Studies on Simuliidae (Diptera), with particular reference to *Austrosimulium tillyardianum*

Volume 2 -- Appendices

A thesis presented for the degree of Doctor of Philosophy in Zoology in the University of Canterbury, Christchurch, New Zealand

by

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1974
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Appendix 1

Use of the common names "sandfly" and "black fly"
for species of Simuliidae (Diptera)

Accepted for publication in: New Zealand Entomologist
In New Zealand, Simuliidae are called "sandflies", a usage that has persisted since the voyages of exploration of Captain Cook between 1769 and 1775 (Dumbleton 1973). Throughout the remainder of the English-speaking world, Simuliidae are generally referred to as "black flies", a name apparently of North American origin.

The use of both these common names for the Simuliidae can be confusing. In most parts of the English-speaking world, "sandflies" is the common name generally applied to psychodid flies belonging to the subfamily Phlebotominae, although this name is often used, especially in conversation, for the biting midges of the family Ceratopogonidae (Oldroyd 1964). Dumbleton (1973) suggested that since there were no biting Psychodidae in New Zealand, and only one biting ceratopogonid of localized distribution, the New Zealand use of "sandflies" for Simuliidae caused no confusion. But, if "sandflies" is used in publications, authors should realize that other researchers who do not know of the equivalence of "sandflies" and "black flies" may be confused.

The name "black fly" may also be ambiguous at times. Thus "blackfly" written as one word is often used as a common name for some aphids, such as the bean aphis (Oldroyd 1964), and this spelling has also been used in many publications on Simuliidae.

Because of the confusion surrounding the use of common names, the term "simuliid" which is being increasingly used in the scientific literature is preferred to either "black fly" or "sandfly".

HISTORICAL USE

Dumbleton (1973) remarked that the Oxford English Dictionary (O.E.D.) defined "sandfly" as a small fly or midge, especially one belonging to the genus *Simulium*, and cited its use as early as 1748 in Anson's "Voyage round the World". The association of the word "sand-flies" in the citation and the genus *Simulium* by the compilers of the O.E.D. was given through Boas (1896) in his "Text book of zoology" page 276: 'The sand-fly (*Simulia*), . . .' (edition translated from the German by Kirkaldy & Pollard).

However, the full citation from Anson in which the term "sand-flies" is used leaves doubt as to whether it is in fact simuliids that are referred to: 'And at sun-set, when the musquitoes [sic] re-tired, they were succeeded by an infinity of sand-flies, which, though scarce discernible to the naked eye, make a mighty buzzing, and wherever they bite raise a small bump in the flesh, which is soon attended with a painful itching . . .' (Walter, undated.
At the time of writing, Anson was anchored in the harbour of the Island of Santa Catarina (called St. Catherine by Anson) just off the mainland of Brazil. Three simuliid species have been recorded from the nearby mainland (Vulcano 1967), one of which bites man, Simulium (Simulium) dinelli (Joan); however, it does not fit the description of the citation. The references to the very small size, buzzing, biting at sunset, and the effect of the bite describe better a ceratopogonid, biting midges to which the common name "sandfly" is often applied. For example, Christy (1903) described the attack of an Ugandan ceratopogonid as: 'This minute fly ... bites terribly, leaving an irritating wheal, which itches for days. It makes a sharp short peevish buzz when settling, fully as loud as a mosquito'.

Probably then the earliest authentic reference to Simuliidae as "sandflies" would be that by Forster (1777) from Cook's second voyage to New Zealand: Dusky Sound, 3-5 April 1773 '... where a sort of little crane-flies ... became remarkably troublesome during the bad weather. They were numerous in the skirts of the woods, not half so large as gnats or musketeoes, and our sailors called them sandflies'.

Strangely, the common name "black fly" was not defined in the main part of the O.E.D. but was defined in the Supplement as 'any one of the species of the genus Simulium ...', this definition originating from "The Century Dictionary, 1889", an American publication. Boas (1896) had used the word "black-flies" a few lines under "sand-fly", and apparently this had been overlooked by the compilers of the O.E.D.: 'others, Black-flies, e.g., Simulium molestum', while Davies, Peterson & Wood (1962) record an earlier use of "black fly" for Simuliidae by Talbot (1824). Still earlier references to Simuliidae in North America are usually given under the common name "mosquitoes" (Davies, Peterson & Wood 1962), a name probably used with the original Spanish meaning of "little flies".

ACKNOWLEDGMENTS

I wish to thank Dr M.J. Winterbourn for his helpful criticisms of this paper. The above work was supported by a New Zealand Postgraduate Scholarship.
COMMON NAMES

LITERATURE CITED


TALBOT, E. A., 1824: Black fly. In Five years' residence in the Canadas (including a tour through part of the United States of America in the year 1823). Volume I: 243-244. London. (Cited by Davies, Peterson & Wood (1962)).


Appendix 2

A gynandromorph of Austrosimulium (Austrosimulium) australense (Schiner) from New Zealand
(Diptera : Simuliidae)

Accepted for publication in: Journal of Natural History
Introduction

When examining a collection of females of *Austrosimulium (Austrosimulium) australense* (Schiner) and *A. (A.) unguilatum* Tonnoir from Punakaiki, West Coast, South Island, a gynandromorph of *A. (A.) australense* was discovered. This individual had the head of a female, but the thorax and abdomen were a mosaic of both male and female characters. According to the classification of gynandromorphs outlined by Puri (1933), this specimen would be a primary somatic hermaphrodite since it possessed parts of the internal and external secondary sexual apparatus of both sexes.

Description of the *A. (A.) australense* gynandromorph

For comparison, descriptions of the normal male and female may be found in Tonnoir (1925) and Dumbleton (1973).

*Head.* That of a normal female. Head dichoptic, eye facets uniformly small. Mouthparts well developed, mandibles and maxillae normally toothed.

*Thorax.* Left side: that of a normal female, with overlying pruinose appearance, scutum with short decumbent hairs, prescutellar depression and scutellum with long black hairs. Haltere light yellow. Wing normal.

Right side: resembling a male, about 1/3 normal number of long black hairs present on prescutellar depression and scutellum. Haltere dark yellow-brown. Wing with very few macrotrichia on costal vein, otherwise normal.

Two features of right side are found in neither sex: overlying pruinose appearance absent; scutum bare, lacking decumbent hairs.

*Legs.* Legs of the left side and the right hind leg female; the right fore and mid legs male, as shown by the presence on each of a finely striated sclerotized pad extending distally from tarsus 5.

*Abdomen.* Basal fringe of hairs on tergite 1; those of left side light as in female; those of right side black as in male, but sparser. Shape of tergites 2-8 indeterminate, intermediate between male and female. Traces of sternites 3 and 5 present (none present in a normal female), shape of sternites 6-8 resembles a male. Lateral tufts of abdominal hairs; those of left side light as in female; those of right side black as in male, but sparser.

*Genitalia.* Internally, no organs recognizable as gonads.

Female structures: complete left and right paraprocts, cerci and anterior gonapophyses present, these external structures occupying their normal terminal position on abdomen, anterior gonapophyses faint; genital fork present but with articulation of right side absent, lightly sclerotized;
A GYNANDROMORPH OF AUSTROSIMULIUM AUSTRALENSE

spermatheca present, with short internal hairs, granular material present in spermatheca but not recognizable as sperm.

**Male structures:** external structures confined to extreme right of segment 9 of abdomen; fully developed right coxite, style and paramere present; style with 3 apical teeth; a small knob of tissue under the right anterior gonapophysis probably represents the left coxite and style; ventral plate present, but about 1/2 normal size; aedeagal membrane with combs of fine spinules present.

**Locality.** Punakaiki Camping Ground, 42° 07'S, 171° 20'E, 18.viii.70, P.M. Johns.

Collected inside a hut on a window together with females of A. (A.) australense and A. (A.) ungulatum. Preserved in 90% ethanol.

**Discussion**

Only one case of gynandromorphism in adult Simuliidae has been described previously, that of an individual of *Simulium* (*Simulium*) palmatum Puri from India (Puri, 1933). This individual was a secondary somatic hermaphrodite, a gynandromorph that possessed the secondary sexual apparatus of one sex only. Gynandromorphs of a similar type were reported for two species by Rubzov (1958), *Simulium* (*Wilhelmia*) equinum (Linnaeus) from the Leningrad district of Russia and *Simulium* (*Wilhelmia*) mediterraneum Puri from Central Asia, but neither was described. Intersexuality appears to be commoner than gynandromorphism, and has been described in four species; *Simulium* (*Obuchovia*) auricoma Meigen from France (Grenier & Bertrand, 1949), *Simulium* (*Simulium*) paramorsitans Rubzov from Russia (Rubzov, 1958), and *Metacnephia* terterjani (Rubzov) and *Simulium* (*Eusimulium*) delizhanense Rubzov from Armenia (Terteryan, 1961); and has been reported for two other species, *Simulium* (*Schoenbaueria*) subpusillum Rubzov and *Simulium* (*Simulium*) morsitans Edwards from the Leningrad district of Russia (Rubzov, 1958). In all described cases specimens were hatched or dissected from pupae that had been collected in the field and brought back to the laboratory for examination.

Overall, female characters were more fully expressed in the A. (A.) australense gynandromorph than those of the male, this dominance being shown most clearly by the hairs of the thoracic and abdominal regions. All female regions were fully haired as in a normal female, but most male regions were more sparsely haired than in a normal male.

Although both female and male genitalia were present in the gynandromorph, only the female genitalia were located in their normal terminal
position on the abdomen. The incomplete set of male genitalia appeared to be confined to the extreme right side, perhaps because of a lack of room for their complete development.

The behaviour of the A. (A.) australense gynandromorph appeared to be that of a typical female since I have found only females in collections of adults taken from windows. The absence of sperm from the spermatheca of the gynandromorph is not surprising, for, even if it was capable of normal female mating behaviour, the presence of male genitalia probably would have prevented successful copulation. In comparison, the twenty normal females of A. (A.) australense examined from the same collection all had sperm present in the spermatheca.

