AFRICAN TRYPANOSOMIASIS RESEARCH, 1900-1985: GROWTH AND BIBLIOMETRIC CHARACTERISTICS

Growth Behaviour and Characteristics
Authorship and Research Collaboration
The Application of Bihliometric Laws

BY

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A THESIS

SUBMITTED TO THE POSTGRADUATE SCHOOL
AHMADU BELLO UNIVERSITY,

IN PARTIAL FULFILLMENT OF THE REOUIREMENTS
FOR THE DEGREE OF MASTER OF LIBRARY SCIENCE

Department of Library Science
Faculty of Education
Ahmadu Bello University, Zaria

1988

DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification

Signed .....

Date .....

CERTIFICATION

This thesis entitled

'AFRICAN TRYPANOSOMIASIS RESEARCH, 1900-1985:
GROWTH AND BIBLIOMETRIC CHARACTERISTICS'

by G.A. Thompson meets the regulation governing the award of the degree of Masters in Library Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation

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DEDICATION

to the memory of

My DEAR MOTHER who did not wait to eat any fruit of my education. She left twenty-four years ago!!

Too bad, isn't it?

and also to

MATILDA, a dear and patient wife and our children Urowoli, Oritsegbubemi, Ori'esuwa, Bemituale and Oritsetimehin (deceased).

ACKNOWLEDGEMENTS

I must first thank God for the accomplishment of this work. I acknowledge His support in the wisdom and understanding that went into every task. He directed me to relevant data/ information at times of dire need.

I am most sincerely grateful to Dr. M. Afolabi, the principal supervisor of the project and also to Mr. Ekere.

I am very much indebted to Mr. M.I.H. Zia of the Department of Library Science. His persistent concern and encouragement was a high inspiration and driving force for this work.

For the sponsorship of the course, and facilities used, I thank the Director; I am indeed indebted to the Nigerian Institute for Trypanosomiasis Research, (N.I.T.R.) for the support.

I deeply acknowledge the assistance of the following N.I.T.R. Library staff: Joshua, Duniya (Miss), Coker (Mrs.), and Usman (Mrs.). They all assisted relentlessly in collating and analysing the data which have not been easy tasks indeed. The Secretarial staff, Mr. Gbatsan and Ogunbiyi (Mrs.) typed the manuscripts.

PREFACE

Deep and penetrating insight into the characteristics and behaviour pattern of subject literatures seems important for any meaningful information service programme. Characteristic future trends may be discerned from past patterns.

Various problems of library and information management require basic theoretical approach and principles therefrom as guide for effective performance.

The peculiar nature and the multidisciplinary component of biomedical disciplines such as the tropical diseases seem not to have been considered in most previous studies.

This study was conceived and designed in the light of these various requirements and problems.

ABSTRACT

This study was designed to elucidate the growth and bibliometric characteristics Of a typical biomedical discipline, namely African Trypanosomiasis. A number of questions instigated the project. Some aspects of the pattern of growth is still enigmatic because *no* studies have focussed on the multidisciplinary nature in terms of the growth of the components. Does each component grow exponentially, linearly or otherwise? How does the growth of each component relate to the overall?

Does the author productivity pattern fit Lotka's law? Also does the literature dispersion corroborate Bradford's law? Based on the journal productivity pattern which journals can be acquired for cost-effective and cost-benefit information services? Besides what effect has PABIT (Far-Backc-In-Time, analysis of the literature on the rank of journals?

How do the authors collaborate in producing the papers? What is the pattern of multiple authorship in relation to single authorship? A total of 5139 articles, 1900—1985, were analysed from Tropical Diseases Bulletin and Tsetse and trypanosomiasis Quarterly (TTIQ) using the counting method.

African trypanosomiasis literature, earlier characterised by a fluctuating growth, is now one of steady infective exponential growth with a 53-year doubling rate. The decennial average growth rate was about 73% while the average cumulative growth rate was about 48%.

All the literature components grow exponentially. The most active are Entomology, (70-year doubling) and Parasitology (60-year doubling). The Overall exponential growth seemed derived by superimposing each component on and above each other—implying a compoundment of exponential growth.

Lotka's law does not apply in its original form. However it does apply in the generalised form with exponent of 2.03 when tested with K-S statistical test. The maximum difference in the observed and estimated values of the proportion of the authors was highly insignificant at 0.01 level.

The core journals were determined based on the Bradford-Zipf bibliograph. Twelve titles contributed 50% of the articles. Seventy-two published 75% while 240 titles published 90%. The degree of overlap, c, between the FABIT list and the **1965—85** list, is 0,90. The coefficient of correlation, R, is 0.93, showing a high degree of relatedness.

Single author papers were 38.51% while 61.49% (3160) were multiple author. The degree of collaboration se indicated by the weighted average is 2.19. The average number of authors per paper is between 2 and 3, though there is an indication of a tilt beyond this.

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CHAPTER ONE

BACKGROUND AND PROBLEMS

For more than thirty-five years, the Nigerian Institute for Trypanosomiasis Research (N.I.T.R.) has been conducting research into various aspects of African trypanosomiasis, a disease of no mean economic importance. In 1975, a new role was vested on the institute to conduct research into all aspects of another important disease, namely onchocerciasis.

Then came the acute and overriding problem of economic and budgetary constraints which forced the need to reduce considerably the number of current journal titles being received. The question then is: which journals should be retained and which ones should the institute forego, at least for the meantime? The question is not easy to answer without a factual quantitative and perhaps qualitative analysis of the periodicals in the field. This is because the field is multi-disciplinary. Considerable number of journals on the subject are also multi-disciplinary. One can therefore not be sure if potentially useful journals have been chosen without applying some form of measures other than the hitherto arbitrary ones particularly the use of consensus of experts.

Infact as early as 1933, Price Butler had pioneered the clarion call for the application of statistical methods in those areas of librarianship where they are appropriate,

though a few years earlier Gross and Gross (1927) devised a method which they applied in the service of research workers in chemistry.

This preliminary motive engineered the searching of the literature for possible data or information useful for the specified purpose. It was found that no such empirical study has been carried out on the literature of African trypanosomiasis. Most of the studies on other biomedical literatures are either subject or geographically biased. In particular no studies have been undertaken to determine the core journals in the field. Neither has there been any investigation into its growth or other bibliometric characteristics in the field. It is obviously clear that a study on African trypanosomiasis periodical literature and in particular to select journals to meet the needs of bioscientists in the research programme is required.

So this study is designed to provide answers to the following questions on African trypanosomiasis research. Firstly, what is the characteristic growth pattern of the literature as a typical biomedical discipline. For example how does the component parts grow in relation to the overall? Is the overall growth logistic or exponential? If the latter what is the doubling rate?

Secondly how does the productivity of the authors fit the Lotka's law and how do they collaborate in producing the research papers? Furthermore does the literature corroborate

Bradford's law? If so how are the articles dispersed among various journals? Which journals can be acquired for cost-effective and cost-benefit information service? What is the possible effect of a Far-Back-In-Time analysis of the literature on the journal ranks?

Thirdly because of the interdisciplinary and intradisciplinary nature of the required collection, what objective decision model for acquisition can be used in order to satisfy the idiosyncratic needs of present and potential scientists? These questions, among others, instigated this project.

1.1 GROWTH OF THE LITERATURE

The first aspect relates to the growth of the periodical literature. A literature grows as a result of the quest for more knowledge which is consecuent upon attempts to know more about the solution to problems which affect mankind. The ultimate objective, of course, is to solve these problems. There are two aspects of periodical literature growth of interest. One is the growth in number of journals. Since the inception of the first journal - Journal de Scavans - in January 1665, the growth of journals in number and type has been highly unpropitious. A study of successive editions of the World List of Scientific Periodicals (Sengupta 1970) shows that the rate of increase of scientific periodicals was over 108 percent during the twenty-nine years ending in 1952; the total number of periodicals issued from 1900 - 1921 was 25,000.

It was 50,000 in the third edition covering the period up to 1950 and it had increased to 60,000 by 1960 when the fourth edition was out. He conjectures that if the trend continues the total number of periodical in the world list may reach 100,000 by the end of the century.

Several factors could be responsible for this. Some may be categorised as:

(a) Geographical e.g Indian Journal of Medical Science as distinct from Nigerian Journal of Medical Science; European J. of Biochemistry.as distinct from Indian Journal of Biochemistry.

(b) Subject or knowledge fractionalization e.g Journal of Biochemistry as distinct from such others as Nucleic Acids Research, Parasite Immunology etc.

(c) Subject Recombination e.g J. of Protozoology or Parasitology as distinct from such others as Journal of Microbiology and Immunology.

The effect of this growth on libraries is enormous. As noted by Wilson (1983), "fractionalization of scientific knowledge has led to a disapportionate growth of serials literature with reference to the growth of scientific workers; attempts to keep abreast of it have been crippling the ability of great research libraries to maintain the quality of collection ....."

(d) A fourth factor is the growth of associations and institutions. The evolution of these institutions or organisations triggers the evolution of journals which represent means of communicating ideas between members. All these factors in some ways, present formidable tasks

in decision making for those charged with the management and development of libraries.

What actually triggers the evolution of these journals is the need to publish articles (or papers) in order to communicate information or ideas to others in the same or similar fields or disciplines. The growth of these articles is also of interest. In Africa trypanosomiasis research, knowledge proliferation has resulted into disseminating information via various means, more particularly through publishing articles in various journals.

Its literature has gradually built up into considerable volume and ranks second only to that of malaria among those of the tropical diseases (IBAR Doc. No. AHH 531, 1979. P. 9). Over 600 journals have been used to publish various articles. This project attempts to determine how those periodical articles have grown as a biomedical discipline.

1.1.1 Growth Characteristics

One will want to know the overall growth pattern of the literature with respect to published papers. Moreover what is the pattern of growth in each component which constitutes the biomedical literature? In particular how does this relate to the overall pattern?

The most popular version of how literature grows is that it is virtually exponential. In a situation as found in a biomedical literature, being made of several components, how is the overall pattern derived? For example if it is exponential,

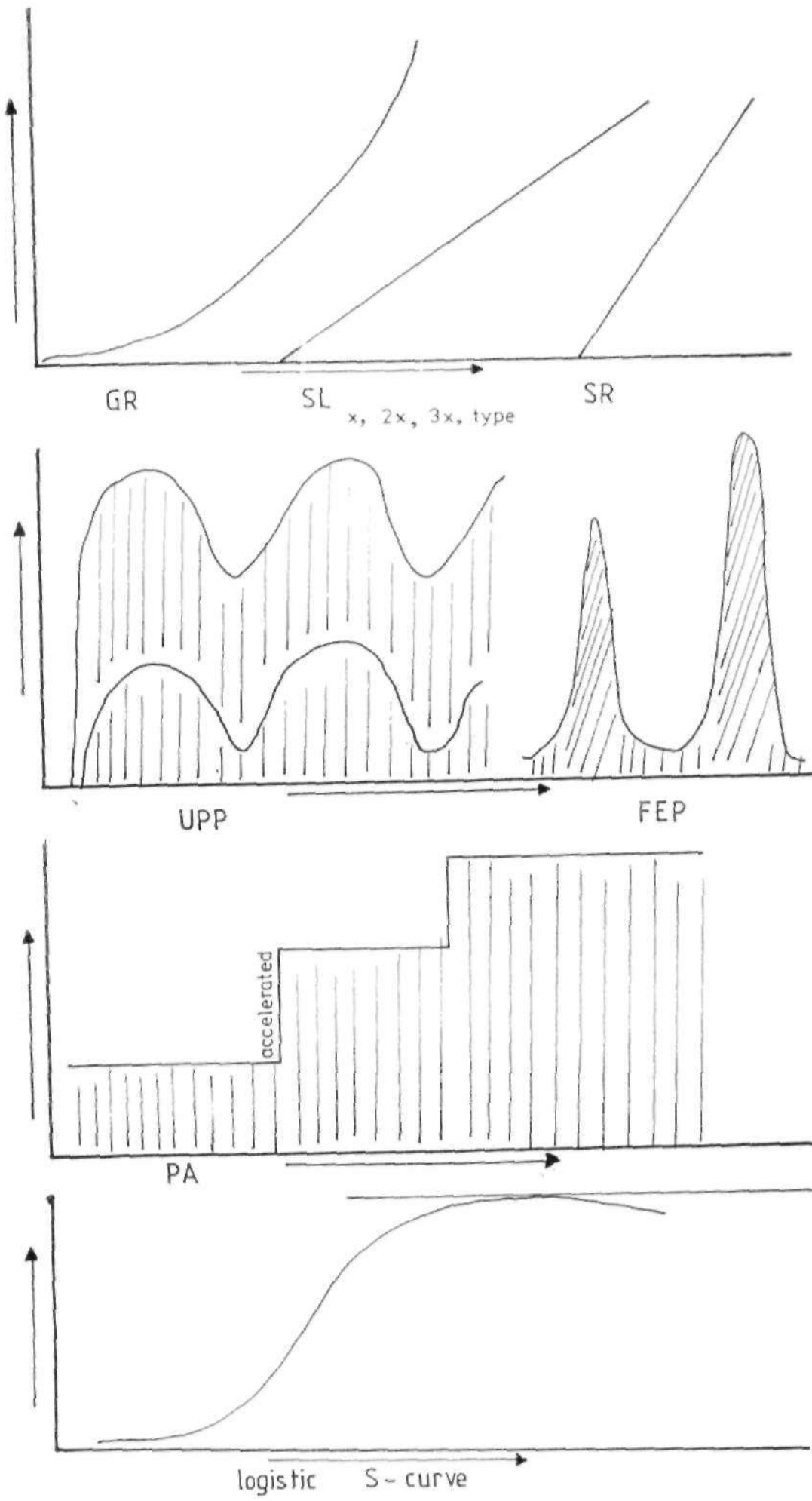
what growth curves of the components are superimposed over and upon each other? The central question that the study wants to answer here is this: does the growth of subfields of a biomedical discipline show different patterns from that of the literature as a whole? If the growth of the subfield is, for example, linear, then the assumed exponential model is the creation of these subfields on top of the linear growth of already existing field (Magyar, 1974; Anaehobi, 1984).

Bottle (1983) commented thus:

The work of de Solla Price on growth rates of large areas of knowledge is well known ..... If, however, we examine the growth of small subject fields, some different patterns are observable.

What patterns are observable in African trypanosomiasis literature? Many such patterns are, infact, discernible. There could be one of gradual rise (GR) or sharp rise (SR) or steep increase (SI). Another could be an undulating plateau type (UPT) or fluctuating epidemic type (FET) peaks, the latter depicting possible 'epidemics' - a state in which publications are present at high levels and possibly capable of quickly infecting large number of people. The peaks could be successive, either with a long or short period of low activity before the early levels are again reached and surpassed (Bottle (1983). In other, there is no low period of activity in this sense, but characterised by periodic accelerated growth as in America trypanosomiasis literature, 1900 - 1969 (Thompson, 1987). Finally there is the logistic, S-shaped, curve which depicts a

FIG. B. DIFFERENT SHAPES OF GROWTH PATTERNS



saturated literature, which perhaps is a culmination of and exponental growth.

Exponential pattern implies that the growth expounds with an exponent or a power rise (Price 1963), depicting a geometric progression in publications. A geometric progression indicates a series of quantities each of which has the same ratio to its predecessor. e.g 10, 10^2 (100), 10^3 (1,000), 10^4 (10,000) etc.

as against arithmetic where the series increase or diminish by a common difference e.g 7, 10, 13, 16, 19, etc. or 12, 10½, 9, 7½, 6 etc. What is the doubling period for African trypanosomiasis literature before, perhaps, settling to a logistic pattern, if at all?

How can one really confirm if, indeed, an exponential growth has taken place? One way according to Price is to compute the doubling times based on a graphical method. Another approach is, possibly to determine the expected or theoretical annual growth rate of the literature and establish whether or not this is consistent with an observed rate of a determined exponential pattern (Oliver, 1971). Oliver (1971) gave a formula (based on Brookes, 1970) for determining the expected annual growth rate, g, of an exponential or geometric growth thus:

$$g = \frac{1}{T} \log_e (P_T/P_o) \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

where P is the number of published papers at years O and T respectively. For this study 1981 (year O) and 1985 (year T), were examined. The use of 'e' as the base of the natural

logarithm assumes that the data runs into hundreds and thus assumes an exponential increase in the number of articles. This formula is hereby referred to as Exponential Annual Growth rate (EAGr) formula.

P_o, P_T has to be derived by cumulation or the Bradford method, whose details are explained in chapter three.

The basic assumption is that if a theoretical annual growth rate is calculated using this formula and it can be shown that the difference between its value and that found by observation (i.e counting) in relevant abstracting source, (here TTIQ) is not significant, then a truely exponential pattern must have been established. An hypothesis is hereby formulated namely .....that there is no significant difference between the values of observed annual growth rate and the expected/theoretical annual growth rate derived using the 'EAGr. formula. Is there any statistical difference when subjected to chi-squared (X^2) test?

1.2 AUTHOR PRODUCTIVITY

A further aspect of the work concerns the productivity of authors and how they collaborate in research. Lotka's law was applied to expiscate the productivity pattern of the authors. Lotka (1926) investigated the productivity of authors in a scientific subject. He found that a small number of authors produce a large proportion of literature and these are distributed such that the number of people producing n papers is approximately proportional to $1/n^2$.

Price puts it this way: that if 60% of the total authors should contribute 1 paper, the number making n contribution should be $1/n^2$ of those making 1 paper. This implies that if 60% of authors should rroduce 1, then $\frac{60}{2^2}$ = 15% of the authors should produce 2 papers; $\frac{60}{4^2}$ = 3.75% of the authors should produce 4 papers etc. The question is: will all disciplines conform to this distribution pattern?

In this project the productivity figures for African trypanosomiasis are computed and compared to the theoretical model proposed by Lotka to determine if the computation fits the Lotka's model? If not how farther or close is the data to it?

1.3 PATTERN OF AUTHORSHIP AND COLLABORATION

Another area which this study examined was the pattern of authorship and research collaboration of contributing scientists. Scientists author papers and such authoring indicates that they have carried out a particular research and consequently created the intellectual content of the paper. In this context authorship could be single or collaborative. If single, it means that everything about the paper, at least its intellectual content, may be credited presumably to that one author. But if the paper is co-authored, more than one author, i.e two, three, four etc. must have contributed to its production.

A number of assertions has been made as to why collaborative studies are necessary. Generally, collaboration is said to lead to greater productivity in research. It is said to have

the 'social function of squeezing out papers' (Subramanyam, 1983 quoted price and Beaver). This implies that productivity, as indicated by the number of papers, increases as more scientists collaborate in research. The pattern of authorship should reflect the level or degree of collaboration. But this is not always the case. As noted by Subramanyam (1983) the practice of naming co-authors varies widely and depends on the attitude and perception of the individuals involved and the policies and tradition of the organization in which the research endeavour takes place. For these reasons, among others, studies of authorship and research collaboration are condidered of interest and worthwhile.

At present there seems to be three topical problem areas (Subramanyam, 1983). One is how to define and assess collaboration at different levels. A second concerns explicating the nature and magnitude of research collaboration which varies from one discipline to another. And the third relates to the impact of collaboration on the organization of research and communicating science.

An attempt is made in this study to examine collaboration at different authorship levels and to determine what percent of the biomedical (African trypanosomiasis) literature is the result of single and multiple authorship respectively. The magnitude of collaboration as guaged by papers with different levels of multiple authorship was also investigated.

Subramanyam (1983) suggested a formula for the degree of

collaboration, C, given by

$$C = \frac{Nm}{Nm+Ns}$$

$$= \frac{\text{(No. of multiple-author papers per year, T}}{\text{(No. of multiple author paper + No. of single author paper per year, T)}}$$

This value, along with the weighted average number of authors per paper, he said, would give a clear idea of the extent of collaboration. This, perhaps is an indirect weighted average technique. A direct weighted average method could also be used. For example if 500 papers were produced such that 200 are 1 author, 150 are 2 authors, 80 are 3 authors and 70 are 4 authors, then the degree of collaboration, C, given in weighted average will be,

$$C = \frac{(200x1)+(150x2)+(80x3)+(70x4)}{500}$$

$$= \frac{1020}{500} = 2.04$$

This method reflects the number of contribution or size of each level of authorship. As this number increases, the value of the weighted average also increases. This latter method of direct weighted average is used in this study.

1.4 RELATIONSHIP OF BIBLIOMETRIC PARAMETERS

The study further considered how the numerical characteristics of African trypanosomiasis literature relate to those of other biomedical disciplines in line with the view of Goffman and Warren (1969).

They analysed two (bio)medical literatures, that of mast cell and schistosomiasis and proposed that there is a relationship

between the parameters of the two. They found that the ratio of journals to authors for each literature is a constant at about 0.27. Further, on the basis of their data, they found that there were three times as many schistosomiasis authors as mast cell authors; three times as many journals containing schistosomiasis articles as mast cell articles etc.

They contend that although the literatures were different in size as well as content, the relationship of identical ratio of journals to authors may be constant for all (bio)medical disciplines.

If this proposal is to be accepted, then more studies are needed on the relationship between mast cell literature and such other medical literatures, namely trypanosomiasis, onchocerciasis, malaria etc., which have similar dissimilarity or constrast as that of mast cell and schistosomiasis.

For this purpose the figures for African trypanosomiasis in relation to mast cell literature were computed.

1.5 THE APPLICATION OF BRADFORD'S LAW

Another area of major concern is ranking and determining the 'core' of the journals which publish articles on the subject.

This requires the application of Bradford's law. This law describes the distribution of papers among journals and provides an avenue to know the journals ranking highest as publication outlet. In various studies the law has been applied to some subject literatures to ascertain whether or not it fits the distribution of articles in various producing journals and have

found corroboration with the law. Will African trypanosomiasis literature conform to Bradford's distribution? If it does, then it will lead us to determine the core and representative journals in the field.

1.5.1 Ranking of Journals: FABIT effect

The journals will be ranked according to the number of articles they produce. An important contribution to knowledge would be to determine the effect of ranking FAR-BACK-IN-TIME (FABIT)

As far as could be ascertained in the literature no empirical studies have really sought to show the effect of FABIT analysis on the core or representative journals from one point in time to another. Such a study would show if any significant changes occurred in the ranks of journals when ranking was done far back in time. What this study sought to know is whether the core journals would be different from one point in time to another and hence affect the journals a library can acquire for such different periods in time. Will FABIT analysis reduce ranks of newer journals compared to older ones, thus creating a bias in favour of the latter? What is the extent of such a bias if any? (Lawani, 1972).

