1974

A comparative study of the aquatic insect populations of Rock Creek Montana and its major tributaries

Ralph Edward Driear
The University of Montana

A COMPARATIVE STUDY OF THE AQUATIC INSECT POPULATIONS OF ROCK CREEK, MONTANA AND ITS MAJOR TRIBUTARIES

By

Ralph E. Driear

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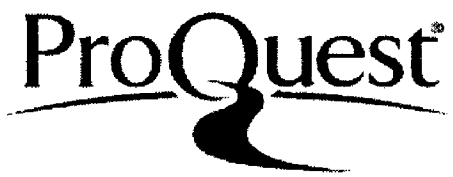
Approved by:

Royal Bruce Brunson
Chairman, Board of Examiners

John M. Stewart
Dean, Graduate School

July 8, 1974
Date



"The greatest social problem facing man today is the ecological one of adjustment to the ecosystems of which he is a part. Ecologists must provide technical answers, and they must come to fill an increasingly important role in formulating national and international policies. We are in nowise suggesting that it is possible or even desirable to maintain the ecosphere in a primeval state; what we are suggesting is that it well behooves man to learn to predict the effects of his activities on the ecosphere and to govern those activities accordingly."

Frank Blair, 1964

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ACKNOWLEDGEMENTS

Many people have provided assistance in numerous ways throughout the course of this study, and for this help I am sincerely grateful.

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CHAPTER I

INTRODUCTION

Rock Creek originates in the Anaconda-Pintlar Wilderness area in western Montana, and is one of seven Montana streams currently classified as class-one, or "blue-ribbon" trout streams. The stream system has a drainage of approximately 900 miles, 80% of which is under U.S. Forest Service management.

Recent history reveals a new era of land development about to begin. The small farm acreages along the lower section of Rock Creek have already been sub-divided into lots for summer homes, and an additional 5,000 acres of land north of Giller Bridge is suitable for this type of land development (Haugen, 1972). Increased usage of the area by transient recreationalists is also adding to the environmental pressures present in the drainage. There is no doubt that this area will continue to increase in recreational popularity.

In addition to the above conditions, several other interests are contributing to the increased land usage along Rock Creek. The U.S. Forest Service land that comprises the drainage is divided into two districts, Lolo and Deerlodge National Forests. Management policies in timber sales, clear cuts, road construction, and access development all help to define the quality of water flowing through these areas. The future dependency of the timber supported industries on this drainage for raw materials will also have a marked impact on the usage of the area.

Mining interests look to the area for important minerals, and appear only to be waiting for higher prices to move into the area and

add even further to the management problems of the drainage.

The recent increase in man's activities along the drainage has accelerate his influence on the ecosystems that comprise the total environment of the Rock Creek drainage. This along with the increased future usage of the area has created the potential for a degraded stream environment. With this situation in mind, the U.S. Forest Service initiated an extensive program of classifying and monitoring of the water quality and fishery habitat of the drainage in 1970. Water chemisty data for the drainage was monitored during the years of 1970 and 1971 by the University of Oklahoma in co-operation with the U.S. Forest Service. Information obtained from these continuing studies has been, and continues to be very important in the formation of today's management policies for the water shed.

To insure that Rock Creek maintains its present classifications it is important that there be found yet other methods of monitoring stream quality and detecting changes in the watershed. One of the dynamic forces that comprise any watershed is the community of aquatic insects that inhabit its water. These communities form an elaborate relationship with the other forces responsible for shaping the drainage. They are very sensitive to changes in their environment and are important indicators that such changes are occurring. A change in the community structure will reflect an altering in the desirability of habitat available at the site (Hynes, 1972). Such an alteration could imply a change in the quality of water available at that site, and suggest a more comprehensive study to determine the reason. With this in mind, a qualitative study of the aquatic insects and their

distribution throughout the Rock Creek drainage was initiated in July, 1972. The study spanned a twelve-month sampling period, the results of which are the subject of this paper.

This study has provided information upon which future studies may be based to determine changes that might occur in the quality of water present in the Rock Creek drainage. It has provided data upon which the effectiveness of present management programs can be judged, and the future pressures of man's accelerated usage of the drainage assessed.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

The Rock Creek drainage system comprises a major tributary of the Clark's Fork of the Columbia river. The system lies principally in the Lolo and Deerlodge National Forest in Granite county, with a small portion near the mouth located in Missoula county. The drainage system is bounded on the west and southwest by the Sapphire mountains. The John Long mountains form the eastern boundary. (Miner, 1968)

The area has a dendritic drainage pattern, and is drained by numerous small intermittent and permanent streams, including five major tributaries to the main channel. The East Fork and Middle Fork have their headwaters in the Anaconda range at an elevation of about 8,500 feet. The Ross Fork, and West Fork drain the east facing slopes of the Sapphire mountains. The main channel of Rock Creek begins at an elevation of 5,100 feet and runs north for approximately 40 miles, where it enters the Clark's Fork between Drummond and Missoula at an elevation of approximately 3,600 feet. (Miner, 1968)

The geologic structure and history of the area are similar to adjacent areas. Nearly all of the major structural features trend in a general northeast-southwest direction and include synclinal folding, northward thrusting, and normal faulting (Montgomery, 1958).

Sedimentary rocks which range in age from Proterozoic to recent are believed to have been deposited under marine conditions. The deposits have an aggregate thickness of at least 20,000 feet and have been subdivided into five Proterozoic, eleven Paleozoic, one Mesozoic, and one Quarternary formation. (Miner, 1968)

Fig. 1. U.S.F.S. classification of the Rock Creek drainage.

ROCK CR. DRAINAGE

1 Rock Cr.
2 Rock Cr.
2A Welcome Cr.
3 Rock Cr.
4 Wyman Cr.
5 Alder Cr.
6 Willow Cr. – upper
6A Willow Cr.
7 Rock Cr.
8 West Fk.
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

Primary viewing area-canyon type

High mountain area

Primary viewing area-open woodland

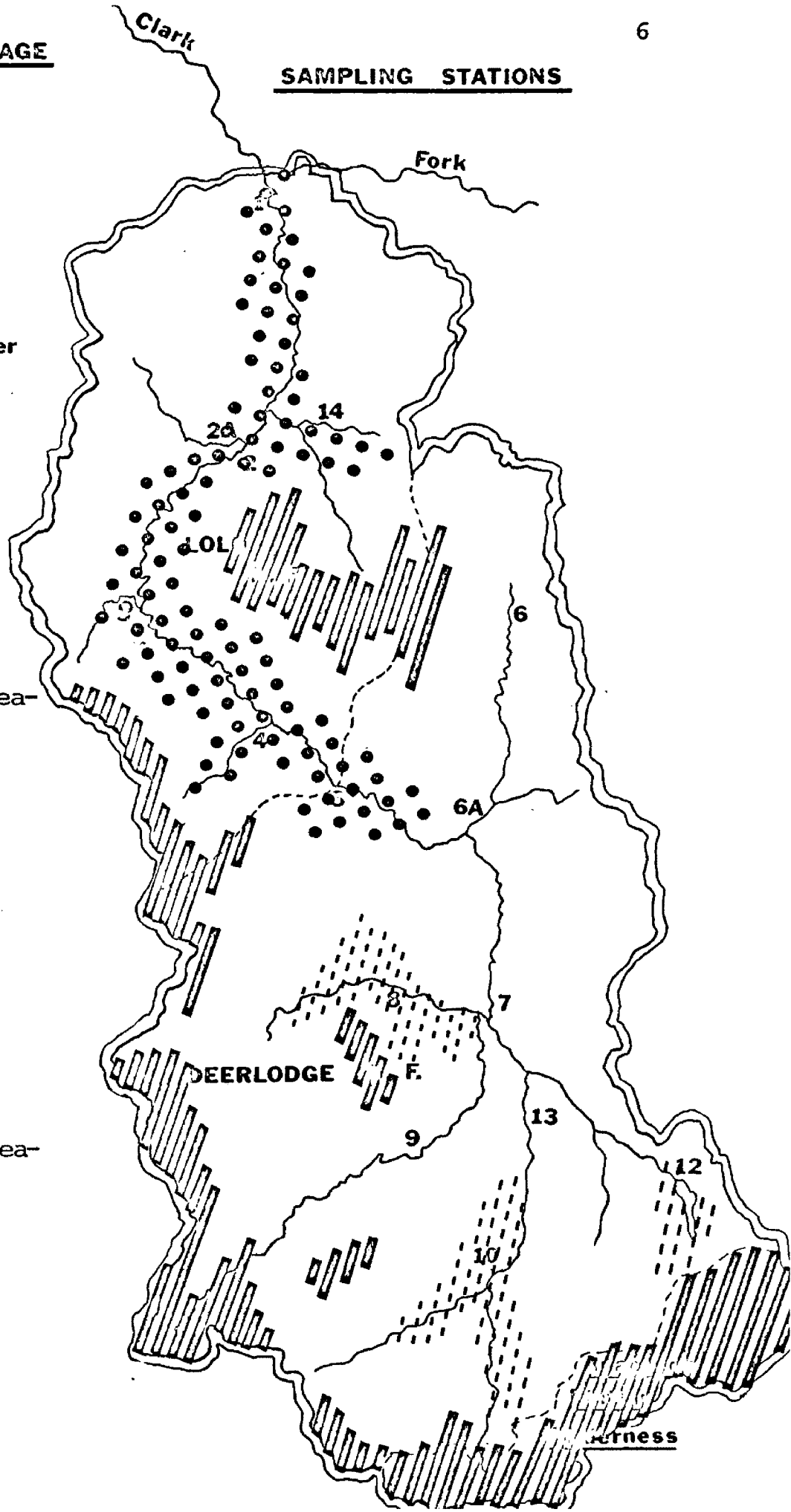

Fig. 2. Elevation of the sample sites.

ROCK CR. DRAINAGE

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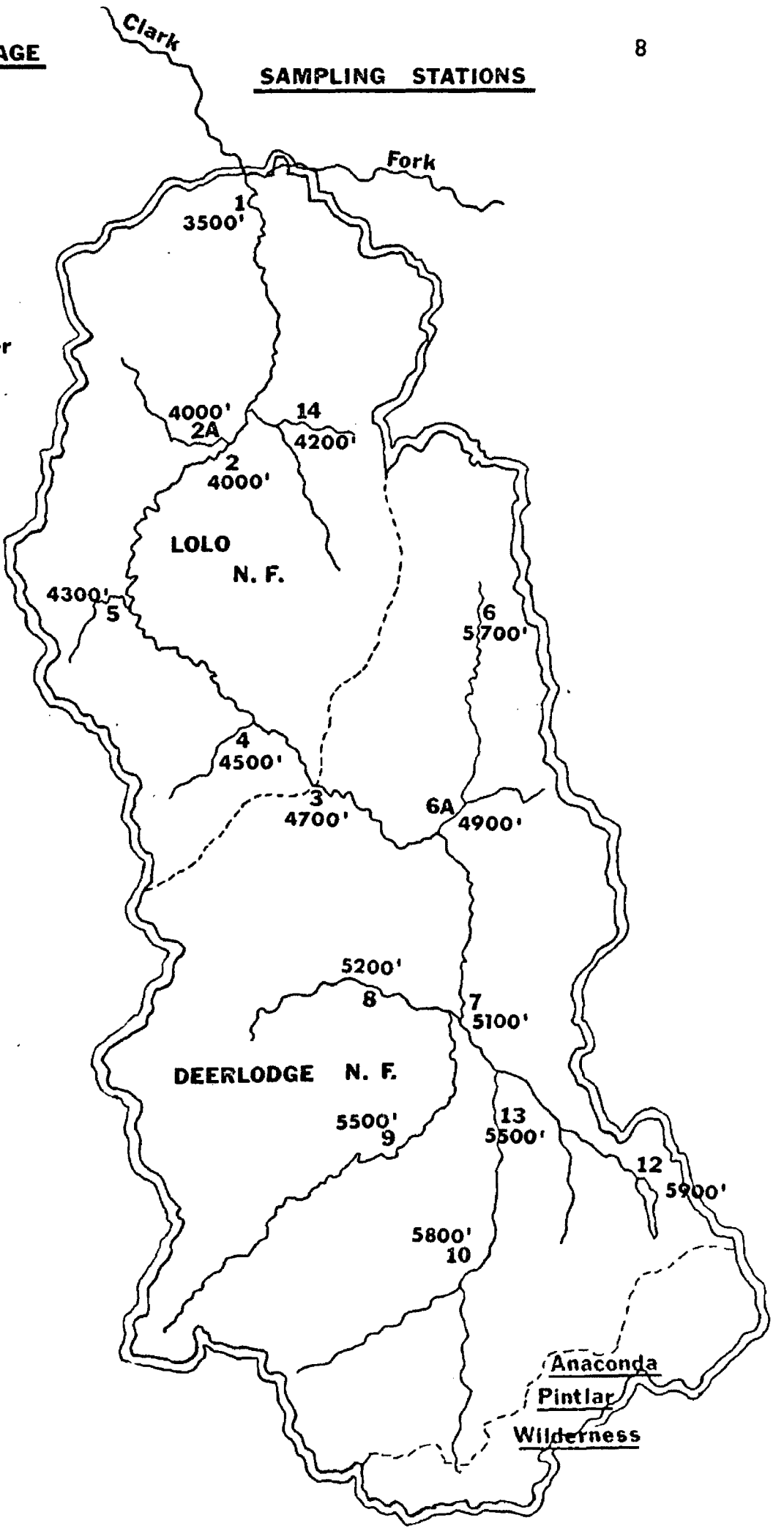


The Rock Creek drainage system shows no signs of recent glaciation, which is much in evidence in the adjacent Bitterroot range. The valleys cut by streams are typically V-shaped, with generally steep gradient. Such valleys carry streams with rapid sometimes torrential seasonal flow. The main channel is relatively straight with a gradient of approximately 35 feet per mile. (Miner, 1968)

A cool temperate, semiarid, climate prevails in the region which has an annual precipitation of 12.5 inches. It is characteristic of the Northern Rocky Mountain Province to have wide seasonal and daily variations. The temperature ranges from a -37°F. in the winter, to 103 F. in the summer with a yearly average of 42°F. according to data obtained from the Missoula Weather Bureau Station. (Montgomery, 1958)

CHAPTER III

DESCRIPTION OF SAMPLE SITES

Site One

Site 1 is located near the mouth of Rock Creek, Sec. 13, T. 11N., R. 17W.. The stream at this point is wide, approximately 85 feet and has an average depth of 14 inches. The banks of the stream are moderately unstable, being composed of clay, sand, and loose gravel.

The area shows evidence of a constantly changing stream channel. There are numerous side channels that contain water during peak discharge periods. Depending on the discharge volumes, and erosional patterns during any given year, many of the side channels have the potential to become main water carrying courses. Large cottonwood trees (Populus deltoides) are found on either side of the stream, with red dogwood (Cornus stolonifera) and small willows (Salix spp.) dominating the side channel and island areas between the major banks. When flow is reduced during the summer months, large areas of gravel are exposed. This gravel composes the substrate of the side channels during periods of higher discharge.

Many maches with grazing livestock are located along this section of Rock Creek. Summer homes and cabins are also numerous in the area.

Site Two

Site 2 is located near Sec. 2, T. 10N., R. 17W. in the Dalles area of Rock Creek above the mouth of Welcome Creek. The stream is narrower here than at site 1, and the gradient is greater. Much of the stream substrate is coarse rubble and boulders. Many very large

boulders are present along the stream banks and in the stream, causing a turbulent flow at this location. There are frequent deep pools created as the water flows around and over the large boulders. Small sized substrate is deposited opposite the areas of turbulent flow and around the edges of pools. Areas absent of large rock, and having a substrate of uniform rubble are also present.

The stream flows through a timbered canyon at this point. The stream banks and areas adjacent to the stream support a community of Douglas fir (Abies grandis), Ponderosa pine (Pinus ponderosa), and a few large cottonwood trees.

The area is a popular fishing location, and a suspension foot-bridge exists across the stream.

Site Three

Site 3 is located near Sec. 7, T. 7N., R. 16W on Rock Creek in the vicinity of the boundary between the Deerlodge and Lolo National Forests. The stream flows along the base of the Sapphire mountains which rise from the west bank of the stream. The main valley floor of the Rock Creek drainage borders the stream on the east side. Rock Creek is approximately 75 feet wide and has an average depth of 12 inches along this section. The substrate is coarse rubble to boulders and is fairly consistent throughout the area. The water flow is swift and even, with very few areas of turbulence. The gradient along the section is low.

The area to the west of the stream is densely timbered hillside with a few large cottonwood trees present along the stream bank. The area along the east side of the stream has many large cottonwood

trees and red dogwood present. Some grazing land for livestock is located along the east side of the valley and adjacent to Rock Creek.

Site Four

Site 4 is located near Sec. 2, T. 7N., R.17W on Wyman Creek, about 300 feet above the mouth. Wyman Creek is a small tributary of Rock Creek. It flows east out of a narrow canyon with steep timbered hillsides.

Dense growths of alder (Alnus sp.) and other small trees occupy eith side of the stream as it flows through the canyon. The stream appears to receive very little solar radiation.

A large amount of debris is present in the stream channel.. Numerous small falls and pools are created as the water flows over and around the debris. Areas of sand substrate are found around the pools and adjacent to the banks. Coarse gravel to fine rubble comprise the remainder of the substrate. The stream exhibits a high gradient, and is typical of the small tributaries found in mountainous regions.

Site Five

Site 5 is located near Sec. I, T. 8N., R.18W on Alder Creek, about 500 feet above the mouth. Alder Creek is a small tributary of Rock Creek. It flows east out of a timbered canyon that is moderately narrow.

Dense growths of alder and other trees occur on either side of the stream. Ponderosa pine and Douglas fir are found in areas adjacent to the site location. Also adjacent to the stream on the north side is a newly subdivided area for summer homes.

The substrate is coarse gravel to fine rubble, with areas of finer

substrate found where the velocity of the water is reduced. The stream gradient is near 5%.

Site Six

Site 6 is located on upper Willow Creek above the U.S. Forest Service boundary near the south section line of Sec. 33, T. 9N., R. 15W.. The channel of upper Willow Creek meanders through the center of a large mountain valley. Land on both sides of upper Willow Creek is leased for livestock grazing and used for the production of hay. Much of this land is boggy for a large amount of the year.

Upper Willow Creek has a border of heavy brush along it's route. There are areas of slow, deep flow with large amounts of channel debris, and areas where the flow is fast and the channel shallow. The slower areas exhibit a substrate composed of mostly organic debris, while the faster flowing areas have a substrate of medium sized rubble. Bryophytes occur attached to the substrate in the swifter flowing areas.

There is evidence of extensive bank overflow during the periods of peak discharge.

Site Seven

Site 7 is located on Rock Creek near Sec. 3I, T. 6N., R. 15W., just below the confluence of the major tributaries; the West, and the Middle Forks. Rock Creek is approximately 70 feet wide at this location.

The substrate is coarse to fine rubble, with a few large boulders present. The flow is fast, with occasional areas of turbulence.

The area adjacent to this location represents a change from the

typical "primary viewing area-canyon type"* topography that dominated the stream below this location, to a "primary viewing area-open woodland"* topography. The land is much more open, and cottonwood trees, juniper, and sagebrush dominate the streamside vegetation. Large areas along the stream are used for livestock grazing. Most of the land bordering the stream along this section is privately owned, and ranches are numerous. The Skalkaho road crosses Rock Creek at this location.

Site Eight

Site 8 is located near Sec. 35, T. 6N., R. 16W., on the West Fork of Rock Creek downstream from the U.S. Forest Service boundary in the West Fork Work Station on BLM land. The stream flows through the West Fork valley, an area nationally known for the rich deposits of sapphires located along the stream.

Heavy growths of brush define the course of the stream as it flows along the valley floor. Juniper and sagebrush occur adjacent to the stream.

The substrate is composed of coarse gravel to fine rubble. There are large areas of fine debris that are evident of turbulent flow during periods of peak discharge. The gradient is moderate.

Site Nine

Site 9 is located near Sec. 26, T. 5N., R. 16W., on the Ross Fork, just upstream from the U.S. Forest Service boundary. Ross Fork is a tributary of Rock Creek, and has a drainage of nearly 70 miles. The stream flows through Ross Fork valley before joining Rock Creek.

* U.S. Forest Service classification-Lolo National Forest.

The stream is approximately 25 feet wide at this site, with an average depth of 8 inches. The flow is swift, with little turbulence evident. The substrate is coarse gravel to fine rubble with a few large rocks scattered along the stream bottom. Areas of muck and fine organic debris occur along the banks and in slack water areas.

The stream flows through a timbered valley at this location. Douglas fir and species of pine dominate the streamside vegetation, along with several deciduous species.

Site Ten

Site 10 is located on the Middle Fork of Rock Creek, just upstream from the U.S. Forest Service boundary at the Forest bridge crossing. The site is in Sec. 18, T. 4N., R. 15W.. The drainage of the Middle Fork of Rock Creek is approximately 100 miles long.

The Middle Fork flows through a timbered valley at this location. Streamside vegetation is predominately Douglas fir and other coniferous species. Small deciduous trees also occur, although they are generally restricted to areas immediately adjacent to the stream.

The substrate is predominately fine rubble, with areas of coarse gravel and sand occasionally present. The stream width is approximately 35 feet, and the flow is swift, with areas of turbulence. The gradient is moderate.

The area adjacent and above this stream site is a popular recreational location. Two U.S. Forest Service recreation sites, and a Forest Service station are located in the area.

Site Twelve

Site 12 is located on the East Fork of Rock Creek, in the vicinity of the East Fork Forest Service Campground (Sec. 6, T. 5N., R. 14W.). This area is immediately downstream from the East Fork Dam and Reservoir.

There is a diversion channel located at this site. It is used to divert the waters flowing from the East Fork Reservoir into a bypass channel for irrigation further downstream. This seriously depletes the amount of water allowed to flow through the natural channel of the East Fork. During times of high demand for irrigation water, the natural channel of the East Fork is nearly absent of water flow. Samples were taken from the area of stream above the diversion channels.

The width of the channel at this location is approximately 20 feet, and the depth averages 8 inches. The gradient is low (1%). The substrate is predominately coarse gravel, which is distributed evenly across the channel. The water velocity is approximately 2 f.p.s.. In areas of slack water there are abundant amounts of algae (Spirogyra spp.) present.

Dense growths of red dogwood and willows occur along the stream banks. Timbered slopes arise on both sides of the stream valley, which is several hundred yards wide at this location.

A few summer cabins are located along this section of stream. The area is also used for livestock grazing.

Site Thirteen

Site 13 is located on the Middle Fork of Rock Creek, near Sec. 13, T. 5N., R. 16W., upstream from the U.S. Forest Service gage located at

the county bridge crossing. This site is approximately 4 miles from site 10.

The stream width along this section of the Middle Fork is approximately 30 feet, and is fairly consistant. The stream depth is an average of 10 inches. The substrate is coarse to fine rubble, distributed evenly across the stream bed. The average velocity of the water is 3.3 feet per second (Haugen, 1973).

A small debris bar is located downstream from the bridge. It is caused by the support pillars of the bridge. The pillars interrupt the flow of water, creating an area of slack water below the bridge. This allows the deposition of debris carried by the water.

The stream flows through a valley bordered by low, rolling hills. The hills are covered by grassland, with areas of sagebrush and juniper trees. The stream channel follows a predominately straight course through this location. Small deciduous trees occur along the banks of the stream. The land bordering this section of stream is privately owned, and is used predominately for livestock grazing.

Site Fourteen

Site 14 is located one mile up Grizzly Creek from the U.S. Forest Service road crossing, near it's junction with Ranch Creek. This site is in Sec. 31. T. 10N., R. 16W..

Grizzly Creek flows through a small wooded canyon, with steep timbered slopes. The canyon is narrow and is only a few hundred yards across at the bottom. Growths of Ponderosa pine dominate the more open areas of the canyon floor. Small deciduous trees dominte the streamside vegetation. The growth is thick and solar radiation

reaching the stream is limited.

The substrate of the stream is predominately fine to coarse gravel with occasional areas of coarse sized rubble present.

The stream has an average width of 9 feet, and an average depth of 3.3 inches. The average gradient is 2.2%. The water velocity is approximately 1.7 f.p.s. (Haugen, 1971).

Access to this stream is limited. A U.S. Forest Service campground is located nears it's mouth, and a dirt road exists for about a mile upstream. All access beyond the end of the road is by trail only. The stream originates in a mountainous basin about 4 miles upstream from this point.

Site Two-A

Site 2A is located on Welcome Creek near it's confluence with Rock Creek (Sec. 2, T. 10N., R. 17W.). A small log footbridge exists to allow foot travel across Welcome Creek at this site. It is used to gain access to U.S. Forest Service Trail #225, which is the only access to the Welcome Creek drainage.

The average width of Welcome Creek at site 2A is 14 feet, and the average depth is 6.4 inches. The stream exhibits a rapid water velocity (2.8 f.p.s.), and has a gradient of 5% (Haugen, 1971). Numerous small waterfalls occur where organic debris such as fallen trees block the stream. Boulder-size blocks of rubble interrupt the stream flow in some sections, creating areas of turbulence as the swiftly flowing water is forced to flow over and around the obstacles.

The substrate of Welcome Creek at site 2A is predominately fine to coarse-sized rubble. As previously mentioned, some areas of

boulder-sized rocks are also present along the channel. Deposits of sand and fine organic debris are found along the stream sides in areas of slack water or less turbulent flow.

Numerous species of small deciduous trees and shrubs dominate the vegetation of the stream bank. Douglas fir and a few large cottonwood trees occur on either side of the stream. The cottonwood trees, however, are limited to the extreme lower sections of the stream near it's confluence with Rock Creek.

Welcome Creek flows out of a narrow, mountainous canyon with steep timbered slopes, and is typical of the small, fast tributaries of mountainous regions of the West.

Site Six-A

Site 6A is located on lower Willow Creek, near it's confluence with Rock Creek (Sec. 19, T. 7N., R. 15W.). This site is downstream approximately 15 miles from site 6.

Willow Creek flows through the center of a broad valley at site 6A. Hills rise on both sides of the valley. Their slopes predominately exhibit grass and sagebrush cover with occasional juniper trees. The higher portions of these hills are timbered with species of pine. The valley floor is used extensively for livestock grazing and for the production of grass hay. Numerous ranches are located along the valley. Their land is irrigated with water from Willow Creek.

The Willow Creek channel follows a meandering coarse through the lower Willow Creek valley, generally occupying areas near the center of the valley. A dense border growth of willows and red dogwood define the winding stream channel. Beyond the stream channel on either side is

grassland used for livestock grazing. Much of the low land bordering the stream is marshy in the spring. This is because of the frequent bank overflows occuring during periods of peak discharge. Channel blockage by ice frequently occurs in the spring.

The substrate at site 6A is predominately fine rubble. with occasional areas of coarse rubble. Areas with a heavy accumulation of fine organic debris and mud occur where the stream exhibits a slowed velocity and increased depth. The velocity of lower Willow Creek is less than that of the other small tributaries, and the gradient is near 1%. Width of the stream averages 15 feet. Depth is highly variable along the section of stream near site 6A, ranging from near 4 feet in the slower, deeper areas, to 4 inches in the fast flowing areas.

CHAPTER IV

METHODS AND MATERIALS

Physical Data

The physical measurements of each sample site, and stream in this study were provided by courtesy of the Lolo National Forest. Permanent water quality monitoring stations are operated and maintained at each of the sample sites by the Lolo National Forest.

The temperature of the water at each sample site was taken during the monthly sampling trips to each site. Previous water temperature data that was taken by the Lolo National Forest for past years is included in the discussion of the physical characteristics of each stream.

The velocities measured by the Lolo National Forest represent approximate values, and are not to be interpreted as precise measurements.

Chemical Data

No attempt was made to correlate the aquatic insect distributions with the chemical characteristics of each sample site.

Sampling Procedures

All qualitative sampling was done using a Turtox fine mesh invertebrate sampling kick screen. A minimum of three samples were taken from each site during the sampling procedure each month. The area of substrate sampled in each kick screen sample was approximately one-half meter. Niche sampling was onducted on an eyeball basis in an attempt to sample as varied a substrate area as possible.

Each screen was sorted in the field. Only one or two of the commonest species were collected. Unidentified species were collected in as great a number as was possible. Specimens were preserved in containers of 70% ethyl alcohol, and transported back to the lab for identification.

Sample Trips

The sample program provided for each of fifteen sample sites to be collected once a month, for a twelve month period. The period was from July, 1972 to June, 1973. Because of the seasonal condition of many of the roads in the area, and heavy snowfall during the winter months, many of the more remote sample sites were not sampled each month. The sample data for each site, and the days of each month that the sites were sampled are found in the Appendix of this paper.

Distributions

Distribution maps for each of the species of aquatic insect that was found to occur in the sample sites of the study area are presented.

Statistical Analysis

To best illustrate the relationships present between each of the sample sites in this study, a cluster analysis method was chosen. The cluster method considered is an agglomerative method, i.e. that in which each sub-group in an hierarchical classification is built up from the union of two smaller groups.

A similarity coefficient was chosen to best illustrate the

relationships between the sample sites using the presence-absence data for the aquatic insects that were found to occur.

The similarity index is given by:

$$S = \frac{2C}{A + B} = 1.0 \text{ maximum similarity}$$

where A = number of species that occur in site A
B = number of species that occur in site B
2C = 2 X number of species common to both site A and site B

On the basis of the similarity data, the cluster analysis was illustrated with the use of dendrograms. Two dendrograms were presented. One dendrogram used the average pair-group method of similarity for the construction, whereas the other dendrogram used the nearest-neighbor similarity method. These methods have been discussed in detail in the discussion of the dendrogram results.

CHAPTER V

DISTRIBUTION MAPS AND QUALITATIVE DATA

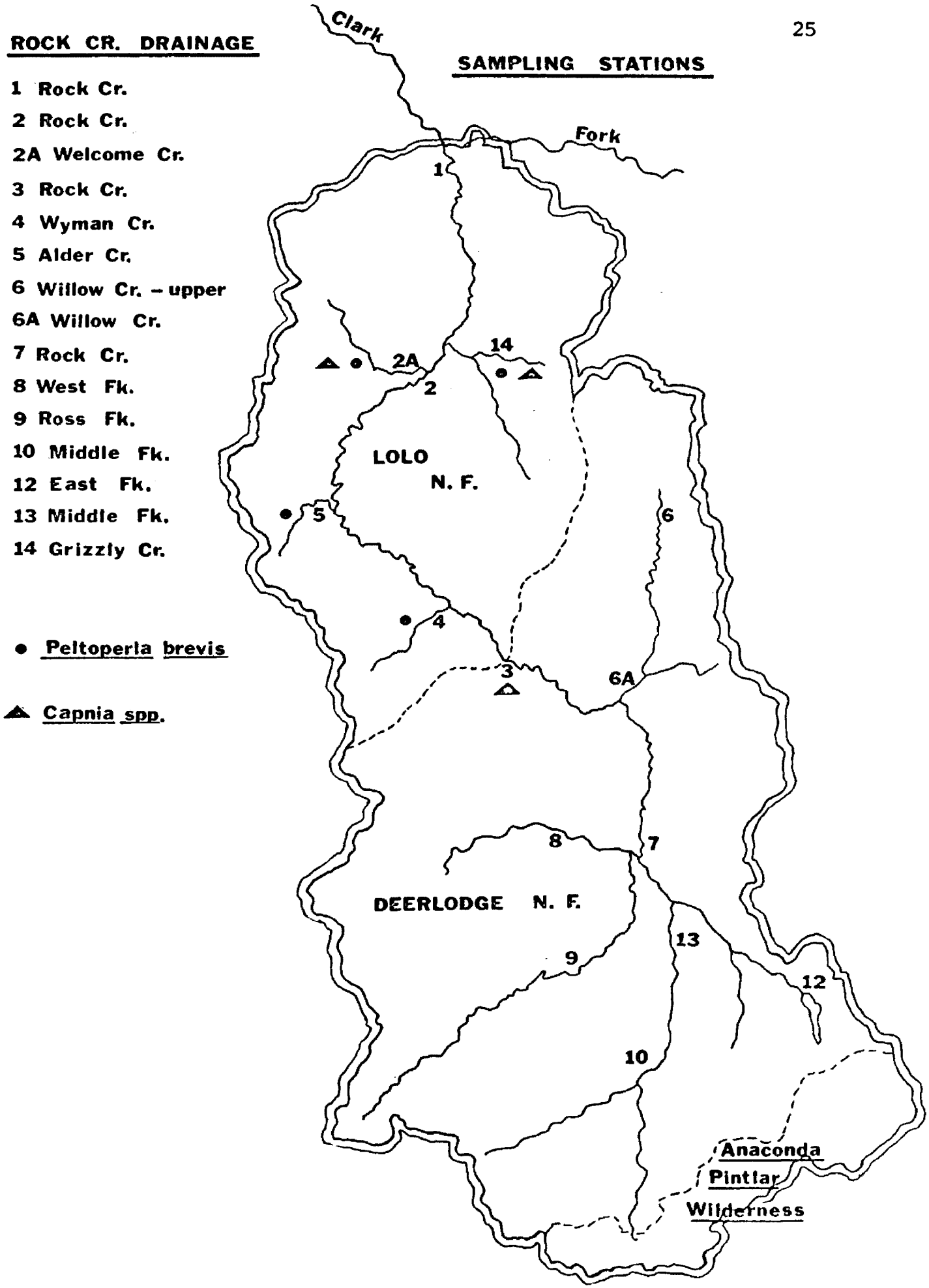
The distributions of the aquatic insects that were found to occur in the sample sites of the Rock Creek drainage are illustrated in the following pages. The maps represent the results of the qualitative data that were obtained. The qualitative data have been presented in Figure 3, and represent the presence or absence of each species in the sample sites of the study.

ROCK CR. DRAINAGE

1 Rock Cr.
2 Rock Cr.
2A Welcome Cr.
3 Rock Cr.
4 Wyman Cr.
5 Alder Cr.
6 Willow Cr. – upper
6A Willow Cr.
7 Rock Cr.
8 West Fk.
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Peltoperla brevis

▲ Capnia spp.



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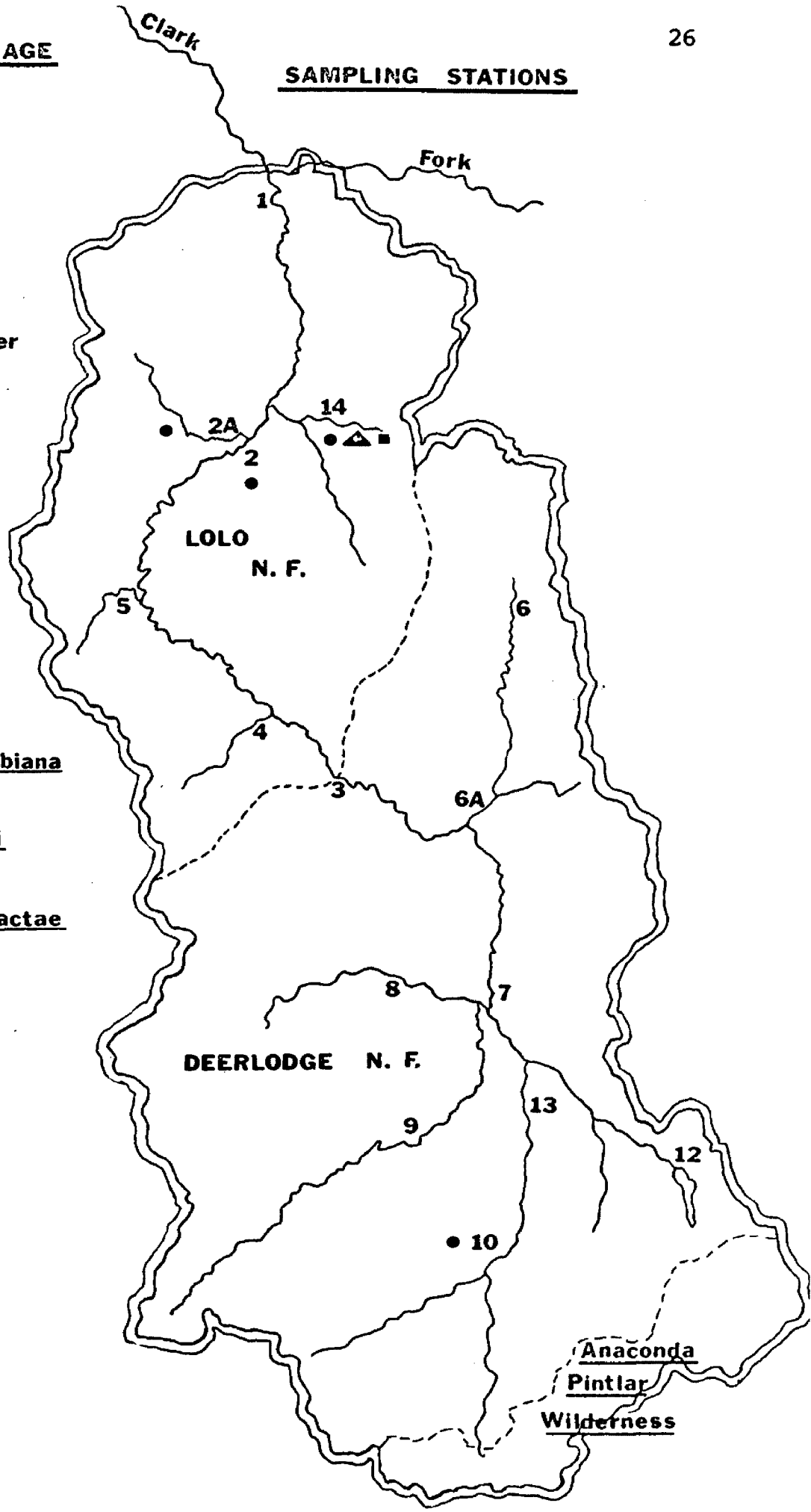
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Nemoura columbiana

■ N. haysii

▲ N. cataractae



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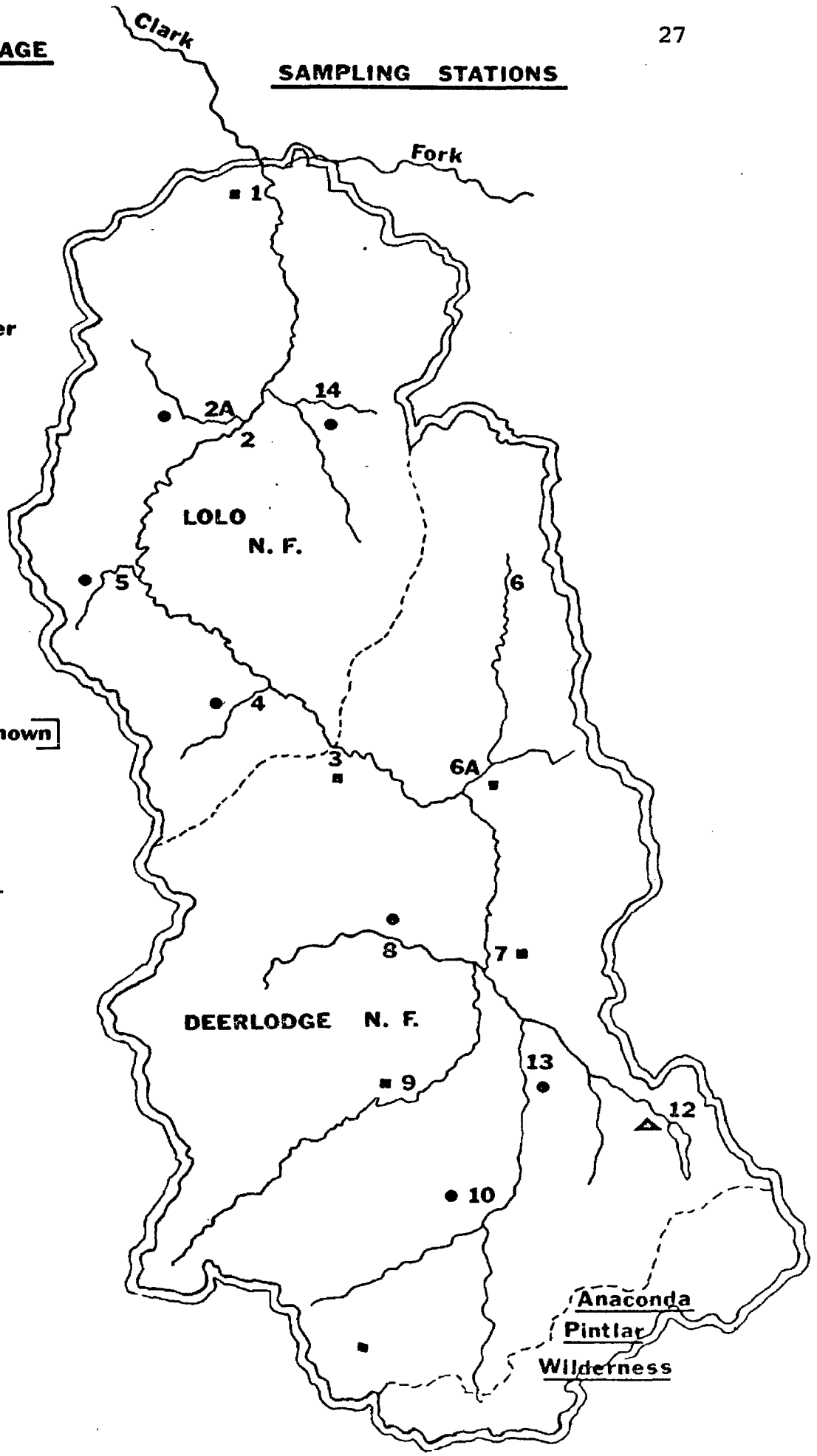
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

■ Nemoura sp. [unknown]

▲ N. flexura

● N. cinctipes



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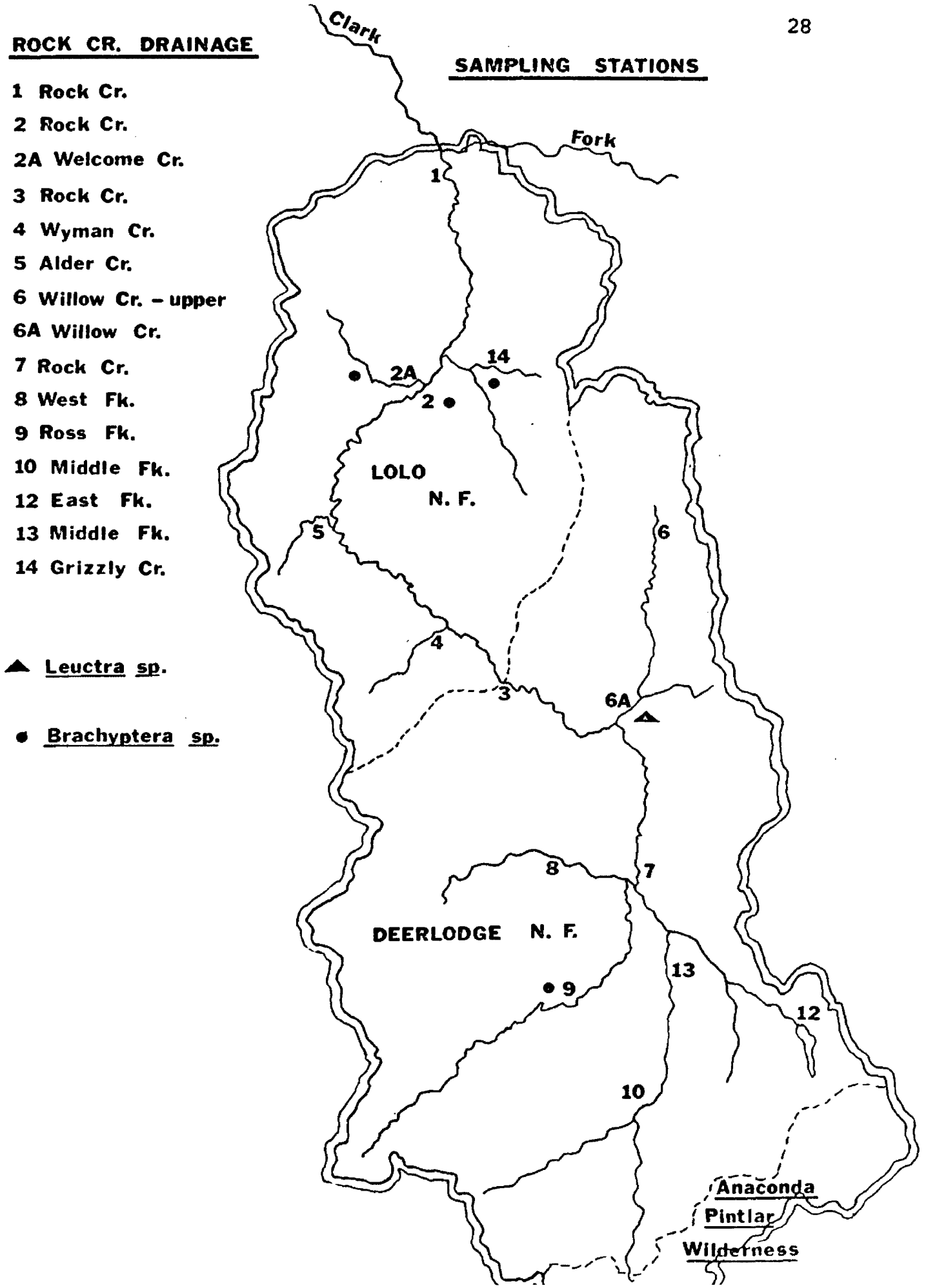
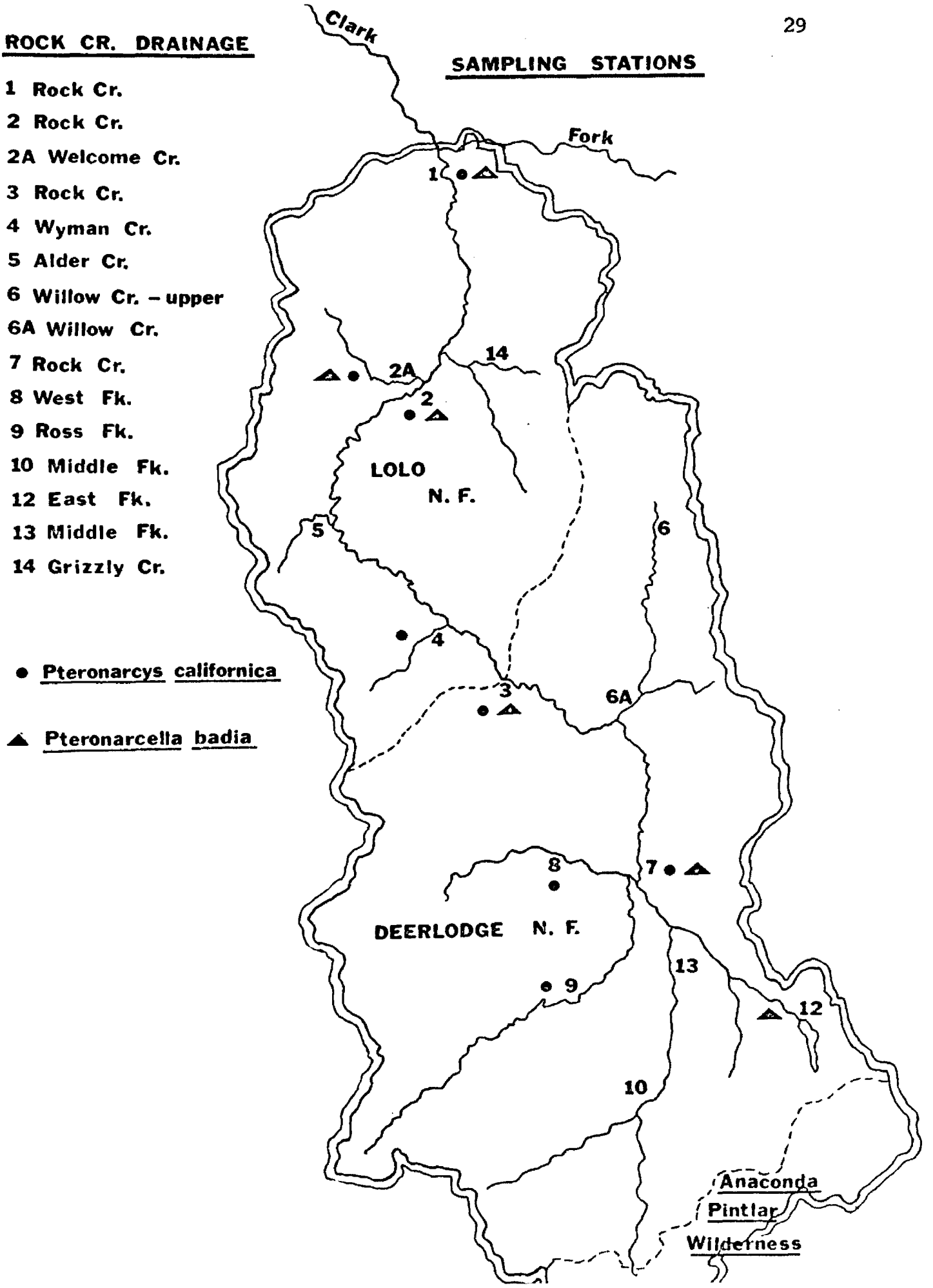
13 Middle Fk.
14 Grizzly Cr.

