i>Enoplurus</i> sp. | „ | „ |
| „ | Gen. and sp. ? | . (Larvae). | About 1 doz. |

Ephemeroptera.

| | | | |
|----------|-------------------|-----------|---------|
| Baetidae | <i>Cloëon</i> sp. | (Larvae). | Common. |
|----------|-------------------|-----------|---------|

Diptera.

| | | | |
|--------------|-----------------------|-------------|--------|
| Chironomidae | <i>Culicoides</i> sp. | . (Larvae). | A few. |
| „ | Gen. and sp. ? | „ | „ |

Under stones on the sides of the water channel the earwig *Labidura riparia* and a spider, *Lycosa*, sp. were present.

* In the opinion of Mr. S. Maulik, the presence of *Psylliodes tenebrosus* in salt water is probably accidental.

Date and time of collection.—9th April, 1931. 8—9 a.m.

Physical and Chemical condition of the water.—Temp. 20.7°C ; PH 7.95 ; Oxygen 3.4 cc. per litre ; Halogen content 68.66 ; Salinity 123.961.

Fauna.—The *Berosus* beetle, may-fly and chironomid larvae obtained in October, 1930 were not found. In addition to the other animals obtained in October, 1930, the following were collected :—

Coleoptera.

Hydrophilidae . Probably *Berosus* sp. . (Larvae). Common.
Staphylinidae *Platystethus cornutus* Gr. (Adult). Few.

Sta. 3.

About $\frac{1}{4}$ mile beyond station 2. Water clear, thickly covered with algae of several species, e.g., *Enteromorpha* sp., near *salina* Kutz. ; *Chaetomorpha herbipolensis* Lag. and *Cocconeis pediculus* Ehr. Bottom rocky or covered with pebbles. Depth 1-2 ft.

Date and time of collection.—13th October, 1930. 8—11 a.m.

Physical and Chemical condition of water.—Temp. 24.4°C ; Oxygen 4.65 cc. per litre ; PH 8.05 ; Alkali reserve 0.0052 N ; Total solids 40.916 ; Ca 1.2 ; Mg 0.17 ; K 0.086 ; Na 15.059 ; SO₄ 1.473 ; HCO₃ 0.0174 ; NO₃ 0.0124 ; Conductivity 8.264 ; Halogen content 23.45 ; Salinity 42.357.

Na 36.81 per cent. ; Cl 55.97 per cent. ; Ca 2.93 per cent. (Tables I and II).

Fauna.—No animal life except insects.

Coleoptera.

| | | | |
|-----------------------|--|---------------------------------|-----------|
| Hydrophilidae | <i>Berosus punctulatus</i> f. col. <i>immaculicollis</i> Fairm. sensu Knisch | (Adult). | A few. |
| „ | <i>Octhebius</i> sp. | „ | „ |
| „ | <i>Enochrus</i> sp. | „ | „ |
| Dytiscidae | <i>Potamodytes</i> sp.† | „ | Few. |
| Dryopidae | <i>Dryops</i> sp. | „ | „ |
| <i>Ephemeroptera.</i> | | | |
| Baetidae | <i>Cloëon</i> spp. | (Larvae and dead adults). | Numerous. |

Under stones near the sides of the water channel, the earwig *Labidura riparia* present.

Date and time of collection.—9th April, 1931. 9—10 a.m.

Physical and Chemical condition of water.—Temp. 21.7°C ; PH 8.1 ; Oxygen 4.1 cc. per litre ; Halogen content 28.27 ; Salinity 51.057.

Algae in great abundance.

Fauna.—*Berosus*, *Potamodytes* and *Dryops* beetles obtained in October, 1930 were absent. In addition to the other species obtained in October, 1930, the larvae of a species of *Tabanus* were found in large number.

† Dr. H. Kuntzen considers this to be a new species.

Sta. 4.

A small and shallow streamlet flowing out of the main stream near station 3. Bed covered with small stones, water clear, slightly yellowish. Sides covered with deposits of salts. Hardly any vegetation.

Date and time of collection.—13th October, 1930. 7—9-30 a.m.

Physical and Chemical condition of water.—Temp. 24·0°C; Oxygen 2·85 cc. per litre; PH 8·1; Alkali reserve 0·0038 N. Total solids 137·84; Ca 2·752; Mg 0·372; K 0·152; Na 54·064; SO₄ 0·783; HCO₃ 0·0126; NO₃ 0·0124; Conductivity 22·42; Halogen content 79·70; Salinity 143·889.

Na 39·23 per cent. (more than in any other water examined), Cl 57·84 per cent.; NO₃ 0·009 per cent. (least); Ca 2·00 per cent. (Tables I and II).

Fauna.—No animal life except insects.

Coleoptera.

| | | | | |
|---------------|-------------------------------|-------|----------|-------------------|
| Hydrophilidae | <i>Octhebius</i> sp. | . . . | (Adult). | Extremely common. |
| | <i>Berosus punctulatus</i> | | | . |
| | f. col. <i>immaculicollis</i> | | | |
| | Fairm. <i>sensus</i> Knisch | | „ | Some. |
| | <i>Enochrus</i> sp. | . . . | „ | „ |
| | <i>Enoplurus</i> sp. | . . . | „ | „ |

Date and time of collection.—9th April, 1931. 8—9 a.m.

Physical and Chemical condition of water.—Temp. 23·8°C; PH 7·8; Oxygen 2·8 cc. per litre; Halogen content 72·46; Salinity 130·82.

Fauna.—No animal life except insects. *Berosus*, *Enochrus* and *Enoplurus* beetles not found. In addition to *Octhebius* sp. which was very common, a specimen of a Thysanuran and a large number of Scio-myzid larvae (Diptera) were found.

Sta. 5.

A large, deep pool in the course of the stream near its first sharp turning. Bottom rocky, in some places muddy or covered with coarse shingle. Water clear. Several species of algae present, e.g., *Spirogyra* sp., *Oedogonium* sp., *Navicula* (*Pinnularia*) *parva* Ehrenb., *Cymbella helvetica* Kutz., *C. cymbiformis* Kutz., *Synedra acus* Kutz., *Nitzschia angustata* W. Sm. var. *genuina* Meist. and *Tryblionella punctata* (W. Sm.) Grun.

Date and time of collection.—14th October, 1930. 9-30—11-30 a.m.

Physical and Chemical condition of water.—Temp. 25·2°C; Oxygen 5 cc. per litre; PH 8·0; Alkali reserve 0·0054 N. Total solids 38·224; Ca 1·140; Mg 0·178; K 0·129; Na 13·856; SO₄ 1·463; HCO₃ 0·0183; NO₃ 0·0124; Conductivity 7·874; Halogen content 21·51; Salinity 38·856.

Na 36.25 per cent. ; Cl 56.06 per cent. ; Ca 2.98 per cent. ; K 0.337 per cent. ; SO₄ 3.83 per cent. (Tables I and II).

Fauna.—No animal life except insects.

Coleoptera.

| | | |
|----------------------|--|---------|
| Hydrophilidae | <i>Berosus punctulatus</i> f. col. <i>immaculicollis</i> Fairm. <i>sensu</i> Knisch (Adult). | Common. |
| | <i>Enochrus</i> sp. | A few. |
| Dytiscidae | <i>Potamodytes</i> sp. | Common. |
| Dryopidae | <i>Dryops</i> sp. | Some. |

Ephemeroptera.

| | | |
|--------------------|--------------------------------------|---------|
| Baetidae | <i>Cloëon</i> spp. (Larvae). | Common. |
|--------------------|--------------------------------------|---------|

Diptera.

| | | |
|-----------|----------------------------|---|
| Tabanidae | <i>Tabanus</i> sp. | „ |
|-----------|----------------------------|---|

Date and time of collection.—9th April, 1931. 9—10 a.m.

Physical and Chemical condition of water.—Temp. 21.7°C ; PH 7.7 ; Oxygen 4.8 cc. per litre.

Fauna.—In addition to the species found in October, 1930, a few specimens of the Carabid *Tachys quadrillum* Schaum and the Hemipteron *Heleocoris* were obtained. The beetle *Enochrus* sp. was much more common. Some dead specimens of adult may-flies (*Cloëon* spp.) were also obtained.

Sta. 6.

The stream at the first sharp turning, about 50 yds. from Sta. 5 ; Water clear, depth 2—2.5 ft. Bottom covered with pebbles, stones and large pieces of rock. Several species of algae present, e.g., *Enteromorpha* sp. prox. *salina* Kutz., *Chaetomorpha herbipolensis* Lag., *Cocconeis pediculus* Ehr., *Amphora* sp., *Nitzschia* sp.

Date and time of collection.—14th October, 1930. 7-15—10-30 a.m.

Physical and Chemical condition of water.—Temp. 23.20°C ; Oxygen 5.7 cc. per litre ; PH 8.15 ; Alkali reserve 0.0052 N. Total solids 9.928 ; Ca 0.436 ; Mg 0.090 ; K 0.096 ; Na 3.345 ; SO₄ 0.482 ; HCO₃ 0.0177 ; NO₃ 0.0124 ; Conductivity 2.278 ; Halogen content 6.01 ; Salinity 10.878.

With the exception of Na and Cl the percentage of all the ions more than at the previous five stations. Na 33.7 per cent. ; Cl 54.91 per cent. ; Ca 4.39 per cent. ; Mg 0.906 per cent. (Tables I and II).

Fauna.—In addition to insects, an amphibian and some fish were also obtained.

Insecta.

Coleoptera.

| | | |
|------------|--------------------------------------|--------------|
| Dryopidae | <i>Dryops</i> sp. (Adult). | Very common. |
| Dytiscidae | <i>Hydaticus fabricii</i> , Mac-Leay | „ Some. |
| „ | <i>Potamodytes</i> sp. | „ Common. |

Ephemeroptera.

| | | |
|--------------------|-----------------------------|-----------|
| Baetidae | <i>Cloëon</i> sp. (Larvae). | Numerous. |
|--------------------|-----------------------------|-----------|

| | | | |
|------------------|--|-----------|-------|
| <i>Odonata.</i> | | | |
| Libellulidae | <i>Trithemis</i> sp., probably <i>festiva</i> (Ramb.) | (Nymphs). | Some. |
| <i>Diptera.</i> | | | |
| Tabanidae | <i>Tabanus</i> sp. | (Larvae). | Some. |
| <i>Amphibia.</i> | | | |
| Ranidae | <i>Rana cyanophlyctis</i> Schneid. | (Adult). | Some. |
| <i>Pisces.</i> | | | |
| Cyprinidae | <i>Barilius vagra</i> (Ham. Buch.) | | Some. |

The lip of a small fall at the head of station 6 was covered with a thick growth of algae in which Chironomid larvae (forming tubes on stones) and a Veliid bug (Hydrometridae) were fairly abundant.

