TRANSACTIONS

OF THE

ROYAL SOCIETY OF NEW ZEALAND

ZOOLOGY

VOL. 2. No. 25 NOVEMBER 30, 1962

Studies on Ephemeroptera
II.—*Coloburiscus humeralis* (Walker); Ecology and Distribution of the Nymphs

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[*Received by the Editor, May 30, 1962.*]

Abstract

THE physical conditions and associates of *Coloburiscus* nymphs in Purau Stream, Banks Peninsula, N.Z., are described. It is suggested that the apparent absence of trout (*Salmo trutta*) from this habitat is associated with a lack of suitable spawning beds. Streams and a river subjected to periodic flooding and scouring in the Cass Basin, Canterbury, were apparently uninhabited by nymphs. The four streams in which nymphs were abundant were "stable"; i.e., not affected greatly by flooding. The probable buffering action of lakes in maintaining these conditions locally is discussed. In the Selwyn River, Canterbury, the abundance of nymphs appeared to vary with the nature of the substratum. Nymphs were not found where flood scouring had produced a hard bed with very few loose stones; but they were abundant where the bed consisted of undisturbed loosely-packed, small stones, provided surface water was present all the year. It is suggested that *Coloburiscus* nymphs are indicators of stable conditions; and that when an abundance of nymphs is found in a substratum of small, loosely-packed stones, the area is probably suitable for redd making, spawning and the subsequent development of young trout.

INTRODUCTION

DURING an investigation of the early life history of *Coloburiscus humeralis* (Wisely, 1962) it was noticed that although this species was often found associated with trout in fast-running rivers and streams, there were some anomalous exceptions. *Coloburiscus* was abundant in Purau Stream but trout were apparently absent; some streams in the Cass Basin contained both *Coloburiscus* and trout, but others lacked the former. Parts of the Selwyn River bore large trout populations but *Coloburiscus* was not found. The present paper describes some aspects of the ecology and distribution of *Coloburiscus* nymphs in these habits, and attempts to outline their distribution in other New Zealand rivers and streams.

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Published by the Royal Society of New Zealand, c/o Victoria University of Wellington, P.O. Box 196, Wellington.

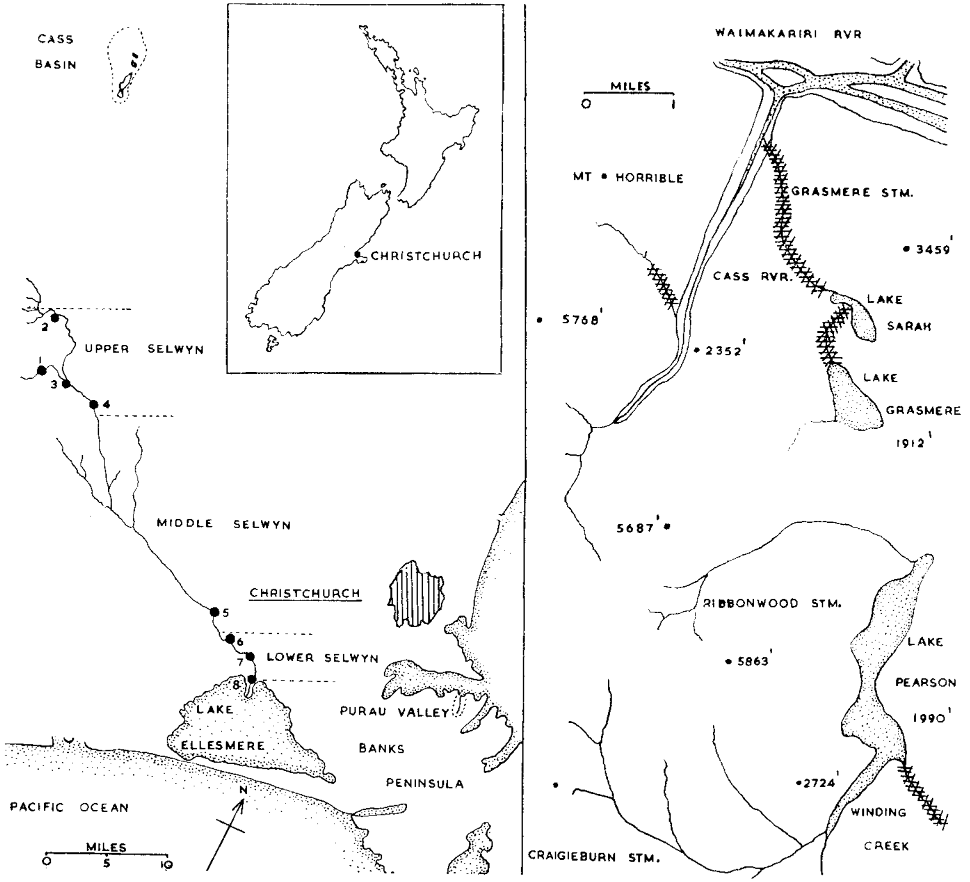

Fig. 1.—Left: Map showing the location of Purau Stream, the Cass Basin and the Selwyn River relative to Christchurch in the South Island of New Zealand. The Selwyn River sampling stations are marked. Right: The Cass Basin in more detail showing the streams containing *Coloburiscus* nymphs (cross hatched).

