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About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

5th May 1970

Dr. David J. Rogers
Department of Biology
Armory Building 101
Campus

Dear Dave:

I am still awaiting definite budget information from NSF with regard to the proposal 69.5.163 on "The Climatic Environment of the east slope of the Front Range". However, I have been reviewing the budgetary and other implications of the project in the light of the post-January, 1970 situation of the Taximetric group and feel I should let you know without further delay that I consider the work can best be carried out by my working directly with George Estabrook.

As you know, much of the pilot study was developed in this way and, in view of the importance of this project to the Institute's long-range programs and to me personally, I wish to retain maximum direct control over its direction and execution. Moreover, some of the budget estimates were purposely rather 'tight' (to keep to a figure of \$40,000), and I think that certain savings can be made on the taximetrics figure of \$17,500, over years 1 and 2, in a direct consultancy operation.

Whilst I realize that this decision will disappoint you, I trust that you will appreciate my wish to conduct the program in as uncomplicated a manner as possible.

Yours sincerely,

Roger G. Barry
Associate Professor of Geography

RGB/jep

May 7, 1970

TAXIMETRICS LABORATORY
ARMORY 101

The National Science Foundation
Washington, D.C.

Gentlemen:

Dr. Roger Barry, principal investigator, Institute of Arctic and Alpine Research, the University of Colorado, has chosen to exclude the Taximetrics Laboratory from the operations of the grant from NSF entitled "The Climatic Environment of the East Slope of the Colorado Front Range." Please see enclosed copy of letter from Barry, to Dr. David J. Rogers (director of the Taximetrics Laboratory), dated 5th May, 1970.

Since the body of the grant instrument heavily depends on activities of the Taximetrics Laboratory, and the Taximetrics Laboratory is mentioned specifically on pages 11, 12, 19, and in the budget, and since the principal investigator has chosen not use our services, I must request that the grant instrument be rewritten to exclude any such involvement. As the grant presently is written, Barry is free to employ any services required. He is not free, however, to let the National Science Foundation understand that the Taximetrics Laboratory has any responsibility for the work, given his choice as indicated in the enclosed letter. Since the work was scheduled by the Laboratory, rather than by any individual in the Laboratory, the Director of the Taximetrics Laboratory is responsible. Since Barry desires exclusion of the Laboratory, I cannot permit the grant instrument to convey the idea that any such obligation exists.

I will appreciate your attention to this matter.

Sincerely yours,

David J. Rogers, Professor
Director of Taximetrics Laboratory
Chmn, Division of Population Studies

Encl.: ltr from Dr. Barry to D.J.R.

cc.: Dr. Barry
Dr. Thurston Manning
Dr. Askeff Löve

UNIVERSITY OF COLORADO
INSTITUTE OF ARCTIC AND ALPINE RESEARCH
BOULDER, COLORADO 80302

5th May 1970

Dr. David J. Rogers
Department of Biology
Armory Building 101
Campus

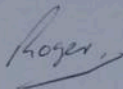
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Whilst I realize that this decision will disappoint you, I trust that you will appreciate my wish to conduct the program in as uncomplicated a manner as possible.

Yours sincerely,



Roger G. Barry
Associate Professor of Geography

RGB/jep

A Proposal to the
NATIONAL SCIENCE FOUNDATION
for support of
THE CLIMATIC ENVIRONMENT OF THE EAST SLOPE OF THE COLORADO
FRONT RANGE

Name and Address of Institution: The Regents of the
University of Colorado
Boulder, Colorado, 80302

Desired Starting Date: September 1, 1969

Amount Requested from NSF: \$40,590

Time Period for Which Support is Requested: 21 Months.

Principal Investigator: Roger G. Barry
Associate Professor of Geography
Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado, 80302
Telephone: (303) 443-2211, Ext. 6387.

J.D. Ives
J.D. Ives, Director
Institute of Arctic & Alpine
Research

R.G. Barry
R.G. Barry
Principal Investigator

I certify that the distribution of costs between the direct and indirect categories as shown in the proposal conforms to the usual accounting practices of the institution and to the distribution used by the cognizant Federal audit agency.

Thurston E. Manning
Thurston E. Manning
Vice President for Academic Affairs

ABSTRACT

The proposal aims to provide a thorough analysis and interpretation of data collected over the last 16 years at four elevations in the Indian Peaks area on the east slope of the Colorado Front Range. The analysis will utilize a new data-storage and retrieval system based on experience gained in a small pilot study. Interpretation of the material will include a synoptic climatological study for 6 years of data using a published catalogue of 'features-of-circulation' over the western United States.

The results of the study will provide vital background material on the climatic environment for other proposed research programs of the Institute of Arctic and Alpine Research apart from their intrinsic importance. There is surprisingly little general information on the characteristics of mountain climate in east slope situations.

Curriculum Vitae

R.G. Barry

Born 1935 at Sheffield, England.

1952-54 Scientific Assistant in the Meteorological Office at Workshop R.A.F. station, Nottinghamshire, performing weather observations, plotting surface and upper-air data.

1954-57 University of Liverpool. Honours degree course in Geography (special in climatology) and Minors in Mathematics and Geology.

1957-58 McGill Sub-Arctic Research Laboratory, Schefferville, P.Q., as meteorological observer. Research in the synoptic climatology of Labrador-Ungava.

1958-59 Attended McGill University to complete M.Sc. thesis and work as Research Assistant with Arctic Meteorology Research Group on stratospheric analysis.

1959-60 Leverhulme Research Fellow, University of Liverpool. Initiation of Ph.D. research into vapour flux over north-eastern North America using the DEUCE computer.

1960-66 Lecturer in Geography, University of Southampton. (1st, 2nd and 3rd year courses in Climatology, 2nd year course in Statistical Methods and 3rd year half course in Biogeography; Supervision of graduate research.)

Field research in summer 1963 and spring 1964 as meteorologist with Defence Research Board (Ottawa) Expedition to Tanquary Fiord, Ellesmere Island, N.W.T.

Albedo studies in Hampshire and Dorset 1964-65 supported by

University Committee for Advanced Studies, University Air Squadron and Royal Meteorological Society.

1966-67 Research Officer, Geographical Branch, Department of Energy, Mines and Resources, Ottawa. Research program into the present synoptic climatology of Baffin Island and moisture flux over the area.

1967-68 Lecturer, University of Southampton.

October 1968 Associate Professor of Geography, Institute of Arctic and Alpine Research, University of Colorado (2/3 of time for research in the Institute).

Research Interests: Arctic climatology and palaeoclimatology.
 Synoptic climatology.
 Moisture flux.
 Surface albedo and energy budget studies.

RELEVANT EXPERIENCE AND PUBLICATIONS OF APPLICANT

1. Statistical and Computational Work:

- i. The punched card and its application in geographical research.
Erdkunde, 15 (1961), pp. 140-2.
- ii. An introduction to numerical and mechanical methods.
Appendix to "Maps and Diagrams" (2nd Ed.). by F.J. Monkhouse
and H.R. Wilkinson (Methuen), 1963, pp. 385-423.

Research Use:

DEUCE computer, University of Liverpool, 1960-1962, and programming.
PEGASUS computer, University of Southampton, 1962-1964 "
CDC 6400 " Dept. of Energy, Mines and Resources, Ottawa
1966-1967.

Courses Taught:

'Introduction to statistical methods' in Geography Department
University of Southampton, 1962-1968.
Major contributions to 'Data Processing in the Earth Sciences'
Graduate course, University of Colorado, 1968-1969.

2. Climatological Studies:

- (a) Synoptic Climatology.
 - iii. A synoptic climatology for Labrador-Ungava, Arctic Met. Res.
Group. Rep. No. 17. McGill University (1959), 159 pp.
 - iv. The application of synoptic studies in paleoclimatology.
Geografiska Annaler, 42 (1960) pp. 36-44.
 - v. A note on the synoptic climatology of Labrador-Ungava. Q.J.
Roy. Met. S. 86(1960), pp. 557-65.
 - vi. Aspects of the synoptic climatology of central South England.

- Meteorol. Mag. 92(1963), pp. 300-8.
- vii. The prospect for synoptic climatology in R.W. Steel and R. Lawton, (Editors), "Liverpool Essays in Geography" (Longmans, 1967) pp. 85-106.
- viii. Variations in the content and flux of water vapour over north-eastern North America during two winter seasons. Q.J. Roy. Met. S. 93(1967), pp. 535-543.
- ix. Meteorological aspects of the glacial history of Labrador-Ungava with special reference to atmospheric vapour transport. Geog. Bull., (1966) 8, pp. 319-340.
- x. 'Weather type' frequencies and the recent temperature fluctuations (with A.H. Perry). Nature (in press).
- (b) Other Local Climatic Investigations.
- xi. Weather conditions at Tanquary Fiord, summer 1963. (1964) Hazen 23, Defence Research Board, D. Phys. Res. (Geophysics), 28 pp.
- xii. Summer weather conditions at Tanquary Fiord, N.W.T., 1963-1967 (with C.I. Jackson). Arctic and Alpine Res., 1(3)(in press).
- xiii. Climatology studies of Baffin Island, Northwest Territories (with S. Fogarasi). Tech. Bull. No. 13. Department of Energy, Mines and Resources, Inland Waters Branch, Ottawa, 106 pp.
- (c) General.
- xiv. Models in meteorology and climatology, in R.J. Chorley and P. Haggett, (Editors), "Models in Geography" (Methuen, 1968), pp. 97-144.
- xv. "Atmosphere, Weather and Climate", (with R.J. Chorley). (Methuen 1968) 319 pp. Not available in U.S.A. American Edition in press

with Holt, Rinehart and Winston (1969).

xvi. The world hydrological cycle pp. 11-29.

Precipitation pp. 113-129.

Evaporation and transpiration pp. 169-184.

Long-term Precipitation trends pp. 513-23. in R.J. Chorley
(Editor), "Water, Earth and Man" (Methuen, 1969 in press).

Present Teaching:

'Synoptic and Dynamic Climatology'. Graduate course 510-3
(2 contact hours for 1 semester).

Proposed new graduate course for spring 1970 'Seminar on
Climatic change' (2 contact hours for 1 semester).