Date and time of collection.—29th March, 1931. 10—11-30 a.m.

Physical and Chemical condition of water.—Temp. 21.6°C; PH 7.9; Oxygen 6.4 cc. per litre; Halogen content 5.26; Salinity 9.524.

Fauna.—May-fly larvae were absent. In addition to the other species found in October, 1930, the following were obtained:—

Coleoptera.

| | | | |
|---------------|----------------------|-----------|---------|
| Hydrophilidae | ? <i>Berosus</i> sp. | (Adult). | Common. |
| „ | <i>Enochrus</i> sp. | „ | Some. |
| „ | Gen. and sp. ? | (Larvae). | Common. |

Sta. 7

A large pool in the course of the stream, about 100 yds. from Sta. 6. Water clear, greatest depth 6 ft., bottom sandy. Algae few, *e.g.*, stray filaments of *Oedogonium* sp., *Phromidium molle* (Kutz.), and *Cocconeis pediculus* Ehrenb.

Date and time of collection.—14th October, 1930. 9-45—11-30 a.m.

Physical and Chemical condition of water.—Temp. 23.3°C; Oxygen 5.0 cc. per litre; PH 8.0; Alkali reserve 0.0051 N. Total solids 4.42; Ca 0.284; Mg 0.122; K 0.034; Na 1.376; SO₄ 0.304; HCO₃ 0.0171; NO₃ 0.0124; Conductivity 1.064; Halogen content 2.85; Salinity 5.174.

Percentage of Na and Cl less, and that of all other ions higher than at the previous stations. Great increase in the percentage of Ca (6.43 per cent.) and Mg (2.76 per cent.). (Tables I and II.)

Fauna.—Representatives of Insecta, Mollusca, Amphibia and Pisces obtained.

Insecta.

Coleoptera.

| | | | |
|---------------|---------------------|----------|---------|
| Hydrophilidae | Gen. and sp. ? | (Adult). | Common. |
| „ | <i>Enochrus</i> sp. | „ | Some. |

Ephemeroptera.

| | | | |
|----------|-------------------|-----------|-------|
| Baetidae | <i>Cloëon</i> sp. | (Larvae). | Some. |
|----------|-------------------|-----------|-------|

Trichoptera.

Polycentropidae Gen. and sp. ? . . (Larvae) Some.

Odonata.

Libellulidae . *Trithemis* sp. probably
festiva (Ramb.) . (Nymphs). Common.

Rhynchota.

Nepidae . *Ranatra elongata* Fabr. (Adult). Some.

Mollusca.

Melanidae *Melanoides flavidus*
(Nevill) . Common.

Amphibia.

Ranidae . *Rana cyanophlyctis*
Schneid. . (Adult). Common.

Pisces.

Cyprinidae *Scaphiodon readingi*
Hora Common.

Date and time of collection.—31st March, 1931. 9-30—10-30 a.m.

Physical and Chemical condition of water.—Temp. 21.2°C; PH 7.7;
Oxygen 6 cc. per litre; Halogen content 3.51; Salinity 6.366.

Fauna.—In addition to the animals obtained in the autumn of 1930,
the following species were collected :—

*Insecta.**Rhynchota.*

Notonectidae *Enithares lineatipes*
Horv. . . (Adult). A few.

Coleoptera.

Carabidae *Dyschirius* sp. . (Adult). A few
Hydrophilidae ? *Berosus* sp. ,, Common.
Dytiscidae . *Potamodytes* sp. . ,, A few.
Dryopidae . *Dryops* sp. . . ,, Common.

Diptera.

Tabanidae . *Tabanus* sp. . (Larvae). Some.

Pisces.

Cyprinidae . *Crossochilus latius* (Ham.
Buch.) . . . Some.

Sta. 8.

A deep pool below a water fall near the second dam across the stream.
Water clear. Bottom sandy or covered with gravel and small stones.
Several species of algae present, e.g., *Oedogonium* sp. (stray filaments,
sterile); *Phromidium molle* (Kutz.) Gom., *Denticula crassula* Naeg.,
Gomphonema subclavatum Grun., *Calothrix minima* Fremy.

Date and time of collection.—15th October, 1930. 8—10 a. m.

Physical and Chemical condition of water.—Temp. 23·0°C ; Oxygen 5·0 cc. per litre ; PH 8·20 ; Alkali reserve 0·0053 N. Total solids 1·744 ; Ca 0·224 ; Mg 0·107 ; K 0·020 ; Na 0·385 ; SO₄ 0·276 ; Cl 0·710 ; HCO₃ 0·0093 ; NO₃ 0·0124 ; Conductivity 0·422 ; Halogen content 0·74 ; Salinity 1·366.

Sudden fall in the percentage of Na (22·08 per cent.) and Cl (40·71 per cent.) and sudden rise in that of Ca (12·84 per cent.), Mg (6·13 per cent.), K (1·147 per cent.) and SO₄ (15·83 per cent.), etc. (Tables I and II).

Fauna.—Representatives of Platyhelminthes, Annulata, Crustacea, Insecta, Mollusca, Amphibia and Pisces obtained.

Platyhelminthes.

Turbellaridae . Gen. and sp. ? . . Common on stones.

Annulata.

Hirudinea . *Glossiphonia reticulata*
Kaburaki . . . 2 specimens.

Crustacea.

Potamonidae *Potamon (Potamon) fluviatile* (Latr.) var.
monticola W.-M. . Common under stones.

Insecta.

Coleoptera.

Dryopidae *Dryops* sp. . . (Adult). Few.

Ephemeroptera.

Baetidae *Caenis* sp. . . (Larvae). Few.

Choroterpes sp. . . " "

Trichoptera.

Polycentropidae Gen. and sp. ? . . (Larvae). Very common.

Odonata.

Aeschnidae . *Anax guttatus* Burm. (Nymphs). A few.

Mollusca.

Melanidae . *Melanoides flavidus* (Nevill) . . Common on stones near the edges.

Amphibia.

Ranidae . . *Rana cyanophlyctis* Schneid. . Common.

Pisces.

Cyprinidae . *Garra montis-salsi* Hora . .
Crossochilus latius (Ham. Buch.) . Some.
Scaphiodon readingi Hora Common.

Date and time of collection.—10th April, 1931.

Physical and Chemical condition of water.—Temp. 21·4°C ; PH 7·8 ; Oxygen 5·72 cc. per litre ; Halogen content 1·08 ; Salinity 1·979.

Fauna.—Planarians and *Choroterpes* larvae (Ephemeroptera) were not found. In addition to the other animals obtained in the autumn of 1930, the following were collected :—

*Insecta.**Coleoptera.*

| | | | |
|------------|----------------------------------|----------|----------------|
| Carabidae | <i>Tachys blandus</i> Andr. | (Adult). | Some. |
| Dytiscidae | <i>Potamodytes</i> sp. | „ | Fairly common. |
| „ | <i>Hydaticus</i> sp. | „ | A few. |
| „ | Gen. and sp. ? | „ | „ |
| Elateridae | <i>Drasterius collaris</i> Cand. | „ | „ |

Rhynchota.

| | | | |
|--------------|--------------------------------------|----------|-------|
| Nepidae | <i>Ranatra elongata</i> Fabr. | (Adult). | Some. |
| Notonectidae | <i>Enithares lineatipes</i> Horv. | „ | „ |

Odonata.

| | | | |
|--------------|--|-----------|-------|
| Libellulidae | <i>Trithemis</i> sp., probably <i>festiva</i> (Ramb.) | (Nymphs). | Some. |
|--------------|--|-----------|-------|

At the lip of the fall at the head of station 8, aquatic caterpillars belonging to the genus *Aulocodes* (Pyrilidae), a small Veliid bug (Hydrometridae), a tiny Corixid bug (considered to be a new species by Dr. Lundblad) and Chironomid larvae were obtained.

Sta. 9.

A series of small pools and rapids in the course of the stream, 50 yds. beyond station 8. Bottom and sides rocky (limestone). Five species of algae present, viz., *Chaetomorpha herbipolensis* Lag., *Fragillaria capucina* Desm., *Nitzschia palea* Kutz., *Cymbella heloetica* Kutz., *Amphora* sp.

Date and time of collection.—15th October, 1930. 10—12 a.m.

Physical and Chemical condition of water.—Temp. 23.4°C; Oxygen 6.3 cc. per litre; PH 8.25; Alkali reserve 0.0056 N. Total solids 1.344; Ca 0.168; Mg 0.052; K 0.032; Na 0.431; SO₄ 0.107; HCO₃ 0.0162; NO₃ 0.0124; Conductivity 0.317; Halogen content 0.51; Salinity 0.951.

Great increase in the percentage of K (2.381 per cent.); Ca and Cl about same as at Sta. 8; Na 32.07 per cent. (Tables I and II).

Fauna.—Representatives of Insecta, Mollusca, Amphibia and Pisces obtained.

Insecta.

Coleoptera Gen. and sp. ? (Larvae). Common.

Ephemeroptera.

Baetidae . *Baetis* sp. „ „

Trichoptera.

Polycentropidae Gen. and sp. ? (Larvae). Common.

Rhynchota.