Summary

A gynandromorph of Austrosimulium (Austrosimulium) australense (Schiner) is described. This individual had the head of a female, whereas the thorax and abdomen were a mosaic of male and female characters. The genitalia of both sexes were present, but only the female set was complete. Overall, the female characters of this specimen appeared to be more fully expressed than those of the male.

Acknowledgments

I wish to thank Dr M.J. Winterbourn for his helpful criticisms of this paper. The above work was supported by a New Zealand Postgraduate Scholarship.

References


'A library's most satisfied customer tends to be an elderly scientist who has been in the university for a long time and who cannot understand what all the fuss is about because the collection can provide what he needs for his own work.'

McEldowney (1973) New Zealand University Library Resources 1972 pp. 95-6
On the basis of his experience in assembling a collection of reprints in specialised subject areas using the interloan system a research scientist considers Garfield's proposal that major library centres housing "the least used journals" should be set up for servicing interlibrary loans. Such a proposal has both advantages and limitations, but would not lessen the need, nor provide a substitute for good local collections held at centres where research is being undertaken.
An integral part of any research programme is searching the literature and obtaining papers that are relevant to the research problem. The efficacy of information services or reprint distribution in helping to achieve this aim has been discussed by several authors recently, either expressing their praise or doubts about such systems (1-11).

The thoroughness of a literature search is normally influenced by the abstracting journals or indexing services available, and the time the investigator is prepared to search before deciding that a point has been reached where the returns no longer match the effort expended. Often useful papers are overlooked or ignored because they are not written in the investigator's native language, they have misleading titles that do not indicate the full scope of the paper, or because the source journal is not readily available. This last factor is particularly important in small research centres where library holdings, facilities and finance are normally limited (12, 13) and where specialised reprint collections are probably not available.

The purpose of this paper is to present the results of assembling a reprint collection in such a small centre, the University of Canterbury, Christchurch, New Zealand. The main method of obtaining the literature was through the interlibrary loan (interloan) system, the type of system that has been proposed (14) as being suitable for obtaining papers in the "least used journals" perhaps "stored in regional, national or even international library centers". Since some aspects of my search were carried out in greater depth than others, the efficiency of the interloan system with respect to differing user requirements could be assessed, and also the probable effectiveness and limitations of Garfield's (14) scheme could be evaluated. The papers sought between March 1969 and June 1972 were those concerned with black flies (Diptera: Simuliidae) or with methods of analysing multivariate data.

The reprints were analysed by dividing the collection into four sections (Table I), each representing a different degree of completeness and intensity of search effort depending upon the importance that I had placed upon the section as part of my study. These sections may be characterised as follows:
1. Biology of Simulidae; studies on the biology of larvae and adults. No restrictions on the availability of source journals, no language bias.

2. Catalogue; taxonomic papers affecting simuliid nomenclature, required to compile a catalogue of world species. No restrictions on the availability of source journals, no language bias.

3. Other simuliid papers; studies on parasites, predators, diseases, related ecological methods, morphology, salivary gland chromosomes, control, and taxonomic papers not affecting nomenclature. Mainly from source journals available in New Zealand; English, French and German language bias.

4. Multivariate analysis; mainly discriminant function analysis; a selection of papers sought. Mainly from source journals readily available in New Zealand; English language bias.

TABLE I. Number of reprints in collection compared with the total number of references recorded in card file.

<table>
<thead>
<tr>
<th></th>
<th>Total references recorded</th>
<th>Number of reprints</th>
<th>Percentage of potential reprints in collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>395</td>
<td>272</td>
<td>68.9</td>
</tr>
<tr>
<td>Catalogue</td>
<td>658</td>
<td>588</td>
<td>89.4</td>
</tr>
<tr>
<td>Other simuliid</td>
<td>1,206</td>
<td>526</td>
<td>43.6</td>
</tr>
<tr>
<td>Multivariate</td>
<td>169</td>
<td>111</td>
<td>65.7</td>
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<tr>
<td>TOTAL</td>
<td>2,428</td>
<td>1,497</td>
<td>61.7</td>
</tr>
</tbody>
</table>

TABLE II. Source of the reprints in collection.

<table>
<thead>
<tr>
<th>University of Canterbury libraries</th>
<th>Sent by author</th>
<th>Sent on interloan</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sciences Library, on shelves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>13</td>
<td>3</td>
<td>46</td>
</tr>
<tr>
<td>Catalogue</td>
<td>15</td>
<td>26</td>
<td>62</td>
</tr>
<tr>
<td>Other simuliid</td>
<td>38</td>
<td>24</td>
<td>116</td>
</tr>
<tr>
<td>Multivariate</td>
<td>22</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>88</td>
<td>66</td>
<td>227</td>
</tr>
</tbody>
</table>

| Other libraries or storage         |                |                   |       |
| Biology                            | 3              |                   | 210   |
| Catalogue                          | 26             |                   | 485   |
| Other simuliid                     | 24             |                   | 348   |
| Multivariate                       | 13             |                   | 73    |
| TOTAL                              | 66             |                   | 1,116 |

| Sent by author                     |                |                   |       |
| biology                            | 46             |                   | 272   |
| Catalogue                          | 62             |                   | 588   |
| Other simuliid                     | 116            |                   | 526   |
| Multivariate                       | 3              |                   | 111   |
| TOTAL                              | 227            |                   | 1,497 |
TABLE II—continued

One hundred and fifty-four out of the total of 1,497 were photocopied from the University of Canterbury holdings. About 90 of the reprints sent by authors are available in the University of Canterbury libraries. Therefore, about 16.3 per cent of my collection is available in the libraries.

Of the total references in the card file, about 11 per cent are available in the University of Canterbury libraries.

The means of obtaining 1,497 papers in my reprint collection over the three and a quarter year period are summarised in Table II. The small number of articles shelved in the Sciences Library, University of Canterbury, is striking, and in fact less than 12 per cent of the literature relevant to my study was accessible for consultation from the shelves at the moment it may have been required. To obtain all other literature, at least one request form of some kind had to be filled.

Efficiency of the University of Canterbury Interloan System

The University of Canterbury interloan system is efficient (Table III), even for "in-depth" studies. If an article cannot be located in New Zealand, requests are sent to libraries in Australia, North America, and Britain, usually in that order. If an article has still not been located, often a request is sent to the National Library of the country in which the article has been published. Most articles were obtained, although they were from about 400 different journals and 100 books.

TABLE III. Number of interloans obtained compared with the number requested.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Number requested</th>
<th>Number obtained</th>
<th>Percentage obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>210</td>
<td>210</td>
<td>100.0</td>
</tr>
<tr>
<td>Catalogue</td>
<td>546</td>
<td>485</td>
<td>88.8</td>
</tr>
<tr>
<td>Other simulii</td>
<td>348</td>
<td>348</td>
<td>100.0</td>
</tr>
<tr>
<td>Multivariate</td>
<td>74</td>
<td>73</td>
<td>98.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,178</td>
<td>1,116</td>
<td>94.7</td>
</tr>
</tbody>
</table>

The section "Catalogue" provided a particularly exacting test of the efficiency of the interloan system (Table III) since there was no bias towards requesting only articles that it was thought that the library could locate. Three hundred and seventy-eight journal articles from 240 journals
were obtained; of the 31 requests for journal articles not obtained, 18 were in the above journals but the appropriate volume could not be located, whereas the other 13 were in 13 journals that could not be located. There were 76 interloan requests for books containing articles on simuliid taxonomy and 46 were received; most of the 30 not received were published before 1850, and many of these are rare.

**TABLE IV. Time taken for interloans to arrive.**

<table>
<thead>
<tr>
<th>TIME (weeks)</th>
<th>Less than 1</th>
<th>1-2</th>
<th>2-4</th>
<th>4-8</th>
<th>8-26</th>
<th>26-52</th>
<th>52-104</th>
<th>More than 104</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>12</td>
<td>31</td>
<td>59</td>
<td>56</td>
<td>44</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>210</td>
</tr>
<tr>
<td>Catalogue</td>
<td>4</td>
<td>32</td>
<td>104</td>
<td>142</td>
<td>141</td>
<td>58</td>
<td>11</td>
<td>3</td>
<td>485</td>
</tr>
<tr>
<td>Other simuliid</td>
<td>18</td>
<td>70</td>
<td>152</td>
<td>71</td>
<td>27</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>348</td>
</tr>
<tr>
<td>Multivariate</td>
<td>13</td>
<td>20</td>
<td>25</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>73</td>
</tr>
<tr>
<td>TOTAL</td>
<td>47</td>
<td>143</td>
<td>340</td>
<td>276</td>
<td>219</td>
<td>74</td>
<td>12</td>
<td>5</td>
<td>1,116</td>
</tr>
</tbody>
</table>

Even though the interloan system was efficient, it had the disadvantage that there was a time lag between the time of requesting and the time of receiving items (Table IV). The time scale in Table IV has been divided into units that reflect to some extent the current "usefulness" of an article to a user at the time it is received. About 48 per cent of requests were received in four weeks, a further 44 per cent within 26 weeks, and the remaining eight per cent took up to two years, or even longer, to arrive. In general, the interloans received within four weeks were those obtained in New Zealand, overseas interloans normally took longer than four weeks to arrive; some requests from Australia however, were received within two weeks. The section "Catalogue" provided the best indication of the time required to obtain articles if a complete literature search is being undertaken. This showed that a six-month delay can be expected before most of the literature can be assessed with any degree of confidence.

**Evaluation of Garfield's (14) proposal**

Most libraries in the world are unable to purchase all the journals that they would like to. Therefore major library centres housing "the least used journals" set up for servicing interlibrary loans could be of considerable value. For example, the National Lending Library for Science
and Technology at Boston Spa is a central repository for journals in Britain, and serves to some extent such a function.

Such centres would benefit both users and librarians. Librarians could request an interloan from their nearest centre, and be assured that the article would be serviced and returned quickly no matter how "obscure" the journal. Similarly, the user would know that any paper requested would be obtained in a reasonable period of time, even though it would require form-filling followed by a time lag before receipt.

Publishers of small "local interest" journals would also benefit, as it is this type of journal that libraries are usually unable to purchase. A list of the "small journal" centres would indicate to publishers the libraries likely to subscribe to the journal. As well, authors would be assured that their publication was readily available to all researchers.