Ecology of Purau Stream, Banks Peninsula

1. General Description, Rainfall and Temperature

Purau Stream drains Purau Valley into Lyttelton Harbour (Fig. 1). It is short (*c.* 3½ miles) and runs from south to north draining the slopes of Mt. Evans (2,308ft) from the east and Herbert Pk. (3,014ft) from the west. Most of the original timber has been felled and the slopes are now used for grazing sheep and cattle. Native tussocks (*Poa caespitosa, Festuca novae-zelandiae* and *Danthonia pilosa*) occur, together with imported English pasture grasses. Native trees and shrubs have been left along many of the tributary streamlets, and in some of the gullies; the main species present are *Griselinia littoralis, Carpodetus serratus, Melicytus ramiflorus, Edwardsia tetraptera, Podocarpus spicatus, P. dacrydiodes* and *P. totara.* There seems to be little evidence of overstocking, or of erosion.

The rainfall is not accurately known. Speight (1916) estimated an average annual rainfall of 30–40in for the whole of Banks Peninsula. Barley (1946) presented figures for Kaituna Valley, which adjoins Purau Valley but lies on the slightly wetter, southern side. For 1923–1946, and at an altitude of 400ft six miles up the valley, the average annual rainfall was 54.50in with a range from

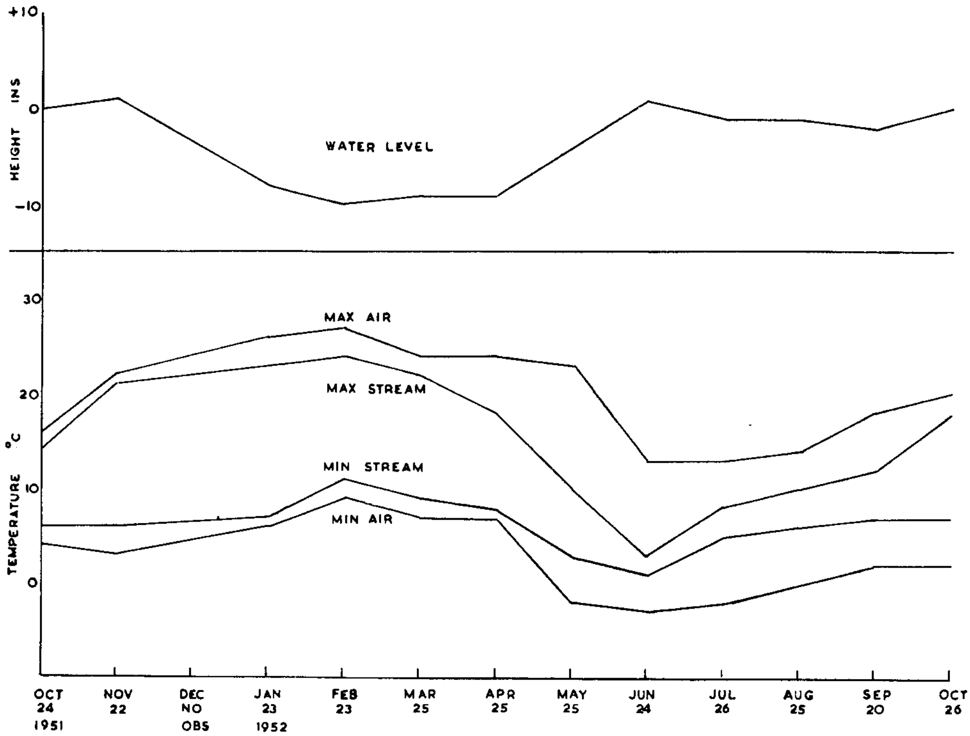

FIG. 2.—Water levels and air and water temperatures for Purau Stream, October, 1951–October, 1952.

31.95 (1933) to 80.18 (1945). Ford (1949) quoted an average of 35.60 in from 1926–1945 for Little Akaloa Valley, which lies north-east of Purau Valley.

Some records of water and air temperature are available from Purau Valley. Hamilton (1931) found a maximum water temperature of 21.5° C. in Purau Stream on December 31, 1930, and a minimum of 4.5° C. on July 13, 1931. In the present study maximum and minimum thermometers were left in Purau Stream bed 200 yards from the mouth for a year (September, 1951–September, 1952). Air temperatures were also recorded at the same point 12ft above the stream in shade. The results are graphed in Figure 2. The maximum water temperature was recorded between November 22, 1951, and January 23, 1952, when 23.3° C. was reached. The minimum (1.1° C.) fell between May 25 and June 24, 1952. The maximum air temperature was between January 23 and February 23, 1952 (26.7° C.), and the minimum between May 25 and June 24, 1952 (-3.3° C.).

2. The Stream Bed

The bed components are of volcanic origin and showed a great variety in size (Plate 1, fig. 3). In the slower waters (current speed 0.4–1.0 f.p.s.) the bottom was lightly coated with fine silt. Gravels (<1.0 in in diam.) were uncommon. Many of the stones were 6–12in in diameter and occasional boulders were 3–4ft. The ratio of these components varied greatly in areas only a few yards apart; this was probably attributable to the short length and steep slope of the stream. The larger bed components (stones and boulders) were usually smooth-surfaced, irregularly shaped, and embedded. In the pools fine silt had filled up the interstices so that there were no cavities present between the stones Loose stones were not plentiful except in the rapids, and it was in these areas that the most cavities and aquatic insect larvae were found.