Gerridae . *Metrocoris stali* (Dohrn) (Adult). Some.
Metrocoris sp. „ „

Mollusca.

| | | | |
|-----------|--|---|-------|
| Melanidae | <i>Melanoides flavidus</i> (Nevill) | . | Some. |
|-----------|--|---|-------|

Amphibia.

| | | | |
|---------|---------------------------------------|---|---------------|
| Ranidae | <i>Rana cyanophlyctis</i> Schneid. | . | Quite common. |
|---------|---------------------------------------|---|---------------|

Pisces.

| | | | |
|------------|--|---|-------|
| Cyprinidae | <i>Garra montis-salsi</i> Hora | . | Some. |
| " | <i>Crossochilus latius</i> (Ham. Buch.) | . | " |
| " | <i>Scaphiodon readingi</i> Hora | . | " |

Date and time of collection.—10th April, 1931.

Physical and Chemical condition of water.—Temp. 21.6°C ; PH 7.85 ; Oxygen 6.88 cc. per litre ; Halogen content 1.08 ; Salinity 1.979.

Fauna.—In addition to the animals obtained in the autumn of 1930, the following were collected :—

Coleoptera.

| | | | |
|---------------|--|----------|---------|
| Hydrophilidae | ? <i>Berosus</i> sp. | (Adult). | Common. |
| Dytiscidae | <i>Potamodytes</i> sp. | . | " |
| " | <i>Hydaticus fabricii</i> Mac- Leay | . | A few. |

Odonata.

| | | | |
|--------------|--|-----------|---------|
| Libellulidae | <i>Trithemis</i> sp., probably <i>festiva</i> (Ramb.) | (Nymphs). | Common. |
|--------------|--|-----------|---------|

Rhynchota.

| | | | |
|--------------|--------------------------------------|-----------|--------|
| Notonectidae | <i>Enithares lineatipes</i> Horv. | (Adult). | A few. |
| Gerridae | <i>Metrocoris stali</i> Dohrn. | . | Some. |
| Naucoridae | <i>Heleocoris</i> sp. | (Nymphs). | " |

Diptera.

| | | | |
|--------------|---------------------|-----------|-------|
| Simuliidae | <i>Simulium</i> sp. | (Larvae). | Some. |
| Chironomidae | Gen. and sp. ? | . | " |

Trichoptera.

| | | | |
|-----------------|----------------|-----------|-------|
| Polycentropidae | Gen. and sp. ? | (Larvae). | Some. |
|-----------------|----------------|-----------|-------|

Sta. 10.

About $\frac{1}{4}$ mile from station 9, where the water pipes cross the stream. Water shallow, flowing very slowly. Bottom rocky. Four species of algae present, viz., *Spirogyra* sp. (sterile), *Fragillaria capucina* Desm., *Denticula crassula* Naeg., *Cymbella ehrenbergi* Kutz.

Date and time of collection.—18th October, 1930.

Physical and Chemical condition of water.—Temp. 23.0°C ; PH 8.1 ; Alkali reserve 0.0084 N ; Oxygen 5.75 cc. per litre. Total solids 0.480 ; Ca 0.152 ; Mg 0.039 ; K 0.004 ; Na 0.066 ; SO₄ 0.136 ; HCO₃ 0.0144 ; NO₃ 0.0186 ; Conductivity 0.112 ; Halogen content 0.08 ; Salinity 0.174.

Na 13.75 per cent. (least) ; Cl 10.42 per cent. (very low) ; percentage of Ca (31.67 per cent.), Mg (8.12 per cent.), SO₄ (28.33 per cent.), NO₃ (3.85 per cent.) and HCO₃ (3.0005 per cent.) higher than at any other place in the Khewra Gorge.

Fauna.—Representatives of Insecta, Crustacea, Mollusca and Pisces obtained.

Insecta.

Rhynchota.

Nepidae . *Ranatra elongata* Fabr. (Adult). A few.

Gerridae . *Metrocoris* sp. " "

Ephemeroptera.

Baetidae *Choroterpes* sp. (Larvae). Common.

Odonata.

Aeschnidae . *Anax guttatus* Burm. (Nymphs). Common.

" . *Brachydiplax* sp. " A few.

" *Gomphus* sp. " "

Crustacea.

Potamonidae *Potamon (Potamon) fluviatile* (Latr.) var. *monticola* W.-M. Some.

Mollusca.

Melanidae *Melanoides flavidus* (Nevill) Common.

Pisces.

Cyprinidae *Scaphiodon readingi* Hora . (Young). Common.

Date and time of collection.—2nd April, 1931.

Physical and Chemical condition of water.—Halogen content 0.32 ; Salinity 0.608.

Fauna.—In addition to the animals obtained in the autumn of 1930, the following were collected :—

Insecta.

Coleoptera.

Carabidae *Tachys blandus* Andr. . (Adult). Some.

Dytiscidae *Potamodytes* sp. " "

" Gen. and sp. ? (Larvae). A few.

" Gen. and sp. ? " "

Hydrophilidae ? *Berosus* sp. . (Adult). "

Elateridae *Drasterius collaris* Cand. " "

Ephemeroptera.

Baetidae *Choroterpes* sp. (Larvae). Very common.

" *Ephemera* sp. (Larva). 1 specimen.

Rhynchota.

Naucoridae *Heleocoris* sp. (Adult). A few.

Diptera.

Chironomidae . Gen. and sp. ? (Larvae). Some.

Sta. 11.

A series of shallow pools, rapids and falls above the water reservoir. Water clear; bed rocky. Several species of algae present, e.g., *Spirogyra* sp. (sterile); *Oedogonium* sp. (sterile); *Cosmarium* sp. (rare); *Cymbella helvetica* Kutz.; *Denticula crassula* Naeg.; *Gomphonema subclavatum* Grun.; *Navicula (Pinnularia) parva* Ehrenb.; *Rhopalodia gibba* (Ehrenb.) Muller; *Cymbella ventricosa* Kutz.; *Chroococcus turgidus* (Kutz.) Naeg.; *Homoeothrix* sp., prox. *juliana* (Menegh.) Kirchn.

Date and time of collection.—18th October, 1930. 8-30—11-30 a.m.

Physical and Chemical condition of water.—Temp. 21.0°C; Oxygen 6.5 cc. per litre; PH 8.1; Alkali reserve 0.0048 N. Total solids 0.720; Ca 0.204; Mg 0.044; K 0.040; Na 0.233; SO₄ 0.113; HCO₃ 0.0171; NO₃ 0.0186; Conductivity 0.1171; Halogen content 0.05; Salinity 0.120.

Percentage of K (5.556 per cent.) much higher and that of Cl (6.94 per cent.) lower than in any other water investigated. Ca (28.34 per cent.), NO₃ (2.5835 per cent.) and HCO₃ (2.3750 per cent.) very high; Na 32.36 per cent. (Tables I and II).

Fauna.—Representatives of Platyhelminthes, Insecta, Crustacea, Mollusca, Amphibia and Pisces obtained.

Platyhelminthes.

Turbellariidae Gen. and sp. ? . Common.

Insecta.

Ephemeroptera

Baetidae *Baetis* sp. . . (Larvae). Common.

Trichoptera.

Polycentropidae Gen. and sp. ? . (Larvae). Common.

Rhynchota.

Gerridae . *Metrocoris stali* (Dohrn) (Adult). Some.

Metrocoris sp. . . " "

Veliidae . . Gen. and sp. ? . . " Common in rapid water.

Diptera.

Chironomidae Gen. and sp. ? . (Larvae). Common in rapid water.

Crustacea.

Potamonidae . *Potamon (Potamon) fluviatile* (Lat.) var. *ibericum* (Mar. deBieb.) .. Some.

Mollusca.

Melanidae . *Melanoides flavidus* (Nevill) . .. Common.

Amphibia.

Ranidae *Rana cyanophlyctis* Schneid. Fairly common.

Pisces.

Cyprinidae . *Scaphiodon readingi* Hora . Very common.

„ *Garra montis-salsi* Hora . Common.

„ *Crossochilus latius* (Ham. Buch.) . . . „

Date and time of collection.—3rd April, 1931.

Physical and Chemical condition of water.—Halogen content 0.09; Salinity 0.192.

Fauna.—Planarians were not found. In addition to the other animals collected in October, 1930, the following were obtained :—

Insecta.

Coleoptera.

| | | | |
|---------------|--------------------------------------|----------|--------|
| Hydrophilidae | ? <i>Berosus</i> sp. | (Adult). | Some. |
| Dytiscidae | <i>Potamodytes</i> sp. | „ | A few. |
| „ | <i>Laccophilus flexuosus</i> Aube | „ | „ |

Rhynchota.

| | | | |
|--------------|--------------------------------------|--|--------|
| Naucoridae | <i>Heleocoris</i> sp. | | A few. |
| Notonectidae | <i>Enithares lineatipes</i> Horv. | | „ |

A LARGE TANK NEAR THE CHALISA RAILWAY STATION.

Close to the Railway line. Water slightly turbid. Bottom muddy. Plenty of vegetation both on the shore and in the water. The alga *Cyclotella kutzingiana* Thwait very common.

Date and time of collection.—22nd October, 1931. 6.30—9.30 a.m.

Physical and Chemical condition of water.—Temp. 24.2°C; Oxygen 5.00 cc. per litre; PH 8.7; Alkali reserve 0.0012 N. Total solids 6.920; Ca 0.660; Mg 0.143; K 0.132; Na 1.755; SO₄ 0.854; HCO₃ 0.0036; NO₃ 0.0139; Conductivity 1.548; Halogen content 3.27; Salinity 5.932.

Ca 9.54 per cent.; Mg 2.07 per cent.; K 1.907 per cent.; Na 25.36 per cent.; SO₄ 12.34 per cent.; Cl 48.52 per cent.

Fauna.—Representatives of Insecta and Pisces obtained.

Insecta.