My experience in using the University of Canterbury interloan system suggests that there could be several limitations in Garfield's scheme however. A major problem could be the expense of operating such a scheme. It would be the smaller libraries that would make the greatest use of such centres, and if too many requests were made by researchers in a small library available finance might be insufficient to service all requests. Some form of priority would therefore have to be established.

In the scheme, photocopying methods and standards would have to be high, since it is unlikely that the original volumes containing the requested articles would be lent. This particularly applies to the copying of photographs, since at the moment copied photographs are seldom as informative as the originals. This is one reason why reprints are requested by individuals even though the article may be readily available for photocopying.

Often the exact date of publication of an article is required, particularly in taxonomic studies. Because some journals are actually issued at a different date to that stated on the cover (e.g., cover date December, 1972; actual publication date February, 1973), photocopies should state the actual date of publication. Otherwise, mistakes will result when the papers are cited by researchers. In many journals it is difficult to find the actual date of publication, and this could cause problems in the "small journal" centres when servicing such requests.
Perhaps the biggest disadvantage to a user if all interloans are sent as photocopies will be the loss of the "browsing factor"; that is, other papers in the same volume as the requested article that are of direct or fringe interest to the researcher or to his colleagues will not be seen. In my experience many papers of interest were found in volumes sent on interloan, either for myself or for colleagues. In this respect photocopied interloans cannot adequately compensate for the lack of a journal in a library.

To summarise, Garfield's proposal has advantages and limitations. On final analysis however the existence of major library centres operating efficient interloan systems does not lessen the need, nor provide a substitute, for good local collections held at centres where research is being undertaken. The function of any interloan system should be only that of a "back-up" service for specialist needs of researchers, and not for obtaining readily available journals that should be a basic part of any library collection.

Acknowledgments

I wish to thank Mr W.J. McEldowney (University Librarian, University of Otago, Dunedin) and Dr M.J. Winterbourn for their helpful discussions and criticism of this paper. Special thanks go to the staff of the University of Canterbury Library for their efforts in satisfying my requests; in particular, Mr R.N. Erwin and those of the interloan section, Pam Barnett, Alison Eng, Pam Lock, and Elizabeth Russell. I am indebted to Mr P. Hodgson (National Library of Australia, Canberra) who formulated a MEDLARS search for me. The above work was supported by a New Zealand Postgraduate Scholarship.

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3 Garfield, E. Citations-to divided by items-published gives journal impact factor; ISI lists the top fifty high-impact journals of science. Current Contents 23 Feb.:6-9, 1972.

4 ---- Is citation frequency a valid criterion for selecting journals? Current Contents 5 Apr.:5-6, 1972.

5 ---- Citation analysis as a tool in journal evaluation. Science 178:471-9, 1972.


7 Garfield, E. If you can't stand the heat, get out of the kitchen! Publishing journals is not kid-stuff!! Current Contents 7 Mar.:5, 1973.


14 Garfield, E. Citation studies indicate that two copies may be cheaper than one! Current Contents 7 June:5-6, 1972.

15 ---- Should journal publication dates be controlled by legislation? Current Contents 29 Mar.:5-6, 1972.
'Neusner loved computers and statistical theory and his papers were famous for the sheets of numbers that masked the fantasy of his conclusions.'

Updike (1969) Couples p. 111
Appendix 4

Instar determination data and programs

Appendix table 1 -- Measurements of the standardization set of larvae AP 19
Appendix table 2 -- Measurements of the test sets of larvae AP 23
Appendix table 3 -- Standardization set of discriminant function equations AP 27
Appendix table 4 -- Discriminant values of the standardization set of larvae in the standardization set of discriminant function equations AP 36
Appendix table 5 -- Means and variances of the discriminant values of the standardization set of larvae in the standardization set of discriminant function equations AP 52
Calculation of quadratic discriminant function equations AP 56
Multiple discriminant function analysis program -- MDISC AP 61
Program for evaluating discriminant function equations -- DSEV AP 70
Program for counting outlier discriminant values -- LIMIT AP 72
## INSTAR DETERMINATION DATA

### Appendix table 1 -- Measurements of the standardization set of *Austrosimulium tillyardianum* larvae.

#### INSTAR 1

<table>
<thead>
<tr>
<th>SPECIMEN NUMBER</th>
<th>STANDARDIZATION SET OF VARIABLES</th>
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</tr>
<tr>
<td>1</td>
<td>1</td>
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**Appendix table 1 -- continued.**

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* X = SPECIMENS WITH MISCELLANEOUS MEASUREMENTS, NOT USED IN THE MULTIPLE DISCRIMINANT FUNCTION ANALYSES
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**INSTANT DETrMINATION DATA**

**AP 22**

**APPENDIX TABLE 1 -- CONTINUED.**

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**X = SPECIMENS WITH MISSING MEASUREMENTS; NOT USED IN THE MULTIPLE DISCRIMINANT FUNCTION ANALYSES.**
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**X** = SPECIMENS WITH MISSING MEASUREMENTS, NOT USED IN THE MULTIPLE DISCRIMINANT FUNCTION ANALYSES

## Appendix table 2 -- Measurements of the test sets of *Austrostimulium stillvadianum* larvae

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**AP 24**
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## Discriminant Function Equations

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### Discriminant Function Equations

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6  -15001.4644  0.0  -5.9307  -6.7963  -3.2746  -11.1428  -2.7435  -1.0755  7.1265

SELECTION..... 2  VARIABLES USED  2  3  4  5  7  8  9  10  11
INSTAR  CONSTANT  *  COEFFICIENTS
5  -137.7685  0.2109  -0.7490  0.2474  0.3869  0.6191  -2.0264
6  -196.5967  0.2197  -0.0746  0.1777  0.3241  0.4353  1.1444  -3.6420

SELECTION..... 3  VARIABLES USED  4  5  10
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5  -73.6668  0.0229  0.5918  0.5456
6  -123.8164  0.0199  0.7642  0.7350

SELECTION..... 4  VARIABLES USED  5  10
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5  -73.5240  0.6255  0.5908
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5  -14.5609  3.2379  0.1924
6  -53.8465  2.4979  0.2134

SELECTION..... 6  VARIABLES USED  4  5
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5  -65.9271  0.0247  0.8493
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**DISCRIMINANT FUNCTION EQUATIONS**

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### Discriminant Function Equations

**Equations to Discriminate Between Instars 8 & 9**

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# INSTAR DETERMINATION DATA

Appendix table 4 -- continued.

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**Note:** The table continues with more data for Instars 5 and 6.
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**Appendix table 4 -- continued.**

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For Discriminant Function Equations
### INSTAR DETERMINATION DATA

**Appendix table 4 -- continued.**

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Means ($\bar{Y}$) and variances ($s^2$) of discriminant values for larvae of standardization set evaluated using the standardization set of discriminant function equations

a) The discriminant function equation for instar 1 used to separate all 9 instars

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Appendix table 5 -- continued.

f) For separating instars 4 and 5

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g) For separating instars 5 and 6

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h) For separating instars 6 and 7

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APPENDIX TABLE 5 -- continued.

**i) For separating instars 7 and 8**

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**j) For separating instars 8 and 9**

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<td>372.7</td>
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</table>
Calculation of quadratic discriminant function equations

Step 1

The means of the variables for each of the groups are first calculated.

\[ \bar{x}_k = \frac{1}{n_k} \sum_{i=1}^{n_k} x_{ijk} \]

where \( k = 1, 2, \ldots, g \) are groups
\( n_k \) = sample size in the \( k \)th group
\( x_{ijk} \) = the \( i \)th individual of the \( k \)th group
\( j = 1, 2, \ldots, m \) are variables

Step 2

The sum of cross-products of deviations from means is then calculated for each group.

\[ S_k = \{ s_{jl}^k \} = \sum (x_{ijk} - \bar{x}_{jk})(x_{ilk} - \bar{x}_{lk}) \]

where \( j = 1, 2, \ldots, m \)
\( l = 1, 2, \ldots, m \)

Step 3

The pooled dispersion matrix (pooled variance-covariance matrix), \( D \), is computed using the \( S_k \) matrices.

\[ D = \frac{g}{\sum_{k=1}^{g} n_k - g} \sum_{k=1}^{g} S_k \]

where \( g = \) number of groups

An element in the \( i \)th row and \( j \)th column of the matrix is designated as \( s_{ij} \).
Step 4

The inverse of this matrix, \( D^{-1} \), is then found. An element in the \( i^{th} \) row and \( j^{th} \) column of this matrix is designated as \( s^{ij} \). Calculation of the inverse is by the Gauss-Jordan method where the elements of a pivotal row, the covariances, are divided by a pivot (diagonal) element, the variance, and every other row is reduced by the products of its elements times the modified elements of the pivot row (Searle, 1966). As a result of this operation, when the matrix \( D \) is multiplied by its inverse \( D^{-1} \), an identity matrix \( I \) is obtained (an identity matrix is a matrix containing 1's in the diagonal elements and 0's in the off-diagonal elements). The lengthy formulae required to invert a matrix are given by Pennington (1970).

Step 5

The coefficients and constant for each of the \( k_\star = 1, 2, \ldots, g \) discriminant functions are now computed.

Coefficients:

\[
c_{ik_\star} = \sum_{j=1}^{m} s^{ij} \cdot \bar{x}_{jk}
\]

where \( i = 1, 2, \ldots, m \)

\( k = k_\star \)

\( s^{ij} \) = an inverse element of the pooled dispersion matrix \( D \).

Constant:

\[
c_{0k_\star} = -\frac{1}{2} \sum_{j=1}^{m} \sum_{l=1}^{m} s^{jl} \cdot \bar{x}_{jk} \cdot \bar{x}_{lk}
\]

Step 6

By evaluating the discriminant functions for each \( i^{th} \) individual of each \( k^{th} \) group, the probability of an individual belonging to an assigned group can be assessed.

Discriminant functions:

\[
z_{k_\star} = \sum_{j=1}^{m} c_{jk_\star} \cdot x_{ijk} + c_{0k_\star}
\]

where \( k_\star = 1, 2, \ldots, g \)
Probability of being associated with the largest discriminant function:
\[ P_L = \frac{1}{\sum_{k=1}^{g} e^{(z_{k*} - z_L)}} \]

where \( z_L \) = value of the largest discriminant function.
\( L \) = subscript of the largest discriminant function.