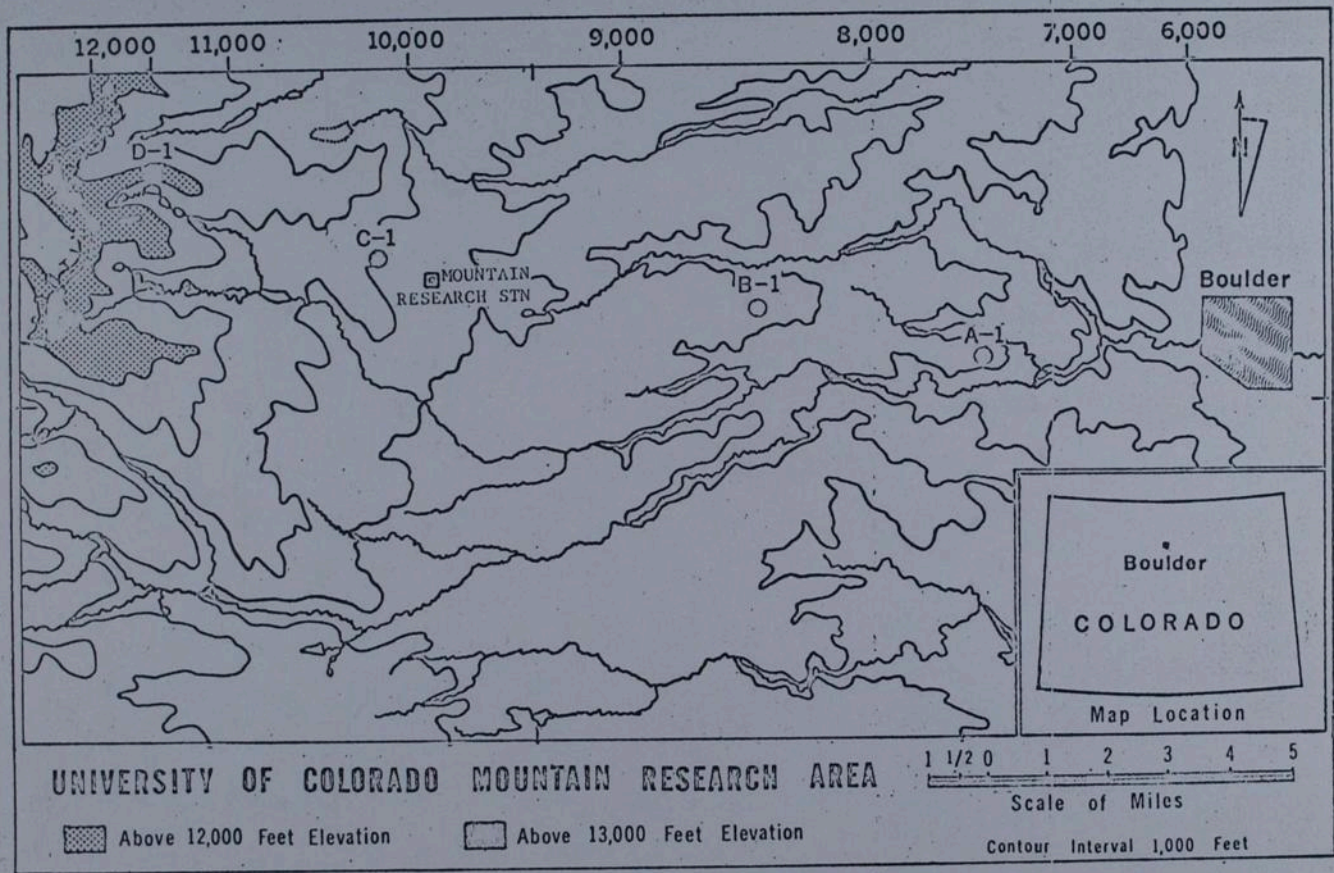
INTRODUCTION

Climatological observations have been maintained by the Institute of Arctic and Alpine Research since 1953 at four elevations in the Indian Peaks area on the east slope of the Colorado Front Range, west of Boulder (see Fig. 1). The four stations are sited in distinctive vegetation zones:- Lower Montane Forest (2195 m.), Upper Montane Forest (2591 m.) Sub-Alpine (3048 m.), and Alpine (3750 m.), at the indicated elevation.

The wide range of research opportunities in the Indian Peaks area and its ready access from the campus of a major university make it unique in North America. In the past 15 years requests for environmental (climatic) data from many botanists, ecologists and zoologists could not be met due to (i) the lack of analysis of the data already collected and (ii) the absence of a full-time climatologist at the Institute.

Data from the early period of the record have been summarized in conjunction with ecological descriptions of the four zones by Marr (1967, 1968), but there has been no thorough, general analysis and interpretation of the climatological characteristics of the area. This proposal aims to provide such a study using a new data-storage and retrieval system (TAXIR). A small pilot-study using the system has already shown considerable promise. Interpretation of the analyzed characteristics will be based in part on synoptic climatological methods utilizing an existing catalogue of circulation features over the western United States for 1958-1963 (Sands) and also on a factor analysis of the data.

The Indian Peaks area has been accepted by the Tundra Biome of the



International Biological Program as an intensive study site for the investigation of alpine tundra ecosystems. An important secondary objective of the present proposal to the provision of background data on the climatic environment for those aspects of a tundra productivity study which involve physiological ecology. The sixteen years of record ensure that a fairly representative picture of the range of climatic conditions can be obtained.

It is further intended that the results of the proposed study will form part of an evaluation of the present Mountain Research Station climatological observing program and facilitate the formulation of viable long-range research programs in the area.

PURPOSE

1. To conduct a detailed analysis of the main climatic elements measured at the four stations using the TAXIR data-retrieval system developed by the Taximetrics Group, University of Colorado. This will include:
 - A. Frequency analysis of temperature, humidity, precipitation, windspeed, insolation, by months.
 - B. Inter-station analysis of association/correlation for temperature, precipitation, etc.
 - C. Synoptic-climatological analysis using the catalogue of "circulation features" prepared by R.D. Sands (1966) for 1958-1963.
2. The results of these analyses will provide information for characterization of east slope climate under various circulation regimes.

Apart from its intrinsic climatological interest this material will serve as a basis for developing programs concerned with glaciological, geomorphological, hydrological and ecological problems in the area.
3. A further aim is to test fully the potential of the TAXIR system for the

analysis of climatological data. This will include the use of TAXIR as a research tool, by attaching statistical modules to the existing system, as well as using the presently available classificatory system of the "Accesioneer" module. The testing of this system is an essential prerequisite to the possible eventual, installation of automatic data-logging equipment for climatic and other parameters (biological, hydrological, glaciological) in the mountains. A valuable feature of the TAXIR system is that it provides a detailed cost-effectiveness evaluation of the data analysis.

Data.

1. The climatological records are stored on punched cards for 27 station-years. The data for the other 56 station-years is largely tabulated and will be put onto punched tape for analysis. (Appendix 1 summarizes the information available at each station).
2. The Sand's catalogue of "circulation features" for 1958-1963 is tabulated for the surface and 500 mb level on two punched cards per day. These are available on loan from the Geography Department, University of Denver.

ANALYTICAL TECHNIQUES

The TAXIR retrieval system was developed for both qualitative and quantitative information under NSF GN-656. A pilot study on one year of climatological data (see Appendix 2) shows that the system is capable of providing a valuable analytical tool for quantitative data with only slight modifications to the prototype system presently available. The retrieval system operates as follows:

A data bank is built according to predetermined instructions and the TAXIR system permits the abstraction of data from the bank in specified subsets

by means of plain-language questions (query statements). Examples of query statements and the responses are included in Appendix 2 and further details on the system are contained in Appendix 3.

Three data banks will be stored on magnetic tape files arranged as follows:

- A. By station and date - for single stations assessments.
- B. By date - to allow inter-station analysis.
- C. A subsidiary bank of the Sand's feature-of-circulation catalogue.

Query statements will obtain the following major categories of information:

- i. Frequency distributions for each month of each observed element (Appendix 1) and additional derived ones such as temperature range, degree-days above and below specified limits, windchill, 'lapse-rates' between stations.
- ii. Measures of association of the observed elements between stations.
- iii. A repeat of (i) and (ii) in terms of the synoptic types for 1958-1963.

Application of a number of standard statistical programs to the TAXIR output will provide additional information as follows:

- iv. Means and standard deviations for the data obtained in i, ii and iii.
- v. Significance tests of station differences; synoptic type differences, etc.
- vi. Factor analysis of the basic data to provide further insight into the possible existence of simpler climatic relationships between the stations, and as a means of hypothesis generation.

The Involvement of the Taximetrics Laboratory.

Appendix 4 contains a detailed work program specifying what problems the Taximetrics Laboratory will face as consultants.

In general, the Taximetric Laboratory will work closely with Dr. Barry and his staff throughout all phases of the project.

Specifically, the Taximetrics Laboratory staff will address the

following problems:

1. Modification of TAXIR for manipulation of the information in the Sand's data.
2. The conversion of the Sand's data to TAXIR Define Item statements.
3. The conversion of Station Day data now in machine readable form (1952, 1953, 1954, 1965) to TAXIR define Item statements.
4. The training of input device operator for making machine readable all other station day data - and to verify all data.
5. The training of an operator to call TAXIR on the CDC 6400, and to write and execute the necessary TAXIR control statements.
6. The interfacing of TAXIR to the various data analysis (statistical) packages which may be needed.
7. To be available for trouble shooting during the entire project.
8. Making a complete cost/effectiveness analysis of the project and specifically of the effectiveness of the TAXIR systems.

The costs for the entire dialog, system modification, training of Dr. Barry's staff and system installation are given in the budget as an aggregate. Actual breakdown of costs will be made available in the cost/effectiveness analysis as the program proceeds.

RESULTS

The information obtained from the above procedures will be used for both specific and general problems as outlined on the following page:

A. Specific Problems:

1. Is there a distinct zone of maximum precipitation on the east slope of the Front Range?
2. If so, how does the vertical distribution pattern vary with different synoptic types?

The coarse profile provided by the 4 stations will be supplemented during spring-summer 1969 by a subsidiary network of about 20 gauges between the two upper stations to be operated under a research program of Dr. N. Caine of the Institute of Arctic and Alpine Research.

3. What is the vertical pattern of solar radiation receipts?
4. How do (slope) lapse rates vary seasonally and with respect to different circulation types? What is their relationship to free-air lapse rates? (using Denver rawinsonde data). This consideration will complement Samson's (1965) study for Pike's Peak which is topographically more isolated than the Indian Peaks area.
5. Is the "feature-of-circulation" approach to synoptic climatology a useful basis for differentiating "weather types" in this area?