This raises another crucial point and that is the effect of the researchers idiosyncracies which may create a bias in journals selected for acquisition. After producing the rank list of journals (based on a study such as this), one may be faced with such question as: do the journals purportedly needed by the research scientist fall within the core or representative

journals selected? The converse question is also askable, namely, are there any journals or set of journals which any category of scientists consider important which appear very low in rank beyond an acceptable cut off point as determined by substantive coverage of relevant articles? These questions are very pertinent considering the local need effect imposed by the nature of research logistics and the nature of the literature itself. It is important to know the extent of this Idiosyncracy Factor (IF) against a model collection drawn using say the Bradford 'productivity' method.

1.6 Significance of the Problems

The problems highlighted in this study are paramount and concern topical issues. Saracevic (1980) gave a number of central premises which should form the goals for all working towards improving medical librarianship in Africa. He said the surest part to improving the quality of (bio)medical libraries in the developing countries is through an increase in the professional knowledge and skills of librarians. Since our province of information work is the literature, the problems associated with its control and the structural characteristics are crucial and should arrest our intuitive and interrogative mind.

On the growth of scientific literature a number of contentions make studies on it still necessary. Price (1963) found that scientific literature grows exponentially. However some contributors to the problem have pointed out that literature growth should no longer be exponential. It is either levelling off or would do so after sometime (cited in Aulakh et al 1983) Price himself pointed out that no natural growth process whether biologic, social or economic is purely exponential; and that real growth curve are always logistic (S-shaped) functions. Actually the exponential growth and '15-year doubling' statement of Price (1963) took into consideration the total number of scientific journals 'founded', rather than those surviving and

'all periodicals' containing science. No wonder he said it was an 'overall picture' and predicted that the growth rate of science and its products, the scientific literature, would begin to stabilize in the near future i.e would depart from a purely exponential increase.

Another reason why the problems are significant is that based on literature growth patterns, it is possible to evolve general principles for bibliographic services. When research activity in a given subject area stabilizes or decreases, the bibliographic service specialising in this area either increases the scope of its subject coverage to include related areas or ceases operation. The formal properties of a discipline's literature could provide evidence of the structural features of the discipline itself. For example the impact of various subject areas on a discipline can be shown by analysing the literature for the contribution from various subjects. We have seen that subfields exhibit different types of growth. Some show active but irregular growth; others show fluctuations in the rate of appearances of new publications. New research areas illustrate rapid initial growth followed by relative slowing. Examining these problems might contribute knowledge on bibliographic and conceptional information that could lead to better research for the scientists.

A further aspect focussed on problems of core journals. Bradford's law provides an avenue to know the journals ranking highest as publication outlet. Bradford himself said, as noted in Fairthorne's review, that by reading only the core periodicals of ones speciality, one would miss about 40% of articles r relevant to it. This conclusion was in respect of special libraries. Observably, the question of core in Bradford's law arouses a lot of interest. Is it really definitive? For example if an acceptable core is combined with an additional zone to form a new core, Bradford's law is reproduced. ' There is yet an apparent illusion regarding this core. It is a core no doubt, in terms of productivity or 'size'. But is it necessarily so in terms of 'information' or idiosyncratic need? In this latter context can the need not be within the domain of the 40% that can be missed in Bradford's view? Moreover in the biomedical field such as African trypanosomiasis, research draws multi-disciplinarily i.e from different disciplines, e.g biochemistry, immunology etc. and a journal that could be of major need may not be in the core or even in a higher rank of the 40% category. To what extent can we jettison these assertions in ATREP - the African Trypanosomiasis Research Programme?

Furthermore the FABIT analysis problem seems an intriguing one because there could be a significant swopping of ranks between ceased publications and current journals? No empirical

studies have yet examined these issues. This investigator considers that such study will be of practical value for information services and acquisition policies, and may, hopefully, contribute to knowledge.

1.7 Significance of the study

The study is significant in that it attempts to examine a number of topical theoretical, and practical problems as explicated in the section above. The growth problem is, to some extent, enigmatic and consequently a further consideration is necessary. There is need to test the exponential growth phenomenon practically.

Another highlight of the study is that it considers the uniqueness of a biomedical discipline as typified by African trypanosomiasis against most other studies which have been based on mono-disciplinary subjects such as entomology, biochemistry, physics etc. What then are the major characteristic differences displayed?

On the question of core journals the study hypothesises that 'coreship' of a set of journals is time limited. Significant changes occur from one point in time to another. An attempt is made to test this hypothesis by analysing a collection of journals on the subject within specific time periods.

Perhaps the significance of this study will be more appreciated by the need for more bibliometic studies on the literatures emanating from the developing countries especially the African continent. In the review in chapter two, the importance of this need was highlighted because of the relatively scarce empirical data which throw light on the communication, knowledge transfer, and literature conditions of this part of the world.

From these perspectives the study hopes to contribute some new knowledge which may be of theoretical or practical value.

1.8 Objectives

The object of this investigation falls into the following main parts.

Firstly, to examine the productivity and growth patterns of the periodical literature and the contributing scientists. How do these scientists co-author and collaborate in producing the papers? The former will certainly be of interest because the literature is of a composite structure being derived from several subject disciplines. A further question to be answered is: does the scientists productivity pattern follow the Lotka's law?

The Goffman and Warren study on the relationship between the numerical characteristics of mast cell and schistosomiasis was only indicative. More studies are needed for any conclusive

evidence. So the numerical characteristics of African trypanosomiasis literature derived from this study will be compared to that of mast cell so as to affirm the generality or otherwise of their proposition.

Based on the application of Bradfords law, the core journals will be determined. The FABIT effect on journal ranking will also be determined since no empirical study had sought to critically examine how far-back-in-time (FABIT) analysis of journal productivity affected core or current journals.

1.9 Delimitations

The study is limited to the literature of African trypanosomiasis. World trypanosomiasis literature is made of African and American types. Besides the geographical separation of the diseases, they are distinct in their causative and transmitting agents. They display distinct characteristic features.

Furthermore only the periodical literature is examined. Periodical articles, their appearance, and distribution in different journals are of great interest and importance to the work of librarians and research scientists in terms of practical use and contribution to theoretical knowledge. The geneology of this interest derived from the well known study of Bradford. As far as African trypanosomiasis is concerned, one can safely conjecture that about 90% of its publications are in the form

of periodical literature. Apted and Glunville made this remark:

"The diseases of man and animals in Africa (referring to African trypanosomiasis) has a literature which must rival that of malaria, but little of it is in the form of books and monographs" (Apted and Glunville In L. T. Merton, ed The Use of Medical Literature, London, Butterworths).

They listed just four books and monographs. In a preliminary study (Thompson, 1979) , it was found that 84% of the 2,137 collections analysed were journal articles. The analysis of the remaining 16% revealed the order of 6%, 4.5%, 1.5%, 1.4%, 0.98%, and 0.33% for conference papers, Reports, Review articles, Books, Monographs and dissertations respectively.

The periodical literature constitutes a main source of information for research and it is a pivotal service tool for the librarian especially in the special libraries.

The source of the data are two abstracting services in the field. The implication of this is that any policies binding the services are bound to affect the data collected. The extent of coverage of the abstracts will determine the data analysed. It is an accepted fact that there are limitations in the coverage of journals by abstracting services. (Martin, 1964; 1967).

1.10 Organization of the Study

The project is organized into six chapters. The first chapter introduces the study and highlights the justification for it. The emphasis here is the exposition of the problems and why these problems are significant. It continues by portentously discussing how and in what area the study would contribute to knowledge, stressing the relationship between the problems raised and the main study thrust. The various aspects of the study and its objectives are uniquely spelt out and explicated.

In chapter two, the literature review is presented. It focuses on a number of topical issues and discusses research efforts that have made some contributions relating to the problems. These include methods pioneered for ranking and selecting periodicals, (Gross and Gross (1927) and its variants - Index of Research Potential (Raising Miles (1960), and Journal Impact Factor (Gardield (1972); the 'size' or 'productivity' model which evolved from the Bradford law (1948); the consensus of Experts or specialists/librarians and use and 'user' judgement approach.

The chapter continued with the present status of the research on the growth of the literature of different fields or disciplines, emphasizing the importance of this knowledge in the bibliographic functions of librarians as well as in formulating principles that govern the information phenomena.

Chapter three is mainly concerned with the method used both in collecting data and also in analysing the data. The statistical approach used in analysing and interpreting the data is outlined.

In chapter four, the background to African trypanosomiasis and its research is presented. Areas discussed include the characteristic features of the disease, its historical background and that of its research and documentation; various disciplines via which research is pursued and the logistics of research etc.

The results of the analysis of data and the discussion of the findings are presented in chapter five.

Finally, chapter six summarises the findings and present the conclusions and possible recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

There is a growing demand for better and improved services in the Library and Information profession. Perhaps there is no other sphere of librarianship in which this need is more exigent than in the special libraries. There is need to forge tools and methodologies useful in the management of and research into bibliographic matters. There is also the need for an enhansive research or proactive information service different from the hitherto passive or at most reactive service which is prevalent as the operational model in most library organizations.

These needs demand among other things, (1) familiarity with the conceptual context of the subject literature; (2) knowledge of the documentary channels and the type of information or data in each form of the literature; (3) knowledge of the structural factors and characteristics of the literature; (4) knowledge of the literature growth pattern and trend of research; (5) knowledge of the distribution of articles among the journals and that of the core lists of serials which are indispensable tools for collection development.

This review considers what contributions have been made that shed light on these topical issues. In which areas have researchers been emphatic and where are there gaps? Perhaps we may need to note that the Library and Information Science profession is not alone in the research efforts concerning the areas outlined. For historians of Science e.g D.J. Solla Price and those interested in the sociology of Science, e.g Stephen Cole, Luhn etc. the literature offers a potential for the examination of the structure, the socio-scientific and growth aspects of science. Studies which are useful and of practical value to librarians and Information Scientists and bearing on the area of this study are the main object dealt with below.

Perhaps before reviewing specific research efforts it may be worthwhile to mention that since Aiyepeku's study in 1973 some bibliometric studies have been carried out on the literature emanating from the African regions, but there is still an acute paucity gap. Such studies are important and necessary because not only do they indicate research output and performance but as Nicholas and Ritchie said '..... also provide information about the structure of knowledge and how it is communicated' (P.14) . Besides they can be used to predicate acquisition policies, search strategies etc. Some of the few recent empirical studies, which may be referred to latter

include those of Adenaike, 1982 , Anaehobi, 1984) , Alabi, 1984 , and Gupta, 1987 . This study hopes to contribute to filling this paucity gap.

2.1.1 Research Efforts

Of the five catagories, it seems efforts have concentrated, as far as could be discerned, on the area of distribution of articles among journals and journal ranking as publication outlet. Though authors have paid attention to the foundation of some empirically discovered bibliometric laws, more attention has been paid to the practical application of these laws. Most of them concerned Bradford's law describing the scattering of scientific journals and papers as it relates to a definite problem or discipline. Leimkuhler, (1967) , Brookes, (1968 ; 1969) ; Goffman and Warren (1969) and Wilkinson (1972) among others discussed problems inherent in the application of Bradford's law.

2.2 Growth and Characteristics

Researchers have also been pre-occupied with problems that relate to information or literature growth. Two areas of interest are the growth in the number of articles and in the number of journals. Infact the imperative need to make choice among journals and a wise choice for that matter is because of the considerable growth in the number of these journals. Journals grow because they are vehicles for communicating research findings in form of articles. The growth of articles in specific and

specialised journal, which is regarded as 'productivity' is of concern to librarians.

That literatures grow is not contestable but the question is how? Several scholars of science have discussed this problem citing the vast growth of science and the impact that growth has on the individual as well as institutions. Debons attempted to summarise these views in as much as they reflect major contributions to the issues and problem facing information science. The contributions of De Solla Price and Lukasiewicz were discussed. De J. Solla Price correlates the growth of Science with the production of publications and suggests that both publications and manpower tend to double every 15 years. So far Price has established the exponential growth pattern for science as a whole. This perhaps suggests that the literature of medicine or biomedicine grows exponentially; that of physics grows exponentially; that of biology grows exponentially etc.

Exponential growth supposedly leads to the logistic. Infact Price (1963) said .....in general the growth rate of branches of sciences proceeds in a logistic curve. Exponential growth inevitably reach a period of saturation when a breakdown begins followed by an interval of restraint which may lead to escalation or fluctuation.

One wonders what Price implies in the last part of the statement above. It is acceptable that in the context being discussed literature growth is expected to be logistic. This concept is usually attributed to biological growths (i.e in plants or animals) in which once growth got started, the rate is very high during the early stages; then gradually decline or reach a saturation level and begin to taper. This tapering i.e gradual diminishing is a feature of logistic curves.

Such a pattern should, perhaps, be expected in the literature of the branches of sciences as research problems gradually get solved. Once this happens, it is not expected or likely that escalation would follow as a result of an interval of restraint as conjectured by Price. However if this happens, it would presumably be due to some inevitable socio-scientific problems. In the case of the natural biological growth, a saturation state culminates from a'natural' factor. So an 'interval of restraint' should not, in my view, be a concomitant of a saturated condition.

Respective disciplines are made up of several subfields. It can be assumed that the growth in these respective subfields eventually lead to the overall exponential pattern. What is the pattern in these subfields? How does this relate to the overall? The evidence from the literature shows that subfields have peculiar patterns and doubling rates.

Orr and Leed (1964) indicated a growth rate with a doubling rate of 38 years for the biomedical serial literature. This is, of course, in variance with the general trend in science postulated by Price. They further illustrated different types of growth for three subfields namely Cardiovascular, Psychopharmacology and Poliomyelitis. The curve for cardiovascular represented very active but irregular growth. That for psychopharmacology illustrated a rapid initial growth followed by a relative slowing that is commonly seen in new research areas. Poliomyelitis on the contrary exhibited a pattern in a research area when some of its important problems have been solved. Bottle et al (1983) drew attention to the studies of the literature on optical rotatory dispersion and liquid crystals. Growth pattern of the former is typified by an early peak followed by a period of low activity before the early levels are again reached and surpassed. In the latter, the early peak was not surpassed for nearly thirty years. They further cited the case of Interferon literature which again exhibits exponential growth exemplifying a new field instataneously recognised as theoretically and/or commercially important. The literature of cowpea exhibited a steady growth pattern and a doubling rate of 20 years (Adenaike, 1984) , while rice literature doubles at 6 year period (Lawani and Seriki, 1974; cited in Adenaike, 1984). Both subfields are agricultural.

Magyar (1974) and Anaehobi (1984) studed the literature of dyelassers, a subfield of physics and (Food and Industrial) microbiology from Africa respectively. They found that the growth of each subfield is linear ..... the X, 2X, 3X, 4X type different from the assumed exponential model of science. Magyar postulated that it is the creation of these subfields, on the top of the linear growth of already existing field which might lead to the overall exponential growth. This implies that a compoundment of linear growths results in exponential.

The biomedical discipline seems ideal to further test this assumption. Biomedical disciplines, as typified by the tropical diseases such as African trypanosomiasis, onchocerciasis, schistosomiasis, malaria etc. are composite in nature. They comprise many components because research into them are multi-disciplinary. For example African trypanosomiasis draws from entomology, biochemistry, parasitology, genetics, etc. No studies have looked into how these components grow in relation to the overall. Does each component grow linearly, exponentially or otherwise? Which components control the overall growth in terms of relative size: These questions, among others need answers which this study hopes to provide.

2.3 The Application of Lotka's law

Lotka's law (1926) seems to be the first empirical investigation of a collection of publications for the purpose of studying

scientific output. He plotted the frequencies of persons who made 1, 2, 3 ..... contributions, against these numbers, 1, 2, 3, ... of contributions, both variables on a logarithmic scale and found that in each case the points were rather closely scattered about an essentially straight line having a slope of approximately two to one. The general formula for the relation thus found to exist between the frequency, y, of persons making x contributions is

$$x^n y = k(\text{constant}) \quad \ldots\ldots\ldots\ldots\ldots\ldots 2$$

For a special case that n = 2 (inverse square law of scientific productivity), the value of the constant K was found to be 0.6079 or 60.79 percent.

Because the exponent in Lotka's examples had approximate value of 2, about 1.89 for chemical authors and 2.021 for the physicists and comparing this with the inverse square law, Lotka stated his result in a simple form thus:

......"In the cases examined it is found that the number of persons making 2 contributions is about one-fourth of those making one; the number making 3 contributions is about one-nineth; the number making n contribution is about $\frac{1}{n2}$ of those making one and the proportion of all contributors that make a single contribution is about 60 percent.

The fundamental point of the law is that the number of scientific authors who wrote a given number of papers is inversely proportional to the square of this number of papers. Basically it assumed that only a few authors contribute the most and most of them contribute few number of papers. Based on this assumption a generalized form of the law was derived.

Three parameters seem to determine the general form of the law:

(1) the number of authors with a single paper each, x

(2) the number of authors contributing n number of papers each, where $n = 1, 2, 3, \ldots\ldots n_{max}$ (maximum productivity of authors) and

(3) the characteristic exponent, @ (which in the original form = 2 giving the relationship

$$a_n = \frac{x}{n^2} \quad \ldots\ldots\ldots\ldots \quad 3$$

Based on the Riemann series, $\sum \frac{K}{X^Y}$, Gupta (1987) wrote, for the generalized form of the law $a_n = \frac{KX}{n^{*@}}$ .....

where n = 1, 2, 3 .....n

For an exact value of 2 for the exponent, the sum to infinity of the Riemann series is known to be $\frac{\pi^2}{6}$:

$$\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6} \quad (n_{max} \longrightarrow \infty) \ \ldots\ldots$$

Because the Lotka's law is based on this Riemann series, it assumes as shown by the infinity tendency above, that the productivity of the most prolific authors, n_{max}, tend to infinity

(Price, 1971); Brookes, 1983) . This is a situation that is not in concordance with the principle of human limitation. This issue of the productivity of prolific authors has been taken up in complex mathematical treatment and expositions (Price, 1971; Allison, et al, 1976).

However Lotka's discovery of the statistical regularity in scientific authorship has now been generally accepted and various values of the exponent, ranging from 1.5 to 3.5 have been found, according to Brookes, by many that have applied the law. Egghe (1985) discussed another dimension of the law, namely its consequences for the law of Bradford which he points out as a mathematical consequence of Leimkuhler's law. The intricacies of this equivalence is not the concern in this study.

Below, a number of studies on its applicability to various literatures, and which have raised some interesting issues concerning the law are highlighted. Pertinent questions addressed in various studies are: does the law apply in all types of subject fields or disciplines?

Moreover how do different social conditions affect the statistical regularity in the distribution of scientific authorship? Brookes (1983) mentioned Vlachy (1978) who reported examples of data which conform with the law. Gupta (1987) cited the paper by Yablonsky (1980) and the review by Potter (1981). Potter gave details of several studies which

support that productivity distributions for fields like physics, chemistry, and mathematics conform to the original form of the law. But it does not apply in cases relating to patterns in the humanities and social sciences.

The question raised and dealt with by Munch-Petersen (1981) was: Can the law be used for a sociological study of literature and society? He used the law to find the dominating element of produced fictions in order to discover what literature was really read by the reading masses, irrespective of its quality, for a period of time.

Another interesting aspect which Gupta (1987) pointed out recently is that while the law may apply in well established disciplines it may not be applicable in the case of an emerging field. Furthermore that the pattern of subject literatures of developing countries may be different from that of well-established regional areas. This seems to imply that different social background and socio-scientific conditions may be reflected in the regularity of the scientific authorship distribution.

The effect is shown, it seems in the value of the exponent. From the generalized form of the law, it was deduced that the proportion of single paper authors P^1 is a function of the exponents, @

$$\text{ie } K(@) = P^1 = \frac{\sum_{n-1}^{n_{max}} \frac{1}{n}}{}$$

Based on the above Gupta (1987) highlighted what Fairthorne concluded earlier in his 1969 review:

> .....an increase of @ is accompanied by the increase of low productive scientist.
>
> .....for a given value of N and for a large value of @, the proportion of highly productive scientists will decrease. Therefore the larher the value of @, the greater the gap between the productivity of individual groups of scientists.

He drew attention to the interesting hypothesis that the difference in the values of characteristic exponent for different subject areas or research fields is a reflection of the socio-scientific environmentof those research fields.

Studies of subject literatures of the developing countries against those of the developed ones in order to subject this assumption to empirical verification will be a worthy cause. The world trypanosomiasis literature, a biomedical subfield would appear ideal for this kind of study. Two types make up the world trypanosomiasis data - namely the American and the African. One expects that intrinsic socio-scientific differences and conditions would lead to different bibliometric parameters which should be reflected in the exponent index. This study is concerned with the African type with a view to comparing it with the American type being taken up.

2.4 Authorship and Research Collaboration

Subramanyam (1983) epitomised, in retrospect, views on the issue of collaborative research and consequent authorship of published papers. He outlined different forms of collaborative effort and several factors which seem to instigate such congeniality. Different levels of multiple authorship result from this team work system.

Some topical aspect of the problems and issues of coauthorship in the literature have been highlighted in the previous chapter (chapter one). The increasing interest and concern for studies like this generate from previous findings which tend to show that the productivity of scientists increases with the increase in collaborative efforts or the degree of multiple authoship (Price and Beaver; In Subramanyam 1985).

One crucial problem is how to assess collaboration. Subramanyam calls for studies to evolve methods for this purpose. The extent of contribution to a paper various from one organization to another. What earns a scientist a coauthorship even differs from one department to another within the same organization. Citing from a research organization, the Nigerian Institute for Trypanosomiasis Research, one finds that in one department contributions are graded for every research project e.g initiation 25%, participation/execution 30%, data collation/analysis and interpretation 20%, write-up 25%. In such a case an author must score not less than 40% to qualify or at least 10% from each area. Authors are then arranged according to their scores, the highest

score earning the principal authorship. In another team work, the ideaman who lays the plan of research assumes principal authorship. Apart from this purely quantitative/intellectual contribution approach, authorship could be earned as a result of reasons unconnected with intellectual contribution such as sheer politics or leadership of an organization. Infact Technical Assistants are even given the status of coauthorship, not necessarily for what they contribute per se but to sustain and keep their interest for further work!

