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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.

X International Botanical Congress

OPENING PLENARY SESSION

Usher Hall

3 AUGUST 1964 · 1915 for 2000 hours

THE HONORARY SECRETARY OF THE CONGRESS (Dr Harold R. Fletcher) will read a message from the Patron of the Congress, H.R.H. THE PRINCE PHILIP, DUKE OF EDINBURGH.

THE CHAIRMAN OF THE EXECUTIVE COMMITTEE (Sir George Taylor) will read a message from the Honorary President of the Congress, H.M. KING GUSTAF VI ADOLF OF SWEDEN.

THE LORD PROVOST OF THE CITY OF EDINBURGH (The Rt. Hon. Duncan M. Weatherstone) will welcome the Congress on behalf of the City.

THE RT. HON. MICHAEL A. C. NOBLE, Secretary of State for Scotland, will open the Congress.

THE PRESIDENT (Professor Harry Godwin) will reply.

THE VICE-CHANCELLOR OF THE UNIVERSITY OF EDINBURGH (Sir Edward V. Appleton) will welcome the Congress on behalf of the University.

THE PRESIDENT OF THE ROYAL SOCIETY OF EDINBURGH (Professor Sir Edmund Hirst) will welcome the Congress on behalf of the Royal Societies of London and Edinburgh.

PROFESSOR ROGER HEIM will reply to the Lord Provost, the Vice-Chancellor and Professor Sir Edmund Hirst.

THE PRESIDENT will deliver his address.

PROFESSOR DR HUGO OSVALD will thank the President.

THE SECRETARY OF THE EXECUTIVE COMMITTEE (Dr Alan J. Brook) will make announcements regarding resolutions and procedure.

THE SECRETARY OF THE PROGRAMME COMMITTEE (Professor Gordon E. Fogg) will speak on changes in the Programme.

THE PRESIDENT will move that members of the Tenth International Botanical Congress beg leave to offer respectful greetings to HER MOST GRACIOUS MAJESTY QUEEN ELIZABETH II.

GOD SAVE THE QUEEN

Seminar
Eclectic typing

I. The overall endeavor in taxonomy--chart

1. Many parts in taxonomy

a. pattern recognition

b. clustering

c. information retrieval

d. logical ordering

10 min

2. Our program begins with the problem of clustering

a. ~~assumes knowledge of patterns~~

b. ends with the determined cluster

c. logical ordering of clusters not done

d. does not include nomenclature

II. The problems of a computer; "feed the data to the computer."

1. The determination of a model or logic

2. The mathematical expression

3. The programming

4. ~~The size of the problem and the difficulties with the computer memory~~

5. 32,000 48 bit word memory - presently limited to 250 objects

III. Description of program - ONLY to the beginning of clustering -

1. Similarity ratio

a. Pair-wise comparison of objects

b. Ratio from number of matching attributes over number of attributes tested $\frac{M}{N}$

c. ~~Versus the Sij from M's over number of attributes possible. Diagram.~~ There are other methods of developing a similarity ratio. The incorporation of a no-information.

d. Problems of attribute selection

e. Mutually exclusive attributes

Qualitative or quantitative info. can be used.

III. Description of program (continued)

2. Conversion to a distance function

a. A spatial relationship in taxonomic thinking

b. Distance function patterned after Shannon $-\log_2 S_{ij}$ describing the variability

c. ~~Related to "on-off" of signals--reasonable resemblance to attributes present or absent.~~

3. Starting points for cluster analysis

a. Development of R, H, and T values

(1) R value--rough measure of over-all relation of each object to every other

A count of no. of times one object related to all others. each

(2) H value--a finer measure needed to find centrality

determination of most centroid object

H = sum of the d_{ij}'s from each to all others

H does not give center of greatest density of objects

(3) T value = $\frac{H}{R}$ gives ranking on degree of relationship and the number of objects to which one specific object is related

(4) value of T ranking

(5) the objects of T array, in descending order, are used as centers when cluster analysis starts.

b. Nodal distance array

(1) needed to determine the order of entering objects in cluster analysis

(2) linear ordering of all objects from each of the objects used as centers from the T array

(3) each object is summed to all others, the least distant entered first.