B. General Problems:

1. The determination of basic climatic parameters and their variability as a background to the geomorphological-hydrological program of Dr. Caine (submitted to N.S.F., Earth Sciences), the glaciological-climatological program of Drs. Ives, Andrews and Barry (submitted to N.S.F., Earth Sciences), and the Tundra Biome, I.B.P. program to be directed by Dr. Webber (to be submitted to N.S.F., Biological Sciences).
2. What degree of correlation exists between the four stations for various weather parameters at different times of year? Also, how far do 16 years

of data provide adequate indication of climatic variability in the mountains and useful probability estimates of extremes? Following from these considerations, which stations, if any, could be discontinued without prejudicing foreseeable developments of climatological, ecological, glaciological and hydrological research programs in the area? Also, which station(s) would be most suitable as a long-term climatological bench-mark station representative of alpine climatic conditions?

3. Cost-effectiveness evaluation of the techniques in terms of its potential for similar applications with climatological, hydrological data. The results will be submitted for publication in relevant journals.

REFERENCES REFERRED TO IN THE PROPOSAL

- Marr, J.W. 1967: Ecosystems of the east slope of the Front Range in Colorado
Contrib. No. 4. Inst. Arctic Alpine Res., University of
Colorado, 134 pp.
- _____ 1967, 1968: Data on Mountain Environments, I, II, III. Contrib.
Nos. 51, 52, 53. Inst. Arctic Alpine Res., University of
Colorado.
- Sansom, C.A. 1965: A comparison of mountain slope and radiosonde observations.
Mon. Wea. Rev. 93, 327-330 pp.
- Sands, R.D. 1966: A feature-of-circulation approach to synoptic climatology
applied to western United States. Publication in Geography
66-2, University of Denver, 332 pp.

APPENDIX 1

DATA AVAILABLE AT THE MOUNTAIN WEATHER STATIONS

<u>DAILY</u>	<u>WEEKLY</u>
Maximum temperature	Run of wind
Minimum temperature	Precipitation total
Maximum R.H.	Max. soil temperature (6" and 12") (1953 - 1963)
Minimum R.H.	Min. soil temperature (6" and 12") (1953 - 1963)
Precipitation (1965 +)	Soil moisture (6" and 12") (1953 - 1963)
Solar radiation (1965 + Station C 1965 only Stations B and D)	Snow depth

FORMAT

Oct. 1952 - Sept 1953	Tabulated, Punched Cards	16 stations*
Sept 1953 - 1954	" " "	4 stations
1955 - 1964	" only.	4 stations
1965	" Punched Cards	6 stations
1966 - 1969	Partially tabulated	4 stations

* During this period 4 stations were operated in each vegetation (altitudinal) zone - N-slope, S-slope, valley and ridge-top sites.

APPENDIX 3

GENERAL INFORMATION ON TAXIR

As indicated TAXIR was developed under a grant, GN 656, from the National Science Foundation, OSIS; Dr. David Rogers, Project Director. The system was demonstrated in October 1968, and was seen by an NSF representative, Dr. Thomas Galloway, of OSIS.

The general TAXIR system is now operational, although work continues on specific information problems.

The dialog with Dr. Barry's staff began shortly after the October demonstration. During the dialogs the general research problem was explored. Conversions of subsets of the climatic data were done, and a TAXIR accessioner was set up. Queries and responses are shown in Appendix 2.

Papers about TAXIR.

- Item 1. In this appendix, an Introduction to TAXIR which describes the system.
- Item 2. A brief history of the Taximetrics group and explanation of how the group operates.

At the moment the Taximetrics Laboratory is in the process of becoming an Institute of the University of Colorado (April 1969).

APPENDIX 4

WORK PROGRAM OF THE TAXIMETRIC GROUP

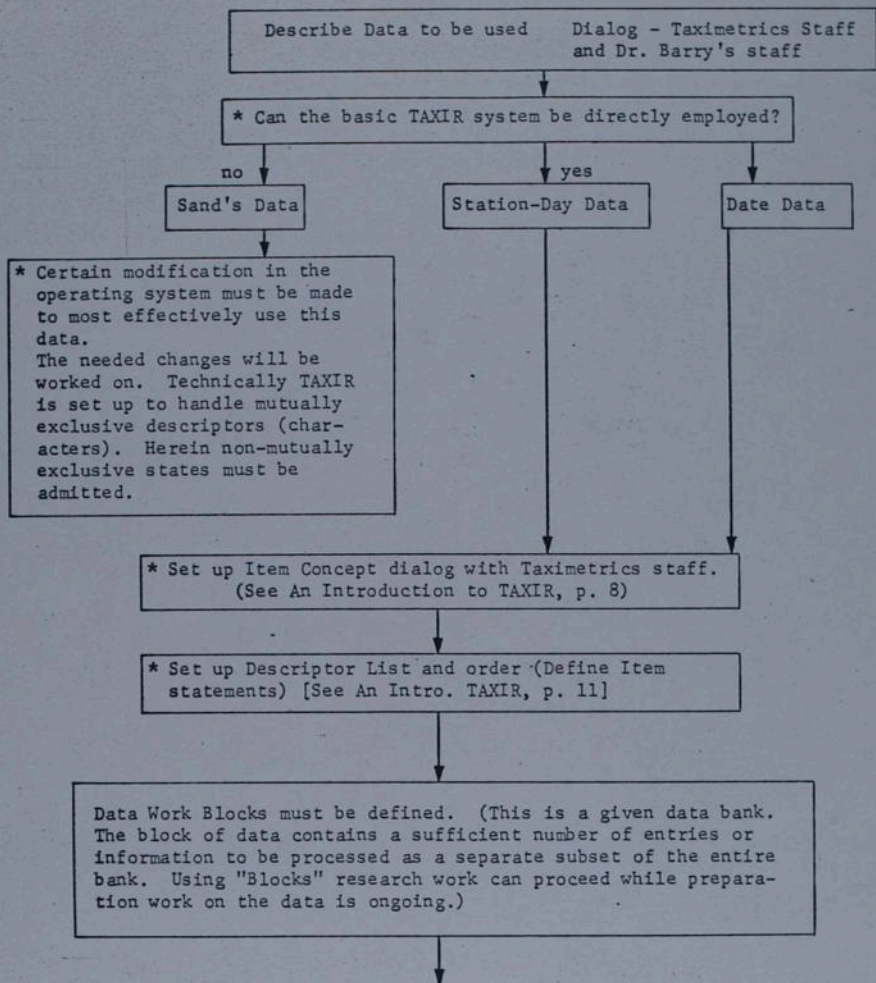
IN CONJUNCTION WITH THE APPLICANT

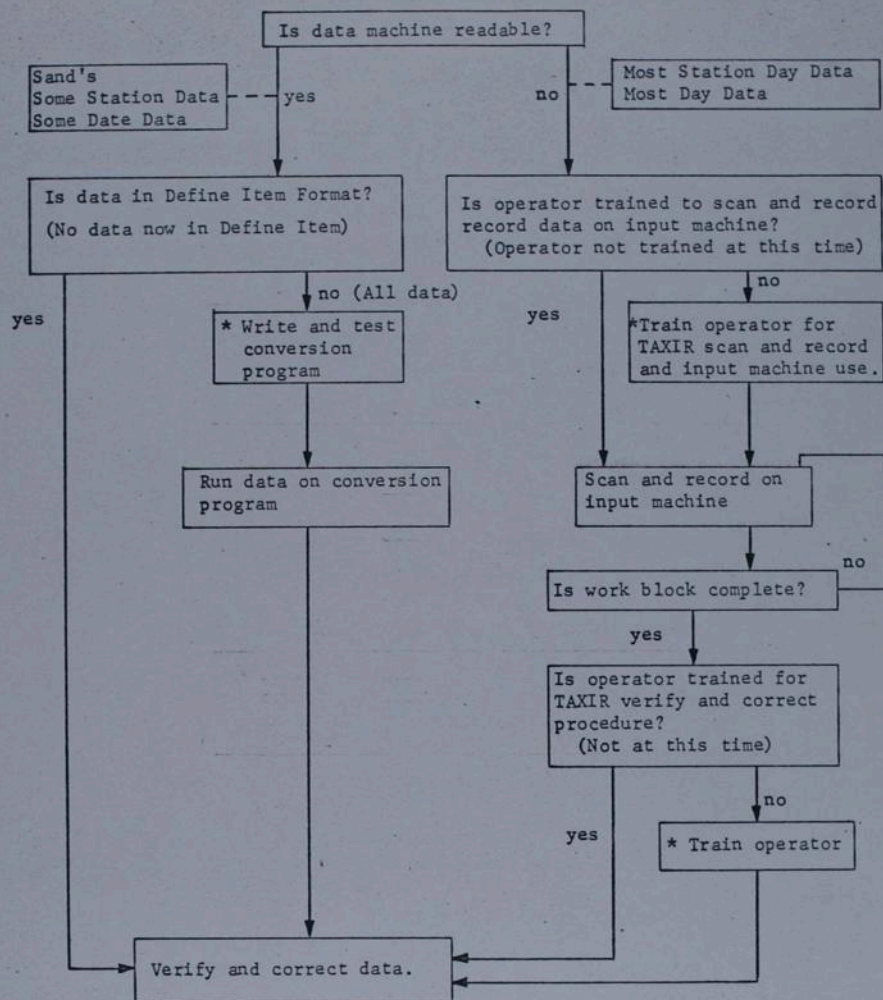
The Taximetrics Laboratory staff will address all the operations in the following flow charts.

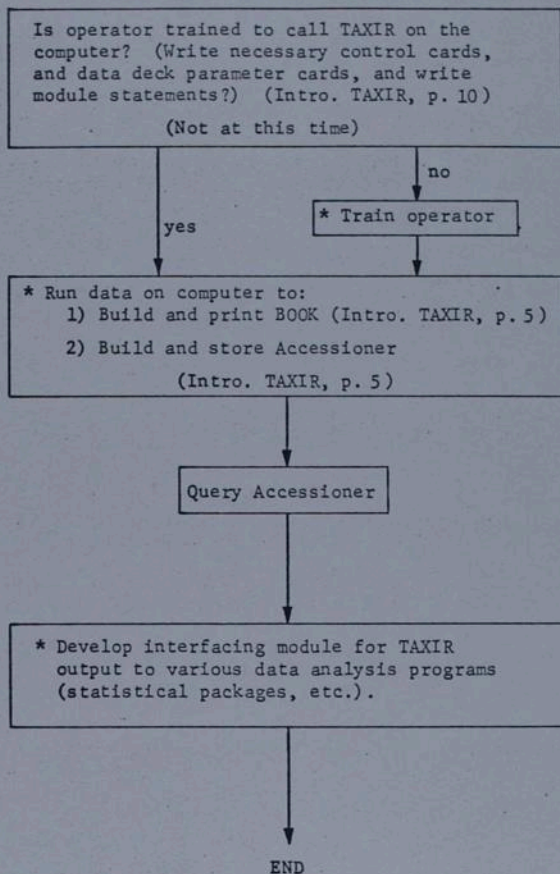
Those which are marked with an * are specific tasks which will be worked on.