Step 7

As a measure of the distance between groups, the generalized Mahalanobis \( D^2 \) statistic, \( V \), is calculated.

Common means:
\[ \bar{y}_j = \frac{\sum_{k=1}^{g} n_k \bar{y}_{jk}}{\sum_{k=1}^{g} n_k} \]

Mahalanobis \( D^2 \):
\[ V = \sum_{i=1}^{m} \sum_{j=1}^{m} s_{ij} \sum_{k=1}^{g} n_k (\bar{y}_{ik} - \bar{y}_i)(\bar{y}_{jk} - \bar{y}_j) \]

\( V \) can be used as chi-square (under assumption of normality) with \( m(g - 1) \) degrees of freedom, to test the hypothesis that the mean values are the same in all the \( g \) groups for these \( m \) variables.

LITERATURE CITED


The calculation of discriminant function equations is illustrated using the simplest case of discriminating between two groups by two variables. The two groups are the 3rd and 4th larval instars of *A. tillyardianum*, and the two variables are numbers 5 (mandible length) and 10 (antennal segment 3 length) of the standardization set of data. Sample size in each case is 19.

1. Means for the variables of the groups.

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<tr>
<td>Instar 4</td>
<td>105.21045</td>
<td>84.05783</td>
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2. Sum of cross-products of deviations from means

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3. Pooled dispersion matrix, $D$

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4. Inverse of pooled dispersion matrix, $D^{-1}$

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</tr>
<tr>
<td>$x_2$</td>
<td>-0.02113</td>
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</table>

5. To check the distinctness of the instar groups, the Mahalanobis $D^2$ statistic $V$ is computed.
Common means:

\[ \bar{Y}_1 = 91.07359 \quad \bar{Y}_2 = 71.31833 \]

where

\[ \bar{Y}_1 = \frac{(19 \times 76.93675) + (19 \times 105.21045)}{19 + 19} \]

Calculation of the generalized Mahalanobis \( D^2 \) statistic gives the value 269.78540 with 2 degrees of freedom, demonstrating that there are significant differences between the instar groups.

6. Discriminant functions

\[ z_1 (\text{instar } 3, x_1, x_2) = 2.73464 \times x_1 - 0.04049 \times x_2 - 104.01082 \]

\[ z_{II} (\text{instar } 4, x_1, x_2) = 3.65610 \times x_1 + 0.05156 \times x_2 - 194.49634 \]

The coefficient for the variable \( x_1 \) of the discriminant function associated with instar 3, \( c_{I,1} \), is calculated as follows.

\[ c_{I,1} = s_{11} \times \bar{X}_{I,1} + s_{12} \times \bar{X}_{I,2} \]

\[ = (0.05163 \times 76.93675) + (-0.02113 \times 58.57886) \]

\[ = 2.73464 \]

The constant for the discriminant function associated with instar 3, \( c_{I,0} \), is given by:

\[ c_{I,0} = -1/2 \left( c_{I,1} \times \bar{X}_{I,1} + c_{I,2} \times \bar{X}_{I,2} \right) \]

\[ = -1/2 ((2.73464 \times 76.93675) + (-0.04049 \times 58.57886)) \]

\[ = 104.01082 \]

7. Group membership probabilities of individuals

Measurements of individuals are now substituted in the equations. For example, an individual with mandible length of 85.0 \( \mu \)m and antennal segment 3 length of 60.5 \( \mu \)m gives discriminant values of

\[ z_1 (\text{instar } 3) = 125.984 \]

\[ z_{II} (\text{instar } 4) = 119.392 \]

Since \( z_1 \) is larger than \( z_{II} \) this individual is a member of instar 3. The probability of this individual being associated with instar 3 can be calculated as being 0.99863.
Computer program for Multiple Discriminant Function Analysis -- MDISC. (FORTRAN IV language for an IBM 360/44 machine).

MODEL 44 PS  VERSION 3, LEVEL 3  DATE 72327

MULTIPLE DISCRIMINANT FUNCTION ANALYSIS -- MDISC

MODIFICATION OF IBM APPLICATION PROGRAM
SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE

T. K. CRUSEY  AUGUST 1971

PURPOSE

TO CLASSIFY AN INDIVIDUAL INTO ONE OF SEVERAL CATEGORIES USING A SERIES OF MEASUREMENTS. IN MOST CASES IT CAN BE ASSUMED THAT THERE ARE A FINITE NUMBER OF CATEGORIES OR POPULATIONS EACH OF WHICH THE INDIVIDUAL MAY HAVE COME AND EACH POPULATION IS CHARACTERIZED BY A PROBABILITY DISTRIBUTION OF THE MEASUREMENTS.

METHOD

A SET OF LINEAR FUNCTIONS IS CALCULATED FROM A STANDARDIZATION SET OF DATA ON GROUPS TO ALLOW THE CLASSIFICATION OF INDIVIDUALS INTO ONE OF SEVERAL GROUPS. THE CLASSIFICATION OF INDIVIDUALS IS PERFORMED BY EVALUATING EACH OF THE CALCULATED LINEAR FUNCTIONS, THEN FINDING THE GROUP FOR WHICH THE VALUE IS LARGEST. THE LINEAR FUNCTIONS CAN BE USED FOR EVALUATING ANOTHER TEST SET OF NEW INDIVIDUALS TO SEE WHICH GROUP THEY BELONG TO (DISCRIMINANT EVALUATION PROGRAM).

METHOD


SUBROUTINE: SL/PROGRAMS REQUIRE

READ FOR EACH DATA SET ARE
1) A PARAMETER CARD,
2) A CARD CONTAINING THE STANDARDIZATION COEFFICIENTS FOR THE VARIABLES,
3) A VARIABLE FORMAT CARD DESCRIBING THE PUNCHING OF THE INPUT DATA, AND
4) THE DATA WHICH ARE PLACED IN A 3-DIMENSIONAL FORTRAN ARRAY.

FOLLOWING ARE A VARIABLE NUMBER OF SELECTION CARDS TO SELECT DATA CLASSIFICATION
5) THE SELECTION TYPE INDICATING THE GROUP NUMBERS TO BE USED IN THE SELECTION OF INDIVIDUALS.

A BLANK CARD AFTER 6) WILL CAUSE A NEW GROUP SELECTION CARD TO BE READ STARTING FROM 1). A CARD WITH A POSITIVE NUMBER FOLLOWING THE SELECTION INDICATES THAT ALL ANALYSES HAVE BEEN COMPLETED.

THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO THE NUMBER OF GROUPS, M.

DIMENSION H(M)

THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO THE NUMBER OF VARIABLES, N.

DIMENSION CMEAN(N)

THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO THE PRODUCT OF N(M).

DIMENSION XBED(N)

THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO THE PRODUCT OF (M-1)K.

DIMENSION C1(12)

THE FOLLOWING DIMENSION MUST BE GREATER THAN OR EQUAL TO THE PRODUCT OF N(M).

DIMENSION D1(12)

THE FOLLOWING DIMENSIONS MUST BE GREATER THAN OR EQUAL TO THE TOTAL OF SAMPLE SIZES OF K GROUPS COMBINED, T (T = T1*...*K).

DIMENSION P(250), LG(250)
VECTOR CONTAINING A DATA SUBSET

OTHER DIMENSIONS ADDED TO THE IBM VERSION

DIMENSION XA(4000)

DIMENSION FAIT(20)

DIMENSION ITTRANS(40)

DIMENSION XA(9,25,34)

DIMENSION KGROUP(9)

DIMENSION KGROUP(9)

DIMENSION NLIST(9)

DIMENSION XA(9,25,34)

VECTOR CONTAINING THE GROUP NUMBERS TO BE USED IN A SELECTION

VECTOR CONTAINING THE GROUP SIZES TO BE USED IN A SELECTION

VECTOR CONTAINING THE VARIABLE NUMBERS TO BE USED IN A SELECTION

VECTOR FOR WRITING OUT THE INVERSE OF THE POLED DISPERSION MATRIX

THE COMMON ARRAY XA MUST BE THE SAME DIMENSIONS AS IN THE SUBROUTINE SUBPROGRAM DATA.

IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE STATEMENT WHICH FOR FCLLChG.

THE COMMON PRECISION CPEAN, KEPAN, CDET, GVP

THE COMMON PRECISION STATEMENTS APPEARING IN OTHER ROUTINES SHOULD BE REMOVED FROM THIS ROUTINE.

COMMON XA

1 FORMAT (24 A A, A5, E15.5)
2 FORMAT (24 A A, A5, E15.5)
3 FORMAT (24 A A, A5, E15.5)
4 FORMAT (24 A A, A5, E15.5)
5 FORMAT (24 A A, A5, E15.5)
6 FORMAT (24 A A, A5, E15.5)
7 FORMAT (24 A A, A5, E15.5)
8 FORMAT (24 A A, A5, E15.5)
9 FORMAT (24 A A, A5, E15.5)
10 FORMAT (24 A A, A5, E15.5)
11 FORMAT (24 A A, A5, E15.5)
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18 FORMAT (24 A A, A5, E15.5)
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21 FORMAT (24 A A, A5, E15.5)
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23 FORMAT (24 A A, A5, E15.5)
24 FORMAT (24 A A, A5, E15.5)
INSTAR DETERMINATION PROGRAMS

25 ARE THE SAMPLES IN ALL THE '12,' GROUPS FOR THESE '13,' VARIABLES.

READ PROBLEM PARAMETER CARD

100 READ (5,1,END=999) PR, PRI, K, H, IDATA, IPUNCH, N(1), I=1,K)

PR: PROBLEM NUMBER (MAY BE ALPHABETIC)

PRI: PROBLEM NUMBER (CONTINUE)