Coleoptera.

| | | | |
|---------------|---------------------------------------|----------|--------------|
| Hydrophilidae | <i>Enoplurus indica</i> Motsch. | (Adult). | Some. |
| Dytiscidae | <i>Laccophilus flexuosus</i> Aube | „ | Very common. |
| „ | <i>Canthydrus laetabilis</i> Walk. | „ | A few. |

Rhynchota.

| | | | |
|--------------|---|-----------|---------|
| Nepidae | <i>Ranatra sordidula</i> Dist. | (Adult). | Common. |
| „ | <i>Laccotrephes</i> sp. | (Nymphs). | Some. |
| Gerridae | <i>Gerris tristan</i> Kirk. | (Adult). | „ |
| „ | <i>Gerris spinolae</i> Leth. and Serv. | „ | „ |
| „ | <i>Gerris fossarum</i> Fabr. | „ | „ |
| Belostomidae | <i>Sphaerodema molestum</i> Duf. | „ | A few. |
| Notonectidae | <i>Anisops</i> sp. | „ | „ |
| „ | <i>Plea</i> sp. | „ | „ |

| | | |
|-----------------------|--|------------------------|
| <i>Odonata.</i> | | |
| Agrionidae | <i>Ischnura aurora</i> (Brauer) | (Nymphs). Very common. |
| Coenagrionidae | Gen. and sp. ? | „ A few. |
| Aeschnidae | <i>Anax guttatus</i> (Burm.) | „ „ |
| <i>Ephemeroptera.</i> | | |
| Baetidae | <i>Cloëon</i> sp. | (Larvae). Numerous. |
| „ | <i>Baetis</i> sp. | „ Some. |
| <i>Diptera.</i> | | |
| Chironomidae | <i>Culicoides</i> or <i>Dasyhelea</i> sp. | (Larvae). Common. |
| „ | Gen. and sp. ? | „ „ |
| <i>Trichoptera.</i> | | |
| Sericostomati- dae | Gen. and sp. ? | (Larvae). Common. |
| <i>Pisces.</i> | | |
| Cyprinidae | <i>Chela punjabensis</i> Day | Common. |
| „ | <i>Barbus punjabensis</i> Day | „ |

TWO PONDS NEAR THE SODI RAILWAY STATION.

Water shallow, bottom muddy. Plenty of vegetation both on the shore and in the water. Three species of algae present, viz., *Cyrosigma acuminatum* Kütz., stray filaments of *Spirogyra* sp. (sterile) and *Oedogonium franklianum* Witter.

Date and time of collection.—17th October, 1930. 4-30—6-30 p.m.

Physical and Chemical condition of water.—Temp. 27.0°C; Oxygen 8.88 cc. per litre; PH about 10; Alkali reserve 0.0015 N. Total solids 23.474; Ca 1.188; Mg 0.772; K 0.056; Na 6.247; SO₄ 7.744; CO₃ 0.003; HCO₃ 0.0001; NO₃ 0.0124; Conductivity 3.02; Halogen content 7.01; Salinity 12.683.

Percentage of SO₄ (33.00 per cent.) higher than in any other water investigated; Ca 5.06 per cent.; Mg 3.29 per cent.; K 0.239 per cent.; Na 26.61 per cent.; Cl 31.76 per cent. (Tables I and II).

Fauna.—Representatives of Insecta and Pisces obtained.

Insecta.

Coleoptera.

| | | |
|------------|--|-----------------------|
| Dytiscidae | <i>Eretes sticticus</i> L. sub-sp. <i>griseus</i> Fabr. | (Adult). Very common. |
|------------|--|-----------------------|

Rhynchota.

| | | |
|--------------|---------------------|-----------------------|
| Notonectidae | <i>Anisops</i> sp.. | (Adult). Very common. |
|--------------|---------------------|-----------------------|

Odonata.

| | | |
|----------------|--|------------------|
| Coenagrionidae | Gen. & sp.? | (Nymphs). A few. |
| Agrionidae | <i>Agriocnemis</i> sp. . | „ Some. |
| Libellulidae | Gen. and sp. ? | „ A few. |
| „ | <i>Trithemis</i> sp., probably <i>festiva</i> (Ramb.) | „ „ |

Pisces.

| | | |
|------------|-------------------------------|------------|
| Cyprinidae | <i>Barbus punjabensis</i> Day | .. Common. |
|------------|-------------------------------|------------|

THE KALLAR KAHAR LAKE.

A large body of water, about a mile long and half a mile broad. Greatest depth 3 or 4 ft. Margins formed of black fetid mud. Plenty of vegetation in the water, making rowing of even a small boat difficult. Hardly any tree on the sides. No macroscopic free swimming algae, but the following found in bits:—*Cladophora*, *Anabaena*, *Chroococcus*, *Aphanocapsa*, etc.

Date and time of collection.—20th October, 1931. 3-30—6 p.m., and 21st October, 1931. 7—10 a.m.

Physical and Chemical condition of water.—PH 9.5; Alkali reserve 0.0010 N. Total solids 4.508; Ca 0.080; Mg 0.116; K 0.312; Na 1.2716; SO₄ 0.8443; CO₃ 0.0156; HCO₃ 0.0132; NO₃ 0.0093; Conductivity 0.954; Halogen content 1.83; Salinity 3.333.

Percentage of K (6.92 per cent.) higher than in any other water investigated; SO₄ 18.72 per cent. (very high); Ca 1.771 per cent.; Mg 2.57 per cent.; Na 28.20 per cent.; Cl 40.95 per cent. (Tables I and II).

Fauna. No animal life except insects.

Rhynchota.

Notonectidae *Anisops* sp. (Adult). Very common.

Trichoptera.

Sericostomatidae Gen. and sp. (Larvae). Very common.

Odonata.

Libellulidae Gen. and sp. ? (Nymphs). A few.

Coenagrionidae Gen. and sp. ? . . . „ Common.

Diptera.

Chironomidae *Tanytarsus* sp. . . (Larvae). Common.

„ *Chironomus* sp. „ „

A great variety of Diptera (Ephydriidae, Dolichopodidae, Anthomyiidae) were seen hovering near the edges of the lake. This indicates that the larval life of these forms is most probably passed in this water.

Remarks.—The animal life in the Kallar Kahar Lake was undoubtedly poor, but it was not so poor as in 1922 when Dr. Hora visited it and reported that “no animals were found to live in it”.

THE SAN SAKESAR LAKE.

A large and shallow body of water, with hardly any vegetation. Shores absolutely bare, of very soft, dark mud. At some distance from the lake the soil suitable for ordinary crops.

Date and time of collection.—17th April, 1931. 4—6 p.m.

Physical and Chemical condition of water.—Total solids 53.34; Ca 0.058; Mg 1.545; K 0.323; Na 18.1; SO₄ 13.1; CO₃ 0.18; HCO₃ 0.41; N 0.01593; Halogen content 17.86; Salinity 32.267.

Percentage of Ca (0.11 per cent.) lower than in any other water investigated; Mg 2.95 per cent.; K 0.615 per cent.; Na 34.46 per cent.; Cl 35.67 per cent.; SO₄ 24.98 per cent. (Tables I and II).

Fauna.—The collection was mostly made near the edges of the lake, it being impossible to get to the centre. The only animal obtained was a red coloured Cyclop, *Diaptomus salinus* v. Daday, which was in such large numbers that it gave to the water a reddish hue. This and several other species of *Diaptomus* are known from salt waters of Central Asia (Sars, 1903), Algeria and Tunis (Roy and Gauthier, 1927).

Remarks.—This lake has recently been visited by Mr. G. E. Hutchinson, a member of the Yale University North-India Expedition, who informs me that he has found nothing in the lake except *Microcystis roseopersicina* which is probably the food of *Diaptomus salinus*.

REMARKS ON THE POWER OF VARIOUS GROUPS OF ANIMALS COLLECTED TO WITHSTAND HIGH SALINITIES.

Platyhelminthes.—A Planarian was collected in the Khewra Gorge at Stations 9 (Sal. 0.95) and 11 (Sal. 0.12) in October, 1930. It was not met with in April, 1931, when the salinity of these two stations was 1.97 and 0.19 respectively. Obviously its absence at station 10 (Sal. 0.32—0.80) was not due to a higher salinity, but probably due to the peculiar chemical condition of the water (see p. 99).

Annulata.—HIRUDINEA. Several species of this group have been obtained from brackish waters. Annandale and Kemp obtained *Limnatis nilotica* from salt water springs in Seistan. Two specimens of the Leech *Glossiphonia reticulata* Kaburaki were collected in the Khewra Gorge at station 8 (Sal. 1.36) in October, 1930. None was obtained in April, 1931. Kaburaki described this species from a single specimen found attached to the mantle of a species of *Anodonta** at Jullundur (Punjab). According to Harding and Moore (1926), the family Glossiphonidae, under which *G. reticulata* is included, is known to occur in fresh water only. But it appears that the genus *Glossiphonia* has some attraction for salt water, as two species of this genus were collected from the Chilka Lake (Harding, 1920 and Kaburaki, 1921), while *G. reticulata* as mentioned above, has been obtained from the Khewra Gorge.

Crustacea.—The crab *Potamon (Potamon) fluviatile* (Latr.) var. *monticola* W.-M. was collected in the Khewra Gorge at stations 8 (Sal. 1.97) and 10 (Sal. 0.08). At station 11 (Sal. 0.12) the variety *ibericum* (Mar. de Bieb.) was obtained. These crabs were met with both in October, 1930 and April, 1931. The variety *ibericum* which was described from Assam has so far not been reported from the Punjab, though the variety *monticola* occurs abundantly in this area. The San Sakesar Lake (Sal. 32.26) had no animal life except the Crustacean, *Diaptomus salinus*, which was found in extremely large numbers. Blanchard and Richard (*loc. cit.*), Roy and Gauthier (*loc. cit.*), Sars (*loc. cit.*) and Annandale and Kemp gave an account of the Ostracoda, Cladocera and Copepoda of several salt waters of North Africa, Central Asia and Seistan. Kemp (1915 and 1918) and Sewell (1924) recorded several fresh-water Crustacea from the Chilka Lake, with water of 1.008—1.011

* Dr. Bains Prashad informs me that *Anodonta* is not known to occur in the plains of the Punjab and that most probably it was a species of the genus *Lamellidens* on which the above leech was found.

specific gravity, the sea water being 1.027 Becking (1920) obtained *Artemia salina* from concentrated brine (35 per cent. salt). Tattersall (1921) described several species of Mysidacea, Tanaidacea and Isopoda from brackish waters (the Tále Sap) in Siam.

Insecta.—This is the only group of animals which was found to be represented in all the waters investigated. It is, therefore, evident that some insects can tolerate salinity higher than 160, which is about 5 times as much as that of the Indian Ocean. The different orders of Insecta were restricted to definite salinities. The distribution of this group is described in detail hereafter in a separate chapter.