▲ Leuctra sp.

● Brachyptera sp.





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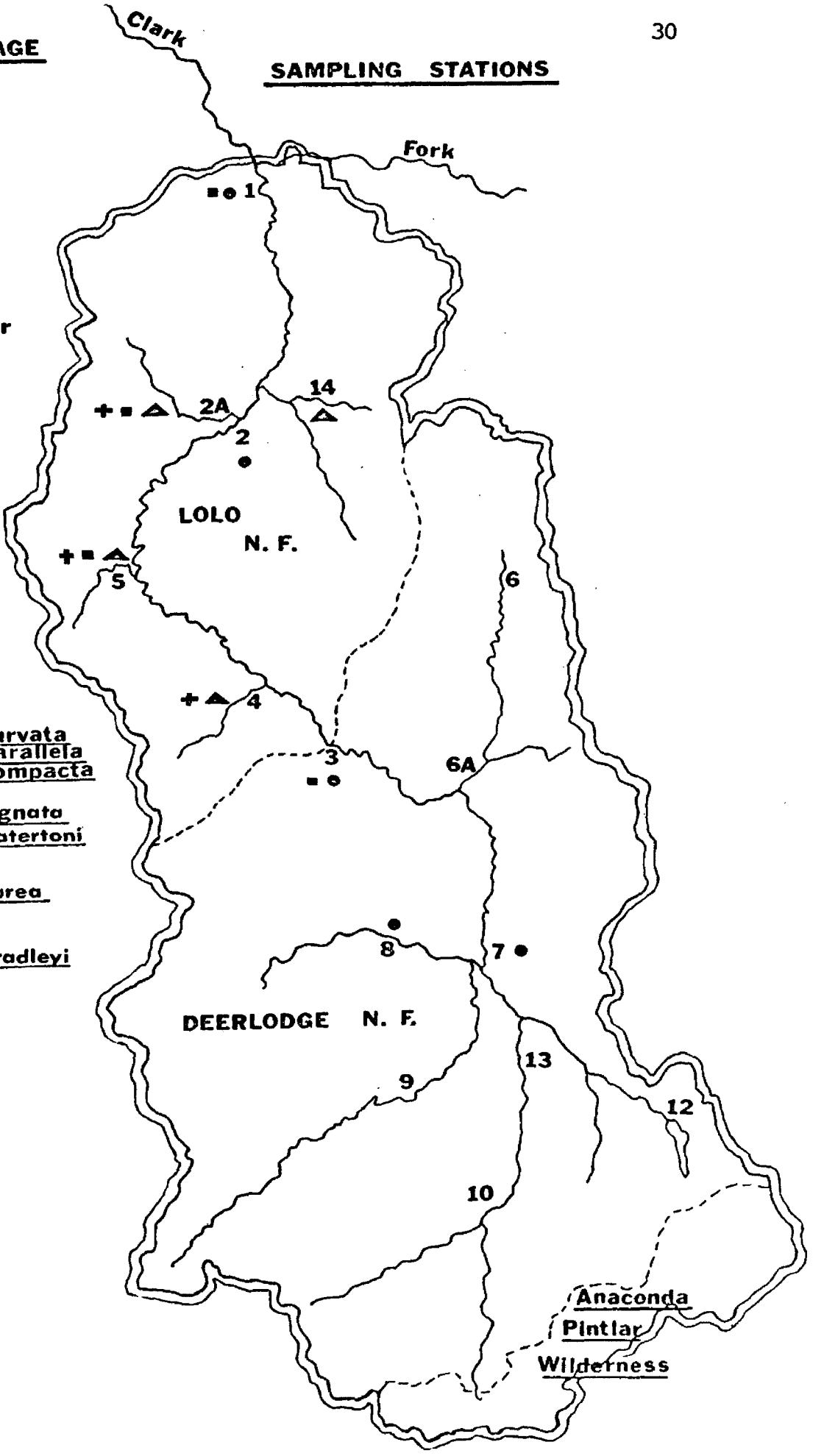
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Arcynopteryx curvata or parallela or compacta

▲ A. signata or watertoni

■ A. aurea

\+ A. bradleyi

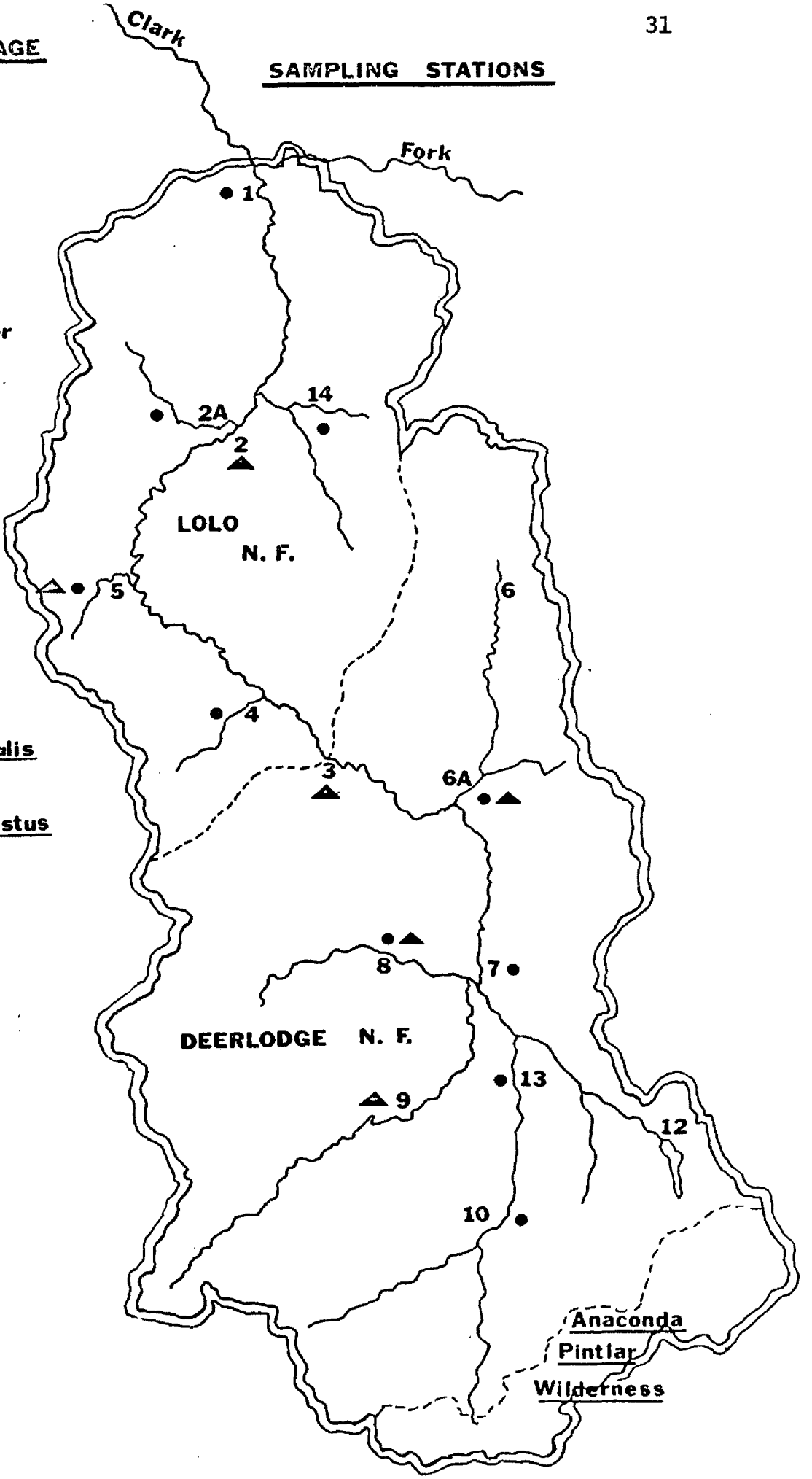


ROCK CR. DRAINAGE

1 Rock Cr.
2 Rock Cr.
2A Welcome Cr.
3 Rock Cr.
4 Wyman Cr.
5 Alder Cr.
6 Willow Cr. – upper
6A Willow Cr.
7 Rock Cr.
8 West Fk.
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

▲ Isogenus aestivalis

● I. modestus



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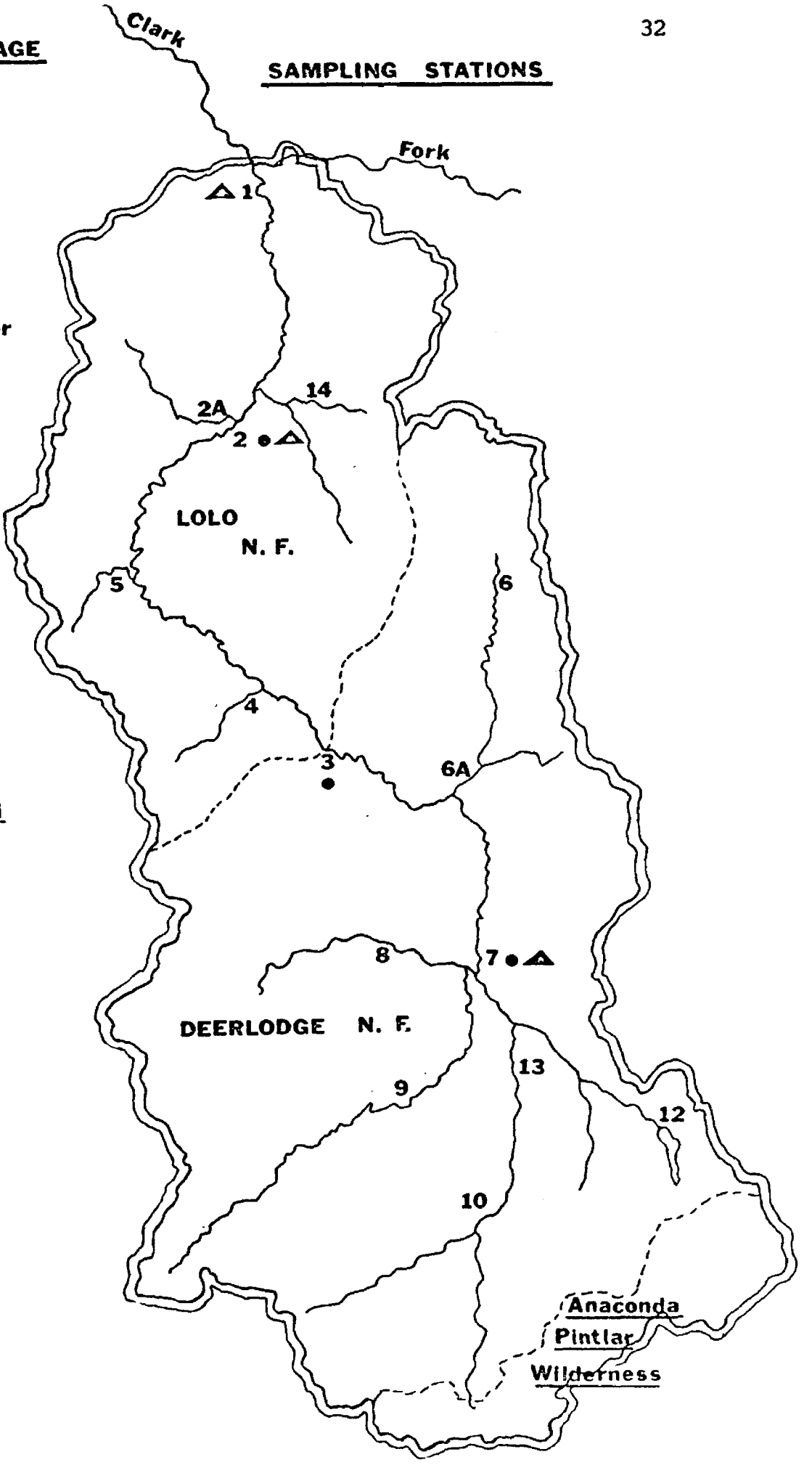
8 West Fk.
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Isoperla fulva

▲ Diura knowltoni



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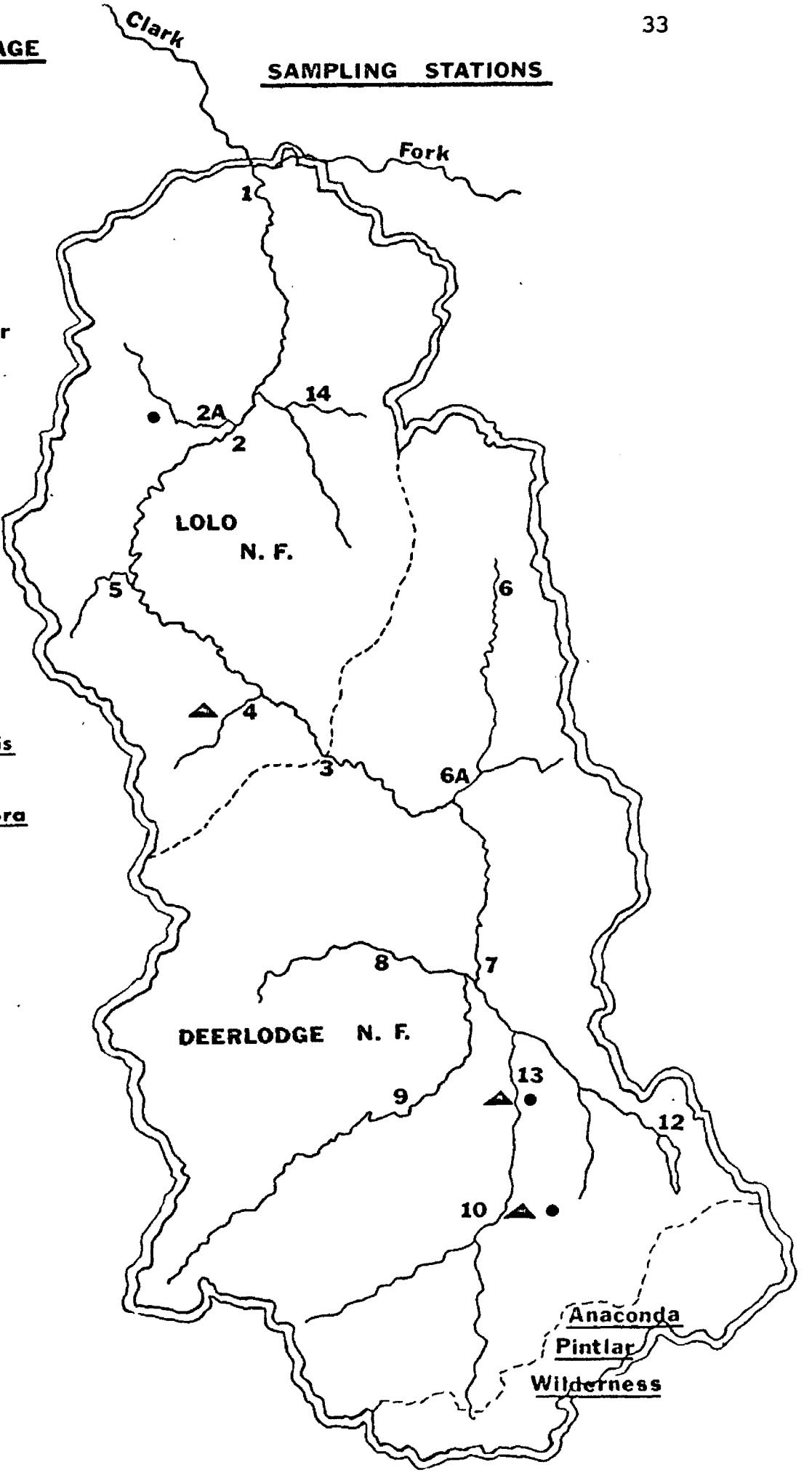
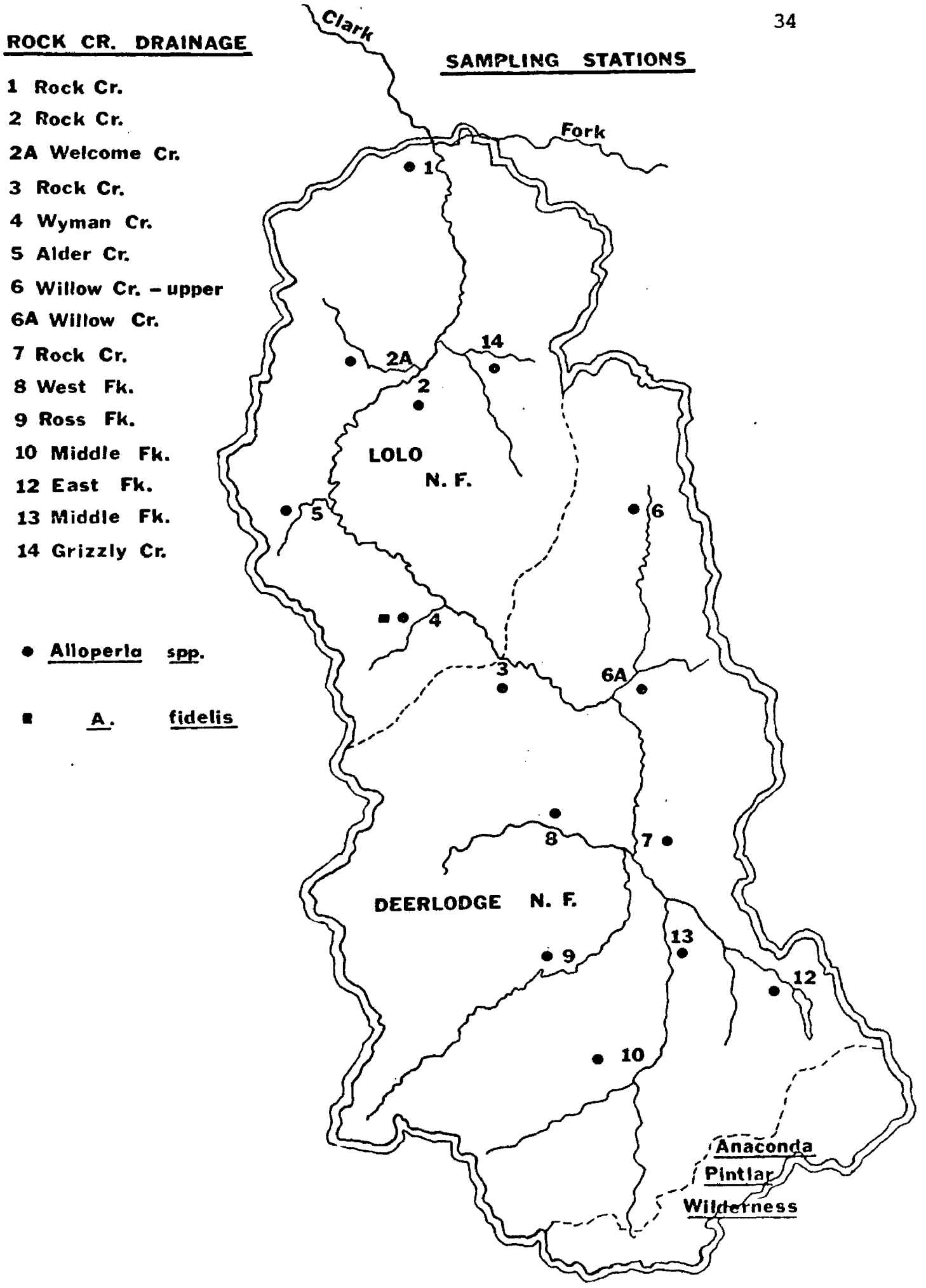
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Paraperla frontalis

▲ Utaperla sopladora





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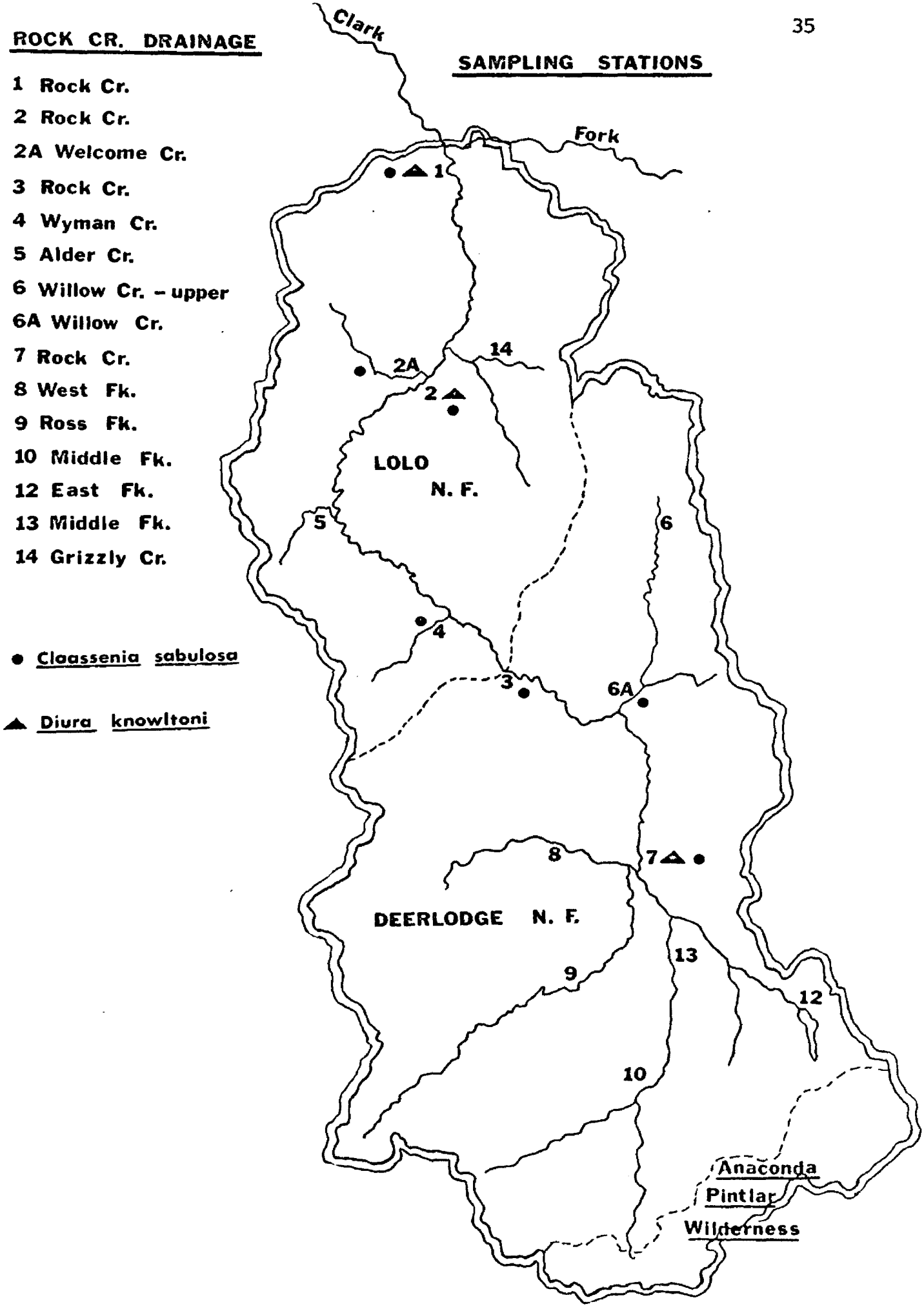
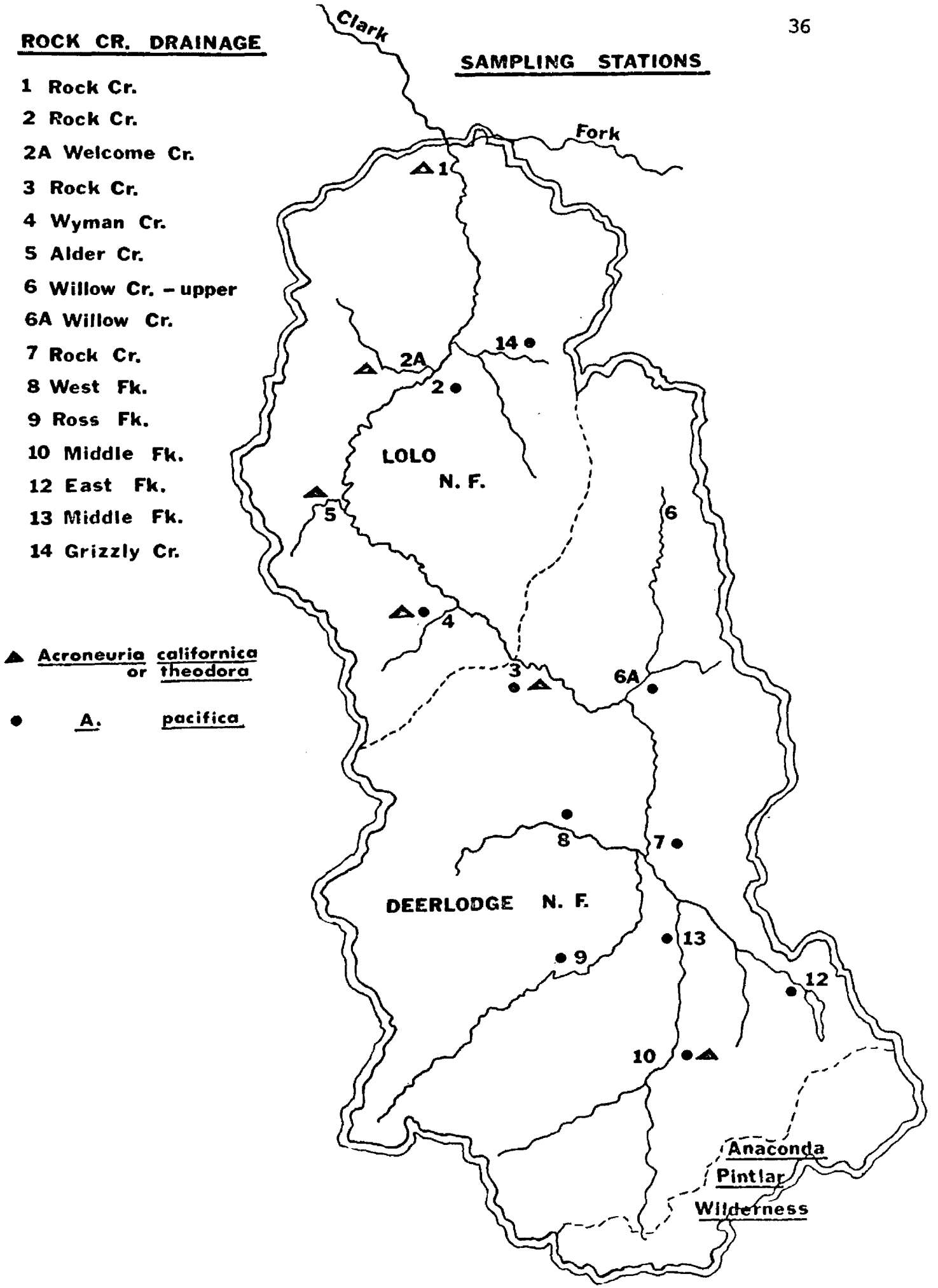
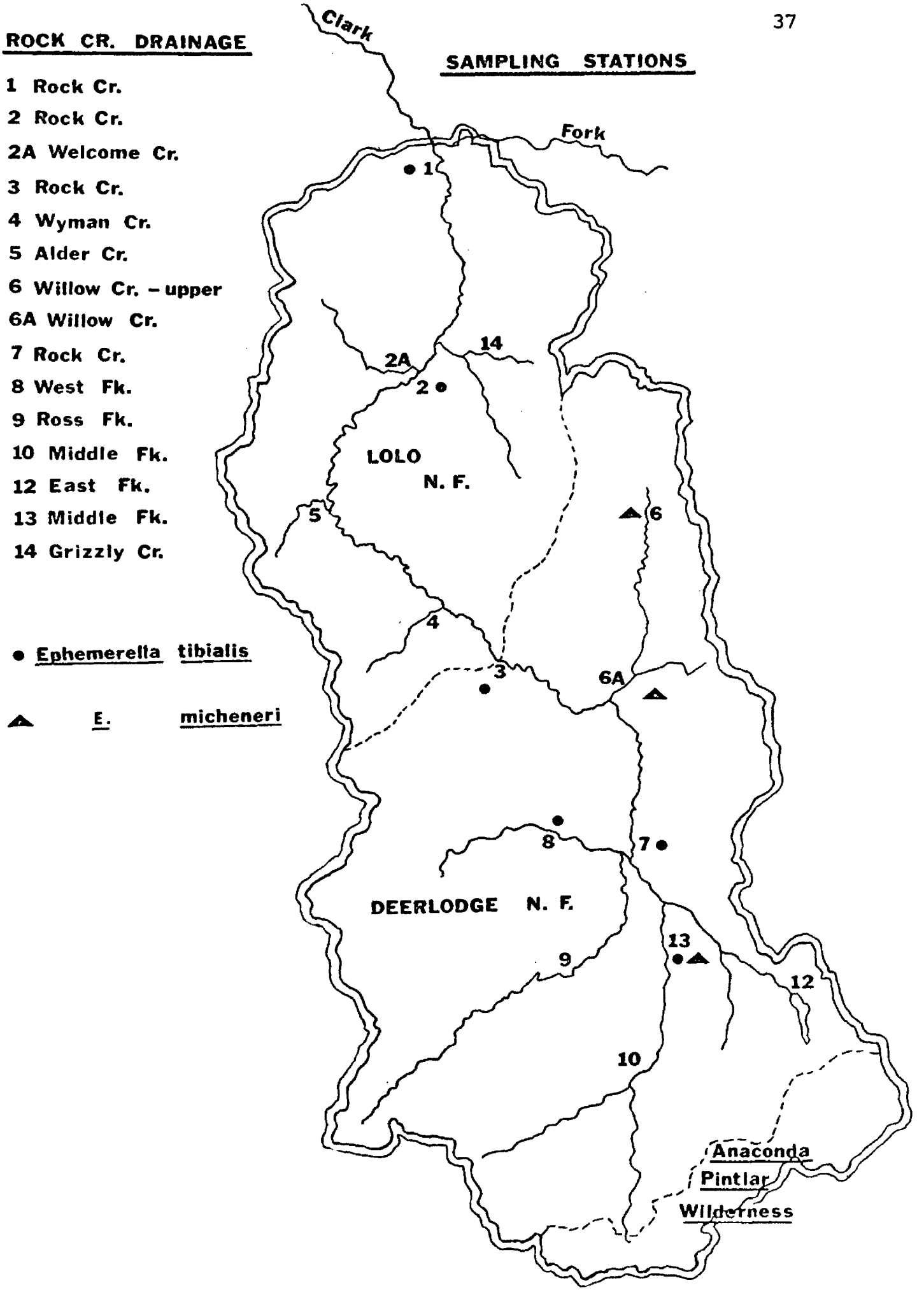
13 Middle Fk.
14 Grizzly Cr.

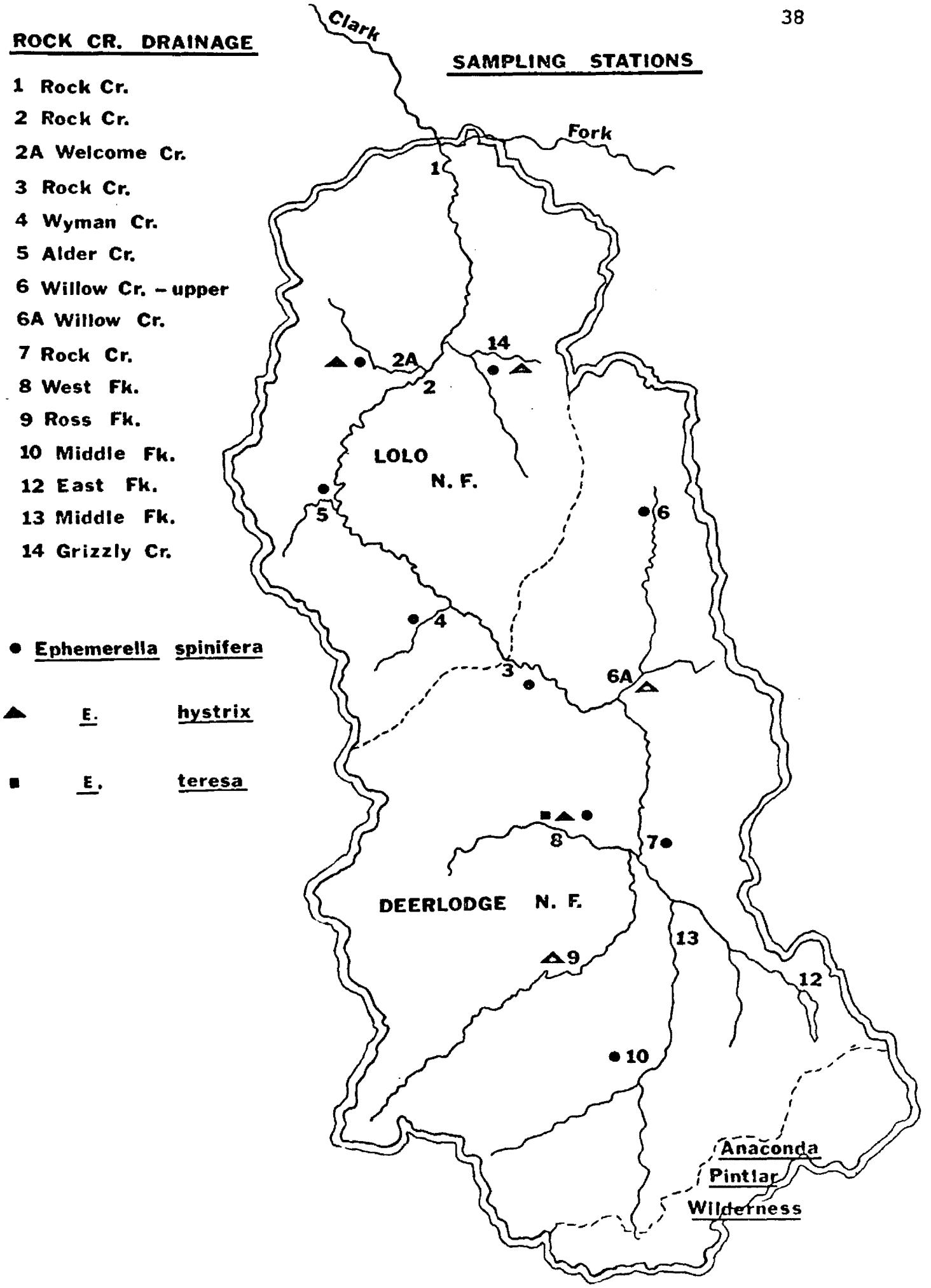
● Claassenia sabulosa

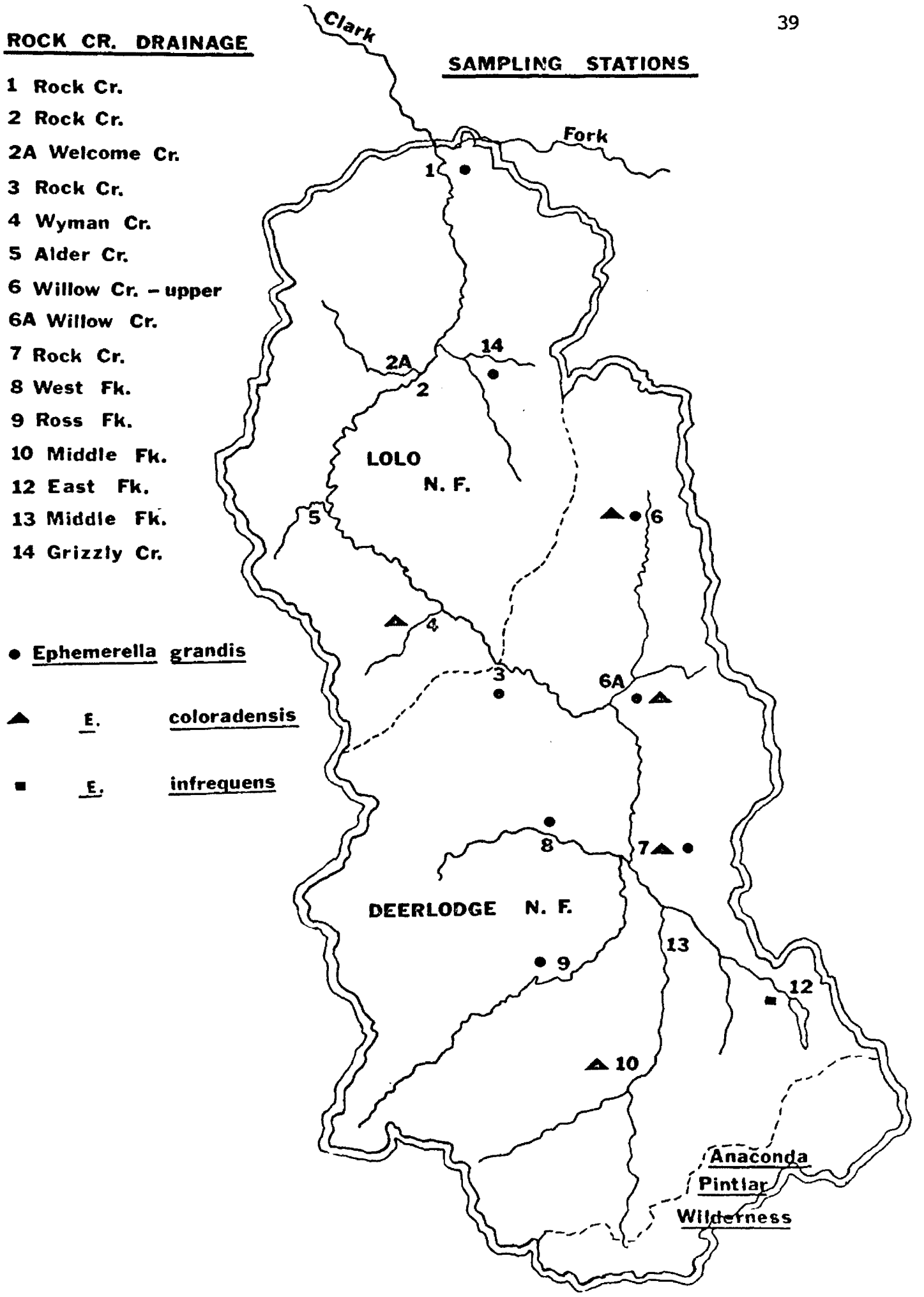
▲ Diura knowltoni

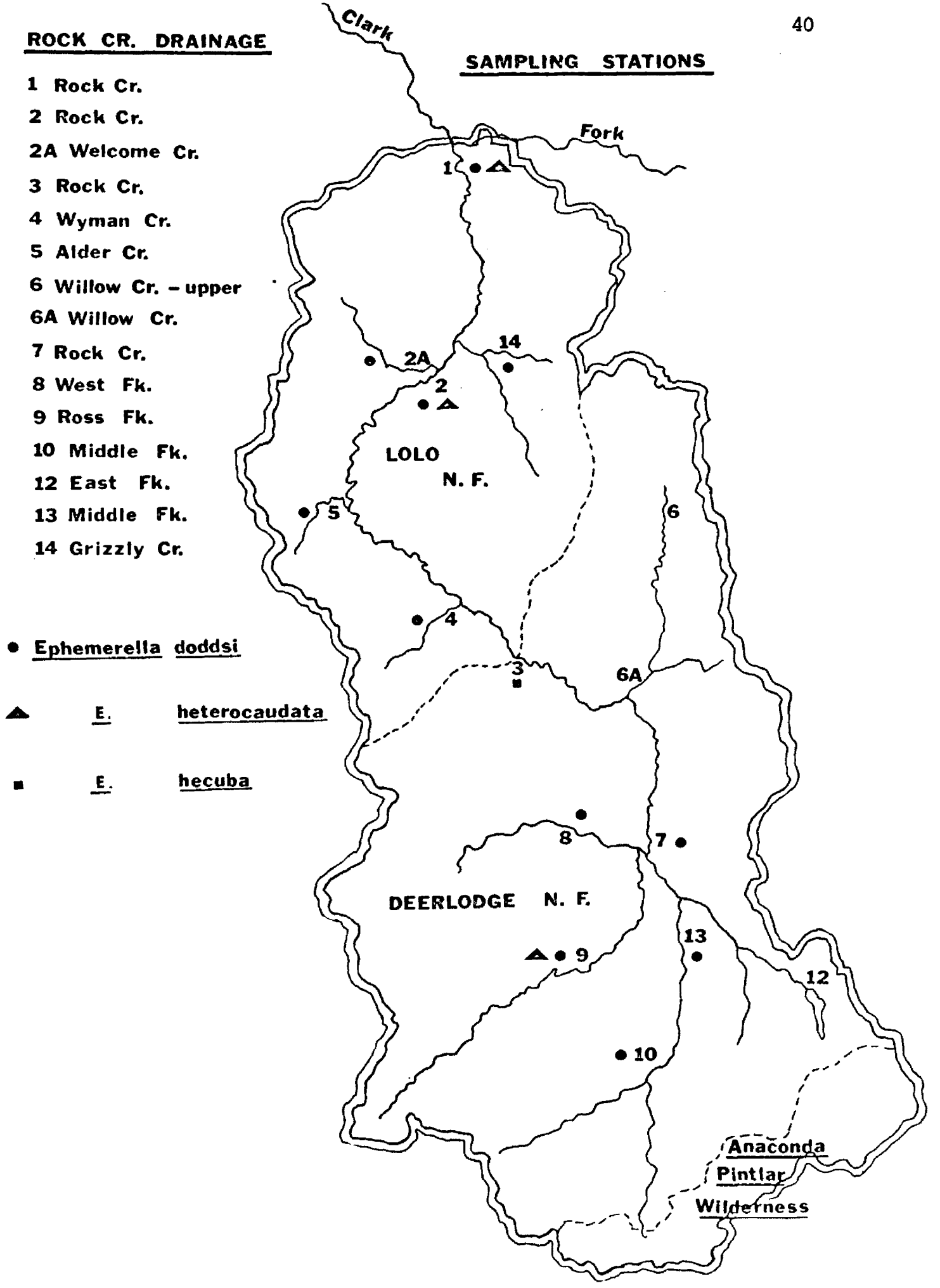


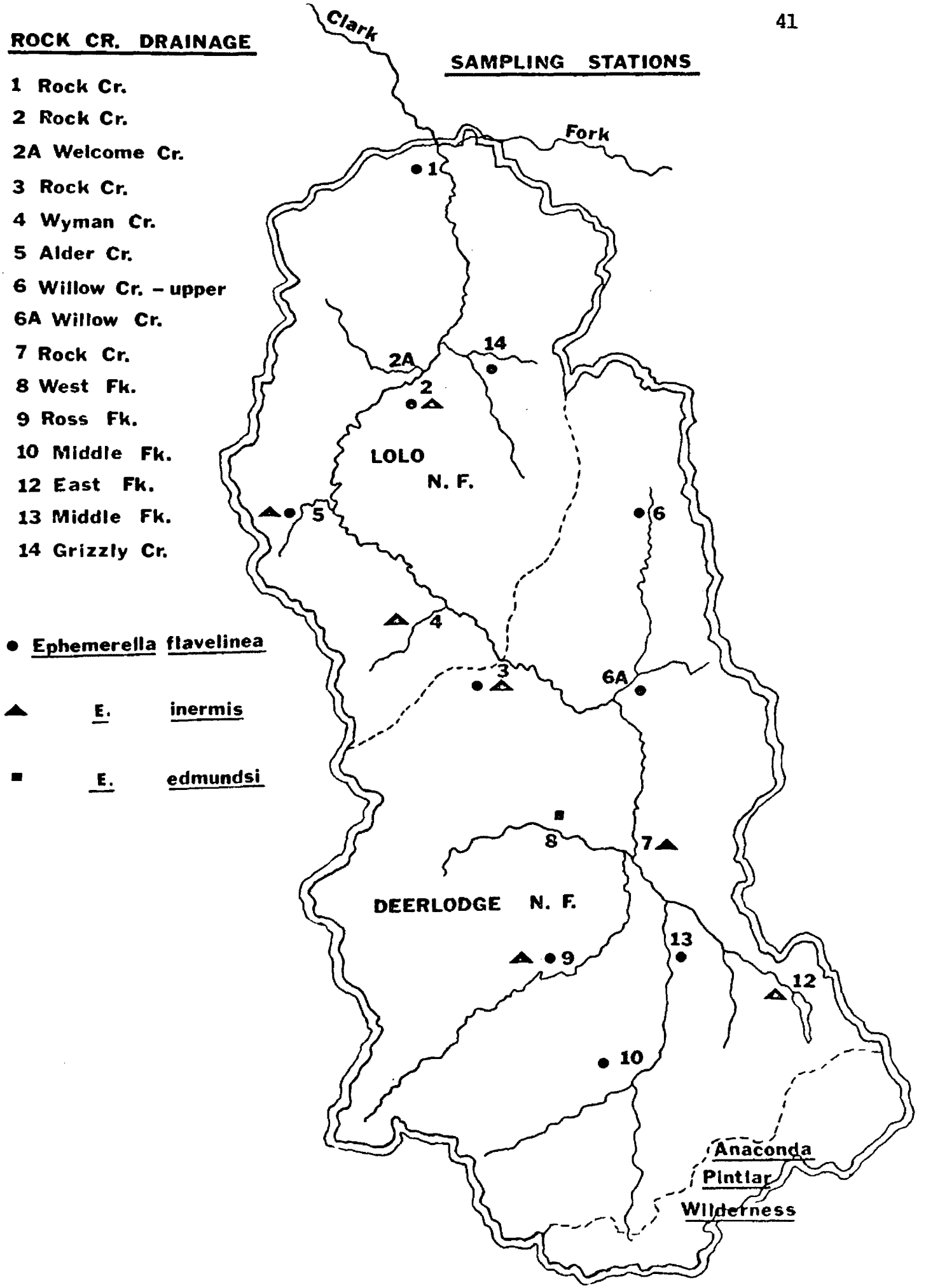












ROCK CR. DRAINAGE

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3 Rock Cr.
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5 Alder Cr.
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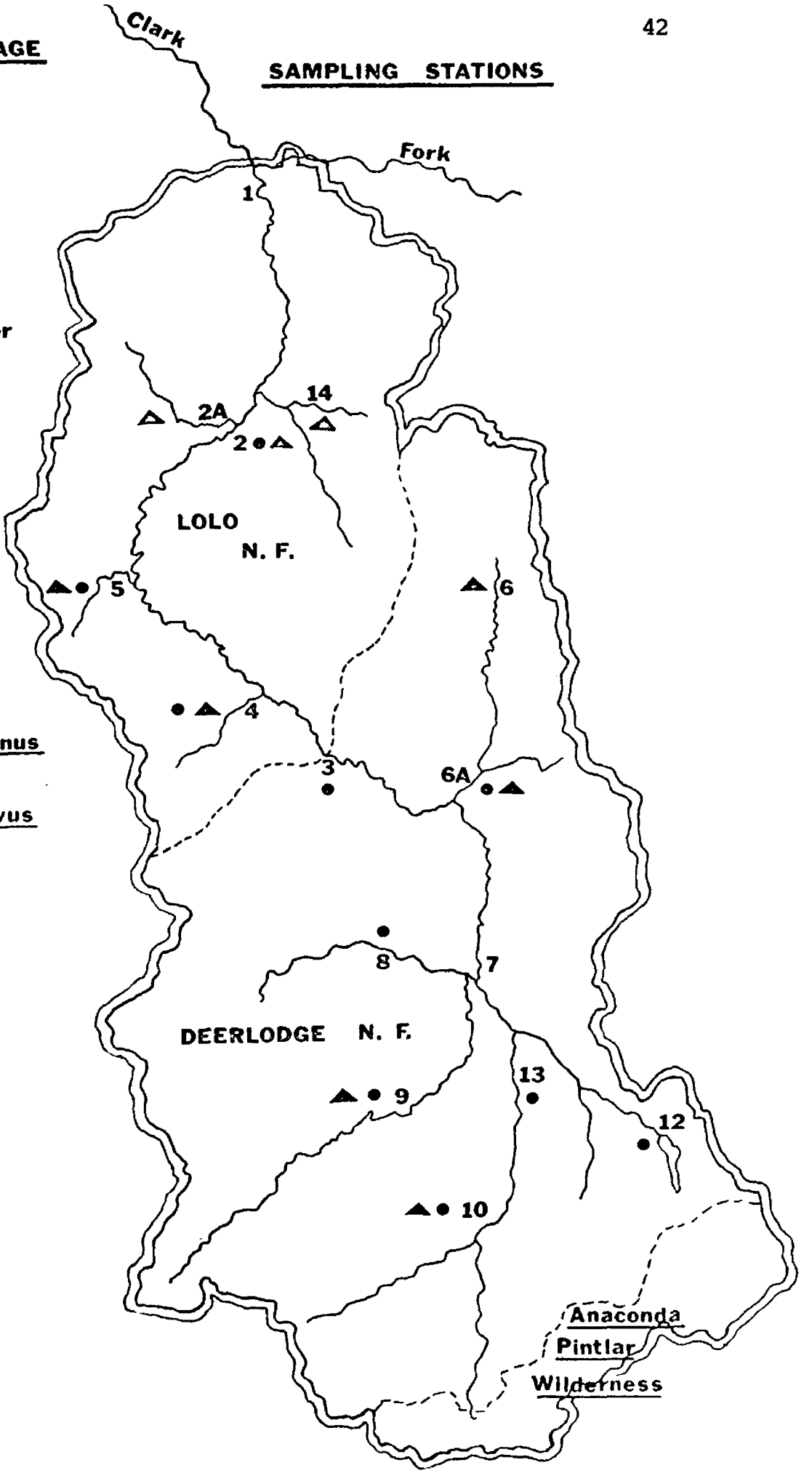
6A Willow Cr.
7 Rock Cr.
8 West Fk.
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Epeorus longimanus