III. Description of program (continued)

3. Starting points for cluster analysis (continued)

c. Determination of the inhomogeneity

(1) For all the objects to be tested β

(2) For each "cluster" of objects Un

(3) Application of Shannon's entropy function in communication theory

(a) If members of a set have internal consistency, low inhomogeneity and vice versa

(b) Measure of inhomogeneity for full set

(4) If one extraneous object in an otherwise homogeneous cluster is removed, an abrupt drop in Un; this abrupt drop = δ

(5) δ should give a measure, or constant, for a cluster

d. EN test

(1) When provisional cluster formed with 2 objects, Un will not work (no disorder between two objects)

(2) Use a factor, EN, equivalent to 68% similarity, to test whether the two objects in the provisional cluster are sufficiently alike to be put together.

4. Three constants entered at beginning of program

a. β = inhomogeneity for all objects

b. δ = jump in inhomogeneity to provide a measure for clustering

c. EN = degree of statistical similarity for the cluster

IV. Clustering analysis--~~refer to diagram (slides)~~

Summary-

1. Succesfully used with Halimeda, a genus of marine algae with 28 taxa.
2. Important aspects of method-
   1. Employs a semi-metric space concept-
   2. Can handle situations where data are lacking - no comparison.
   3. Contains objective method of measuring the variability within and between taxa.
   4. Can be used equally for the analysis of value of characteristics and attributes.
   5. Program runs completely through cluster analysis without stopping.

I. The overall endeavor in taxonomy--chart

1. Many parts in taxonomy

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d. logical ordering

2. Our program begins with the problem of clustering

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a. Pair-wise comparison of objects

b. Ratio from number of matching attributes over number of attributes tested $\frac{M}{N}$

c. Versus the S_{ij} from M's over number of attributes possible. Diagram.

d. Problems of attribute selection

e. Mutually exclusive attributes

III. Description of program (continued)

2. Conversion to a distance function

a. A spatial relationship in taxonomic thinking

b. Distance function patterned after Shannon

$D_{ij} = -\log_2 S_{ij}$ describing the variability

c. Related to "on-off" of signals--reasonable resemblance to attributes present or absent.

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b. Nodal distance array

(1) needed to determine the order of entering objects in cluster analysis

(2) linear ordering of all objects from each of the objects used as centers from the T array

(3) each object is summed to all others, the first [illegible] [illegible]

III. Description of program (continued)

3. Starting points for cluster analysis (continued)

c. Determination of the inhomogeneity

(1) For all the objects to be tested β

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4. Three constants entered at beginning of program