3. Water Levels, Rates of Flow and Chemical Composition

Purau Stream consists of series of rapids, pools and slow-flowing stretches. Horizontal rods were driven into the bank at water level in October, 1951, and levels measured relative to these at monthly intervals. These levels varied inversely with the air and water temperatures (Fig. 2). The maximum height of water occurred in the spring (November) and was *c.* 1ft in rapids, 3–4ft in pools, and 1–2ft in the slow-flowing stretches. It fell 9–10in in summer and autumn (January–April) before rising to datum during winter and spring (June–November). The stream was not in flood when any of the levels were measured but examination of debris marks on the banks and conversations with local residents made it possible to estimate the variation. Rises after heavy rain were not more than 3ft and the level returned to normal rapidly (2–3 days). A heavy flood had occurred during previous years, as evidenced by debris adhering to bridge piles 6ft 9in above datum.

The surface rate of flow was estimated by timing the movements of corks over long, measured distances. Representative values were for a pool 0.4 f.p.s., a slow-flowing stretch 1.2 f.p.s., a rapid 1.5 f.p.s., and for the fastest part of a rapid 2.5 f.p.s. *Coloburiscus* nymphs usually occur in rapids, but since much variation in the rates of flow of these has been noted in various parts of New Zealand the above values cannot be considered critical.

Water samples were kindly analysed by the Government Analyst, Christchurch (Table I), to whom the author is grateful. Evidently the water was supersaturated with oxygen. The saturation value for distilled water at the temperature of the samples (17° C.) is 9.48 p.p.m.; which is considerably lower than the value obtained (11.6 p.p.m.). Other features of interest were the slight alkalinity (pH 7.3); high chloride content (19.0 p.p.m.) due to sea spray deposition in the lower part of the valley; and high oxygen uptake rate denoting the presence of oxygen absorbing organisms (1.3 p.p.m. absorbed in 4 hr at 80° F.).

Table I.

Chemical Composition of Water Samples Taken 150 Yards from the Mouth of Purau Stream, October 1, 1952. Water temperature, 17° C.

Component	Concentration (p.p.m.)	Component	Concentration (p.p.m.)
Chlorine in chlorides	19.0	Iron (Fe)	0.15
Nitrate nitrogen	0.4	Hardness temporary	28
Nitrite nitrogen	nil	Hardness permanent	6
Ammoniacal nitrogen	nil	Calcium ($Ca\,Co_3$)	15
Albuminoid nitrogen	trace	Magnesium ($Mg\,CO_3$)	19
Oxygen absorbed in 4hr at 80° F.	1.3	pH = 7.3	
Dissolved oxygen	11.6	Earthy smell and slightly clouded appearance	

4. Associates

Rivers and streams inhabited by *Coloburiscus* usually contain a varied and abundant fauna; many of the organisms given below occur with *Coloburiscus* in other areas. Identification sources have been included where possible.

Diatomaceae

Samples taken near the stream mouth in March, 1951, contained large numbers of *Melosira varians,* a proportion of *Gomphonema constrictum,* and smaller numbers of *Stauroneis phoenicenteron, Cymbella turgida, Meridion circulare, Cocconeis* sp., *Navicula cuspidata* (var.), *Amphora ovalis,* and *Synedra ulna.* The author is grateful to Mr F. Reid, of Christchurch, for kindly identifying these organisms.

MOLLUSCA

The gasteropods *Potamopyrgus corolla* and *P. antipodum* occurred sparingly in the main stream but more abundantly in the tributaries. The distribution of the small bivalve *Corneocyclas novae-zelandiae* was similar (Suter, 1913).

CRUSTACEA

A prawn *Xiphocaris curvirostris* occurred mainly near the stream mouth under overhanging banks (Hutton, 1904).

INSECTA

Larvae of the blepharocerid fly *Curupira chiltoni* (Campbell 1923) were common on submerged boulders in the upper regions. Swarms of adults were seen clinging to the shaded downstream sides of projecting boulders in October, and larvae 2 mm in length were abundant in January. Sandfly larvae were also plentiful; the pupae of *Austrosimulium tillyardi* were found through the summer until March. Carnivorous larvae of the Dobson Fly *Archichauliodes dubitatus* (Tillyard, 1926) were common in the lower regions of the stream. Larvae of 5 mm in length were present in April, and adults began to appear in November; empty exuviae were found on the stream banks through December and January. Larvae of the Green Stonefly *Stenoperla prasina* (Tillyard 1926) were more plentiful in the tributaries than in the main stream. Larvae of the Black Stonefly (*Austroperla cyrene*) and *Nesoperla triavacuata* and *Zelandoperla decorata* were also found; the latter was particularly abundant.