K: NUMBER OF GROUPS

H: NUMBER OF VARIABLES

IDATA: PRINTLY OF DATA INPUT OPTION

IPUNCH: DISCRIMINANT EQUATIONS PUNCHED ON CARDS OPTION

N: VECTOR OF LENGTH K CONTAINING SAMPLE SIZES

IF (K LE 1, G) GC TO 999

WRITE (6,3) PR, PRI, K, H

READ TRANSFORMATION CODES OF VARIABLES

READ (5,18) [TRANS(I)], I = 1, M

WRITE (6,21) [TRANS(I)], I = 1, M

READ VARIABLE FORMAT OF DATA

READ (5,2) FMT

READ DATA SET AND PLACE IN ARRAY XA

WRITE (6,30) I, XA(I)

TRANSFORM DATA IF REQUIRED

CALL DATA (M, I, J, TRANS)

CONTINUE

120 CONTINUE

READ GROUP NUMBERS SELECTION CARD

300 READ (5,19) KGROUP, (KGROUP(I), II = 1, NGROUP)

KGROUP: NUMBER OF GROUPS IN SELECTION

KGROUP(I): THE NUMBERS OF THE GROUPS IN SELECTION

IF (NGROUP) 999, 100, 200

WRITE (6,22) I, KGROUP(I), II = 1, NGROUP

CONTINUE

READ VARIABLE NUMBERS SELECTION CARD

400 READ (5,18) KKJ, (KKJ(I), JJ = 1, NKJ)

KKJ: NUMBER OF VARIABLES IN SELECTION

KKJ(I): THE NUMBERS OF THE VARIABLES IN SELECTION

IF (NKJ) 999, 300, 230

WRITE (6,23) KL, KKJ(I), JJ = 1, NKJ

CONTINUE

TRANSFER DATA SUBSET FROM XA TO X

WRITE (6,24) KL, NKJ, (X(I), I = 1, KL)

CONTINUE

END
MISC -- continued.

I = LAG
N1 = NA(1)
DO 240 I1 = 1, K1
L = L + 1
N2 = N1
DO 240 JJ = 1, NKJ
JJ = KJ(JJ)
C(NEAN(IJ)) = XA(IAG, IN, JK)
N2 = NMIN
X(IJ) = C(NEAN(IJ))
240 L = N2

TRANSFER GROUP SIZES IN SELECTION FROM N TO NA

DC 800 I1 = KGRCP
LAG = KGRCLP(I1)
I = LAG
N1 = N(I1)
N2 = N(I1)
K = NGRCP
P = NKJ
C

CALL DRATX(K,P,N,A,XBAR,C,MEAN)

PRINT PEAKS AND PCCLE Dispersion Matrix

LD = DC 270 I = 1, K
NL = KGRCP(I1)
DO 260 J = 1, P
NL = 1

260 WRITE(6,63) NG, C(NEAN(IJ), J = 1, P)
WRITE(6,47) I
LD = 1
DO 160 J = 1, P
LD = 1

160 C(NEAN(IJ)) = XBAR(J)
WRITE(6,8) I, J, C(NEAN(IJ), J = 1, P)

C

PRINT PCCLE Dispersion Inverse and Determinant

WRITE (6,22) I
LD = 0
DO 162 I = 1, P
DC 161 J = 1, P
L = L + 1

162 WRITE(6,23) I,

C

CALL DISCR(K,P,N,A,XBAR,C,MEAN,V,C,P,LAG)

PRINT COMMON MEANS

WRITE (6,7) C(NEAN(IJ), I = 1, P)

PRINT GENERALIZED VARIANCES C-SQUARE

WRITE (6,10) V
IFP = (K, I = 1, P)
WRITE (6,24) V, IFP, X, P

PRINT Constants and Coefficients of Discriminant Functions

N1 = N
N2 = N
DC 180 I = 1, K
WRITE (6,11) I, C(IJ), J = N1, N2

CHECK IF THE CONSTANT AND COEFFICIENTS OF THE DISCRIMINANT FUNCTIONS ARE TO BE PUNCH CUT

IF I PUNCH A.E. C1 GC TO 171

GO TO 174

171 PJ = (N2 - N1) + 1
WRITE (7) PJ, (C(IJ), J = N1, N2)

C

PRINT EVALUATION OF CLASSIFICATION FUNCTIONS FOR EACH OBSERVATION

WRITE (6,12) I
N1 = N
N2 = N(1)
DO 210 I1 = 1, K1
NG = KGRCLP(I1)
WRITE (6,13) NG
LD = C(IJ, J = N1, N2)
L = 1

210 WRITE (6,14) I, PJ, I(LEII)
IF I ERKJ 200

GO TO 190

200 N1 = N1 + NA(1)
N2 = N2 + NA(1) + 1

C

CONTINUE

C

STOP

END
SUBROUTINE DPATX

PURPOSE

COMPLETE MEANS OF VARIABLES IN EACH GROUP AND A PCCELE DISPERSION MATRIX FOR ALL THE GROUPS. NUMERICAL THIS SUB-
Routines IS USED IN THE PERFORMANCE OF DISCRIMINANT ANALYSIS.

USAGE

CALL DPATX (K,P,N,X,XBAR,D,CPMEAN)

DESCRIPTION OF PARAMETERS

K - NUMBER OF VARIABLES (MUST BE THE SAME FOR ALL

N - INPUT VECTOR OF LENGTH K CONTAINING SAMPLE SIZES OF

X - INPUT VECTOR CONTAINING DATA IN THE PANNER EQUIVA-

CANT TO A 3-DIMENSIONAL FORTRAN ALIAS, XI(1:1,11), XI(2:1,11), ETC. THE FIRST SUBSCRIPT IS

CASE NUMBER, THE SECOND SUBSCRIPT IS VARIABLE NUMBER

AND THE THIRD SUBSCRIPT IS GROUP NUMBER. THE

LENGTH OF VECTOR X IS EQUAL TO THE TOTAL NUMBER

OF CASE POINTS, NPK, WHERE I = N(1) + N(2) +...+ N(K).

XBAR - OUTPUT MATRIX (P X K) CONTAINING MEANS OF VARIABLES

IN K GROUPS.

D - OUTPUT MATRIX (P X M) CONTAINING PCCELE DISPERSION.

CPMEAN - WORKING VECTOR OF LENGTH P.

REMARKS

THE NUMBER OF VARIABLES MUST BE GREATER THAN OR EQUAL TO

THE NUMBER OF GROUPS.

SUBRoutines AND FUNCTION SUBPROGRAMS REQUIRED

NONE

METHOD

REFER TO BMD COMPUTER PROGRAMS MANUAL, EDITED BY J. J.

CITICA, UCLA 1964, AND T. W. ANDERSON, INTRODUCTION TO

MULTIVARIATE STATISTICAL ANALYSIS. JOHN WILEY AND SONS,

1958, SECTION 6.6-6.8.

SUBROUTINE DPATX (K,P,N,X,XBAR,D,CPMEAN)

DIMENSION N(1),X(1:1,XBAR(1),D(1:1),CPMEAN(1))

DOUBLE PRECISION XBAR,D,CPMEAN

IF A DOUBLE PRECISION VERSION OF THIS ROUTINE ISEEDED THE

STATEMENTS WHICH USE CPCLCS.

DOUBLE PRECISION XBAR,D,CPMEAN

THE E PLT ALSO BE RECIPIE FROM DOUBLE PRECISION STATEMENTS

IN OTHER Routines USED IN CONJUNCTION WITH THIS

Routines.

INITIALIZATION

N=N+1,M=I+1,M

10 C DC 100 I=1,M

DC 100 N=1,N

DC 100 NG=1,K

DC N(1)=1,N

DC I=1:1,M

12 C XBAR=0.0

DC I(1)=1,M

13 C XBAR=0.0

14 C XBAR=0.0

15 C XBAR=0.0

16 C XBAR=0.0

17 C XBAR=0.0

18 C XBAR=0.0

19 C XBAR=0.0

RETURN

END
SUBROUTINE MINV

PURPOSE

INVERT A MATRIX

USAGE

CALL MINV(A,N,C,L,M,K)

DESCRIPTION OF PARAMETERS

A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY RESULTANT INVERSE.
N - NUMBER OF ROWS OF MATRIX A.
C - RESULTANT DETERMINANT. IF N=0 THEN DETERMINANT IS ALREADY IN A.
L - WORK VECTOR OF LENGTH N.
M - WORK VECTOR OF LENGTH N.
K - RESULTANT SINGULARITY INDICATOR. K=0 THEN DETERMINANT NOTZERO.

REMARKS

MATRIX A MUST BE A GENERAL MATRIX
SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
NONE

METHOD

THE STAGNAR GAUSS-JORDAN METHOD IS USED; THE DETERMINANT IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT THE MATRIX IS SINGULAR.

SUBROUTINE MINV(N,C,L,M,K)

DIMENSION A(N,L,M,K)

IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED THE STATEMENT WHICH FOLLOWS MUST BE REMOVED FROM THE DOUBLE PRECISION STATEMENT WHICH FOLLOWS.

DOUBLE PRECISION A,D,BIGA,PIV

THE C MUST ALSO BE REPLACED FROM DOUBLE PRECISION STATEMENTS APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS ROUTINE.

THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS. ABS IN STATEMENT 10 MUST BE CHANGED TO DBS.

SEARCH FOR LARGEST ELEMENT

D=1.0
K=0
DO 10 K=K+1,N
DD=DD+K**2
10 CONTINUE

INTERCHANGE ROWS

J=J(K)
10 FLJ=K, K=J
25 CONTINUE

INTERCHANGE COLUMNS

35 J=J(K)
36 FLJ=K, K=J
SUBROUTINE DISC

PURPOSE

COMPLETE A SET OF LINEAR FUNCTIONS WHICH SERVE AS INDICES FOR CLASSIFYING OR DETERMINING INTO ONE OF THE FIFTY STATES. NORMALLY THIS SUBROUTINE IS USED IN THE PERFORMANCE OF DISCRIMINANT ANALYSIS.