a. β = inhomogeneity for all objects

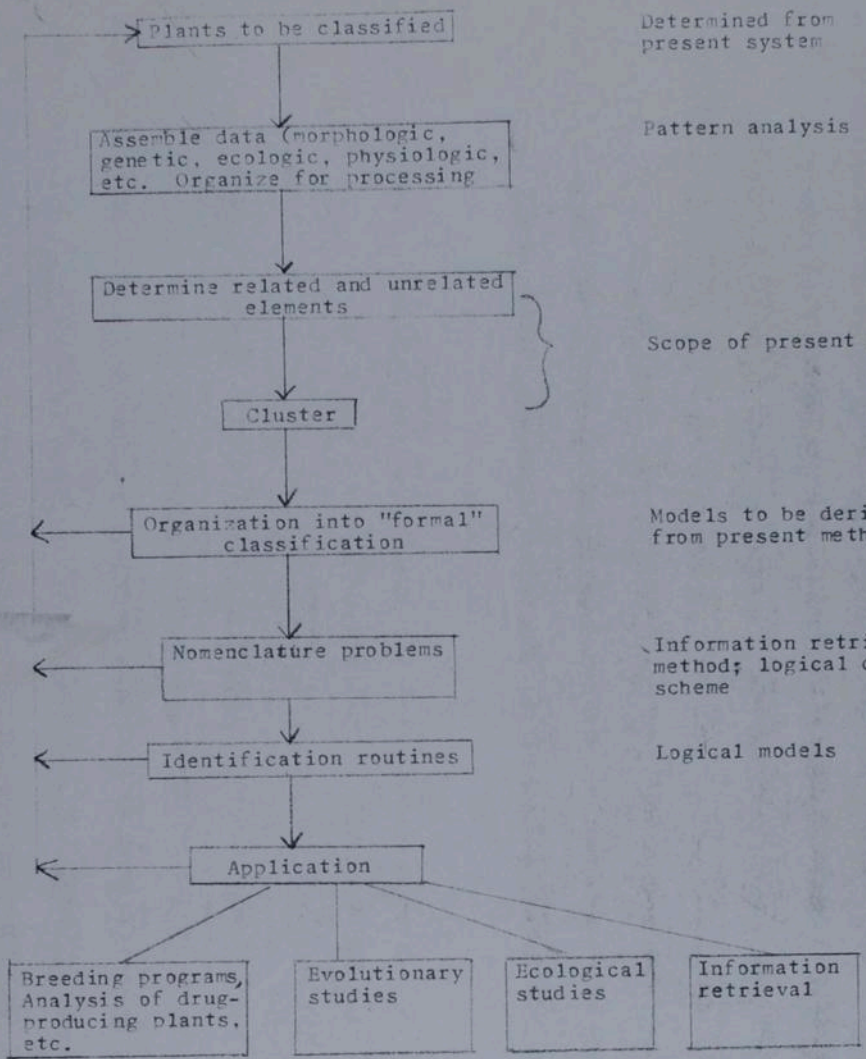
b. δ = jump in inhomogeneity to provide a measure for clustering

c. EN=the test of two objects in one cluster

IV. Clustering analysis--refer to diagrams (slides)

1. No. Inf.
2. Program runs completely through clustering end up with print out of clusters.
3. Att mutually exclusive - logical decision prevent redundancy
4. objective value for variability of taxon
5. measure of disjunction between sets
6.

PROCESSING TAXONOMIC PROBLEMS



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III. Description of program (continued)