Mayflies were well represented. The black and yellow-spotted nymphs of *Atalophlebia versicolor* and the reddish nymphs of *Deleatidium* (*Atalophlebiodes*) *cromwelli* were present in pools in the main stream, and in some of the tributaries. Large burrowing *Ichthybotus bicolor* nymphs were found occasionally amongst clay and rubble conglomerates, or in clay banks. The fast-swimming nymphs of *Nesameletus ornatus* were common along most of the stream, but the distribution of *Ameletopsis perscitus,* which is believed to be carnivorous (Phillips 1930), seemed to be restricted. Only two specimens were taken during a year's routine sampling in which about 3,000 *Coloburiscus* nymphs, and probably as many *Deleatidium lilii, D. vernale,* and *D. Myzobranchia,* were collected. Several other species of *Deleatidium* and *Atalophlebia* were also noted but could not be identified with certainty from Phillips' (1930) keys.

The caddis flies *Olinga feredayi, Helicopsyche* sp., *Hydropsyche* sp., and *Hydrobiosis* sp., were identified, but several others were present. *Olinga feredayi* and *Helicopsyche* sp., were found pupating in clusters of about 50. (Tillyard, 1921b, 1924; McFarlane, 1951).

PISCES

Small specimens of the Long-finned and Short-finned Eel (*Anguilla dieffenbachi* and *A. australis*) were often found under stones in rapids. The Long-fins were from 83–185 mm in length, and the Short-fins from 80–300 mm. They were identified from Cairns' (1950) descriptions. *Galaxias attenuatus* were common near the mouth of the stream, and a 127 mm specimen of *G. fasciatus* was collected in a tributary by Mr G. Stokell, of Springston (pers. comm.). *Gobiomorphus gobiodes* occurred throughout the stream. The Shark-nosed Bully, *Cheimarrichthys fosteri* (Waite, 1919) was sometimes collected in the rapids but was rare; only 20 were taken during a year's routine collecting, representing a collecting time total of about 24 hours. All these were taken at the downstream edge of the rapid shown in Plate I, fig. 2. Occasional specimens were collected further upstream.

Trout (*Salmo trutta*) were not observed in Purau Stream, although there is evidence of their presence in various sea arms around Banks Peninsula. Hobbs (1948, p. 25) presents records; and in correspondence mentioned seeing trout netted at Port Levy on numerous occasions. The author has seen two specimens netted in Menzies Bay. About 1930, the late Mr H. Gardiner, of Purau Valley, liberated some 1,700 young fry in Purau Stream, but this was apparently unsuccessful.

It is suggested that the apparent absence of trout from Purau Stream is associated with the unsuitability of the bed as a spawning ground. Spawning grounds usually consist of fairly uniform, small, loosely-packed stones which can be shifted readily by trout in making their redds. Examples of these can be seen in the Selwyn River, the upper Avon River, and in Slovens and Winding Creek near Cass. As noted previously, Purau Stream shows great discontinuity in the size of its bed components. It would be difficult for trout to find areas of gravels or stones suitable for making redds.

5. *Symbionts, Parasites and Predators*

A vorticellid ciliate and a species of sessile rotifer were found attached to the abdominal tergites of Purau Stream nymphs. A few small nematodes were noted in the developing gonads of both Purau and Cass nymphs. One male imago taken at Cass (December 12, 1950) had a red larval mite of the family Trombidiodae well embedded in its head. This was identified by Mr H. Womersley of the South Australian Museum, Adelaide. The length of the mite was 1.5 mm. The following list of predators has been compiled from field observations, and the literature.

Nymph. 1. *Archichauliodes dubitatus* larvae Purau Stream, June 24, 1952. 2. *Gobiomorphus gobiodes* Wellington streams (Phillips, 1929, p. 27). 3. Adult *Galaxias* sp. (Percival, 1932, p. 17). 4. *Salmo trutta* Horokiwi Stream (Allen, 1951, p. 139). 5. *Anguilla dieffenbachii,* length 18.5 cm, Purau Stream, March 25, 1952. 6. *Anguilla australis,* length 30.0 cm, Purau Stream, October 25, 1952. 7. *Salar salar,* Waiau River, Southland (Phillips, 1931, p. 403).

Subimago. Chaffinch (*Fringilla caelebs*) Purau Valley, October 24, 1952.

Imago. 1. Spider (*Orsinome herbigrada*) Cass, December 19, 1950. 2. Predatory fly, Cass, December 19, 1950.

Distribution in the Cass Basin, Canterbury

During 1950 and 1951 the distribution of *Coloburiscus* nymphs was examined in the Cass Basin in the Southern Alps (Fig. 1). Nymphs were found consistently only in four of its water courses, all on the basin floor. These were: Grasmere Stream, draining Lakes Grasmere and Sarah. 2. The original outlet stream of Lake Grasmere, now joining Grasmere Stream below Lake Sarah. 3. Winding Creek, draining Lake Pearson. 4. A small stream leaving " Power Line Gully " (viz., between Mts Misery and Horrible) and following a south-westerly course to discharge into the Cass River.