DESCRIPTION OF PARAMETERS

K - NUMBER OF GROUPS. K MUST BE GREATER THAN ONE.
N - INPUT VECTOR OF LENGTH K CONTAINING SAMPLE SIZES OF GROUPS.
X - INPUT VECTOR CONTAINING DATA IN THE FORM EQUIVALENT TO A 3-DIMENSIONAL FRACTION ARRAY, X(J,I,K), WHERE J IS THE SECOND SUBSCRIPT, I IS THE THIRD SUBSCRIPT, AND THE FIRST SUBSCRIPT IS GROUP NUMBER. THE TOTAL NUMBER OF DATA POINTS, N, WHERE N = (N1)(N2)(N3), ARE THE MEANS OF DATA POINTS IN K GROUPS.
XBAR - INPUT MATRIX (K X K) CONTAINING MEANS OF VARIABLES IN K GROUPS.
YBAR - OUTPUT VARIABLE CONTAINING GENERALIZED POPULATION MEANS.
C - OUTPUT MATRIX (K X K) CONTAINING THE COEFFICIENTS OF DISCRIMINANT FUNCTIONS. THE FIRST POSITION OF EACH COLUMN (FUNCTION) CONTAINS THE VALUE OF THE CONSTANT FOR THAT FUNCTION.
P - OUTPUT VECTOR CONTAINING THE PROPORTION ASSOCIATED WITH THE LARGEST DISCRIMINANT FUNCTIONS OF ALL CASES. THE OCCURRENCE AND OCCURRANCE OF THE DATA LINES (K X 1) ARE THE MEAN LINES OF VECTORS X AND Y.
LG - OUTPUT VECTOR CONTAINING THE LINES OF VECTORS X AND Y AS THE MEAN LINES OF VECTORS X AND Y.
MDISC -- continued.

REMARKS
1. THE NUMBER OF VARIABLES MUST BE GREATER THAN OR EQUAL TO
   THE NUMBER OF GROUPS.
2. SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRE
   NO CODE.

METHOD
1. REFER TO "PDP COMPILER PROGRAMS MANUAL", EDITED BY W. J.
   DIXON, U.C.L.A, 1965, AND T. W. ANDERSON, "INTRODUCTION TO
   MULTIVARIATE STATISTICAL ANALYSIS", JOHN WILEY AND SONS,
   1958, SECTION 6.8.4.1.

SUBROUTINE DISCR (K,N,XBAR,D,CMEAN,N,C,P,L,G)
DIMENSION N(I),X(I),XBAR(I),D(I),CMEAN(I),C(I),P(I),L(I),G(L)

IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE
STATEMENT WHICH FOLLOWS.

THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS
APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS
ROUTINE.

THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO
CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS. EXP IN STATEMENT
250 MUST BE CHANGED TO CEXP.

CALCULATE COPPEN MEANS
1 = 1, N

CALCULATE GENERALIZED MAPALONDBIS D SQUARE

CALCULATE THE COEFFICIENTS OF DISCRIMINANT FUNCTIONS

FOR EACH CASE IN EACH GROUP, CALCULATE..
SUBROUTINE DATA

PURPOSE TO CHECK IF INPUT DATA ARE TO BE TRANSFORMED TO A NEW SCALE.
DATA MAY BE TRANSFORMED AS FOLLOWS
  1 - ARGUMENT VALUE
  2 - SQUARE ROOT
  3 - SQUARE ROOT + G.5
  4 - VALUE SCALING
  5 - LOGARITHM OF VALUE BASE 10
  6 - ARSIN OF VALUE; A PERCENT BETWEEN ZERO AND ONE
  7 - RECIPROCAL OF VALUE

USAGE CALL DATA (PI,JL,ITRANS)

DESCRIPTION OF PARAMETERS
  M = NUMBER OF VARIABLES IN DATA SET
  I = CLASS NUMBER
  JL = NUMBER OF AN INDIVIDUAL IN THE CLASS
  ITRANS = VECTOR CONTAINING TRANSFORMATION CODES OF THE VARIABLES

REMARKS
THE COMMON ARRAY XA MUST BE THE SAME DIMENSIONS AS IN THE
MAINLINE PROGRAM MDISC

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
FREE

METHOD REFER R.R. SCKAL AND F.I. RCHLF, "BIOMETRY", W.I.
FREE AND COMPANY, SAN FRANCISCO, 1969, APPENDIX 3.
Computer program for evaluating discriminant function equations -- DSEV. (FORTRAN IV language for an IBM 360/44 machine).

---

PROGRAM FOR EVALUATING DISCRIMINANT FUNCTION EQUATIONS - DSEV
T. K. CROSBY AUGUST 1971

PURPOSE
TO READ A DATA SET AND FOR EACH INDIVIDUAL, CALCULATE THE DISCRIMINANT VALUES FROM THE GIVEN DISCRIMINANT FUNCTION EQUATIONS. USE IT TO SELECT THE GROUP FROM WHICH A TEST SET OF DATA TO BE EVALUATED IN A STANDARDIZATION SET OF DISCRIMINANT FUNCTION EQUATIONS.

SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
DATA

REMARKS
THE PROGRAM HAS BEEN WRITTEN WITH THE FOLLOWING MAXIMUM DIMENSIONS:
- NUMBER OF GROUPS: 9
- OBSERVATIONS PER GROUP: 40
- NUMBER OF VARIABLES: 16

THE MEASUREMENTS OF AN INDIVIDUAL CAN BE EVALUATED IN 12 DIFFERENT DISCRIMINANT FUNCTION EQUATIONS IN EACH PROGRAM RUN.

THE COMMON ARRAY D MUST BE THE SAME DIMENSIONS AS IN THE SUBROUTINE SUBPROGRAM DATA.

ONLY ONE DATA SET CAN BE EVALUATED IN EACH PROGRAM RUN.

READ FOR A DATA SET ARE THE FOLLOWING CARDS:
- GROUP CARD FOR THE DATA SET
- GROUP DIMENSIONS OF THE DATA SET
- TRANSFORMATION CODES FOR THE VARIABLES
- FORMAT CARD DESCRIBING THE PUNCHING OF THE INPUT DATA
- THE DATA, WHICH ARE PLACED IN A 3-DIMENSIONAL FORTRAN ARRAY FOLLOWING ARE A VARIABLE NUMBER OF SELECTION CARDS TO SELECT DATA SUBSETS, AND TO EVALUATE DISCRIMINANT EQUATIONS.
- THE FIRST TYPE INDICATING THE GROUP NUMBERS TO BE USED IN THE SELECTION.
- THE SECOND TYPE INDICATING THE VARIABLE NUMBERS TO BE USED IN THE SELECTION. THERE MAY BE SEVERAL OF THESE CARDS FOR EACH GROUP SELECTION CARD.
- THE THIRD TYPE PROVIDING THE DISCRIMINANT EQUATIONS TO BE USED IN THE SELECTION. THERE MAY BE SEVERAL OF THESE CARDS FOR EACH VARIABLE SELECTION CARD.

TWO blank cards after 81 will cause the discriminant values calculated to be printed and punched. A card with a negative number following the selections indicates that all calculations have been completed.

---

DIMENSION D(40,16),HEADNG(20),FMT(20),COEFF(16),KJ(16)
DIMENSION NC(9),KGROUP(9),LGROUP(9),ITRANS(16),SSUM(16,160)
COMMON D,FMT,COEFF,HEADNG


READ AND PRINT HEADING CARD OF DATA SET
100 READ (5,1,END=999,ERR=999) HEADNG
WRITE (6,11) HEADNG

READ THE GROUP DIMENSIONS OF THE DATA SET
READ (5,23) KA, M, (N(I), I = 1, KA)

KA = NUMBER OF GROUPS
M = NUMBER OF VARIABLES
C

SIZE OF THE GROUPS

IF (M .LE. 0) GO TO 999

WRITE (16,1) KA

DO 150 I = 1, KA

150 WRITE (16,12) I, N(I)

READ TRANSFORMATION CODES OF VARIABLES

READ (5,2) (ITRANS(I), I = 1, M)

READ VARIABLE FORMAT OF DATA

READ (5,1) FMT

DO 165 I = 1, KA

165 WRITE 16,13 I

READ DATA SET AND PLACE IN ARRAY D

READ (5,FMT) ID(I,IH,J), J = 1, M

TRANSFORM DATA IF REQUIRED

CALL DATA (N(I),IH,ITRANS)

CONTINUE

PRINT THE INPUT DATA, THE TRANSFORMED VALUES ARE PRINTED IF
TRANSFORMATION WAS REQUESTED

DO 175 I = 1, KA

175 WRITE (16,14) I, (D(I,IH,J), J = 1, M)

READ GROUP NUMBERS SELECTION CARD

READ (5,2) NGROUP, (KGROUP(I)), I = 1, NGROUP

NGROUP ••• NUMBER OF GROUPS TO BE USED IN THIS SERIES

KGROUP(I) ••• THE NUMBERS OF THE GROUPS TO BE USED

IF (NGROUP .EQ. 999, 500, 20)

IF NEGATIVE, CALCULATIONS COMPLETED

IF ZERO OR-blank, CONTROL IS TRANSFERRED TO STATEMENT NUMBER 500.

IF DISCRIMINANT VALUES ARE PRINTED

IF POSITIVE, CONTINUE

CONTINUE

WRITE (16,4) (KGROUP(I), I = 1, NGROUP)

11 = 1

NGROUP = NGROUP

DO 80 II = 1, NGROUP

80 GGROUP(II) = KGROUP(II)

READ VARIABLES NUMBERS SELECTION CARD

READ (5,2) NEQ, NKJ, (KJ(J), JJ = 1, NKJ)

NEQ ••• NUMBER OF EQUATIONS IN THIS SELECTION

KJ(J) ••• THE NUMBERS OF THE VARIABLES TO BE USED IN SELECTION

IF (NEQ .EQ. 999, 200, 30)

IF NEGATIVE, CALCULATIONS COMPLETED

IF ZERO OR blank, GO TO STATEMENT NUMBER 200 TO SEE IF
DISCRIMINANT VALUES ARE TO BE PRINTED

IF POSITIVE, CONTINUE

CONTINUE

WRITE (6,5) KL, (KJ(J), JJ = 1, NKJ)

KL = KL + 1

DO 60 K = 1, NEQ

READ THE DISCRIMINANT FUNCTION EQUATIONS

READ(5,6) NCOEF, (COEF(I), I = 1, NCOEF)

NCOEF ••• NUMBER OF COEFFICIENTS IN THE EQUATION (PLUS CONSTANT)

COEF •••••• THE CONSTANT AND COEFFICIENTS OF THE EQUATION

WRITE (6,7) K, (COEF(I), I = 1, NCOEF)

CALCULATE THE DISCRIMINANT VALUES FOR EACH INDIVIDUAL

DO 50 II = 1, NGROUP

LC = KGROUP(II)

NI = N(LG)
DSEV -- continued.