Subramanyam (1983) suggested bibliometric method as the most unobtrusive, less arbitrary and more objective approach to the study of research collaboration. This is because, it is non-reactive i.e the process of ascertaining collaboration does not affect the process of collaboration itself; it is easily quantifiable and invariant. He further said the approach facilitates the investigation of the relationship between research collaboration and variables pertaining to the research problem or research environment by applying statistical techniques such as regression, correlation and factor analysis. A number of these variables occur in research organizations.

Funds is one such variable. It is seen in these days of constraints that solo research effects are being put aside where it is possible. In the multidisciplinary field such as the African trypanosomiasis, research projects are planned such that different research disciplines are involved in one project e.g biochemistry, pathology or parasitology etc. all working in concert.

It is necessary to test the causal relationship or correlation between the various variables.

In 1982, Subramanyam did a preliminary study of collaboration in biochemistry and chemical engineering. He guaged the extent of collaboration by the ratio of research papers with multiple authors to the total number of research papers published in leading journals. Based on this he defined a degree of collaboration ratio, C, as discussed previously on page 13. Here it is suggested that direct weighted average number may be less cumbersome or easier and more direct and illuminating in application.

The trend noticed in the authorship of papers is that coauthorship is, in general, in creasing. More research is being done by collaborative efforts than hitherto in the past. Price in his Little Science, Big Science implied that the relationship between multiple authored papers and single author papers would be like that between the Lord Jesus and John the Baptist in the scriptures. John said while He (the Lord Jesus) will increase I will decrease (Gospel according to St. John Chapt. 1). This 'John effect' has not happened as predicted by Price who said that by 1980 single author papers may be extinct. However the results of Subramanyam (1982) showed a relatively very high percentage of multiple author paper to single author paper, 91%: 9% for biochemistry and 87%: 13% for chemical engineering.

Does this not signal a high tiit to the 'John effect'? (remember Matthew effect in science). (Actually when Jesus started His Ministry, John's closed. There is a need for further studies to establish the current state of the 'John effect' and if indeed the problem with Price's prediction was a question of time. But I doubt. The status attribute and award for efforts is a high prize.

Is the situation which prompted Clarke to challenge Price in 1964 the same today in the biomedical literature? Beverly Clarke (1964) produced data on authorship from 1934 to 1963 to show that the average number of authors per paper had renamed almost steady at about 2.3 during that period as against Price's contention of rapidly decreasing single authorship.

2.5 Periodical Ranking and Core list of Journals

The earliest approach for selecting journals was the use of consensus of experts' or specialists' opinions as well as the librarians prerogative. But this technique has been subject to various criticisms. These critics claim that the approach is subjective and that more objective one is needed.

Considerable number of papers have discussed the more general methods and criteria which have evolved. These include citation ranking, ranking by library 'use' and 'user' judgement and the 'size' or productivity approach. In many studies these methods have been applied in the ranking and compiling of lists which

have been useful, no doubt, for local or particular needs.

The earlier methods used by (Allen (1929), Mcnecly and Crossno 1930, Jenkin, 1931) were strictly quantitative. Later, critics such as Miles 1960 , Garfield 1972 among others offered what they claim to be improved techniques designed to measure qualitative value of scientific serial by means of a related quantitative approach.

For example Miles calculated what he described as Index of Research Potential (RPR) for each journal and for each period. The index represents the relationship of the number of articles quoted to the number of articles published.

Sengupta prepared a ranking list of periodicals in medicine, in the field of biomedical sciences (1970) and in biochemistry (1973) . The first two were from the Indian Scientists' point of view. In 1974 Sengupta produced another list, though based on the counting of references from the bibliography at the end of each article of the Annual Reviews, a nonprimary serial publication. This method reflects the impact of individual journals on the progress of knowledge in a particular field, this time biomedical research. Comparing the two lists showed that only 10 titles in the 1970 list ranked within the first 40 titles of the 1974 list. The 1970 list was based on 1959-1968 periodicals. The time factor may be responsible for the disparity. But more important reason could be the source used.

Infact Croft (1983) cited some studies such as Line's (1979) which show that the type of source material can affect results. Ranked journals (highly cited) were found to contain a higher proportion of reference to recent articles than ranking selected journals.

Dhawan (1980) compared results of citation analysis of primary literature (citation indexes), citation analysis of secondary literature (abstracting and indexing services) and journal use pattern studies as journal selection technique. He found that use and citation patterns gave different results in journal ranking and suggests that journals in the overlap area (i.e journals which are cited, abstracted and used) should form the core of a library's holdings. This is quite a challenging and formidable task for two reasons. First the usefulness of ranking is a function of time. As we found in most of the studies, a list compiled during a particular period may be out of date after some time, especially for local use. This would involve compiling several lists for particular periods in time. Secondly the source of data would be quite cumbersome and highly demanding.

Ranking journals by the use made of them by a group of library users has been popular. There are several ways of doing it e.g asking users, watching them, examining journals left on desks, putting 'unobstrusive seals' on volumes and then checking

whether they have been broken subsequently, inter-library loans, photocopy requests etc. Again such ranking are for particular libraries. Infact most studies of these types reflect the users outside the Africancontinent and the developing countries.

The 'size' or 'productivity' method came into limelight probably with Bradford's observation in 1934 which has since been formulated into law (1948) and discussed. For size, one thinks of some measure e.g no. of papers or articles and rank the journals accordingly. But for productivity, it refers to some measure of quantity (usually number of articles) which has to be relevant to the subject field of interest.

Considereable efforts have been made to examine critically Bradford's law and how it can be used as a practical library tool. Concerned about this, Brookes pioneered the Bradford-Zipf distribution as a basis of deriving the core of a collection of journals. In his formulation of Bradford-Zipf thus, he was able to estimate the total number of contributing source to a journal collection once data on the nucleus is established and hence could be used by a library.

Apart from attempts to find out if the law would fit several other subject literatures such as Adenaike (1982), Aulakh (1983), Alabi 1984 more pragmatic investigations sought to look into cost-effective ranking by Bradford's order where there may be

a saving in cost and effort. Brookes (1970) suggested a way of estimating the likely savings if a library changes over to getting photocopies when the number of relevant papers, photocopy charge/average paper, is less than the subcription and other library costs of obtaining the periodical. These cost-effective and relevance inclinatons are significant because of the present economic constraints.

The choice of productivity method for this present study is considered in the light that the use will satisfactorily serve the users. The present collection will satisfy such a distribution. The approach would provide a better coverage of useful journals and more widely useful result than the parochial use of user judgement. The productivity list can be easily adopted for local use.

CHAPTER THREE

3.0 DATA AND ANALYTICAL TECHNIQUE

3.1 Data

The data comprised 5139 articles abstracted in two major abstracting journals namely the Tropical Diseases Bulletin (TDB) and Tsetse and Trypanosomiasis Information Quarterly (TTIQ) . Two thousand five hundred and twenty-one (2521) articles covering 1900-77 were analysed from TDB. These excluded 18 anonymous papers. While 2618 articles were analysed from TTIQ covering 1978-1985.

TDB started as an abstracting service for Sleeping Sickness about 1909, and was then published as Sleeping Sickness Service by the Sleeping Sickness Bureau. Originally it contained both abstracts and bibliographies on trypanosomiasis.

The bibliography then was a complete list of references as it was possible to obtain from the earliest published papers to the end of March, 1909. From then onwards a subjourned list took up from the references and was published in subsequent bulletins as 'Monthly List of References' (Bull NO. 7 pages 284-286). The list continued till September 1912 (Vols. 1-4 of the Bulletin).

Between 1912 and 1913, the monthly list was changed to a quarterly list of references and grouped together at the end of the bulletin. Apparently realising the duplication of efforts the quarterly lists was stopped in 1913 and the service continued simply as an abstracting one without an additional summary list at the end of the volumes. The lists of references from 1909 to 1913 were extracted to form the starting point for the analysis on African trypanosomiasis. Subsequent volumes from 1914 were checked and titles of abstracts were extracted and compiled into a bibliography 1900-1977. TTIQ started in 1978 and is being published as a quarterly abstracting service. Unlike TDB which publishes abstracts on other tropical diseases, it is devoted mainly to tsetse and trypanosomiasis.

3.2 ANALYTICAL TECHNIQUE: GENERAL

The usual counting method was employed in all the parts of the study.

3.2.1 Growth and Productivity

The number of articles per year in African trypanosomiasis research was determined by counting the total articles published each year in various journals from 1900 to 1985 inclusive. Productivity is measured by the number of articles published in the respective journals based on the period under study. The periodical literature was assessed by counting the total number of articles published by each journal.

In order to determine whether or not the literature made any rapid step forward the number of articles each year was cumulated. Each of these figures was calculated as a percent of the total articles. The percentages were then plotted against time in years.

3.2.2 Growth rates

Two methods were employed in determining the growth rates, i.e average rate of increase or change in the data analysed.

For example if

A = figure for 1981

B = figure for 1982

the rate of change is given by

$$\frac{B - A}{A} \times 100\%$$

So for annual growth rate, A for each year and B for the year following are calculated. From this the rate per year for the period is determined.

Another method is the GM,-Geometric mean-technique for estimating rate of change. GM is defined as follows. If there are three number, 1, 3, and 9, the average rate of change is given by

$$GM = \sqrt[3]{1 \times 3 \times 9} = \sqrt[3]{27} = \sqrt[3]{3^3} = 3$$

For n numbers therefore

$$GM = \sqrt[n]{X_1 \cdot X_2 \cdot X_3 \cdots\cdots X_n}$$

Assume that the rate of production of papers has increased 10 percent from the first year to the second and 20 percent from the second to the third year as follows:

1st year 100

2nd year 110 10% change (increase)

3rd year 132 20% change (increase)

The average rate of increase during the two years is found thus: Since the second year is 110 percent of the first year and the third year is 120 percent of the second, the

$$GM = \sqrt{1.10 \times 1.20} = \sqrt{1.32} = 1.149$$

or the average rate of change is 14.9%.

3.2.3 Exponential Growth

As was noted before, the number of publications in various disciplines has been said to increase exponentially. Such pattern implies that literature growths are characterised by various doubling times.

The exponential pattern for African trypanosomiasis literature was determined by graphical method, plotting the sum of the number of papers (Y-axis) against time (x-axis). The data was further plotted on semilog coordinates. The doubling rate was derived from these graphs.

3.2.4 Test of Exponential Growth

The basis of this test is the annual growth rates (observed and expected) of the literature. If by the graphical method exponential growth is established and its doubling pace determined then the observed average growth rate (found by counting relevant

portion of TTIQ for a chosen period - here 1981-1985 should not be significantly different from the theoretical growth rate as estimated using the EAGr equation (P.8) i.e

$$g = \frac{1}{T} \log_e (P_T/P_o)$$

It has been said that this equation assumes an exponential growth, (Oliver 1971). P_T and P_o represent the number of published papers, P each, at years O and T which for this study are 1981 (year O) and 1985 (year T) respectively. Since the value required is the estimated or expected value, the Bradford-Zipf bibliograph for the two years were drawn in order to estimate the expected number of papers in a complete search i.e the complete search total for years O (1981) and year T, (1985). Brookes' formula for complete search total was used (P. 86 81) $\frac{1}{T}$ equals $\frac{1}{5}$ since T represents the total number of years which in this case equals five (i.e 1981 - 1985). The Bradford cumulative sum method was used to calculate the number of articles because it ensures cancelling out of error that may result from manual search.

The two values were then subjected to X^2 test for goodness of fit. This test was applied because it is a non-parametric case of one sample. The question to be answered is: Is the sample data consistent with the theory? The X^2 analysis in this case is said to measure the goodness of fit.

X^2 is given by $\frac{(|f_o - f_e|)^2}{f_e}$

where f_o = observed frequency

f_e = expected frequency

The f_o in this case is the value based on the actual count from TTIQ, while f_e is the figure derived for g by the EAGr formula.

Author Productivity

3.3 Lotka's law

The number of scientists and the corresponding number of publications were counted as follows:

- o the number of authors against which appeared 1, 2, 3 .....publications. Each of the alphabets was analysed separately but treated in aggregate in the final analysis. The expected figures, based on Lotka's original model were also computed. Both figures were then subjected to chi-squared test. The generalised form of the law was also tested based on K-S statistic .

At 0.01 level of significance, K-S statistic value is given by $1.63 \times \sqrt{n}$

where n = No. of authors

If the maximum difference, D, between the estimated and observed values of the productivity (author's) is less than the K-S statistic then the difference between the two is not significant.

But if it is the contrary, then the difference is significant and hence the observed data does not fit the modified form of the law. The maximum difference, D, is given by

$$D = \text{Max}\left|F(X) - S_n(X)\right|$$

$S_n(X)$ = Summation of fractions, X, of authors, n, contributing 1, 2, 3 ..... papers based on observed data

$F(X)$ = Summation of fraction, X, of authors contributing 1, 2, 3 ..... papers based on expected data.

3.4 Components of the literature

Each of the major disciplines used for African trypanosomiasis research and in which scientists produced publications was discerned. The number of publications produced in each field for each year was counted.

The relative changes in the number of publications or articles in each of the categories was examined for the last two decades i.e 1966 - 1985 a period which portrays the prevailing or what can be regarded as current relative figures.

3.5 Research collaboration

All the scientists counted by byeline of principal authorship were determined. Scientists who appear as single authors and never collaborated with others were identified and counted.

Others who appear as co-authors were determined according to the different levels of multiple authorship thus:

.....2 - authorship

3 - authorship

4 - authorship

.

.

.

.

.

n - authorship

Weighted average index number was calculated to determine the extent or degree of collaboration (see P.13)

3.6 Selecting Periodicals

The abstracting journals which contain articles on the subject were analysed according to the number of articles published in each journal and the journals were then arranged in a decreasing order of magnitude. The journals in decreasing order were then zoned into groups determined by almost or the same number of articles.

Bradford first used this method in studying the literatures of Applied Geophysics and lubrication and he established that for any given set of subject literature, there is a core or 'nucleus' of journals more particularly devoted to the subject and additional groups containing the same number of articles as the nucleus. He deduced that the number of periodicals in the nucleus and the succeeding groups is in the ratio 1: n : n^2 .....

with a constant multiplying factor depends on the total number of zones or groups identified in the set of literature.

While Bradford's division was done arbitrarily, based on approximately equal number of articles in the zones, other workers (Goffman and Morris,(1970) attempted to provide a basis for such divisions.

Arguing against the arbitrary divisions by Bradford, Goffman and Warren (1969) proposed as follows. For a collection of journals where j, the number of relevant papers in the most productive journals is greater than Z/2 (Z being the total number of articles having one article each), the minimal nucleus would contain one journal.

The smallest number of articles which can possibly effect a maximum division A/M in a collection of journals is obtained analytically from the knowledge of its journal distribution and its production constant as follows:-

$$A/M = J_m = g \times Z/2 \quad \ldots\ldots\ldots\ldots$$

where g is given by the number of articles per author.
Using this method the total zones in the set of trypanosomiasis literature were determined.

Brookes graphical method was used to determine the core journals. Although Bradford himself presented a graphical formulation of

his law, it was not until 1969 that Brookes expressed the law mathematically. This was done in two parts:-

$$R(n) = an^b \qquad (1 \leq N \leq C)$$

$$= N\log n/s \qquad (C \leq n \leq N)$$

3.6.1 Bradford-Zipf bibliograph.

The values of R(n) were plotted against (the logs. of) the values of n to produce the Bradford-Zipf distribution curve. The values of N, C, R, (n),R(n), and a were derived from the bibliograph.

N= expected number of journals in a complete literature search.

R(N) = total sum of expected number of first N journals.

n = total relevant papers observed.

R(n) = sum of total relevant papers in the first n journals

a = number of articles produced by the most productive journal

c = Core journals (reference point of deviation from linear curve as observed in the biliograph).

s = Value of slope of curve.

3.7 Bibliographic Scatter

The values of the cumulative percentage of all papers were plotted against the cumulative number of titles of journals in rank order (T) in order to determine the distribution of articles in journals.

3.7.1 Scattering Co-efficient

Cole (in Lawani (1972) proposed that the slope of the graph of the cumulative fraction of references against the logarithm of the

cumulative fraction of titles is the measure of the extent of scatter. The numerical value is termed Reference Scattering co-efficient. The co-efficient for African trypanosomiasis literature was calculated from the slope of the graph.

3.8 Effect of Far-Back-In-Time (FABIT) analysis

Specifically the study wants to ascertain whether there is FABIT effect on

(1) the ranks of journals such that those journals which could have been high ranking and core (or representative) in NOFABIT (Not Far-Back-in-Time) list were significantly displaced from their positions.

The productivity of the journals was computed for the period covering 1900 - 1985 inclusive. This is the FABIT list. Another one - the NOFABIT list covering 1965 - 1985 was separated from the former. The journals for each period were then ranked in decreasing order of productivity. Comparisons were made based on the number of common titles, C, i.e the fraction of the number of titles in common in the first n rank. Also Spearman's co-efficient of correlation was computed using $r = 1 - \frac{6 \sum d^2}{(n^2-1)}$.

to test the extent of correlation that exists.

The Bradford-Zipf bibliograph for each period was also drawn and the core journals determined in order to establish if there was any significant changes as a result of FABIT analysis.

CHAPTER FOUR

BACKGROUND INFORMATION ON INFECTIOUS DISEASES

4.0 INTRODUCTION

It is not proposed here to give a detailed treatise of this group of diseases. Only outline of the pertinent diseases is given.

The team infectious denotes diseases that are communicable and caused by infective agents. These agents are usually living pathogenous organisms.

4.1 GENERAL OUTLINE

Weinman and Ristic (1968) outlined the diseases of major importance to man as follows:-

1. Bartonellosis.
2. Malaria.
3. Human Trypanosomiasis.
   (a) African Trypanosomiasis.
   (b) American Trypanosomiasis.
4. Relapsing Fever.

Diseases of Importance to Domestic and Common/Laboratory Animals

1. Babesiosis.
2. Theileriasis.
3. Animal Trypanosomiasis (referred to as Nagana).
4. Haemobartenelosis, Eperthrozoonosis Grahamellosis and Ehrlichiosis.
5. Anaydasmosis.

Others are:-

1. Leprosy.
2. Leishmani asis.
3. Schistosomiasis.
4. Filariasis.
   a. Bancroftian and Brugian Filariasis.
   b. Onchocerciasis.
   c. Loiasis.
   d. Guineaworm Infection.

4.2 FEATURES

Infectious diseases have peculiar features that have important implications for Information Services.

All are transmitted by arthropod vectors. In majority of the arthropod-borne diseases such as malaria, trypanosomiasis and leishmaniasis, we have the vector phase and the host-phase.

Varied scientific disciplines are involved in the research effort to control the diseases. For example fig A shows a diagramatic representation of the route of scientific research directed to the control of African trypanosomiasis. Consequently scientists of varied background are involved in studying and controlling the diseases. Efforts of Protozoologists, Microbiologists, Biophysicists, Biochemists, Entomologists, Immunologists, molecular geneticists etc. are involved, all using modern research tools for the analysis of hitherto unsolved problems.

All these features contribute to the communication problems and the generation of documents. The biomedical discipline is more complex than other subfields and the exploitation of the literature presents more formidable problem than other subfields of medicine.

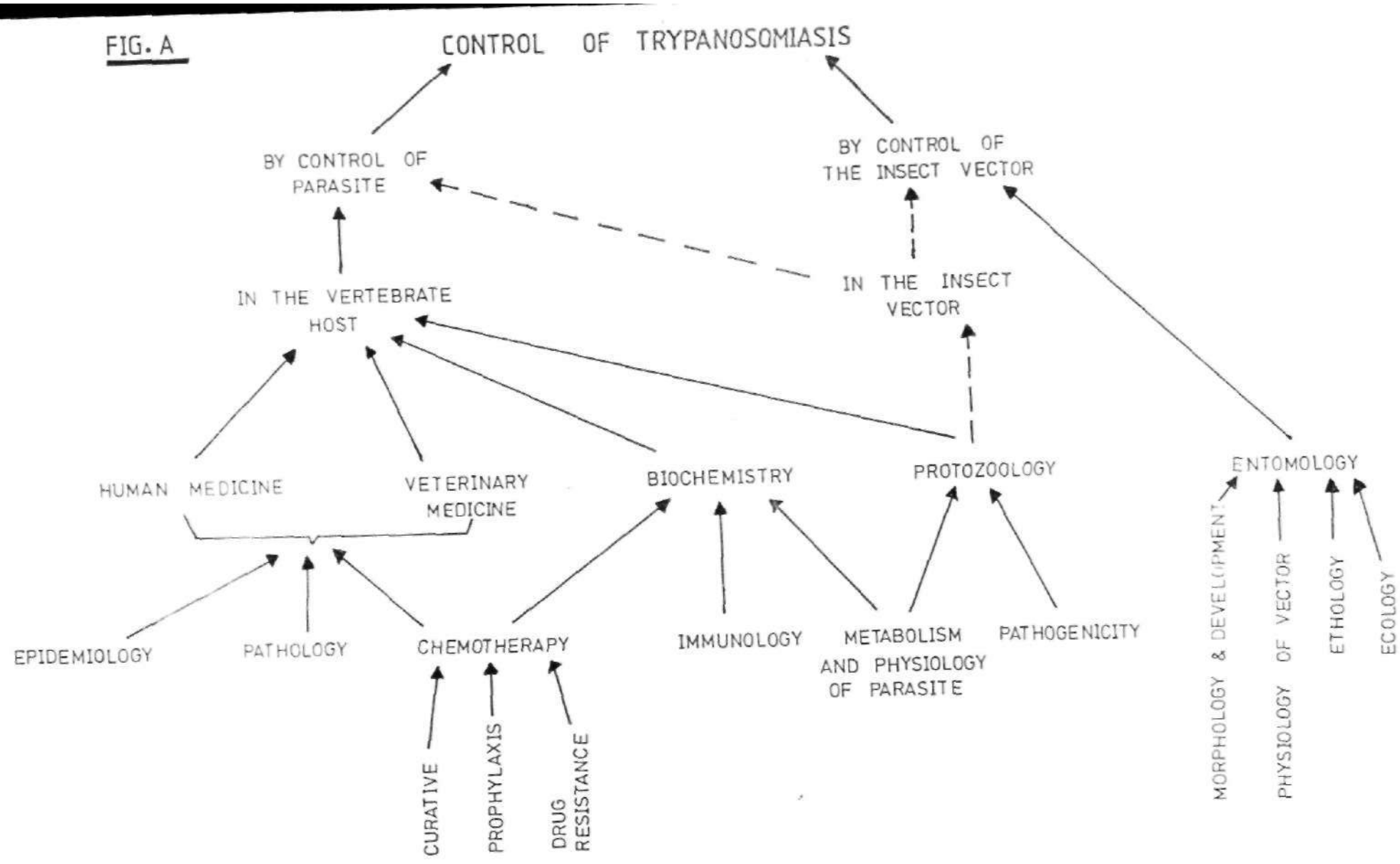
4.4 AFRICAN TRYPANOSOMIASIS

4.4.1 Historical Background

Various accounts have pointed to the fact that African trypanosomiasis have existed long ago in the continent. It prevails throughout 36 countries in tropical Africa.