The basic feature of these four streams seemed to be that they were " stable "; that is, not affected greatly by flooding or scouring. Probably Lakes Grasmere, Sarah and Pearson act as buffers against such abrasive action in the first three streams. During heavy rains the numerous water courses draining the steep basin sides (e.g., Ribbonwood and Craigieburn Streams) become swollen and discoloured and carry much suspended sand and silt. Since the carrying capacity of water is proportional to the third or the fourth power of its velocity (Twenhofel, 1950), much of this suspended matter drops when these water courses discharge into the lakes on the valley floor. These lakes are large (Fig. 1), and

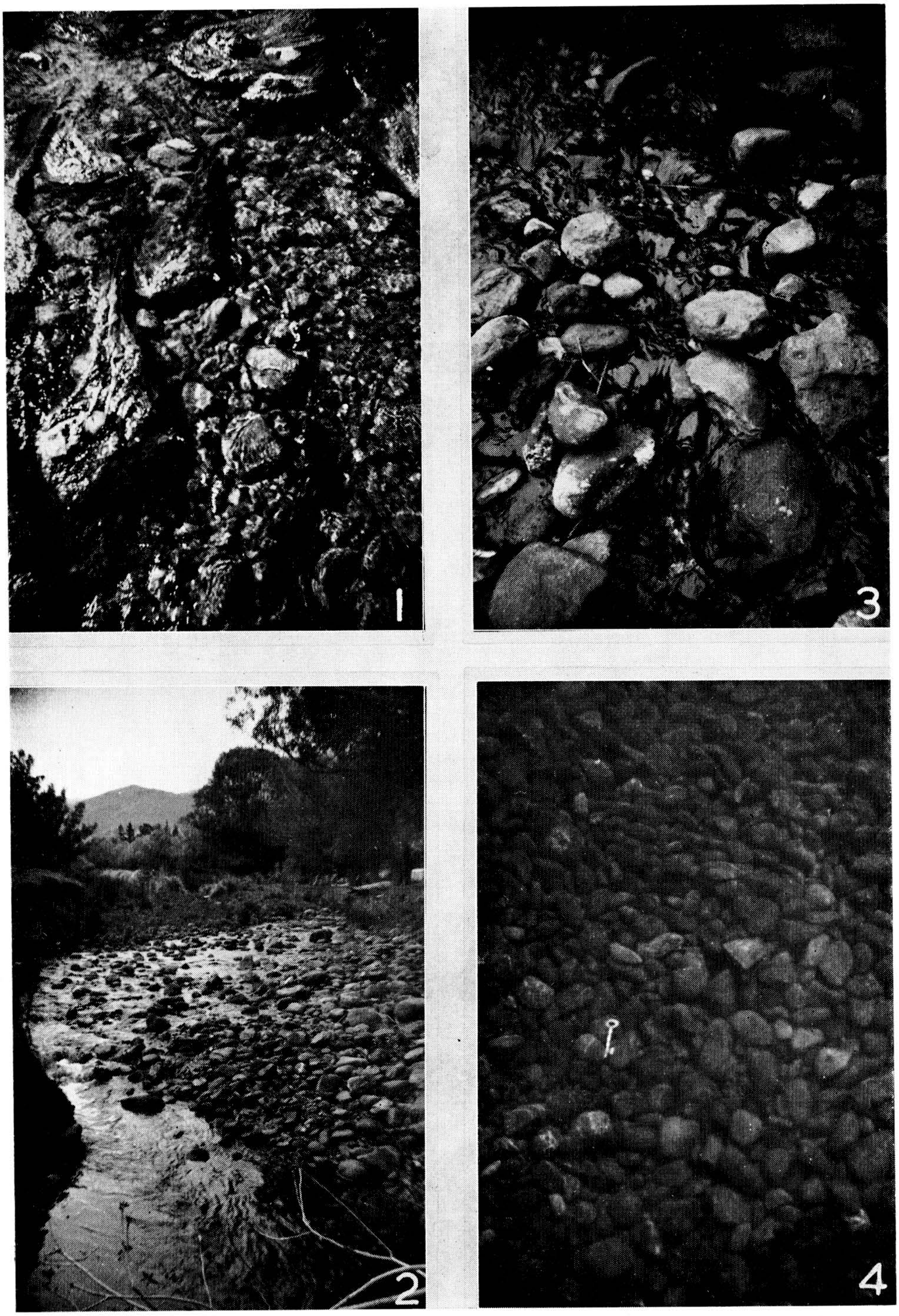

FIG. 1.—View of the substratum at Station 6, Upper Selwyn River. The stones and boulders were 6in to 2ft in diameter and embedded in a hard matrix. Loose stones, cavities between or beneath stones, and *Coloburiscus* nymphs were virtually absent.

FIG. 2.—Typical rapid in Purau Stream from which 3,000 *Coloburiscus* nymphs were collected during 1951 and 1952.

FIG. 3.—Part of the rapid shown in Fig. 2 showing the considerable variations in the size of the bed components. Numerous cavities and nymphs were present between the stones and boulders.