3. Starting points for cluster analysis (continued)

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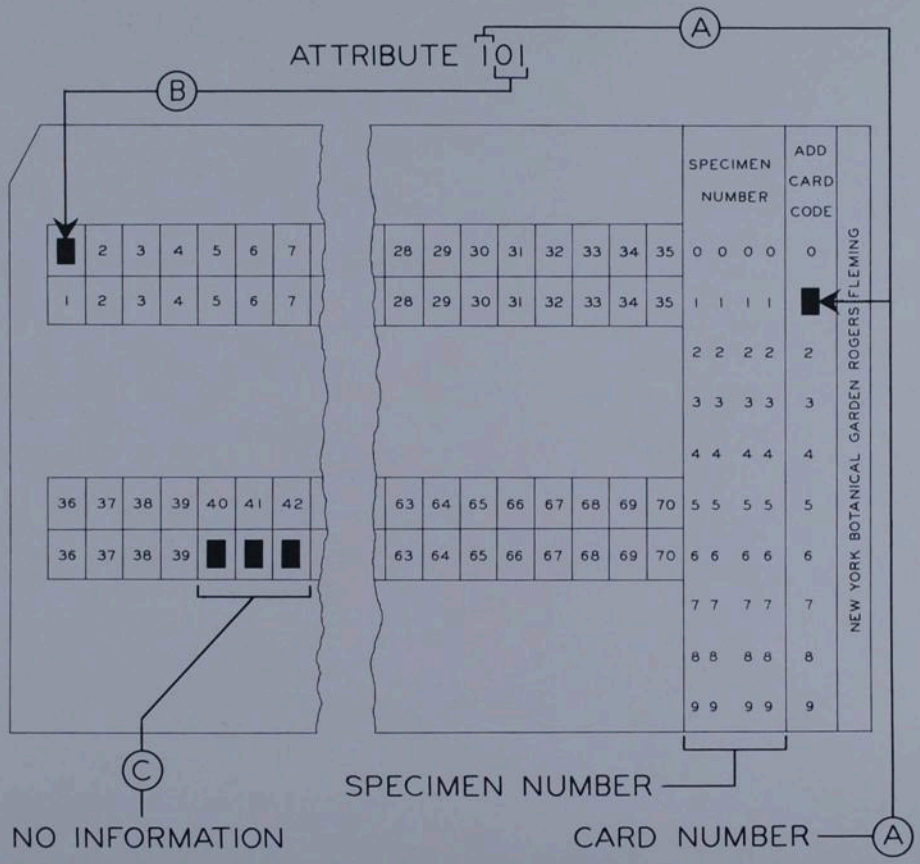
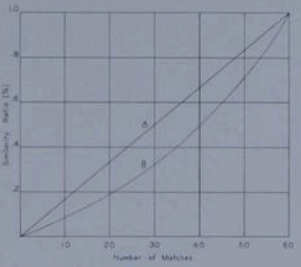
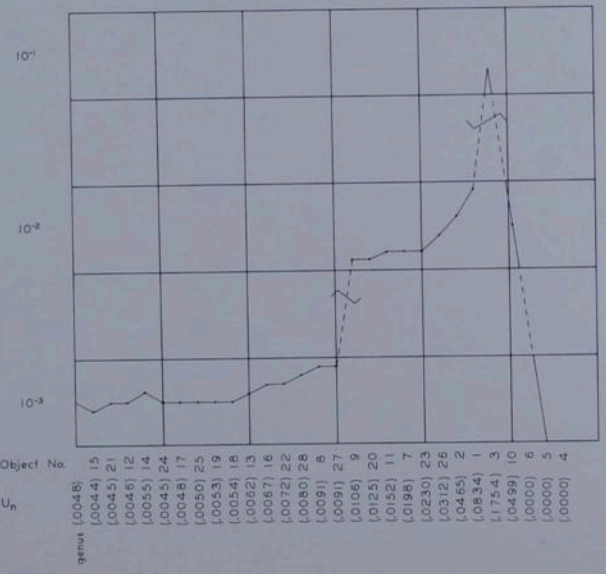
IV. Clustering analysis--refer to diagrams (slides)







SUMMARY OF PROCEDURE

STEP I. PREPARATION

STEP II. PRELIMINARY ANALYSIS ON DIGITAL COMPUTER

STEP III. PREPARATORY STAGE TO CLUSTER ANALYSIS

STEP IV. CLUSTER ANALYSIS

From step 2 onward, the program continues automatically through the computer.

STEP I. PREPARATION

1. ASSEMBLE MATERIAL (TAXA, SPECIMENS) TO BE CLASSIFIED.
2. SELECT ATTRIBUTES THAT DESCRIBE THE OBJECTS.
3. TRANSFER DATA TO ~~PORT-A-~~PUNCH CARDS.
4. CONTINUE TO STEP II.

STEP II. PRELIMINARY ANALYSIS ON DIGITAL COMPUTER

1. ~~TRANSFER PORT-A-PUNCH CARDS TO BINARY CARDS (A MACHINE OPERATION).~~

2. INSTRUCT COMPUTER ON NUMBER OF OBJECTS AND ATTRIBUTES AND THE CONSTANTS, EN, β, and δ.

3. CALCULATE NUMBER OF IDENTICAL ATTRIBUTES (M) AND NUMBER OF ATTRIBUTES COMPARED (N) FOR EVERY PAIR-WISE COMPARISON OF THE OBJECTS.