The history of the disease has been said to have an enormous force on human development throughout an extensive area over a long period of time. Morris (1960) reported that the disease has been present in West Africa for over 600 years and he traced the spread of a series

FIG. A



* Source: Annual Review of Entomology, vol. 8, 1963 p. 200

of epidemics from West to East across Uganda, each following a big population movement.

Quoting Scott and other authors, Duggan said the earliest known human case concerns a sultan of the Western Sudan who died in 1373 - 1374 after two years of "sleeping sickness", a disease that frequently befalls the inhabitants of these countries.

Tsetse fly, of the genus Glossina responsible for the transmission of the parasite was discovered in 1830 by Wieldeman. It was not until 1895 that Bruce working in Zululand was able to relate trypanosomes, the causative parasite, to tsetse flies. He showed that nagana, an anciently known fly-conveyed cattle diseases of Africa, would be transmitted by Glossina and was caused by a trypanosome latter named T. brucei (Weinman P. 102).

Duggan (1962) gave a historical account of the early observations in West Africa and surveyed the sleeping sickness situation in Northern Nigeria from the earliest times up to 1962. The basic situation was that of primordial endemic zone of classified Gambian sleeping sickness along the valleys of the Niger and Benue rivers. A more diffuse primordial zone exists along certain river draining into Lake Chad where the diseases was most acute. Then there was an extension of the diseases from the Niger-Benue endemic zone along the communication system which followed the direction of the Kaduna river.

In the review given by Dr. Charles Wilcocks (1963) the former director, Bureau of Hygiene and Tropical Medicine, London,

he drew from the account of the distribution of trypanosomiasis in man and animals throughout Africa given by Vaucel et al. Tsetse flies were reported to cover more than 8 million sq. kilo of the continent (see map 1) and there are 23 species and 13 subspecies each with its own preference for habitat and for animals on which it feeds. The authors note, according to Wilcocks, that human trypanosomiasis extends from the Sahara Southwards to latitude $20^{o}5$ and that animal trypanosomiasis is even more wide-spread. Thay gave a country by country review of the situation dealing with the countries of Western and Central Africa and then with those of Eastern Africa. The survey was brought up to 1961.

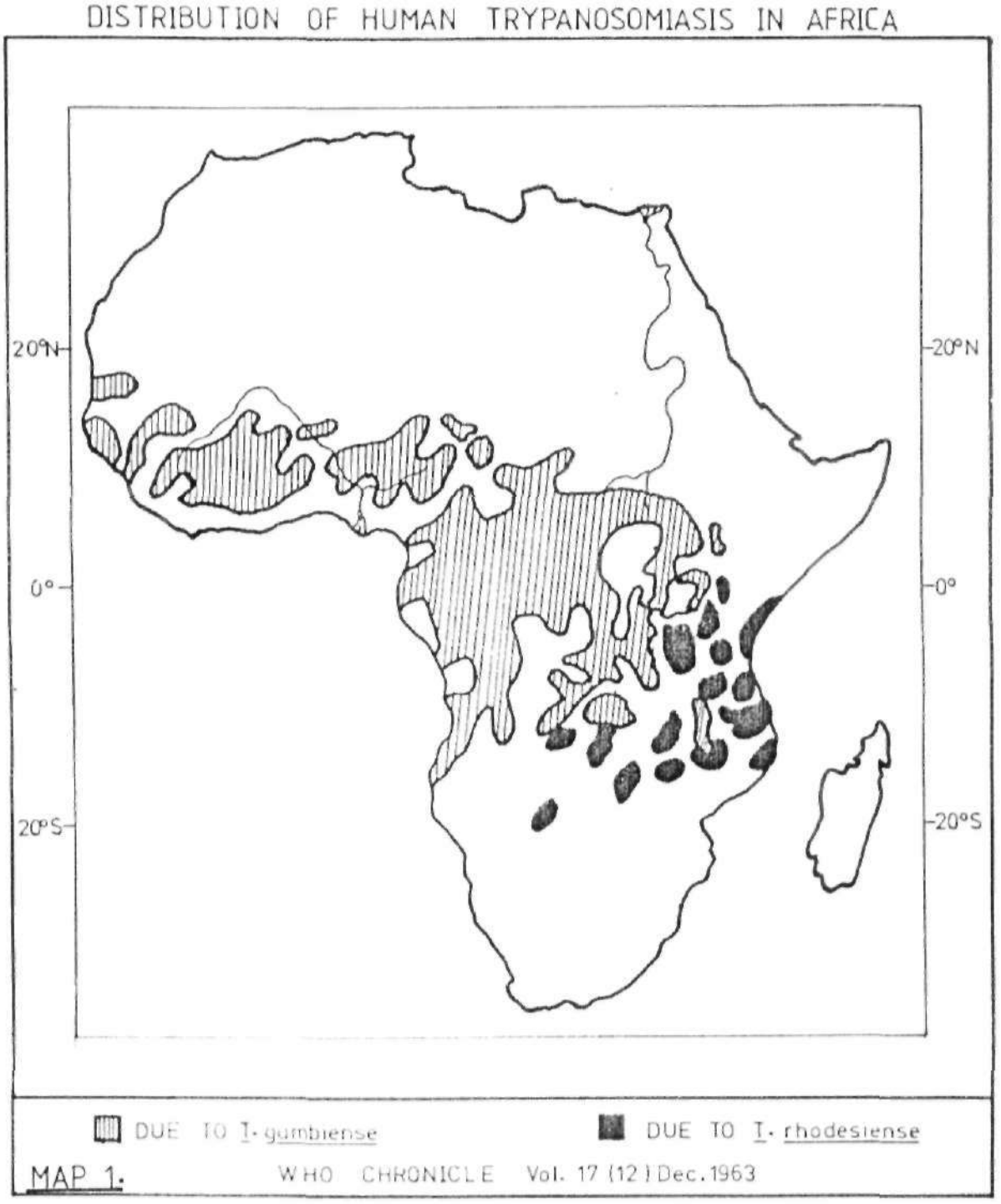
4.5 Nature of the Disease and importance in Nigeria

It can be seen already that the diseases are caused by a group of protozoon parasites called trypanosomes and that there are two types viz, human and animal. The human trypanosomiasis in West and Central Africa is more chronic type and attributed to T. gambiense and the East African type attributed to Trypanosoma rhodesiense. The mammalian trypanosomes that are confined to Africa are the tsetse borne species.

Other trypanosomes effecting domestic animals, T. vivax, T. congolense, T. Simiae T. brucei and T. suie are all prevalent in the tropical zone of Africa.

African trypanosomiases affect both man (Sleeping sickness) and animals (nagana of samore in Nigeria).

DISTRIBUTION OF HUMAN TRYPANOSOMIASIS IN AFRICA

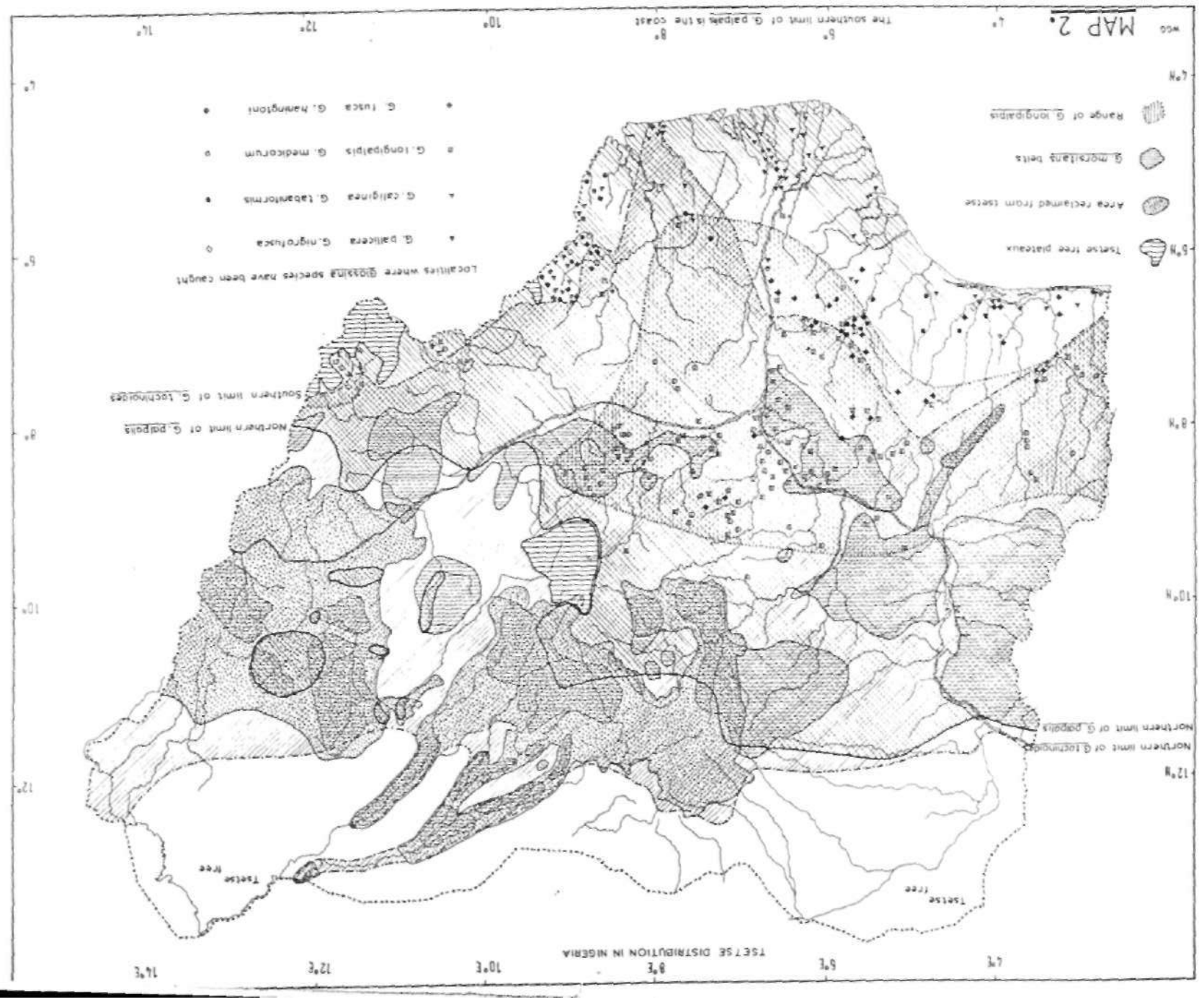


MAP 1. WHO CHRONICLE Vol. 17 (12) Dec. 1963

They are called 'African' .....because the diseases are carried by tsetse-fly, an insect confined to Africa. The diseases have both socio-economic and socio-cultural consequencies. Vast areas of Nigeria which are good for livestock and crop farming cannot be used because of the presence of tsetse and hence trypanosomiases. These areas add up to about fourfifths of the total land area of the country (see map 2 drawn by Dr. J.A. Onyiah, N.I.T.R.).

Nigeria incurs extensive economic losses due to the disease in areas of the country where livestock and trypanosomiasis exist together. These losses arise from, among others, death, retarded growth, weight loss, abortion and cost of control. Death rate has been reported to vary between 2.8 and 10.0% among cattle treated for trypanosomiasis in Nigeria while in certain situations about 50% of untreated animals have died. For pig trypanosomiasis death rate of 100% is very common. Researchers have made an estimated loss of about ₦135 million annually due to trypanosomiasis (Magaji, 1987).

"If tsetse fly can be controlled or eradicated" has been a common rider in articles and reports on livestock development projects in Nigeria (Ilemobade, p. 17). This is a big 'IF' indeed. Tsetse and trypanosomiasis have been a major hindrance to settling the nomadic graziers - Fulanis and Kanuris. Livestock specialists cannot therefore introduce improvement measures. The Inter-national Livestock Centre for Africa (ILCA) in Addis-Ababa have suggested that pastoralists can use a larger proportion of the best


MAP 2.
TSETSE DISTRIBUTION IN NIGERIA
Tsetse free
Tsetse free
Tsetse free
Northern limit of G. palpalis
Northern limit of G. tachinoides
Range of G. longipalpis
G. morsitans beta
Area reclaimed from tsetse
Tsetse free plateaux
G. palpalis G. nigrofusca
G. caligines G. tabaniformis
G. longipalpis G. medicorum
G. fusca G. Hamptoni
Localities where Glossina species have been caught
Northern limit of G. palpalis
Southern limit of G. tachinoides
The southern limit of G. palpalis is the coast
4°
6°
8°
10°
12°
14°
16°
4°N
6°N
8°N
10°N
12°N

watered and most fertile land in Nigeria with practically no development inputs, if trypanosomiases risk is removed.

Zebu cattle cannot be raised in the Southern States of the country, e.g Ondo State, even in the presence of fodder and almost year-round water. Only the trypanotolerant dwarf breed. - Muturu and N'Dama are found in these areas. This is due to trypanosomiasis more than any other factor.

4.6 RESEARCH AND DOCUMENTATION

It did not take long for the world at large to realise the importance of trypanosomiasis and hence research and documentation was organised early enough.

Before the 19th century and for sometimes thereafter most of the documents were reports of exploratory work, reports of commissions and committees, report of series of surveys carried out by the Governments of the various colonial territories etc. The geographical distribution of the disease extend to the French, Portuguese, British West Africa, the Cameroons, British East Africa, South Africa, Rhodesia, French Equitorial Africa and the Congo.

The basis for research or scientific study was established in the 19th century when the vector, Glossina, was discovered in 1830. Trypanosoma the causative parasite was seen in 1843 and the relationship of the parasite to the disease was shown by Evans in 1880. Bruce related Trypanosomes to tsetse in 1895. Thus the road was set for research designed to give necessary intensive knowledge of tsetse-fly which will

allow for control and also substantive knowledge of the diseases and the organisms which cause them.

In June 1907, a first International Conference on Trypanosomiasis (sleeping sickness) was held in London. Another meeting was held again in 1908. These meetings gave birth to the Bureau of HYGIENE and TROPICAL DISEASE. The Inter-national Conferences were to concert measures for the control of that disease which was reported to have been spreading rapidly in tropical Africa. The bureau was to extract and circulate all new literature on sleeping sickness.

The bureau began its work in 1908 in a small apartment of the Royal Society of London under the directorship of Dr. A. G. Bagshawe, then of the Ugandan Medical services. Between 1908 and 1912, the first four years of existence the bureau issued four volumes (with 40 numbers) of SLEEPING SICKNESS BULLETIN and other popular pamphlets on the means of prevention of sleeping sickness and also issued a bibliography of the literature of trypanosomiasis.

In 1911 another bulletin-THE KALA AZAR BULLETIN was started by the bureau. The two bulletins were combined and published as the TROPICAL DISEASES BULLETIN. The first issue appeared in 1912.

It became clear that the work of the bureau could be extended to include all tropical diseases generally. In later issues malaria, relapsing fever, helminthiasis, filariasis including onchocerciasis were added etc. It contains abstracts of the most recent researchers on every tropical disease in every country.

Today this bulletin is the most authentic and comprehensive "second knowledge" base for all tropical disease, since TTIQ is relatively new.

4.6.1 Efforts in Africa

The need for basic and applied research on the diseases in Africa was recognised early enough and by the 1930s special services for research and field control came into existence throughout Africa. Work on trypanosomiasis was established in West, East, and Central Africa. Tsetse research and reclamation schemes were organised mostly under the agricultural and veterinary division of the Ministries of Agriculture.

Research was put into full-scale activity with the establishment of two basic research Institutes: The Nigerian Institute for Trypanosomiasis Research (N.I.T.R.) (formerly West African Institute for Trypanosomiasis Research (W.A.I.T.R.) was established about 1947. Its work was to elucidate on the problems in Nigeria and other British West African countries (N.I.T.R. is now mainly responsible for the problems of gambian trypanosomiasis as manifested in Nigeria).

By the end of 1948 research and tsetse reclamation schemes in East Africa were re-organised and were taken over by the East African Trypanosomiasis Research organisation (EATRO).

4.6.2 Research Logistics

Relatively recent, in the 1970s, effort to apply socio-economic research techniques into the work of trypanosomiasis and other tropical diseases was started by the World Health Organization. The objective was mainly the application of social science and economics methods to understanding the role played by social and economic factors in disease transmission and control. Projects considered in this area include research into behaviour, attitude, knowledge, perception, economic conditions, and cost-effectiveness of control measures. They also include management strategies for disease controls, evaluation of the involvement of individuals and communities in control programmes, socio-economic incentives to ensure continued use of control measures etc. This is an example of an inter-disciplinary approach and typifies how a new disciplinary research programme can be initiated.

There is a clear indication of linkage, not only between medical and social science disciplines, but also between research and operational institutions. One linkage factor is the intra-subject system of research. Here methods previously used in one field are invoked to control another. For example, knowledge of the use of Insect Growth Regulations (IGRs) in the Control of mosquitoes and malaria was drawn upon the control of tsetse and trypanosomiasis. IGRs are a group of growth of hormones which controls the reproductive system and growth in insects.

The technique has been used predominantly in the research to control other insects e.g Musca domestica, Drosophila Melanogaster Manduca sexta, mosquitoes etc. In early mid-70s the method was introduced for Glossina control. Such injection from other subject areas affects not only search access and mechanisms, but also search coverage and the overall control of the literature of particular research field by the information scientists or Librarians.

Knowledge on African trypanosomiasis has been disseminated via various methods and in particular through published works. From the time of the inception of research its literature has gradually built up into a considerable volume and, no doubt among the tropical diseases, the literature is probably second only to the literature on mosquitoes and malaria in volume and its contribution to biomedical science.

CHAPTER FIVE

5.0 RESULTS AND DISCUSSIONS

5.1 Productivity and Growth Charateristics

The results of the counts of papers are presented numerically in Table 1, and graphically in Figs. 1 and 2. Table 1(A) shows the annual growth of all the papers from 1900 - 1985 while Table 1(B) shows the quinquennial growth. In Fig. 1, the quinquennial rate of change is shown while Fig. 2 depicts the cumulative growth (by percent).

It can be seen that for many years, at least up to 1950 the state of African trypanosomiasis literature was not stable. It was characterised by fluctuating and undulating growth pattern (Fig. 1). The average number of papers per year rise and fall as shown by five year periods (Table 1).

Also the quinquennial and decennial Rate of Growth (ROG) increased and decreased respectively as shown in Table 2. However the overall rate shows an increase. The quinquennial average rate of increase was about 103% (102.82) while the decennial average rate of increase was about 73%(72.80). This shows that the growth is not linear. It indicates also a slowing down of productivity from the five year rate. By this inference, the

Table 1(A)

African trypanosomiasis research

Yearly growth of Periodical literature

Year	No. of articles	Year	No. of articles	Year	No. of articles	Year	No. of articles
1900	0	1922	2	1944	27	1966	54
1901	0	1923	3	1945	20	1967	56
1902	2	1924	9	1946	41	1968	75
1903	3	1925	5	1947	61	1969	92
1904	5	1926	4	1948	44	1970	72
1905	6	1927	6	1949	70	1971	58
1906	7	1928	3	1950	57	1972	50
1907	1	1929	5	1951	28	1973	17
1908	7	1930	14	1952	45	1974	12
1909	29	1931	12	1953	61	1975	14
1910	87	1932	9	1954	87	1976	19
1911	76	1933	9	1955	42	1977	32
1912	69	1934	21	1956	68	1978	219
1913	47	1935	15	1957	74	1979	450
1914	6	1936	14	1958	65	1980	210
1915	4	1937	81	1959	71	1981	262
1916	16	1938	62	1960	19	1982	406
1917	11	1939	14	1961	79	1983	399
1918	4	1940	33	1962	30	1984	349
1919	1	1941	21	1963	51	1985	323
1920	5	1942	17	1964	35		
1921	1	1943	13	1965	37		

Table 1(B) Quinquennial growth of articles.