▲ E. deceptivus



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13 Middle Fk.
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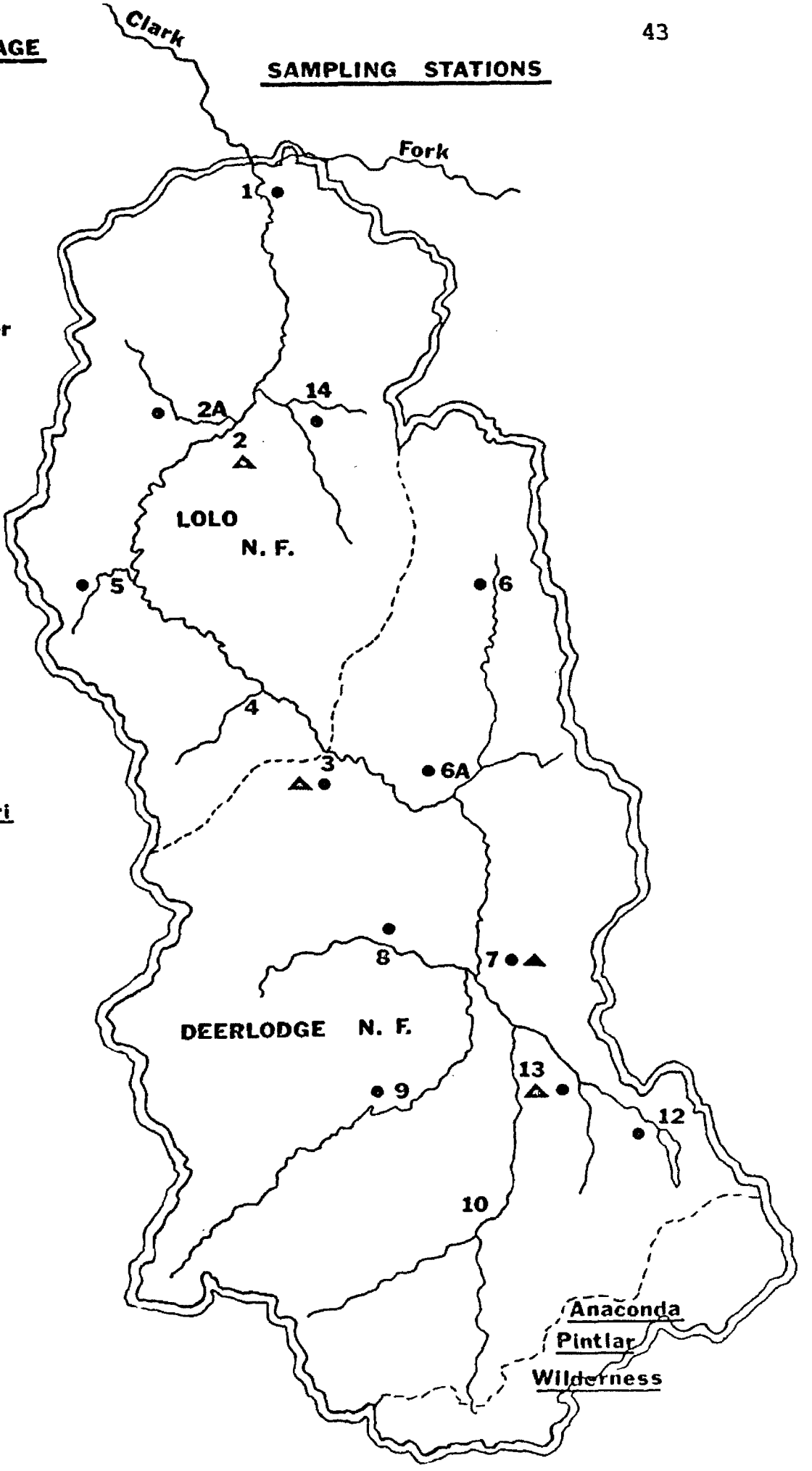
● Baetis parvus

▲ B. alexanderi



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12 East Fk.
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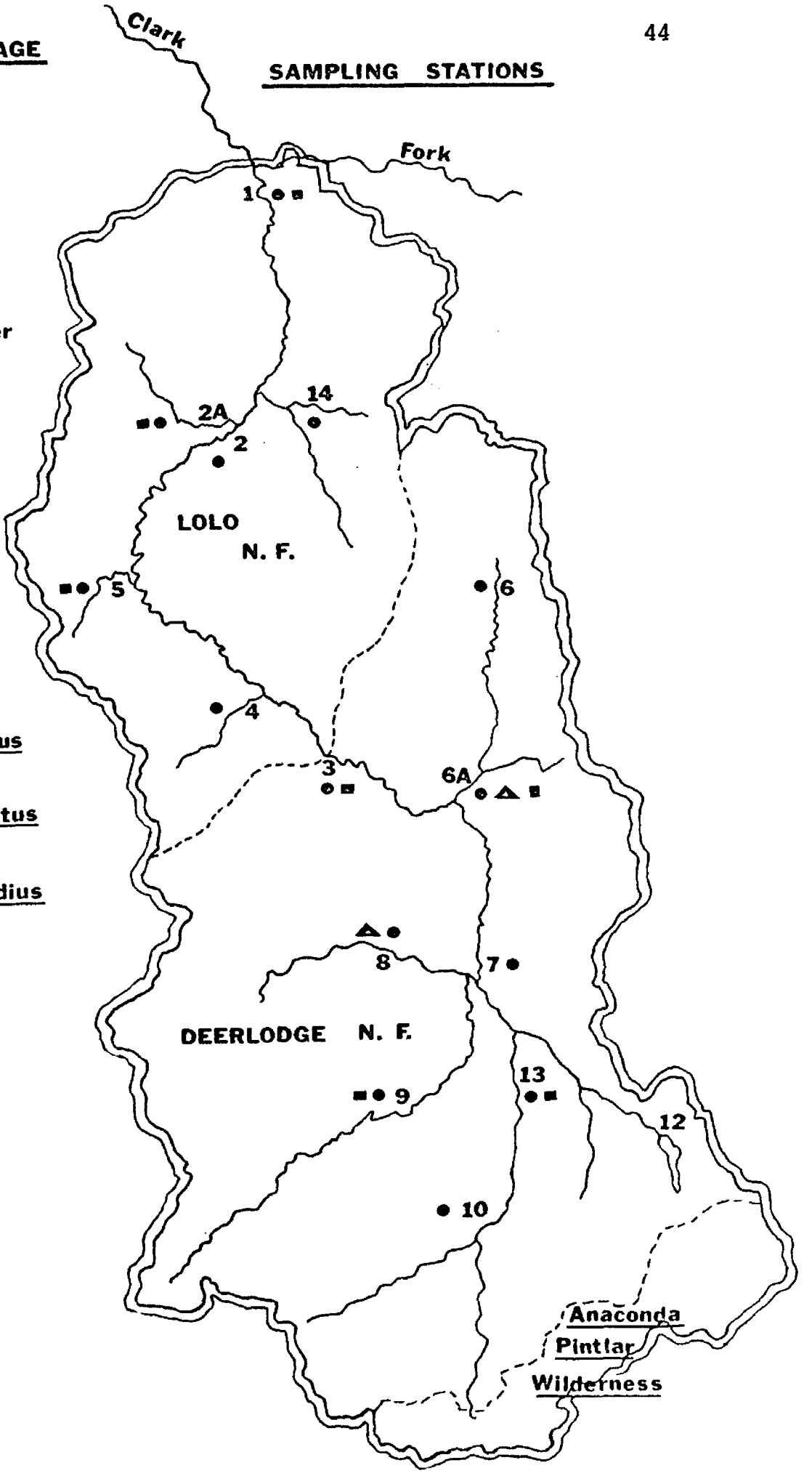
14 Grizzly Cr.

● Baetis bicaudatus

▲ B. tricaudatus

■ B. intermedius



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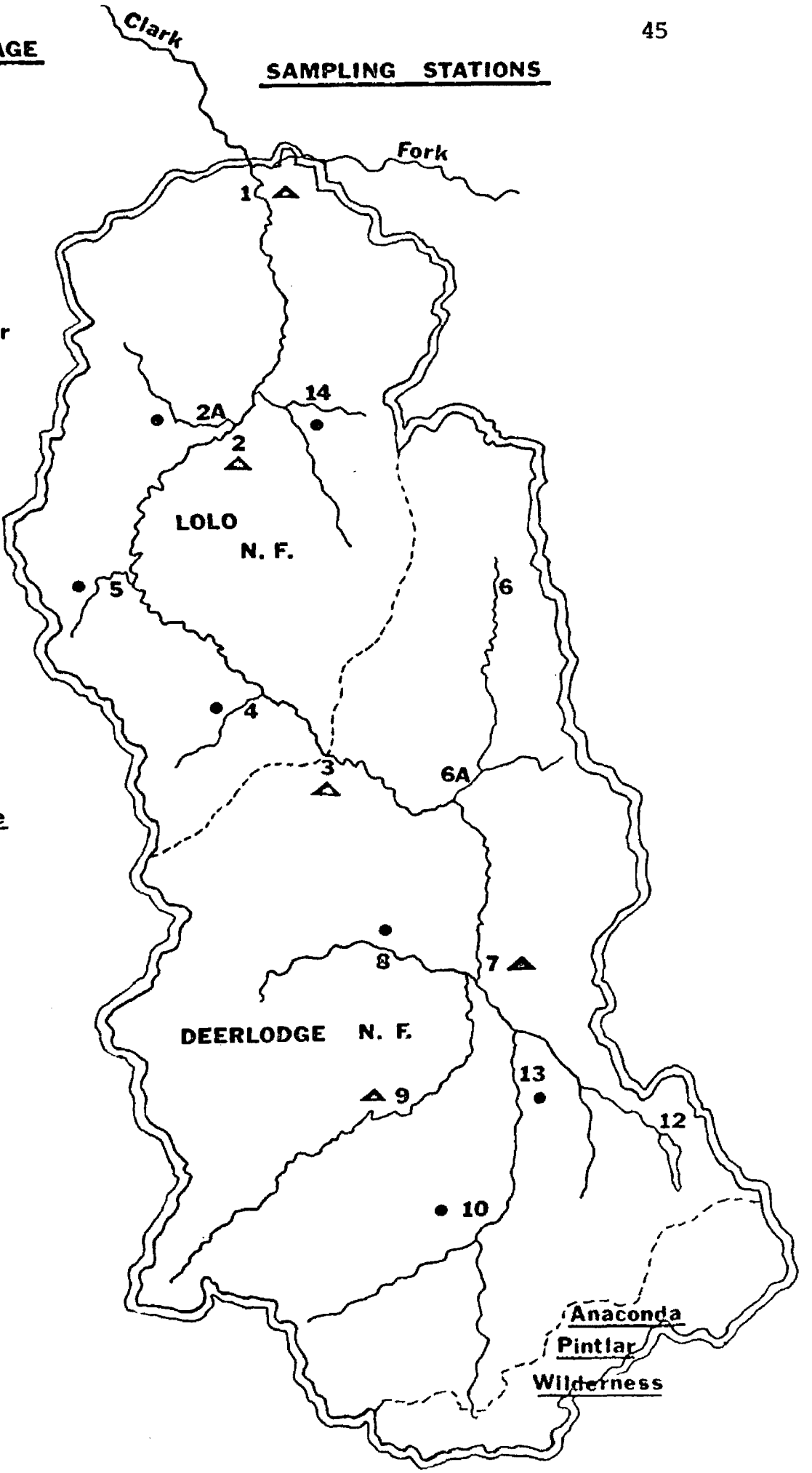
14 Grizzly Cr.

● Epeorus grandis

▲ E. albertae



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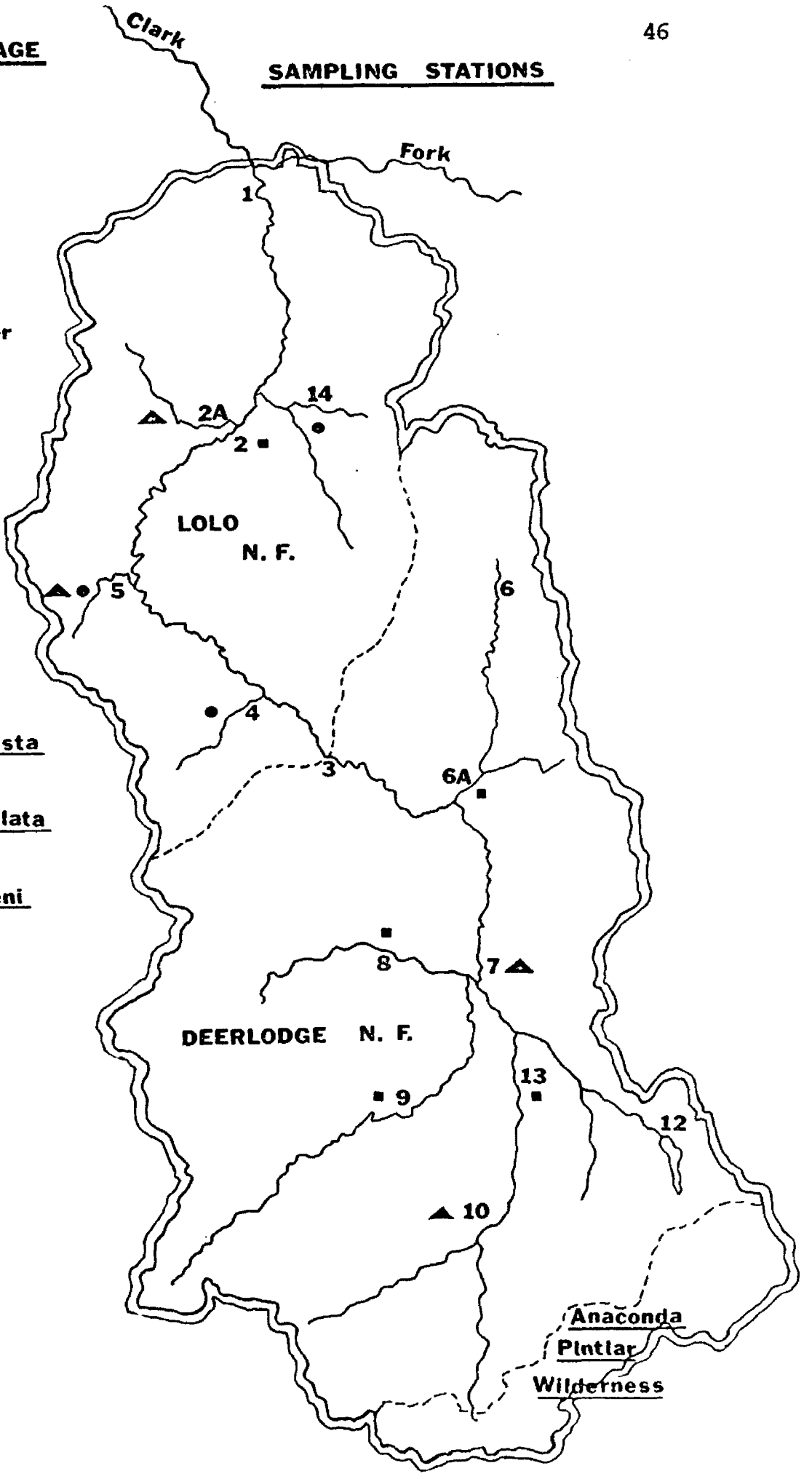
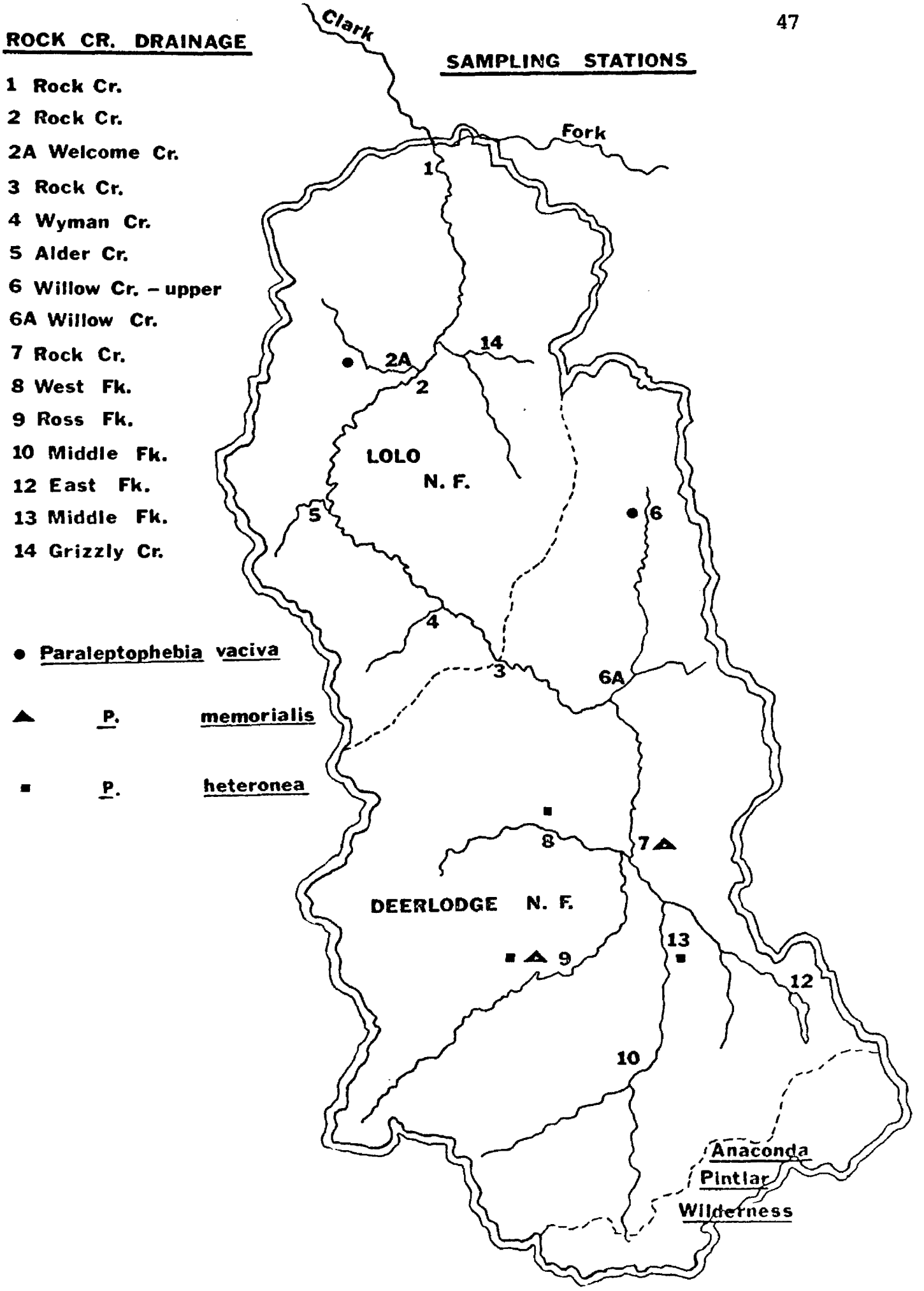
● Rithrogenia robusta

▲ R. undulata

■ R. hageni





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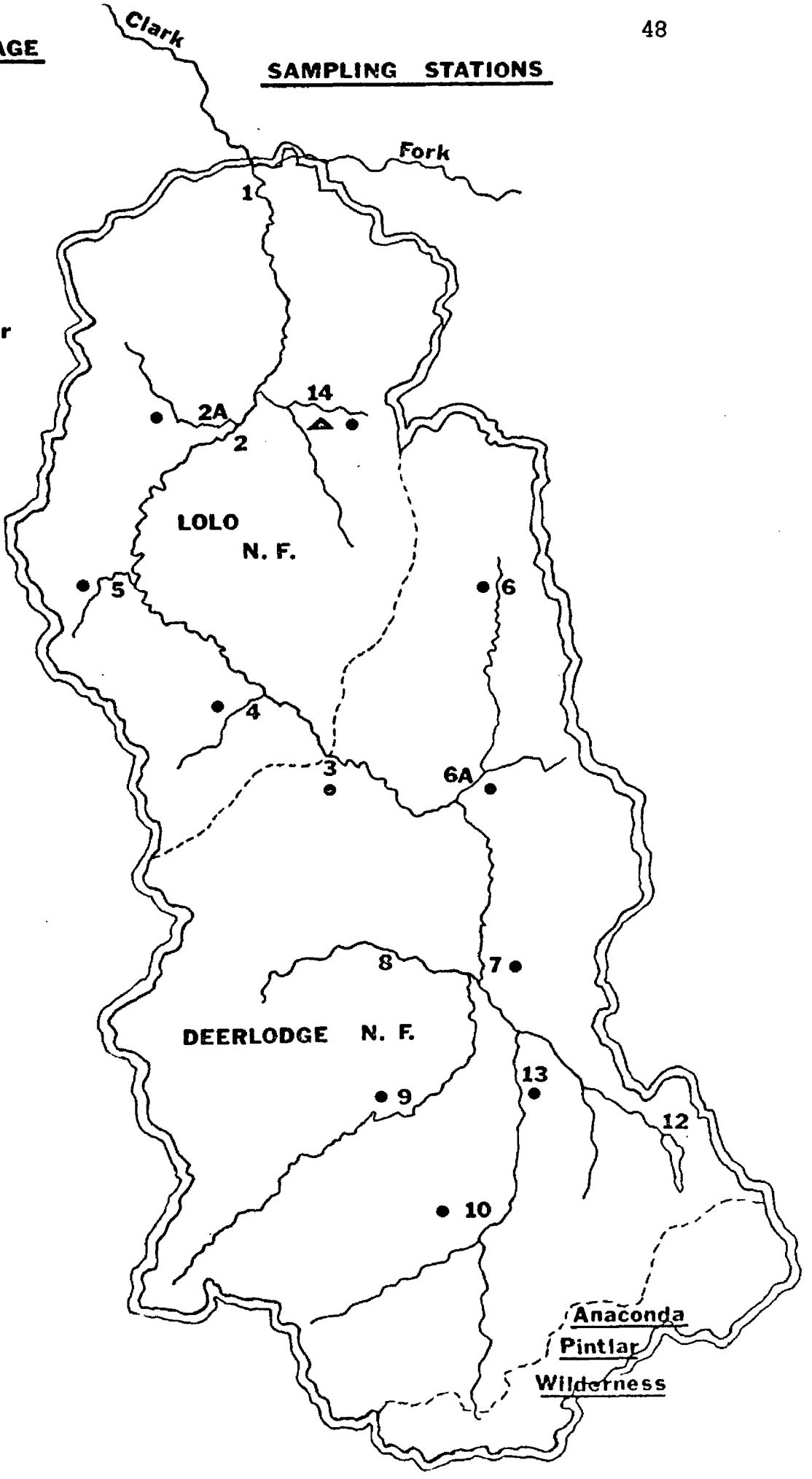
13 Middle Fk.
14 Grizzly Cr.

▲ Siphlonurus sp.

● Cinygmula spp.



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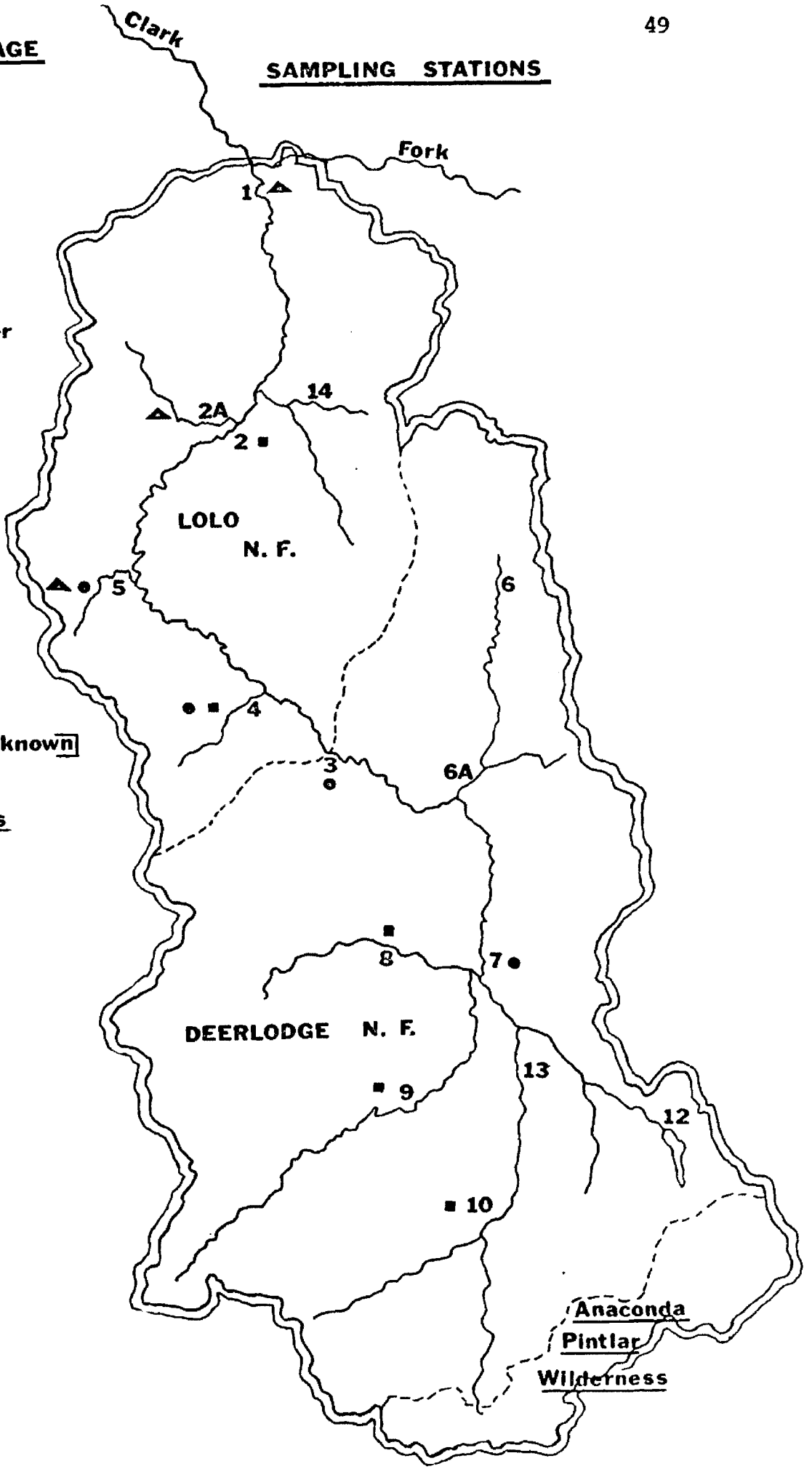
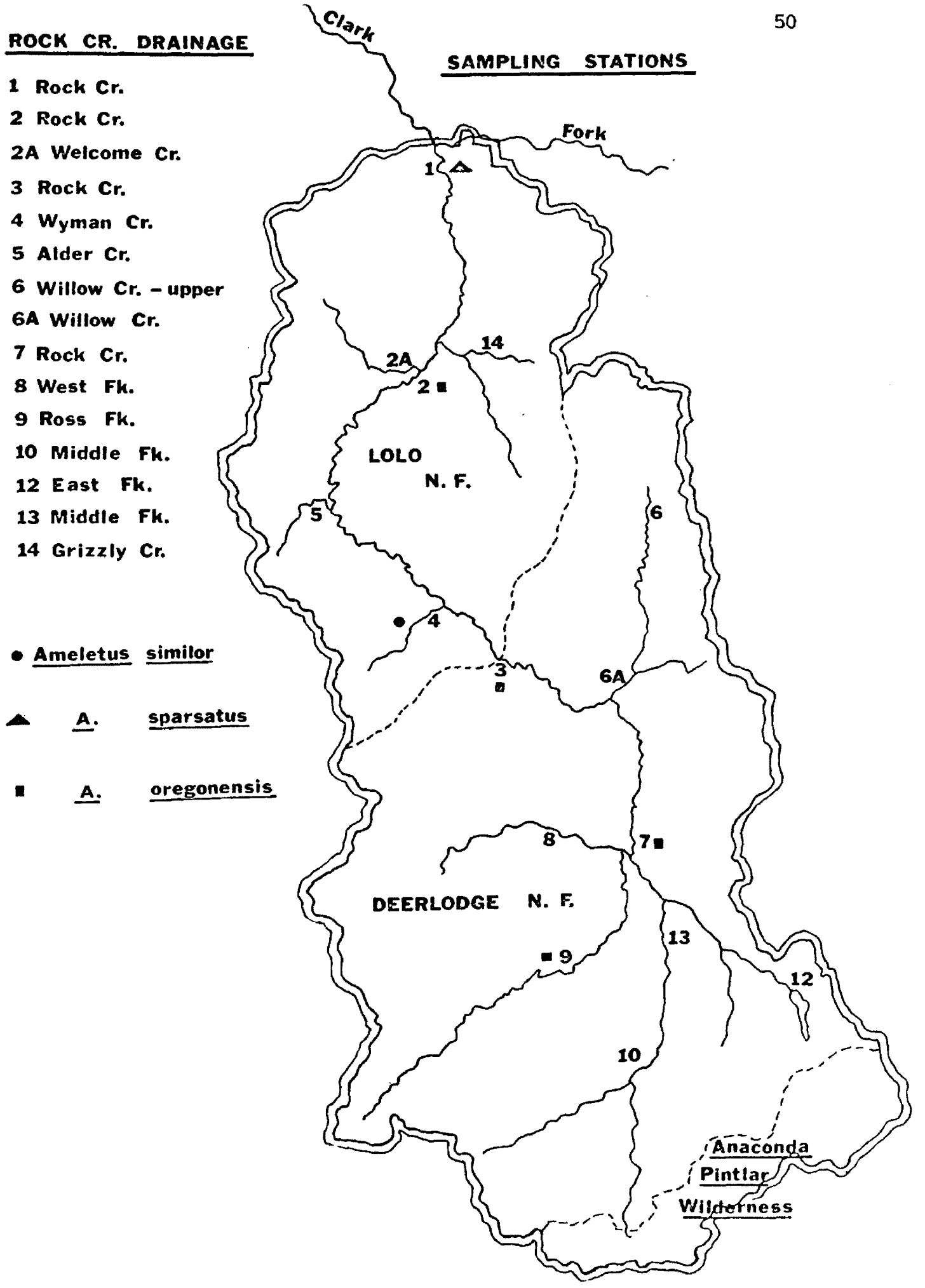
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

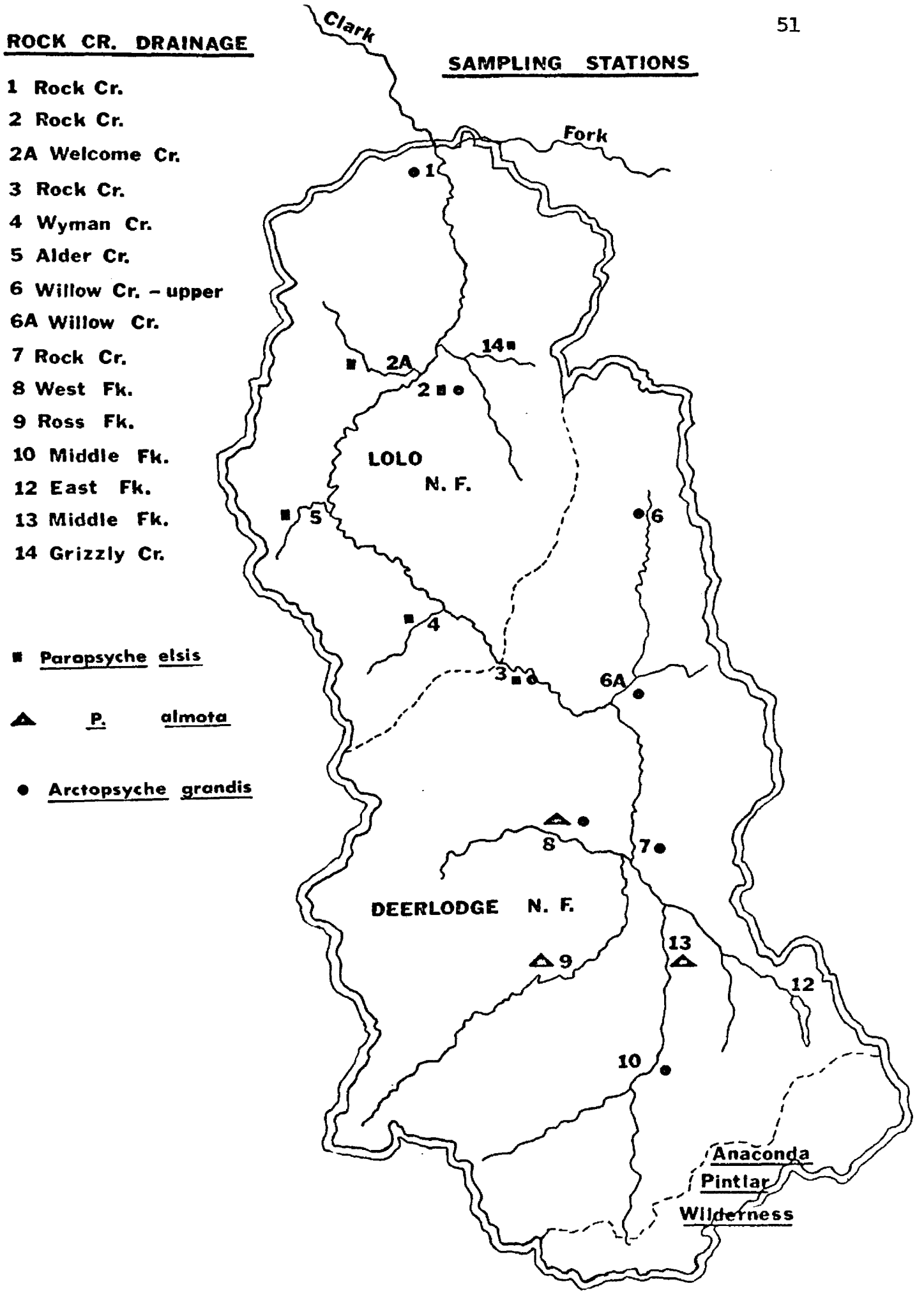
● Ameletus sp. unknown

▲ A. validus

■ A. cooki







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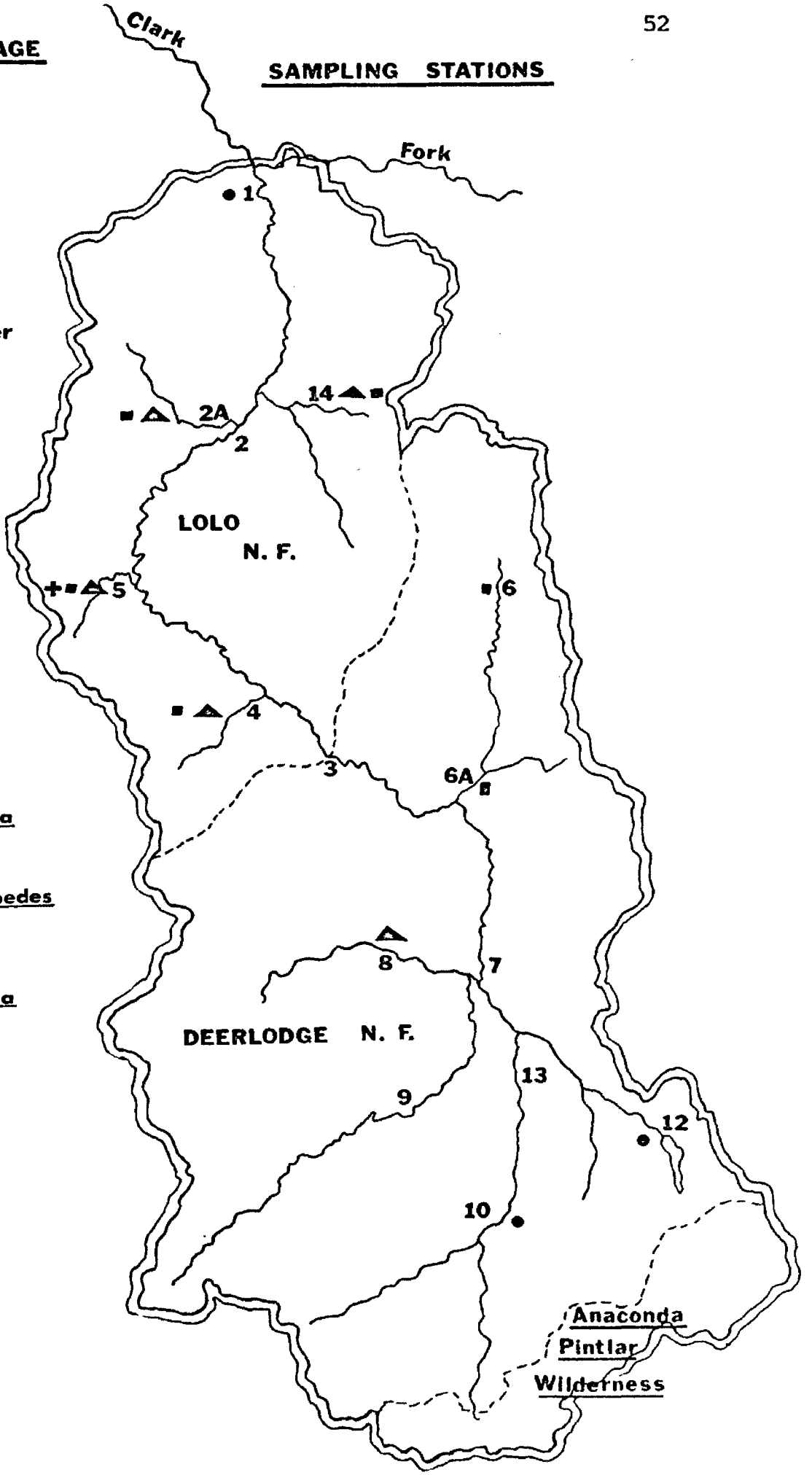
9 Ross Fk.
10 Middle Fk.
12 East Fk.
13 Middle Fk.
14 Grizzly Cr.

● Rhyacophila spp.

▲ R. vaccua

■ R. acropedes or vao

+ R. tucula



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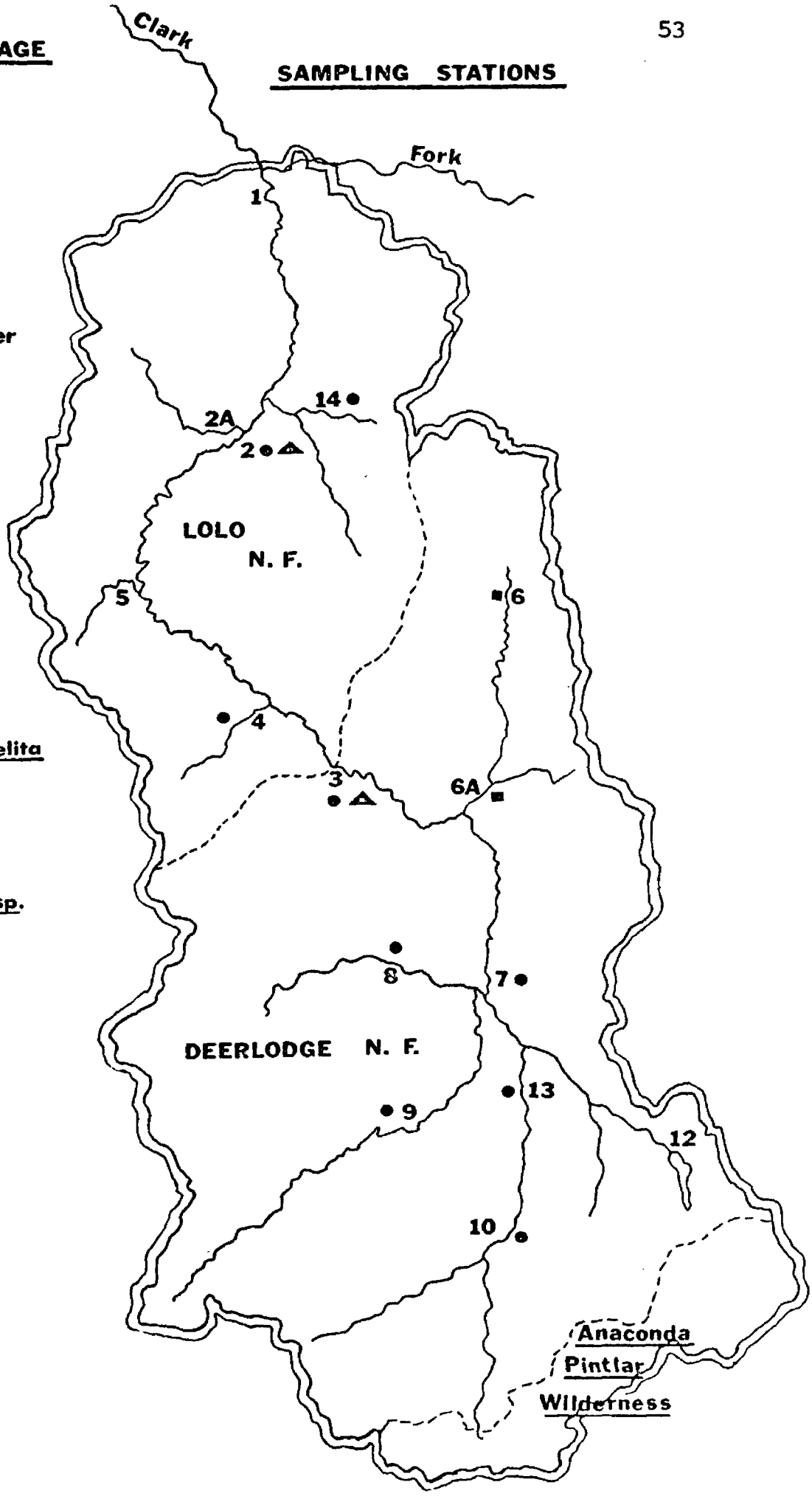
■ Rhyacophila angelita

▲ Hydropsyche sp.

● Branchycentrus sp.