Mollusca.—Many brackish water mollusca are known (see Nevill, 1880, Annandale and Kemp, 1916, Eliot, 1917 and Annandale, 1921), but only one species of this phylum, namely, *Melanoides flavidus* (Nevill) was found in the Khewra Gorge at stations 7—11, where the salinity ranged from 0.12 to 6.36. This species mostly occurs in fresh water. In addition to the Salt Range, this species is known only from the desert regions of Southern Baluchistan, from Seistan and Iraq.

Amphibia.—The frog *Rana cyanophlyctis* Schneider was fairly common in the Khewra Gorge at stations 6—11, having salinity varying from 0.12 to 9.5. This frog is distributed from Arabia to India, Ceylon and Northern parts of the Malay peninsula. It mostly occurs in fresh water, but has been obtained in several salt waters as well, e.g., some salt lakes near Calcutta, the Tále Sap in Siam, the Chilka Lake, some brackish water pools near Port Canning (NaCl 13.8 gms. per litre), etc. As pointed out by Annandale, this is a very adaptable species. In the Tále Sap, Annandale and Kemp obtained seven other species of Batrachia in addition to *R. cyanophlyctis*.

Pisces.—Many freshwater fishes are known from salt waters. Chaudhuri (1916) and Hora (1923 and 1924) recorded several such species from the Chilka Lake and from the Tále Sap (Siam). Freshwater fishes generally do not occur in highly saline waters.

Scaphiodon readingi Hora was fairly common both in October, 1930 and April, 1931 in the Khewra Gorge at station 7 to 11 (Salinity 0.12—12.63). This species is widely distributed in the freshwater streams of the Salt Range, where according to Hora it is endemic.

Crossochilus latius (H. B.) Day was met with at the same stations as the above species but was more common in April, 1931 than in October, 1930. This species is quite common in fresh water in all parts of India and Burma. Chaudhuri (*loc. cit.*) recorded it from the Chilka Lake, when its salinity was as much as that of the sea water.

Garra montis-salsi Hora was found along with the above two species except at stations 7 and 10. Its absence at station 7 may be due to the higher salinity, but at station 10 it was obviously due to some other factor, most probably the nature of the bed of the stream, or the peculiar chemical composition of the water (p. 99). This species also is widely distributed in the Salt Range.

Barilius vagra (Ham. Buch.) Day was found in the Khewra Gorge at station 6 only (Sal. 9.5). Hora obtained it from a small stream near Dheri Jaba. This fish is common in almost all parts of India.

Barilius sophore (Ham. Buch.) Day was obtained in fairly large numbers from the pond near Sodi (Sal. 12.683). This species was described from Assam and the Khasi hills.

Barbus punjabensis Day and *Chela punjabensis* Day were obtained in small numbers from the pond at Chalisa (Sal. 5.93). The former was also present in the ponds at Sodi (Sal. 12.683). *Chela punjabensis* was described from the river Ravi, near Lahore. *Barbus punjabensis* is, however, more widely distributed. It has been obtained from Sind, Lahore and Jubbulpore. Chaudhuri (*loc. cit.*) recorded several species of *Barbus* from the Chilka Lake.

INSECTA.

As mentioned above, the group Insecta was represented in all the waters investigated. But the distribution of its different orders was limited to a definite range of salinity. Below is given the distribution of various groups of insects collected.

COLEOPTERA.

Of all the different orders of Insecta, Coleoptera seems to be the most common group met with in salt waters. Thienemann (1913), Wesenburg Lund (1915), Keys (1918), Walsch (1925), Lengerken (1929), etc. have given a long list of "Halophile" and "Halobionte" beetles met with on the coasts of several parts of Europe. Annandale and Kemp collected numerous species of this order from the Chilka Lake and from some salt water springs in Seistan.

HYDROPHILIDAE.—Members of this family were collected from very highly saline waters. *Octhebius* sp. was obtained both in October, 1930 and April, 1931, from the Khewra Gorge at stations 1 to 4, where the salinity ranged from 78.5 to 166.8. It was not met with at other stations where the water was less saline or almost fresh and thus it appears that this species has become entirely adapted to highly saline waters. The genus *Octhebius* is represented in fresh, brackish and sea water. According to Hase (1926), *O. quadricollis* can live in all these three habitats and can stand a salinity up to 27 per cent. Becking (1920) obtained this species from highly concentrated brine (35 per cent. salt). Lengerken included four species of *Octhebius* under his "Halophile" and one, *O. auriculatus* Key, under "Halobionte" categories. Walsch and Keys mentioned two species of *Octhebius* frequenting British coasts as truly brackish water forms.

Berosus punctulatus f. col. *immaculicollis* Fairm. *sensu* Knisch. was collected in the Khewra Gorge from stations 1 to 5, where the salinity varied from 38.8 to 143.8. Except at station 5 this species was obtained only in October, 1930. Its absence at other stations in the Khewra Gorge indicates that like *Octhebius* sp., enumerated above, this species also seems to have become adapted to highly saline waters. Prof. Kuntzen of Berlin informs me that this species is widely distributed in salt waters of the Indo-Australian and Ethiopian regions.

In April, 1931 I obtained another species of (?) *Berosus* in fairly large numbers from stations 7 to 11, where the salinity varied from 0.19 to 6.3.

Berosus is a typical salt water genus. *Berosus spinosus* Stev. is fairly common in brackish water on the northern coasts of Europe and the south coast of England (Lengerken and Watsch). This genus is represented in polluted waters also (Alexander, 1925).

Enochrus sp. was collected in the Khewra Gorge at stations 2 to 7, where the salinity varied from 6.36 to 143.8. This species was nowhere obtained in large numbers. Walsch found *E. bicolor* in fresh and brackish waters of England.

Enoplurus indicus Motsch. was obtained in small numbers from the pond at Chalisa only (Sal. 5.9).

Another species of *Enoplurus* was obtained in small numbers from stations 2 and 4 in the Khewra Gorge (Sal. 91.2 and 143.8).

DYTISCIDAE.—As compared with Hydrophilidae, this family is represented in waters of comparatively lower salinity. Lengerken (op. cit.) included only one species of this family under the "Halophile" category.

An undescribed species of the genus *Potamodytes* was obtained in the Khewra Gorge at stations 3, 5, 6, 7, 9, 10, 11, with salinity varying from 0.192 to 42.3. It was most common at station 6 (Sal. 10.8). This species was found to be more common in April, 1931 than in October, 1930, except at station 3 where it was not found in April, 1931 at all, when the salinity there was 51.05.

Hydaticus fabricii MacLeay was obtained from stations 6 (Sal. 10.87) and 9 (Sal. 1.97) only, being fairly common at the former locality.

Laccophilus flexuosus Aubè. was very common in the pond at Chalisa (Sal. 5.93). It was also obtained in small numbers from station 11 (Sal. 0.19) in the Khewra Gorge.

The genus *Laccophilus* is represented in both fresh and salt waters. *L. variegatum* Germ. occurs commonly in fresh and brackish waters of England and of the continent of Europe.

Canthydrus laetabilis Walk. was found in small numbers in the pond at Chalisa, having salinity 5.93.

Eretes sticticus L. subsp. *griseus* Fabr. was very common in ponds at Sodi (Salinity 12.68).

E. sticticus L. is very widely distributed. It is found in Africa, tropical and sub-tropical regions of Asia, Australia and on the Pacific side of America. The subsp. *griseus* has been recorded from North India and the Andamans.

It may be mentioned that with the exception of *Potamodytes* sp., which as already mentioned is considered to be a new species, all the above named Dytiscid beetles are known from salt waters.

DRYOPIDAE (PARNIDAE).—*Dryops* sp. was found in the Khewra Gorge at stations 3, 5, 7 and 8, with salinity varying from 1.97 to 51.05. It was obtained in large numbers in April, 1931 than in October, 1930 and was most common at stations 5 and 7

STAPHYLINIDAE.—Many Staphylinid beetles have not been found to occur near or in salt waters. Cameron (1930) enumerated the following from the sea shore under sea weed :—certain *Trogophlaeus*, *Thinobius*,

Cafius, *Phucobius* and numerous Aleocharinae. I have found the following species in the Khewra Gorge :—

Platystethus cornutus Gr.—Some specimens of this species were collected from station 2, with salinity 123·9. Cameron recorded this species from Dehra Dun, Chakrata and Mussoorie districts, Pusa (Bihar) and Poona. This species occurs also in Europe and the Canary Islands.

A few specimens of another species of *Platystethus*, which Mr. Cameron thinks to be new, were obtained from station 9 (Sal. 1·97).

Two specimens of *Aleochara bipustulata* were also obtained from station 9.

Four specimens of a new species of *Chilopora*, which Mr. Cameron will be describing in a separate paper, were collected from under stones on the sides of the water at station 5.

DIPTERA.

The Diptera are next in importance to Coleoptera in their power to live in highly saline waters. In fact, Buxton (1926) put this order at the top of all others from this point of view. Several Diptera (mostly Chironomidae) are permanent inhabitants of the sea (Carpenter 1884, Thienemann 1915-1916, Kieffer 1913, Edwards, 1926, etc.). Chironomid larvae have been obtained from waters of a salinity as high as 28·53 per cent. (Suworow, 1908). Dalziel (1920) and Balfour (1921-1922) mentioned a large number of mosquito larvae which can live in waters having salinities up to 2·88 per cent. Sewell (1913) obtained larvae of a *Culex* from a rock pool on the Burma coast, which was nearly three times as concentrated as ordinary sea water. Annandale and Kemp (1915) obtained the larvae of a Syrphid fly, of *Anopheles rossi* and *Palpomyia* sp. (Chironomidae) from the Chilka Lake, when the specific gravity of its water was 1·000—1·015 and that of the sea water was 1·027. The occurrence of Ephydrid diptera has been reported from waters of salinity up to 10 times as much as that of sea water (Becking, 1920; Günther, 1899; Thienemann, 1913; etc.).