Methods for training and supervising of data input have been devised from experience in using the system.

During all phases, cost/effectiveness will be examined and reported.







ITEM 1

AN INTRODUCTION TO TAXIR*

G. F. Estabrook

October 1968

Contents

- I Information Retrieval (I/R) in Biology
- II The Functions of an I/R System
- III Introduction to the TAXIR System
- IV The Modules of the TAXIR System
- V How to Use the TAXIR System
- VI Concluding Remarks

*Taxonomic Information Retrieval System developed
by the Taximetrics Laboratory.

I. I/R in BIOLOGY

The concept of information retrieval, although a topic of much recent interest, is not new to the biological community. Systematic biologists have been contending with the problem of information retrieval for hundreds of years. So, too have librarians and others in various positions, such as inventory control specialists. Many workable solutions to this problem have been developed, not the least of which is our taxonomic system. This system enables us to store and retrieve vast amounts of biological information. In this sense, many of us are already experts in information storage and retrieval and it is altogether fitting that modern advances in this field should come from a discipline whose traditional objective has been to create better information storage/retrieval systems for biology, agriculture, and medicine.

And our taxonomic system does not serve merely to embody conceptual information about the natural affinities of living organisms. It further serves us for curating small and large collections of biological specimens as well. It is to the problem of managing the information attendant with biological collections that we feel our present systems contribute.

There are essentially two types of biological collections which are amassed; those large collections found in museums or herbaria, and those smaller collections compiled by monographers or floristic workers. These two types overlap. In either type, specimens are arranged in cabinets, on shelves, etc. For this collection to be useful, certain subsets of it must be capable of abstraction with moderate ease. It is the curator who is largely responsible for guaranteeing this usefulness. Given the limited funds and restricted facilities which characterize many museum operations these men do remarkable jobs, but of course at a sacrifice to their own research.

In meeting this charge, curators make heavy use of the taxonomic information storage retrieval system. By physically arranging specimens in the museum in

accordance with a taxonomic system, specimens whose taxonomic names are known may be recovered with ease. By physically arranging specimens in the museum in accordance with the geographical location of the place of collections, specimens whose places of origin are known may be recovered with ease. By combining these two, which is a common practice, the museum becomes a very workable information storage retrieval system for the collections which it houses.

For this reason, it is not our purpose or intent to discard this already extant system. Rather, we accept this system as our working base, and make it an object of study and inspiration.

II. THE FUNCTIONS OF AN I/R SYSTEM

Any information retrieval system must serve two functions. It must serve as a repository for information, and as an accessioner to abstract from the repository the information stored there. As the names imply, one of these functions is a passive one, to serve as a resting place for information, while the other of these functions is active, to abstract from the repository some of the information that is there.

Let us consider the biological museum as an information retrieval system. It must serve as both repository and accessioner. It serves as repository insofar as it houses specimens each of which is itself a storehouse of information. It serves as an accessioner insofar as the physical arrangement of the specimens is in accordance with useful locating criteria such as taxonomic name or geographic location of collection.

Occasionally additional accessioner facilities are employed in museums. These often take the form of a card file. A card file is an information storage retrieval system very analogous to the museum itself. It acts as a repository for a small subset of the information attendant with the specimens. This

repository function of a card file is met insofar as some of the information about a given specimen is recorded on a given card. The card file acts as an accessioner in the same way as does the museum: the physical arrangement of the cards reflects some locating criterion of interest. Since the cards in the card file may be physically arranged in a way different from the arrangement of the specimens in the museum, items may be found in the card file with different locating criteria than that by means of which specimens are located in the museum. Whenever it is possible to establish a correspondence between cards in the card file and specimens in the museum, the locating criteria reflected in the physical arrangement of the card file may be used to locate specimens in the museum as well. In this way a card file may serve as an additional accessioner for the museum itself.

Since a card file admits only one physical arrangement at a time, there must exist a complete and distinct card file for each auxiliary locating criterion which is to be used to locate specimens in the museum. For this reason museums, where time and funds permit, maintain two or three separate card files arranged on such criteria as taxonomic name, geographical location of collection, collector, etc.

In some museums, where not only are time and funds limited but also collections tend to be extremely large, the museum must serve as its own accessioner facility with no help from auxiliary card files. For example, the curators of the entomological collections at the U. S. National Museum do a remarkable job of maintaining a collection of over 15 million specimens with no comprehensive card files at all.

III. INTRODUCTION TO THE TAXIR SYSTEM

TAXIR stands for TAXonomic Information Retrieval. It is a system designed to help systematic biologists organize and manipulate their collections and the

information they embody easier, faster, and more comprehensively.

The TAXIR system embraces, among other things, a language which enables the biologist to communicate directly with it in a manner natural and familiar to him. The TAXIR language closely resembles English and its grammar and syntax can be mastered with a few hours' effort. The translating capacity of TAXIR enables the biologist to use this language directly. The need for a computer specialist to intermediate between the biologist and his information system is thus obviated.

The information manipulating and organizing capacity of the TAXIR system enables the biologist to take fuller advantage of the vast amounts of information which present day museums represent. In this way we can reap greater returns on the investment which has already been made in the amassing and curation of our collections. The justification for this investment which our museums represent is realized in the extent to which they are used.

It is further envisioned that the TAXIR system will relieve the curator of many of the tasks now required of him which compete for his time with the pursuit of professional research interests. With the information currently represented in museums more readily available to the biological community through the TAXIR system the curator's function as go-between for the biologist and the museum is greatly reduced.

Much discussion, some of it in what would seem an almost fanciful vein, has been made concerning information exchange by means of intricate networks of computers located throughout the country and the world. The need for greater information exchange is real, but through the TAXIR system this need can be met now; and in a way perhaps more natural to this generation of professional biologists.

When information retrieval is discussed, one generally has in mind an enormous and highly complex information bank, administered by a heavily funded organization. "If we can't do the full-blown, bang-up job, then it just doesn't

pay," we think. But the TAXIR system is relatively inexpensive and sufficiently adaptable that it can be employed at all levels of complexity. It can even be made to behave as a personal scratch-pad system for an individual monographer or floristic worker.

IV. THE MODULES OF THE TAXIR SYSTEM

The TAXIR system exists in many essentially independent but related modules. Some of these modules are:

1. Accessioner - fully developed in prototype
2. Display - under development
3. Book - fully developed in prototype
4. Data Vet - under development

These modules, functioning alone or in combinations, serve to strengthen the repository and accessioner facilities of biological collections.

1. THE ACCESSIONER

Stored in the accessioner is that subset of the information, attendant with the specimens in a collection, which might be used as locating criteria by means of which we may locate those items in the collection which are of interest.

The accessioner functions very much like the auxiliary card files discussed in Section II. Here, however, all the locating criteria may be embodied into one integrated system and the criteria may be used independently of each other, as with multiple card files; or it may be used simultaneously in any conceivable logical combination.

As with auxiliary card files, whenever there exists a correspondence between the specimens in the museum and their associated locating information as stored in the accessioner, the accessioner may function to relieve the collection of its former need to provide locating information about the specimens which it houses.

2. DISPLAY

As the accessioner serves the active function of an I/R system, display serves the passive function associated with a repository. A collection which has been relieved of its accessioner function by the availability of the accessioner module of the TAXIR system is now responsible only for the repository function of information retrieval. So relieved of part of its traditional role, the collection may now exist to serve its residual repository function more completely. Its only specific restriction is that it must maintain the correspondence between its specimens and the associated locating information in the accessioner. This correspondence may be maintained in a wide variety of ways; some extremely nontraditional and worthy of further empirical study.

The display module of the TAXIR system is designed to serve the repository function which the collection itself now serves. It will be particularly important when the biological collection is itself not accessible to the biologist. For this reason completion of the development of this module has been postponed to enable the completion of the more desperately needed modules.

3. BOOK

The Book module of the TAXIR system might most properly be thought of as a combination of the accessioner and the display modules. Book functions as a little of each.

There is much information associated with the specimens in a collection which will be of interest to us either without or before actually looking at and handling the specimens in the collection. In fact, presently, much unnecessary handling of specimens occurs because this information is not now readily available without direct involvement with the collection itself.

On the other hand, many of our locating criteria, particularly at the onset of our involvement with a museum collection, are relatively simple and do not

require sophisticated logical combinations to express them adequately. Such locating criteria as taxonomic name, geographical location of collection, collector name, time of year of collection, and others are of this type.

The Book module accepts a small number (six or so) of criteria for comparison, or descriptors as our information carrying units are called, organizes this information as associated with the specimens in the collection in an hierarchical manner, and prints a book of the information reflecting this organization.

The book so printed is a list of all the specimens in the collection (or items, the more general term by which they are known to the TAXIR system), together with the appropriate previously stipulated half dozen pieces of information respectively associated with each item, and is arranged in an hierarchical order determined by this associated information itself.

By means of the TAXIR language the biologist communicates his desired hierarchical order to the Book module, usually indicating locating criteria (accessioner descriptors) such as taxonomic name or geographical location of collection as primary criteria for the hierarchy, and indicating display information (display descriptors) such as herbarium number, collector number, or completeness of the specimen, as secondary criteria for the hierarchy. In this way a book with hierarchy family, genus, geographical location, collector, collector number, species, would arrange items in the collection first alphabetically by family name, within groups of items with the same family name, alphabetically by genus, within groups of items with the same family and genus name, alphabetically by geographic location of collection, etc. With this book information about family, genus and geographical location can be used to discover information about collector, collector number and species.

Once the Book module has created such a book, it can be readily printed from computer tape several times at little extra expense. In this way museums

may exchange information arranged in a useful way, in familiar hard copy form.

(See Section III, paragraph 5)

The book (or indeed system of books) further provides the members of the biological community a more direct access to biological collections and partially relieves curators of the barrage of queries to which they would otherwise have to respond.

4. DATA VET

The Data Vet module of the TAXIR system is presently under development. The function of this module is to check or proof-read the information before incorporation in the other modules. Whereas the two functioning modules of the TAXIR system are liberally interlaced with user error messages the need for a DATA VET module is very real for the quality of any system is always limited by the quality of the information which it embodies. Experience with the Accessioner and Book modules will reveal the types of errors to be encountered. Until the Accessioner and Book modules of this system have undergone more extensive field testing, the Data Vet module cannot be completed.