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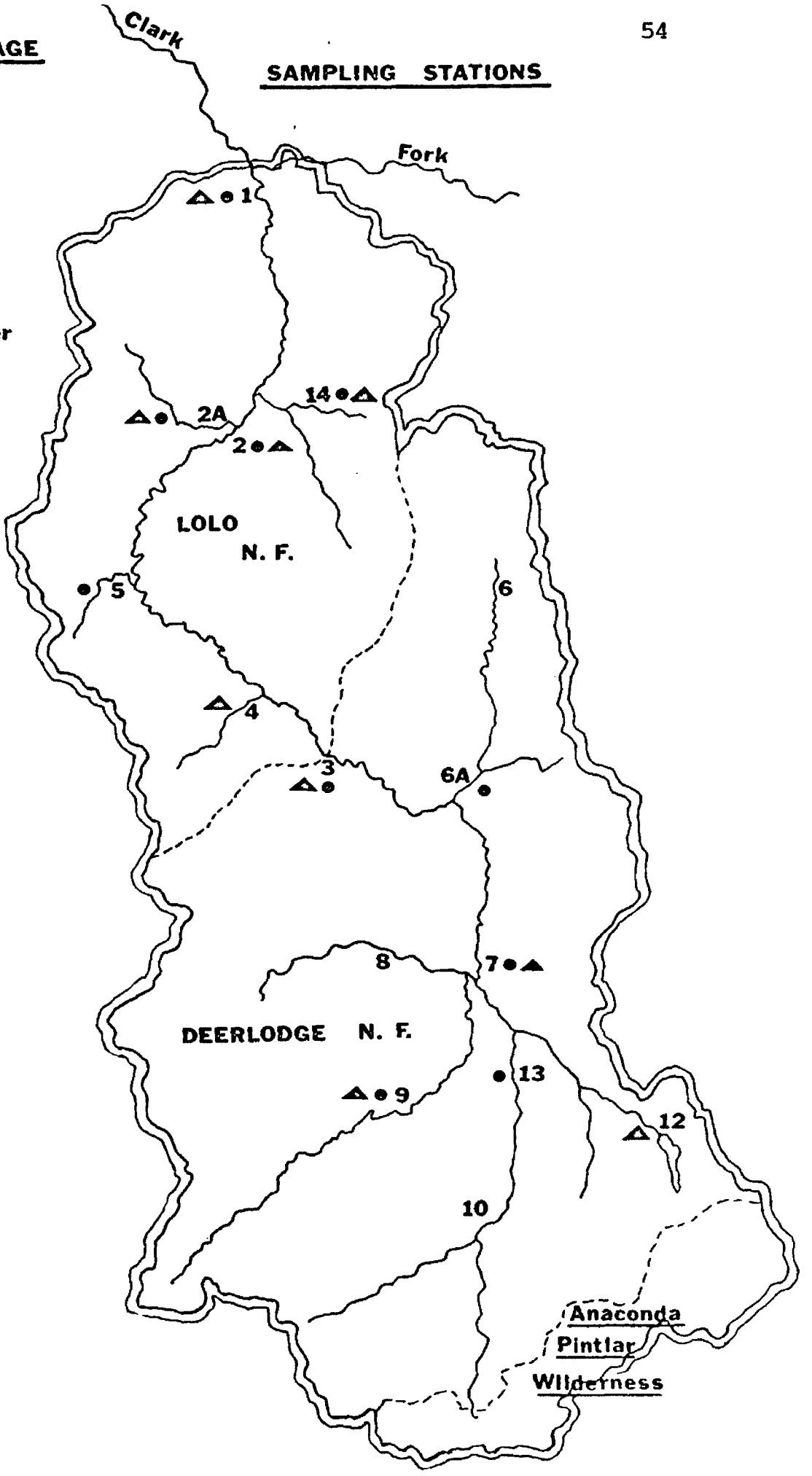
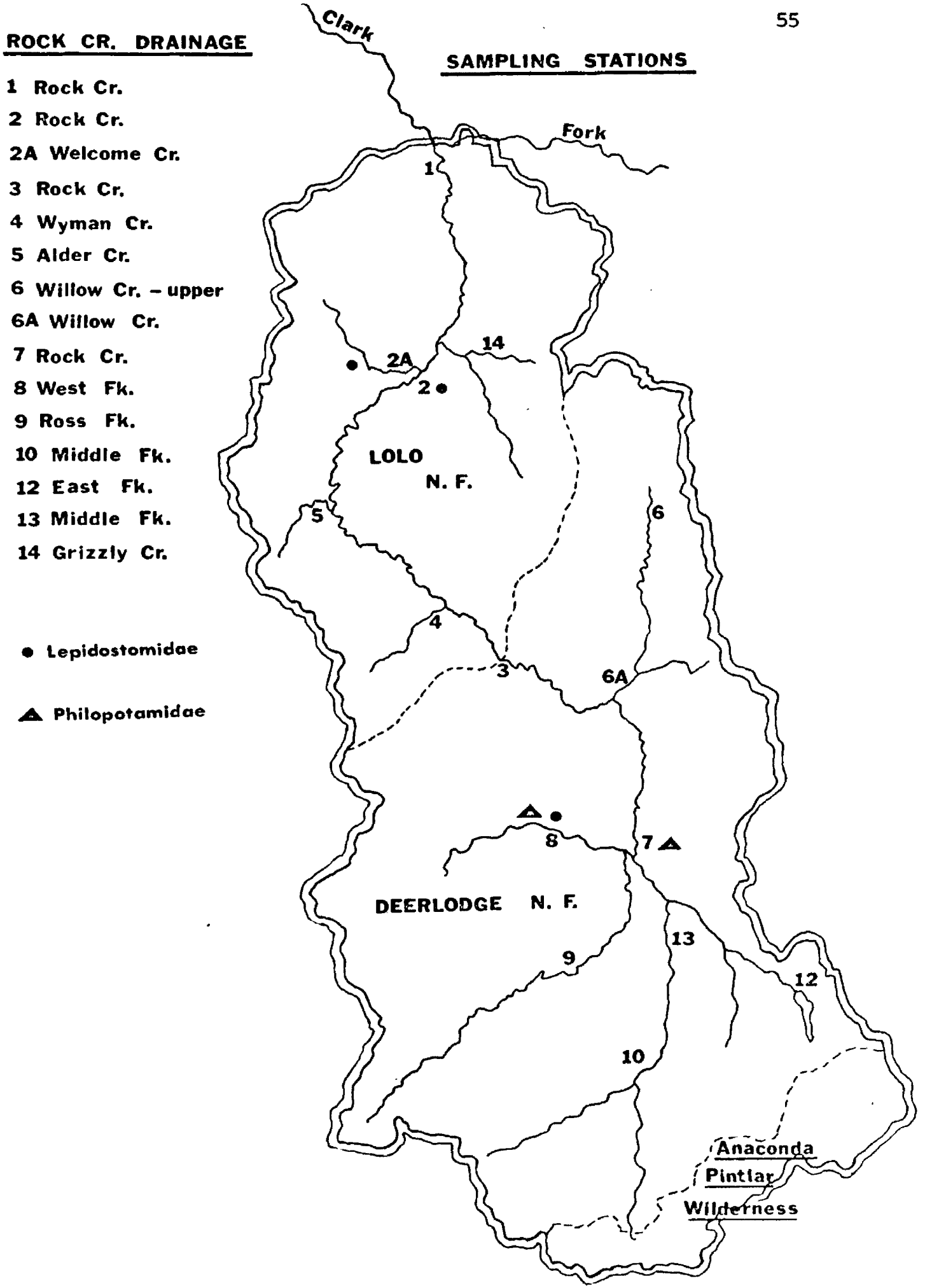
13 Middle Fk.
14 Grizzly Cr.

● Leptocella sp.

▲ Limnophilidae

■ Psychomiidae





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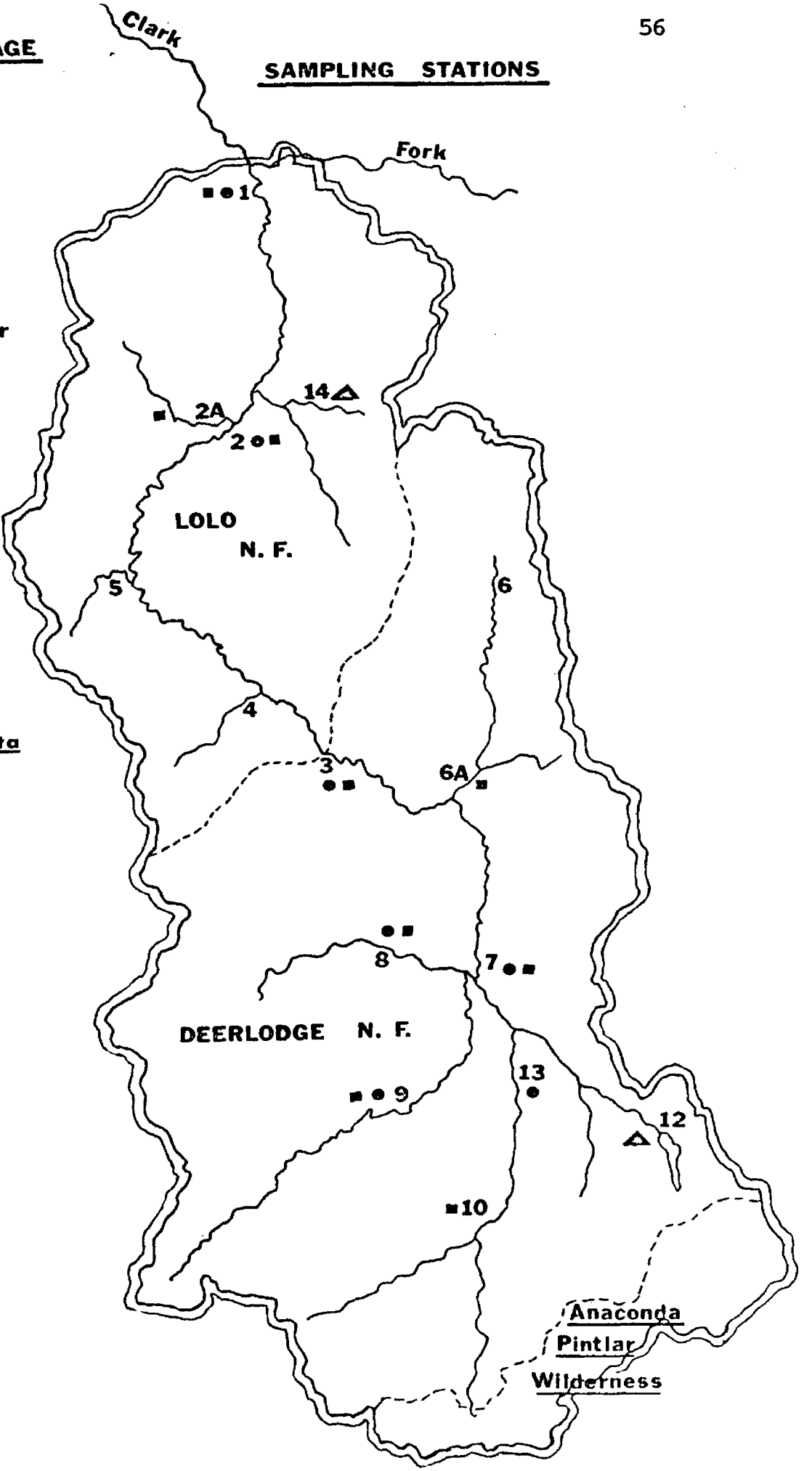
● Atherix variegata

▲ Tipulidae

■ Hexatoma sp.



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● Tendipedidae

▲ Simulidae

■ Blephariceridae

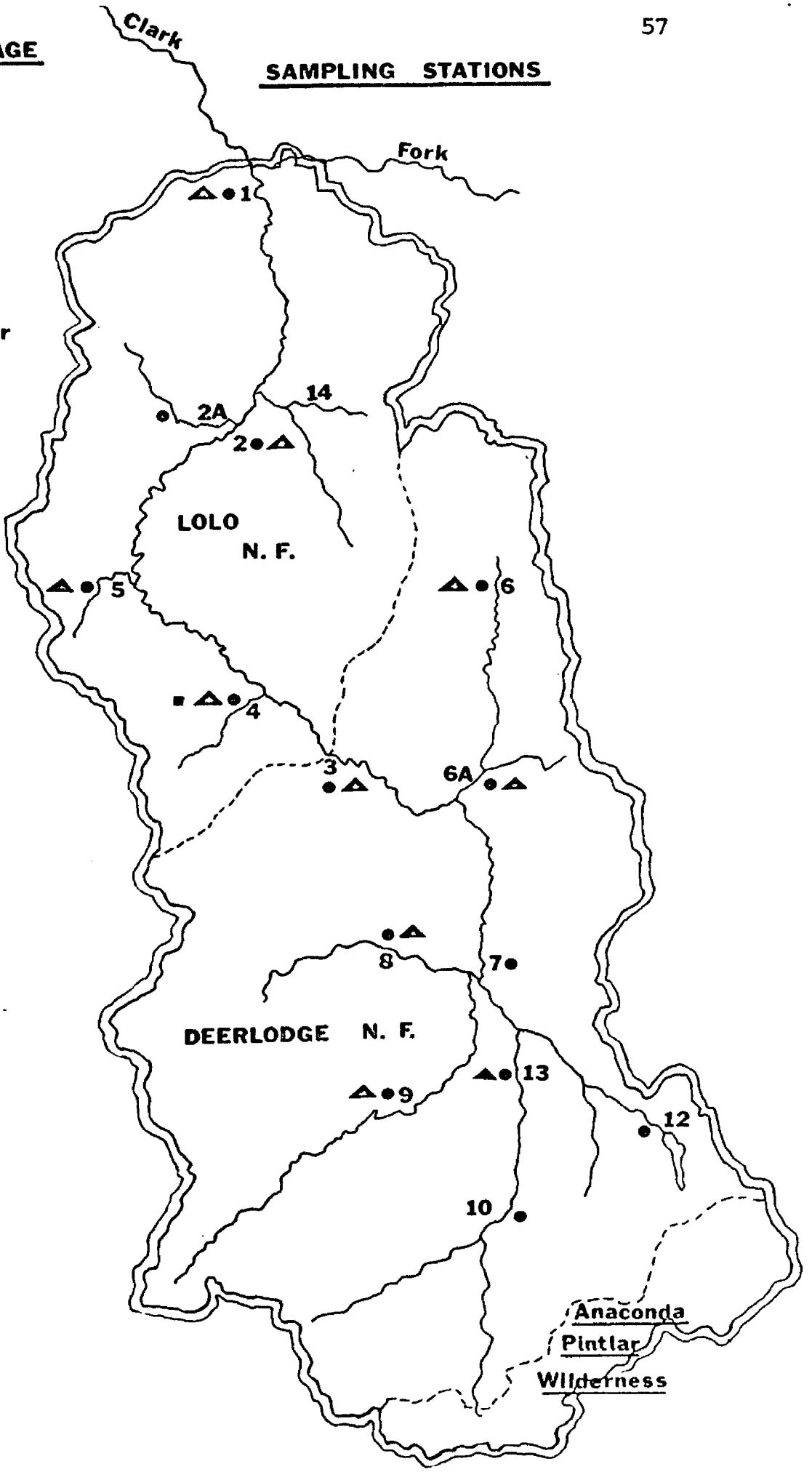
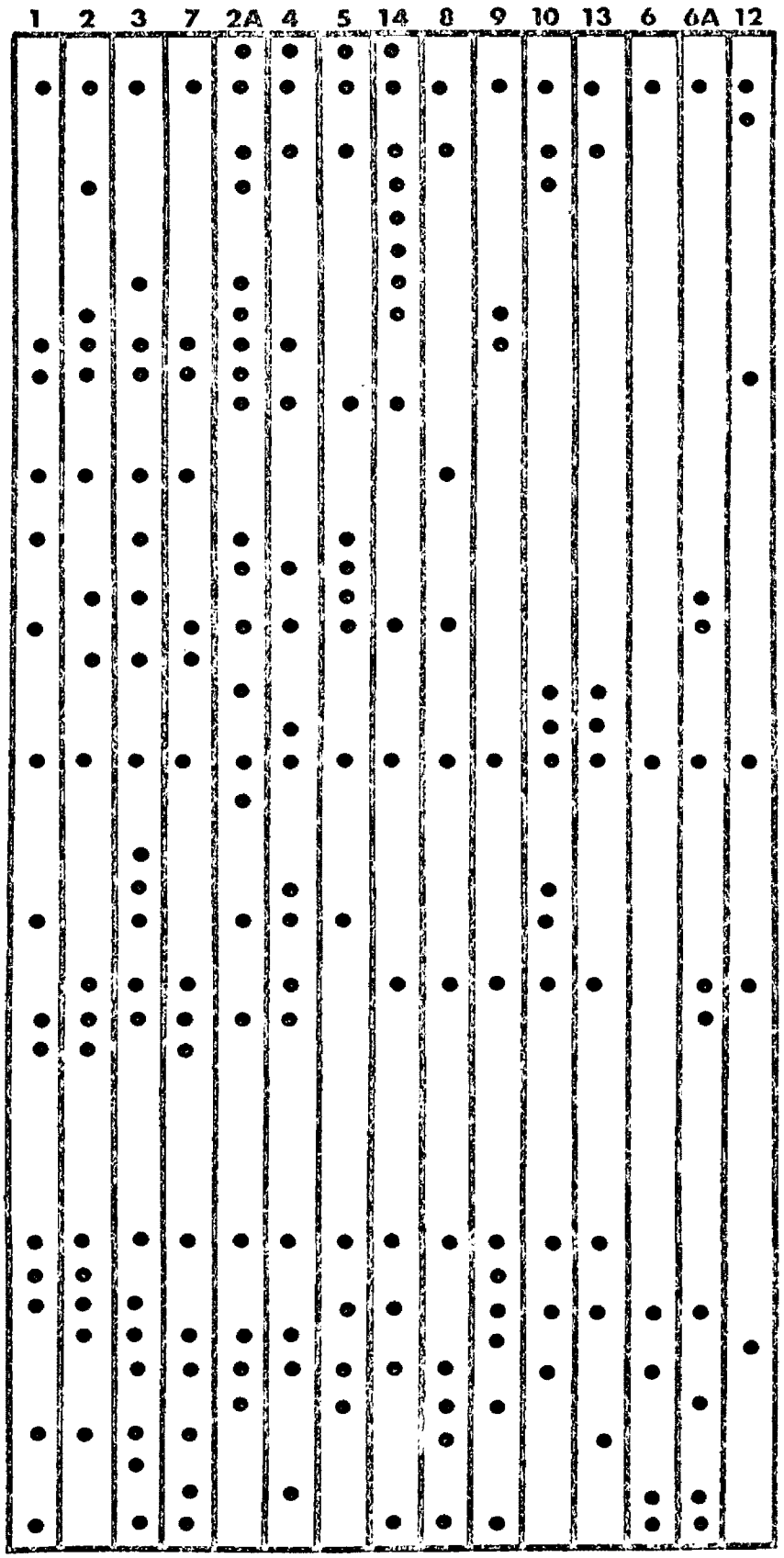
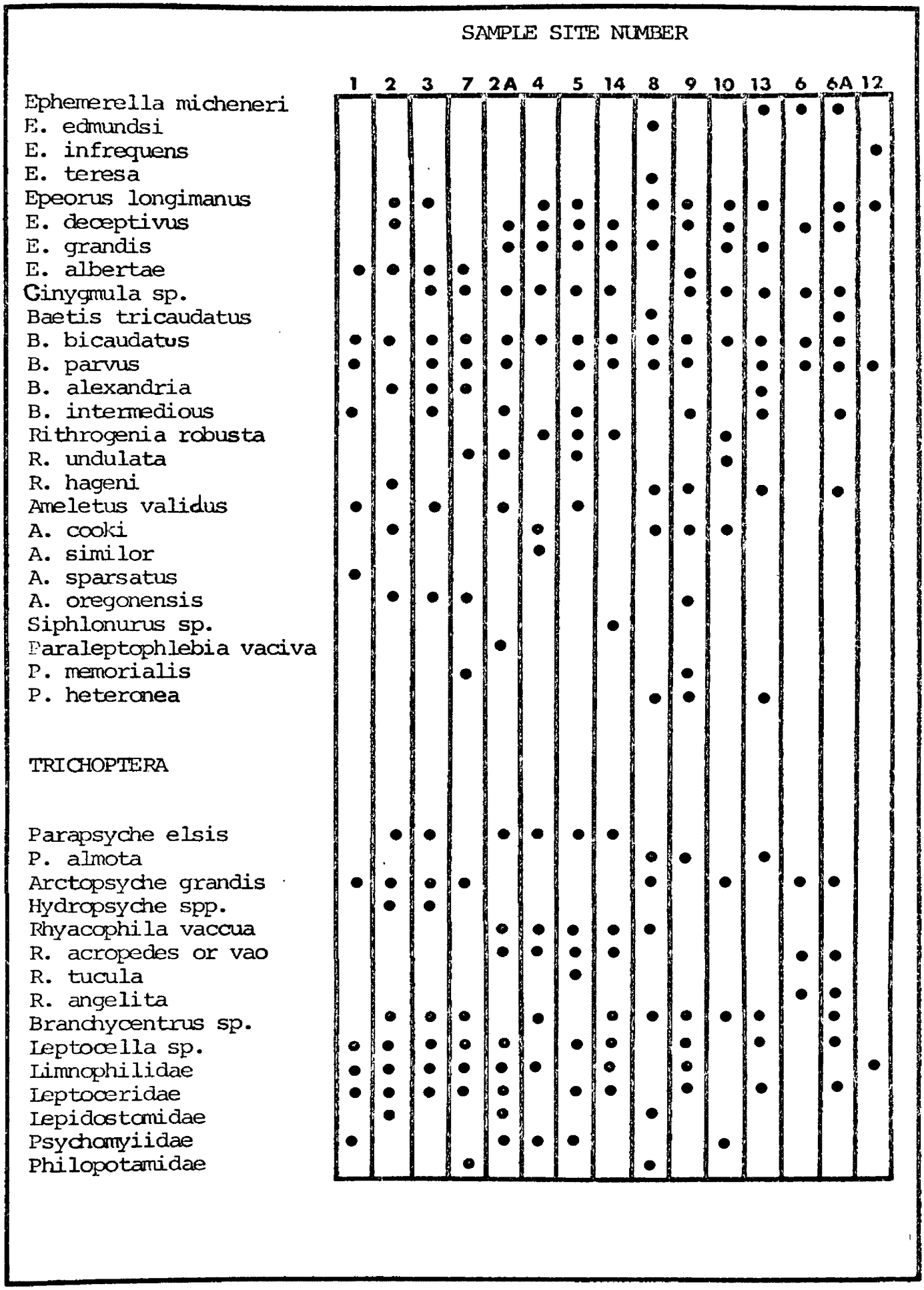
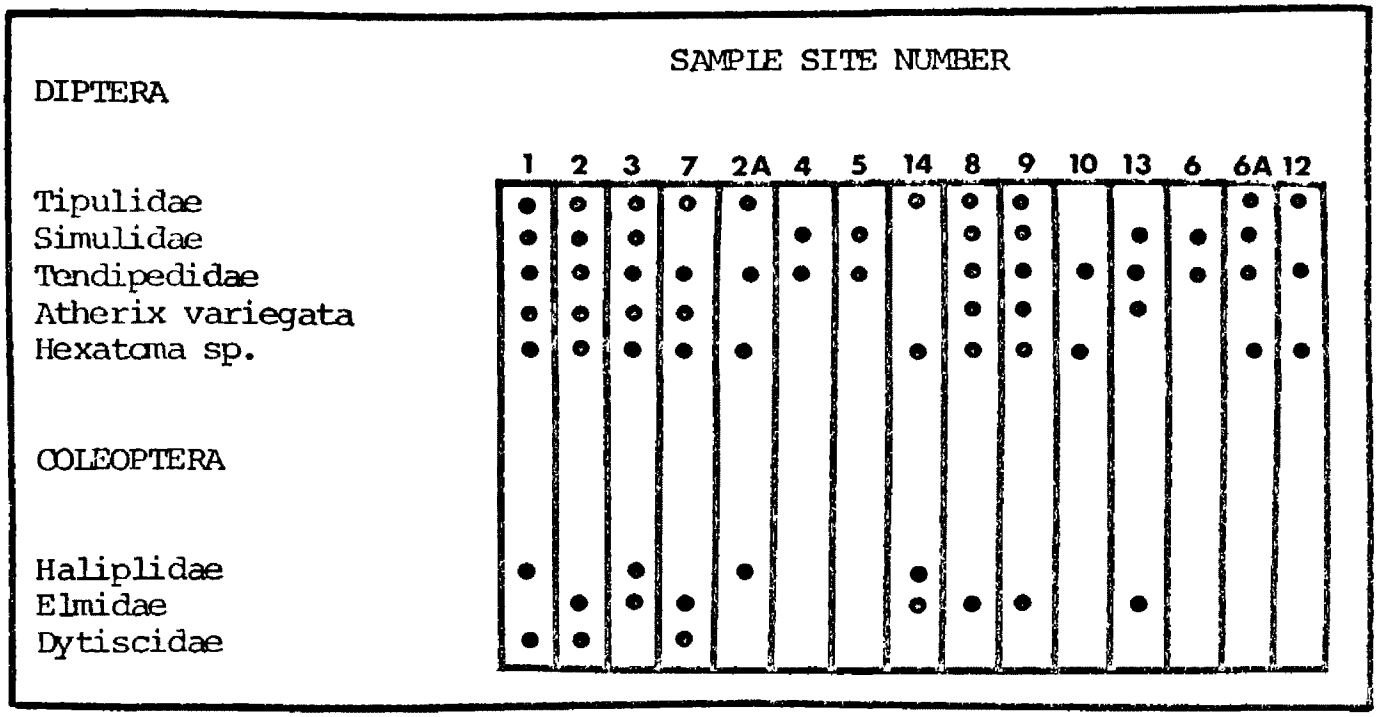


Fig. 3. Qualitative data for the period July, 1972 to June, 1973.

SAMPLE SITE NUMBER







CHAPTER VI

STATISTICAL ANALYSIS

The statistical methods used for this paper have been chosen to utilize best the qualitative data which were obtained from the study of the aquatic insects within the study areas of the Rock Creek drainage. A similarity index was used to obtain data which would illustrate the relationship between sample sites using the presence or absence of aquatic insects as the components of the index. The exact formula for the index is given in the methods section of this paper. The similarity index data were used in the construction of dendrograms, a method of gluster analysis. The dendrograms allow the researcher to construct a simple hierarchy for his samples (Jardine, and Sibson, 1971).

The cluster method considered here is an "agglomerative method", i.e. that in which each sub-group in an hierarchical classification is built up from the union of two small groups. Many different agglomerative clustering methods have been proposed, but the most widely used are the "group" methods proposed by Sokal and Michener (1958). To illustrate best the qualitative data that were obtained in this study, I have chosen the pair-group methods, in which the clustering process contains only two members. These groups of forms are produced by pairing those individual forms, or groups of forms produced at an earlier stage in the clustering process, for which the relation "is most similar to" is reflexive (A. J. Boyle, 1969).

Using the data that were obtained by performing the similarity index on the aquatic insect occurrence records for each site in the study

Table 1. Similarity index data for each sample site.

Site	1	2	2A	3	4	5	6	6A	7	8	9	10	12	13	14
1	-														
2	0.600														
2A	0.521	0.410													
3	0.666	0.763	0.533												
4	0.406	0.470	0.597	0.485											
5	0.516	0.393	0.707	0.500	0.700										
6	0.416	0.307	0.353	0.388	0.434	0.500									
6A	0.566	0.507	0.444	0.545	0.482	0.535	0.666								
7	0.645	0.637	0.411	0.676	0.413	0.294	0.340	0.474							
8	0.484	0.514	0.463	0.555	0.468	0.419	0.333	0.600	0.553						
9	0.567	0.591	0.428	0.630	0.461	0.476	0.408	0.622	0.545	0.656					
10	0.440	0.444	0.516	0.461	0.701	0.581	0.487	0.603	0.448	0.542	0.400				
12	0.355	0.326	0.333	0.392	0.372	0.341	0.370	0.410	0.363	0.400	0.347	0.421			
13	0.448	0.451	0.393	0.592	0.464	0.481	0.450	0.576	0.491	0.630	0.576	0.549	0.324		
14	0.433	0.406	0.603	0.515	0.517	0.571	0.476	0.518	0.440	0.533	0.524	0.528	0.410	0.500	-

Similarity Index Data

Table 2. Average pair-group similarity data for each sample site.

Site	2-3	2A-5	10-4	6-6A	8-9
1	0.633	0.518	0.423	0.491	0.525
2	-	-	-	-	-
2A	0.471	-	-	-	-
3	-	-	-	-	-
4	0.477	0.648	-	-	-
5	0.446	-	-	-	-
6	0.348	0.426	0.460	-	-
6A	0.526	0.489	0.542	-	-
7	0.656	0.353	0.430	0.407	0.549
8	0.534	0.441	0.505	0.466	-
9	0.610	0.452	0.430	0.515	-
10	0.452	0.548	-	-	-
12	0.359	0.337	0.396	0.390	0.373
13	0.521	0.437	0.506	0.513	0.598
14	0.460	0.587	0.522	0.497	0.528
2-3	-	0.459	0.513	0.437	0.528
2A-5	-	-	0.598	0.458	0.446
10-4	-	-	-	0.501	0.467
6-6A	-	-	-	-	0.490

Average Pair-Group Similarity Index Data

area, two dendrograms have been constructed.

The first dendrogram (Fig. 4) illustrates a hierarchy formed using the raw similarity index values. These values are listed in Table 1. The pairing formed represent a simple nearest-neighbor regressive construction. The highest similarity index value between any two sample sites is used as the basic relationship. The next highest value is then taken and placed into the dendrogram in the proper position. This continues until all the sites have been related to each other, and represented in the dendrogram.

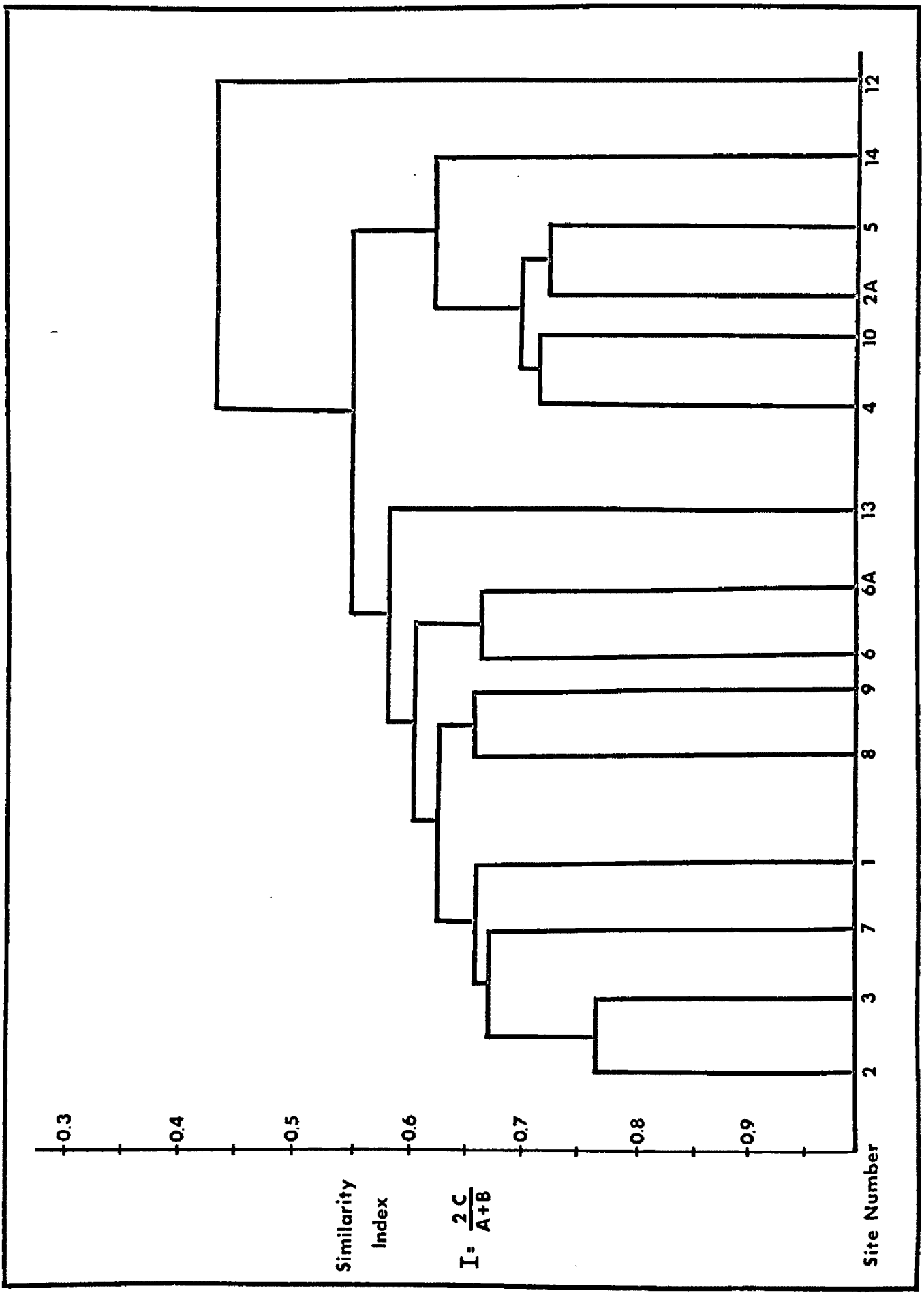
The second dendrogram (Fig. 5) represents a refinement of the first, and could be said to place the sample sites in a hierarchy that more closely represents an accurate form. This dendrogram utilizes an average pair-group method representing the similarity values. This method measures the similarity between two groups as the arithmetic mean of the similarities between the individuals which make up the two groups (A.J. Boyle, 1969). Table 2 lists the arithmetic mean values used in the construction of the dendrogram.

The Nearest Neighbor dendrogram allows us to visualize a basic three component structure in the sample site hierarchy. Sample sites 2,3,7, and 1 form the first grouping, sites 8 and 9 form the second, and sites 4,5,10, and 2A form the third group (Fig. 4).

The Average Pair-Group dendrogram merges two of the basic groups found in the first dendrogram into a single unit of sites 2,3,7,1,9, and 8. Site 9 is now joined to the first grouping and site 8 has become related to the new grouping of sites 2,3,7,1, and 9.

The level of hierarchy has also changed in the grouping of sites

Fig. 4. Nearest neighbor dendrogram showing the relationship between the sample sites of the Rock Creek drainage.



2A,4,5,10, and 14. The N-N (Nearest Neighbor) grouping of site 4 and 10, and 2A and 5 has been replaced with a foundation P-G (Pair-Group) grouping of sites 2A and 5. Site 4 then joins the basic pair group to form a new grouping of sites 2A,5, and 4. Site 14 and 10 follow in stair step fashion until a grouping representing the second major component of the first level of the P-G dendrogram is formed.

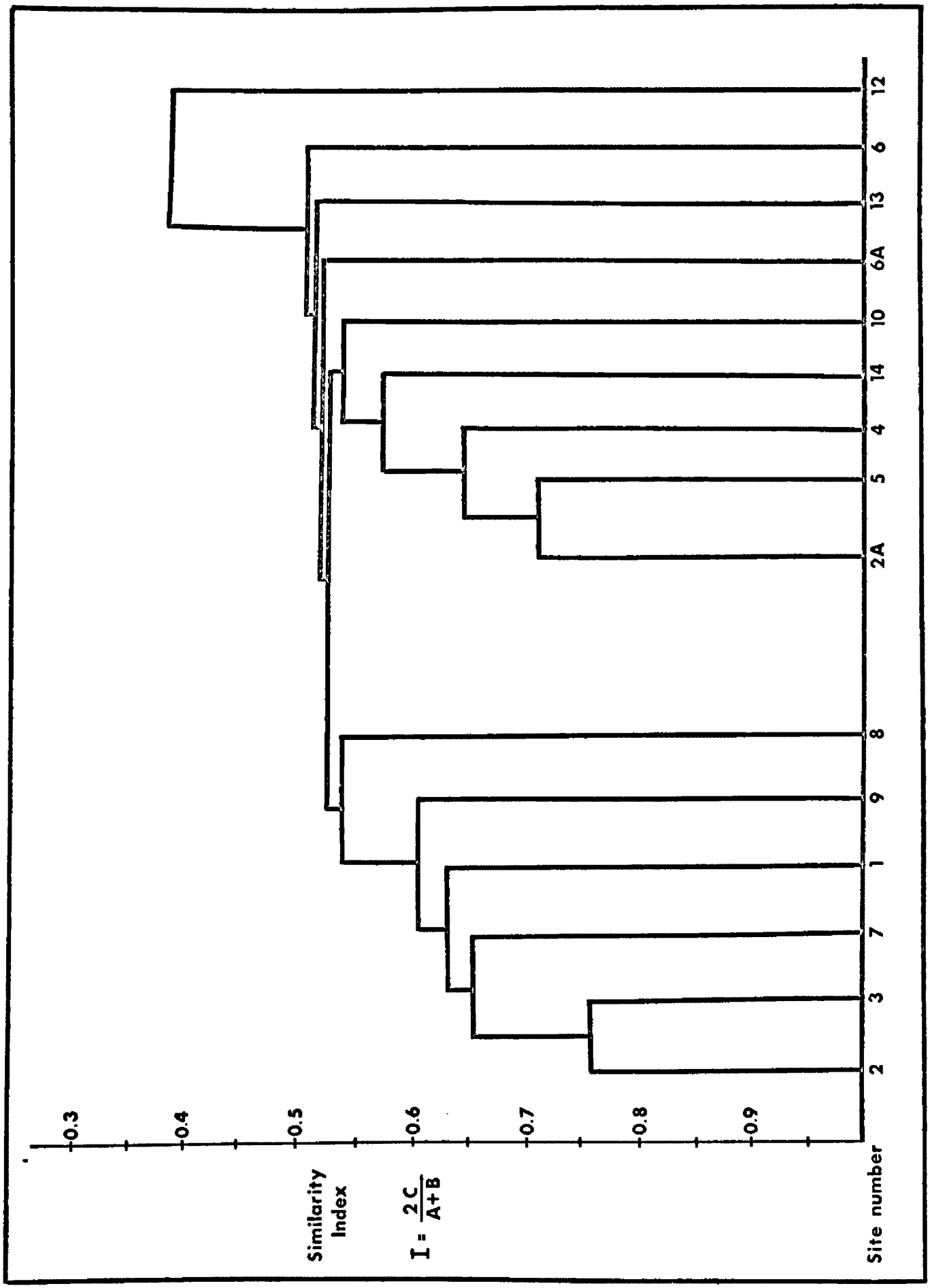
The second level in the N-N dendrogram is formed when the sites 6 and 6A join the first level grouping to form the new grouping of sites 2,3,7,1,8,9,and 6. Also in the second level is the addition of site 14 to the grouping of sites 2A, 5,4,and 10.

Three basic components of the N-N dendrogram have now been merged to form two major components on the second level. The N-N dendrogram now more closely resembles the P-G dendrogram.

The second level of the P-G dendrogram is formed by the merging of two basic component site groupings to form the new grouping of sites 2,3,7,1,9,8,2A,5,4, and 10. The third, fourth, and fifth levels at which these three sites enter the dendrogram are very similar, and as such, the position of the sites in the dendrogram should not be considered rigid. The identification of a single aquatic insect found to occur in any one of the sites, but not collected during this study, could rearrange the position of these three sites.

It is to be noted that the dendrogram is theoretically three dimensional in form, with the groupings able to rotate at each pivot point, depending on the factors involved at any given point in time. However, the difference in the similarity values of the groupings at each pivot point serves to indicate the relative stability of the groupings position.

Fig. 5. Average pair-group dendrogram showing the relationship between the sample sites of the Rock Creek drainage.



In the N-N dendrogram, site 13 joins the second level groupings of sites to form the new third level. The second level of the third basic component grouping of this dendrogram then joins with the combined third level of the first and second basic component grouping to form the fourth level. The fifth level in the N-N dendrogram is formed by the entry of site 12, a dissimilar distance from the combined members of the fourth level.

Site 12 eneters the P-G dendrogram at a likewise dissimilar distance from the sites of the fifth level to form the sixth and final level of the dendrogram.

The two dendrograms, though different in structure, illustrate that certain groups or pairs of sample sites within the study area exhibit a greater relationship with some sites than others. This shows that the sample sites are not randomly associated, that is, their communities of aquatic insects are not unique unto themselves.

From the dendrograms there appears to be at least two major community structures present in the sample sites of the drainage. A thrid community is also indicated, although it is not as well defined as the other two. The third community structure is represented by the sample sites on the larger tributaries of Rock Creek, and by the sites representing a unique situation, such as Willow Creek and the East Fork of Rock Creek. The structure of this community is much more variable than the structure of the other two communities. However, it exhibits similarities to both the main stream and small tributary communities. A good example is the sample sites on the Middle Fork of Rock Creek. Although both the sites (10 and 13) are located on the same stream, the N-N dendrogram shows us that site 10 is related most

to the smaller tributaries, and site 13 is related most to the main stream sites and other large tributaries. The P-G dendrogram illustrates the same thing, although it allows us to see that the two sites are not as dissimilar as the N-N dendrogram might indicate.

It is evident from both dendrograms that site 12 on the East Fork of Rock Creek is the least similar of the sample sites in the drainage. The community of aquatic insects that is found to occur at this site is unique, and represents the unique limiting factors found at the site.

The fact that some aquatic insects, largely the order Plecoptera, were not identified to a specific level undoubtedly altered the dendrograms from a more accurate form. Once all the aquatic insects that comprise the communities of each sample site are known as species, a more accurate hierarchy can be constructed.

It must be cautioned that the dendrograms presented in this paper represent general trends in community associations, not rigid relationships. However, the dendrograms did illustrate that a definable relationship and hierarchy exist within the aquatic insect communities of the sample sites of the study area.

CHAPTER VII

STREAM CLASSIFICATIONS

There have been several attempts by limnologists to classify streams and aquatic habitats for the purpose of ecological analysis. The outcome of such attempts has usually been of little practical value. Nevertheless, useful generalizations and a clearer understanding have resulted from certain broadly based ecological classifications.

Different classifications have been proposed for the streams of the European continent (Huet, 1948), the British Isles (Carpenter, 1928), Yellowstone National Park (Muttkowski, 1929), Ontario (Ricker, 1934), and other areas. The classifications have been alternately based upon source of water, size, speed of current, slope, elevations, temperature, substrate, permanence, oxygen, carbon dioxide, pH, hardness of water, productivity, or any combination of the above factors. Usinger (1968) stated that "it may well be that no classification can be devised that will reveal in a meaningful way all the complicated interrelations."

Usinger (1968) proposed a classification system for the streams of the state of California. This classification grouped the streams under their biotic province, and sources and permanence of water. He included eight boitic provinces ranging from alpine to the desert phase of larger rivers.

Micheal Miner (1968) proposed a classification system for the Rock Creek drainage on the basis of stonefly (Plecoptera) habitat. His system was oriented exclusively on chemical and physiographical data. A description of his classification system, and his placement of streams studied in this paper follows.

Stony River

A small oligotrophic river typical of mountainous regions, exhibiting a stony substratum, with stones 10 to 50 cm. in diameter, and a moderate to rapid current; 3,000 to 5,000 feet elevations. Miner Placed 8 sample sites into this classification, all them on main Rock Creek. Two of these sites correspond with sites 2 and 7 of this paper.

Small Stony Streams

Tributary streams typical of oligotrophic forested regions, two to five yards wide, having stony substratum, 5 to 30 cm. in diameter, and rapid current; 3,000 feet to 5,000 feet elevation. Miner placed 8 sample sites in this classification, all located on tributaries of Rock Creek. Sites 8 and 2A correspond with two of Miner's sample sites in this category.

Small High Stony Streams

Small oligotrophic tributary streams and the higher reaches of stony streams. One to two yards wide, having a gravel substratum 1.0 to 5.0 cm. in diameter and rapid to torrential current; 5,000 to 8,000 feet elevation. Miner included 8 sample sites in this category. Three of the sample sites in this paper are included in this level of Miner's classification: 14,9, and 6.

Miner stated that "according to Hynes (1941) this method of stream classification has the distinct disadvantage of overlapping the various type habitats; however, these three habitat divisions are applicable to the hydrobiology of the study area."

Using the physical and biotic information gather for each stream,

Table 3. Table illustrating the physical characteristics of each of the stream classifications.

	Division I.	Division II. Tributaries				
	Type A. Main Rock Creek	Type B.	Type C.	Type D. Class a.	Type D. Class b.	Type E.
Sites	(1) (2) (3) (7)	(14) (2A) (4) (5)	(8) (9)	(10)	(13)	(6) (6A)
Average Depth	10" - 12"	4" - 6"	6" - 8"	10"	12"	12"
Average Width	70' - 85'	3' - 10'	10' - 20'	25' - 30'	35' - 40'	12'
Gradient Range	1 - 2%	2 - 7%	2 - 3%	2 - 3%	1 - 2%	1 - 2%
Substrate Range	Large boulders to Sand	Fine rubble to Organic debris	Fine rubble to Coarse gravel	Fine rubble to Coarse gravel	Fine rubble to Coarse gravel	Coarse gravel to Organic Debris
Drainage Description	Upper Drainage: Wide Valley Floor. Lower Drainage: Timbered Canyon.	Narrow Timbered Canyons, Low Solar Radiation.	Mountain Valleys, Timbered & Grassland.	Timbered Mountain Valley.	Mountain Grassland Valley.	Wet Grassland Valley.

this paper has proposed a six level classification system for the streams of the Rock Creek drainage. The classification involves only those streams that have U.S. Forest Service water quality sample stations on their course. This was done in an attempt to provide practical data that can be used to help in the assessment of exisiting management policies.

The system included two major divisions; (1) the main Rock Creek sample sites, and (2) the tributary stream sample sites. The system is labeled as follows;

Division 1 Type A (1,2,3,7)
Division 2 Type B (2A, 14,4,5)
Type C (8,9)
Type D (10,13) Class 1 - site 10 Class 2 - site 13
Type E (6,6A)
Type F (12)

The construction of biotic dendrograms using a "similarity index" was used as a further indication of stream similarities, and aided in the classification of the streams.

The classifications presented in this paper are by no means rigid. Each category is flexible, and may be modified in the event quantitative studies are performed on the waters of the drainage.

It is hoped that the broad system of classification presented will add to the knowledge and understanding of the aquatic insect habitats present in the Rock Creek drainage.

The biological results have been presented using qualitative data. A discussion for biota of each "Type" stream classification is presented.

Many aquatic insects cannot be identified beyond a family or generic level without adult specimens. In such cases notations have been made to inform the reader of this fact. Nymphs and immature

forms of aquatic insects were collected for this study. On special occasions adults of the order Plecoptera were collected. The identification of the Plecoptera from the adult specimens is noted in the collection data.

A percent-occurrence classification system has been created in an attempt to utilize the qualitative information. This was done to indicate the relative possibility of a given insect occurring at a given sample site (Table 4). The percentages represent the percent of times an aquatic insects was collected from that site during the study period of twelve months. Special consideration was given those sample sites that were not sampled each month.

The divisions in the system are arbitrary, and were made for the singular purpose of better illustrating the distribution and occurrence of aquatic insects within the Rock Creek drainage. The delineations within the system are not intended to represent the numbers of each organism present, or their relative abundance at each site. The system does not in any way indicate quantitative results. The system is divided as follows;

0% - Absent (no letter)
1 - 20% Rare (R)
21 - 50% Not Common (NC)
51 - 70% Common (C)
71 - 100% Very Common (VC)

It is hoped that this system will aid in the understanding of the distribution of the aquatic insects within the Rock Creek drainage.