PERIOD	NO. OF ARTICLES	CUMULATIVE NO. OF ARTICLES	PERCENT CUMULATION	AVERAGE ARTICLES PER YEAR
1901 - 1905	16	16	0.311	3.2
1906 - 1910	131	147	2.860	26.2
1911 - 1915	202	349	6.791	40.4
1916 - 1920	37	386	7.511	7.4
1921 - 1925	20	406	7.900	4.0
1926 - 1930	32	438	8.523	6.4
1931 - 1935	67	505	9.827	13.4
1936 - 1940	204	709	13.796	40.6
1941 - 1945	98	807	15.703	[illegible]
1946 - 1950	273	1080	[illegible]	54.6
1951 - 1955	263	1343	26.133	52.6
1956 - 1960	397	1740	33.859	79.4
1961 - 1965	232	1972	38.373	46.6
1966 - 1970	349	2321	45.164	69.8
1971 - 1975	151	2472	48.103	26.2
1976 - 1980	930	3402	66.200	186.00
1981 - 1985	1737	5139	100.000	347.40

FIG. 1. GROWTH OF AFRICAN TRYPANOSOMIASIS LITERATURE
RATE OF CHANGE PER FIVE YEARS

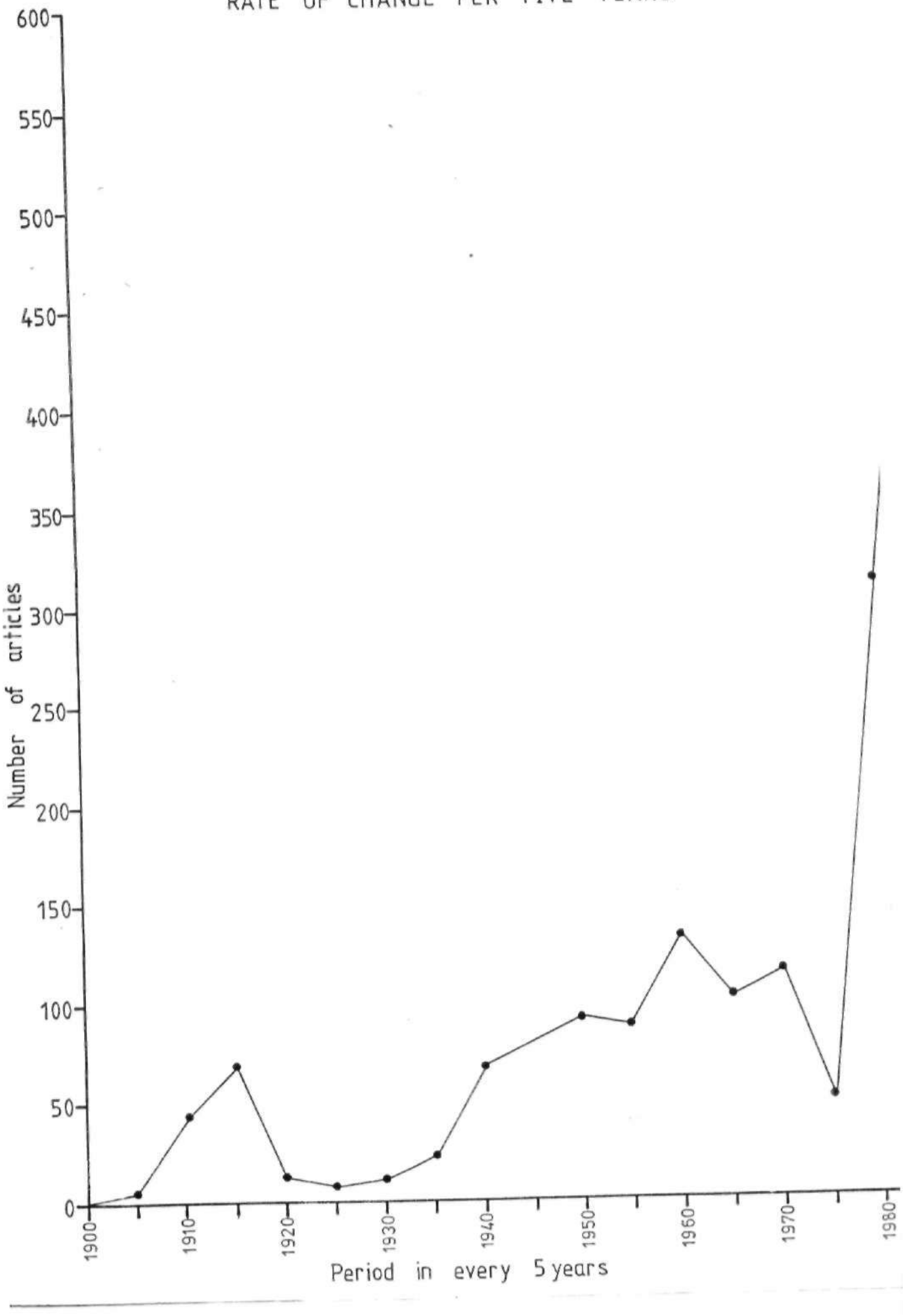


FIG. 2. AFRICAN TRYPANOSOMIASIS LITERATURE
FIVE-YEAR CUMULATIVE GROWTH

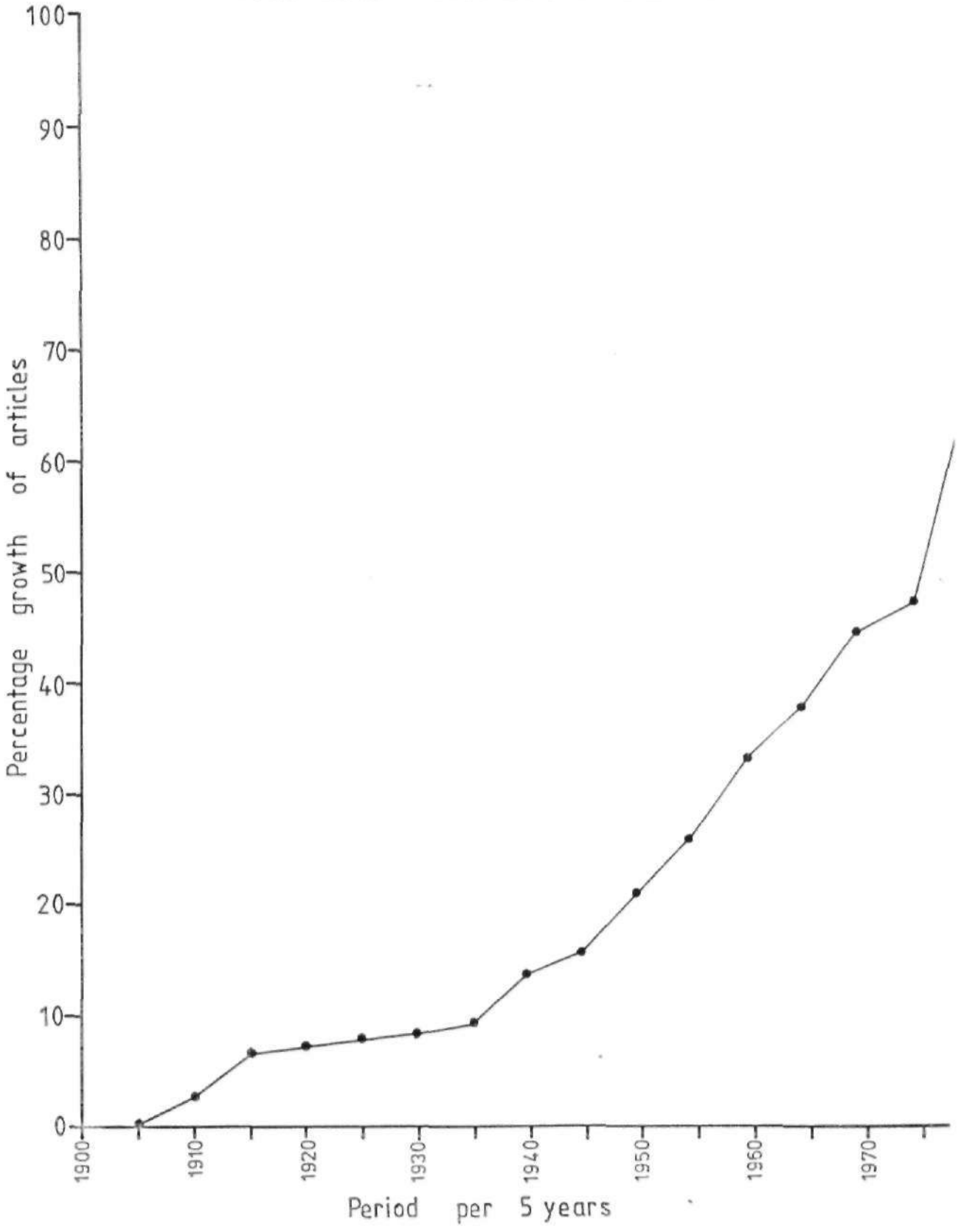


Table 2

African Trypanosomiasis literature, 1900 - 1985

Quinquennial Growth (No. of Papers)		Rate of Growth (ROG) Quinquennial ROG(%)	Decennial growth	Decennial ROG(%)	Decennial Cumulative Growth	Decennial Cumulative ROG(%)
00-05	16	-				
	131	+ 718.75 (increase)	147	-	147	-
	202	+ 54.19 (increase)				
	37	- 81.68 (decrease)	239	+62.58(increase)	386	162.58
	20	- 45.95 (decrease)				
	32	+ 60.00 (increase)	52	-78.06(decrease)	438	13.47
	67	+ 109.38 (increase)				
	204	+ 204.48 (increase)	271	+421.14(increase)	709	61.87
	98	- 51.96 (decrease)				
	273	+ 173.57 (increase)	371	+ 36.90(increase)	1080	52.23
	263	- 3.66 (decrease)				
	397	+ 50.95 (increase)	660	+ 77.90(increase)	1740	61.11
	232	- 41.56 (decrease)				
	349	+ 50.43 (increase)	581	- 11.97(decrease)	2321	33.39
	151	- 56.73 (decrease)				
	930	+ 515.89 (increase)	1081	+ 86.00(increase)	3402	46.57
81-85	1737*	+ 86.77 (increase)	1737	+ 60.68(increase)	5139*	51.06
		Quinquennial average increase rate = 102.82%		Decennial average increase rate = 72.80		Decennial average cumulative increase rate = 48.23%

cumulative growth or increase rate should be relatively slower. As Table 2 shows, the average cumulative growth rate or increase was about 48%(48.23%). Fig. 1 revealed that there was virtually no published work at the beginning of the century. The first five years (1900-1905) recorded an average of 3.2 papers per year. There was an 'epidemic' surge between 1900 - 1915 but the situation deteriorated again until 1945. The surge must have resulted from the biological discoveries which perhaps prompted more active research than was done before then.

The vector of the parasite, Glossina, was discovered in 1830 (Wieldeman). Trypanosoma, the causative parasite was identified in 1843. In 1880 Evans showed the relationship of the parasite to the disease. It was not until 1895 that Bruce, working in Zululand, was able to relate trypanosomes to Glossina i.e (tsetse fly). He showed that 'nagana', an anciently known fly-conveyed cattle disease of Africa was transmitted by Glossina. The parasite T. brucei was named after him. These discoveries must have stimulated intensive research during the period. However the decline which set in latter was probably as a result of socio-political problems which possibly started with the world wars.

Since then comparatively increasing growth has been recorded except for the period 1971 - 1975. As from 1978 the growth factor has been dramatic. The 'epidemics' during the terminal decade of the period of study shows a very high incidence of 'infective' publications. Compared to the first five years, the increase factor for 1976 - 1980 is more than 58 while the next(1981 - 1985) recorded a growth factor of more than 108. These findings seem to indicate that African trypanosomiasis research is still an active field which has not yet peaked and declined in interest inspite of the earlier fluctuations in publication output.

From the figures, it is clear that the literature is not in a saturated state, implying that the growth is not logistic (S-shaped curve). The characteristic of the logistic curve is that, once it got started, the rate of growth is very high during the early stages and then gradually decline or reach a saturation level as is common to biological growth which rises and tapers (Price 1963). Such a pattern should, perhaps, be expected from basic research programmes as the research problems gradually get solved. It seems a prerequisite for such logistic curves is an initial exponential growth with data showing the behaviour of a geometric sequence which Price has rightly pointed. This brings us to the exponential pattern in African trypanosomiasis literature.

5.1.2 Exponential Growth

This growth behaviour implies that the literature is characterised by doubling after certain period of time. One way to express this, according to Price, is to compute the doubling times.

This was done based on the average decennial increase rate found to be 72.8% (Table 2) i.e on the order of magnitude of ten years as shown in Table 3.

Table 3

Doubling rate of African trypanosomiasis literature, 1900-1985

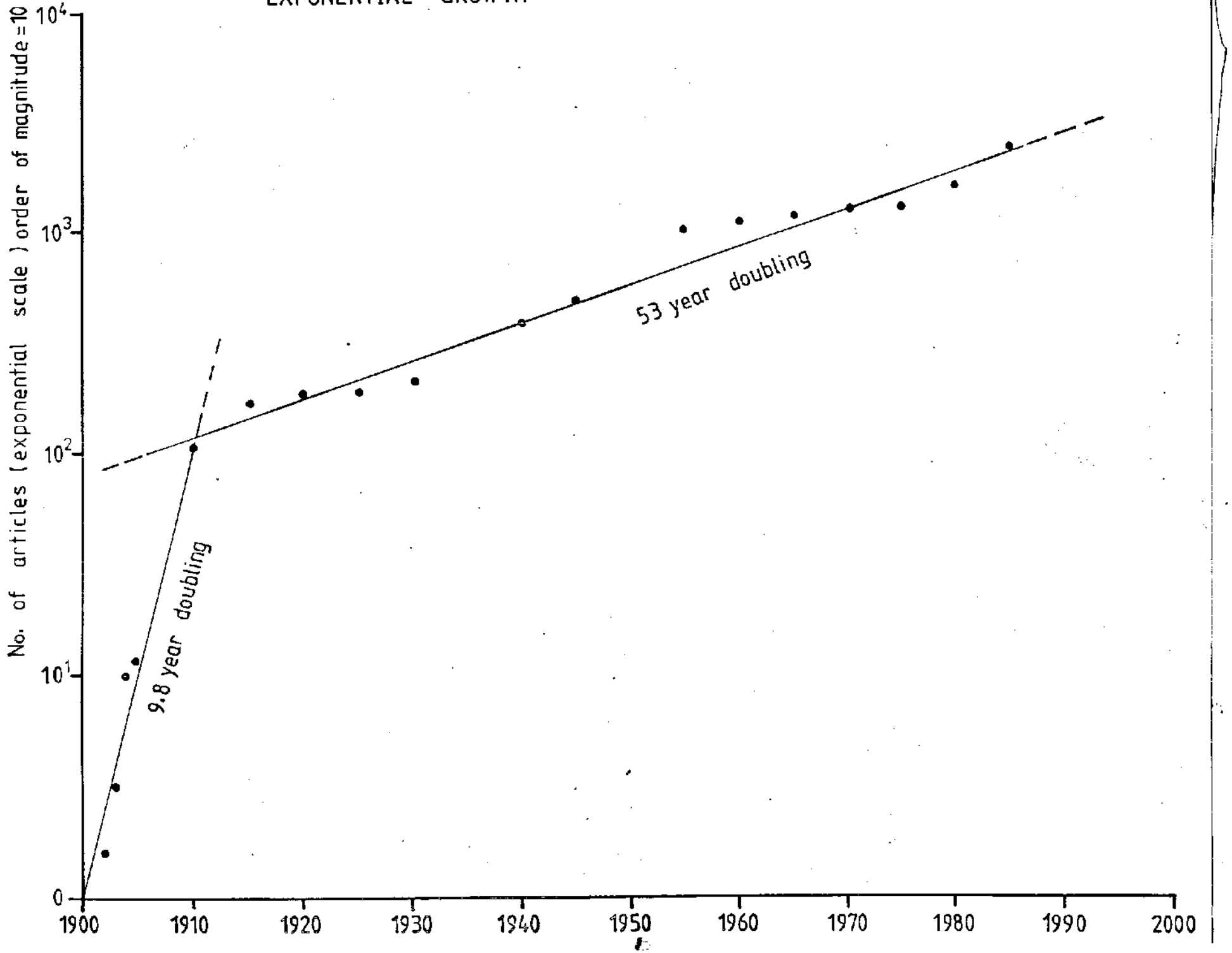
Decade	No. of articles found	Expected based on average decennial growth rate of 72,80%
Base 1900-1910	147	
1920	386	254
1930	438	439
1940	709	759
1950	1080	1305
1960	1740	2255

It can be seen that the doubling time, calculated from the productivity of the first decade should be between 50-60 years, knowing that from 10^2 (100) to 10^3 (1000) as seen in Table 3 should be about 50 years. A graphical method was

employed to determine the exponential rate. The data was first plotted on ordinary plot (Fig.3). This figure depicts the exponentially upturned curve. Fig. 5(A) shows the same data on semilog coordinates. The doubling time as shown by these curves is about 53 year doubling on a ten-fold (i.e order of magnitude increase). Though Fig.3 indicated an initial faster average of about 9.8 year doubling, it is assumed that this is not a characteristic of the literature as infact revealed from the computation in Table 3. Fig 5 seems to confirm this exponential growth rate. If figures 1 and 3 are related, a parallel can be drawn. The yearly epidemic created the setting for the first doubling time. After this, though there was a decline in the average output, the articles gradually increased in number, a setting which explained the longer or extended 53 - year doubling. It could be implied that the high incidence or another epidemic set in from the early 80s with an average 347.4 articles (Table 1A). The term 'epidemic' as used denotes high level of productivity capable, presumably, of infecting larger number of researchers in the field.

To further confirm the authenticity of this exponential growth finding the annual growth rate observed from the literature was compared to the expected or theoretical growth rate by testing for goodness of fit using the chi-squared (X^2) test. The average annual growth rate based on the last five years

FIG. 3. AFRICAN TRYPANOSOMIASIS LITERATURE
EXPONENTIAL GROWTH



was calculated as follows:

Table 4

Observed Annual growth rate 1981 - 1985

Year	No. of articles	Rate of growth (ROG(%)	
1981	262	- %	(increase)
1982	406	54.96	(increase)
1983	399	- 1.72	(decrease)
1984	349	-12.53	(decrease)
1985	323	- 7.45	(decrease)

$$\text{Annual Average increase rate} = \frac{33.26}{5}$$
$$= 6.65\%$$

The period, 1981 - 85, was chosen because it seems, as shown in Table 1, the most active period. Secondly it is relative to the present decade and would consequently represent an 'active' factor. A five year period was designed based on the suggestion by Oliver (1971) in deriving the expected annual growth rate, given by

$$g = \frac{1}{T} \log_e (P_T/P_o) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

To determine P_T and P_o, Brookes' method for estimating complete search total was used. This is given thus

$$r(n) = K \log_e n = R(n) \quad \ldots\ldots\ldots\ldots\ldots$$

The parameters needed to use this formula were derived from the Bradford-Zipf bibliograph. Since the periods chosen are 1981 and 1985 the Bradford-Zipf bibliograph for the periods 1981

(year 0) and 1985 (year T) were drawn. Fig. 4 shows that of 1985, giving the resulting plot of cumulative sum of papers versus periodicals ranked in order of productivity (Table 5).

It was estimated from the curve in Fig. 4 that there should be 80 journals contributing at least one paper during 1985 (against the 63 actually found). Similarly 82 journals should contribute at least 1 in 1981 (as against 75 actually found (Table 6)).
The total number of papers P_T and P_o were 351 and 231 respectively. P_T and P_o were calculated using Brookes' formula thus:

$$r(n) = K \log_e n = R(n) \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

When n, the total number of relevant articles runs into hundreds,

$$\text{then } \log_e \left(1-\frac{1}{n}\right) = -\frac{1}{n}$$

thus setting the condition for n = k

$$\therefore K = n = \frac{(R_n)}{\log_e r(n)}$$

n = rank position

r(n) = sum of rank position

R(n) = sum of relevant papers

Deriving from the linear part of the graph (Fig. 4)

$$r(10) = K \log_e 10 = 242$$

$$K = n = \frac{183}{2.3} = 79.56$$

= 80.00 journals

Table 5

African trypanosomiasis literature

Dispersion of articles among periodicals, 1985

No. of articles per title	No. of titles	Cumulation of titles	Total No. articles in group in colum 1	Cumulation of articles
42	1	1	42	42
30	1	2	30	72
26	1	3	26	98
24	1	4	24	122
23	1	5	23	145
21	1	6	21	166
7	5	11	35	201
6	5	16	30	231
5	2	18	10	241
4	3	21	12	253
3	5	26	15	268
2	10	36	20	288
1	27	63	27	315

FIG. 4. BIBLIOGRAPH OF AFRICAN TRYPANOSOMIASIS (1985)

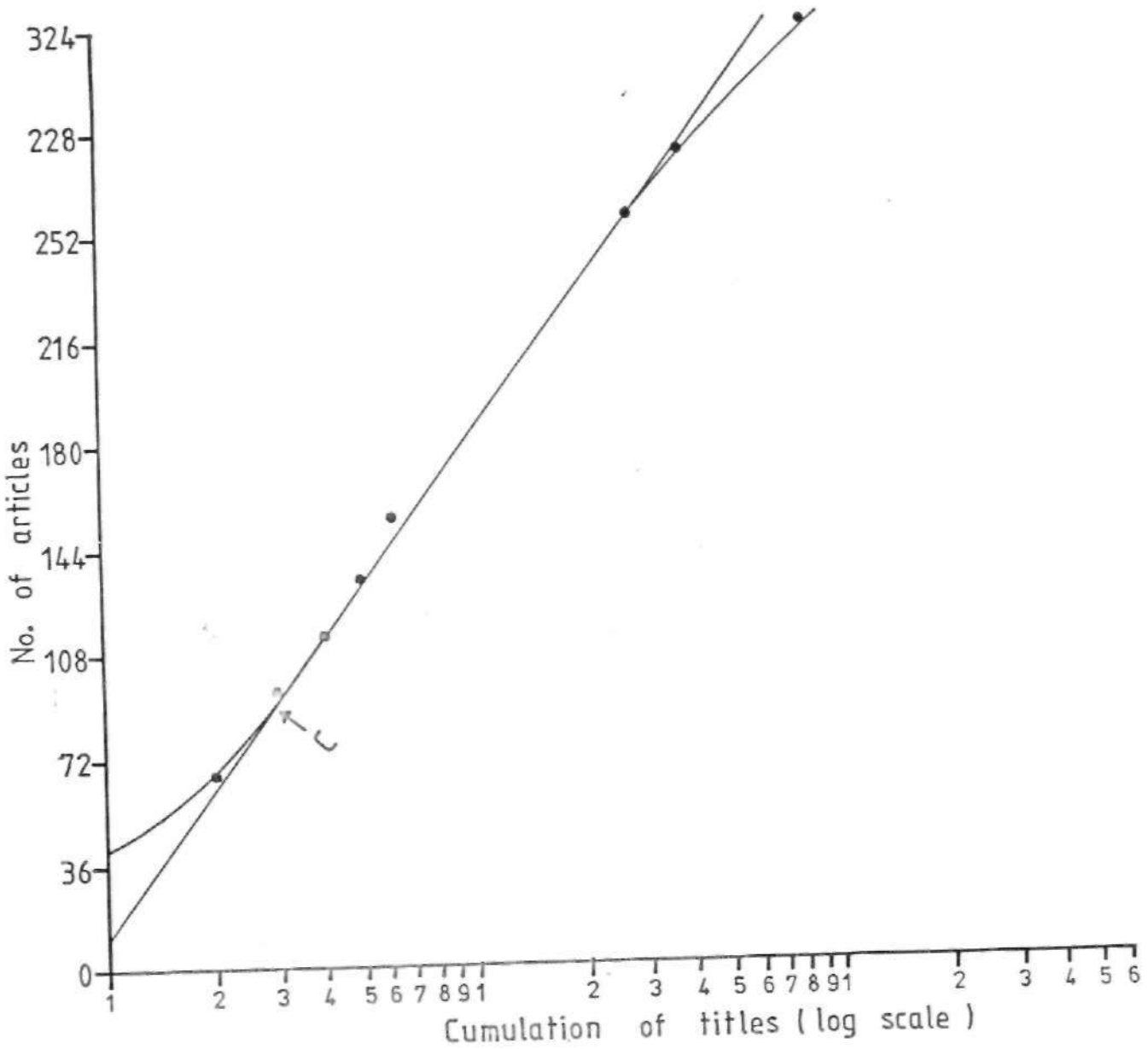


Table 6

African trypanosomiasis literature

Dispersion of articles among periodicals, 1981

No. of articles per title	No. of titles	Cumulation of titles	Total No. of articles in group in column 1	Cumulation of articles
20	1	1	20	20
19	1	2	19	39
13	2	4	26	65
12	3	7	36	101
9	1	8	9	110
8	7	15	56	166
7	4	19	28	194
6-3	0	19	0	194
2	12	31	24	218
1	44	75	44	262

The total number of papers R(n) is given by

$$R(n) = K \log_e (n) = 80$$

$$R(n) = K \log_e 80$$

$$= 80 \log_e 80$$

$$= 80 \times 4.382$$

$$= 351 \text{ papers} = P_T$$

Similarly that for 1981 i.e P_o was derived based on bibliograph plotted from Table 6. The value was 231 papers.