4. CALCULATE SIMILARITY RATIO, Sr. $Sr = M/N$.

5. EXPRESS SIMILARITY IN GEOMETRICAL SENSE. $d_{ij} = -\log_2 S_{ij}$.

6. CALCULATE AMOUNT OF INHOMOGENEITY (U_n) PRESENT IN ASSEMBLED OBJECTS.

7. a. IF GREATER THAN β, GO TO 9.

   b. IF LESS THAN β, GO TO 8.

8. a. IF THE DISTANCE BETWEEN THE OBJECTS EXCEEDS EN, THEN EACH OBJECT IS A SEPARATE VALID CLUSTER.

   b. IF THE DISTANCE BETWEEN THE OBJECTS IS LESS THAN EN, THEN ALL THE OBJECTS COMPRISE ONE VALID CLUSTER.

9. CONTINUE TO STEP III.

STEP III. PREPARATORY STAGE TO CLUSTER ANALYSIS

1. DETERMINE R FOR EACH OBJECT AND RANK. R = NUMBER OF OBJECTS TO WHICH A PARTICULAR OBJECT IS RELATED.
2. DETERMINE H (DEGREE OF RELATEDNESS) FOR EACH OBJECT AND RANK. H = SUM OF THE $-\log_2 S_{ij}$.
3. DETERMINE T FOR EACH OBJECT AND RANK. T = H/R.
4. CONTINUE TO STEP IV.

STEP IV. CLUSTER ANALYSIS

1. SELECT FIRST RANKED OBJECT IN T ARRAY AND PLACE IN CENTER OF SPHERE.

2. SELECT SECOND RANKED OBJECT IN T ARRAY AND PLACE ON PERIPHERY OF SPHERE.

3. DETERMINE THE DISTANCE BETWEEN THESE TWO POINTS.

4. ASCERTAIN WHICH OBJECTS ARE CONTAINED WITHIN THE SPHERE DELIMITED BY THIS RADIUS (DISTANCE). SEE NODAL DISTANCE ARRAY.

5. EXCLUDE OBJECT ON THE PERIPHERY OF THE SPHERE.

6. IF LESS THAN THREE OBJECTS WITHIN SPHERE (PROVISIONAL CLUSTER), USE EN TEST. GO TO 14.

   IF THREE OR MORE OBJECTS WITHIN SPHERE (PROVISIONAL CLUSTER), GO TO 7.

7. CALCULATE U_n. a. IF GREATER THAN β, GO TO 8.

   b. IF LESS THAN β, GO TO 15.

8. REMOVE OBJECT ON PERIPHERY OF SPHERE (COLLAPSING SPHERE).

STEP IV. CLUSTER ANALYSIS (CONTINUED)

9. CALCULATE U_n.

10. CALCULATE "JUMP" IN U_n (DIFFERENCE IN INHOMOGENEITY IN LAST TWO SPHERES).

11. COMPARE "JUMP" WITH δ.

    a. IF "JUMP" GREATER THAN δ, GO TO 12.

    b. IF "JUMP" LESS THAN δ, GO TO 13.

12. PRINT OUT OBJECTS IN LAST SPHERE (VALID CLUSTER) AND GO TO 23.

13. CONTINUE TO REMOVE OBJECTS (GO TO 8) BUT IF NO "JUMP" OCCURS BEFORE SECOND OBJECT FROM CENTER, GO TO 14 (EN TEST).

14. IF EN NOT EXCEEDED, PRINT OUT BOTH OBJECTS AS COMPRISING A VALID CLUSTER.

    IF EN EXCEEDED, PRINT OUT ONLY CENTER OBJECT AS VALID CLUSTER.

    IN EITHER RESULT AFTER PRINT-OUT, GO TO 23.

15. ADD NEXT CASE (SECOND RANKED OBJECT IN $\underline{T}$ ARRAY) (EXPANDING SPHERE).

16. CALCULATE U_n (AS IN 9).

17. CALCULATE "JUMP" IN U_n (AS IN 10).

18. COMPARE "JUMP" with δ.

    a. IF "JUMP" GREATER THAN δ, GO TO 19.

    b. IF "JUMP" LESS THAN δ, GO TO 20.