Table 4. Aquatic insect relative occurrence data for each sample site.

	Stream Type Classification					
Plecoptera	A	B	C	D-1	D-2	E
Peltoperla brevis		VC				
Nemoura spp.	C	VC	C	VC	VC	VC
N. flexura						
N. cinctipes						
N. columbiana						
N. haysii						
N. cataractae						
Capnia spp.	R	NC				
Brachyptera sp.	R	R	R			
Pteronarcys californica	VC	R	VC			
Pteronarcella badia	VC	R				
Arcynopteryx signata or watertoni		VC				
A. curvata or parallela or compacta	VC		R			
A. aurea	C	R				
A. bradleyi		NC				
Isogenus aestivalis	NC	R	C			C
I. modestus	NC	C	R	VC	VC	C
Isoperla fulva	VC					
Paraperla frontalis		R		NC	NC	
Utaperla sopladora		R		R	R	
Alloperla spp.	VC	VC	VC	VC	VC	VC
A. fidelis						
A. diversa						
A. severa						
A. coloradensis						
Acroneuria californica or theodora	NC	C		VC		
A. pacifica	C	NC	VC	C	VC	VC
Claassenia sabulosa	VC	NC			VC	VC
Diura knowltoni	VC					
Ephemeroptera						
Ephemerella doddsi	VC	VC	VC	VC	VC	VC
E. heterocaudata	NC		NC			
E. flavilinia	NC	NC	NC	VC	VC	VC
E. inermis	NC	R	NC			
E. spinifera	NC	VC	NC	VC		
E. hystrix	R	NC				VC
E. tibialis	R		R		C	
E. hecuba	R					
E. coloradensis	R	R		C		C
E. grandis	NC	R	C			VC

	STREAM TYPE CLASSIFICATION					
	A	B	C	D-1	D-2	E
Ephemerella micheneri					C	C
E. edmundsi			NC			
E. infrequens						
E. teresa			NC			
Epeorus longimanus	NC	NC	C	VC	VC	C
E. deceptivus	R	VC	NC	NC		C
E. grandis		VC	NC	VC	C	
E. albertae	C		R			
Cinygmula sp.	C	VC	R	VC	VC	VC
Baetis tricaudatus			VC			VC
B. bicaudatus	VC	VC	VC	VC	VC	VC
B. parvus	C	C	C		R	VC
B. alexandria	VC				VC	
B. intermedious	NC	R	NC		R	NC
Rithrogenia robusta		C				
R. undulata	R	NC		C		
R. hageni	R		VC		VC	VC
Ameletus validus	R	NC				
A. cooki	R	R	VC	C		
A. similor		R				
A. sparsatus	R					
A. oregonensis	C		R			
Siphlonurus sp.		R				
Paraleptophlebia vaciva	R	R			VC	
P. memorialis			NC			
P. heteronea			C			
Trichoptera						
Parapsyche elsis	C	VC			VC	
P. almota			VC			
Arctopsyche grandis	VC		C	VC		VC
Hydropsyche spp.	NC					
Rhyacophila vaccua		C	C			
R. acropedes or vao		VC				VC
R. tucula		R				
R. angelita						NC
Branchycentrus sp.	C	R	C	VC	VC	VC
Leptocella sp.	VC	NC			C	
Limnophilidae	VC	VC	NC			
Leptoceridae	NC	NC	NC			C
Lepidostomidae	R	R				
Psychomyiidae	R	NC		C		
Philopotamidae	R		R			

	Stream Type Classification					
	A	B	C	D-1	D-2	E
Diptera						
Tipulidae	C	NC	VC	VC		VC
Simulidae	C	NC	C		C	VC
Tendipedidae	C	NC	VC	VC	VC	VC
Atherix variegata	VC		VC		C	
Hexatoma sp.	VC		VC	VC		VC
Coleoptera						
Haliplidae	R	R				
Elmidae	NC	R	C		C	
Dytiscidae	R					

CHAPTER VIII

STREAM TYPES

Type - A

Sites 1,2,3, and 7 are the sample sites located on the main Rock Creek course, and are the sites that comprise this classification. The altitudinal location represented by these sites ranges from near 3500 feet at site 1, to 5100 feet at site 7. The average gradient along this section of Rock Creek is approximately 1 - 2%, with areas in which the gradient is occasionally greater.

The topography of the area (Fig. 1) ranges from an open valley situation at site 7, to a timbered valley typical of sites 1,2, and 3.

The width of the sample sites in this classification (Table 3) ranges from approximately 70 feet at site 7, to near 85 feet at site 1. Depth of the stream averages approximately 10 to 12 inches, with occasional areas of much greater depth occurring in some locations along the stream.

Figure 6 illustrates the relationship between the width and average gradient for the sites in this study. It is noted that the sites in this classification occupy the far right area of the figure. They appear as a single grouping of sites, widely separated from the body of the other sample sites. This would seem to indicate a different set of limitations that may be imposed on the organisms found to occur there. This figure, along with the others, serves to strengthen the justification of this classification for the sample sites located on the main course of Rock Creek.

The summer temperatures ranged from near 5 C. in May, to 19 C. in

Fig. 6. Graph illustrating the relationship between the average width of each sample site and the average gradient of each sample site.

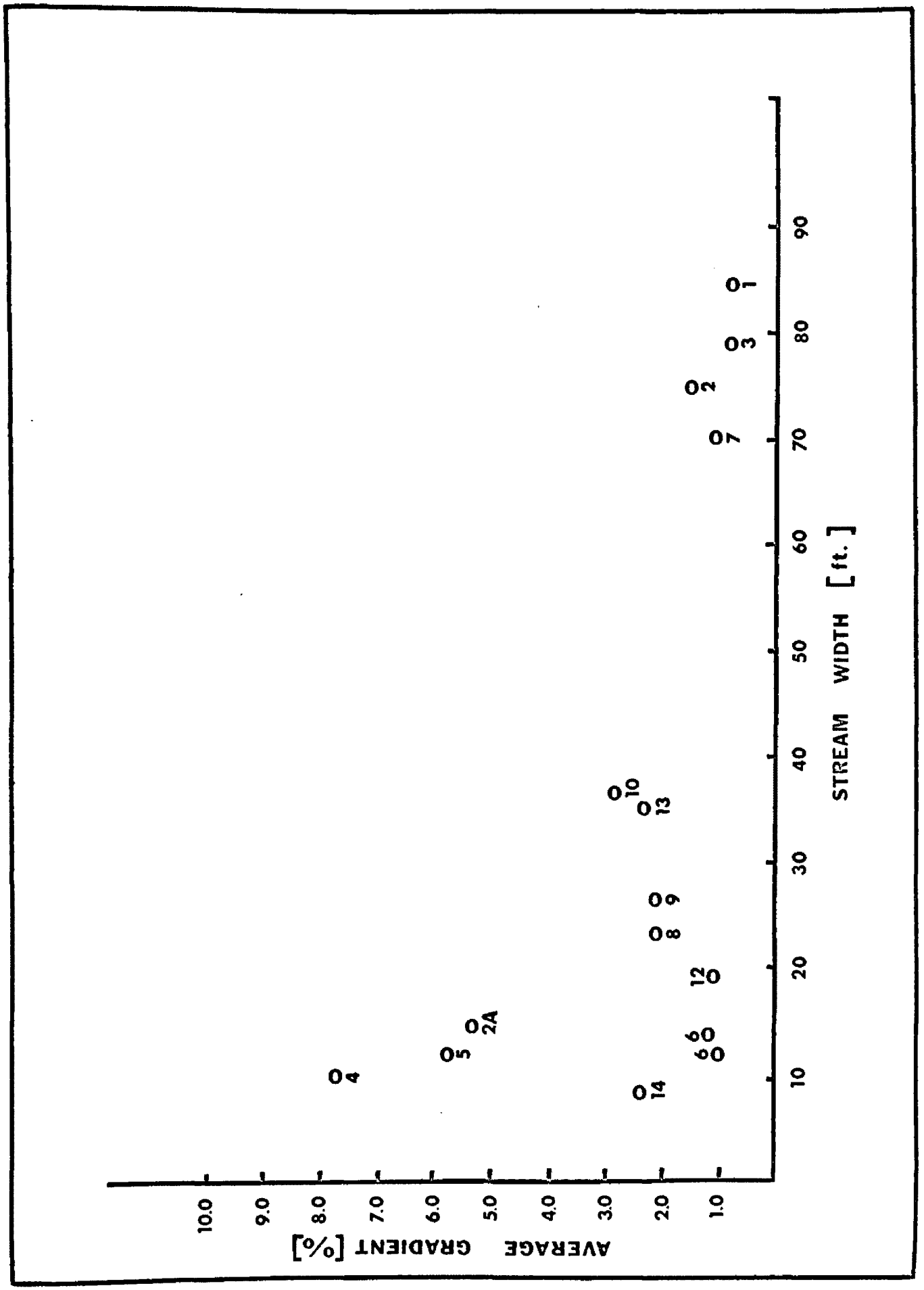


Fig. 7. Average water temperature for each sample site in the Rock Creek drainage for the summer months of 1970, as recorded by the U.S.F.S..

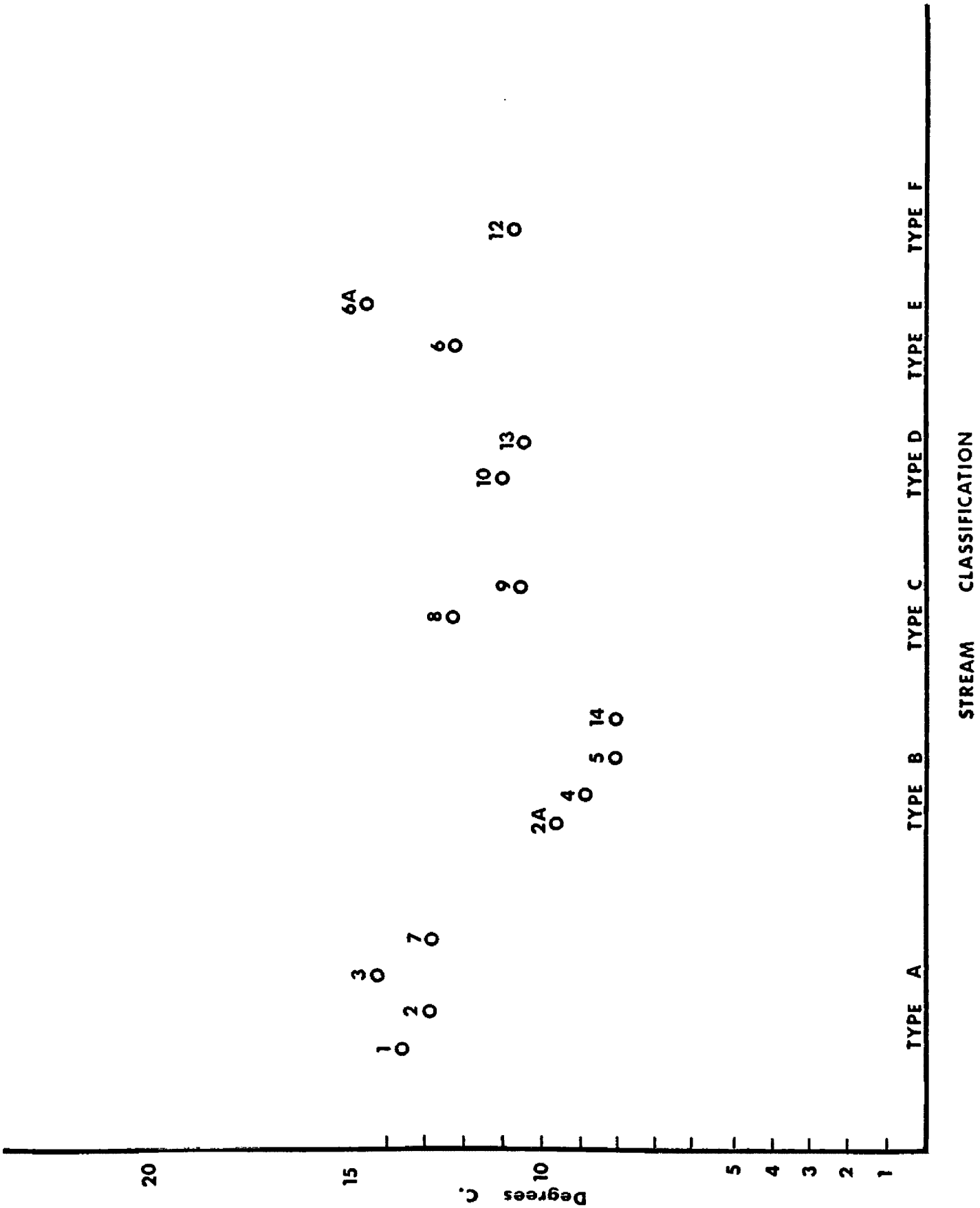


Fig. 8. Water temperature of each sample site for the period from July, 1972, to June, 1973.

SITE	MONTH								
					1973	1972			
	NOV – FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT
1	2'	3'	4'	6'	10'	12'	16'	13'	7'
2	2'	3'	4'	6'	10'	11'	19'	13'	7'
3	2'	3'	4'	7'	10'	–	19'	13'	6'
7	2'	3'	4'	6'	7'	–	14'	11'	–
8	2'	2'	4'	5'	8'	–	14'	10'	–
9	2'	2'	4'	6'	7'	–	11'	8'	–
10	2'	2'	3'	6'	8'	–	14'	8'	–
13	2'	2'	3'	6'	7'	–	12'	8'	–
14	2'	2'	3'	6'	7'	8'	10'	6'	–
2A	2'	2'	3'	4'	7'	9'	12'	7'	5'
4	2'	2'	3'	4'	7'	–	12'	6'	5'
5	2'	2'	3'	4'	7'	10'	11'	5'	4'
6	2'	–	3'	5'	7'	–	11'	6'	5'
6A	2'	2'	3'	5'	7'	–	12'	6'	–
12	2'	2'	3'	6'	7'	–	12'	11'	7'

Fig. 9. Range of water temperature at each sample for the summer months of 1972-1973.

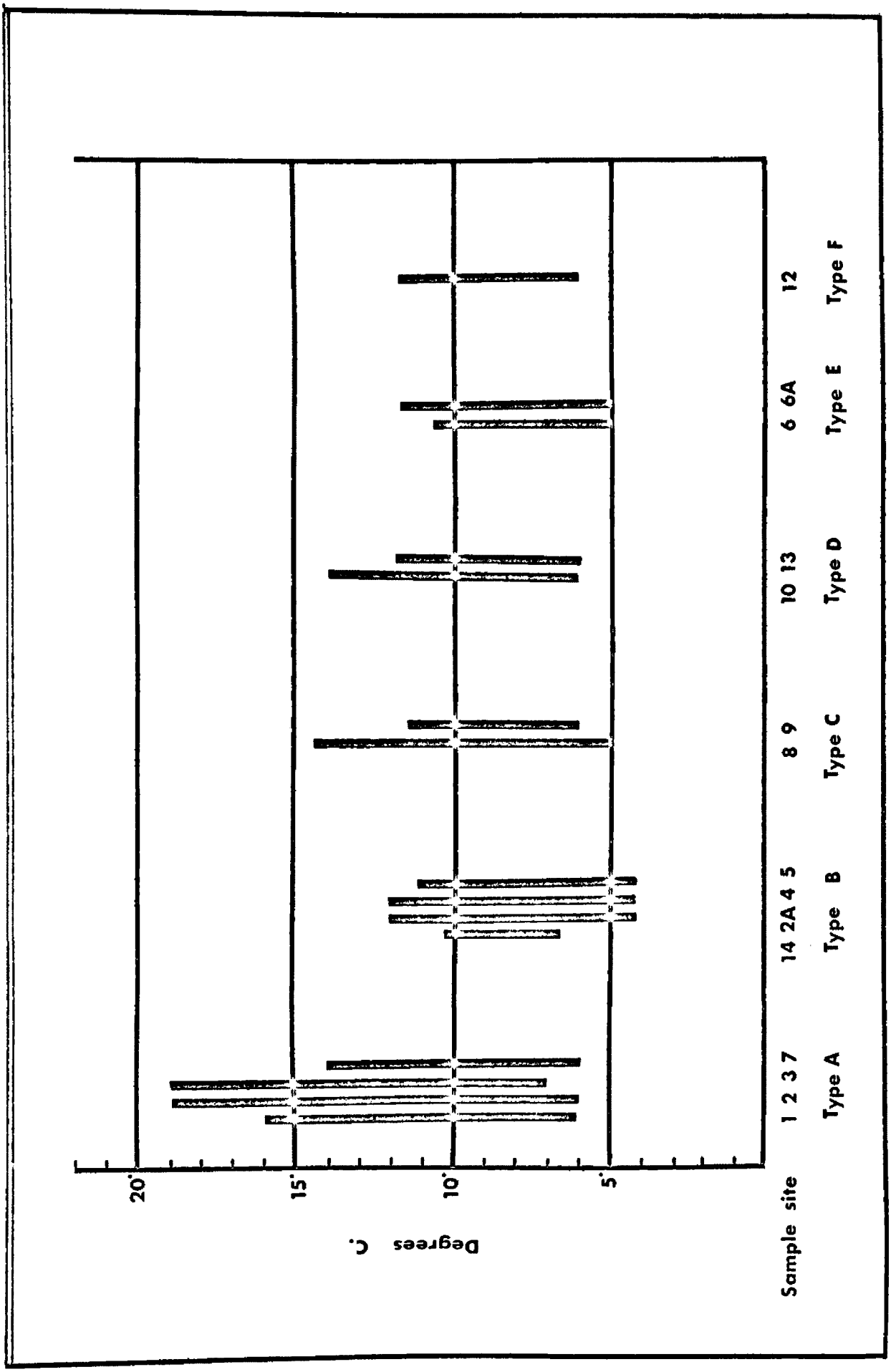
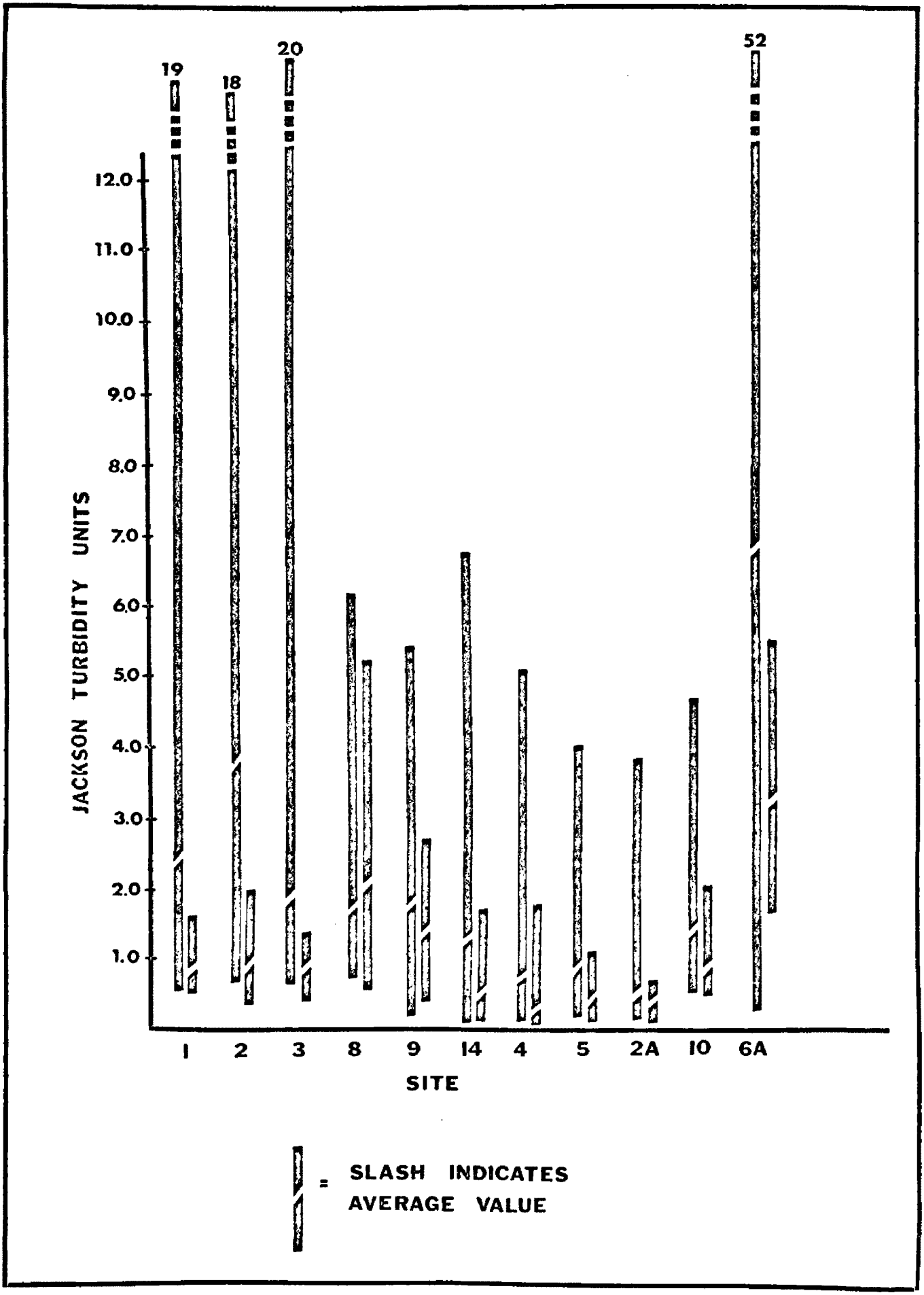


Fig. 10. Range of turbidity and the average turbidity for each sample site during the spring and summer months of 1973, as recorded by the U.S.F.S.. The first bar of each sample site represents the period from April to June, 1973. The second bar represents the period from July to Sept., 1973.



August for the sample sites in this classification (Fig. 8). This was the greatest temperature range exhibited by any of the sites within the drainage (Fig. 9). In a previous study of the physical characteristics of the sample sites by the University of Oklahoma, it was found that the greatest temperature range was exhibited by the tributary streams. No explanation was discussed, however, the data showed that the high temperatures recorded for the tributary streams represented a short duration, and that in fact, the tributary streams had a much lower yearly average temperature than did main Rock Creek. Depending on the snow-pack, and summer weather patterns, the tributary streams may occasionally reach daytime temperatures higher than those recorded for main Rock Creek; however, the yearly average temperature for the main Rock Creek will remain much above that exhibited by the tributary streams.

The range of turbidity recorded for the sites in the classification greatly exceeds that of any other sites, with the exception of site 6A (Fig. 10). This high level of turbidity is of short duration, though, and the sites soon return to an average turbidity level more closely paralleling that of the other sites.

The velocity of the water along this section of stream averages approximately 2.45 f.p.s.. The substrate ranges from large boulders to areas of fine organic debris and sand.

The physical characteristics exhibited by the sample sites in the Type A stream classification present a wide range of conditions to any organism found to occur there. The niche range is extremely large within the sample sites of this classification.

The sample sites of this classification exhibited the greatest aquatic insect diversity within any "Type" stream in the drainage. Members of thirty-six species were collected from sample sites 1,2,3, and 7. Eleven genera were collected that were not identified beyond the generic level, and eleven families were represented that were identified only to a family level. This gave the Type A sample sites a total of fifty-six taxa found to occur during the study period. This was representative of the increased range of habitats and micro-habitats presented by the sample sites on the main channel of Rock Creek, the largest stream considered in the study.

Eleven species of the order Plecoptera were found to occur in the sample sites. In addition, four genera were collected that were not identified beyond the generic level. This stream classification exhibited the greatest number of plecopteran species classified as occurring very commonly.

The most striking feature of the plecopteran fauna was the abundance of the species Pteronarcys californica at each of the sample sites. The species was collected in great numbers during each of the sampling trips. It was found to occur as commonly in only one other stream classification. Pteronarcys californica generally occur under large rocks where there is an accumulation of debris (Gaufin, Ricker, Miner, Hays, 1972). The large substrate size of the sample sites, and the organic debris that it trapped around itself provided an ideal habitat for Pteronarcys californica. The species has a three-year life cycle, and there were three size classes of nymphs collected. This fact may have accounted for the abundance of the species in the form of nymphs. The species is vegetarian.

Another nymph that was collected very commonly was Pteronarcella badia. The distribution of the species closely parallels that of Pteronarcys californica (Gaufin, Ricker, Miner, Milam, Hays, 1972). It was found to occur elsewhere, although rarely.

Nymphs of the genus Nemoura were commonly collected from the sample sites of this classification. The lack of an adequate key to the nymphal species of the genus prevented the indentification of the nymphs. However, one species was tentatively identified. The species was identified as Nemoura columbiana. The species is common in Montana creeks and rivers (Gaufin, Ricker, Miner, Milam, Hays, 1972).

Nymphs of the genus Capnia and Brachyptera were collected from the sample sites, although rarely. The occurrence of these genera throughout the drainage was not common.

Arcynopteryx curvata or parallela or compacta was collected very commonly from the sample sites. The construction of the key used to identify the species of the genus does not allow for the differentiation of the three species listed above. The nymphal section of the key ends with the remaining possibilites of Arcynopteryx curvata, A. parallela, or A. compacta. Because of this, the nymphs that were identifed to this section of the key have been listed as Arcynopteryx curvata, or parallela, or compacta. The other species of Arcynopteryx that was found to occur in the sample sites was Arcynopteryx aurea. The collection of A. aurea was the only occurrence of the species within the sample sites of the drainage, with the exception of the rare collection from Type C streams.

Nymphs of Isogenus modestus and I. aestivalis were collected, although not commonly. Miner (1968) reported the collection of one adult Isogenus from the main Rock Creek area. The species was

identified as I. pilatus.

Isoperla fulva was collected very commonly from the sample sites. This was the only collection of the genus Isoperla from the drainage. The species was found to occur in all the sample sites with the exception of site 1. Miner (1968) reported the abundant collection of the species (adults) from the sites on main Rock Creek. He reported it absent from the sample sites on the tributaries.

The genus Alloperla was found to occur very commonly in the sample sites, as it did in all the sample sites of the drainage. The lack of a key to the nymphs prevented indentification of the specimens. On one occasion a collection of Alloperla adults was made at site 3. The species identified from the adults found at site 3 were Alloperla severa, and A. coloradensis. Miner (1968) reported the collection of six species of adult Alloperla from the sample sites on main Rock Creek, two of which were the species identified above. His collection of A. coloradensis was the most abundant collection of Alloperla found to occur in his main Rock Creek samples.

Acroneuria californica or theodora was collected not commonly . The construction of the key prevented the differentiation of the species Acroneuria californica, and A. theodora when using nymphs to identify the species. The nymphs identified have been listed as Acroneuria californica or theodora. Miner (1968) reported the occurrence of both species in the Rock Creek drainage. His data showed the collection of one adult Acroneuria californica from his main Rock Creek sample sites. Both species are common in streams throughout the state (Gaufin, Ricker, Miner, Milam, Hays, 1972).

Nymphs of another species of the genus Acroneuria, A. pacifica

were found to occur commonly. Miner (1968) reported the species to be the most abundant of the Acroneuria species collected from the main Rock Creek sample sites. The species was found to occur frequently in all the sample sites of the Type A classification with the exception of site 1.

Nymphs of the species Claassenia sabulosa, and Diura knowltoni were collected very commonly from each sample site, with the exception of site 3. Diura knowltoni was absent from site 3. Miner (1968) reported the collection of six adult Claassenia sabulosa from the sample sites on main Rock Creek. He did not report the collection of the species Diura knowltoni from the drainage.

Twenty-two species of the order Ephemeroptera were identified from the sample sites in the Type A stream classification. In addition, the nymphs of two genera were collected that were not identified beyond the generic level.

The genus Ephemerella exhibited the greatest species diversity, with nine species that were identified. The only species of the genus that was found to occur very commonly was Ephemerella doddsi. Nymphs of the species were collected frequently from all the sample sites within the drainage.

Nymphs of the species Ephemerella heterocaudata, E. flavilinea, E. inermis, E. spinifera, and E. grandis were found to occur not commonly in the sample sites.

Ephemerella tibialis, E. hecuba, and E. coloradensis were collected only rarely.

Three species of the genus Epeorus were identified from the

sample sites of the Type A stream classification. Epeorus albertae was found to occur commonly in each of the sample sites. The only other collection of the species from the drainage was from site 9, where it was collected rarely.

Epeorus longimanus was found to occur not commonly. The distribution of the species was widespread throughout the drainage.

Epeorus deceptivus was collected rarely. The distribution of the species was also widespread.

Nymphs of the genus Cinygmula were found to occur commonly in the sample sites. Identification of the species of the nymphs was not possible because of the lack of an adequate key.

Baetis parvus was collected commonly from the sample sites. The distribution of the species is widespread throughout the drainage.

Baetis alexandria, and B. intermedious were collected not commonly. The only other collection of B. alexandria was from site 13, where its occurrence was very common.

Two species of the genus Rithrogenia were collected. Rithrogenia undulata, and R. hageni were found to occur rarely in the sample sites.

Three species of the genus Ameletus were collected. Ameletus validus, A. cooki, and A. sparsatus were found to occur rarely. The collection of the species A. sparsatus was the only occurrence of the species within the drainage.

Nymphs of the genus Paraleptophlebia were collected rarely from the sample sites, occurring only in site 7.

Eleven taxa of the order Trichoptera were found to occur in the sample sites of Type A stream classification. Parapsyche elsis was

found to occur commonly in sites 2 and 3. The species was absent from sites 1 and 7.

The species Arctopsyche grandis was found to occur very commonly in each of the sample sites. The distribution of the species was widespread throughout the drainage.

The genus Rhyacophila was collected rarely from the sample sites. The genus Brachycentrus was found to occur commonly. The distribution of the genus was widespread throughout the drainage. The genus Hydropsyche was collected not commonly. The genus was collected only from sites 2 and 3 within the sample sites of the drainage. The genus Leptocella was collected very commonly from each of the sample sites. The distribution of the genus was widespread.

Three families, Lepidostomidae, Psychomyiidae, and Philopotamidae were collected rarely from the sample sites of the Type A stream classification.

The family Limnophilidae was found to be very common at each of the sample sites. The distribution of the family was widespread.

→ The order Diptera was represented by five taxa of aquatic insects in the sample sites of the Type A stream classification.

The species Atherix variegata was collected very commonly from each of the sample sites. The distribution of the species appears limited to the main stream and large tributaries typical of the Type B classification.

The genus Hexatoma, of the family Tipulidae, was collected very commonly from each of the sample sites. Other larvae of the family Tipulidae that were not identified were found to also occur commonly at each of the sample sites.

The families Simulidae, and Tendipedidae were commonly collected from each of the sample sites.

Three families of the order Coleoptera were found to occur in the sample sites of the Type A stream classification. The family Elmidae was found to occur not commonly. The families Haliplidae and Dytiscidae were collected less frequently, occurring rarely.

TYPE - B

Included in this classification is Grizzly Creek (site 14), Welcome Creek (site 2A), Alder Creek (site 4), and Wyman Creek (site 5). These streams are all small, fast flowing, oligotrophic tributaries of Rock Creek. Three of the streams originate in the high mountainous areas that border Rock Creek to the west. The exception, Grizzly Creek, originates in the mountainous area along the east side of Rock Creek. All the streams originate above 5300 feet elevation, with the exception of Grizzly Creek. Grizzly Creek originates at approximately 4500 feet elevation. All the streams terminate between 4000 feet and 4400 feet elevation.

All the streams exhibit a high average gradient, with the exception of Grizzly Creek. The average gradient of Grizzly Creek is 2.2%. Wyman Creek has the highest average gradient, it being near 7%. (Haugen, 1971)

The substrate of the streams in this classification is predominatly granitic, ranging in size from coarse gravel to fine rubble. Areas of fine organic debris and sand are present at all site. These areas occur along the areas of stream characterised by reduced flow, or near the stream sides. The substrate of the pools fromed by the streams

flowing over debris blocking their channel is often organic.

Water flow at all sites is at times torrential. Measured water velocities for each site range from 1.7 f.p.s. to 2.8 f.p.s. (Haugen, 1971). The early spring of 1972 was characterised by very high peak discharges from Rock Creek and the tributaries. Severe scouring occurred in Rock Creek and many of the tributaries during that period.

The average water temperature during the months of June, July, and August for each of the streams included in Type B tributaries is lower than that recorded for the streams included in the other classifications (Fig. 8). This is caused, in part, by the heavy growth of streamside vegetation at each location. This reduces the amount of solar radiation available to warm the waters. Each of the streams flows through narrow, timbered canyons, which also limits the amount of solar radiation reaching the streams. Reid (1961) stated that the major factor in the warming of stream waters is direct solar radiation. Reid attributed the cooler water temperatures typical of tributaries arising in mountainous areas to "cooling by the substrate, by the shading provided by vegetation, and possibly by the entrance of spring-fed tributaries." The fact that the reduced amount of sunlight reaching the bottom of the canyons allows accumulated snow and ice to remain longer than in the adjacent areas of the valley floor, also prolongs any warming of the waters.

The streams in this category exhibit lower average turbidity levels (Fig. 10) than do those of the other classifications. All the sites have minimum values lower than the other sites in the drainage. The highest levels recorded in each stream represent only a short duration of time.

The average width, and average depth of each stream are less than the other streams in the drainage (Table 3). The depth averages from 4 inches to 6 inches, with occasional areas of deeper water. The width of the streams in this classification ranges from 3 feet to 10 feet.

Members of twenty-four genera, and fourty-two species of aquatic insects were found to occur in the streams of Type B classification. These streams exhibit the second highest number of taxa for any stream classification.

Two genera of the order Plecoptera were found to occur very often in these streams. They are Peltoperla, and Nemoura. Peltoperla brevis occurs only in the streams of Type B classification. It is absent in all other sample sites within the drainage. The occurrence of Peltoperla brevis appears to be limited to the small, fast flowing, granitic tributaries of Rock Creek. Miner (1968) reports finding adult Peltoperla at locations on Rock Creek itself, however it is to be noted that at each of these locations, there is a tributary stream entering Rock Creek. It is highly probably the Peltoperla adults were entering the area from the tributary stream.

The genus Nemoura is represented by four species in Type B streams. Nemoura cinctipes, and Nemoura columbiana were found to occur most frequently, while Nemoura haysii, and Nemoura cataractae occurred only rarely. Nemoura cinctipes is the only species to occur at each site in the classification. It is the most common species of Nemoura found in Montana (Gaufin, Ricker, Miner, Milam, Hays, 1972).

The genera Capnia, Brachyptera, and Pteronarcys were found to occur only occasionally in Type B streams. Capnia was found most

frequently in Welcome Creek, and Grizzly Creek. It is probable that it also occurs at the other sites; however, no nymphs were found. The small size of the nymphs undoubtedly caused many of them to be overlooked when the sample screen was picked. This could account from them not being found with any frequency at any site in the drainage. It is probable that the distribution of the genus Capnia is widespread.

Brachyptera occurred only rarely in the streams of this classification. It's occurrence was limited to Welcome Creek, and Grizzly Creek. It's rare occurrence may be caused by the habit of the nymphs of burrowing deeply into loose substrate. In the January sample at Welcome Creek, the nymphs were so numerous as to clog the net, whereas the next month they were not found. This could have been a prelude to emergence, as the adults of the genus emerge from February to July. Miner (1968) reported identifiing the adults of Brachyptera occidentalis, and B. nigripennis from the Rock Creek drainage.

Pteronarcys californica was found to occur very rarely in the streams of this classification. A single specimen was found in the September sample from Grizzly Creek. Welcome Creek exhibited a more frequent occurrence of Pteronarcys californica, however, it is to be noted that the sample site on Welcome Creek is close to the confluence with Rock Creek. It is probable that Pteronarcys has invaded the stream from Rock Creek. The occurrence of Pteronarcys in Rock Creek immediately below Welcome Creek is very frequent, and they are abundant at that location. Miner (1968) reported finding Pteronarcys only rarely in the tributary streams of Rock Creek.

Three species of the genus Arcynopteryx were found to occur in Type B tributary streams. The occurrence of Arcynopteryx signata or Arcynopteryx was very common in all four streams of this classification. Identification of the nymphs of A. signata and A. watertoni was not possible because of the lack of a nymphal key for the genus. Using the adult key it was possible to identify the nymphs of some Arcynopteryx to species, although the construction of the key prohibited this from being done with the species A. signata and A. watertoni. Because of this, the nymphs collected (other than those identified to known species) are listed as being A. signata or A. watertoni. Miner (1968) confirmed the occurrence of both A. signata and A. watertoni (adults) from the Rock Creek drainage. Miner also reported their occurrence as being limited to the "small stony stream" classification of his paper, with the exception of one other reported occurrence. That occurrence is in Grizzly Creek, which Miner lists as a "small high stony stream". Both A. signata and A. watertoni are common in fast flowing creeks and streams thoughout the state (Gaufin, Ricker, Miner, Milam, Hays, 1972).

Arcynopteryx bradleyi was found to occur in each site of Type B tributaries, with the exception of Grizzly Creek. It appears limited in it's occurrence to the other sites of this classification in the Rock Creek drainage. The species is found in Montana creeks, but it is rare (Gaufin, Ricker, Miner, Milam, Hays, 1972).

Arcynopteryx aurea was found to occur only in Welcome Creek, and Alder Creek. It's occurrence was limited to one occasion, during the month of July at both sites. Sheldon (1972) in a study of the comparative ecology of Arcynopteryx and Diura in Sagehen Creek,

California, reported that A. aurea was a food specialist which was rare although it can occupy a wide range of habitat.

The genus Isogenus is represented by two species in Type B tributaries. I. modestus occurs commonly at all sites in the classification, however, I. aestivalis occurs only in Wyman Creek. The occurrence of I. aestivalis in Wyman Creek is, however, very common. Miner (1968) reported the occurrence of a single species, I. pilatus from Rock Creek near the Walberg Bridge, with the collection of a single adult.

Paraperla frontalis was found to occur only in Welcome Creek. It was collected on five occasions. Miner (1968) reported only a single adult collection of P. frontalis from his classification of small stony streams.

Utaperla sopladora occurred only in Alder Creek in the Type B tributaries. It was collected during the autumn and spring months at this location. Miner (1968) reported the collection of three U. sopladora adults from his classification of small stony streams, and small high stoney streams in the Rock Creek drainage.

The genus Alloperla occurred very commonly at all the locations of Type B tributaries. The lack of a nymphal key for the genus prevented the identification of the species of this genus. This was unfortunate, as Miner (1968), using adult specimens, identified eleven species of the genus as occurring in the drainage. Six of the species identified by Miner were reported to occur in streams listed as Type B tributaries in this paper. Miner stated that the genus Alloperla was the most abundant genus of Plecoptera associated with this habitat. Alloperla fidelis was found by Miner to be the

most abundant species in these streams, with 284 adults collected from Welcome Creek.

During the June 23, 1973 collection trip, adults of the genus Alloperla were collected at Alder Creek. These were identified as members of the species Alloperla fidelis, and A. coloradensis. Both were reported to occur in the small stoney streams of Rock Creek by Miner (1968).

Three species of the genus Acroneuria are known to occur in the State of Montana. Each of the species was reported by Miner to occur in the Rock Creek drainage. Acroneuria californica or theodora occurred commonly in three of the sites in Type B tributaries, the exception was Grizzly Creek (site 14) where it was absent.

Acroneuria pacifica was limited in it's occurrence in Type B tributaries to Wyman Creek and Grizzly Creek. It was found by Miner (1968) to be the most abundant species of Acroneuria occurring in the Rock Creek drainage.

Claassenia sabulosa was found to occur commonly in two of the streams in Type B tributaries. These streams are Welcome Creek, and Wyman Creek. Miner (1968) reported the collection of adult specimens of C. sabulosa from only a single site on Rock Creek.

Ephemeroptera representing eight genera, and nineteen species were found to occur in Type B tributary streams in the Rock Creek drainage. Representatives of each genus found in the drainage were collected from the Type B tributaries. There were six species collected very commonly, and thriteen species that were found not commonly, or rarely. The number of ephemeropteran species in each

occurrence category closely paralleled the number of plecopteran species in each category.

The genus Ephemerella exhibited the greatest diversity of species within the Type B tributaries. There were seven species found to occur in the streams. Two species of Ephemerella were found to occur very commonly; Ephemerella doddsi, and E. spinifera. Both of these species occurred at each site in the classification, and madeup the majority of specimens of Ephemerella collected.

Ephemerella flavilinea was collected from two sites, Grizzly Creek and Alder Creek. It's occurrence was common in each of the streams.

Ephemerella inermis, E. hystrix, E. coloradensis, and E. grandis were collected rarely. Ephemerella inermis was collected from Alder Creek, and Wyman Creek.

Wyman Creek was found to have the only specimens of Ephemerella coloradensis collected from Type B tributaries.

Ephemerella hystrix was collected from Welcome Creek and Grizzly Creek. A single collection during the month of July was the extent of the occurrence of the species in Grizzly Creek. E. hystrix was found to occur during a five-month period in Welcome Creek. It was collected most commonly during the spring and summer months.

Ephemerella grandis was collected during five months from Grizzly Creek. The occurrence of the species was limited to the autumn and winter months, with a collection again in March.

Three species of the genus Epeorus were found to occur in the streams of Type B tributaries in the Rock Creek drainage. Epeorus deceptivus, and E. grandis were collected from each of the streams,

and occurred very commonly throughout the sample period.

Epeorus longimanus was found in both Wyman Creek and Alder Creek. It was very common in each of these streams. It was absent from Welcome Creek and Grizzly Creek.

The genus Cinygmula occurred very commonly in all streams of Type B tributaries. The lack of a nymphal key to the species of this genus prevented their identification. There are undoubtedly several species present in the drainage, as the distribution of the genus is general.

The genus Baetis was represented by three species in the streams of Type B tributaries. Baetis bicaudatus is the most common, and is found very commonly in each stream of this classification.

Baetis intermedious was found to occur in Welcome Creek and Alder Creek. It was more common in Welcome Creek.

Two species of the genus Rithrogenia were collected. Rithrogenia robusta was collected from all the streams except Welcome Creek. The distribution of R. robusta appeared to be limited to the Type B tributaries of the Rock Creek drainage.

Rithrogenia undulata was found to occur in Welcome Creek and Alder Creek. The occurrence of the species in these streams was common.

The genus Ameletus was represented by three species in the streams of this classification. Ameltus validus was collected from Alder Creek and Welcome Creek.

Ameletus cooki, and A. similor were both found to occur in Wyman Creek. A. cooki was the more commonly collected species of this genus. Ameletus similor was less commonly collected.

The genus Siphlonurus was limited in it's occurrence to Grizzly

Creek. It was collected on four occasions from the stream.

A single species of the genus Paraleptophlebia was found to occur in the streams of Type B classification. Paraleptophlebia vaciva was collected from Welcome Creek on five occasions.

The order Trichoptera was represented by four genera, and four species in the streams of Type B tributaries. Also collected were three other families, the larvae of which were not identified to the generic level.

The larval key for the species of the genus Rhyacophila does not differentiate between the species Rhyacophila acropedes or R. vao. For this paper the species is listed as Rhyacophila acropedes or vao. Rhyacophila acropedes or vao, along with Parapsyche elsis were collected very commonly from each of the streams in Type B classification.

The family Limnephilidae was collected very commonly from each of the sites on the streams, with the exception of Alder Creek. Alder Creek suffered scouring from an excessive spring runoff during the spring of 1972. This could account for the absence of the case building Trichoptera.

Rhyacophila vaccua was collected commonly from each stream with the exception of Welcome Creek.

The collection of Rhyacophila tucula from the study streams was limited to Alder Creek. The occurrence of the species in Alder Creek was common.

The genus Brachycentrus was found to occur in Grizzly Creek and Wyman Creek. It was absent from the other streams in this classification.

The genus Leptocella was most commonly collected from Grizzly Creek.

The families Psychomyiidae, and Lepidostomidae occurred less commonly than the other families of the order Trichoptera.

Three families of Diptera were collected from the streams of Type B tributaries of Rock Creek. The family Tendipedidae was the most commonly collected family. It was absent from Grizzly Creek. The family Tipulidae was found to occur in Welcome Creek and Grizzly Creek. This family was the only family of Diptera collected from Grizzly Creek. The family Simulidae was collected commonly in Alder Creek and Wyman Creek.

The order Coleoptera was represented by two aquatic families in the streams of Type B classification. Adults of the family Haliplidae were collected from Welcome Creek and Grizzly Creek. Their occurrence as adults in these streams appeared to be limited to the spring and summer months, although the adults probably occurred throughout the winter months. Adults of some species have been reported to be active under as much as a foot of ice cover (Leech and Chandler, 1968).

The family Elmidae was found to occur in the larval form very commonly only in Grizzly Creek. It was absent from the other streams in this classification.

Type - C

Sample sites 8, on the West Fork of Rock Creek, and 9, on the Ross Fork, are the sample sites that comprise the Type C tributary streams. This type of stream is intermediate in size, between the small tributaries and the large main stream. The average gradient is moderate, approximately 2-3%. The yearly average temperature is usually higher than the average temperature for the small tributaries,

but lower than the temperature for the main stream sites.

Both sites 8 and 9 are located in open woodlands, with an altitudinal range from 5200 feet to 5500 feet.

Figure 6 illustrates the position of sites 8 and 9 in a graph which compares the average gradient with the stream width. The sample sites in this classification occupy an area in the lower portion of the left side of the graph, near sites 13 and 10. The difference in width of the sample sites separates the two site groups.

The range of temperature during the summer months (Fig. 9) is similar between sites 8 and 9, and 10 and 13, an indication of the general physical similarity between the site groupings. The water temperature range for both the sites represents temperatures that are intermediate, occurring between the highs of the main stream sites, and the low of the small tributary sites.

The range of turbidity for sites 8 and 9 is similar to the levels reached by the other tributaries; however, the averages are higher (Fig. 10). Only site 6A has a higher average turbidity level among the tributary streams.

The substrate at site 9 and site 8 ranges from coarse gravel (Table 3) to fine rubble, with occassional areas of larger substrate present.

Streams of the Type C tributaries have been found to have aquatic insects representing twenty different genera, and thirty-three species occurring in their waters. In addition to this there were eight families of aquatic insects found to occur that were not identified to the generic level.

The order Plecoptera was represented by seven genera and six

species which were found to occur in the Ross Fork and West Fork of Rock Creek. The nymphs of the genus Brachyptera, and the genus Alloperla were not identified as species because of the lack of a key for the nymphal forms.

Three genera of the suborder Filipalpia were found to occur in the two streams of Type C tributaries. The genus Nemoura was collected very commonly from each of the streams. Nemoura cinctipes was identified from nymphs taken from the West Fork. The nymphs of this genus taken from Ross Fork remained unidentified because of the lack of an adequate nymphal key.

The genus Brachyptera was collected on two occasions from the Ross Fork of Rock Creek. The collection of nymphs of Brachyptera in the entire drainage showed a more common occurrence during the winter months.

Pteronarcys californica was found to occur frequently in both streams of this classification. The collections of P. californica from the Ross Fork and West Fork of Rock Creek are the only other common occurrence of this species in streams other than the main channel of Rock Creek.