V. HOW TO USE THE TAXIR SYSTEM

The concepts and terms needed to understand more fully the TAXIR system (Section III) are not completely foreign to the biologist for the system derives much of its structure from the already extant principles of museum curation. We do use some of the fundamental principles of logic in the TAXIR query language and it will be necessary for the user to become familiar with these if he is not already.

1. DEFINITION OF TERMS

1. ITEM: This is the general term which is used to refer to the basic units comprising the collection. The term specimen has been used earlier in

this exposition. However, in some collections, item may refer to lots, jars, populations, or any other conceptual unit which may be under study.

ii. DESCRIPTOR: this term refers to the information carrying unit in the system. There are many ways of envisioning this concept. Let me discuss two.

a. A descriptor is a basis for comparing any two items in the collection. With respect to this basis for comparison, it must always be possible to decide if two items are similar or different. An example of a descriptor which has already been mentioned in this exposition is the Family to which an item belongs. Two items are similar with respect to the families to which they belong if they each belong to the same family; and different if they each belong to different families. Similarly, country of collection, collector, genus, species, storage location in museum, month of collection and many more could be considered as useful bases for comparison or descriptors.

b. A descriptor is a partition, or a dividing into exclusive and exhaustive subsets, of the collection of items. The notion of similar and different, discussed in (a), is derived from this partition in a natural way: items which belong to the same subdivision of the partition are similar, and those which belong to different subdivisions are different. Any partition can be a descriptor; however to be useful, the notion of similar and different associated with the partition must be interpretable in a meaningful way.

This notion of similar and different is known mathematically as an equivalence relation. A theorem in mathematics teaches us that there is a bi-unique correspondence between equivalence relations and partitions. However, a moment's reflection should convince us that concept (a) and concept (b) are indeed the same thing.

iii. DESCRIPTOR STATE: In analogue with the two equivalent concepts of descriptor, there are two concepts of descriptor state. If we think of a

descriptor as a partition then we may think of a descriptor state as one of the "classes" or subdivisions of the partition. If we think of a descriptor as a basis for comparison, then we may think of a descriptor state as one of the possible conditions of that basis. In this way, a description of the common property shared by all the items which belong to the same subdivision of a partition may be considered a descriptor state. To continue our earlier example, the descriptor 'Family' would have for its states the names of the families represented by the items in the collection.

iv. DATA BANK: To design an information retrieval system using the TAXIR modules, it is necessary to have a specific collection of items of interest in mind. This collection may be enlarged, decreased, or altered at any time, but it is necessary to have some specific collection under consideration at the onset. It is further necessary to designate at the onset some number of descriptors for this collection. These, in turn, may be changed, deleted, or enlarged. The Data Bank is the totality of items with the associated descriptor states for each respective item.

v. CONTROL VOCABULARY: This is the totality of all descriptor names together with all descriptor state names. It is with this vocabulary, enriched slightly by the addition of a few special words, expressed through the grammar and syntax of the TAXIR language, that we communicate with the TAXIR system.

2. THE TAXIR LANGUAGE

The TAXIR language is comprised of basic statement types. Some of these basic statement types are:

i. I.D.: This statement enables you to identify yourself to the system. Your identifying comments will be associated with each response you receive from the system.

ii. ACCESSIONER MODULE STATEMENT: By means of this statement you describe

to the Accessioner module the basic structure of the accessioner you wish to design. It is through this statement that the system learns the names of the descriptors you wish to use as locating information. In response to this statement, the system establishes the necessary tables and dictionaries, and makes available the appropriate processors required to create an accessioner meeting your specifications.

iii. BOOK MODULE STATEMENT: This statement is the analogue, in the Book module, of the Accessioner module statement.

iv. DEFINE ITEM: By means of these statements, one per item, the data bank is described to the system. The Define Item statement is the means by which we associate an item with the descriptor states to which it belongs.

v. PRINT BOOK: Statements (iii) and (iv) enable us to make available to the TAXIR system the information required to create a Book. The statement causes the Book to be created and printed.

vi. PRINT CONTROL VOCABULARY: Statements (ii) and (iv) enable us to create an accessioner. This statement asks the system to provide us with that portion of the control vocabulary which is needed in order to communicate with the accessioner.

vii. QUERY: There are essentially two types of Queries, known as Query 1 and Query 2.

a. Query 1: By means of Query 1 we can provide a logical combination of locating information to the Accessioner. The Accessioner responds by providing the list of items which meet this locating criterion. To illustrate this let us assume that we are interested to see what specimens in the genus Manihot from Arizona and New Mexico were collected between 1940 and 1968 by persons other than Dr. D. J. Rogers. The Query would look like:

QUERY, Please list items with genus, Manihot AND state of collection, Arizona OR New Mexico AND year of collection, FROM 1940 TO 1968 AND NOT collector, D.J.Rogers*

b. Query 2: This statement is very similar to Query 1 except that it requests additional information be associated with each item in the response list.

viii. KEY TO: This statement enables us to use the TAXIR accessioner as an identifying device.

ix. MEMO: If we wish to include with the response additional comments, it can be done by means of this statement.

These are not all of the statement types in the TAXIR language. This brief list does, however, serve to illustrate the power and flexibility of the TAXIR system. An exhaustive exposition of the TAXIR language is inappropriate in this introductory document. This information will be found in the Users' Manual, "The TAXIR Primer," which is presently under development.

3. BUILDING A DATA BANK

To use the TAXIR system to aid the management of information represented in a biological collection it is necessary to build a Data Bank. There are three parts to the process.

First it is necessary to decide what descriptors are desired. These will depend on the nature of the material to be described and the purpose to which the system will be put. This choice of descriptors may be made without considerations of whether they will be used in the Accessioner, in any of the Books, in Display or in any combination of the three. Further, with but few exceptions, it will not be necessary to decide on states for the chosen descriptors at this time. When the descriptors have been chosen they are arranged in a fixed but arbitrary order, called DEFINE ITEM order.

Second it is necessary to design a means of assigning item identification numbers to the items in the collection (see Section II, par. 3; Sect. IV, 1, par. 3; Sect. IV, 2, par. 1) in such a way that the item identification number enables one to locate the specimen in the collection. Frequently museum accession numbers

serve this purpose already. In other cases, a new item identification number may prove useful. In other cases, an item identification number directly interpretable in terms of row, cabinet, shelf, etc. would be convenient. Some consideration has been given to the advantages of a sequential assignment of item identification number.

The final phase, and indeed the most costly in time and money, is the description of the items in the collection. By means of TAXIR Define Item statements each item must be described (1) by associating it with the appropriate states of the descriptors established in the first phase, and (2) by assigning to it an item identification number in accordance with the scheme established in the second phase. These Define Item statements, one per item, are then punched into computer cards (or for that matter any machine readable medium) to be read by the TAXIR system.

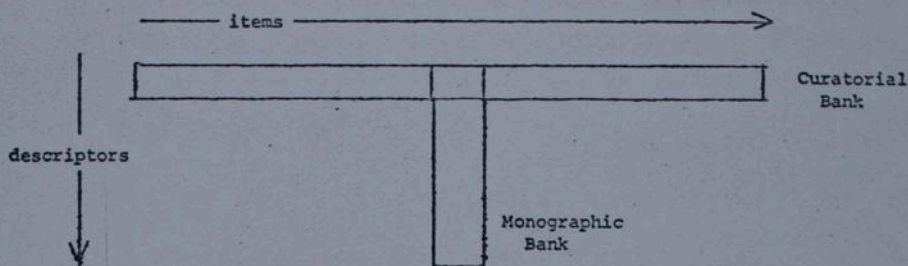
The Define Item statement begins with the words DEFINE ITEM and continues with the item identification number for the item being defined. This is followed with a comma; then the name of the appropriate state for the first descriptor (first in the Define Item order); then another separating comma; then the name of the appropriate state for the second descriptor; then a comma and so forth until the name of the last descriptor state is entered. This last is followed not with a comma but with an asterisk which indicates the end of the statement.

The Data Bank has been defined when a Define Item statement has been constructed for each item in the collection. These Define Item statements may now be used to describe the Data Bank to any of the modules in the TAXIR system.

4. APPLICATIONS OF THE MODULES OF TAXIR

There are two basic applications of the TAXIR system (Sect. I, par. 3): the museum application and the monographic application. In the museum application, the data bank is characterized by many items but relatively few descriptors. In the monographic application the data bank is characterized by relatively few items

but a depth of descriptors. (See figure.)



It is anticipated that the monographer who will need to describe his items in depth, recognizing descriptors of morphology, cytology, ecology, as well as the essential curatorial descriptors, will be able to take full advantage of the information manipulating powers of the TAXIR accessioner.

The curator, whose concern is a larger collection, which, at least in the short run, does not possibly admit description in such depth, will find the Book module a useful application of the TAXIR system.

The anticipated DATA VET module will be useful in either application.

VI. CONCLUDING REMARKS

The TAXIR system is an automated tool which, when taken together with the modern principles and practices of biological museum curation, can be used to render the information storage/retrieval methods in biology more complete, more flexible, and easier to use. It can in no way be construed to replace the museum, the curator, or the biologist. Rather, it recognizes the immense contribution which museums make to the advancement of biological science, and exists to defend and strengthen the position of the museum in the biological community.

George F. Estabrook

ITEM 2

The name "Taximetrics," first adopted as a title for this group in 1963 (Rogers, 1963) signifies a concern for the need for applying soundly based mathematical methods to areas of synthetic biology. The recent advances in computing machines and non-analytic mathematics, and some new thoughts about the general usefulness of the time-honored discipline, taxonomy, stimulated us to investigate the thought processes underlying the intuitive methods of those who classify biological objects. We recognized the need to bring together specialists in the areas of biology, mathematics, and systems analysis to work on this problem.

Grants to David J. Rogers as Principal Investigator from the Office of Naval Research (from 1961 to 1964, totaling \$96,000) and from the National Institute of General Medicine (from 1965 to 1967, totaling \$65,000) provided the nucleus of the present group. A grant from the National Science Foundation, Office of Scientific Information Services (for \$287,500) started when we moved to the University of Colorado in July, 1967, allowing the formation of the present staff.

The team approach has been very rewarding, bringing to bear on problems of synthesis of information the combined strengths of biologists, mathematicians and systems analysts. These efforts have produced useful results for the bioscientific community.

The group has discovered, for example, that the intuitive processes in the synthetic areas of biology can be formulated into basic rules, from which a mathematical model has been

derived, and from which operating algorithms have been developed. These programs have great value in biological and in the sister disciplines of psychology, sociology, economics, geography, geology and library sciences.