From equation 1, the theoretical annual average growth rate was calculated thus:

$$g = \frac{1}{5} \log_e 351/231 = 0.2 \times 0.420$$

$$= 8.37\% = 8.4\%$$

A figure for g, 6.65%, was found in the relevant section of the abstracts.

Is this difference by chance? The figures were tested for goodness of fit using X^2 test shown below. The hypothesis is that there is no significant difference between the two average growth rates.

	fo	fo
	0.0665	0.0751
	0.0837	0.0751
Total	0.1502	0.1502

$$X^2 = \frac{(\frac{1}{2}fo - fe\ \frac{1}{2})^2}{fe}$$

fo	fe	fo - fe	$\frac{1}{2}$fo - fe$\frac{1}{2}$	$\frac{1}{2}$fo - fe$\frac{1}{2}$	$\frac{(fo - fe)^2}{fe}$
0.0665	0.0751	-0.0086	0.0086	0.000074	0.00098
0.0837	0.0751	0.0086	0.0086	0.000074	0.00098
					X^2 =0.00196

df = no of factor - 1 = 2-1 = 1

X^2 for df 1 at 0.05 = 3.84

X^2cal is very much less than X^2c

∴ the hypothesis cannot be rejected. This result at least, indicates, that the nature of exponential growth is possible in African trypanosomiasis literature.

5.1.3 Research discipline and the component of the literature

An effort was made to determine the distribution of research output by discipline. It is useful to know how this output is distributed among the relevant research fields. This will

indicate in which area is research emphasis high and or modest. This should bring the librarian in closer awareness of the expanse and nature of his work tool and hence facilitate the functional approach.

As clearly discerned from the analysis of the literature there are two mainfronts of research activity, namely, a focus on the vector and another on the parasite. A vector is an organism (often an insect) that carries diseases from one host to another. It usually involves some reproduction of the pathogen (the disease carrying organism i.e the parasite , in the vector. Below is the detail of various disciplines in which research is going on in African trypanosomiasis.

	Discipline	Research activity
1.	Entomology	relating to insects; studies dealing with insects
2.	Ecology	deals with how living things react on one another and with the environment
3.	Parasitology.....	a branch of biology that deals with parasites and their habits
4.	Biochemistry	chemistry in relation to life processes i.e chemistry of living organisism
5.	Histochemistry	deals with the chemical constitute of living cells and tissues by combining the techniques of biochemistry and histology
6.	Microbiology	a branch of biology dealing with microscopic form of life (as bacteria, protozoa etc.

Discipline		Research activity
7.	Immunology	deals with the phenomena and cause of immunity. Immunity in this context is a condition of being able to or the capacity to resist a particular disease especially through preventing development of a pathogenic micro-organisim or by counteracting the effects of its production.
	Immunochemistry ..... 7 (i)	branch of chemistry that deals with substances (as antibodies, antigens) and reactions (as concerned in the phenomena of immunity-antibody production)
(ii)	Immuno-genetics	deals with the inter-relation of immunity to disease and genetic make-up.
(iii)	Immuno-therapy	treatment of or prohylaxis against disease that is based on the production of antibodies or induction of immunity and that chiefly employ antigens or antigenic preparation (as antisera, toxoids, vaccines)
8.	Physiology	deals with processes, activities and phenomena characteristic of life. The study of the function and activities of living organ (as of organs, tissues, or cells.
	Physio-pathology (patho-physiology)	of and relating to both physiology and pathology, involving pathological alteration of bodily functions.
9.	Pathology	study of abnormality especially of diseases, their essential nature, causes, and development and the structural and functional changes produced by them. Anatomic and physiologic deviation from the normal in the tissue of animals that manifest as diseases.
	Pathological anatomy	deals with stuctural changes acompanying diseases

10.	Therapy and prophylaxis (i) Chemotherapy	The treatment and prevention of especially infectious diseases in living organisms by use of chemical agents
	(ii) Immunotherapy	See above
	(iii) biotherapy	treatment of diseases with products produced by living organisms (as vaccine, antigens, antigens)
11.	Histology	Branch of anatomy that deals with the minute structure of tissue of living organisms as discermble with the microscope.
	(i) histopathology	branch of pathology concerned with the tissue change of disease tissues that affect a part or accompany a disease
	(ii) histophysiology	branch of physiology concerned with the function and activities of tissues
	(iii) histogenetics	concerned with the genetic significance and basis of somatic variation.
12.	Genetics	branch of biology that deals with the heredity or variation of organism with the mechanism by which these are effected
13.	Cytology	concerned with the study of cells as vital units with reference to their structure, function multiplication, pathology and life-history.
	(i) cytopathology	branch of pathology that deals with manifestation of disease on cellular level
	(ii) cytohistology	integrated study of cells and tissues
	(iii) cytogenetics	branch of biology that deals with the study of heredity and variation by the methods of both cytology and genetics.
	(iv) cyto-chemistry	chemistry of cells

14.	Epidemiology	deals with incidence, distribution, and control of diseases in a population study of how diseases are trransmitted and what makes the number of cases rise and fall
15.	Haematology	involving blood; deals with the blood and blood forming organs.
16.	Toxicology	deals with poisons and their effects on living organisms with substances otherwise harmless that prove toxic under particular conditions.
17.	Socio-economic	of or relating to or involving a combination of social and economic factors.

The output of each of the fields is presented in Table 7.

Figure 6 disaggregates the data in Fig. 2 and focuses on each of seven major research disciplines in which researchers produce >100 publications during the period. Of the 5139 articles analysed, about 4380 were distributed according to various fields identified. The classfication was, in most cases, broad and not highly specific as done in the breakdown above. For example studies on immunochemistry, immunogenetics etc were grouped under Immunology; those on chemotherapy, immunotherapy, biotherapy, prophylaxis etc. were classed under Therapy; Entomology in our context embraces almost all studies on the fly, tsetse (Glossina sp). Studies that are general in nature are excluded,. Below is the summary of the number of publications from each field in order of magnitude **(Table 8).**

Table 7

Distributions of Publications by fields of Research

	ENT.	BIOCH.	PARA.	THERAPY	IMMUN.	PATH.	EPID.	GENETIC	CYTO.
1900-1905	9	0	3	0	0	0	3	0	0
1906-1910	80	0	40	0	0	0	0	0	0
1911-1915	135	0	38	0	5	2	0	0	0
1916-1920	12	0	8	0	0	1	0	0	0
1921-1925	11	0	2	1	0	0	0	0	0
1926-1930	16	0	6	0	1	1	0	0	0
1931-1935	33	1	12	2	0	1	2	0	0
1936-1940	44	4	46	25	10	1	5	1	1
1941-1945	42	2	13	15	6	1	1	1	0
1946-1950	62	1	24	18	3	2	1	1	1
1951-1955	61	5	50	24	7	1	5	0	1
1956-1960	155	9	125	52	29	5	7	1	0
1961-1965	81	20	48	25	8	3	13	0	0
1966-1970	114	38	92	9	20	10	16	0	6
1971-1975	49	4	48	4	16	6	6	1	0
1976-1980	146	62	136	49	148	108	100	11	0
1981-1985	240	259	88	187	240	83	115	17	3
	1290	445	779	411	493	225	274	33	12

HAEM.	PHYS.	HIST.	VET.	CLIN. SIGNS
0	0			
0	0			
0	0			
0	0			
0	0			
0	0			
0	0			
4	0	C		
0	0	C		
1	1	1		
2	2	1		
0	0	2		
0	0	0		
1	0	0		
1	1	0		
1	107	0	42	5
2	142	0	45	26
12	253	4	87	31

Table 8

Summary of number of Publications in each field

Field	No. of articles	Percent %
Entomology	1290	29.45 (30%)
Parasitology	779	17.78 (18%)
Immunology	493	11.25 (11%)
Biochemistry	445	10.15 (10%)
Therapy	411	9.38 (9%)
Epidemiology	274	6.25 (6%)
Physiology	253	5.77 (6%)
Pathology	225	5.14 (5%)
Vet. and Livestock	87	1.98 (2%)
Genetics	33	0.75 (1%)
Ecology	32	0.73 (1%)
Clinical signs	31	0.71 (1%)
Others	28	0.07
Total	4381	100%

The lion share of growth occurred in entomology, closely followed by parasitology. In these areas research started far back at the beginning of the century. In the latter disciplines, as shown in Fig. 6, research did not start until towards the end of the sixties. However since the start in the 1961-65 decade, the trend has been one of increasing output.

In figure 6, the growth pattern of each of the disciplines is compared. They all appear to show similar trend. Infact relating Figs. 6 and 1 indicates also that the behavour of each contributiing component appears the same with that of African trypanosomiasis in general. Indeed a closer similitude was exhibited by the two most active components-entomology and parasitology. It could be deduced from this that the output from entomological and parasitological studies seem to control and determine the growth pattern of African trypanosomiasis in general.

How does this relate to the exponential nature of growth? We have seen above that the growth of African trypanosomiasis in general is monotonic (i.e an extended sameness) with the components, particularly those of entomology and parasitology.

To comfirm this hypothesis, we expect that the exponential increase pattern should follow sooth. In Fig. 5 the profiles of the exponential increase of the component parts were compared with the profile of the mainstream data of African trypanosomiasis. The heavy straight lines (which would be an exponentially upturned curve if it were on an ordinary plot instead of on the semilog coordinates), of course indicate roughly the approximate maximum available to African trypanosomiasis in any period or year.

Entomology exhibited a 70-year doubling while parasitology showed a 60-year doubling (both on ten-fold order-of-magnitude - again a monotonic pattern (see Fig 5A). This is quite interesting

FIG. 5. AFRICAN TRYPANOSOMIASIS - EXPONENTIAL INCREASE
(1900 - 1985)

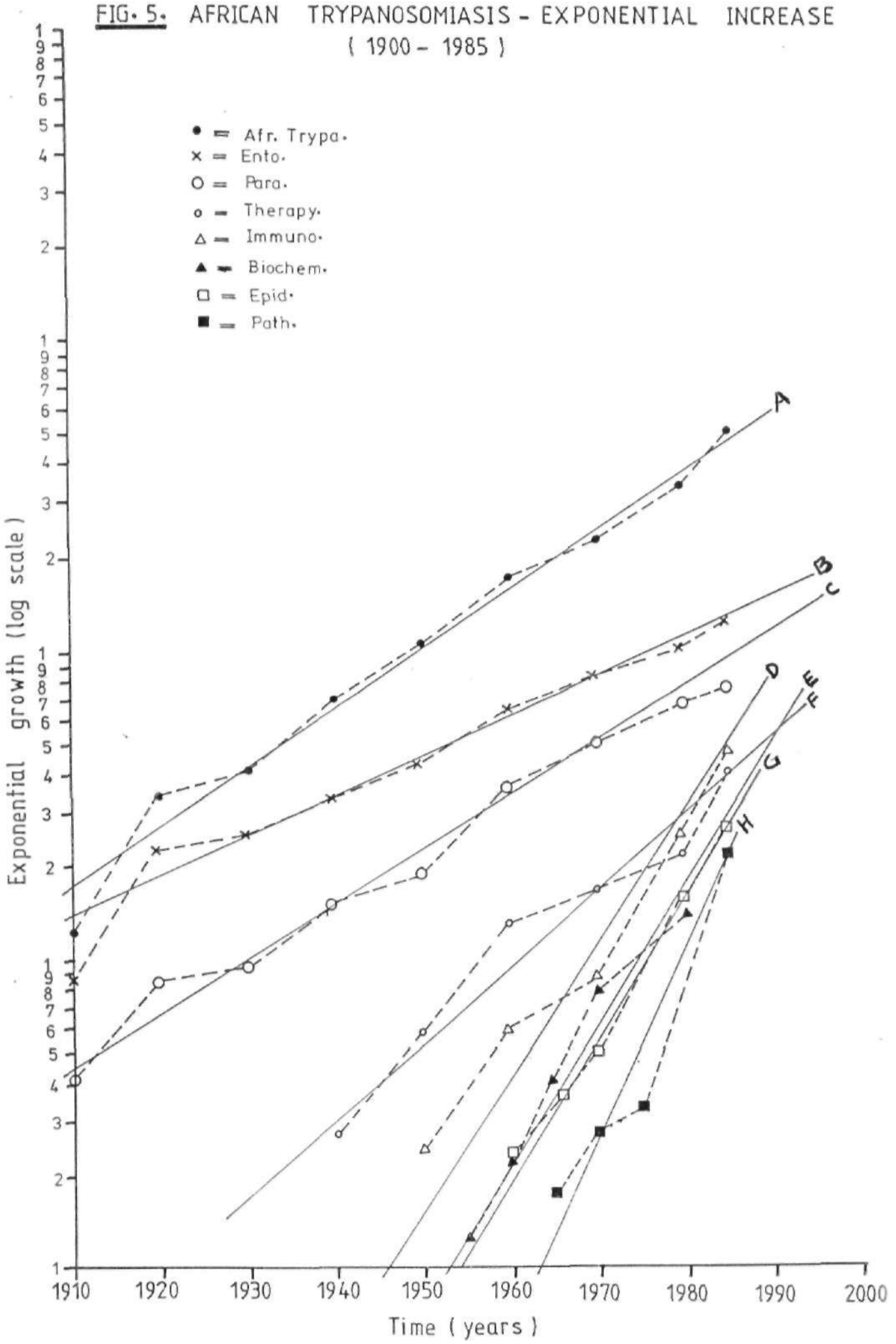
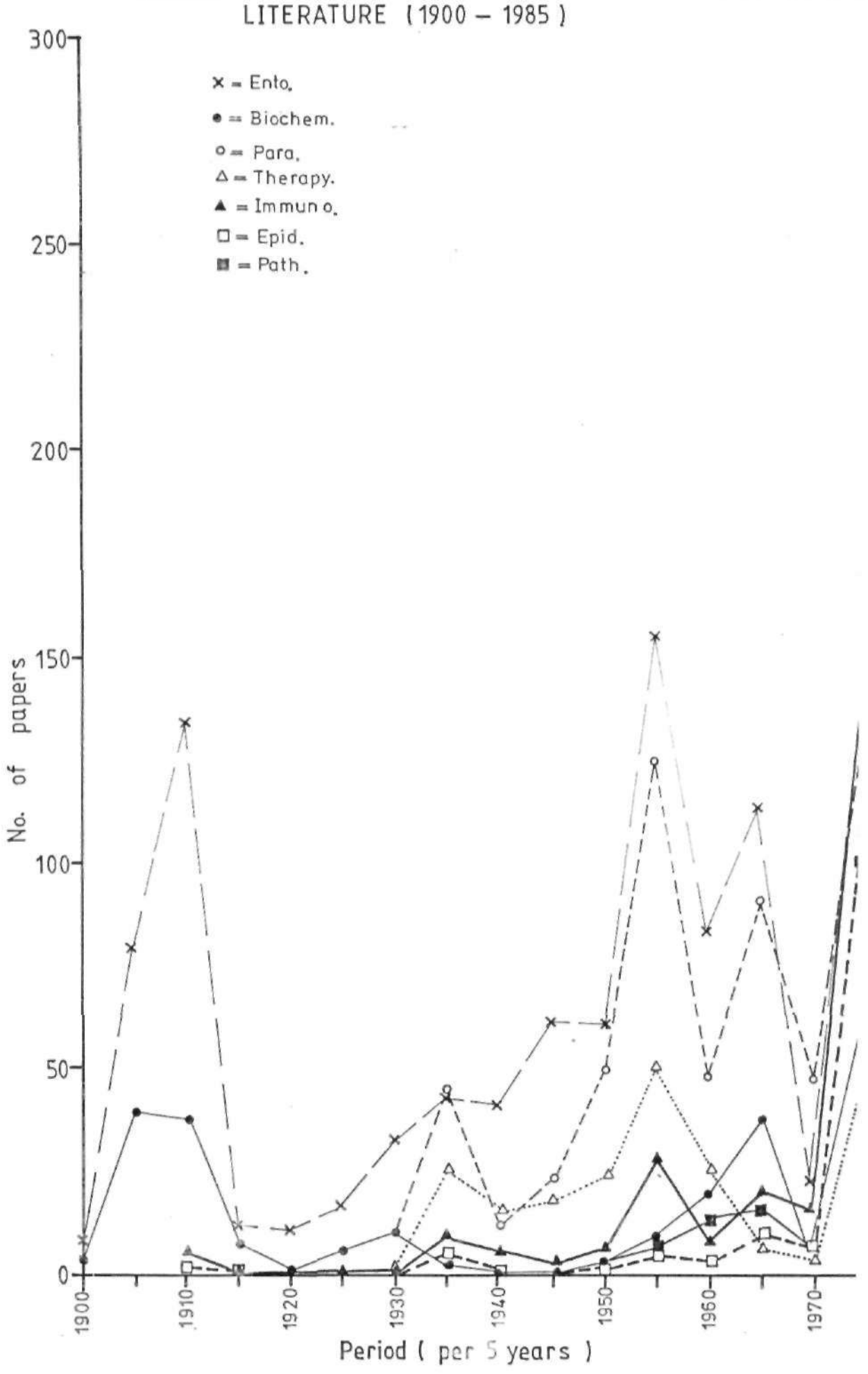


FIG. 6. AFRICAN TRYPANOSOMIASIS – MAJOR COMPONENTS LITERATURE (1900 – 1985)



in that it confirms the controlling characteristic of these components indeed. However the other components, Figs. 5 (D-H), the ten-fold order of magnitude seem to reduce to 5 fold. This implies a relatively shorter doubling period. Here it is just about 20 years.

If this interpretation is in consonance with the hypothesis, we should anticipate a spurt of exponential growth of published papers before showing signs of dramatic downturn. The growth of publications for each of the components especially towards the terminal decades of the study suggests a confirmation of the hypothesis. This also implies that there is a reservoir of active researchers fuelling the growth of publications. The integration into the mainstream of data appear to be by superimposing the monotonic components on and above each other and this gives the exponential pattern of the bulk of African trypanosomiasis literature. This implies that a compoundment of exponential growth is a possibility.

5.2 Comparison of bibliometic characteristics in some biomedical disciplines

Some numerical characteristics computed were compared to those of mast cell literature as Goffman and Warren did using schistosomiasis literature. Table 9 shows the parameters.

Table 9

Parameters of African trypanosomiasis
and mast cell literatures

	African trypanosomiasis (1900 - 1985)		Mast cell* (1877-69)	
	Number	Notation	Number	Notation
Articles	5139	At_1	2378	A_c
Authors	3022	at_1	2195	a_c
Journals	673	Jt_1	587	J_c
Most articles in one journal	454	jt_1	66	j_c
Journals with one article	380	Zt_1	328	Z_c
Articles per author	1.7	$gt_1=\frac{At_1}{at_1}$	1.1	$gc=\frac{Ac}{a_c}$

* Taken from Goffman, W. and K.S. Warren.

The purpose of this comparison is to test whether the proposition that some parameters may be constant for all (bio)medical literatures is true or not. Such applications are needed to enable any generalized hypothesis to be made.

On the basis of the data shown in Table 9 it follows that for African trypanosomiasis literature, (1900 - 1985)

$$ac/at1 = 0.73;\ J_c/J_{t1} = Z_c/Z_{t1} = 0.82$$

Based on the same table the ratio of journals to authors W for each literature is

(1) $J_{t1}/a_{t1} = 6.73/3022 = 0.22$

(2) $J_c/a_c = 587/2195 = 0.27$

Goffman and Warren found that there were three times as many schistosomiasis authors as mast cell authors; three times as many journals containing schistosomiasis articles as mast cell articles; and three times as many journals containing one schistosomiasis paper as those containing one mast cell article. This study shows a different relationship. There are more African trypanosomiasis authors than mast cell authors; as many journals containing African trypanosomiasis articles as mast cell and as many journals containing one African trypanosomiasis paper as those containing one mast cell article.

The ratio of journals to authors, W, for African trypanosomiasis literature is 0.22 while that for mast cell and schistosomiasis literature is 0.27.

5.3 Author's Productivity

The Application of Lotka's law

Details of the productivity pattern of the authors are presented in Table 10.