The suborder Setipalpia was represented by four genera from the collection sites on the Ross Fork and West Fork of Rock Creek. The genus Arcynopteryx was found to occur only on one occasion in the West Fork of Rock Creek. It was absent from the Ross Fork. The nymphs were identified as Arcynopteryx curvata, or A. parallela, or A. compacta. The species is listed as Arcynopteryx curvata, or parallela, or compacta. The only other collection of these nymphs was in the sample sites of Type A classification.

The genus Isogenus was commonly collected from each stream in the form of the species Isogenus aestivalis. However, a single collection of Isogenus modestus was taken from the West Fork of Rock Creek in August, 1972.

Nymphs of the genus Alloperla were collected very commonly at each of the streams. As noted previously, identification of the nymphs to species was not possible. Miner (1968) reported the collection of four species of adult Alloperla from the West Fork and Ross Fork of Rock Creek.

Acroneuria pacifica was the only species of the genus Acroneuria to be collected from the streams in this classification. The occurrence in each of the streams was very common.

Each genus of the order Ephemeroptera which was found to occur in the Rock Creek drainage, was found to occur in Type C tributaries, with the exception of the genus Siphlonurus.

The genus Ephemerella exhibited the greatest diversity of species with a total of ten species collected from the West Fork or Ross Fork of Rock Creek. Ephemerella doddsi was found to occur very commonly in both streams.

Ephemerella grandis occurred most commonly in samples taken from the West Fork of Rock Creek. It occurred in only one sample from Ross Fork.

Ephemerella heterocaudata, E. flavilinea, and E. inermis occurred only in the Ross Fork of Rock Creek. Their occurrence was common.

Ephemerella hystrix occurred commonly in the sample from the West Fork of Rock Creek. It occurred only in the January, 1973 sample from Ross Fork.

Also occurring commonly from the samples that were taken in the West Fork was Ephemerella spinifera. This species was absent from the Ross Fork.

Ephemerella tibialis was found to occur only in the West Fork of Rock Creek, where the occurrence was rare.

Ephemerella edmundsi and E. teresa were found to occur in the West Fork. This is the only occurrence of these species within the study streams of the drainage. Ephemerella edmundsi was found to occur very commonly, and E. teresa not commonly in the samples.

The genus Epeorus was represented by four species in the streams of Type C classification. Epeorus longimanus was commonly collected from both streams; however, it was found to occur more frequently in the samples from the West Fork of Rock Creek.

Epeorus deceptivus was collected frequently from the Ross Fork. It was absent from the West Fork.

Epeorus grandis occurred very commonly in the samples that were taken from the West Fork, and was absent from the Ross Fork.

Epeorus albertae was found to be not common in the collections from Ross Fork of Rock Creek. It was absent from the West Fork samples.

The genus Rithrogenia was represented by a single species in the Type C tributaries. Rithrogenia hageni occurred very commonly in each of the streams.

The genus Ameletus was found to occur frequently in each stream. Ameletus cooki was the most commonly collected species, with A. oregonensis collected on only one occasion. This collection was from Ross Fork.

Paraleptophlebia heteronea was found to occur in both streams of the Type C tributaries. It was collected more frequently from the West Fork.

Paraleptophlebia memorialis was collected from the Ross Fork on six occasions, during the winter and spring months of the sample period.

The order Trichoptera is represented by seven families, four of which were not identified to the generic level, within the stream of Type C tributaries.

The family Hydropsychidae was found to occur in both streams of this classification. The genus Parapsyche was represented by the species Parapsyche almota at both streams. Parapsyche almota was collected very commonly throughout the sample period.

Arctopsyche grandis was collected only from the samples that were taken from the West Fork of Rock Creek. The occurrence there was very common.

The family Rhyacophilidae, and the genus Rhyacophila, were found to occur only in the West Fork of Rock Creek in the Type C tributaries. Rhyacophila vaccua was collected very commonly from the West Fork. The only other occurrence of R. vaccua in the Rock Creek drainage was from the streams of the Type B tributaries.

The genus Brachycentrus was collected commonly from both streams in the Type C tributaries. It was found to occur more frequently in the samples taken from the Ross Fork.

The family Limnephilidae occurred very commonly in the samples from the Ross Fork. It was absent from those taken in the West Fork.

The families Leptoceridae and Philopotamidae occurred only rarely

in the streams of Type C tributaries.

The family Lepidostomidae was collected from the West Fork of Rock Creek, and was found to occur commonly in the samples.

Each family of the order Diptera that was found to occur in the Rock Creek drainage was also found to occur in the streams of Type C tributaries. The families Tipulidae and Tendipedidae were collected very commonly from both streams, as were the genera Atherix and Hexatoma.

The family Simulidae was collected less commonly than the other families of the order Diptera. The family was collected most frequently from the Ross Fork of Rock Creek.

The order Coleoptera was represented by a single family in the Type C tributaries. The family Elmidae was collected from both streams. It was common in it's occurrence.

Type - D

A single large tributary stream, the Middle Fork of Rock Creek, was included in the Type D stream classification. Sample sites 10 and 13 are located on the Middle Fork of Rock Creek. Site 10 is located on a section of the stream that flows through a timbered valley, above the open grasslands in which site 13 is located.

Because of the general topographical differences between the two sites, and the difference in limiting factors that this may indicate, site 10 has been placed in a separate "class" than site 13. The average gradient of site 10 is greater (Table 3) than that found to occur at site 13. Because of this, site 10 had a generally more turbulent flow than did site 13.

The average summer water temperatures recorded for both classes was similar, as was the water temperature range (Fig. 9) exhibited by both classes.

There were no turbidity measurements taken for site 13; however, the measurements taken for site 10 indicate average values above those of the small tributaries, and similar to sites 8 and 9 (Fig. 10).

The substrate found at both sites is similar, ranging from coarse gravel to fine rubble with occasional areas of sand or fine organic debris present. The width of both sample sites is approximately thirty-five to forty feet.

As with the Type C sample sites, the separation of sites 10 and 13 into separate classification, and a further division into "classes" is supported by the collected biological data.

There were sixteen species of aquatic insects collected from Class 1 (site 10), and five genera that were not keyed beyond the generic level. In addition, there were three families collected that were not identified to the generic level.

The order Plecoptera was represented by five species, and two genera that were not identified to a species level.

The species Acroneuria californica or theodora was very common; however, Acroneuria pacifica was found less commonly. This appeared to be the general rule for the distribution of the two species. If both species were present in a sample site, one species was found to occur more commonly than the other species. This may be an indication of a niche overlap between the two species.

The species Paraperla frontalis was not frequently collected, and is classified as not common.

The nymphs of the species Paraperla sopladora were collected. This was only one of two sites known to have a population of Paraperla sopladora present. The species was collected rarely.

The order Ephemereoptera was represented by ten species, and two genera that were not identified as species. Four species of the genus Ephemerella were collected. Ephemerella doddsi and E. flavilinea, along with E. spinifera were found very commonly. Nymphs of the species Ephemerella coloradensis were collected less frequently. E. spinifera and E. colradensis were not found in the samples from Class 2.

Three species of the genus Epeorus were collected. Epeorus longimanus and Epeorus grandis were found to occur very commonly. Also collected, although occurring less frequently, was the species E. deceptivus.

Nymphs of the genus Cinygmula were collected frequently, and are classified as very common.

Baetis bicaudatus, which occurs frequently throughout the drainage, was found in all but a few of the samples from site 10.

Rithrogenia undulata and Ameletus cooki were collected commonly. These species are absent from Class 2.

The order Trichoptera was represented by the collection of one species, and two genera that were not identified beyond the generic level. In addition, one family was collected that was not identified beyond the family level.

Larvae of the family Psychomyiidae were collected frequently. The family was not collected from Class 2.

The species Arctopsyche grandis, and the nymphs of the genus

Brachycentrus were found very commonly in site 10. The larvae of Arctopsyche grandis was not collected from class 2.

Larvae of the genus Rhyacophila were found to occur commonly. The genus is absent from class 2.

Two families, Tipulidae and Tendipedidae, of the order Diptera were collected frequently, and were classified as very common during the study period.

The genus Hexatoma was identified as one of the larvae of the family Tendipedidae collected. Other larvae were collected, but were not identified.

The plecopteran fauna present in Class 2 was generally similar to that found in Class 1. There was, however, two striking differences. Acroneuria californica or theodora, classified as very common at site 10, was absent from the samples taken from site 13. Acroneuria pacifica was collected frequently.

The other difference was the frequent occurrence of Claassenia sabulosa at site 13. Claassenia sabulosa was absnet from the samples that were collected from site 10. It appeared as though the species may have prefered to inhabit streams that have a generally lower gradient, and increased depth. Claassenia sabulosa was found frequently in sample sites of Type E and Type A stream classifications. It occurs in sites 2A and 4 of Type B streams as well, although it does not do so with any regularity.

Four species of the order Ephemeroptera were found to occur frequently at site 13 that were absent from site 10.

The species Ephemerella tibialis, E. micheneri, Baetis alexandria, and Rithrogenia hageni were found to occur very commonly at site 13.

These species were absent from site 10.

Nymphs of the genus Paraleptophlebia were also frequently collected from site 13. This genus was not collected from site 10.

The nymphs of Baetis parvus, and Baetis intermedious were collected only rarely. The two species were absent from site 10.

The species Parapsyche elsis, of the order Trichoptera was found to very common in it's occurrence at site 13. This species was absent from site 10.

Type - E

Sites 6A and 6 on Willow Creek represent the sample sites in this stream classification. Site 6 is located on upper Willow Creek approximately fifteen miles upstream from site 6A. Site 6A is located on Willow Creek near it's confluence with Rock Creek. A generally reduced velocity, greater average depth, and a meandering course through a grassland valley differentiate the physical description of Willow Creek from the other tributary streams.

A striking difference in physical data collected from Willow Creek was the high average level of turbidity that was found to occur in the stream (Fig. 10). The range of turbidity exceeds that from all sample sites in the drainage.

The stream is discolored with fine organic debris much of the year. The large number of cattle grazing near the stream and the natural bogginess of the area increase the discoloration and add to the turbidity of the stream.

The summer water temperature of sites 6A and 6 (Fig. 9) are

similar to that of the other tributaries, but are generally lower. The substrate of Willow Creek ranges from coarse gravel to large areas of fine organic debris.

The aquatic insects of the Type E tributary streams exhibit the second lowest diversity of any Type stream classification in the drainage. The seasonal condition of the road accounted for only five sampling trips during the study period. Because of this, the data for the insects that were collected from site 6 are incomplete, and no attempt to relate their seasonal occurrence to a classification will be taken. The discussion of the insects of site 6 will be limited to a present or absent level.

Adult insects representing sixteen genera were found to occur in Willow Creek. In addition to this three families of the order Diptera were collected that were not identified to the generic level.

Plecoptera representing six genera were collected from Willow Creek. Miner (1968) reported the collection of two genera of adult Plecoptera from Upper Willow Creek.

The genus Nemoura was found to occur at both site 6A and site 6. The occurrence at site 6A was very common. The nymphs could not be identified as species.

The genus Leuctra was collected very commonly from site 6A. This was the only reported occurrence for this genus in the drainage. It was not collected from site 6.

The genus Isogenus was collected very commonly from site 6A. Isogenus aestivalis, and I. modestus were both found to occur frequently. This genus was absent from site 6.

The genus Alloperla occurred very commonly in both site 6A and site 6. The nymphs were not identified to species. Miner (1968) reported the occurrence of adults of Alloperla medveda, and A. fidelis in upper Willow Creek.

Acroneuria pacifica, and Claassenia sabulosa were found to occur very commonly in site 6A. They were absent from site 6.

The order Ephemeroptera was represented by five genera and thirteen species in the Type E tributary. The genus Ephemerella exhibited the greatest diversity of species for any genus of aquatic insect collected in Willow Creek. Ephemerella flavilinea and E. grandis were found to occur togenther in site 6A and site 6. Their occurrence in site 6A was very common.

Ephemerella coloradensis and E. micheneri were also found to occur at both sites on Willow Creek. The occurrence of the species were less common than those previous mentioned.

Two species of Ephemerella were collected exclusively from one site or the other on Willow Creek. Ephemerella hystrix was collected very commonly from site 6A, and was absent from site 6. Ephemerella spinifera was collected from site 6 on upper Willow Creek, and was absent from site 6A.

Epeorus longimanus was collected from site 6A only. It was found to occur more frequently than E. deceptivus in the collections from site 6A.

The genus Cinygmula was collected from both site 6A and site 6 on Willow Creek. It was collected very commonly from site 6A.

Four species of the genus Baetis were found to occur in Willow Creek. Baetis bicaudatus and B. parvus were collected from

both sites. Their occurrence in site 6A was very common.

Baetis tricuadatus and B. intermedious were collected only from site 6A. Baetis tricaudatus was found to occur very commonly, whereas Baetis intermedious was collected on only four occasions.

Rithrogenia hageni was collected from site 6A very commonly during the study period. It was absent from site 6.

Three genera from the order Trichoptera were found to occur in Willow Creek. Specimens of the family Leptoceridae were also collected. This family was not identified to the generic level.

Arctopsyche grandis, and Rhyacophila acropedes or yao were collected from both sites. They were found to occur very commonly at site 6A.

The occurrence of Rhyacophila angelita in Willow Creek was the only collection of the species from any of the study streams. It was collected from site 6A commonly.

Larvae of the genera Brachycentrus and Leptocella were collected from site 6A. The occurrence of both genera was very common.

The order Diptera was represented in Willow Creek by three families and one identified genus. The families Simulidae and Tendipedidae occurred in both site 6A, and site 6 in Willow Creek. Both families were collected very commonly, although the family Tendipedidae was collected more frequently at site 6A.

Type - F

Since this stream classification includes a single sample site on a single tributary (East Fork), please refer to the description of site 12 in the Description of Sample Sites section

of this paper for the physical characteristics.

Site 12 is located on the East Fork of Rock Creek immediately below the East Fork Dam and Reservoir. A diversion channel used for irrigation water is located at this site. During times of drought or dry weather during the summer months, much of the water of the East Fork of Rock Creek is diverted through this channel. This has an effect on the aquatic insects that occur there, and will be discussed in the Conclusion section of this paper.

Because of the seasonal condition of the road, only six sample trips were made. The seasonal occurrence of each aquatic insect will not be discussed because of this; however, those insects collected tended to be present in each sample that was taken. The community of aquatic insects present at site 12, although low in diversity, appeared to exhibit a very stable community structure.

The order Plecoptera is represented by nymphs from four genera at site 12. Nymphs of the genera Nemoura, Pteronarcella, Alloperla, and Acroneuria were collected during the study period.

Nymphs of the species Nemoura flexura were found to occur in four of the six samples taken at site 12. Miner (1968) found that Nemoura flexura was collected most abundantly in the small, stony stream of the drainage.

Pteronarcella badia was found to occur in five of the samples taken during the study period. It's occurrence at this site is puzzling, as it is usually found to occur in association with Pteronarcys californica in the larger streams and rivers of a drainage (Gaufin, Ricker, Miner, Milam, Hays 1972).

Nymphs of the genus Alloperla were collected from site 12

during each sample trip.

Acroneuria pacifica was also collected during each sample trip. This was the only large aquatic insect found to occur at site 12. Nymphs of Acroneuria pacifica are carnivorous, and are apparently the top carnivore at site 12. The lack of abundant forage for the carnivores at site 12 could explain the lack of more large carnivores. Unless environmental conditions improve at site 12, it is probablye that the community of aquatic insects present could not support another large carnivore.

Three genera of the order Ephemeroptera were collected from site 12: Ephemerella, Epeorus, and Baetis.

Epeorus longimanus was found to occur on four occasions, and Baetis parvus was collected on each sample trip to the site.

The diversity of the order Ephemereoptera is severely reduced at site 12, when compared with the other sites on streams within the Rock Creek drainage. The seasonal fluctuation in water levels may be the reason for this.

The genus Rhyacophila was found to occur at site 12, along with the family Limnophilidae. These were the only representatives of the order Trichoptera collected from this site. No members of the net-spinning Trichoptera were collected. In his paper regarding the populations of aquatic insects found in regulated streams, Radford (1970) stated that the absence of net-spinning forms may be caused by an inability of some forms to maintain their abode in fluctuating water levels and velocities, as their nets would probably not be operative over a wide range of conditions.

Two families of the order Diptera were collected from site 12.

Larvae of the families Tipulidae (other than the genus Hexatoma), and Tendipedidae were collected on each sampling trip to the area.

CHAPTER IX

CONCLUSIONS

In the orders of aquatic insects that were found to occur in the sample sites of this study, there were genera and species that were found to be restricted in their occurrence and distribution. The reasons fro this are complex, and can only be speculated upon with the data which were obtained from this study. However, the fact that these genera and species are indeed selective in their distribution within the streams of the Rock Creek drainage will be valuable information in determining the ecology of the aquatic insects that inhabit the streams of the drainage.

Species that were found to be restricted in their distribution have been classified as "habitat specialists". Species that were found to have a widespread common occurrence in a number of various stream types have been called "habitat generalists". These classifications have been made for the purpose of determining a primary ecological versatility for the species of aquatic insects involved. Levins (1968) described ecological versatility as the "niche breadth" of a species, and gave a formula for obtaining the statistical value. For the purpose of this paper, the qualitative data that were obtained were used to indicate a species habitat preference. The terms "habitat generalist" and "habitat specialist" are not intended to be rigid categories. They are used in this paper to indicate trends of habitat preference only.

The species of the order Plecoptera that were found to be "habitat specialists" in their distribution include Peltoperla brevis,

Pteronarcys californica, Pteronarcella badia, Arcynopteryx signata or parallela or compacta, A. bradleyi, A. aurea, Isoperla fulva, and Diura knowltoni.

Species of the order Ephemeroptera that were found to be "habitat specialists" were Ephemerella hystrix, E. edmundsi, E. infrequens, E. hecuba, Epeorus albertae, Baetis tricaudatus, B. alexandria, Rithrogenia robusta, Ameletus similor, A. sparsatus, A. oregonensis, and Paraleptophlebia heteronea.

The fact that an aquatic insect may be classed as a "habitat specialist" does not necessarily indicate that the insect is specialized morphologically. Hynes (1972) stated that although the nymphs of the genus Ephemerella seem to prefer special well-defined stream habitats, they do so with no particularily associated morphological specialization.

Members of the order Trichoptera that were found to be "habitat specialists" included Parapsyche almota, Hydropsyche spp., and the family Psychomyiidae.

The only species of the order Diptera that was found to be a "habitat specialist" was Atherix variegata. This species was restricted in it's occurrence to the sample sites on Main Rock Creek, and the larger tributaries. It was absent from all sample sites on the small tributaries of the Type B stream classification.

Members of the order Plecoptera that I have included in the "habitat generalist" classification include the genera Nemoura, and Alloperla, and the species Isogenus aestivalis, Isogenus modestus, Acroneuria pacifica, and Claassenia sabulosa.

The genera Nemoura and Alloperla are included with a note of caution, as this represents the generic level only, and does not indicate that the species of these genera are also "habitat generalists". Nymphs of both genera were collected commonly from all the sample sites. The lack of a key to the nymphal species prevented the identification of the nymphs. Miner (1968) suggested that some of the species of the genera Nemoura, and Alloperla exhibit habitat preferences in the streams of the Rock Creek drainage.

The species of the order Ephemeroptera that are included in the "habitat generalist" classification are Ephemerella doddsi, E. flavilinea, E. spinifera, Epeorus longimanus, Epeorus deceptivus, E. grandis, Baetis bicaudatus, B. parvus, and Rithrogenia hageni. The genus Cinygmula has also been included.

It was interesting to note that the nymphs of Ephemerella doddsi, which were collected from every sample site except site 12, were entirely carnivorous (Muttkowski and Smith, 1929; Warren 1960). It may have been that the nymphs of Ephemerella doddsi were an opportunist predator, using their "habitat generalist" preference to allow them to compete effectively with the larger carnivores that are often "habitat specialists". It may also have been that the wide "niche breadth" exhibited by Ephemerella doddsi allowed the nymphs to become "niche opportunists" and occupy a wide variation of available niches throughout the drainage.

Another nymphs of the order Ephemeroptera that was collected commonly from each site in the drainage was Baetis bicaudatus. It may be that the "drift" characteristics of this species were the reason

for it's widespread distribution. Hynes (1972) stated that the species was one of the most active drifters of all aquatic insects exhibiting a drift characteristic. It may have been that the occurrence of B. bicaudatus in the headwater areas of the drainage, and the high drift characteristics allowed the species to become distributed throughout the entire drainage.

Members of the order Trichoptera that have been included in the "habitat generalist" classification include Parapsyche elsis, Arctopsyche grandis, the genera Brachycentrus and Leptocella, and the family Limnophilidae.

The families of the order Diptera that were found to be "habitat generalists" were the families Tipulidae, Simulidae, and Tendipedidae. Larvaal forms of these families were commonly collected from most of the sample sites.

The only member of the order Coleoptera that was collected commonly from most of the sample sites belonged to the family Elmidae.

The weaknesses of the habitat versatility classification include the crudeness of the habita distinctions and the limited number of aspects included. The relative interdependence of the dimensions suggests that other attributes, such as the use of microhabitats, might vary in such a way as to make every species a generalist in some dimensions, and a specialist in others (Sheldon, 1972). This is further demonstrated by a study by Linduska (1942) of mayfly distribution in relation to stream bottom types, in Rattlesnake Creek, Montana. He found that not only did mayflies exhibit a preference for certain sections of the stream, but that they also

were found to occur only a certain portion of the stones, such as the tope, side, or underside. The species classified as "habitat generalists" may be found in a number of streams, but they could also be called "habitat specialists" if they prefer to inhabit only a given location on the substrate. More detailed ecological studies will have to be conducted before an accurate differentiation between the two can be identified.

The merits of the habitat classifications are that they do establish a fundamental habitat preference for the speces of aquatic insects which occur in the Rock Creek drainage. This information will be of use in determining the basic ecology of the species invloved, the first step towards a better understanding of the factors involved in maintaining a high quality watershed.

By the nature of it's physical characteristics, main Rock Creek offers the widest variation of habitats and niches within the streams of the drainage. The data collected during this study support this assertion. The sample sites located on main Rock Creek exhibited the greatest species diversity within the sample sites of the drainage. The next highest species diversity was found to occur in the streams of the Type B tributary classification. The other sample sites exhibited a species diversity similar to the Type B streams, although lower.

The physical characteristics of each of the sample sites indicated that certain sample sites shared a general similarity. The degree of physical similarity between the sample sites, along with the biological similarity in the form of a similarity index for each

of the sites was used to classify the sample sites into stream "Types". The Types were listed as A) main Rock Creek, sample sites 1,2,3,and 7, B) small tributary streams, sites 2A, 4, 5, and 14, C) large tributary stream, sites 8 and 9, D) large tributary stream, sites 10 and 13, E) small, slow tributary stream, sites 6 and 6A, F) a regulated tributary, site 12. This system of classification is similar to the idea of "drainage analysis" proposed by Robert A. Horton. The classification acknowledges the fact that communities of aquatic insects will differ significantly as samples are taken progressively towards the headwaters of any stream drainage. Hynes (1972) stated that it is quite possible that the concept of stream order may prove to be of considerable value in biological studies in only to serve as an objective way of classifying watercourses. The concept of stream order is not a new one to biologists; however, its possible usefulness seems not to have been widely realized (Abell, 1961). It is hoped that the stream order presented in this paper for the streams of the Rock Creek drainage will be useful in the further studies of the ecology of the watershed.

The use effectively the qualitative data which were obtained in determining a hierarchy system for the sample sites of the Rock Creek drainage, a similarity index was used in the construction of two types of dendrograms. A dendrogram was constructed using the similarity index data in a regressionary form to illustrate a basic sample site hierarchy. A second dendrogram was constructed utilizing an average pair-group method of representing the similarity

values. From the dendrograms there appeared to be at least two major community structures present in the sample sites of the the study. The first of these is the community of aquatic insects present in the sites in the Type A stream; main Rock Creek. The second community is represented by the aquatic insects found to occur in the small tributary streams; sites 2A, 4, 5, and 14. A third community structure is indicated, although it is not as well defined as the other two. The structure of the third community is variable, with similarities exhibited with both the previous communities. The sites that comprise the loosely structured third community are generally located on the larger tributary streams of Rock Creek; site 10 and 13 (Middle Fork), site 8 (West Fork), site 9 (Ross Fork) and sites 6 and 6A (Willow Creek). Sites 8 and 9 were shown to have a greater similarity to the main stream sites (Type A), while site 10 exhibited a greater similarity with the small tributary sites (Type B). Sites 6 and 6A, as well as site 13 showed the greatest similarity with the community of aquatic insects formed by the combined communities of the two basic structures.

The community of aquatic insects present at site 12 on the East Fork of Rock Creek showed a dissimilarity to any of the other community types represented in either dendrogram hierarchy. This may be explained by the physical characteristics of site 12. The location of this site is immediately below the East Fork Reservoir. The fact that the stream is frequently subjected to a drawdown in water level for use in irrigation by a by-pass channel initiates a unique set of limiting factors. There is very low productivity

at site 12, evidenced by the fact that several more sample screenings had to be taken during each trip to obtain enough nymphs to make their identification possible. However, even though the productivity may have been low, the occurrence of the aquatic insects found at site 12 was very consistent. The same species were collected during each of the trips to the area. This confirms the findings of an earlier work done by D. S. Radford in Canada. Radford (1970) in a study of bottom fauna in a regulated and an unregulated stream in Canada, found that the fauna in the regulated stream, which was subject to widely fluctuating water levels, exhibited a low productivity, and a consistent and stable aquatic insect community structure.

Warren (1971) stated that changes through time and space in the distributions and abundances of particular species and in the composition of communities are caused by persistent environmental changes, and these biological changes can be used as biological indices of environmental changes. It is hoped that the biological data obtained by this study of the aquatic insect distributions, and the hierarchy trends within the streams of the Rock Creek drainage will be useful as biological indices of environmental change that may take place within the watershed.

CHAPTER X

SUMMARY

A comparative study of the aquatic insect populations of Rock Creek, Montana and it s major tributaries was conducted from July, 1972, to June, 1973. Each of fifteen sample sites throughout the drainage were qualitatively sampled once a month to determine the populations of aquatic insects present. The study was initiated at the request of the Lolo National Forest, U.S.F.S..

From the qualitative data, distribution maps were constructed for each of the species of aquatic insects that were found to occur in the drainage. On the basis of the qualitative data, a relative occurrence value was assigned each species. The relative occurrence values reflected the number of times a species was collected from the sample sites.

A statistical analysis of the qualitative data was included. A similarity index value was computed for each of the sample sites, based on the populations of aquatic insects present. Using the similarity index data, dendrograms were constructed to illustrate the hierarchy present within the sample sites of the drainage. The dendrograms showed a basic two level hierarchy present with the sample site. A third level was indicated, although it was not as well defined.

On the basis of the physical and biological data that were obtained during the study, a stream classification system for the sample sites within the Rock Creek drainage was proposed. The

classification system was composed of five levels, each exhibiting different physical and biological characteristics.

The qualitative data that were obtained during the study indicated that there was a difference in the structure of the aquatic insect populations present within the sample sites of the Rock Creek drainage.

The qualitative data was obtained in the hope that the results would be incorporated into an existing system for monitoring the water quality of the Rock Creek drainage, a "blue-ribbon" trout stream. The use of the data as biological indices of environmental change was suggested.

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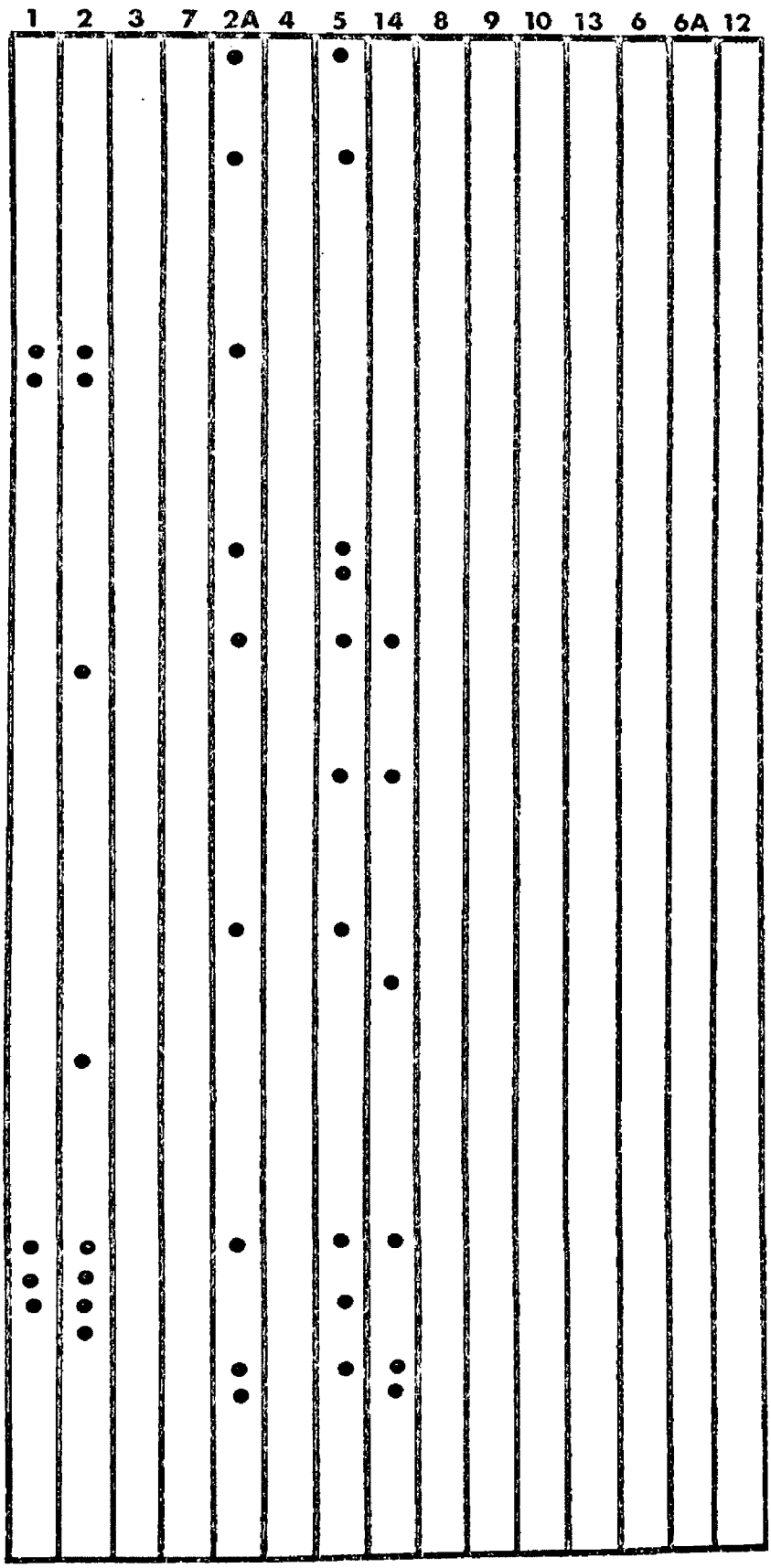
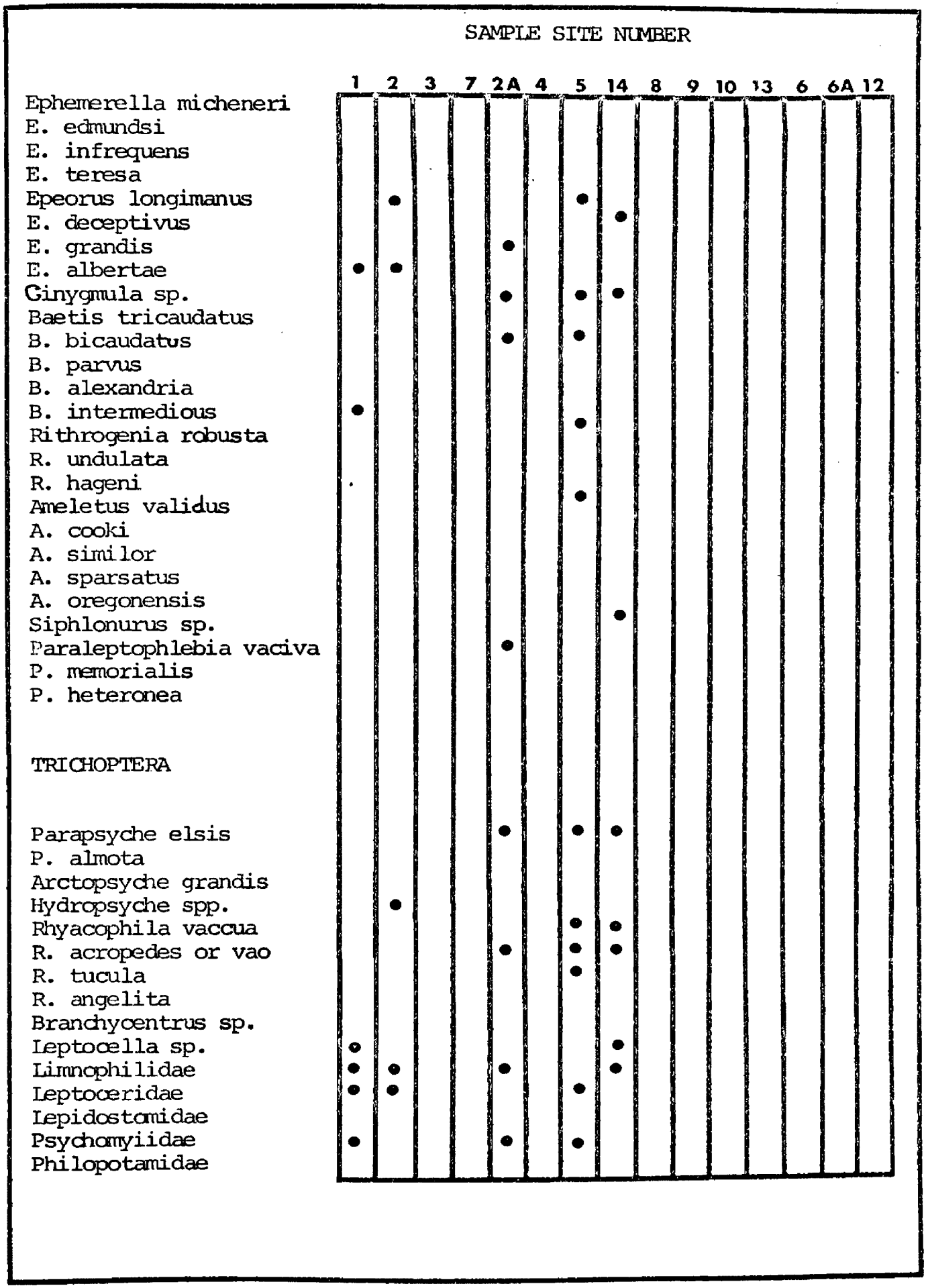
APPENDIX

Table 1. Aquatic insect qualitative sampling data from July 8-9, 1972.

SAMPLE SITE NUMBER





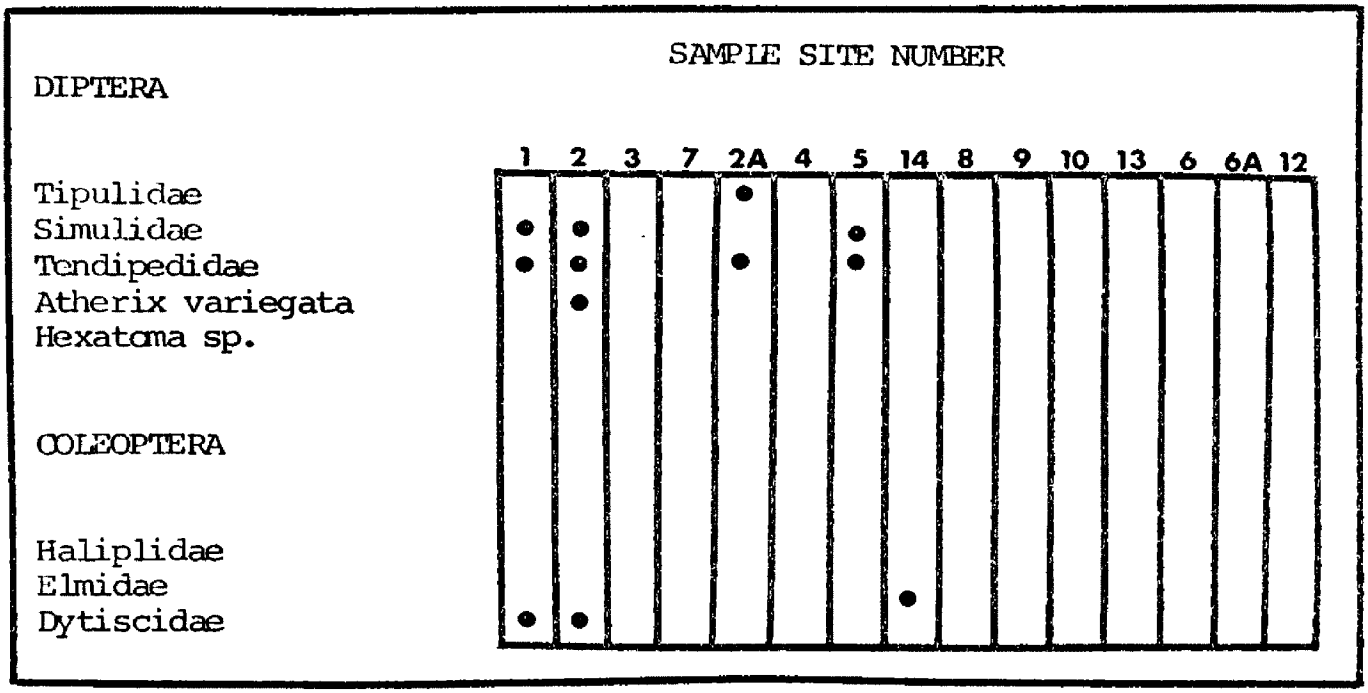
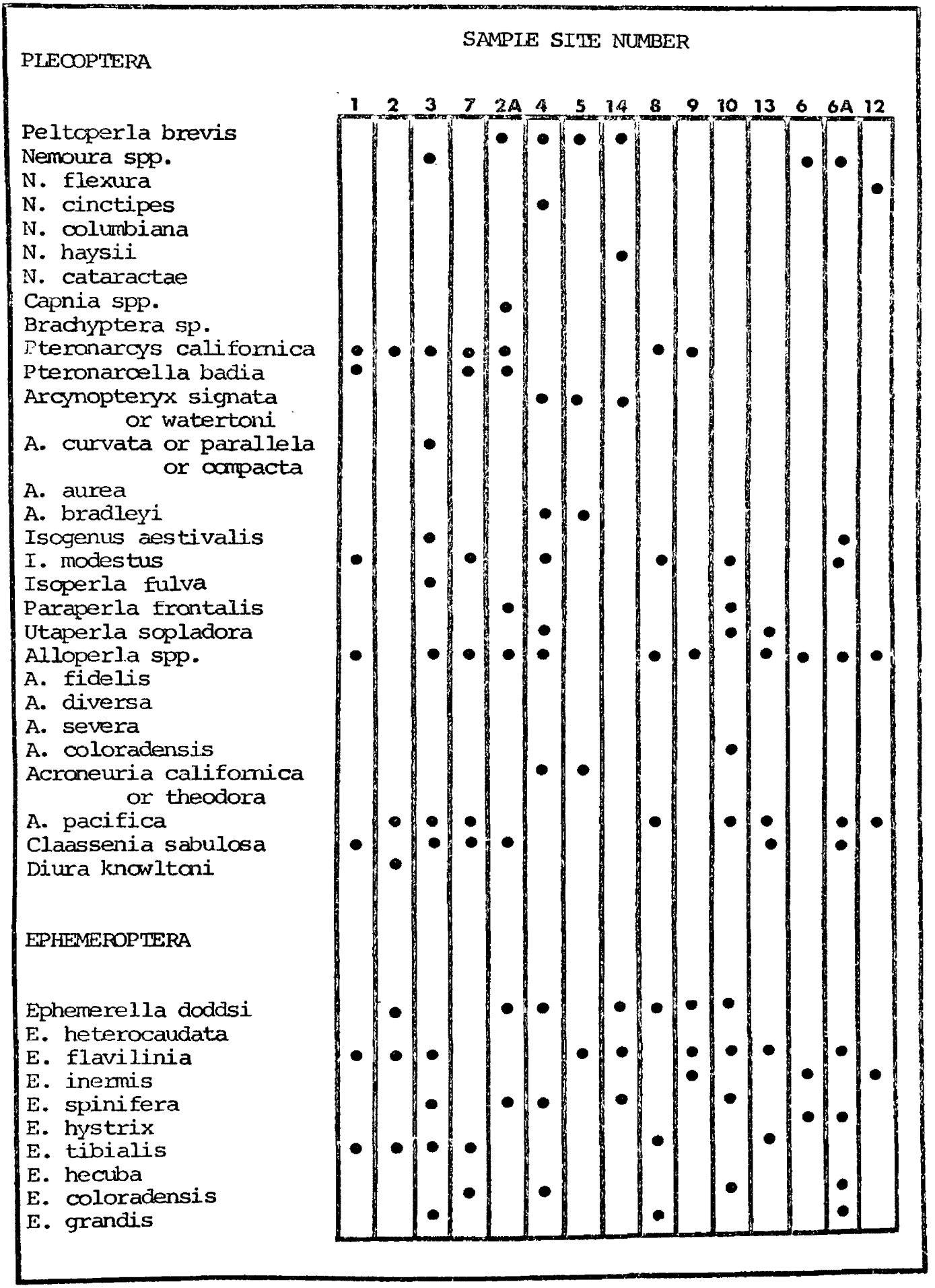
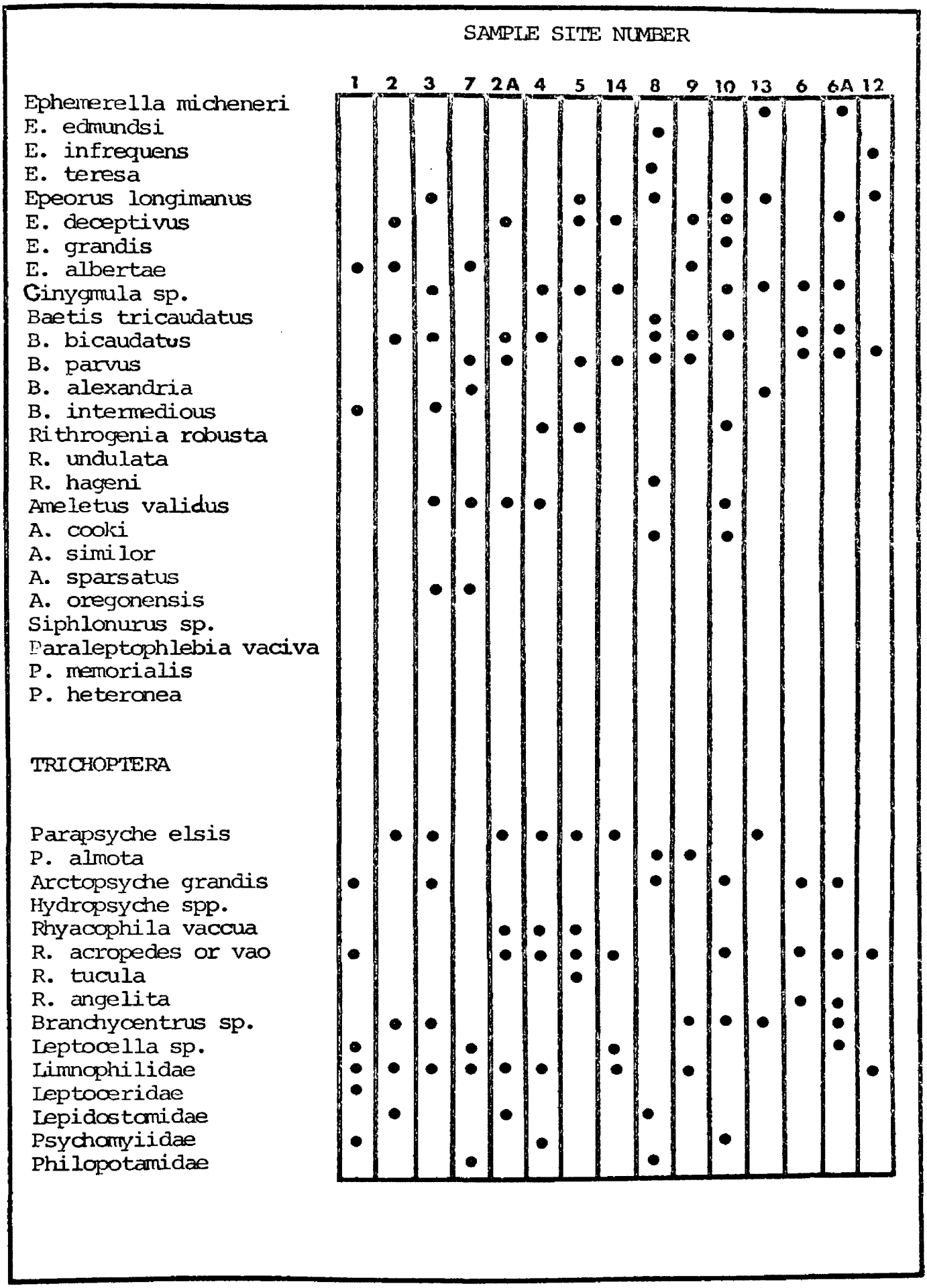


Table 2. Aquatic insect qualitative sampling data from August 5-6-7, 1972.





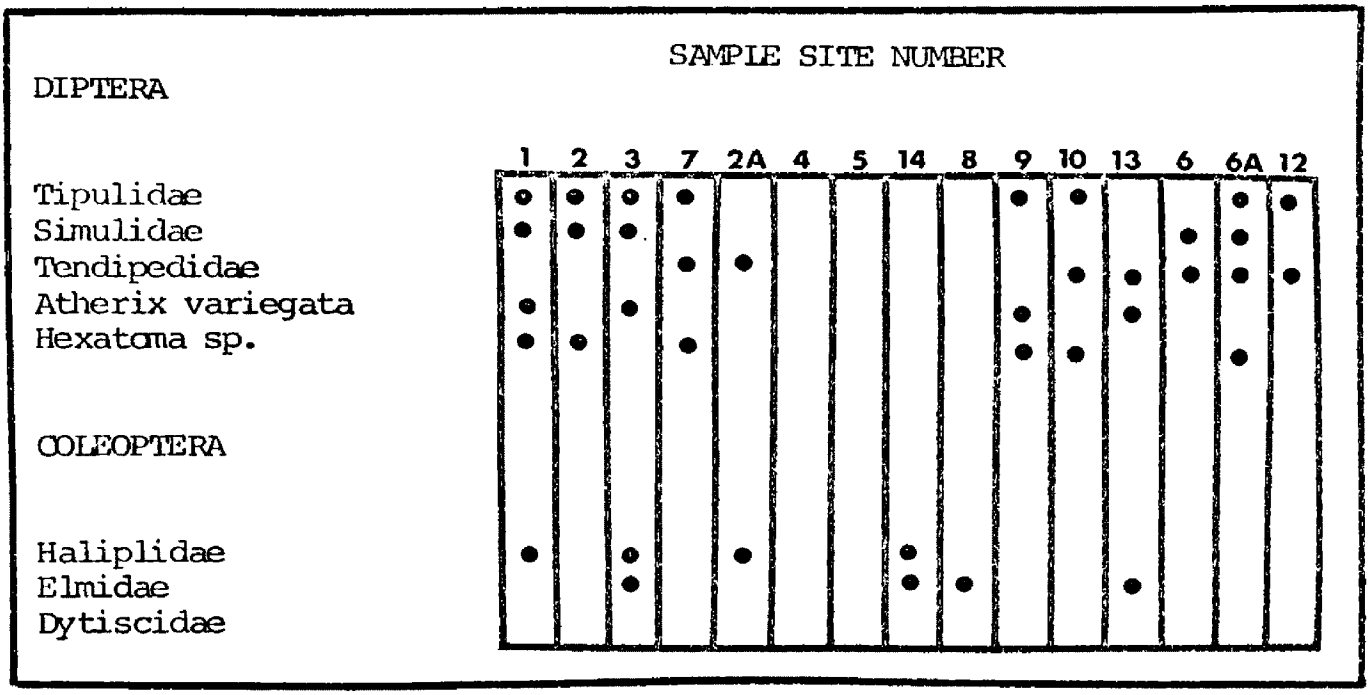


Table 3. Aquatic insect qualitative sampling data from September 24-25, 1972.