DO 50 IH = 1, N1
  SUM = 0.
  DO 2 J = 1, NKJ
     SUM = SUM + COEF(J2) * DLG(1H, J)
  SSM(IDIS, 1055) = SUM
  50 IDIS = IDIS + 1
C
  GO TO 300

CC

OUTPUT OF DISCRIMINANT VALUES

CC

DO 900 IDIS = IDIS-1

CC

DO 990 INCB

CC

PUNCH THE DISCRIMINANT VALUES

CC

WRITE(7,151) (SSUM(IDIS,J), IDIS=1, IDIS)

CC

PRINT THE DISCRIMINANT VALUES

CC

CONTINUE

CC

READ A NEW GROUP NUMBERS SELECTION CARD

CC

GO TO 200

CC

STOP

END

Computer program for counting outlier discriminant values -- LIMIT.
(FORTRAN IV language for an IBM 360/44 machine).

*******************************************************************************

PROGRAM FOR COUNTING OUTLIER DISCRIMINANT VALUES -- LIMIT
T. K. CRESBY NOVEMBER 1971


SLRoutines and function subprograms required:

READ FOR EACH DATA SET ARE THE FOLLOWING CARDS

1) THE NUMBER OF DISCRIMINANT VALUES AND THE VARIABLE FORMAT DESCRIBING THE PUNCHING OF THE DISCRIMINANT VALUES

2) THE DISCRIMINANT VALUES

SUBROUTINE CUT IS CALLED FOR EACH SET OF DISCRIMINANT VALUES IN TURN, AND A CARD CONTAINING THE CORRESPONDING SAMPLE SIZE, MEAN AND VARIANCE OF THE STANDARDIZATION DISCRIMINANT VALUE SET IS READ.

*******************************************************************************

DIMENSION 01(301),02(301),03(301),04(301),05(301),06(301),07(301),08(301),
10(301),101(1301),102(1301),103(1301),104(1301),105(1301),106(1301),107(1301),108(1301),109(1301),110(1301),111(1301),112(1301),113(1301),114(1301),115(1301),116(1301),117(1301),118(1301),119(1301),120(1301)

INPUT DATA

10C READ(1, END=993),(FM1(1), 1=1, 20)
  1 FORMAT(2(F4.4, A2))

READ DISCRIMINANT VALUES

DO 2 I = 1, N
  READ(1, 222),(C11(1), C21(1), C31(1), C41(1), C51(1), C61(1), C71(1), C81(1), C91(1), C101(1), C111(1), C121(1), C131(1), C141(1), C151(1), C161(1), C171(1), C181(1), C191(1), C201(1), C211(1), C221(1), C231(1), C241(1), C251(1), C261(1), C271(1), C281(1), C291(1), C301(1))
  CALL CUT(1, 1, A11)
  CALL CUT(1, 2, B11)
  CALL CUT(1, 3, C11)
  CALL CUT(1, 4, D11)
  CALL CUT(1, 5, E11)
  CALL CUT(1, 6, F11)
  CALL CUT(1, 7, G11)
  CALL CUT(1, 8, H11)
  CALL CUT(1, 9, I11)
  CALL CUT(1, 10, J11)
  CALL CUT(1, 11, K11)
  CALL CUT(1, 12, L11)
  CALL CUT(1, 13, M11)
  CALL CUT(1, 14, N11)
  CALL CUT(1, 15, O11)
  CALL CUT(1, 16, P11)
  CALL CUT(1, 17, Q11)
  CALL CUT(1, 18, R11)
  CALL CUT(1, 19, S11)
  CALL CUT(1, 20, T11)
  2 CONTINUE
C

999 STOP
END
SUBROUTINE CUT

USAGE CALL CUT(V,NC,INFO)

DESCRIPTION OF PARAMETERS
V= VECTOR CONTAINING DISCRIMINANT VALUES
NC = NUMBER OF DISCRIMINANT VALUES
INFO= IDENTIFICATION VECTOR

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
NONE

REMARKS SEE MAINLINE PROGRAM FOR FULL DESCRIPTION OF LSE

DIMENSION V(1),FC(30),TC(30),INFO(2)

T VALUES AT 5 PER CENT LEVEL OF SIGNIFICANCE

DATA T/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,2.228,2.201,2.179,2.150,2.128,2.110,2.103,2.088,2.079,2.072,2.064,2.058,2.052,2.046,2.041,2.036,2.031,2.026,2.021,2.016,2.011,2.007,2.002,2.000,2.000

T VALUES AT 1 PER CENT LEVEL OF SIGNIFICANCE

DATA T/19.675,9.925,5.841,4.604,4.032,3.707,3.355,3.250,3.143,3.031,2.920,2.810,2.700,2.593,2.484,2.378,2.272,2.169,2.064,2.058,2.052,2.046,2.041,2.036,2.031,2.026,2.021,2.016,2.011,2.007,2.002,2.000,2.000

READ PARAMETERS OF STANDARDIZATION SET OF DISCRIMINANT VALUES

REAL YEAR(52)

1 FORMAT('X,5F15.5')

N= NUMBER OF VALUES IN THE STANDARDIZATION SET
'SSV': MEAN OF STANDARDIZATION SET
'SN': VARIANCE OF STANDARDIZATION SET

5=SQTNT(2)
T05=75(N-1)
T0=75(N-1)
DL1=SQR(N-1)/5
DL2=SQR(N-1)/5

CHECK IF A VALUE LIES OUTSIDE THE 95 OR 99 PER CENT CONFIDENCE LIMITS

L1=L1+1
L2=L2+1
L3=L3+1
L4=L4+1
L5=L5+1
PL1-PL1+5
PC1-PC1-5

PRINT THE RESULTS OF THE ANALYSIS

WRITE(6,11)NC,SC,EL,CL,PL,PC
2 FORMAT(9D15.5)

3 WRITE(6,12)NC,SC,EL,CL,PL,PC
2 FORMAT(9D15.5)

4 RETURN
END
'As DeLury (1954) has pointed out, the term "random sample" is often misused by biologists: "... in certain circles, there cannot be such a thing as a plain sample; it must be a 'randomsample'. Like 'damyankee', it is all one word."

Appendix 5

Wainui Valley Stream sampling programme data

Set out of data AP 75

The data for each sample AP 80
There are three data cards per sample, set out as follows.

**CARD 1**

<table>
<thead>
<tr>
<th>Column(s)</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-25</td>
<td>Sample identification and characteristics</td>
</tr>
<tr>
<td>1</td>
<td>Identification column, W = Wainui Valley Stream.</td>
</tr>
<tr>
<td>2</td>
<td>Area, A = experimental channel, N = natural areas.</td>
</tr>
<tr>
<td>3-6</td>
<td>Day and month of 1971.</td>
</tr>
<tr>
<td>7-9</td>
<td>Day of the year.</td>
</tr>
<tr>
<td>10-11</td>
<td>Sample number</td>
</tr>
<tr>
<td>12</td>
<td>Section where sample collected.</td>
</tr>
<tr>
<td></td>
<td>Experimental channel, D = lower part</td>
</tr>
<tr>
<td></td>
<td>M = middle part</td>
</tr>
<tr>
<td></td>
<td>U = upper part</td>
</tr>
<tr>
<td></td>
<td>N = natural area</td>
</tr>
<tr>
<td>13-14</td>
<td>Water temperature (°C)</td>
</tr>
<tr>
<td>15</td>
<td>Water level in experimental channel,</td>
</tr>
<tr>
<td></td>
<td>L = low, M = medium, H = high.</td>
</tr>
<tr>
<td>16-25</td>
<td>Characteristics of the sample stones.</td>
</tr>
<tr>
<td>16</td>
<td>Number of stones to make a sample of about 50 cm² potential attachment area. blank = 1.</td>
</tr>
<tr>
<td>17-19</td>
<td>Potential attachment area in cm² (read as F3.1).</td>
</tr>
<tr>
<td>20</td>
<td>Type of stone, A = experimental stone, N = natural.</td>
</tr>
<tr>
<td>21</td>
<td>Thickness of stone, L = &lt; 10 mm, G = &gt; 10 mm.</td>
</tr>
<tr>
<td>22-24</td>
<td>Texture of stone</td>
</tr>
<tr>
<td>22</td>
<td>Smoothness, 1 = smooth, 0 = rough.</td>
</tr>
<tr>
<td>23</td>
<td>Pitting, 2 = pitted, 0 = otherwise.</td>
</tr>
<tr>
<td>24</td>
<td>Ridges, 3 = ridges present, 0 = otherwise.</td>
</tr>
<tr>
<td>25</td>
<td>Stone shape, 1 = round, 2 = square, 3 = rectangular, 4 = triangular.</td>
</tr>
<tr>
<td>26-63</td>
<td>Number of Austrosimulium tillyardianum Dumbleton (Diptera: Simuliidae).</td>
</tr>
<tr>
<td>26-28</td>
<td>1st larval instar.</td>
</tr>
<tr>
<td>29-30</td>
<td>2nd larval instar.</td>
</tr>
<tr>
<td>31-32</td>
<td>3rd larval instar.</td>
</tr>
</tbody>
</table>
33-34 4th larval instar.
35-36 5th larval instar.
37-38 6th larval instar.
39-40 7th larval instar.
41-42 8th larval instar.
43-44 9th larval instar.
45-47 Total number of larvae.
48-53 Number of unhatched pupae.
   48-49 Males.
   50-51 Females.
   52-53 Total number of unhatched pupae.
54-59 Number of hatched pupae.
   54-55 Males.
   56-57 Females.
   58-59 Total number of hatched pupae (includes those not able to be sexed and those showing evidence of predation).
60 Number of pupae smothered or showing evidence of predation.
61-62 Number of empty cocoons.
63 Number of egg masses on a sample stone (exceptional circumstances allowing laying).
64-76 Number of Neocurupira chiltoni (Campbell) (Diptera: Blephariceridae).
   64 Eggs, P = present.
65-66 1st instar larvae.
67-68 2nd instar larvae.
69-70 3rd instar larvae.
71-72 4th instar larvae.
73-74 Total number of larvae.
75-76 Number of pupae.
77-79 Number of chironomid larvae (2 species of subfamily Orthocladiinae) (Diptera: Chironomidae).
80 Identification as card number 1 of sample.