FIG. 4.—The substratum at Station 6 in the Lower Selwyn River which consisted of small, loosely-packed stones, numerous cavities and an abundance of nymphs.

capable of accommodating considerable volumes of run-off water by increasing their levels only a few feet. Since the pressure of water in such a system depends on its height and not its volume, it follows that the velocity of the water leaving in the outlets inhabited by *Coloburiscus* will only increase slowly during heavy rain. Moreover, the evidence suggests that when this occurs, the excess water readily overflows the banks of the outlets and dissipates over the surrounding flattish valley floor. This would account for the markedly sinuous courses of the outlets, the numerous horseshoe bends, and the permanent, vegetation-covered banks. The appearance of the fourth stream was similar, but it did not lie below a lake; *Coloburiscus* was found only in the relatively sinuous part of it out on the valley floor. The Cass River was similar to the tributaries on the basin slopes in that it readily became discoloured after heavy rain, carried much suspended matter, and did not appear to be inhabited by *Coloburiscus*. On two occasions when it was in light flood, the clanking of stones or boulders being rolled along the bottom by the current could be heard from the bank.

DISTRIBUTION ALONG THE SELWYN RIVER, CANTERBURY

In 1952 a series of samples was taken down the length of the Selwyn River, and an attempt made to associate the presence or absence of *Coloburiscus* nymphs with the nature of the substratum. The Selwyn is one of the numerous large rivers traversing the Canterbury Plains for a distance of about 40–50 miles and showing variation in the substratum from its head waters to its mouth. For convenience, the Selwyn was considered in three sections:—

Section	Range	Length (miles)	Surface Water	*Coloburiscus* nymphs
Upper Selwyn	13 Mile Bush – Coalgate	18	Present all year	Present
Middle Selwyn	Coalgate – 2 miles above Ellesmere Bridge	20	Underground in summer	Practically absent
Lower Selwyn	2 miles above Ellesmere Bridge–Upper Selwyn Huts	6	Present all year	Present

Localities of the sampling stations used are shown in Fig. 1; further details are as follows:—

Station 1. Two and a-half miles up Glendore Stream from Whitecliffs. Bottom stony, with stones irregular in shape but with smooth surfaces, mostly 1–4 inches in diameter and not embedded, nymphs caught in a chain of three rapids. Area draining well-tussocked country of 1–2,000ft.

Station 2. Two miles up the Selwyn River from Whitecliffs. Bottom mainly boulders, 6in–2ft in diameter, mostly embedded, and covered with silt and diatomaceous coverings. Area below five to six miles of gorge, and draining tussock and beech forest of 2–3,000ft.

Station 3. One and a-half miles down the Selwyn River from Whitecliffs. Bottom stony, with stones ¼in to boulders 2ft in diameter, many embedded. A filamentous green alga abundant. Area draining 1 and 2 through flattish plain in a broad river valley.

Station 4. Intersection of Coalgate-Hororata Road and Selwyn River. Stones and boulders regular and smooth, ¼in to 1ft in diameter, many not embedded. Apparently lower limit of permanent water (water race intake going off which supplies stock on the Te Pirita and Dunsandel Plains). Water going underground within the next two miles, leaving a chain of pools.

Station 5. Three miles up the Selwyn River from the Ellesmere Bridge, "Williams's Ford". Bottom stony, stones regular in shape and smooth, mainly ¼in to 6in in diameter, lying loosely on the bottom and coated with dark brown algae. Springs common, supplementing the main stream; but area known to dry up in previous years.

Station 6. One and a-half miles below the Ellesmere Bridge, mapped as "Chamberlain's Ford". (Another ford further upstream is known locally by the same name.) Bottom stony, but stones almost invariably rounded and smooth, 2–5in in diameter, very loosely packed, and with distomaceous coverings.

Station 7. Two and three-quarter miles below the Ellesmere Bridge, "Coe's Ford". Stones as for 6, but river now consisting of deep pools alternating with rapids. (A mechanical grab has been used to deepen the bed from the Selwyn Huts to 200 yards below 6, in an attempt to keep the Selwyn within its banks during floods.)

Station 8. Four and a-half miles below the Ellesmere Bridge, at the Upper Selwyn Huts. Bottom silted with occasional stretches of silted stones. No bottom samples were taken as the water depth was 4ft.

The number of nymphs present at each station were estimated by overturning loose stones in the mouth of a triangular net measuring 16 x 12 x 12 inches at the mouth and 16in in length. The diameter of the openings in the mesh was 2 mm. The number of nymphs caught in 15min constant overturning of stones was recorded and the procedure repeated three times and averaged. Bottom and surface current speeds were measured with a Cole-type Pitot tube, and oxygen determinations were made with a B.D.H. Lovibond Nessleriser. Samples were taken in rapids at midstream at depths of 1ft 6in to 3ft with the exception of Station 8 where, owing to the great depth of water the samples were taken 6in down alongside the bank. The bottom at this station was muddy, and it was highly improbable that *Coloburiscus* nymphs were present. Results are given in Table II.

Table II.

Data on Distribution of *Coloburiscus* Nymphs and Physical Conditions Along the Selwyn River.