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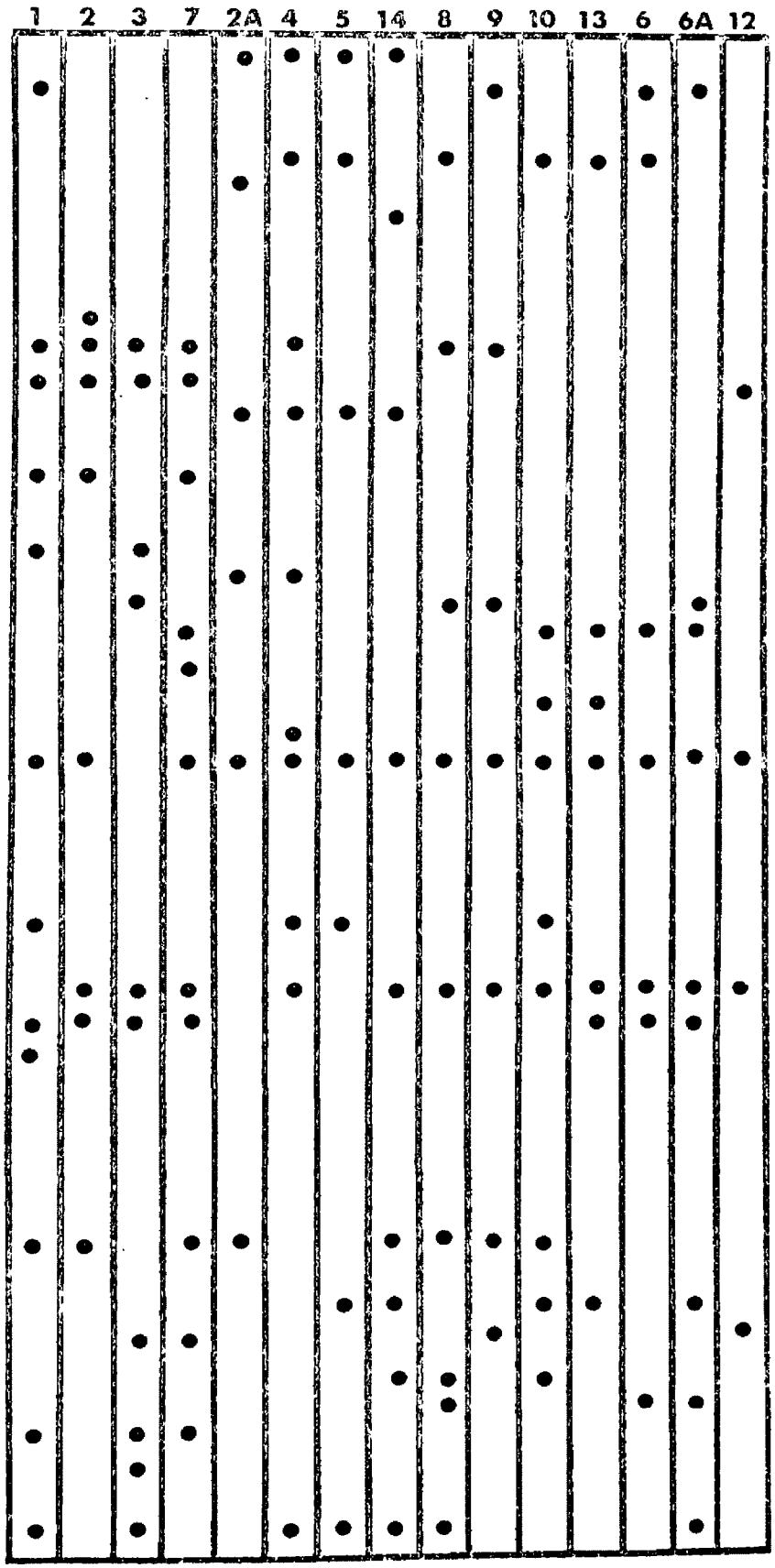

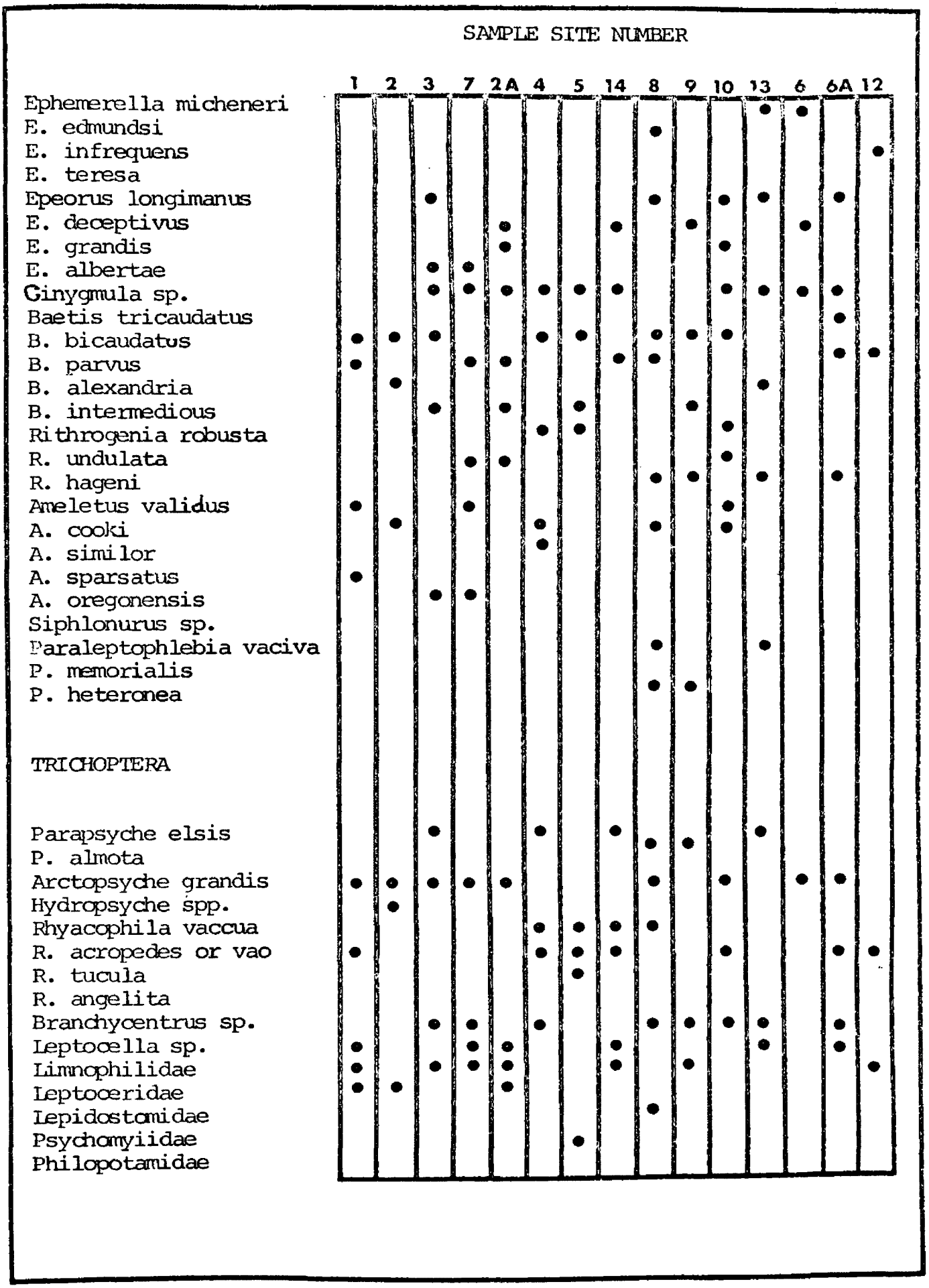

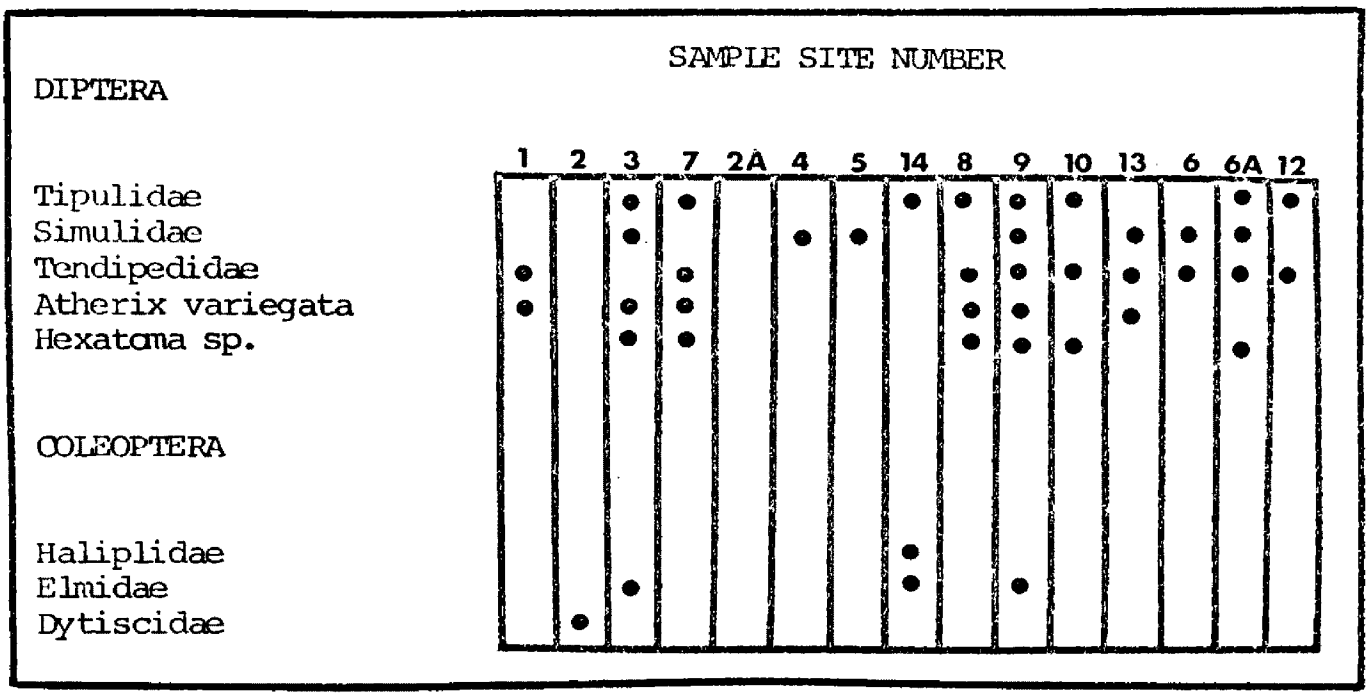

Table 4. Aquatic insect qualitative sampling data from October 11, 1972.

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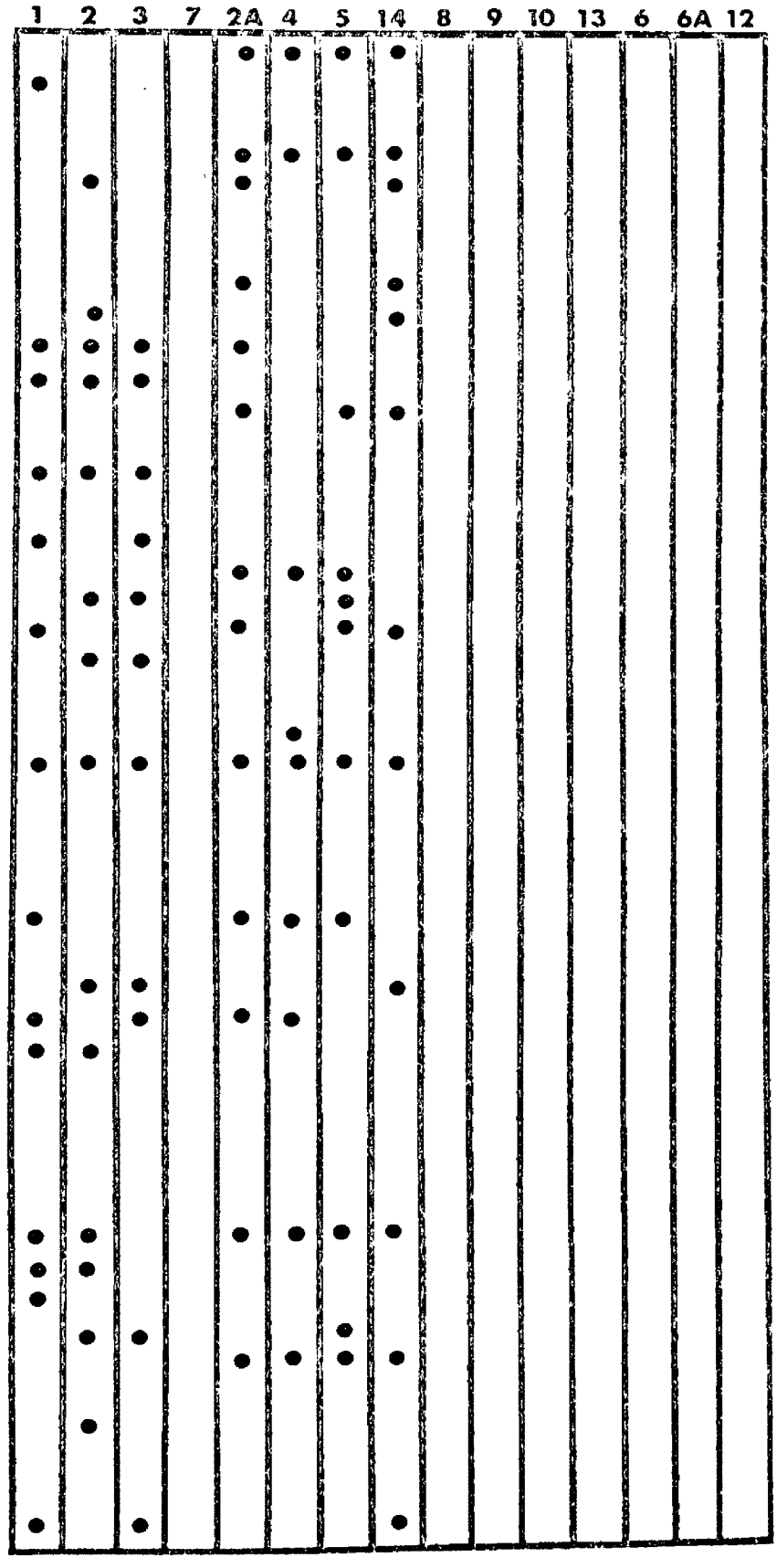
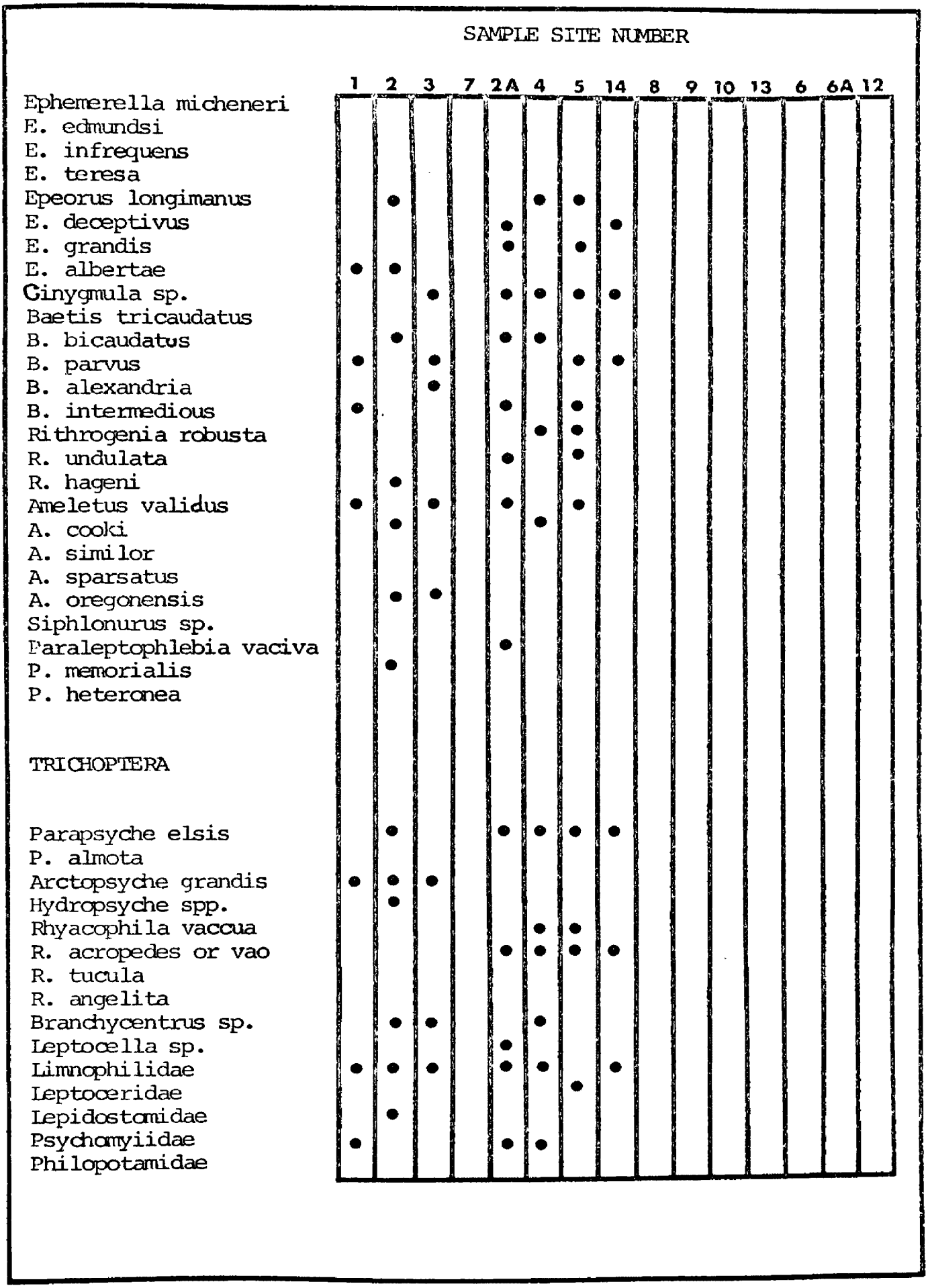




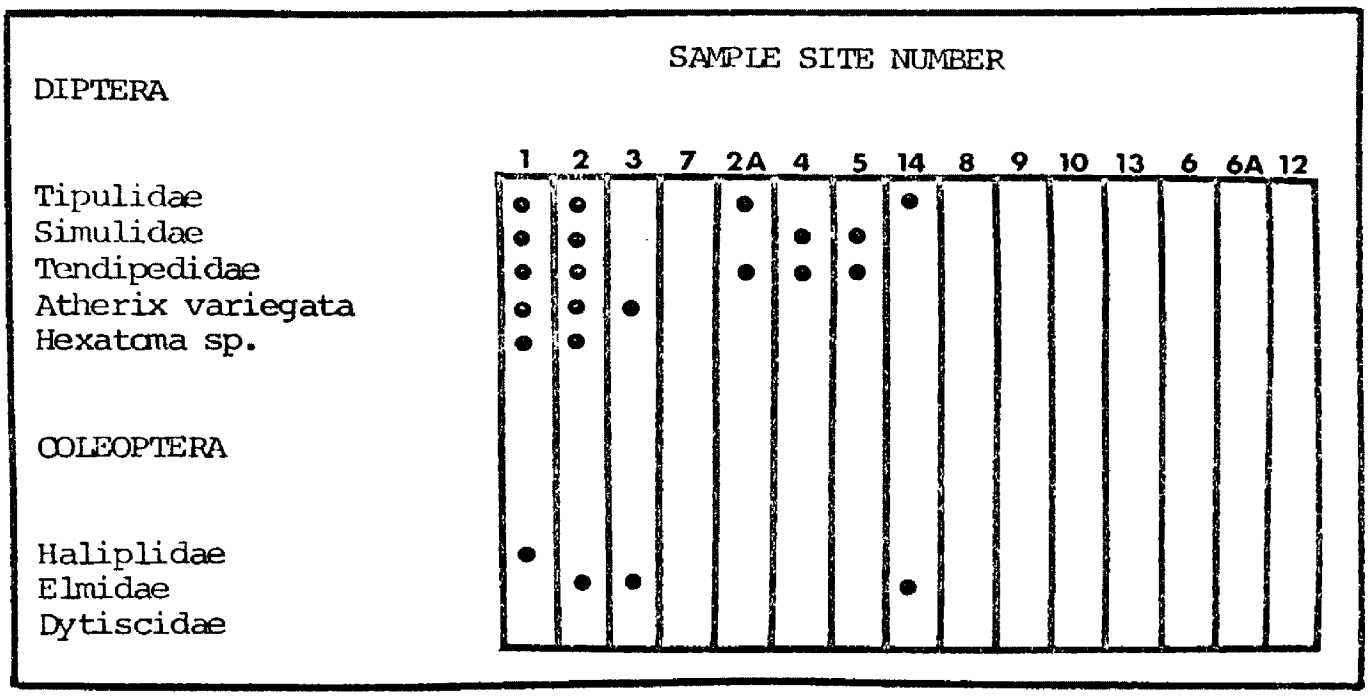
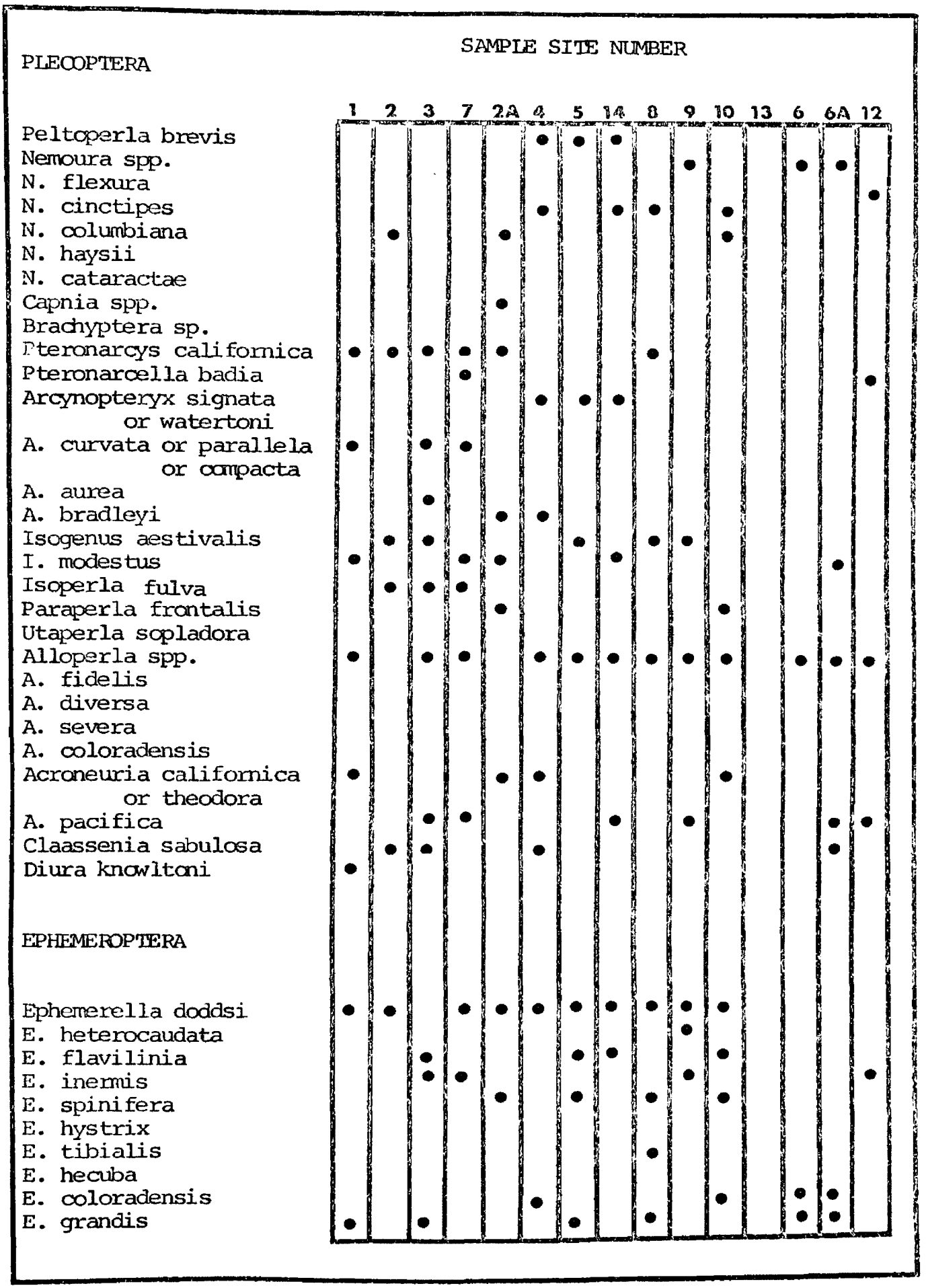
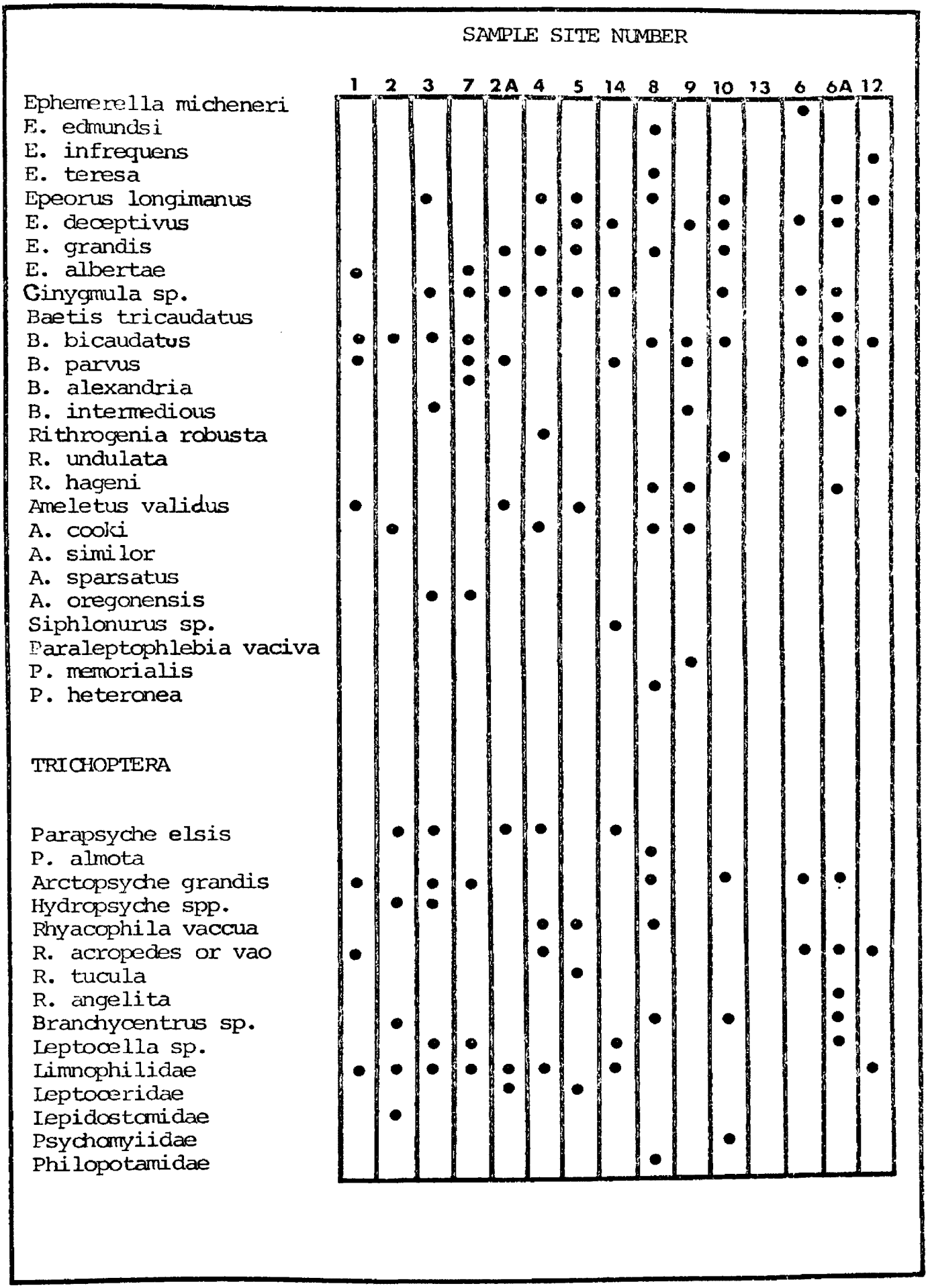


Table 5. Aquatic insect qualitative sampling data from November 22-23, 1972.





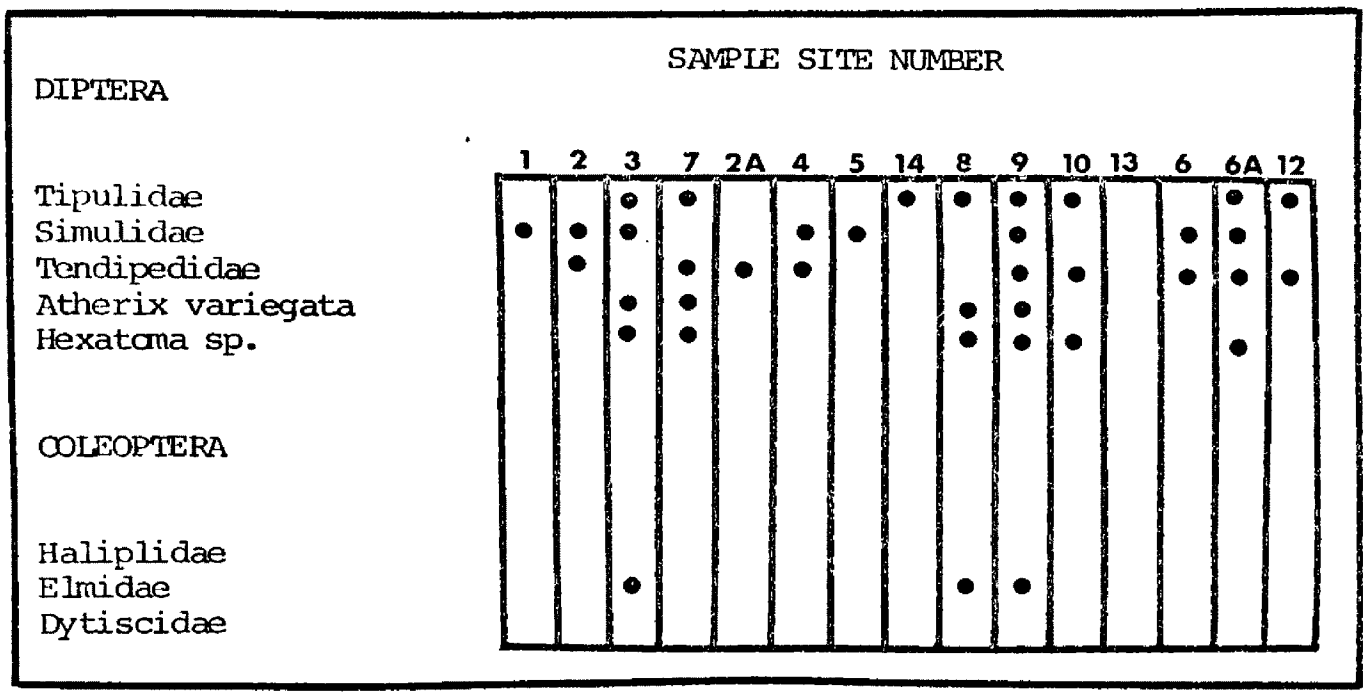
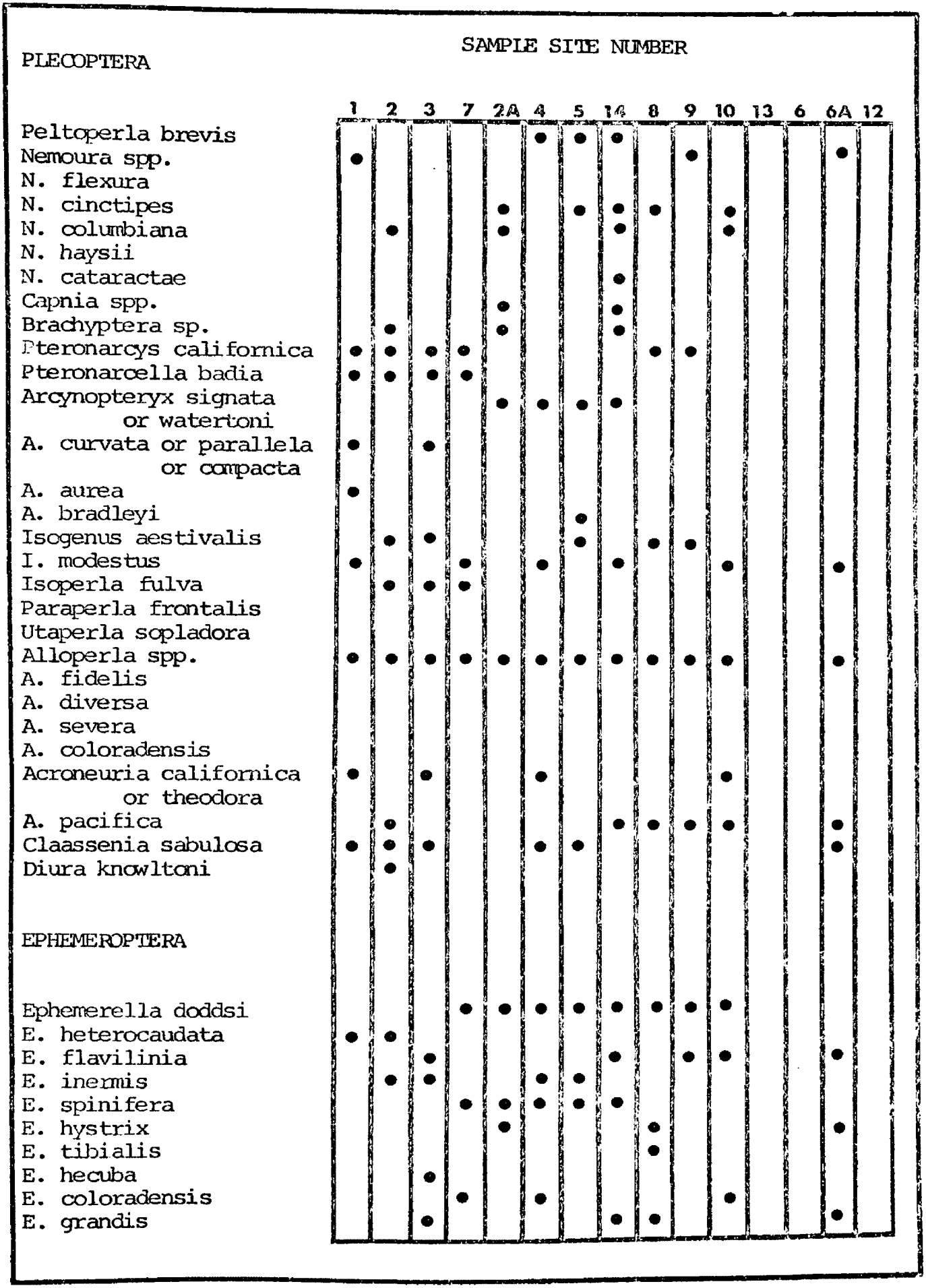
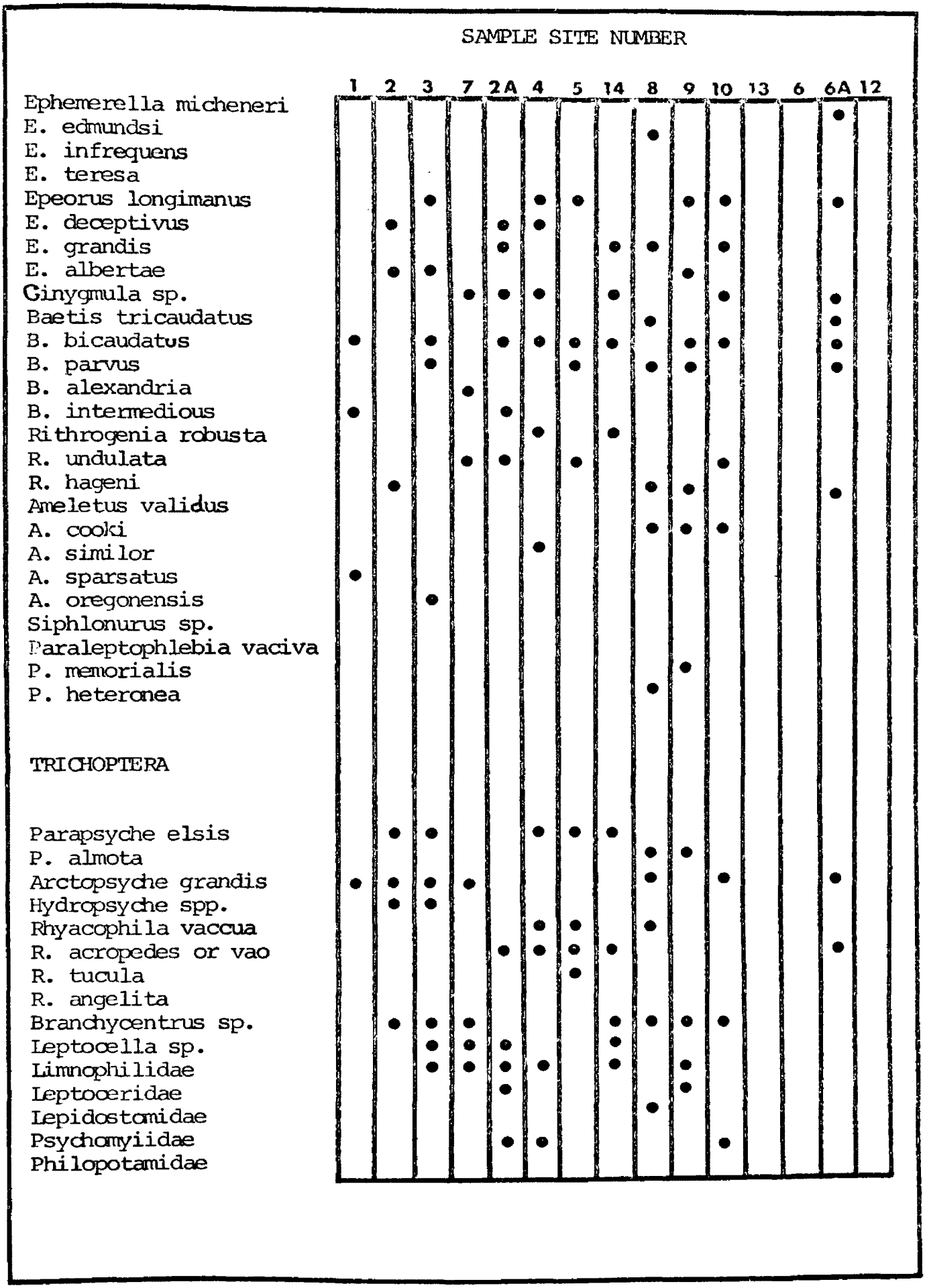


Table 6. Aquatic insect qualitative sampling data from December 27-28, 1972.





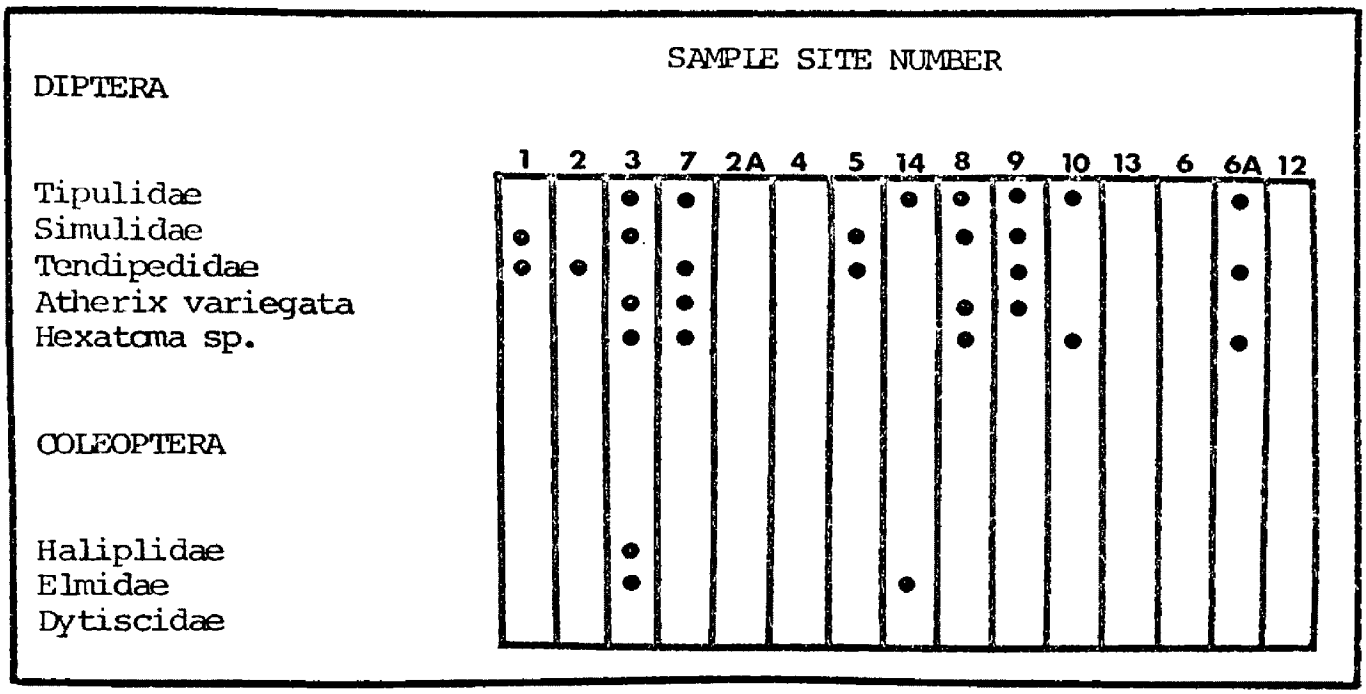
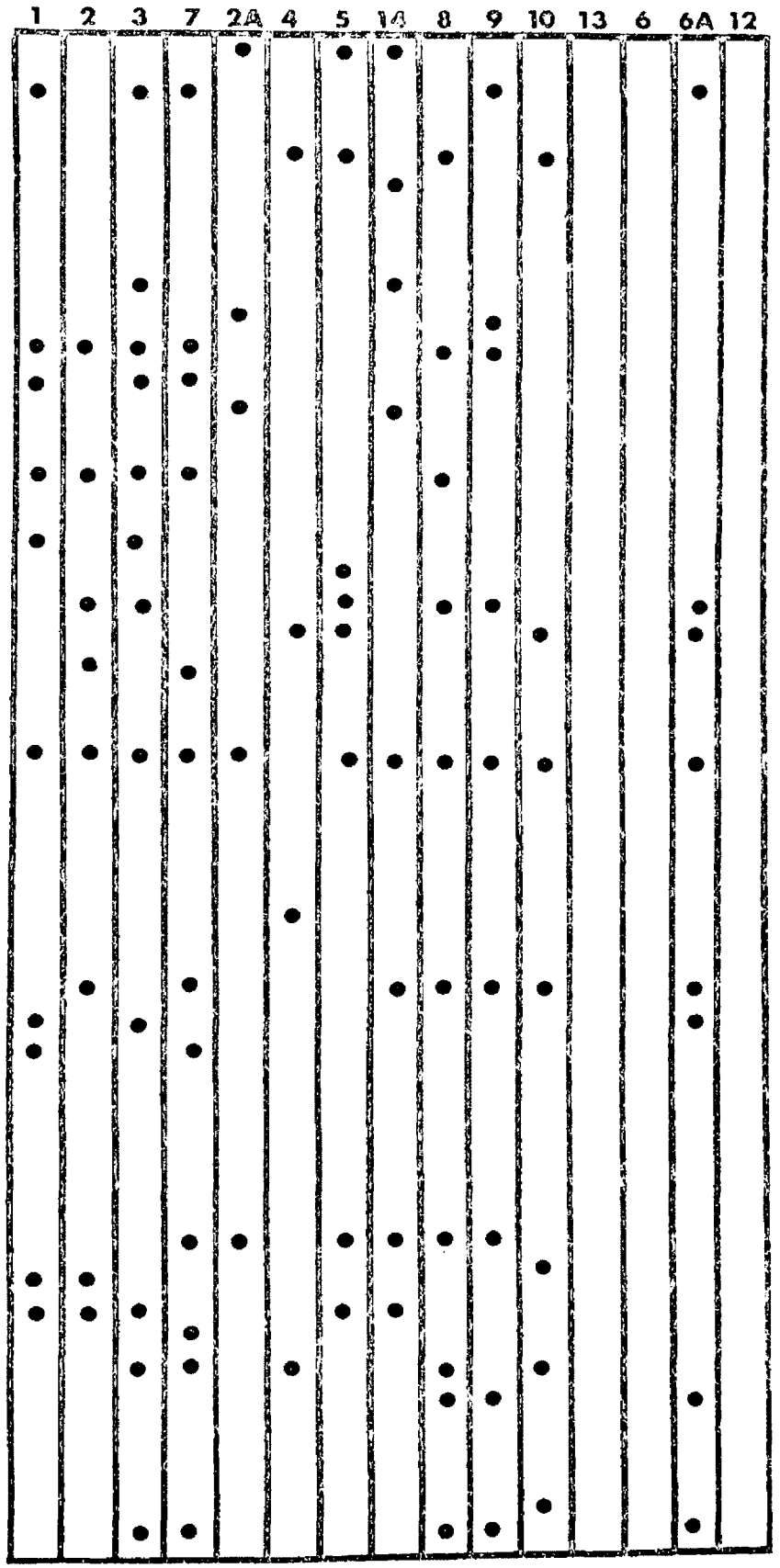
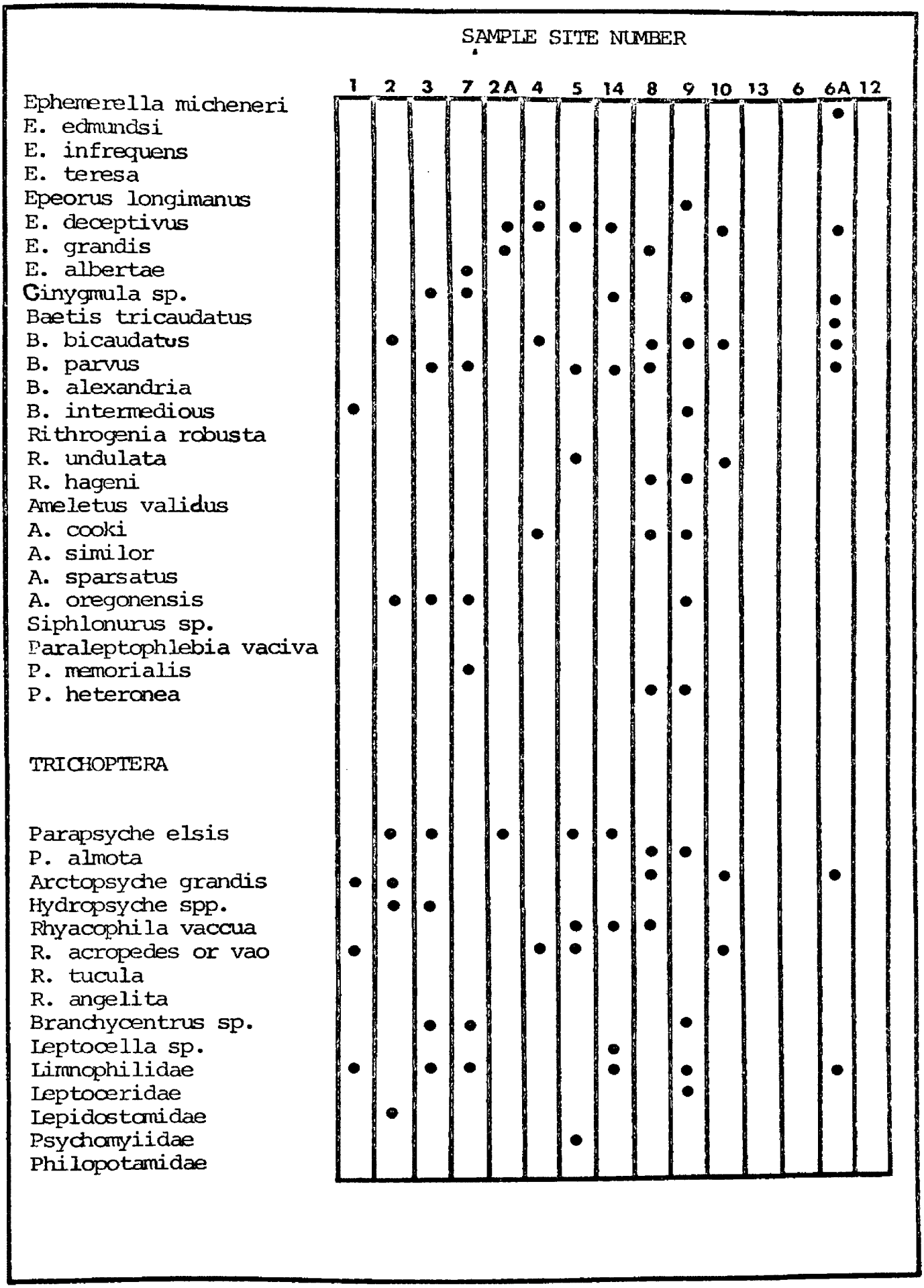


Table 7. Aquatic insect qualitative sampling data from January 15, 1973.