We have designed procedures and operating systems for computer-aided classification, information (data) evaluation, evolutionary studies, and, most recently, information retrieval. Many investigators in varying disciplines have adopted our methods for their own applications.

We have applied the team approach in teaching students about the basic underlying thought processes which allow them to approach their own research problems in a scientific manner. Sufficient mathematical exposition, combined with biological principles, and use of the computer as a tool, go into one formal course now offered in the Biology Department, Taximetrics (Biology 531). The course does not demand extensive prior training in these disciplines, but combines both theoretical and practical aspects. The practical consists of the student working on a problem which can be framed broadly as one of classification, one that is of particular significance to him. It is not intended that the student will become a competent biomathematician, but rather that he become a better investigator in his field, and able to communicate with those in related and ancillary disciplines. While no large number of students has been enrolled, the classes have had members from biology (both botany and zoology), psychology, mathematics, anthropology and geology.

The latest addition to the team, a systems analyst (operations research), broadens and strengthens our efforts and confirms our belief in the power

of the team approach. Thought processes undergirding many disciplines are very similar, and a team can construct theory and build useful procedures addressing many areas of concern to modern society.

Thus, the Taximetrics Laboratory is a highly interdisciplinary team representing biology, mathematics, systems analysis, operations research, and others. The team is unusual in that through its members an interdisciplinary dialog has been achieved which has catalyzed a synergism of these fields, rarely realized in, but increasingly vital to, modern science.

C. The Functioning Dynamics of the Taximetrics Laboratory

(Explanation of the Taximetrics Flow Diagram following page 11)

Definition of the Bio-Scientific Community Relating to the Taximetrics Laboratory

The bio-scientific community addresses in part the problems of analysis and synthesis of environmental information. These problems arise from biology and fields structurally related to biology (e.g. sociology, anthropology, library science, economics, etc.). The bio-scientific community may be defined as all those persons or institutions conducting, administering, disseminating or implementing the results of this research.

Dialog

A dialog is begun between members (collaborators) from the above community and the Taximetrics staff, in which the systematic, structural or methodological problems faced by the former are discussed. An attempt is made to define these problems and place them in a meaningful structural framework. It may be found that the collaborator can gain support in solving these problems from the Taximetrics staff.

With a clear understanding of the problems faced by the collaborating member of the bio-scientific community, the Taximetrics staff reviews the current theoretical models and procedures as they may pertain to the specific problems. If appropriate models have been developed previously, continuing dialog with the collaborator will make this apparent. Steps can now be taken to aid the collaborator in installing the systems and programs which embody the appropriate theory. If appropriate models do not exist, the research and development staff of Taximetrics may assist in building them.

The Taximetrics Theoretic Research Function

The Taximetrics staff attempts to construct appropriate theoretical models which should aid in the solution of the specific problems faced by the collaborator.

In general, such theoretical models broaden the existing theoretical base of the bio-scientific community through various means. (See "Education and Information Dissemination")

Specific models which may have direct application in systematic problem-solving will be developed.

The Taximetrics Operations Research Function

The sets of problems encountered concerning 1) information flow, 2) the organization of work flows, and 3) administrative systems and evaluation systems will be examined for cost/effectiveness. Improved operational models will be built and their cost/effectiveness demonstrated.

The state of the operations art in other and related fields will be constantly reviewed for possible application to the problems of the bio-

scientific community. Systems developed for the bio-scientific community which are highly effective will also be tested in other areas.

Research in personnel training for developed systems is another area of interest in operations research.

(For a clearer understanding of cost/effectiveness analysis, see "Systems Analysis: Cost/Effectiveness," the enclosed paper.)

The Taximetrics System's Development Function

An attempt will be made to create operational systems from given theoretical models. These systems will be constructed to assist the collaborator with aforementioned problems. Developmental aspects include: information systems, research systems, work flow programs, executive systems, evaluation techniques, and educational, training and dissemination techniques.

Installation

If the needs are met, the collaborator will be aided in implementing the systems for his use. First, a full work-program and cost analysis is made for him, making use of the research done in cost/effectiveness of the system. The work program demonstrates the priorities of the work to be done and the cost associated with completing each priority project. If the cost is too high, this is set up so that work can go ahead, even with a limited budget allowed.

Education and Information Dissemination

The Taximetrics Laboratory and its collaborators carry out an intensive program in this area. The approach has two facets: 1) direct teaching, and 2) indirect educational methods.

Through direct teaching undergraduate and graduate students, post-doctoral fellows and interested scientists are invited to the Taximetrics Laboratory for formal and informal study. Theoretical considerations are emphasized, but work is also done in system design and research methodology.

Through the indirect programs, seminars, demonstrations, meetings and publications are used to communicate to the bio-scientific community the current state of the systems art. New methodologies will be developed to meet the growing need for comprehensive and constant communication.

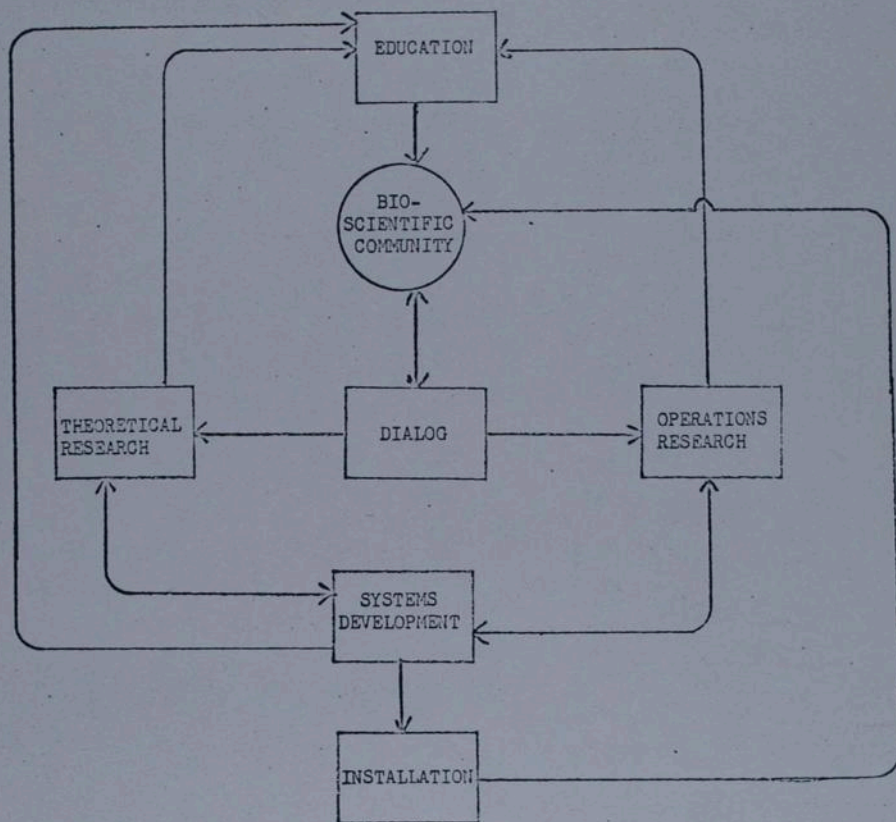
Summary

It is expected that more members of the community will enter into initial dialogs with the Taximetrics staff, bringing forth their systems problems for analysis and subsequent synthesis. In this way, it is possible to attack the problem of systematics in the bio-scientific community through individual collaboration and general education.

The "felt needs" of the members of the community are the stimuli to the Taximetrics staff. Collaborators are selected on the basis of the problems they present. Those of interest are studied--often resulting in models and techniques of general interest to the bio-scientific community--and others.

Once developed, advice may be given on installation techniques.

TAXIMETRIC DYNAMIC FLOW DIAGRAM



CU Proposal No. 69.5.163
4/69

NATIONAL SCIENCE FOUNDATION

Budget

Institution: The Regents of the
University of Colorado
Boulder, Colorado 80302

Title: The Climatic Environment of the East
Slope of the Colorado Front Range

Principal Investigator: Roger G. Barry

Starting Date & Duration: Sept. 1, 1969 (2 yrs.)

	1st Yr.		2nd Yr.	
	NSF	CU	NSF	CU
<u>A. Salaries & Wages</u>				
Principal Investigator: R.G. Barry				
10% time 9 mos. AY		\$ 1,460 (1MM)		
25% time 2 mos. summer	\$ 810 (1MM)			\$ 785 (1MM)
5% time 9 mos. AY				
Research Aide				
100% time 12 mos.	5,775 (12MM)			
Graduate Research Assistant				
50% time 9 mos. AY	2,850 (5MM)	470*		
50% time 3 mos. summer	945 (2MM)			
50% time 4 1/2 mos. AY			\$ 1,485 (2MM)	235*
Total Salaries & Wages	\$ 10,380	\$ 1,930	\$ 1,485	\$ 1,020
<u>B. Fringe Benefits</u>				
TIAA - 7% of faculty salaries	55	100		55
PERA - 6% of staff salaries	345	-0-		-0-
Total Fringe Benefits	400	100	-0-	55
<u>C. Permanent Equipment</u>				
None	-0-		-0-	
<u>D. Expendable Supplies & Equipment</u>				
Magnetic Tapes		125		
Supplies		100		100
Total Expendable Supplies & Equipment	\$ 225		\$ 100	

	1st Yr.		2nd Yr.	
	NSF	CU	NSF	CU
E. <u>Travel</u>				
Domestic: P.I. and one member of taximetrics laboratory to attend one selected scientific meeting to present results			\$ 600	
F. <u>Publication Costs</u>				
Page costs and reprints			250	
Drafting (20 figures)			<u>125</u>	
Total Publication Costs			\$ 375	
G. <u>Other Costs</u>				
1. Taximetrics Laboratory, U. of Colo. (Total costs for 21 mos. for services as described in text and appendix)	\$ 12,500		\$ 5,000	
2. **Rental of Honeywell 700 Keypape machine 12 mos. @\$150/mo.	1,500		300	
3. Computer Costs (CDC 6400) Conversions, TAXIR runs, and statistical packages	<u>900</u>		<u>500</u>	
Total Other Costs	\$ 14,900		\$ 5,800	
H. <u>Total Direct Costs</u>	\$ 25,905	\$ 2,030	\$ 8,360	\$ 1,075
I. <u>Indirect Costs</u>				
On Campus: 53.3% of salaries & wages	<u>5,535</u>	<u>780</u>	<u>790</u>	<u>420</u>
J. <u>Total Costs</u>	<u>\$ 31,440</u>	<u>\$ 2,810</u>	<u>\$ 9,150</u>	<u>\$ 1,495</u>
TOTAL REQUESTED FROM NSF FOR 21 MONTHS:	<u>\$40,590</u>			

*The University waives the difference between out-of-state and in-state tuition for research assistants. The average cost of such waivers for all research assistant is \$470 per research assistant per year which is shown as a University contribution. This amount will be adjusted periodically to reflect actual experience.