Station	1	2	3	4	5	6	7	8
Date	12.IV.52	12.IV	12.IV	13.IV	14.IV	14.IV	14.IV	14.IV
Time	11 a.m.	2 p.m.	6 p.m.	10 a.m.	10 a.m.	1 p.m.	3 p.m.	5 p.m.
Water Temp. ° C.	13.0	16.0	14.5	15.5	14.0	15.0	15.0	15.0
Current f.p.s.	0–2.4	0–2.8	0–3.2	0–3.9	0–3.0	0–2.6	0–2.8	0–.35
O_2 mg. litre	8–10	8–10	8–10	8–10	8–10	8–10	8–10	8–10
Number caught to time taken	1. 92:15	0:30	35:15	2:15	0:30	163:15	18:15	0:0
	2. 105:15	0:0	32:15	0:0	0:0	142:15	13:15	0:0
	3. 101:15	0:0	29:15	0:0	0:0	150:15	14:15	0:0
Av. collecting rate per min.	7	0	2	1	1	10	1	—

Some stations resembled those already sampled in the Cass Basin. Stations 2 and 4 resembled the Cass River in possessing a hard bed in which the majority of stones and boulders were embedded (Plate 1, fig. 1). Loose stones were rare and there was much evidence of flood scouring and silt deposition. *Coloburiscus* was virtually absent. Stations 1, 6 (and to a lesser extent 3, 7) resembled Grasmere Stream in possessing dense populations of *Coloburiscus* nymphs. These areas also contained a high proportion of loosely-packed stones; and there was little evidence of flood scouring and silt deposition. The apparent absence of *Colo-*

buriscus at Station 5 (and in a number of unrecorded stations in the middle Selwyn), was probably associated with the disappearance of surface-flowing water in this section during the summer months. Spackman noticed this first in 1892, and it was also evident in the summers of 1938–1942, and in 1945, 1946 and 1950, when the author was present in this section. The summer disappearance of surface water, accompanied by an apparent absence of *Coloburiscus,* was also noted during the present study in parts of the Ashley and Kowai Rivers (Canterbury) and in some Manawatu Streams (North Island). Conditions for *Coloburiscus* nymphs appeared to be near optimum at Station 6. Here the substratum consisted of small rounded stones (Plate 1, fig. 4) which were very loosely packed. This arrangement resulted in numerous cavities and interstices accommodating large numbers of *Coloburiscus* and other aquatic larvae. Station 7 may have been similar previously, but had been dredged recently to deepen the river and reduce the possibility of it flooding adjoining farms. The river at Station 8 was slow-flowing and the substratum muddy; because *Coloburiscus* was not detected in similar areas of other rivers it was considered unlikely that it was present at Station 8.

Distribution of Nymphs over New Zealand

Coloburiscus humeralis nymphs were found in most areas of New Zealand (Fig. 3) but seemed to be absent from the following habitats:

1. Mountain streams in beech forest (*Nothofagus* sp.) on steep slopes (1:5); with rounded boulders and irregular and rough-surfaced stones, pebbles and gravels. Examples: Middle, Reservoir and Sugarloaf Bush, Cass, December, 1950, August, 1951; Ribbonwood Stream, Cass, January, 1951; tributaries of Hawdon River, Cass, January, 1951; Mt Grey, Mid-Canterbury, April, 1952.

2. Flood regions of swift rivers (approximately 2.8–4.8 f.p.s.) with hard, scoured bottoms and rounded boulders (mostly embedded), and stones, pebbles, and gravels tending to be smooth-surfaced. Silt deposits (diameter .025–.1 mm) usually present and interpreted as the aftermath of flood conditions. Examples: Cass River, December, 1950, November, 1951; Upper Waimakariri River, December, 1950; Lower Ashley River, April, 1952; Upper Selwyn River, April, 1952.

3. Lower stretches of rivers with a sluggish current (.3–.5 f.p.s.) and occasional stones projecting through the silt and mud. Examples: Lower Waikato River, February, 1952; Lower Heathcote River, Christchurch, November, 1950.

4. Portions of rivers and streams that go underground in dry summers. Examples: Kowai River, Amberley, April, 1952; Middle Selwyn River, April, 1952.

In general *Coloburiscus* is widely distributed through New Zealand, but it appears to be absent from estuaries, the sluggish winding coastal portions of rivers, flood regions of swift streams and mountain tributaries on steep slopes.

It is found in streams draining back country lakes, or in other fairly rapid rivers and streams, and it is associated with irregular to rounded boulders, stones or gravels; with somewhat rounded surfaces and a more usual diameter of 1–10in. The stones are often loosely packed on the substratum, and not shifting to any great extent. The current speed in these rapids is usually 1.0–4.0 f.p.s. and diatomaceous and algal growths are present.