What did Lotka say about this? He said 60% of the total, here 2135, should contribute 1 unit. The number making n contributions should be $\frac{1}{n^2}$ of those making one

So 60% of 2135 (1281) should produce 1 unit; $\frac{60}{2^2}$ = 15% of 2135 (320) should produce 2 units, $\frac{60}{3^2}$ = 6.67% of 2135, (142) should produce 3 units, $\frac{60}{4^2}$ = 3.75% of 2135 (80) should produce 4 units etc.

In this way the total number producing 1, 2, 3, 4 etc publications as expected and observed is presented in Table 11 based on Table 10. Comparing the two sets of figures, it seems the number of authors that produced one document unit is more than the 60% proposed by Lotka. This was tested using the X^2 to ascertain if there is any significant difference between the observed and expected (Table 12). The value of the X^2 calculated equals 120.605. But X^2_c at df 27 at 0.05 = 40.11. As seen X^2_{cal} is greater than X^2_c. The hypothesis that there is no significant difference between the observed and expected frequencies is consequently rejected. This implies that the productivity distribution does not fit Lotka's inverse square law in its original form.

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Table 10

Productivity of authors: Frequency distribution pattern.

No. of Contribution	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	TOTAL
1	60	100	93	80	29	70	74	92	12	22	85	66	121	30	39	51	1	62	78	41	1	32	47	0	7	7	1304
2	11	32	22	18	10	20	10	17	2	6	9	21	38	12	8	11	0	9	20	15	3	8	7	0	1	0	318
3	8	9	9	9	2	20	9	8	0	1	5	7	10	3	8	3	0	14	11	8	0	2	6	0	1	2	155
4	7	6	5	3	0	21	5	6	0	0	6	4	7	2	3	6	0	5	4	4	0	0	4	0	3	2	103
5	3	9	5	7	3	5	2	0	2	3	4	3	5	2	0	3	1	3	7	2	0	2	2	0	0	1	74
6	0	3	1	2	1	6	1	3	0	1	2	1	3	1	0	3	0	1	2	1	0	1	2	0	0	0	36
7	1	1	3	1	3	7	1	0	0	0	1	1	5	1	0	2	0	1	0	2	0	3	3	0	0	0	36
8	0	4	1	0		0	1	0	1	0	1	2	1	1	0	1	0	0	1	2	0	0	1	0	0	0	17
9	1	0	3	1		3	2	0	0	1	1	4	0	3	0	2	0	2	2	0	0	0	0	0	0	0	22
10	0	2	0	0		0	0	1	0	0		1	2	0	1	1	0	1	1	1	0	0	1	0	0	0	12
11	1	0	1	0		0	1	1	0	0		2	1	0	1	1	0	0	0	0	0	0	0	0	1	0	10
12	0	1	0	0		0	1	0	0	1		2	1	0	1	0	0	0	1	0	0	1	0	0	0	0	9
13	0	0	0	1		0	1	0	0	1		0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	6
14	0	1	0	0		0	0	0	0	0		0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	3
15	1	1	1	0		0	1	0	0	0		0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	6
16	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17	1	0	1		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
18	0	0	0		0		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	1	1	1		0		0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0				5
20					0		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1				3
21		1			2		0	0	0	0	0	0	0	0								0					2
22		1			0		1						1	0								0					3

Table 10 Contd.

No. of Contribution	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	TOTAL
23					1		0						1	0								1					2
24							0																				0
25							0																				1
26 - 30			0	0	0	0	0	0	0	0	0	0															0
31		1	0	0	0	0		0			0	0															1
32								0			0	0															0
33								0	0	0	0	1															1
34								1																			1
35 - 44	0	0	0	0	0	0								0													0
45														1													1
																											2135

TABLE 11

PRODUCTIVITY OF AUTHORS: AFRICAN TRYPANOSOMIASIS DATA IN RELATION TO LOTKA'S ORIGINAL MODEL

Number of article units produced	Expected according to Lotka (theoretical model)		Observed number of authors	
		%		%
1	(1281)	60.00	(1304)	61.08
2	(320)	15.00	(318)	14.89
3	(142)	6.67	(155)	7.29
4	(80)	3.75	(108)	4.82
5	(51)	2.40	(74)	3.47
6	(36)	1.67	(36)	1.69
7	(26)	1.22	(36)	1.69
8	(20)	0.94	(17)	0.80
9	(16)	0.74	(22)	1.03
10	(13)	0.60	(12)	0.56
11	(11)	0.50	(10)	0.47
12	(9)	0.42	(9)	0.42
13	(8)	0.36	(6)	0.28
14	(7)	0.31	(3)	0.14
15	(6)	0.27	(6)	0.28
16	(5)	0.23	(1)	0.05
17	(5)	0.21	(3)	0.14
18	(4)	0.19	(1)	0.05
19	(4)	0.17	(5)	0.23
20	(3)	0.15	(3)	0.14
21	(3)	00.14	(3)	0.14
22	(3)	0.13	(3)	0.14
23	(2)	0.11	(2)	0.09
24	(2)	0.10	-	-
25	(2)	0.096	(1)	0.05
•				
•				
31	(1)	0.06	(1)	0.05
•				
•				
33	(1)		(1)	
•				
•				
34	(1)		(1)	
•				
•				
45	(1)		(1)	

However the basic assumption of the law is that only a few authors contribute the most and most of them contribute few papers. The productivity distribution as observed in African trypanosomiasis literature seem to follow the generalised form based on this assumption, (Fig. 7). The data was tested for conformity with the generalised form of the law.

Deriving from Gupta's generalised equation, the value of the exponent, Q for African trypanosomiasis data was found to be 2.03*; the value of S (summation of fractions of authors contributing 1, 2, 3.....n papers) was found to be 1.001 and K, the proportion of single paper authors, P^1) to be 0.6120. (Table 13). The expected values were computed using the value of the exponent and then compared with the observed values. The difference in the estimated and observed values was calculated (Table 13).

The maximum difference between the estimated and observed values as shown in Table 13 is 0.0069. This is very low when compared with K-S statistic value of 0.035 at 0.01 level of significance. This shows that the distribution follows Lotka's law with the exponent valu of @ = 2.03. This was further confirmed by using the X^2 test. The X^2_{cal} = 12 was found less than the X^2_c for df 27 at 0.05 which is 40.11

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* Calculating the exponent: $\frac{60}{2^2}$ will produce 2 papers when exponent is exactly 2. Since the figures did not apply exactly to the inverse square

See foot note next page.

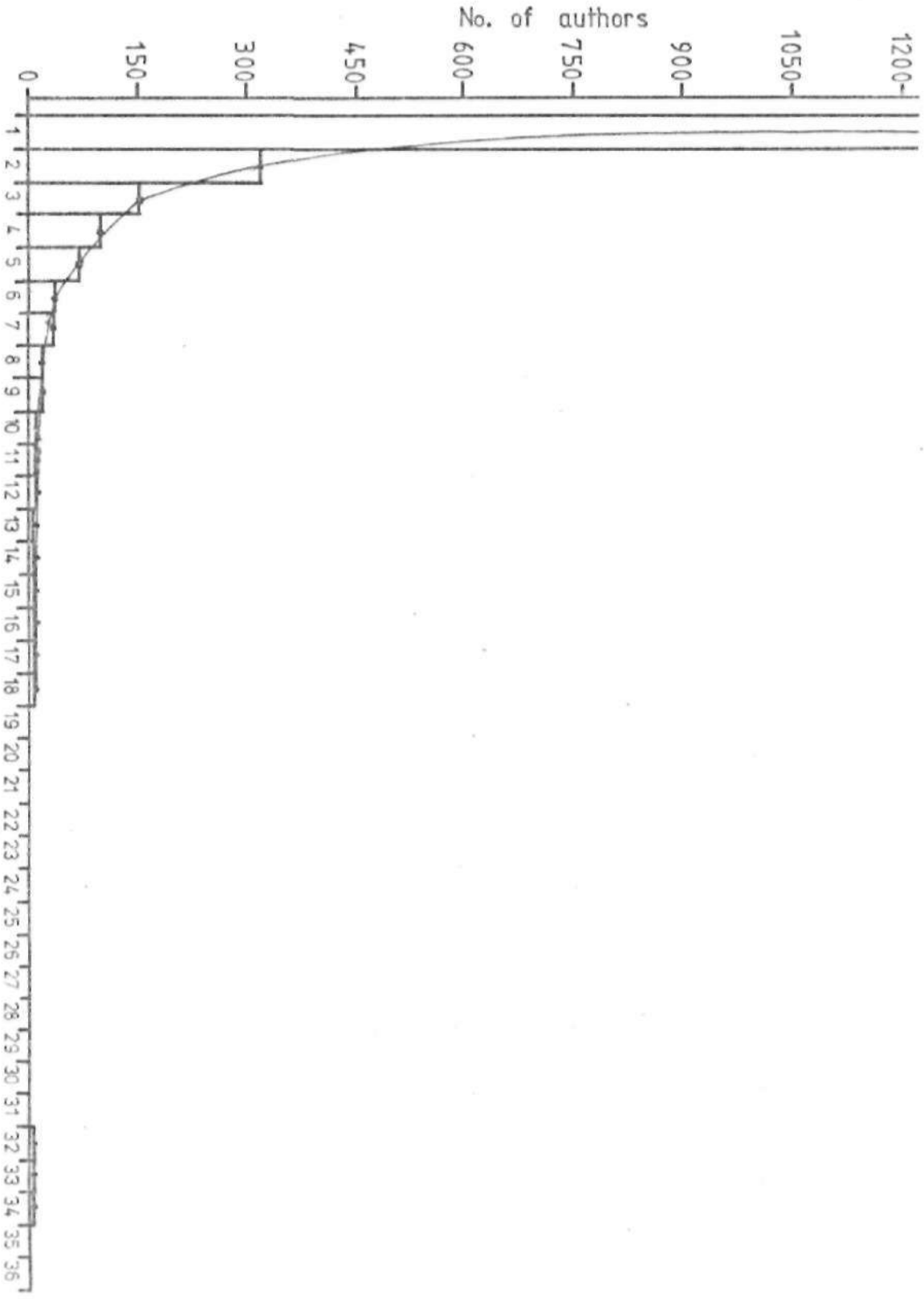

No. of authors
0
150
300
450
600
750
900
1050
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
No. of papers per author

TABLE 12

Chi-squared Test of Significance

No. of Contribution	Frequency of authors observed f_o	Frequency of authors expected f_e	f_o^2	$\frac{f_o^2}{f_e}$
1	1304	1281	1,700,416	1327.413
2	318	320	101,124	316,013
3	155	142	42,025	169,190
4	103	80	10,609	132.613
5	74	51	5,476	107.373
6	36	36	1,296	36.000
7	36	26	1,296	49.846
8	17	20	289	14,450
9	22	16	484	30.250

law, exponent will not be 2. Assume it is X,

then $\frac{60}{2^X}$ = 318 (No. of authors found to produce 2 papers Table 10)

$\therefore \frac{1304}{2^X} = 318 \quad 2^X = \frac{1304}{318} = 4.1006$

$X = \sqrt{4.1006} = 2.025 = \underline{\underline{2.03}}$

Similarly $\frac{60}{3^X}$ = 155 (No. of authors that produced 3 papers)

$3^X = \frac{1304}{155} = 8.4129$

$X = \sqrt[3]{8.4129} = 2.03$

Table 12 CONTD.

10	12	13	144	11.077
11	10	11	100	9.091
12	9	9	81	9.000
13	6	8	36	4.500
14	3	7	9	1.286
15	6	6	36	6.000
16	1	5	1	0.200
17	3	5	9	1.800
18	1	4	1	0.250
19	5	4	25	6.250
20	3	3	9	3.000
21	3	3	9	3.000
22	3	3	3	3.000
23	2	2	4	2.000
25	1	2	1	0.500
31	1	1	1	1.000
33	1	1	1	1.000
34	1	1	1	1.000
45	1	1	1	1.000
	f_o=n=2135			$\frac{fo^2}{fe}$=2255.605

The formula used to calculate X^2 is

$$X^2_{cal} = \frac{fo^2}{fe} - n$$

From Table 12, $\frac{fo^2}{fe} = 2255.605$ and n = 2135

$\therefore X^2_{cal}$ = 2255.605 - 2135

= 120.605

degrees of freedom df = 27

For df 27 and P - 0.05, X^2_c = 40.11

Since X^2_{cal} > X^2_c

The hypothesis, H_o is rejected.

That means there is a significant difference between the observed and expected.

TABLE 13

African trypanosomiasis literature, (1900 - 1985)

Proportion of authors, = 2.03

No. of Contribution	Observed	Sn(X)	Expected	$F_o(X)$	$\lvert F_o(X) - Sn(X) \rvert = D$
1	0.6108	0.6108	0.6120	0.6120	0.0012
2	0.1489	0.7597	0.1511	0.7631	0.0034
3	0.0726	0.8323	0.0737	0.8368	0.0045
4	0.0482	0.8805	0.0489	0.8857	0.0052
5	0.0347	0.9152	0.0352	0.9209	0.0057
6	0.0169	0.9321	0.0172	0.9381	0.0060
7	0.0169	0.9490	0.0172	0.9553	0.0063
8	0.0080	0.9570	0.0081	0.9634	0.0064
9	0.0103	0.9673	0.0105	0.9739	0.0066
10	0.0056	0.9729	0.0057	0.9796	0.0067
11	0.0047	0.9776	0.0048	0.9844	0.0068
12	0.0042	0.9818	0.0043	0.9887	0.0069
13	0.0028	0.9846	0.0028	0.9915	0.0069
14	0.0014	0.9860	0.0014	0.9929	0.0069
15	0.0028	0.9888	0.0028	0.9957	0.0069
16	0.0005	0.9893	0.0005	0.9962	0.0069
17	0.0014	0.9907	0.0014	0.9976	0.0069
18	0.0005	0.9912	0.0005	0.9981	0.0069
19	0.0023	0.9935	0.0023	1.0004	
20	0.0014	0.9949	0.0014	1.0018	
21	0.0014	0.9963	0.0014	1.0032	
22	0.0014	0.9977	0.0014	1.0046	

TABLE 13 CONTD.

No. of Contribution	Observed	Sn(x)	Expected	$F_o(X)$	$\lvert F_o(X) - Sn(X) \rvert = D$
23	0.0009	0.9986	0.0009	1.0055	
25	0.0005	0.9991	0.0005	1.0060	
31	0.0005	0.9996	0.0005	1.0065	
33	0.0005	1.0001	0.0005	1.0070	
34	0.0005	1.0006	0.0005	1.0075	

n - 2135

D - Max $\lvert F(X) - Sn(X) \rvert$ = 0.0069

At 0.01 level of significance, k - S statistic = $1.63/\sqrt{2135}$ = 0.035

D < 0.035, therefore these data fit modified or generalised Lotka's law with the value of x = 2.03

5.4 Pattern of Authorship

5.4.1 Co-authorship and research collaboration

Data on single-author and multiple-author papers is shown in Table 14. The period was divided into two, 1900-77 and 1978-85 principally because the later period will give a situational report relative to the present decade besides giving a comparative overview of the past independent of the influence of the present.

Between 1900-77 about 47% (1188) of the total (2521) papers for that period were of single - authorship while in the latter period 30% (791) of the total (2618) were single-authored. In all the proportion of papers with multiple authors (61.49/) is higher than that of single authors (38.51%). The difference is statistically significant (see Table 14B).

The multiple authors were further analysed to shed more light on the pattern. For 1900-77, the double and triple authorship dominate the collaborative effort both being 87.20% of the total (2521). The collaboration did not extend beyond six author. paper. But for the 1978-85 decade, though the predominant collaborative effort was also the two (40.00%) and three (26.11%) categories of authors repectively, making up about 66.00% for that period, researchers who collaborate extended beyond six and up to eleven per paper. However these later groups are relatively few as shown in Table 15.

TABLE 14

Research collaboration

Papers with single and multiple authors

Year	Single authors		Multiple authors		
	No. of Paper	Percent	Category	No. of Paper	Percent
			2	822	32.606
1900 - 1977	1188	47.123	3	340	13.487
			4	126	4.998
			5	37	1.468
			6	8	0.317
Sub-total	1188	47.123		1333	52.876
1978 - 1985	791	30.214	2	732	27.960
			3	477	18.220
			4	315	12.032
			5	178	6.799
			6	76	2.903
			7	34	1.299
			8	9	0.344
			9	3	0.115
			10	2	0.076
			11	1	0.038
Sub-total	791	30.214		1827	69.786
Grand total	1979	38.509		3160	61.491

X^2=154.85 df=1 = 0.05

TABLE 14(B)

Chi-squared test of Significance

	1900 - 77	1978 - 85	Total
Multiple	1333 (1550)	1827 (1610)	3160
Single	1188 (971)	791 (1008)	1979
	2521	2618	5139 =n

$$X^2 = \sum \frac{fo^2}{fe} - n$$

fo	fe	fo^2	$\frac{fo^2}{fe}$
1333	1550	1776889	1146.38
1188	971	1411344	1453.50
1827	1610	3377929	2073.25
791	1008	625681	620.726

$$\sum \frac{fo^2}{fe} = 5293.85$$

$X^2_{cal} = 5293.85 - 5139$

$X^2_{cal} = 154.85$

$X^2_c = 3.84$ for 1 df at @ = 0.05

$X_{cal} > X^2_c$

H_o is ∴ rejected

Therefore there is a significant difference between multiple author papers and single author papers.

There appears to be higher degree of collaboration (as indicated by the proportion of multiple author papers) in 1978-85 than in 1900-77. This is also indicated by the weighted average for 1978-85 which is higher (about 2.55) than that for 1900-77 (about 1.85). The overall degree of collaboration as indicated by the weighted average for 1900-1985 is about 2.19. It can be seen that the weighted average for this period (1978-85) seem to reflect the overall situation in the field of African trypanosomiasis more thar the previous period. Moreover Table 14 reveals a trend that more researchers are coming together to execute research programmes since the number of coauthors are relatively increasing in number. While multiple authorship is increasing, single authorship seems to be decreasing indicating an inverse relationship. While 1188 (47.12%) were single author: in 1900-1977, 791 were single author in 1978-85. This trend is not new. Infact a number of workers had found this as the case (Price, Derek J de Solla, Beaver and Rosen, (1979) among others. Beaver and Rosen concluded that coauthorship results in above-average productivity. Price even predicted that because the proportion of multiple-author papers accelerated steadily, there is a likelihood that single-author papers would disappear as time went on. This hypothesis is certainly not supported by the data of African trypanosomiasis. Eight years after his predicted date of 1980, single author papers are still relatively high. The reasons for this may not be far-fetched.

Reward for authorship is still highly prized. An author who publishes a paper is duely credited for producing it. Scientists working in research organizations are promoted or should be promoted according to their productivity. Credits for papers solely produced are not shared unlike what probably happens in joint authorship rewards. For example, in the Nigerian Institute for Trypanosomiasis Research an author who produces a journal article scores some marks for every such paper in promotion interviews. However for joint authored papers, the mark is divided among the various authors in ratio 1:2 or 1:3 etc according to the number of coauthors. Because of this nature of reward system, scientist may as much as possible want to publish alone. There could be other reasons. But this is a major reason why single authorship may not completely disappear.

5.4.2 Average number of authors per paper

Based on Table 15 which shows the trend of collaborative research and authorship, 1978-1985, the average number of authors per paper for that period was determined. The method used is the harmonic mean defined as the reciprocal (the reciprocal of a number X is equal to $\frac{1}{X}$) of the arithmetic mean of the reciprocals of the value, X, which is to be averaged.

TABLE 15

Trend of Collaborative Research and Authorship

Year	Authorship										
	Single	Multiple									
		2	3	4	5	6	7	8	9	10	11	Total
1978	96	44	34	23	17	3	0	2	0	0	0	123
1979	151	133	82	48	23	10	3	0	0	0	0	299
1980	81	34	40	22	17	11	5	0	0	0	0	129
1981	80	79	42	33	17	7	3	1	0	0	0	182
1982	117	137	68	52	17	10	3	0	2	0	0	289
1983	100	116	72	58	28	13	9	0	0	2	1	299
1984	91	101	76	35	23	13	7	2	1	0	0	258
1985	75	88	63	44	36	9	4	4	0	0	0	248
Total	791	732	477	315	178	76	34	9	3	2	1	1827

The formula for this mean is given by

$$\text{Harmonic mean} = \frac{n}{\sum\left(\frac{1}{x}\right)}$$

where n = the number of categories of authorship

X = each of the categories of authorship

For 1978 authorship, the average number of authors per paper was found thus:

n = 7

X = 1, 2, 3, 4, 5, 6, 8

$$\therefore \text{Average} = \frac{7}{\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{6} + \frac{1}{8}\right)}$$

$$= \frac{7}{1.0 + 0.5 + 0.33 + 0.25 + 0.2 + 0.17 + 0.125}$$

$$= \frac{7}{2.575} = 2.718$$
$$= 2.72$$

This way, the average number of authors per paper was calculated for each year as shown below.

TABLE 16

Average number of authors per paper

Year	Average No. of Authors per paper	Deviation from mean (DM)	DM^2
1978	2.72	- 0.20	0.0400
1979	2.70	- 0.22	0.0484
1980	2.70	- 0.22	0.0484
1981	2.93	+ 0.01	0.0001
1982	2.96	+ 0.04	0.0016
1983	3.23	+ 0.31	0.0961
1984	3.18	+ 0.26	0.0676
1985	2.94	+ 0.02	0.0004
Mean	2.92	DM=0	DM^2=0.3026

The standard deviation, S, given by the square root of the variance, S^2 was calculated as follows:

$$S^2 = \frac{\sum_{i=1}^{n=8}(DM^2)}{n-1} = \frac{0.3026}{7} = 0.0432285$$

$$\therefore S = 0.2079146$$
$$= 0.208$$

It can be seen that the average number of authors per paper is between 2 and 3 for most of the period. However 1983 and 1984 seem to have tilted above this average. This is because of the relatively few publication produced by the 9, 10 and 11 categories of authors. For meaningful analysis purpose, the total number of publications by any group of authors is set at, at least 5 publications. Based on this, it can safely be assumed that the average number of authors per paper is between 2 and 3 and the figure has not varied significantly in the last 8 years. Infact this can be said with greater degree of confidence if this number of publication is set at 10. This is so because it will afford us the opportunity to include all categories that produced at least 1 publication at any given year during the 8 year period, except perhaps in 1978.