**The Honeywell 700 Keypunch has proved to be faster than a keypunch for initial entry, and especially for data verification and correction.

National Center for Health Care
Research

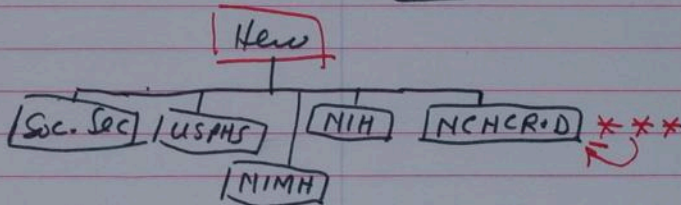
National Center for Health Care Research & Development
Director: Paul Sanazaro M.D. (Lark!)
Deputy Director: Dr. Bruce Waxman

ex head of NIH extramural
computer division

- a fine + great man -
a big computer man

out of NIH since they switched
to supporting small computer things.

Office - songlax on Rockville Pike
emphasis is on Health Care



III. Observations of Behavior

A. The Technique

1. Development of a Behavioral Taxonomy

As outlined in the original proposal, the granting of which has enabled us to accomplish the work described in this Progress Report, our first major task regarding the observations themselves was the identification of the behavioral repertoires of the two species we had chosen to study. In light of the long term and diverse goals of which this was only the first step, behavioral descriptions arrived at had, on the one hand to be as complete and detailed as possible, and on the other to be capable of organization into taxa of varying degrees of complexity suitable for use for different research tasks. The situation described above, in which the groups were housed and observed, seemed well suited to the facilitation of the expression of a large and diverse repertoire of behaviors among the members of both species of various ages and sexes and holding different social roles within the group. Feeling strongly the basic importance of the effort towards careful delineation of the behavioral characteristics of each species, considerable effort in the early months of the program and indeed, almost continuously throughout the past three years, has been devoted towards increasing the precision of definition, extension, reorganization, and updating the catalog of behaviors which we have observed. The most current and complete description of the behaviors of these two species (and to our knowledge the only extensive behavioral description of Macaca radiata), A Behavioral Taxonomy for Macaques: Based On Observations of Macaca nemestrina and Macaca radiata, is included as a part of this Progress Report.

2. Observational Procedure

Naturally, the social behavior interactions of nonhuman primates share a number of basic dimensions in common with the social behavior of any species. Particular behaviors occur with a certain frequency, last for finite durations, are directed at or received from particular social partners,

and occur in certain temporal and ordinal sequences. Since the first goals of our research were to establish the normative base lines of behavior and development in these two species, upon which a later program of experimental manipulation and hypothesis testing would be based, we were faced with the question of which of these dimensions for each behavior would be of most importance to our later work. We felt strongly that such a question required empirical inquiry rather than speculation. As a consequence, the observational technique which we derived was designed to provide us with each of these dimensions for all behaviors observed and flexibility regarding the number of items included. Ultimate conclusions about which behaviors might be most profitably handled in which fashion could then more validly be made in the future. These considerations, as well as the judgment on our part that precise, quantitatively reliable simultaneous observations of the group as a whole could not be made under our conditions, resulted in the adoption of the following technique: focusing upon one subject in the group at a time, using shorthand codes for the behaviors listed in our taxonomy, E dictated into a continuously running tape-dictation machine all of the behaviors in which the focus S engaged, including those it initiated and those of which it was the recipient, along with the partner(s) involved. The continuously running dictation tape provided a record of the elapsed time of each observed behavior. An accurate electric clock connected in parallel with the playback of the recorder allowed the onset and conclusion times of behaviors to be indicated in one second intervals. Thus, all of the dimensions outlined above were potentially obtainable from a typed transcript of the observations of every animal. The total length of the observation period for each S varied as a function of the type of subject involved, e.g., mother and infant, adult male, adolescent, etc., but was often dictated to by the

total number of animals to be observed and the limited size of our staff. We have, in general, attempted to follow the rule of frequent, short observations rather than intermittent longer ones, and the length of observations ranged from 180 seconds to 360 seconds per individual per day (720 for the mother-infant dyad per day) on a 3 to 4 day-a-week basis. Special, longer and more frequent sessions have been done in particular cases, as following births, to give added depth at crucial times. We have also in recent days switched our long term developmental groups, in which most infants have reached slower-paced stages of development, to once per week observations three times as long as the former daily sessions, in an attempt to determine the feasibility of making less frequent observations when long-term longitudinal studies are to be undertaken. These less frequent sessions are also supplemented by more concentrated observations at critical times, as when second or third births occur to the mothers in the group.

3. Computer analysis

a. Translation of data to computer acceptable form

In order to allow rapid and accurate computation and tabulation of the various dimensions of behavior contained in the voluminous data which our research was providing, it became apparent that the use of a high speed computer system was necessary. To make this possible it was necessary to translate our typed observational transcripts and all the segments of information which it contained in proper sequence onto IBM punch cards. In order to facilitate the translation task and ensure its accuracy, a special format card was produced. (See Figure 1). These cards, prenumbered in numerical sequence in their first five columns at the University Computing Center before being punched, ensured that the sequence with which behaviors were observed could not be lost. These cards, containing each of the behaviors observed

(five to a card), in addition to special "header" cards containing information on the group observed, time of observation, date, and experimenter's initials, after being punched and verified, were transferred to magnetic tape for permanent storage and easier handling.

b. Construction of behavior contingency tables

The first task given to the computer was the calculation of the durations of each of the behavioral items indicated in our observational records. In some cases this was quite simple since a specific "stop" call for a given behavior was at times inserted in the records. In most other cases, however, the determination of a given item's duration depended upon information regarding its termination at the onset of some subsequent behavior. Therefore, the computer had to be supplied with information regarding the contingent relationships between all of the behaviors in our taxonomy. Since there were nearly 140 behavioral items in our taxonomy, any one of which might be followed by any other, and since not every behavior stops or even temporarily discontinues the one preceding it, nearly 100,000 such relationships had to be tabled and then translated into computer-acceptable form for later use in the calculations.

c. Duration listings

A detailed outline of the steps involved in the current technique used for duration calculations via random access disk packs on the IBM 1620 computer has been presented in considerable detail in the renewal application accompanying this report. In brief, using the contingency table information placed onto random access disks the computer selects each behavior in turn from an animal's focus period and then scans each subsequent behavior to determine the terminating item. Start-time is then subtracted from termination-time, together with any intervening pauses in the behavior in question and the resulting duration is placed alongside. The results of this stage of the

calculations are then printed out for every focus period for every animal in the form presented in Figure 2.

d. Behavior calendars

In order to facilitate handling and initial analysis of the data¹ acquired through our observations, it is necessary to carry the computer analysis one step further. The first question to be asked of the data is simply how long did each animal spend engaged in each behavior across time and how frequently did each of the behaviors occur. To enable us easily to make comparisons across animals at the same point in time and make determinations of developmental trends in both mother and infant as a function of age of the infant, it was decided to tabulate these data for all animals in each group in a standard format. As seen in Figure 3, this format included week by week summaries of the frequency and duration of each behavior in each animal together with four-week (Lunar month) summaries of each. In addition, the date of the first day of the first week of each lunar month is indicated to facilitate rapid location of specific points in the data. Since the total period of observation within any given week varied somewhat from time to time, in order to make relative judgments of frequency and duration possible, the computer further processed each week's data to present total frequency and duration as a function of the time observed. In succeeding columns then these "calendars" contain the following information:

- (1) Total duration (in seconds) in which this behavior was engaged by this animal during this particular calendar week.
- (2) The number of times this behavior occurred during that week.
- (3) The average duration of each occurrence of the behavior.
- (4) The total number of days in that week on which observations were made.

(5) The total length of time the S in question was observed that week.

(6) The total duration expressed as a percentage of the total observation time, and

(7) Frequency with which the behavior appeared per 100 seconds of observation.

Since our transcription records easily provided the appropriate information wherever required, separate calendars for the initiation and receipt of social behaviors have been created. Up to this time we have received such calendars covering the period of December 1961 through October of 1963 in one pigtail (#1) and one bonnet group (#4).

4. Reliability of observation system

Reliability estimates of the technique were determined by having two trained observers carry out simultaneous observational sessions. This was done for eight days in one bonnet group and eight days in a pigtail group, each of which contained several mothers with infants of various ages. Some inherent difficulty arose in making reliability determinations in our situation since each observer had to make his observations through separate one-way vision screens set at opposite extremes of the front wall of the pen. This meant that with the large number of animals in the pens at the time of observation, as well as the structural features of the pens themselves, including the shelves, ladders, and bars, one observer was at times physically unable to see all that the other could because of the difference in their vantage points. In order that the reliability estimates be made of the technique as a whole, the observation tapes were transcribed in the usual manner, transferred to IBM punch card, and the durations of each behavior calculated in the usual fashion by the computer. A print-out of the type seen in Figure 2 above was provided

for the observations of both observers and compared. An overall estimate of the reliability of the two observers, considering all behaviors together on a moment to moment basis, was calculated, using the data from the pigtail group. Reliability was determined by calculating the total number of seconds of difference in duration of all items expressed as a percentage of the total duration of items observed by the two experimenters and subtracting this percentage from one (1). The records of observer A indicated 1268 items observed, that of observer B, 1226 items observed. The total duration of items for the two observers together was 20,975 seconds. The total number of seconds of duration for various items taken separately in disagreement between the two observers was 3292. Thus, an overall reliability index of .843 was derived for the durations of all items of varying length and complexity. Of the more than 1200 items called by each observer, 7 disagreements occurred regarding the identification of one of the two animals involved in the social interaction. In 7 other cases, there was inter-observer disagreement regarding who was the initiator and who the recipient of a given social behavior. Using the same technique of analysis, calculations were made of the inter-observer agreement on individual behaviors covering the entire span of the reliability sessions. Table 5 includes the total observed durations for the two observers, the differences in their scores, and the percent reliability for all those behaviors observed with sufficient frequency to allow adequate analysis.