STEP IV. CLUSTER ANALYSIS (CONTINUED)

19. PRINT OUT OBJECTS IN SPHERE EXCLUDING LAST INTRODUCED OBJECT (VALID CLUSTER) AND GO TO 23.

20. INTRODUCE NEXT OBJECT (IN NODAL DISTANCE ARRAY) INTO SPHERE.

21. CONTINUE AS IN 16.

22. IF NO VALID CLUSTERS ARE FORMED IN ANY ANALYSIS OF EXPANDING SPHERES, THE VALID CLUSTER CONTAINS ALL THE OBJECTS. GO TO 23.

23. TAKE FIRST AND NEXT SUCCESSIVELY RANKED OBJECT AND GO TO 3, UNLESS THE FIRST TO THE LAST OBJECT HAVE BEEN ANALYZED; THEN GO TO 24.

24. PLACE IN CENTER OF SPHERE EACH OBJECT IN SEQUENCE IN T ARRAY AND PUT EACH OBJECT IN SEQUENCE IN T ARRAY AT PERIPHERY OF SPHERE AND GO TO 3. IF ALL OBJECTS ANALYZED, STOP.

THE NATURE CONSERVANCY
MONKS WOOD EXPERIMENTAL STATION
HUNTINGDON
TELEPHONE: ABBOTS RIPTON 308

PRIVY COUNCIL

May 26th, 1964.

Our reference:
Your reference:

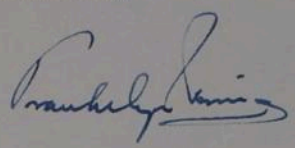
Mr. David J. Rogers,
Curator of Quantitative Taxonomy,
The New York Botanical Garden.

Dear Mr. Rogers,

Thank you for your letter of May 21st. I have much pleasure in sending you a list of speakers at the Symposium. It is a pity that speakers have not been sent this before, but the matter is not in my hands. It is an entirely Anglo-American session: at least we shall start out by speaking the same language.

The date has not been altered as far as I know and we shall meet on Thursday, August 6th, if not before.

Yours sincerely,



"Data-Processing and the Use of Computers in Botany"

Thursday, August 6th.

Morning Session (9.00 - 12.00)

Chairman Dr. G. C. Ainsworth (U.K.)

Dr. F. H. Perring (U.K.)	"The use of punched cards in the making of distribution maps".
Mr. S. W. Gould (U.S.A.)	"The use of punched cards in nomenclature".
Prof. R. R. Sokal (U.S.A.)	"Recent advances in numerical taxonomy".
Dr. P. H. A. Sneath (U.K.)	"Computers in bacterial and botanical taxonomy".
Dr. J. N. R. Jeffers (U.K.)	"Principle component analysis in taxonomic research".
Dr. D. J. Rogers (U.S.A.)	"Translation of taxonomic methods to computer language - theory and practice".

Afternoon Session (2.00 - 5.00)

Chairman Dr. W. C. Steere (U.S.A.)

Dr. W. B. Kendrick (Canada)	"Computers in the classification of Hyphomycetes".
Dr. J. L. Crosby (U.K.)	"Computers and the origin of species".
Prof. W. T. Williams (U.K.)	"The analysis of large-scale botanical survey data".

Discussion.

ABSTRACT

Paper entitled "Translation of taxonomic methods to computer language--theory and practice" to be presented at the Botanical Congress

We have attempted to emulate the taxonomic methods for classification of biological units in a computer program. Starting with numbers of objects (species, specimens, taxa) that are thought to be related, we select information (characteristics) that best reflect our "opinion" that the objects are related. The objects are clustered by placing those with like properties (attributes) together. The closeness of relationship (distance function) is decided by the numbers of, and importance of, particular sets of attributes. An hierarchical order of the universe of objects is obtained by establishing the frequency and universality of the defining properties for each subset of clusters.