The following species of this order have been collected from the salt waters under report :—

CHIRONOMIDAE.—Larvae of a species of *Culicoides* were collected in October, 1930 in the Khewra Gorge at stations 1 (Sal. 78·52) and 2 (Sal. 91·27) and in the pond near Chalisa (Sal. 5·93). Kieffer described several species of *Culicoides* and *Tanytarsus* from Puri on the Orissa Coast.

Another species of Chironomid larvae was found occurring together with *Culicoides* sp. mentioned above. Annandale collected larvae of two Chironomids from brackish water pools at Port Canning.

Larvae of a species of *Chironomus* were obtained from the Khewra Gorge at stations 6, 8, 10, and 11, wherever the water was flowing rapidly. The salinity at these localities did not exceed 10·87

In the lake at Kallar Kahar (Sal. 3·35) larvae of a species of *Tanytarsus* and *Chironomus* were obtained. The presence of Ephydrid, Dolichopidid and Anthomyiid flies near this water indicated that the larval stage of these flies was most probably passed in this water.

SIMULIIDAE.—The larvae of a species of *Simulium* were obtained in large numbers in the Khewra Gorge from stations 9 (Sal. 0.95) and 11 (Sal. 0.12), where the water was flowing rapidly.

TABANIDAE.—The larvae of a big Tabanid fly were found in extremely large numbers in the Khewra Gorge at stations 3 and 5 (Sal. 38.85 and 51.05). Some were found at stations 1, 6 and 7 also. The salinity at these localities varied from 5.17 to 78.52.

SCIOMYZIDAE.—The larvae of a big Sciomyzid fly were found in fairly large numbers in the Khewra Gorge at stations 1 and 4 in April, 1931. The salinity at these stations was very high, being about 166.83.

EPHEMEROPTERA.

This order was very well represented in the Khewra Gorge. Larvae of a species of *Cloëon* were found in great abundance in October, 1930 at stations 1 and 2, where the salinity was 78.5 and 91.27 respectively. This species was also found at stations 3 and 5 (Sal. 38.85—51.05). I think that it is the first record of the occurrence of may-fly larvae in such highly saline waters, *i.e.*, more than twice as much as sea water. Thorpe (1927) recorded the occurrence of may-fly larvae (Baetinae, probably *Cloëon* sp.) in the Suez Canal (Lake Tamsah) in waters of specific gravity 1000—1030.

Another species of *Cloëon* was found in large numbers at stations 3, 5, 6 and 7 and in the ponds at Chalisa (Sal. 6.36—51.05).

The larvae of a species of *Choroterpes* were found at stations 8 (Sal. 1.36) and 10 (Sal. 0.17), being very common at the latter locality.

Some larvae of a species of *Caenis* and *Ephemera* were also found at stations 8 and 10 respectively.

The larvae of a species of *Baetis* were very common at stations 9 (Sal. 0.95) and 11 (Sal. 0.12).

RHYNCHOTA.

Several members of this order can stand fairly saline waters, but not as highly saline as can be tolerated by Coleoptera and Diptera. Annandale obtained several heteropterous genera from brackish water pools at Port Canning, while he and Kemp (1915) obtained about fifteen species of this order from the Chilka Lake and about 10 species from the Tále Sap lake in Siam (Paiva, 1917). Thorpe (*loc. cit.*) described three species of this order from the Suez Canal, while Hutchinson (1927-1929, and 1931) and Poisson (1924) have recorded the occurrence of aquatic bugs in waters having chlorine content up to 14 grms. per litre. Mr. Hutchinson informs me that one species, *Trichocorixa wallengreni* (Stål) was obtained from water probably much more saline than the sea water. *Aepophilus bonnairei* and *Salda phallipes* are known to be truly "Halophile" and occur on the sea coasts of several parts of Europe. *Halobates*, a typical marine genus also belongs to this order.

VELIIDAE.—A small Vellid bug was obtained in the Khewra Gorge at station 11, and near the lips of the falls at the heads of stations 6 and 8, where the water was flowing very rapidly. The salinity at these localities did not exceed 10.87

GERRIDAE.—*Metrocoris stali* Dohrn was fairly common in the Khewra Gorge at stations 9, 10 and 11 (Sal. 0.192—1.97) both in October, 1930 and April, 1931.

Gerris tristan Kirk., *G. spinolae* Leth. and Serv. and *G. fossarum* Fabr. were present in the pond near Chalisa (Sal. 5.93). All these three species of *Gerris* and several others were obtained by Annandale and Kemp from the Chilka Lake and several other salt waters.

NEPIDAE.—*Ranatra elongata* Fabr. was common at stations 7, 8 and 10 (Sal. 0.174—5.17) in the Khewra Gorge.

Ranatra sordidula Dohrn was very common in the pond near Chalisa (Sal. 5.93). This species was also found occurring in the Chilka Lake.

A species of *Laccotrephes* was also common in the Chalisa pond.

NAUCORIDAE.—A few specimens of a species of *Heleocoris* were obtained at stations 5, 9, 10 and 11 (Sal. 0.192—38.85) in the Khewra Gorge in April, 1931.

BELOSTOMIDAE.—A few specimens of *Sphaerodema molestum* Duf. were collected from the pond near Chalisa (Sal. 5.93).

NOTONECTIDAE.—*Enithares lineatipes* Horv. was present in small numbers at stations 7 to 11 (Sal. 0.19—6.36) in the Khewra Gorge in April, 1931. No specimen of the species had been obtained in the previous autumn.

Several species of *Anisops* were very common in the pond at Sodi (Sal. 12.68) and in the Kallar Kahar Lake (Sal. 3.33). Another species of this genus was present in the pond at Chalisa (Sal. 5.93) and at station 10 (Sal. 0.60) in the Khewra Gorge.

A species of *Plea* was present in small numbers in the pond at Chalisa.

CORIXIDAE. A species of *Micronecta* was very common at the lip of a fall at the head of station 8 (Sal. 1.97) in the Khewra Gorge in April, 1931.

ODONATA.

Like Rhynchota, this order is represented in waters of comparatively lower salinities. Dragon-flies are known to breed in coastal lagoons, where the water is brackish. Osburn (1906) showed by a series of experiments that Dragon-fly larvae could withstand a salinity up to a density of 1.01 (sea water being 1.026). At the density of 1.015 the larvae soon died. Osburn appended a list of the species known to breed in brackish water, most of which belong to Libellulinae, Agrioninae and Aeschninae (*Anax*, etc.). Laidlaw (1915) recorded about half a dozen species from the Chilka Lake, when the specific gravity of its water was 1.001—1.008 (sea water being 1.027). Thorpe (*loc. cit.*) recorded three species of Aeschnidae and Agrionidae from the Suez Canal with sp. gr. 1000—1030.

AESCHNIDAE. A few specimens of the nymphs of *Anax guttatus* Burm. were collected from stations 8 and 10 (Sal. 0.174—1.97) in the Khewra Gorge and from the pond near Chalisa (Sal. 5.93).

Gomphus sp. and *Brachydiplax* sp. Nymphs of these forms were collected in large numbers in the Khewra Gorge both in October, 1930 and April, 1931 at station 10, where the salinity varied from 0.174 to 0.608. A species of *Brachydiplax* was also found occurring in the Chilka Lake.

LIBELLULIDAE.—The nymphs of a species of *Trithemis*, probably *festiva* (Ramb.) were met with at stations 6, 7, 8, 9 (Sal. 0.951 to 10.87) in the Khewra Gorge. It was very common at stations 7 and 9, where the salinity was 0.951—5.17.

A few nymphs of a species of *Orthetrum* were collected from the ponds at Sodi (Sal. 12.68).

Nymphs of another species of Libellulinae were found in the lake at Kallar Kahar.

AGRIONIDAE AND COENAGRIONIDAE—Nymphs of *Ischnura aurora* (Br.) were extremely common in the pond near Chalisa (Sal. 5.93). Annandale obtained in large numbers the nymphs of *Ischnura senegalensis* in the Chilka Lake and in the brackish water ponds at Port Canning. Several species of this genus, e.g., *I. ramburri*, *I. verticalis*, etc., breed in brackish waters in certain parts of the United States of America.

Nymphs of a species of Coenagrionidae were abundant in the ponds at Sodi (Sal. 12.68) and were found in small number at Kallar Kahar and Chalisa also (Sal. 3.33 and 5.93 respectively).

In the pond at Sodi there were some nymphs of *Agriocnemis* also. This genus was also found in the Chilka Lake.

TRICHOPTERA.

Very few members of this order live in salt waters. Eaton found some in salt and brackish water streams on the borders of the Sahara, while McLachlan (1883) gave an account of a marine Trichopteron, *Philanisus* from New Zealand, the larvae of which live habitually in rock pools, between high and low water marks. Gresens (1928) described some from Central Europe.

Larvae of a *Polycentropid* Trichopteron were fairly common in the Khewra Gorge at station 11 (Sal. 0.192) and at stations 7 to 9 (Sal. 1.97 to 6.3). Its absence at station 10 (Sal. 0.60) was obviously not due to salinity, but might be due to the peculiar chemical composition of the water. These larvae live in loosely built houses, made of bits of stones held together by means of silk threads. These larvae are also met with in fresh waters in several parts of India.

In the pond near Chalisa (Sal. 5.93), larvae of a Sericostomatid Trichopteron were very abundant. These larvae live in well built houses, made out of straw.

LEPIDOPTERA.

Aquatic caterpillars, most probably belonging to the genus *Aulocodes* (Pyrilidae) were fairly common in the rapid water at the head of station 8 (Sal. 1.36) in the Khewra Gorge in April, 1931. Annandale and Kemp (1915) obtained the caterpillars of *Nymphula diminutales* from the Chilka Lake.

THYSANURA.

A Thysanuran was collected in small numbers at station 4 (Sal. 130.8) in the Khewra Gorge in April, 1931.

CONCLUSIONS.

The foregoing account of the occurrence of different animals in salt waters indicates that most of the species met with therein are also known

from fresh water and that various groups of the animal kingdom are restricted to a definite range of salinity (Table IV). It is only the insects that were found in all the waters investigated, the salinity of which ranged from 0.12 per cent. to as much as 17.0 per cent., *i.e.*, about five times that of the sea water. The few representatives of Platyhelminthes, Hirudinea and Crustacea collected do not seem to tolerate a salinity higher than 2; Mollusca (one species) could stand about 8, whereas Amphibia (one species) and Pisces (numerous species) were found living in waters with salinity up to 11. Thus with the exception of insects, no other group of animals was found in water of a salinity equal to or more than that of sea water.