SAMPLE SITE NUMBER





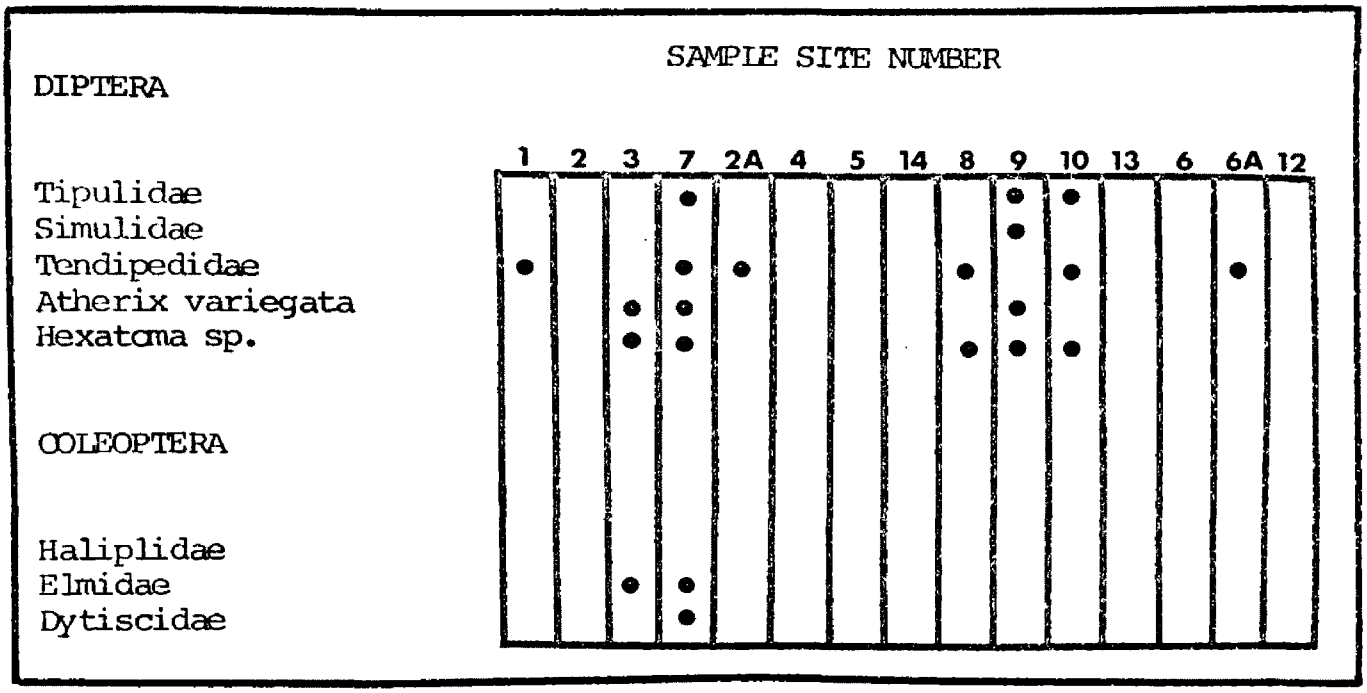
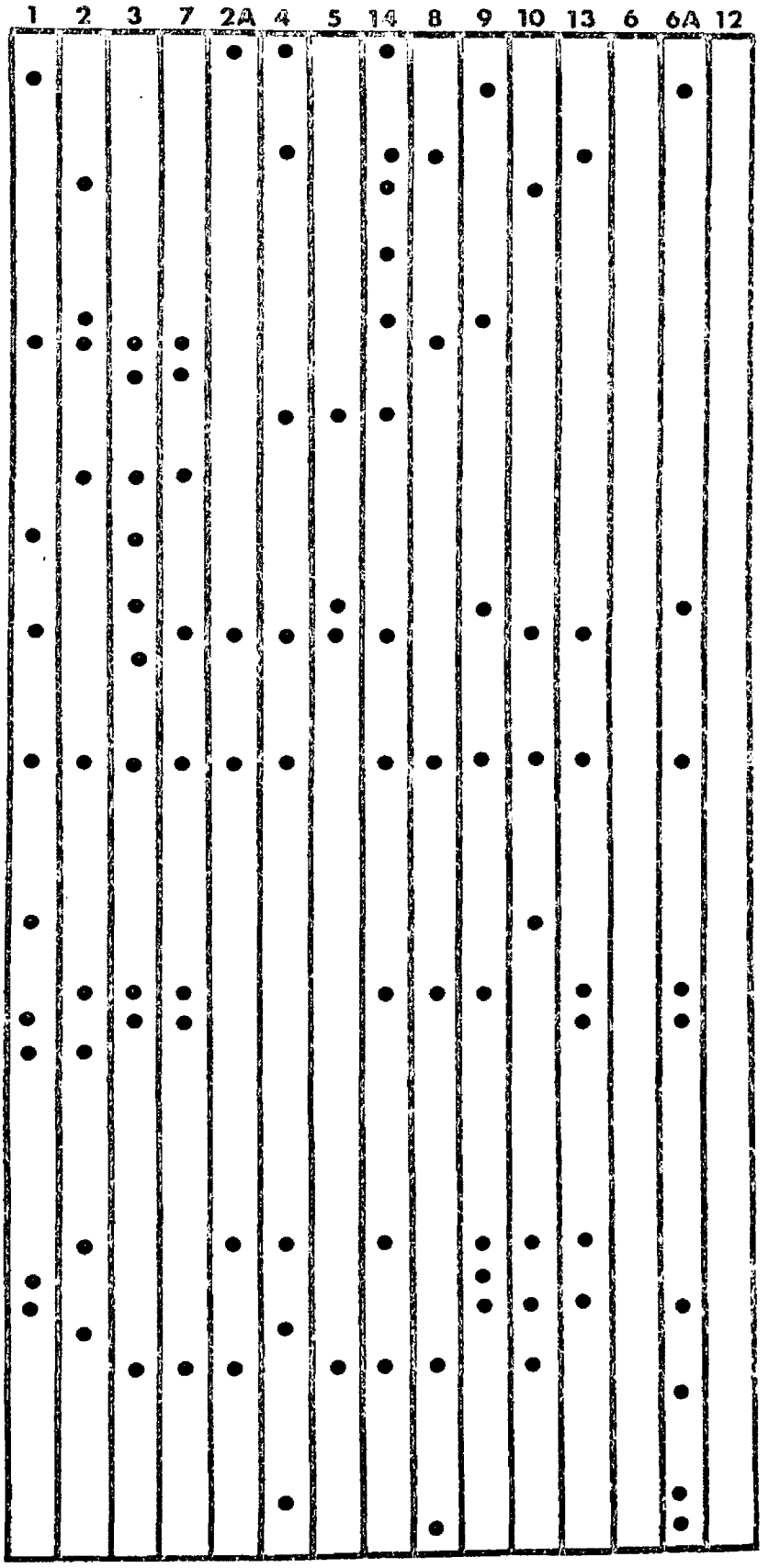
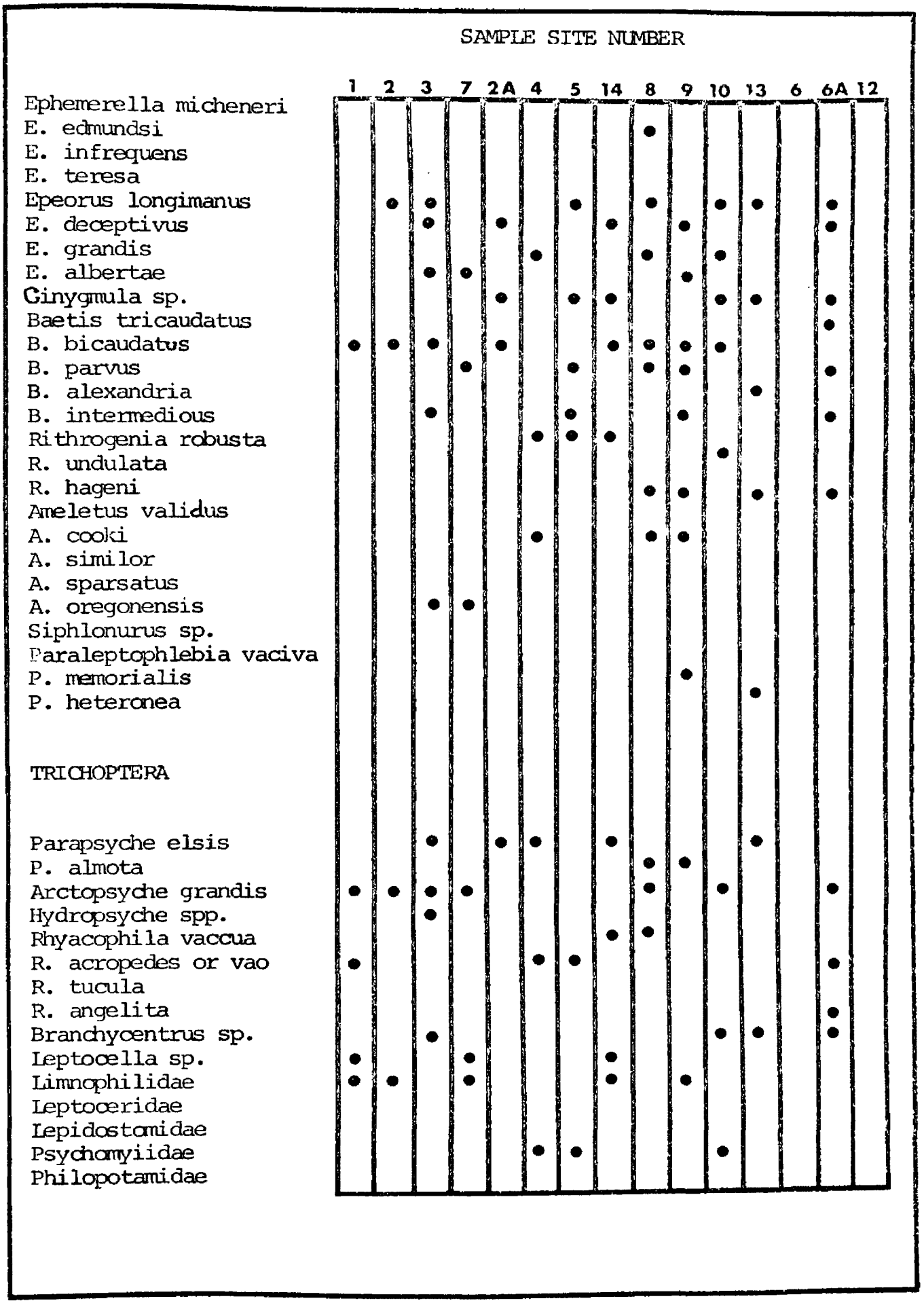


Table 8. Aquatic insect qualitative sampling data from February 21, 1973.

SAMPLE SITE NUMBER





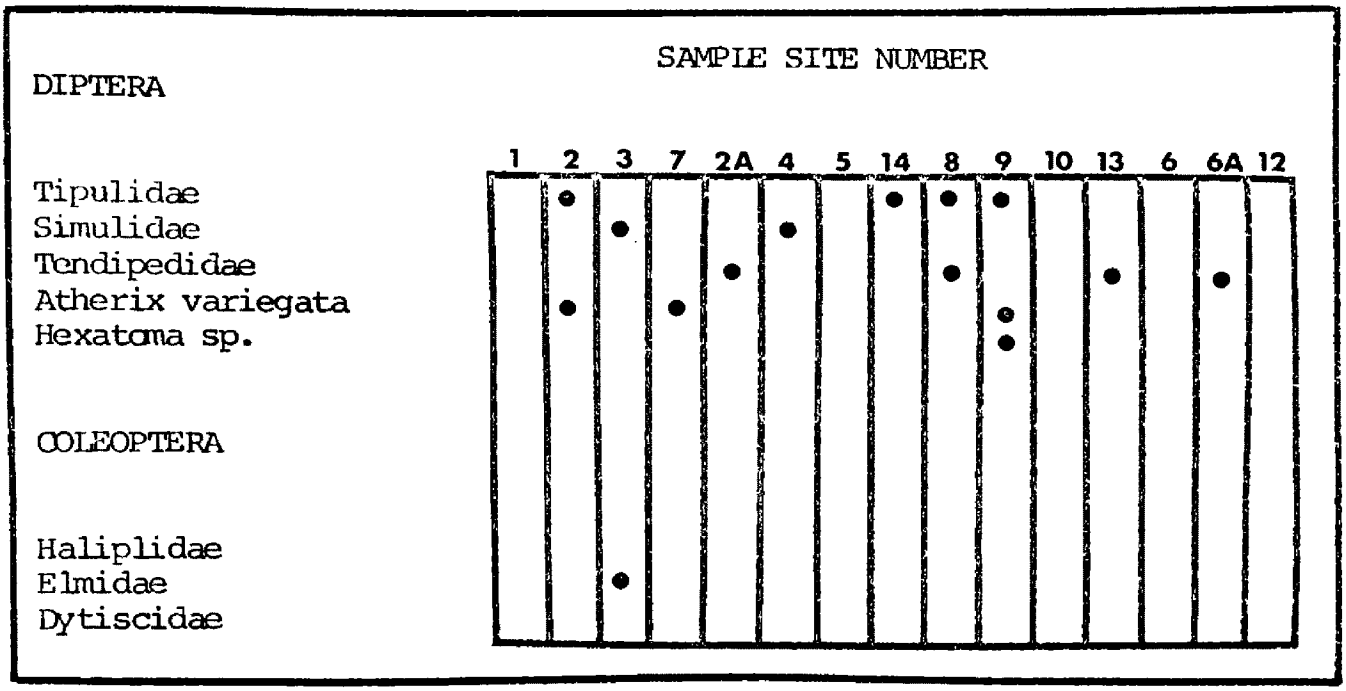
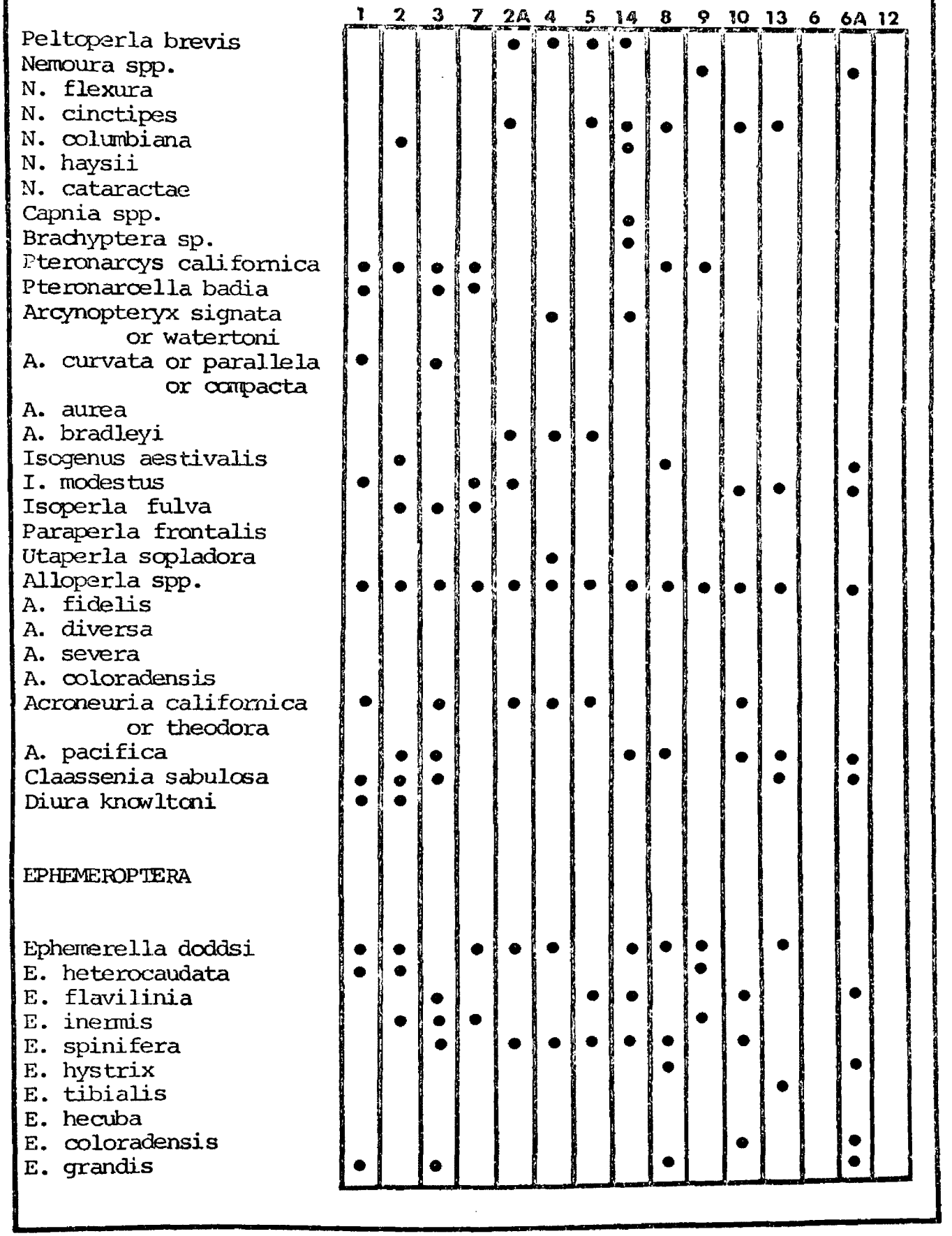
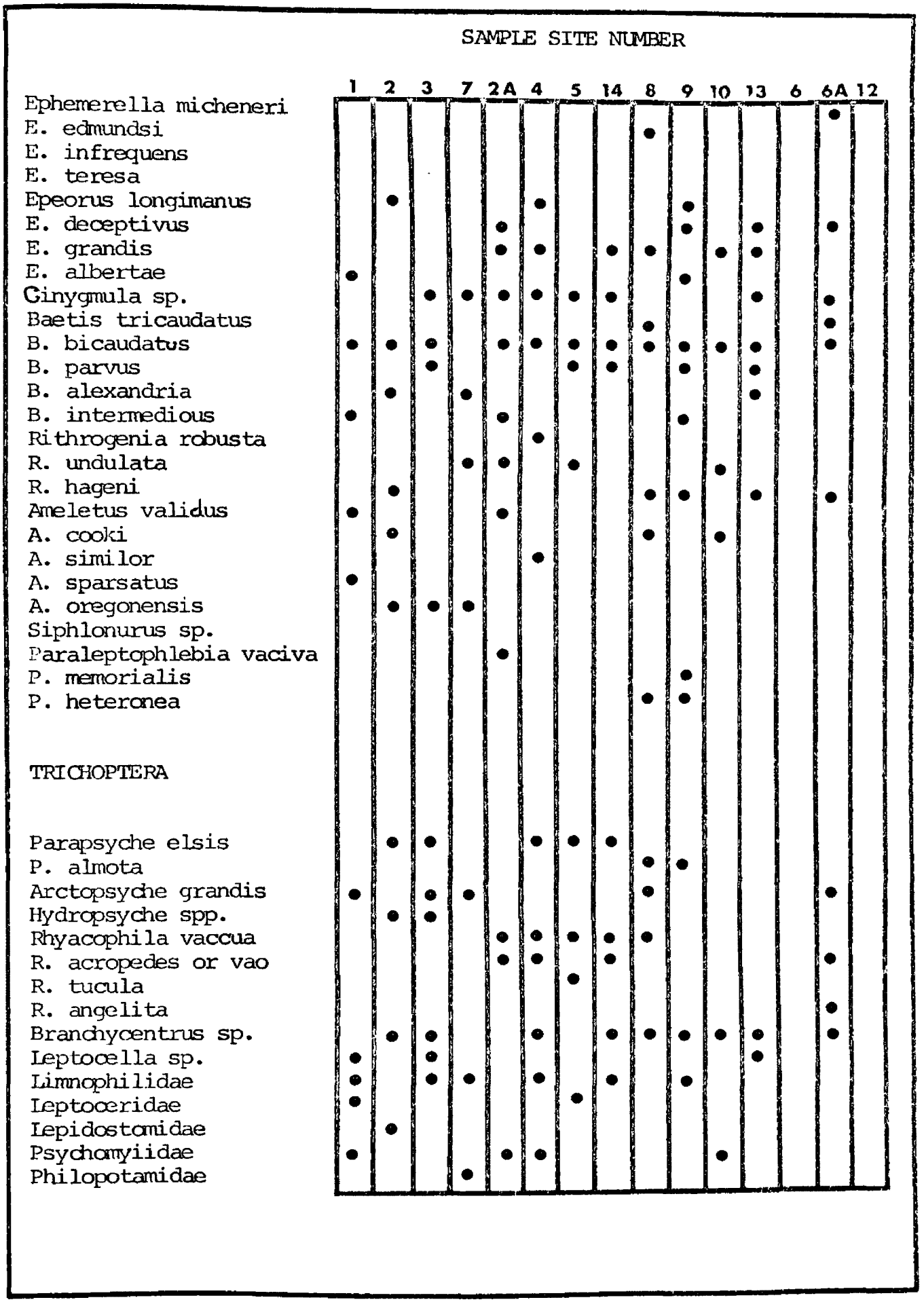


Table 9. Aquatic insect qualitative sampling data from March 8, 1973.

SAMPLE SITE NUMBER





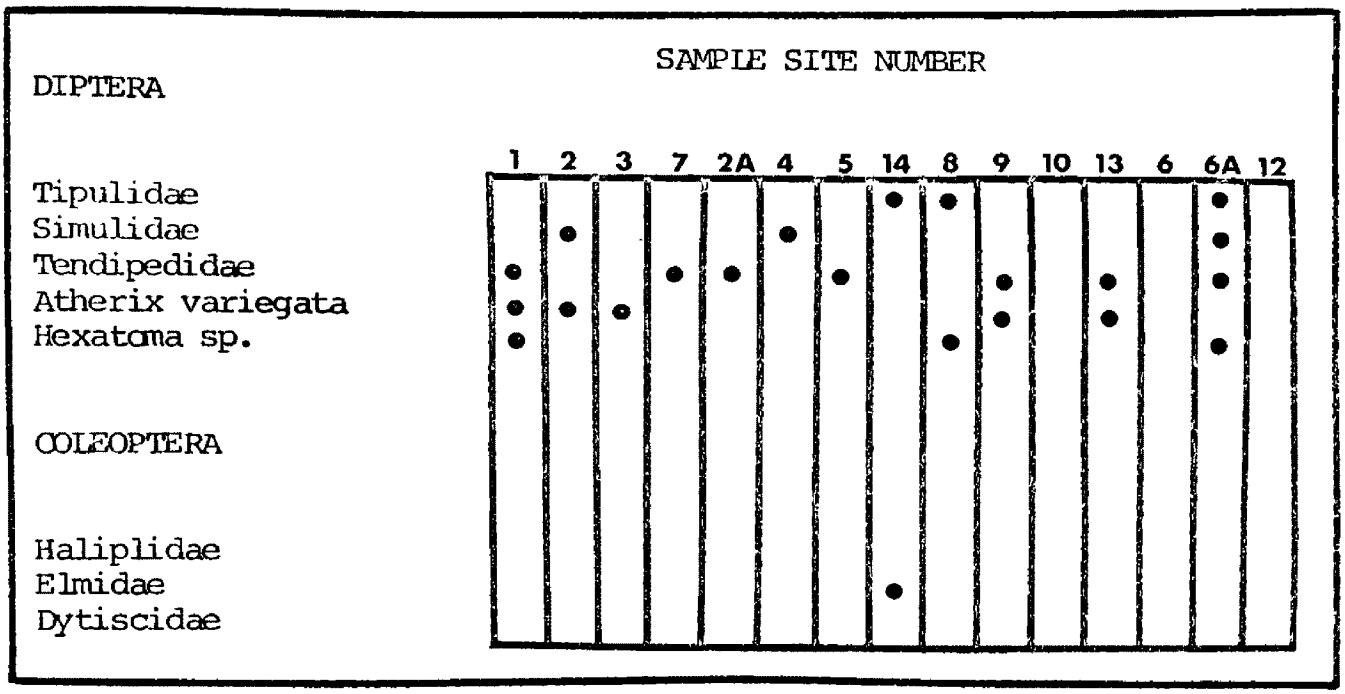
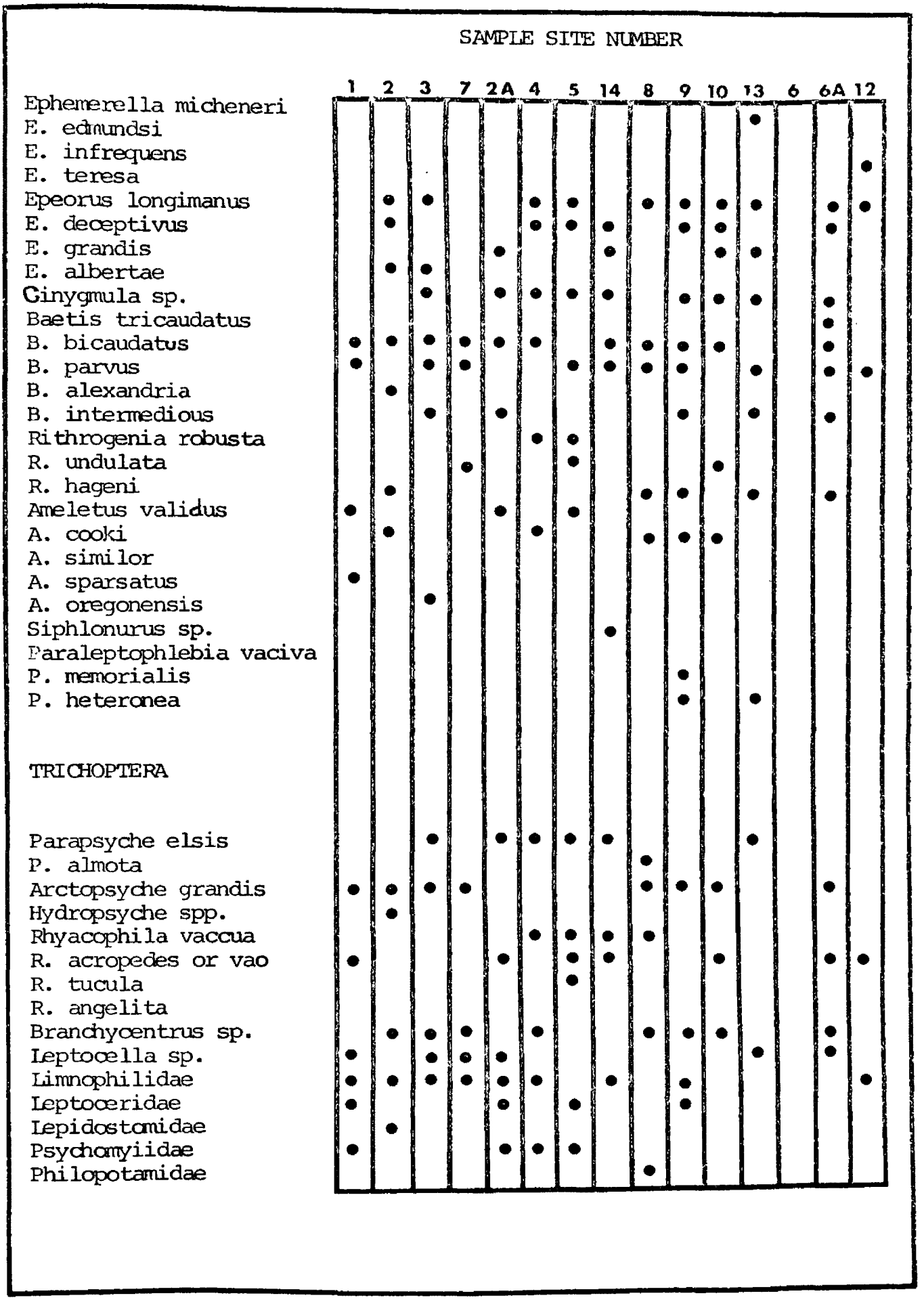


Table 10. Aquatic insect qualitative sampling data from April 11-12, 1973.

SAMPLE SITE NUMBER

	1	2	3	7	2A	4	5	14	8	9	10	13	6	6A	12
PLECOPTERA															
Peltoperla brevis					●	●	●	●							
Nemoura spp.	●									●					
N. flexura															
N. cinctipes						●	●					●			
N. columbiana								●			●				
N. haysii															
N. cataractae								●							
Capnia spp.					●			●							
Brachyptera sp.															
Pteronarcys californica	●	●	●	●	●				●						
Pteronarcella badia	●		●	●											●
Arcynopteryx signata or watertoni					●	●	●	●							
A. curvata or parallela or compacta	●	●	●	●											
A. aurea	●		●												
A. bradleyi					●		●								
Isogenus aestivalis		●	●				●		●					●	
I. modestus				●		●		●			●	●			
Isoperla fulva		●	●												
Paraperla frontalis					●										
Utaperla sopladora						●									
Alloperla spp.	●	●	●	●	●	●	●	●	●	●	●	●		●	●
A. fidelis															
A. diversa															
A. severa															
A. coloradensis															
Acroneuria californica or theodora			●		●	●					●				
A. pacifica		●	●	●				●	●	●	●	●		●	
Claassenia sabulosa	●	●	●	●	●	●						●		●	●
Diura knowltoni		●													
EPHEMEROPTERA															
Ephemerella doddsi	●	●		●	●	●	●	●	●	●	●				
E. heterocaudata		●								●					
E. flavilinia		●	●							●		●		●	
E. inermis		●				●									●
E. spinifera				●		●	●				●				
E. hystrix					●				●						
E. tibialis		●													
E. hecuba															
E. coloradensis															
E. grandis	●		●					●		●				●	



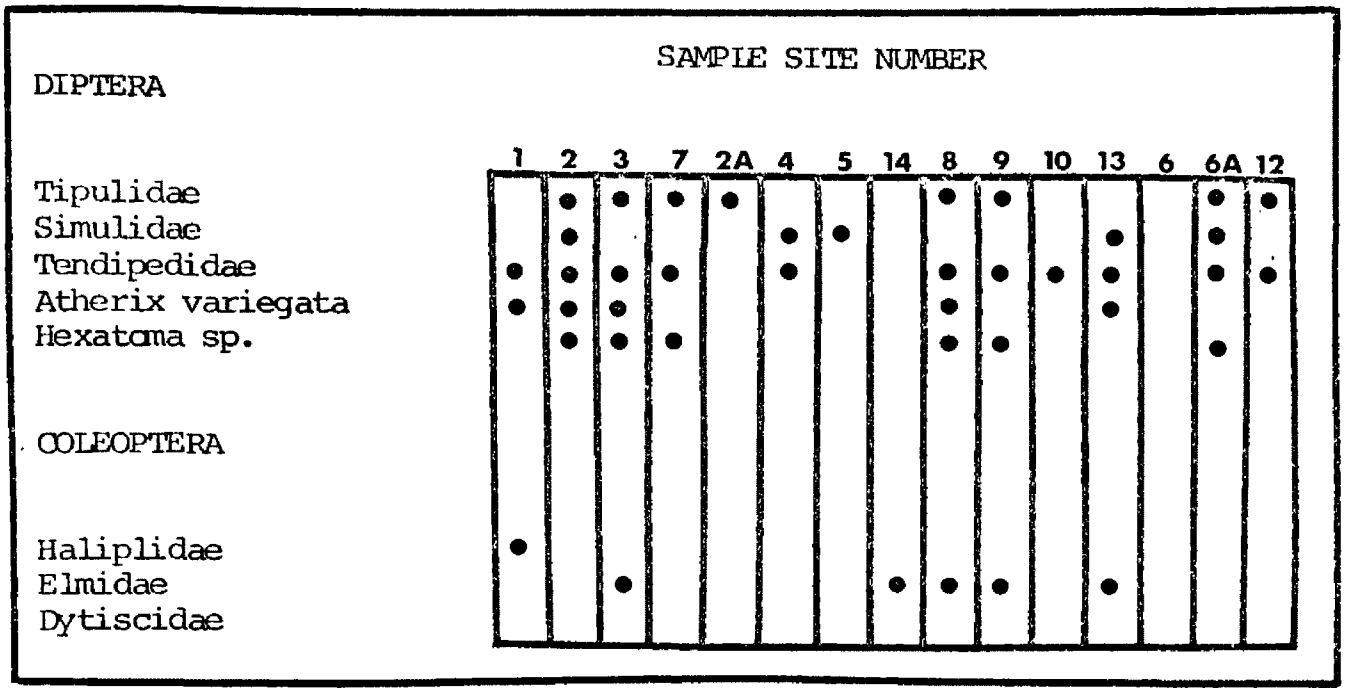
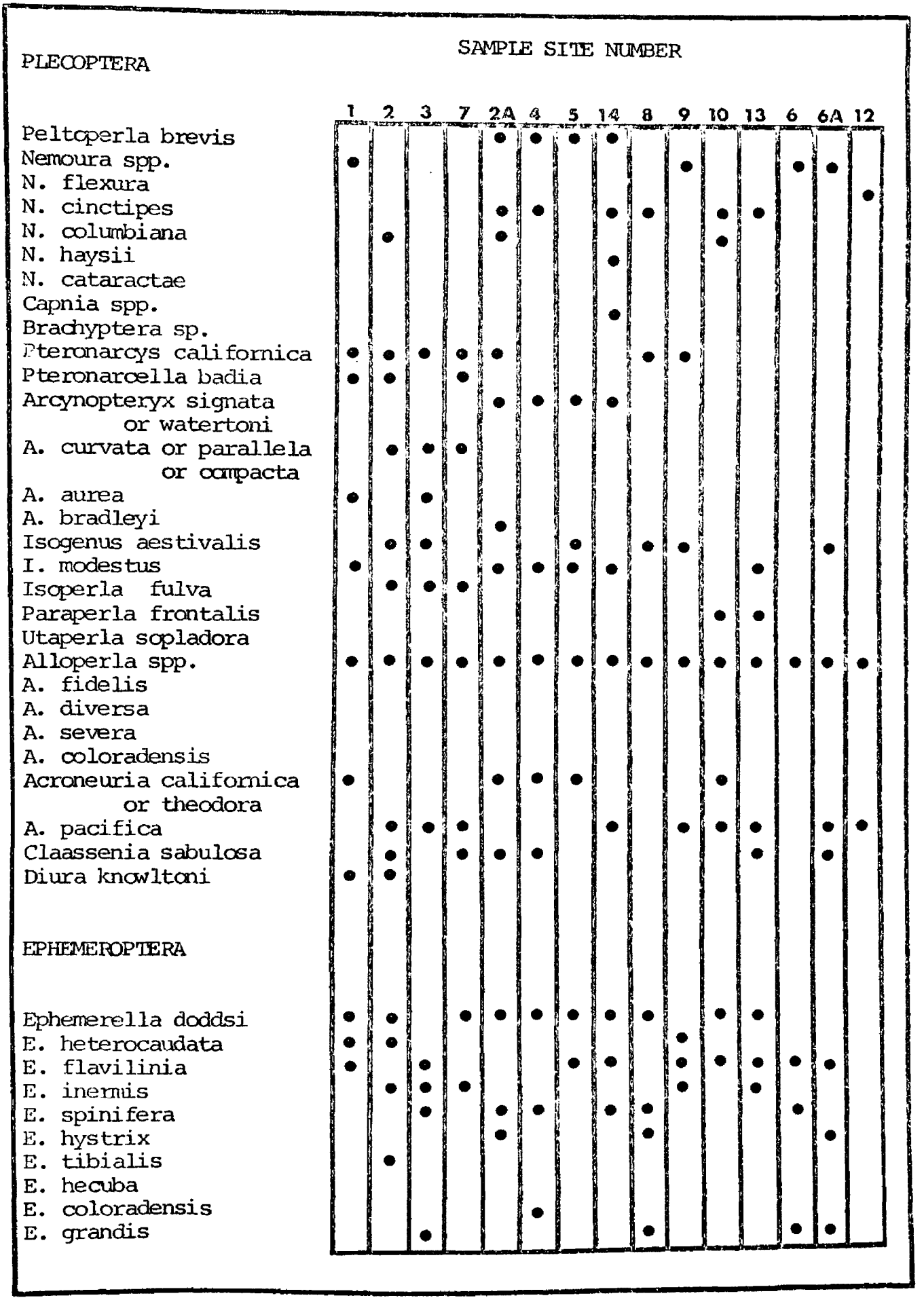
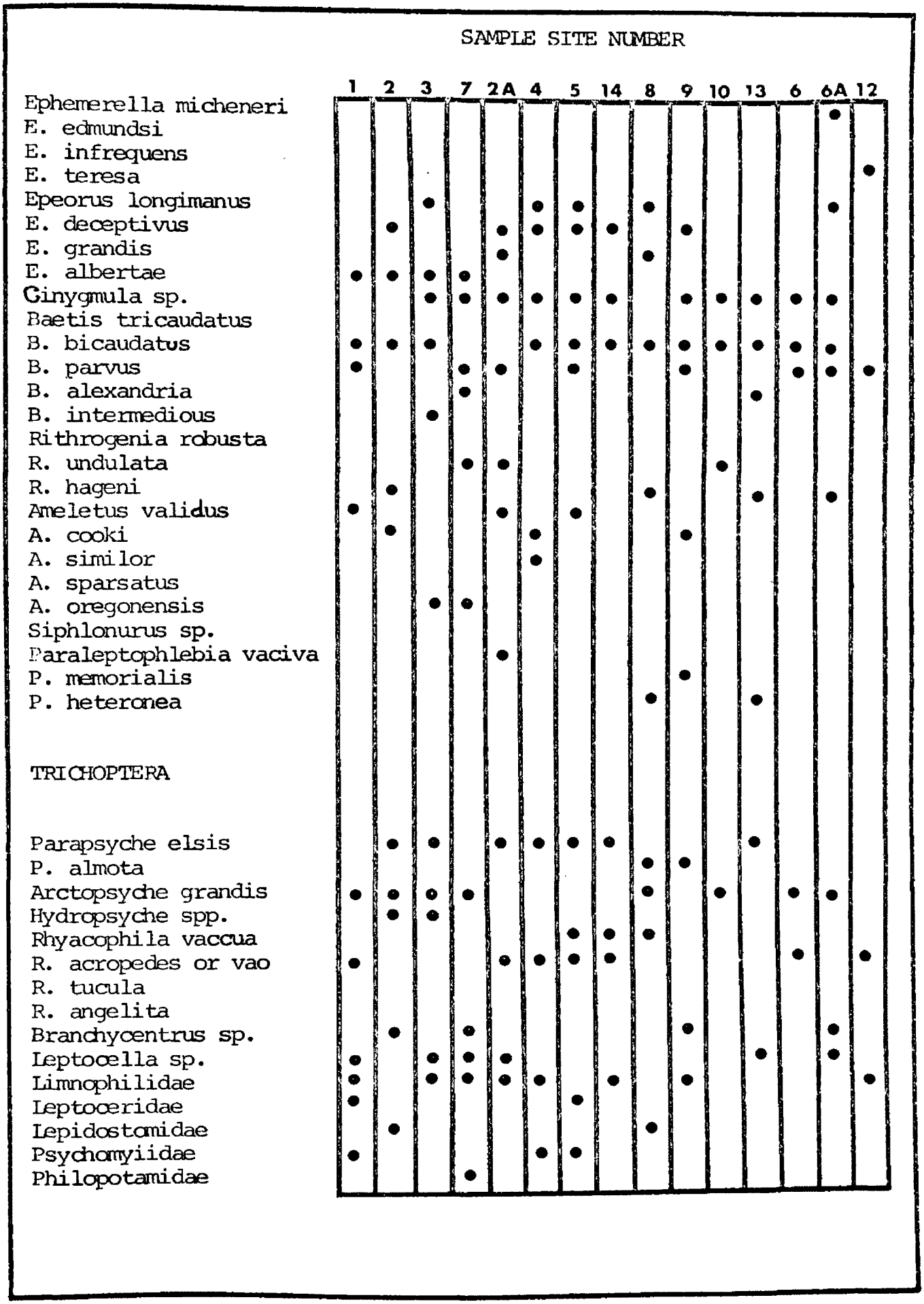


Table 11. Aquatic insect qualitative sampling data from May 19-20, 1973.





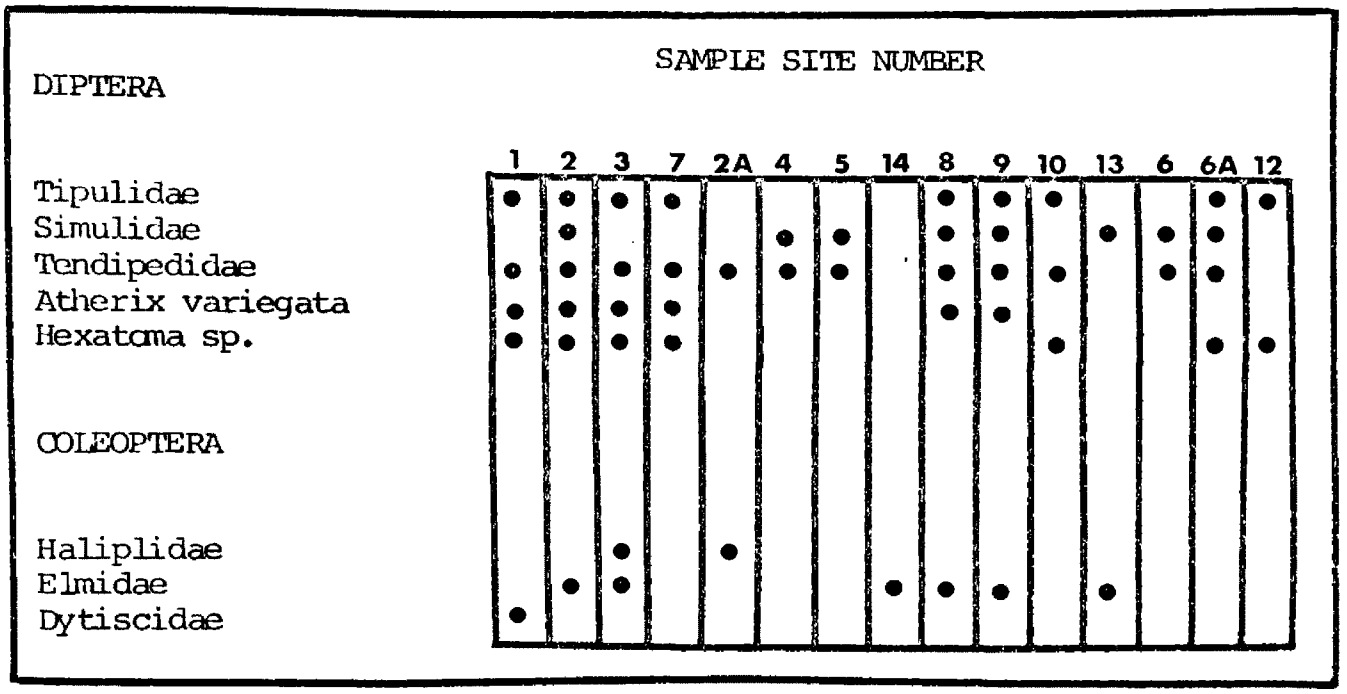


Table 12. Aquatic insect qualitative sampling data from June 23-24, 1973.

SAMPLE SITE NUMBER