300718	107	OBS	101007101350028	24
300718	135	CLI	100402101370002	25
300720	137	PUN	041009201440007	26
300720	140	APP	081000601410001	27
300720	141	RTI	081010801440003	28
300720	144	MOT	101006401470003	29
300720	144	LEA	100405701490005	30
300722	147	APP	100400601490002	31
300722	149	CLI	100402101500001	32
300722	150	PUN	041009201520002	33
300722	152	PRO	100408901620003	34
300722	155	PUN	041009201620007	35
300724	162	LEA	100405701800017	36
300724	162	MOT	101006401640002	37
300724	164	APL	101000501720008	38
300724	170	APP	081000601720002	39
300724	172	RTP	100810901760004	40
300726	176	PRO	100808901770001	41
300726	177	MOT	101006401780001	42
300726	178	APP	100400601790001	43
300726	179	APA	100400401800001	44
300726	180		9999999	45
200728	0	FOCUS		
300730	000	AGR	000000300090009	01
300730	009	RES	000010000250016	02
300730	025	APP	060000600270002	03
300730	027	APPX	060013300280001	04
300730	030	SCR	000011100350005	05
300732	035	XSCR	0000311	06
300732	035	RES	000010000900007	07
300732	042	AGR	000000300900048	08
300732	090		9999999	09
200734	2	FOCUS		
300736	000	OBS	020207100110011	01
300736	000	DLE	020807500200020	02
300736	011	MOT	020206400160005	03
300736	016	OBS	020207100300014	04
300736	020	LEV	080205800220002	05
300738	021	APP	080200600220001	06
300738	022	PRO	020808900250003	07
300738	025	LEA	080205700270002	08
300738	027	ABA	080200100620035	09
300738	030	SCR	020211100320002	10
300740	032	XSCR	0202311	11
300740	032	RES	020210000400005	12
300740	037	BSH	020201400380001	13
300740	038	AGR	020200300400002	14
300740	040	XAGR	0202203	15
300742	040	MOT	020206400470006	16
300742	046	CHE	020801600470001	17
300742	046	IGN	080205100470001	18
300742	047	OBS	020207100520005	19
300742	052	OBE	020207001390087	20
300744	062	LEV	080205800660004	21
300744	064	APP	080200600660002	22
300744	066	PRO	020808901680102	23
300744	139	XOBE	0202270	24
300744	139	SCR	020211101430004	25
300746	143	XSCR	0202311	26
300746	143	OBE	020207001800037	27

S.U.N.Y. DOWNSTATE MEDICAL CENTER PRIMATE LABORATORY DR. ROSENBLUM

GROUP 1 ANIMAL 10 - I

AVERAGE DURATION AND FREQUENCY OF

ABANDON

SUM DUR FREQ AVG DUR DAYS TOT. D/WK D/WK % D/O % F/O								SUM DUR FREQ AVG DUR DAYS TOT. D/WK D/WK % D/O % F/O								SUM DUR FREQ AVG DUR DAYS TOT. D/WK D/WK % D/O % F/O							
12/04/61								1/01/62								1/29/62							
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	00	0000	00.00	00.00	00.00
2/26/62								3/26/62								4/23/62							
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	00	0000	00.00	00.00	00.00
5/21/62								6/18/62								7/16/62							
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00	00000	0000	000.00	3	0540	00.00	00.00	00.00
00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	00	0000	00.00	00.00	00.00	00000	0000	000.00	03	0540	00.00	00.00	00.00
8/13/62								9/10/62								10/08/62							
00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	2	0360	00.00	00.00	00.00
00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	3	0730	00.00	00.00	00.00	00009	0001	009.00	3	0540	01.66	00.18	00.18
00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	1	0180	00.00	00.00	00.00
00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	0	0000	00.00	00.00	00.00
00000	0000	000.00	12	2160	00.00	00.00	00.00	00000	0000	000.00	12	2350	00.00	00.00	00.00	00009	0001	009.00	06	1080	00.83	00.09	00.09
11/05/62								12/03/62								12/31/62							
00024	0001	024.00	4	0720	03.33	00.13	00.13	00004	0001	004.00	3	0540	00.74	00.18	00.18	00105	0002	052.50	3	0540	19.44	00.37	00.37
00000	0000	000.00	2	0360	00.00	00.00	00.00	00033	0002	016.50	3	0540	06.11	00.37	00.37	00013	0001	013.00	4	0720	01.80	00.13	00.13
00145	0002	072.50	3	0540	26.85	00.37	00.37	00026	0003	008.66	2	0360	07.22	00.83	00.83	00079	0006	013.16	4	0720	10.97	00.83	00.83
00000	0000	000.00	3	0540	00.00	00.00	00.00	00000	0000	000.00	2	0360	00.00	00.00	00.00	00206	0004	051.50	2	0720	28.61	00.55	00.55
00169	0003	056.33	12	2160	07.82	00.13	00.13	00063	0006	010.50	10	1800	03.50	00.33	00.33	00403	0013	031.00	13	2700	14.92	00.48	00.48

GROUP 1 ANIMAL 10 - R

AVERAGE DURATION AND FREQUENCY OF

ABANDON

SUM DUR	SUM FREQ	AVG DUR	DAYS TOT.		% D/O		% F/O		SUM DUR	SUM FREQ	AVG DUR	DAYS TOT.		% D/O		% F/O		SUM DUR	SUM FREQ	AVG DUR	DAYS TOT.		% D/O		% F/O	
			D/WK	O/WK								D/WK	O/WK							D/WK	O/WK					
12/04/61								1/01/62								1/29/62										
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	00	0000	00.00	00.00		
2/26/62								3/26/62								4/23/62										
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	00	0000	00.00	00.00		
5/21/62								6/18/62								7/16/62										
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	00	0000	00.00	00.00			00000	0000	000.00	03	0540	00.00	00.00		
8/13/62								9/10/62								10/08/62										
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	2	0360	00.00	00.00		
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	3	0730	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00		
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	1	0180	00.00	00.00		
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	0	0000	00.00	00.00		
00000	0000	000.00	12	2160	00.00	00.00			00000	0000	000.00	12	2350	00.00	00.00			00000	0000	000.00	06	1080	00.00	00.00		
11/05/62								12/03/62								12/31/62										
00000	0000	000.00	4	0720	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00		
00000	0000	000.00	2	0360	00.00	00.00			00000	0000	000.00	3	0540	00.00	00.00			00022	0001	022.00	4	0720	03.05	00.13		
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	2	0360	00.00	00.00			00014	0001	014.00	4	0720	01.94	00.13		
00000	0000	000.00	3	0540	00.00	00.00			00000	0000	000.00	2	0360	00.00	00.00			00035	0001	035.00	2	0720	04.86	00.13		
00000	0000	000.00	12	2160	00.00	00.00			00000	0000	000.00	10	1800	00.00	00.00			00671	0003	023.66	13	2700	02.62	00.11		

TABLE 5

Inter-observer reliability for durations
of specific behaviors occurring in
pigtail and bonnet macaques

<u>Behaviors</u>	<u>Total observed Duration for Both Observers</u>	<u>Total Difference in Durations</u>	<u>% Reliability</u>
Anogenital exploration	117	13	.889
At other levels	987	206	.963
Attack	83	13	.843
Autogrooming	856	50	.942
Chasing play	167	11	.934
Clasp	596	74	.876
Climb on mother	307	65	.788
Contact	5552	96	.983
Cradle carriage	167	17	.898
Cradle stand	135	17	.874
Departure	1553	77	.951
Digit suck	486	150	.691
Enclose	5574	110	.980
Exercise play	249	3	.988
Facing away	1159	7	.994
Inanimate object exploration	756	48	.937
Inanimate object exploration (sawdust)	2371	101	.958
Nipple hold	6068	252	.959
Nonsocial locomotion	2414	822	.966
Proper present	88	60	.318

<u>Behaviors</u>	<u>Total observed Duration for Both Observers</u>	<u>Total Difference in Durations</u>	<u>% Reliability</u>
Proximity	29280	.1100	.963
Punitive deterrence	70	12	.829
Rest	3621	255	.930
Return to same level	2314	418	.819
Rough & tumble play	676	70	.897
Scratch	294	28	.905
Separated	502	194	.614
Sleep	2632	108	.959
Social grooming	3153	115	.964
Sportive contact	183	27	.853
Subordinance	307	77	.749
Tail clasp	48	4	.917
Tail climb	249	27	.892
Ventral-ventral cling	6790	170	.975
Ventral-ventral hold	92	10	.891
Vertical departure	3168	360	.886

NOTES ON THE COMPUTER ANALYSIS
OF BEHAVIORAL DATA

1. Error producing factors:

- A. Observer tape (e.g.) E does not call initiating behavior but does call terminating behavior.
- B. Typed transcript (e.g.) leaving out item or misplacing item.
- C. Key-punch card (e.g.) same as (B) above.

The IBM cards went to a raw-data tape; this tape was screened for the following type errors: Subject errors, i.e., if animal #4 was the focus animal then he must be one of the two animals in all interactions and the only animal in an auto-behavior, e.g. [4-4 REST], [4-1 PROX], [1-4 GROOM], [3-1 APP]* (*error), etc.; Item (behavior) errors, i.e. merely that the item exists and is spelled correctly.

What was not screened was the logical sequence of items which could be out of phase due to any of the error producing factors listed above. An example: #0 is the focus animal in the following sequence -

<u>TIME</u>	<u>SUBJECT I & R</u>	<u>BEHAVIOR</u>
000	0 - 1	PROXIMITY
064	0 - 1	DISMOUNT
065	0 - 1	PROXIMITY

Obviously an item between 000 time and 064 time is missing namely 0 - 1 MOUNT - as a result we've lost an item and received an inflated duration score for 000 0 - 1 PROXIMITY, if indeed the call 0 - 1 DISMOUNT stops 0 - 1 PROXIMITY. This example can have a multitude of variations.

2. Calendars: Give total duration of a behavior for a focus animal during a calendar week, i.e. totaled over all the other animals in the group regardless

of relationship to the focus animal. As a result we lose information about specific interacting pairs, e.g. mother-infant, female-female, female-male, etc.

3. Desirable future output:

A. Weekly summation of behaviors just as is given by the calendars with the additional capacity of breaking down these totals for the focus animal in terms of his specific interactions with every other individual animal in the group, i.e. all possible pairs.

B. Patterns of behavior should be available in the following ways:
1) the frequency of an item X as it occurs when preceded by item Y and is followed by item Z, either with or without additional items preceding or following item X; with or without a time limit, e.g. 10 sec. before and after the occurrence of item X; with or without the same interacting pair involved if it is an interaction item.

C. A group, sub-group, pair and individual profile of the frequency and/or duration (based on the % of observed time) of all items of behavior occurring each calendar week would be of great interest. The profile would give us information on the stability of occurrence of behavior over time and over changing events such as the birth and development of group offspring.