Though the group Insecta was represented in waters with salinity ranging from 0.12 to 17.0, its different orders, however, showed a restricted distribution. In Table V the distribution of the various Insect orders is diagrammatically expressed. The Lepidoptera were found occurring in waters of salinity up to 2, while Trichoptera and Odonata could tolerate a salinity of 8, and Rhynchota and Ephemeroptera 47 and 51 respectively. The Coleoptera and Diptera were found flourishing in all the waters investigated (salinity up to 17.0), though their different families were restricted to definite salinities.

It thus appears that Buxton's conclusion (1926) that the only Insects which live in water containing 3 per cent. or more salts (*i.e.*, water at least as salty as the sea) are some families of Diptera (Ephydriidae, Culicidae and Chironomidae) and a Trichopteron requires modification. In addition to the Dipterous families named above, Tabanid larvae, several families of Coleoptera, May-fly larvae and Rhynchota can live in waters of a salinity much higher than that of the sea.

The occurrence of May-fly larvae in highly saline waters is really very remarkable. The impervious nature of the integument of Coleoptera and Rhynchota may afford protection to the members of these orders against the dehydrating influence of salt waters, but the same cannot be said of the integument of May-fly larvae, which is well known for its delicacy. This suggests that the adaptation to salt water does not necessarily consist in the acquisition of an impervious integument, as is postulated by some authors (Walsh, etc.), but is due to changes in the body fluids so that the osmotic pressure of the latter may be in equilibrium with that of the external medium.

Regarding the interesting question of the colonization of the sea by Insects it is evident from the above that the salinity of sea water is not a barrier, nor is the force of the ocean currents and tides, as many insects can live in mountain torrents having tremendous force and velocity. Furthermore, many insects can live on the sea shore (Flattely and Walton), where the physical effect of the tides is the greatest. The most important difference which one notices on carefully comparing the analyses of the waters of the Salt Range (Tables I and II) with those of the samples of sea water taken by the "Challenger" from different oceans of the world (Table III) is that the percentage of calcium (1.16 to 1.20) in the sea is much less than that in any water investigated by me except the San Sakesar Lake. In this lake calcium was 0.11 per cent., and as mentioned on page 105 there was no insect life at all. Thus it appears that it is most probably the low calcium

content of the sea that does not permit insects to inhabit the sea, while it is the large amount of calcium in the waters of the Salt Range which helps the insects in keeping their body fluids in equilibrium with the highly saline water in which they live. Pantin (1931 (a)), Weil and Pantin (1931) and Pantin (1931 (b)) by means of carefully conducted experiments have recently shown in the case of estuarine animals that calcium has a profound influence on their permeability to water and salts. McCutcheon and Lucke (1928) had earlier shown the influence of this ion on the permeability of *Arbacia*, and Pearsall (1924) while describing the distribution of purely freshwater organisms, demonstrated the significance of calcium, especially in reference to its effect on the sodium and potassium contents of the medium. Thorpe (1931), however, obtained some insects from the saline waters of the Californian desert regions, in which the amount of calcium was less than that in sea water.

I have started experiments with a view to ascertaining the influence of calcium on Insects living in salt waters and will publish the results in due course.

REFERENCES.

- Alexander, C. P., *Bull. Ill. St. Nat. Hist. Surv.*, XV, pp. 439-535 (1925).
 Annandale, N., *Rec. Ind. Mus.*, I, p. 36 (1907).
 Annandale, N., *Mem. Asiat. Soc. Beng.*, VI, Pt. II, p. 119 (1917).
 Annandale, N. and Dover, C., *Journ. Asiat. Soc. Beng.*, XVIII (1923).
 Annandale, N. and Kemp, S., *Mem. Ind. Mus.*, V, No. 2, p. 175 (1915).
 Annandale, N. and Kemp, S., *Mem. Ind. Mus.*, V, No. 4, p. 327 (1916).
 Annandale, N. and Rao, H. S., *Rec. Ind. Mus.*, XXV, p. 387 (1923).
 Balfour, A., *Bull. Ent. Res.*, XII, p. 29 (1921-22).
 Becking, L. G. M. B., *Tijds. ned. dierk ver Leiden*, (3), I, p. 6 (1920).
 Benick, L., *Ent. Blatt.*, 1916, p. 197, and in Thienemann's *Das Salzwasser v. Oldesloe* (1926).
 Bert, P., *C. R. Acad. Sci. Paris*, T. 97, pp. 133-36 (1883).
 Blanchard, R. and Richard, J., *Mem. Soc. Zool. France*, IV, p. 512 (1892).
 Buxton, P. A., *Proc. Zool. Soc. Lond.*, p. 807 (1926).
 Cameron, M., "Staphylinidae" in *Faun. Brit. India* (1930).
 Carpenter, G. H., *Ent. Mon. Mag.*, XXX, pp. 129-130 (1874).
 Chitty, A. J., *Ent. Mon. Mag.*, Ser. 4, XXIX, p. 68 and p. 258 (1893).
 Chaudhuri, B. L., *Mem. Ind. Mus.*, V, Nos. 4-6 and 11 (1916, 1917 and 1923).
 Dalziel, J. M., *Bull. Ent. Res.*, XI, p. 247 (1920).
 Edwards, F. W., *Proc. Zool. Soc. Lond.*, pp. 779-806 (1926).
 Eliot, Ch., *Mem. Asiat. Soc. Beng.*, VI, pt. III, p. 177 (1917).
 Flattely, F. W. and Walton, C. L., "The Biology of the Sea shore". London (1922).
 Gresens., *Zeit. Morphol. Oekol. Tiere, Berlin*, XII, p. 706 (1928).
 Günther, R. T., *Journ. Linn. Soc. Zool.*, XXVII, p. 414 (1899).
 Harding, W. A., *Mem. Ind. Mus.*, V, No. 7, p. 509 (1920).
 Harding, W. A. and Moore, J. P., "Hirudinea" in *Faun. Brit. India* (1927).
 Hase, A., *Intern. Rev. ges. Hydrob. Hydrogr.*, XVI, p. 141 (1926).

- Hora, S. L., *Rec. Ind. Mus.* XXV, pp. 365-368 and 377-385 (1923).
 Hora, S. L., *Mem. Ind. Mus.*, V, No. 11, p. 737 (1923).
 Hora, S. L., *Mem. Asiat. Soc. Beng.*, VI, pt. IX, p. 461 (1924).
 Hutchinson, G. E., *Ann. South Afr. Mus.*, XXV, p. 359 (1927-29).
 Hutchinson, G. E., *Amer. Nat.*, LXV, p. 573 (1931).
 Johnstone, G., *Zool. Journ. London*, Vol. III, p. 325 (1830).
 Johnstone, J., "An Introduction to Oceanography" Liverpool and London (1923).
 Kemp, S., *Mem. Ind. Mus.*, V, No. 3, p. 199 (1915).
 Kemp, S., *Rec. Ind. Mus.*, XII, p. 233 (1917).
 Kemp, S., *Mem. Asiat. Soc. Beng.*, VI, pt. V, p. 217 (1918).
 Kaburaki, T., *Mem. Ind. Mus.*, V, No. 9, p. 661 (1921).
 Keys, J. H., *Journ. Mar. Biol. Ass. U K.*, XI, p. 497 (1918).
 Kieffer, J. J., *Rec. Ind. Mus.*, IX, p. 119 (1913).
 Laidlaw, F. F., *Mem. Ind. Mus.*, V, No. 2, p. 175 (1915).
 Lengerken, v. H., *Grimpe's Tierwelt der Nord und Ostsee*, Tiel XI^c, Leipzig (1929).
 McCutcheon, M. and Lucke, B., *Journ. Gen. Phys.*, XII, p. 129 (1928).
 McLachlan, R., *Journ. Linn. Soc., Zoology*, XVI, p. 417 (1883).
 Miall, L. C., "A Natural History of Aquatic Insects." London (1903).
 Nevill, G., *Journ. Asiat. Soc. Beng.*, XLIX, pt. 2, p. 159 (1880).
 Osburn, R. C., *Amer. Nat.*, XL, pp. 395-399 (1906).
 Paiva, C. A., *Mem. Asiat. Soc. Beng.*, VI, p. 75, pt. II (1917).
 Pantin, C. F. A., *Brit. Journ. Exp. Biol.*, VIII, p. 63 (1931 (a)).
 Pantin, C. F. A., *Ibid.*, VIII, p. 83 (1931 (b)).
 Pearsall, W. H., *Journ. Ecology*, XI, (1924).
 Plateau, F., *C. R. Acad. Sci. Paris*, XCVII, p. 467 (1883).
 Poisson., *C. R. Ass. Fr. Av. Sci. Liege*, p. 983 (1924).
 Richmond, E. A., *Bull. Amer. Mus. Nat. Hist.*, XLII, pp. 1-90 (1920).
 Roy, J. and Gauthier, H., *Bull. Soc. Zool. Fr.*, LII, p. 558 (1927).
 Sars, G. O., *Ann. Mus. Zool. Acad. Sci. Saint-Petersburg*, VIII, p. 233 (1903).
 Schmidt, R., *Die Salzwasser-fauna Westfalens.* In 41st Jahresber. Westfäl. Prov.-Ver. Wiss. Kunst f. 1912-13, p. 29 (1913).
 Sewell, R. B. S., *Journ. Proc. As. Soc. Beng.* (N. S.), IX, p. 334 (1913).
 Sewell, R. B. S., *Mem. Ind. Mus.*, V, No. 12, p. 771 (1924).
 Suworow. *Zool. Anz.*, XXXII, p. 676 (1908).
 Tattersal, W. M., *Mem. Asiat. Soc. Beng.*, VI, pt. VIII, p. 435 (1921).
 Thienemann, A., *Verh. D. Zool. ges. Berlin*, XXIII, pp. 56-68 (1913).
 Thienemann, A., *Arch. Hydrobiol. Suppl.*, II, pp. 443-471, 483-554 (1915 and 1916).
 Thorpe, W. H., *Trans. Zool. Soc. Lond.*, XXII, pp. 447-449 (1927).
 Thorpe, W. H., *Pan-Pacific Entomologist*, VII, pp. 145-153 (1931). and *Nature*, CXXX, p. 629 (1932).
 Tillyard, R. J., "The Biology of Dragon-flies" Cambridge (1917).
 de Varigny, H., *C. R. Acad. Sci. Paris*, 97, p. 54-56 (1883).
 Walsh, G. B., *Ent. Mon. Mag.*, LXI, p. 137 (1925).
 Walsh, G. B., *Ent. Mon. Mag.*, LXII, p. 221 (1926).
 Weil, E. and Pantin, C. F. A., *Brit. Journ. Exp. Biol.*, VIII, p. 73 (1931).
 Wesenburg-Lund, C., "Insektivet i ferske Vande." Copenhagen (1915).