"Distance" is measured in semi-metric space in which, from a biological point of view, two objects similar to one another may have different distance functions from a third object. Using an entropy function, we can determine the amount of disorder within a set (cluster), and determine whether the set should be further subdivided, or remain as one set.

Details of the program will be described by flow charts.

THE UNIVERSITY OF BIRMINGHAM

Department of Botany,

Edgbaston,
BIRMINGHAM, 15.

TELEPHONE:
SELLY OAK 1301

1st November, 1963.

Dr. D. J. Rogers,
The New York Botanical Garden,
Bronx Park,
New York 58
NEW YORK,
U.S.A.

Dear Dr. Rogers,

Thank you for your letter of October 28th and the summary of your paper entitled "Translation of taxonomic methods to computer language - theory and practice" for the symposium on "Data-Processing and the Use of Computers in Botany".

Looking forward to seeing you next year,

Yours sincerely,

J. G. Hawkes

October 28, 1963

Professor J. G. Hawkes
Department of Botany
The University
Birmingham 15, England

Dear Professor Hawkes:

Enclosed herewith is the abstract for the paper entitled "Translation of taxonomic methods to computer language--theory and practise" to be presented at the Botanical Congress.

Sincerely yours

David J. Rogers
Curator of Quantitative Taxonomy

DJR:MDF
Enclosure

THE UNIVERSITY OF BIRMINGHAM

Department of Botany,

Edgbaston,

BIRMINGHAM, 15.

TELEPHONE:
SELLY OAK 1301

28th June, 1963.

Dr. D. J. Rogers,
Curator of Economic Botany,
The New York Botanical Garden,
Bronx Park,
NEW YORK 58,
U.S.A.

Dear Dr. Rogers,

Thank you for your letter of March 25th confirming that you will be able to take part in the Xth International Botanical Congress.

Although I shall not require your summary before October 31st 1963, I should be most grateful to receive a note of the title of your contribution as soon as possible.

With best wishes and many thanks,

Yours sincerely,

J. G. Hawkes

Professor J. G. Hawkes

March 25, 1963

Professor J. G. Hawkes
Department of Botany
The University
Birmingham 15, England

Dear Professor Hawkes:

I am honored to have the invitation to participate in the Tenth International Botanical Congress. I will submit at a later time the requested summary. Thank you for the invitation.

Sincerely yours

David J. Rogers
Curator of Economic Botany

DJR:MDF

TENTH INTERNATIONAL BOTANICAL CONGRESS

5 HOPE PARK SQUARE EDINBURGH 8 SCOTLAND

Telephone: NEWington 2890

Department of Botany,
The University,
Birmingham, 15.
England.

13th March, 1963.

Dr. D. J. Rogers,
Curator of Economic Botany,
The New York Botanical Garden,
Bronx Park,
New York 58,
U.S.A.

Dear Dr. Rogers,

I have the honour to invite you to participate in the Xth International Botanical Congress, to be held at Edinburgh in August, 1964.

I understand from Dr. S. M. Walters and Dr. F. Perring that you have kindly agreed to read a paper entitled "Translation of taxonomic methods to computer language - theory and practice" at the symposium on "Data-Processing and the Use of Computers in Botany". This symposium will take place on Thursday, 6th August in the programme of the section: Taxonomy and Evolution.

I should be grateful to have your confirmation of this arrangement as soon as possible. A summary of not more than 200 words, written in English, French or German, is required not later than 31st October, 1963 so that the Publications Committee can have all summaries printed by the beginning of the Congress.

May I take this opportunity of thanking you on behalf of my Committee for agreeing to participate in the Congress.

Yours sincerely,

J. G. Hawkes

Professor J. G. Hawkes

(Recorder of section: Taxonomy and Evolution)

Please address all communications to: The Secretary (Executive Committee)