CARD 2

1 Number of chironomid pupae.
<table>
<thead>
<tr>
<th></th>
<th>Number of <em>Tasiocera</em> sp. (Diptera: Tipulidae).</th>
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<tbody>
<tr>
<td>2</td>
<td>1st instar larvae.</td>
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<tr>
<td>3</td>
<td>2nd instar larvae.</td>
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<tr>
<td>4</td>
<td>3rd instar larvae.</td>
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<tr>
<td>5</td>
<td>4th instar larvae.</td>
</tr>
<tr>
<td>6</td>
<td>Total number of larvae.</td>
</tr>
<tr>
<td>7</td>
<td>Number of pupae.</td>
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<table>
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<th>Total number of <em>Helicopsyche</em> sp. larvae (Trichoptera: Helicopsychidae).</th>
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<tr>
<td>8-9</td>
<td>Number of <em>Pycnocentria evecta</em> McLachlan (Trichoptera: Sericostomatidae).</td>
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<tr>
<td></td>
<td>1st instar larvae.</td>
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<tr>
<td></td>
<td>2nd instar larvae.</td>
</tr>
<tr>
<td></td>
<td>3rd instar larvae.</td>
</tr>
<tr>
<td></td>
<td>4th instar larvae.</td>
</tr>
<tr>
<td></td>
<td>5th instar larvae.</td>
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<tr>
<td></td>
<td>Total number of larvae.</td>
</tr>
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<td></td>
<td>Number of pupae.</td>
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<table>
<thead>
<tr>
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<th>Number of <em>Pycnocentrodes aureola</em> (McLachlan) (Trichoptera: Sericostomatidae).</th>
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<tr>
<td>10-23</td>
<td>1st instar larvae.</td>
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<tr>
<td>10-11</td>
<td>2nd instar larvae.</td>
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<td>3rd instar larvae.</td>
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<td>14-15</td>
<td>4th instar larvae.</td>
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<td>16-17</td>
<td>5th instar larvae.</td>
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<td>18-19</td>
<td>Total number of larvae.</td>
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<td>20-22</td>
<td>Number of pupae.</td>
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<table>
<thead>
<tr>
<th></th>
<th>Number of <em>Hydrobiosis parumbripennis</em> McFarlane (Trichoptera: Rhyacophilidae).</th>
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<td>24-37</td>
<td>1st instar larvae.</td>
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<td>2nd instar larvae.</td>
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<td>3rd instar larvae.</td>
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<tr>
<td>28-29</td>
<td>4th instar larvae.</td>
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<tr>
<td>30-31</td>
<td>5th instar larvae.</td>
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<td>32-33</td>
<td>Total number of larvae.</td>
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<td>34-36</td>
<td>Number of pupae.</td>
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<table>
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<tr>
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<th>Number of pupae.</th>
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<td>38-44</td>
<td><em>Hydrobiosis parumbripennis</em> McFarlane (Trichoptera: Rhyacophilidae).</td>
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<tr>
<td>38</td>
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<tr>
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<td>40</td>
<td>3rd instar larvae.</td>
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<tr>
<td>41</td>
<td>4th instar larvae.</td>
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<tr>
<td>42</td>
<td>5th instar larvae.</td>
</tr>
<tr>
<td>43</td>
<td>Total number of larvae.</td>
</tr>
<tr>
<td>44</td>
<td>Number of pupae.</td>
</tr>
</tbody>
</table>
| 45-51 | Number of *Hydropsyche colonica* McLachlan (Trichoptera: Hydropsychidae).
| 45   | 1st instar larvae.
| 46   | 2nd instar larvae.
| 47   | 3rd instar larvae.
| 48   | 4th instar larvae.
| 49   | 5th instar larvae.
| 50   | Total number of larvae.
| 51   | Number of pupae.

| 52   | Number of *Olinga feredayi* (McLachlan) larvae (Trichoptera: Sericostomatidae).

| 53   | Number of *Hudsonema amabilis* (McLachlan) larvae (Trichoptera: Leptoceridae).

| 54-61 | Number of *Zelandoperla maculata* (Hare) larvae (Plecoptera: Gripopterygidae).
| 54-55 | Small larvae.
| 56-57 | Medium sized larvae.
| 58-59 | Large larvae.
| 60-61 | Total number of larvae.

| 62-69 | Number of *Deleatidium* sp. larvae (Ephemeroptera: Leptophlebiidae).
| 62-63 | Small larvae.
| 64-65 | Medium sized larvae.
| 66-67 | Large larvae.
| 68-69 | Total number of larvae.

| 70-73 | Number of *Coloburiscus humeralis* (Walker) larvae (Ephemeroptera: Siphlonuridae).
| 70   | Small larvae.
| 71   | Medium sized larvae.
| 72   | Large larvae.
| 73   | Total number of larvae.

| 74-79 | Blank columns.

| 80   | Identification as card number 2 of sample.
1-8 Number of *Potamopyrgus antipodarum* (Gray) (Mollusca: Hydrobiidae). (In mm size classes according to shell height).

<table>
<thead>
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<td>&lt; 1 mm</td>
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<td>1-2 mm</td>
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<td>2-3 mm</td>
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<tr>
<td>3-4 mm</td>
<td>4</td>
</tr>
<tr>
<td>4-5 mm</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 5 mm</td>
<td>6</td>
</tr>
</tbody>
</table>

7-8 Total number of specimens.

9-12 Number of Hydrachnida mites.

<table>
<thead>
<tr>
<th>Size Range</th>
<th>Count</th>
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<tbody>
<tr>
<td>Small</td>
<td>9</td>
</tr>
<tr>
<td>Large</td>
<td>10</td>
</tr>
</tbody>
</table>

11-12 Total number of specimens.

13 Number of *Hydra* sp. (Coeleterata).

14 Number of *Dugesia montana* Nurse (Platyhelminthes).

15 Number of immature annelids.

17-24 Number of *Austrosimulium tillyardianum* larvae moulted between collection and preservation, each with the corresponding head capsule of the preceding larval instar.

<table>
<thead>
<tr>
<th>Instar</th>
<th>Count</th>
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<tbody>
<tr>
<td>2nd</td>
<td>17</td>
</tr>
<tr>
<td>3rd</td>
<td>18</td>
</tr>
<tr>
<td>4th</td>
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<tr>
<td>5th</td>
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<td>8th</td>
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<td>9th</td>
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25 A "1" punched if a special feature had been noted on the data sheet.

26-79 Blank columns.

80 Identification as card number 3 of sample.
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<th>Sample Type</th>
<th>Temperature (°C)</th>
<th>Humidity (%)</th>
<th>Wind Speed (m/s)</th>
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WAINUI VALLEY STREAM SAMPLES  AP 81
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|   | 2 MAY | WA 2 5122 1H13L 492NG 232 | 7 3 5 3 2 11 1 23 | 1 1 | 2 | 1 3 | 71 |
| 87 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 88 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 89 | WA 2 5122 2H13L 342NL 12 2 | 1 2 1 3 | 1 2 1 11 |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 90 |   | 52 6 7 38 | 4 5 4 6 1 201 21 3 | 3 2 | 2 2 4 1 7 |   |   |   |   |   |   |   |   |   |   |
| 91 |   | 52 7 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 92 | WA 2 5122 3H13L 289NG 13 3 8 9 3 5 3 8 9 5 5 | 1 1 | 1 1 1 2 |   |   |   |   |   |   |   |   |   |   |   |   |
| 93 |   | 1 3 3 7 1 2 2 4 9 | 22 2 24 2 2 2 |   |   |   |   |   |   |   |   |   |   |   |   |
| 94 | WA 2 5122 4H13L 290NL 232 | 6 4 4 4 | 1 | 1 1 5 |   |   |   |   |   |   |   |   |   |   |   |   |
| 95 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 96 | WA 2 5122 5H13L 408NG 1 | 4 5 0 12 6 3 1 4 5 2 4 6 2 2 4 | 5 5 5 10 |   |   |   |   |   |   |   |   |   |   |   |   |
| 97 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 98 | WA 2 5122 6H13L 362NG 1 32 | 251611138 8 6 6 6 9 6 | 1 1 2 2 1 3 4 | 2 1 4 7 |   |   |   |   |   |   |   |   |   |   |   |
| 99 |   | 3 1 1 1 | 1 2 2 5 2 2 | 1 2 2 1 1 |   |   |   |   |   |   |   |   |   |   |   |
| 100 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 101 | WA 2 5122 7H13L 267NL 12 3 | 6 1 0 3 6 3 1 1 | 3 0 |   |   |   |   |   |   |   |   |   |   |   |
| 102 |   | 6 1 0 1 6 4 3 2 | 9 1 | 9 1 1 0 1 1 |   |   |   |   |   |   |   |   |   |   |
| 103 | WA 2 5122 8H13L 42NG 1 | 2 5 4 1 2 |   | 1 1 |   |   |   |   |   |   |   |   |   |   |   |
| 104 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 105 | WA 2 5122 9H13L 394NL 12 2 | 3 7 3 3 1 1 2 1 1 19 |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 106 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 107 | WA 2 5122 10H13L 2532NG 1 | 2 5 1 6 9 7 1 2 5 6 5 5 6 | 1 | 3 1 4 | 2 1 |   |   |   |   |   |   |   |   |   |   |
| 108 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 109 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 110 | WA 2 5122 11H13L 459NL 1 | 3 1 4 4 5 5 1 4 1 5 3 0 | 1 |   |   |   |   |   |   |   |   |   |   |   |
| 111 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
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- Solids Dissolved: 11 mg/L
- pH: 2
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