TABLE I.—Physical and Chemical Analyses of water samples. (All values expressed in grms. per litre).

| Localities | Total solids | Ca | Mg | K | Na | SO ₄ | Cl | CO ₂ | HCO ₃ | Conductivity $\frac{1}{R} \times 10^{-3}$ | NO ₃ |
|-----------------------------|--------------|-------|-------|-------|--------|-----------------|--------|-----------------|------------------|--|-----------------|
| Khewra Gorge, Station No. 1 | 75.960 | 1.748 | 0.252 | 0.142 | 27.691 | 1.799 | 44.304 | .. | 0.0114 | 13.98 | 0.0124 |
| Ditto 2 | 87.536 | 1.888 | 0.231 | 0.089 | 33.047 | 1.530 | 50.729 | .. | 0.0126 | 15.65 | 0.0093 |
| Ditto 3 | 40.916 | 1.200 | 0.170 | 0.086 | 15.059 | 1.473 | 22.898 | .. | 0.0174 | 8.264 | 0.0124 |
| Ditto 4 | 137.840 | 2.752 | 0.372 | 0.152 | 54.064 | 0.783 | 79.712 | .. | 0.0126 | 22.42 | 0.0124 |
| Ditto 5 | 38.224 | 1.140 | 0.178 | 0.129 | 13.856 | 1.463 | 21.427 | .. | 0.0183 | 7.874 | 0.0124 |
| Ditto 6 | 9.928 | 0.436 | 0.090 | 0.096 | 3.345 | 0.482 | 5.449 | .. | 0.0177 | 2.278 | 0.0124 |
| Ditto 7 | 4.42 | 0.284 | 0.122 | 0.034 | 1.376 | 0.304 | 2.270 | .. | 0.0171 | 1.064 | 0.0124 |
| Ditto 8 | 1.744 | 0.224 | 0.107 | 0.020 | 0.385 | 0.276 | 0.710 | .. | 0.0093 | 0.422 | 0.0124 |
| Ditto 9 | 1.344 | 0.168 | 0.052 | 0.032 | 0.431 | 0.107 | 0.525 | .. | 0.0162 | 0.317 | 0.0124 |
| Ditto 10 | 0.480 | 0.152 | 0.039 | 0.004 | 0.066 | 0.136 | 0.050 | .. | 0.0144 | 0.112 | 0.0186 |
| Ditto 11 | 0.720 | 0.204 | 0.044 | 0.040 | 0.233 | 0.113 | 0.050 | .. | 0.0171 | 0.1171 | 0.0186 |
| Pond near Chalisa | 6.920 | 0.660 | 0.143 | 0.132 | 1.755 | 0.854 | 3.358 | .. | 0.0036 | 1.548 | 0.0139 |
| The Lake at Kallar Kahar | 4.508 | 0.080 | 0.116 | 0.312 | 1.2716 | 0.8443 | 1.846 | 0.0156 | 0.0132 | 0.954 | 0.0093 |
| Ponds near Sodi | 23.474 | 1.188 | 0.772 | 0.056 | 6.247 | 7.744 | 7.454 | 0.003 | 0.0001 | 3.02 | 0.0124 |
| San Sakesar Lake | 53.34 | 0.058 | 1.545 | 0.323 | 18.1 | 13.1 | 18.7 | 0.18 | 0.41 | .. | .. |

Table II.—*Physical and Chemical Analyses of water samples. (All values expressed as percentages of total solids).*

| Sample No. | Total solids (grms. per litre) | Ca % | Mg % | K % | Na % | SO ₄ % | Cl % | NO ₃ % | HCO ₃ % | CO ₂ % | Conductivity $\frac{1}{R} \times 10^{-2}$ |
|--------------------------|--------------------------------|-------|-------|-------|-------|-------------------|-------|-------------------|--------------------|-------------------|---|
| Khewra Gorge, No. 1 | 75.960 | 2.30 | 0.332 | 0.187 | 36.46 | 2.37 | 58.33 | 0.0163 | 0.0150 | .. | 13.98 |
| Ditto 2 | 87.536 | 2.16 | 0.264 | 0.102 | 37.76 | 1.75 | 57.97 | 0.0106 | 0.0144 | .. | 15.65 |
| Ditto 3 | 40.916 | 2.93 | 0.415 | 0.210 | 36.81 | 3.60 | 55.97 | 0.0303 | 0.0425 | .. | 8.264 |
| Ditto 4 | 137.840 | 2.00 | 0.270 | 0.110 | 39.23 | 0.568 | 57.84 | 0.0090 | 0.0091 | .. | 22.42 |
| Ditto 5 | 38.224 | 2.98 | 0.466 | 0.337 | 36.25 | 3.83 | 56.06 | 0.0324 | 0.0479 | .. | 7.874 |
| Ditto 6 | 9.928 | 4.39 | 0.906 | 0.967 | 33.70 | 4.86 | 54.90 | 0.1249 | 0.1783 | .. | 2.278 |
| Ditto 7 | 4.42 | 6.43 | 2.76 | 0.769 | 31.14 | 6.88 | 51.36 | 0.2806 | 0.3869 | .. | 1.064 |
| Ditto 8 | 1.744 | 12.84 | 6.13 | 1.147 | 22.08 | 15.83 | 40.71 | 0.7110 | 0.5333 | .. | 0.422 |
| Ditto 9 | 1.344 | 12.50 | 3.87 | 2.381 | 32.07 | 7.96 | 39.07 | 0.9226 | 1.2053 | .. | 0.317 |
| Ditto 10 | 0.480 | 31.67 | 8.12 | 0.833 | 13.75 | 28.33 | 10.42 | 3.8750 | 3.0005 | .. | 0.112 |
| Ditto 11 | 0.720 | 28.34 | 6.11 | 5.556 | 32.36 | 15.69 | 6.94 | 2.5835 | 2.3750 | .. | 0.1171 |
| Pond near Chalisa | 6.920 | 9.54 | 2.07 | 1.907 | 25.36 | 12.34 | 48.52 | 0.2008 | 0.0520 | .. | 0.954 |
| The Lake at Kallar Kahar | 4.508 | 1.77 | 2.57 | 6.92 | 28.20 | 18.72 | 40.95 | 0.2060 | 0.2930 | 0.346 | 1.548 |
| Ponds near Sodi | 23.474 | 5.06 | 3.29 | 0.239 | 26.61 | 33.00 | 31.76 | 0.0528 | 0.0004 | 0.0128 | 3.02 |
| San Sakesar Lake | 53.34 | 0.11 | 2.950 | 0.615 | 34.46 | 24.98 | 35.67 | 0.0300 | 0.782 | 0.343 | .. |

TABLE III.—*Chemical Analysis of the Indian Ocean and of the 77 samples of sea water taken by the "Challenger" from different Oceans of the World.**

| Name of the Ocean. | Salinity. | Ca. | Mg. | K. | Na. | SO ₄ . | Cl. | Co ₂ . |
|--------------------|-------------|------|------|------|-------|-------------------|-------|-------------------|
| Indian Ocean | 33.53—36.68 | 1.16 | 3.07 | 0.85 | 30.89 | 7.79 | 55.54 | 0.05 |
| All the Oceans | 33.01—37.37 | 1.20 | 3.73 | 1.11 | 30.59 | 7.69 | 55.48 | 0.21 |

* From Johnstone's "Introduction to Oceanography."

TABLE IV.—*Distribution of various Phyla of the Animal Kingdom in reference to different salinities.*

| Fauna. | Salinity. | | | | |
|----------------------|--|--|---|-----------------------|--|
| | 0.12—2 Stas. 11, 10, 9 & 8. | 5—15 Stas. 7, 6 & waters at Chalisa, Sodi & Kallar Kahar. | 30—55 Stas. 5, 3 & San Sakesar Lake. | 75—95 Stas. 2 & 1. | 120—170 Stas. 2 & 1 (April, 1931) & Sta. 4. |
| Platyhelminthes . | ██████████ | | | | |
| Hirudinea (Annulata) | ██████████ | | | | |
| Crustacea . | ████████████████████ | | | | |
| Insecta . . . | ██ | | | | |
| Mollusca . . | ████████████████ | | | | |
| Amphibia . . | ████████████████████ | | | | |
| Pisces . . | ████████████████████ | | | | |

TABLE V.—*Distribution of various Orders of Insects in reference to different salinities.*

| Fauna. | Salinity. | | | | |
|---------------|-----------------------------------|---|---|-----------------------|---|
| | 0·12—2 Stas. 11, 10, 9 & 8. | 5—15 Stas. 7, 6 & waters at Chalisa, Sodi & Kallar Kahar. | 30—55 Stas. 5, 3 & San Sakesar Lake. | 75—95 Stas. 2 & 1. | 120—170 Stas. 2, 1 (April, 1931) & Sta. 4. |
| Thysanura . | | | | | ———— |
| Ephemeroptera | ———— | | | | |
| Odonata . | ———— | | | | |
| Dermaptera . | | | ———— | | |
| Coleoptera . | ———— | | | | |
| Rhynchota | ———— | | | | |
| Trichoptera . | ———— | | | | |
| Lepidoptera . | ———— | | | | |
| Diptera . | ———— | | | | |