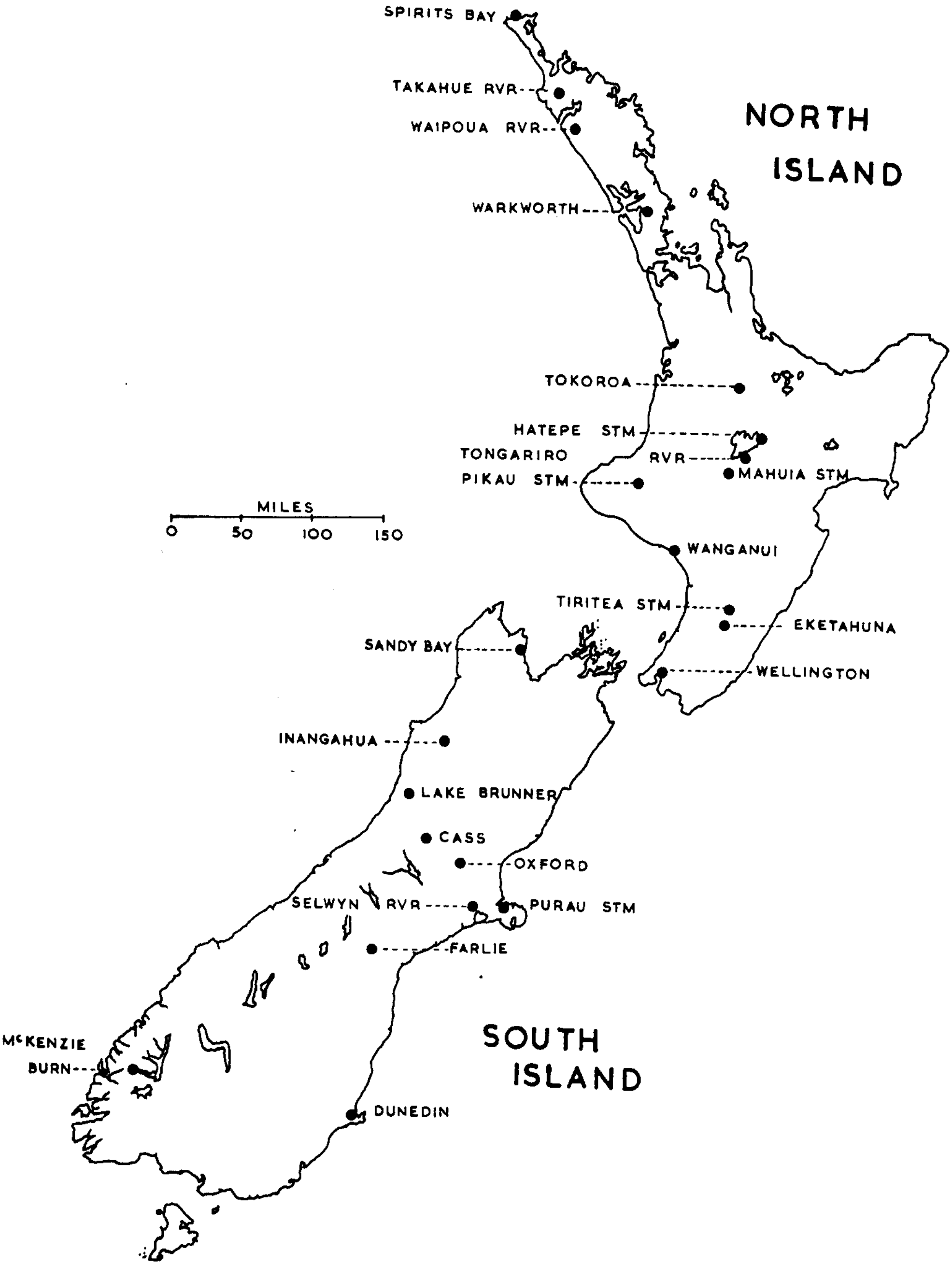

Fig. 3.—Map of New Zealand showing locations where *Coloburiscus* nymphs were found. The eastern North Island and the southern South Island were not examined.

DISCUSSION

It was shown (Wisely, 1962) that *Coloburiscus* nymphs rely on currents to bring them potential food; they sieve out this material using a special series of bristles on their prothoracic legs. During the examination of many different rapids containing nymphs, the latter were never noted on the upper surfaces of stones. They occurred typically on the undersides, or in the cavities between and beneath stones. These observations suggest that current speed, light factors, and the relative abundance of cavities may be factors determining the distribution and abundance of nymphs. Unfortunately experimental work on these variables could not be included in the present study.

The nature of the substratum appears to be a major factor affecting distribution and abundance. In rivers and streams subjected to flooding and scouring loose stones are displaced and the cavities between the stones become tightly packed with silt or larger flood-borne deposits. Station 2 in the Selwyn River (Plate 1, fig. 1) may be considered typical. The substratum consisted of stones and boulders ranging from 6in to 2ft in diameter which were still firmly embedded in a hard bed matrix with only their upper surfaces exposed. There were very few cavities or loose stones, and no nymphs were found during 30min constant searching (Table 2). The Purau Stream substratum (Plate 1, figs. 2 and 3) was more favourable. Although there was marked discontinuity in the size of the bed components there were numerous cavities present beneath and between the components which accommodated *Coloburiscus.* Over 3,000 nymphs were taken from the rapid shown in Plate 1, fig. 2, during a year's routine monthly sampling with no obvious indications of a population decline. The substratum is probably near its optimum when it consists of loosely packed stones 2–5in in diameter. Station 6 in the Selwyn River (Plate 1, fig. 4) may be considered representative. This loose arrangement results in numerous cavities providing niches for *Coloburiscus* and other aquatic larvae. Nymphs (455) were collected there in 45min constant searching (Table II).

The presence of *Coloburiscus* nymphs in the rapids of a river or stream appears to indicate primarily that conditions are liable to be stable; i.e., not greatly affected by flooding, scouring or periodical disappearance of surface water. When the nymphs occur in abundance in a substratum consisting of small loosely packed stones it may be considered that the environment is not only stable, but also probably suitable for redd-making, spawning and the development of young trout.

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