The average for the period 1978-85 this time will be about 2.70. The assertion of no significant change of average number of authorship can be said probably with higher significant precision. The data for the 1900-1977 period also show that the average number of authors per paper is between 2 and 3. The average is about 2.45. Even if it is based on the 10 or >10 publications, the average is about 2.19.

In conclusion it may be said as follows. Based on the productivity of at least 10 publications, the average number of authors per paper of between 2 and 3 has not changed significantly during the period. However it is to be noted that since collaborative effort

has extended to 8, 9, 10 and 11 categories during this decade, the average number of authors per paper is extending or tilting beyond 2 and 3 as shown for 1983 and 1984 (Table 16) This indeed supports the hypothesis that collaborative effort is increasing and may not be constant as Beverly Clarke suggested. Perhaps we may go further and assume that the sample in Table 16 is a part of a larger sample of n observations. In this case the mean, 2.92 and the standard deviation, S = 0.2079 may be regarded as estimates of μ and σ, the mean and standard deviation of the parent population. Is this mean consequently a true mean of the population? How reliable is this sample mean?

By the confidence coefficient of 0.95, it is assumed that if the sampling is repeated large number of times the sample mean is expected to fall within the limits in 95 times out of 100. The general formula for establishing confidence limit for 95% is

$$\bar{X} \pm 1.96\, \sigma_{\bar{X}}$$

where $\sigma_{\bar{X}}$ is the standard error of mean

$$\sigma_{\bar{X}} = \sqrt{\frac{S^2}{n}} = S/\sqrt{n}$$

$S = 0.2079$

$n = 8$

$$\therefore \quad \sigma_{\bar{X}} = \frac{0.2079}{2.828427}$$

$$= 0.0735037$$

$$= 0.074$$

The confidence limit is

$$1.96\sigma\bar{X} = 1.96 \times 0.0735037$$

$$= 0.1440672$$

$$= 0.144$$

If 1 standard deviation is allowed both ways, then the interval is 2.92 ± 0.144 which is from 2.78 to 3.064 (at 68%)

With the 95% chosen, two standard errors on either side of the mean gave a limit or interval of 2.632 and 3.208. This seems a more cautions estimate. Looking at the sample (Table 16), it seems this which is tolerable and it can be said with probable confidence that this mean will occur with a frequency of 95%. The probability of the true mean being outside the range is 0.05.

5.5 The Application of Bradford's law

The essence of applying this law is that libraries might predicate their acquisition policies, search strategies etc. on information derived from the analysis of the Bradfordian law of distribution.

5.5.1 Bradfordic law

Bradford's observation on the scattering of articles on applied geophysics and lubrication led to the following fact:

> That periodicals devoted to a given subject contain individually more articles on that subject than periodicals dealing with other subjects. Periodicals can consequently be arranged in zones of productivity in regard to articles on a given subject such that the journals in order of decreasing productivity may be divided into a nucleus of periodicals more particularly devoted to the subject, and several zones containing the same number of articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be $1:a:a^2.....$

The basis of Bradford zoning was the number of articles in the first (nuclear) zone. This zone contains a small number of highly productive journals, say n_1; the second zone contains a larger number of averagely productive journals, say n_2, and the third still a larger number of journals of low productivity, say n_3.

Vickery pointed out some obscurities in the law as stated above and showed that Bradford's law should apply not only to three zones but with suitably modified values of the ratio a, to four, five or any other number of zones.

Subsequent work based on this knowledge claim confirmed two aspects of the law-the verbal which expresses the theory and the graphical which depicts the observation. African trypanosomiasis literature was considered in light of the above.

The data was first considered based on the verbal formulation. It is possible, with adequate adjustments of the journals arranged in decreasing order of productivity to divide the collection (Appendix 1) into appropriate zones arbitrarily in term of Bradford. But as mentioned earlier the issue of minimal nucleus was raised by Goffman and Morris who stated that, in general, the number of item effecting the first Bradfordian subdivision must exceed half of frequency 1 in the distribution. Their contention is that there should be a minimal nucleus in the sense of Bradford which represents a core of journals separable from the top of an ordered list of periodicals dealing with a given subject.

The maximum divisions of African trypanosomiasis journals were determined based on the deductions of Goffman and Morris (Table 17).

The smallest number of articles A/M which can possibly effect a maximum division in a collection of journal was obtained from the knowledge of its journal distribution and its production constant,

g, as follows:

$$A/M = J_M = g \times Z \text{ .....}$$

where g = number of articles per author

Z = total number of journals having one article each.

For African trypanosomiasis data, therefore, with Z = 380

$$A/M = J_M = 1.7 \times 190 = 323 \text{ articles.}$$

The minimal nucleus should therefore contain

$$J_M/j = 323/454 = 0.711 = 1 \text{ journal}$$

j = number of papers in the most productive journal.

Based on the contention of Goffman and Morris, the smallest number of journals that could possibly be in a nucleus is one and this journal should, by virtue of the value of J_M above, contain not more than 323 articles. If this is applied for zoning the list in Appendix 1 for African trypanosomiasis, the maximum number of divisions that could be derived from the data is shown in Table 17.

TABLE 17

MAXIMUM DIVISIONS OF JOURNALS CONTAINING AFRICAN TRYPANOSOMIASIS ARTICLES

ZONE	ARTICLES	JOURNALS	bm
1	454	1	1.0
2	381	1	1.0
3	329	1	1.0
4	326	2	2.0
5	390	3	1.50
6	396	4	1.30

Table 17 contd.

ZONE	ARTICLES	JOURNALS	bm
7	344	5	1.25
8	355	7	1.40
9	329	10	1.40
10	330	18	1.80
11	331	27	1.50
12	327	48	1.80
13	324	90	1.90
14	323	246	2.70
15*	167	167	
		Average	1.54

* Incomplete zone

5.5.2 Pragmatic effect

As far as acquisition of materials is concerned how and where does one draw the line in the choice of journals? None of these zones seems pragmatically acceptable,taken on individual merits without some form of inadequacy in the acquisition especially with respect to the most productive journals. One then turns to the graphical formulation.

5.5.3 Nucleus of Periodicals from Bradford-Zipf Bibliograph

The starting point for identifying the nuclear zone of periodicals and estimating the 'complete' search total graphically is to plot a graph of cumulative number of relevant items against cumulative

number of journals (rank position). The results of the analysis of the data according to journals are presented in Table 18, based on the list arranged in rank order of journals in Appendix 1.

Figure 8 depicts the plot of the logarithms of the cumulative totals of periodical titles arranged in order of decreasing productivity against the corresponding cumulative totals of articles produced. When also the cumulative fraction of references is plotted against the logarithm of the cumulative fraction of titles, a similar graph was obtained (Fig. 9). The slope of this latter graph is said to be a measure of the extent of scattering in the subject field.

Accepting that the empirical data as per Table 18 is conceived incomplete, the values for the core journals (C), R(n), a, R(N) and N are derived from Fig. 8 and it shows C = 11, a = 470, R(n) = 5160, R(N) = 5200.00 and N = 700

Accepting Brookes interpretation for C, then the number of core journals is 11 and constitute the first 11 journals in Appendix 1. According to Brookes, C+5 i.e 16 journals are the key journals representative of the field of African trypanosomiasis.

5.5.4 Scatter and scattering coefficient

The 5139 articles analysed are distributed among 673 periodicals. Fig. 10 illustrates the scatter. It shows that only about 12 journal titles contributed 50% of the articles, while about 72 titles published 75% of the total articles.

TABLE 18

AFRICAN TRYPANOSOMIASIS LITERATURE

DISTRIBUTION OF ARTICLES AMONG PERIODICAL TITLES

No. of articles per Title	No. of Titles	Cumulation of Titles (T)	Total No. of Articles by Shown in Column 1	Cumulation of Articles (A)	Cumulative Fraction of Titles $\frac{T}{TT}$	Cumulative Fraction of Articles $\frac{A}{AA}$
200 and above	3	3	1164	1164	0.004	0.227
199 - 100	7	10	954	2118	0.015	0.413
99 - 80	1	11	80	2198	0.016	0.429
79 - 60	7	18	484	2682	0.021	0.523
59 - 40	6	24	291	2973	0.036	0.572
39 - 30	6	30	222	3195	0.045	0.623
29 - 20	10	40	239	3434	0.059	0.669
10 - 10	37	77	511	3945	0.114	0.769
9 - 5	65	142	410	4355	0.211	0.849
4 - 3	70	212	233	4588	0.315	0.894
2	81	293	162	4750	0.455	0.926
1	380	673 (TT)	380	5130 (AA)	1.000	1.000

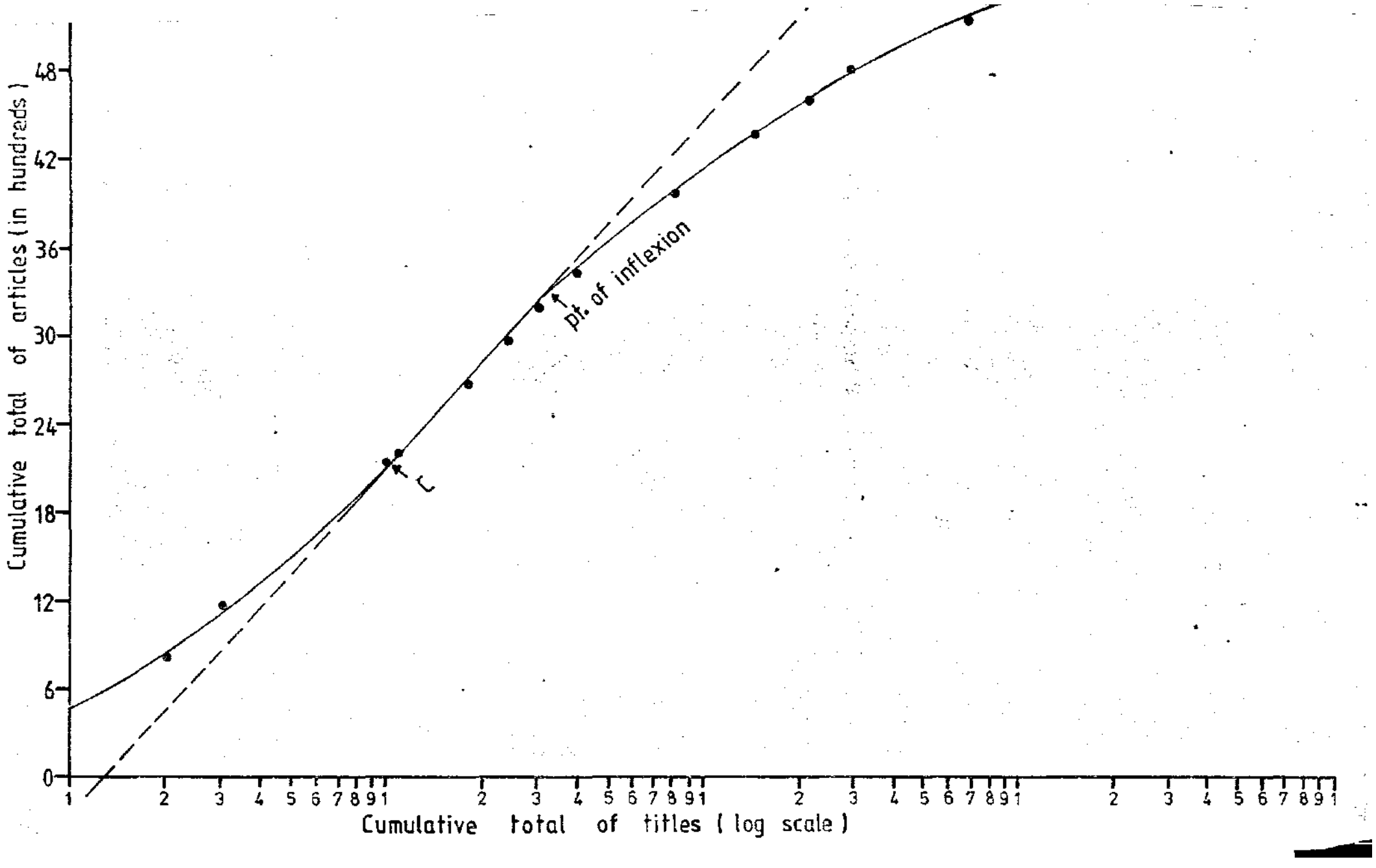

Cumulative total of articles (in hundreds)
0
6
12
18
24
30
36
42
48
pt. of inflexion
C
1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1
Cumulative total of titles (log scale)

FIG. 9. CUMULATIVE FRACTIONS OF TITLES

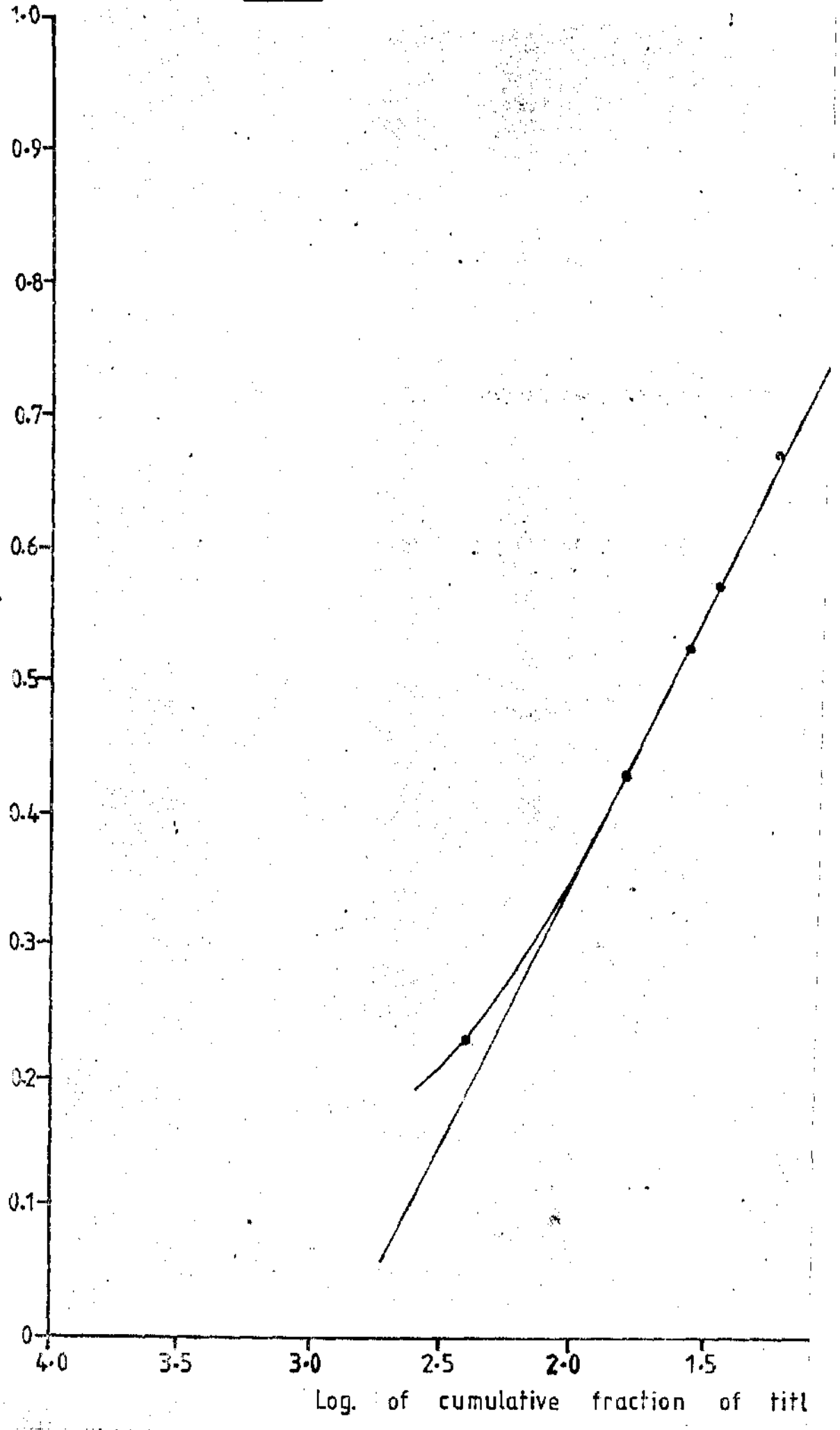
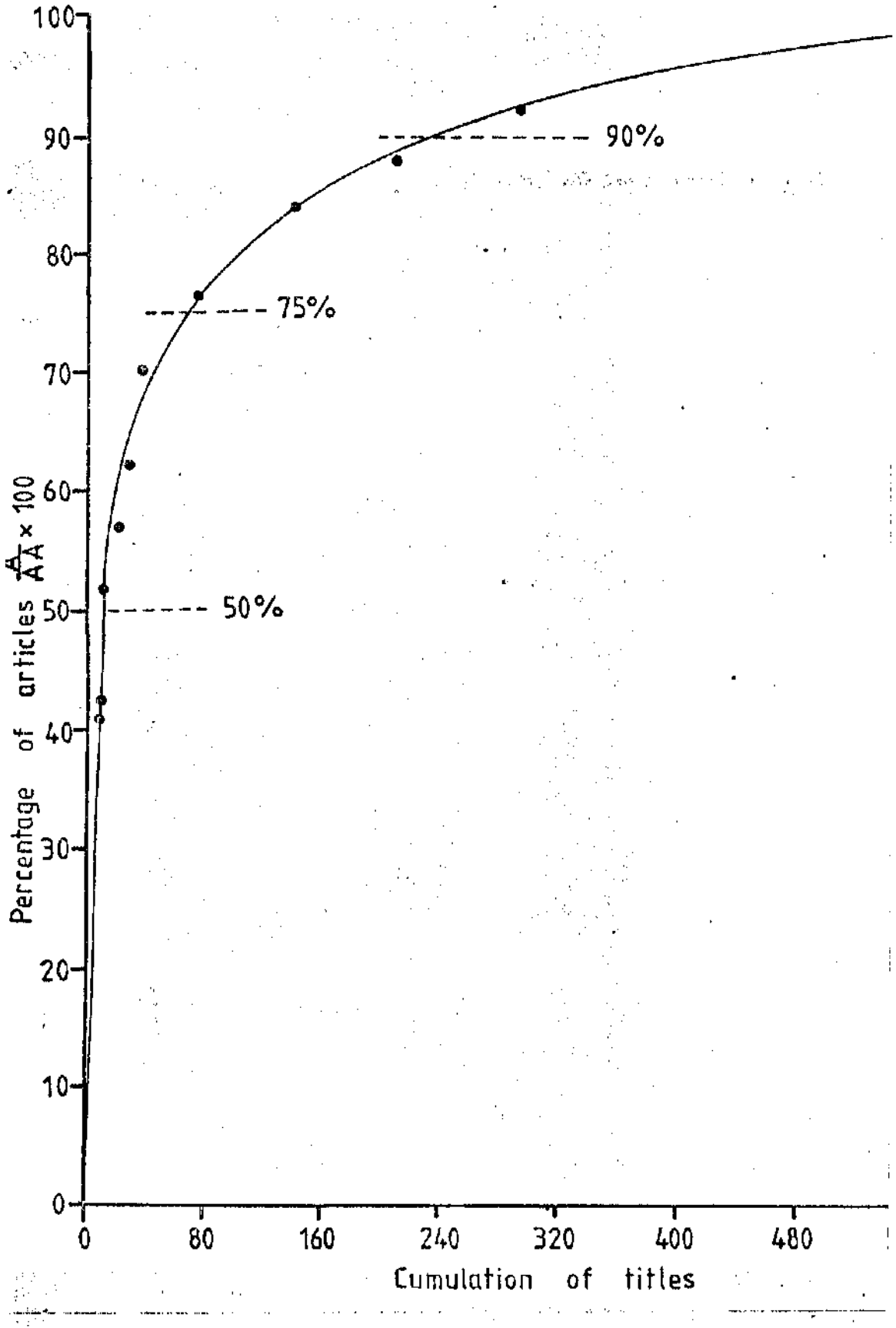


FIG. 10. BIBLIOGRAPHIC SCATTER



About 240 titles produced almost 90% of the total articles. The total articles contributed by the 16 representative journals is 2555 (49.72% of total). The 11 core journals contained 2198 articles (42.77% of total). These distributions seem enhancing in terms of acquisition policies especially at this present state of hard financial constraints. Further aspects of the implications are discussed further on.

The reference scattering co-efficient' for African trypanosomiasis literature as analysed in this study is 0.56. This is derived from the numerical value of the slope of Fig. 9.

Comparing the above distribution to that of tropical and subtropical agriculture, (Lawani, 1972), it is observed that while 12 titles of the latter had over 100 articles each and contributed 1721 articles (about one-fifth of the total), 10 titles of the former had over 100 articles each and contributed 2118 articles (representing about two fifth of the total). African trypanosomiasis articles, though more in number, were published in comparatively lesser number of journals.

Lawani (1972) found the scattering co-efficient for the literature of tropical and sub-tropical agriculture to be 0.61. The implication from those findings is that the greater the co-efficient, the more scattered is the literature. The co-efficient for petroleum literature was 0.43 (from the same source). This may imply that both the literatures of African trypanosomiasis and tropical/sub-tropical agriculture are more scattered than that

. . .

of petroleum.

5.5.5 Estimating 'complete' search total

Using Brookes formula (equation 2 P.), the complete search total was calculated. Deriving from the linear part of the graph for African trypanosomiasis literature, 1900-85, (Fig. 8)

$$r(18) = K \log_e 18 = 2680$$

$$K = n = \frac{2680}{\log_e 18} = \frac{2680}{2.89} = 927 \text{ journals}$$

The corresponding value R(n) is given by

$$R(n) = K \log_e n$$

$$R(927) = 927 \log_e 927 = 927 \times 6.83$$

$$= 6331 \text{ articles (expected)}$$

This figure appears relatively high compared to 5139 analysed. The difference between the observed (5139) and expected (6331) articles) seems significant and amounts to about 1192 articles.

How can this be explained based on the fact that the law of scatter applies exactly to the data of African trypanosomiasis as shown in this study. Fig. 8 exhibits a substantial Groos droop with the point of inflexion at about 35. This implies a need for a substantial or high number of articles to restore the droop to linearity and which should add up to the last few zones. In this situation also the Bradford constant, b_m, must be such as to allow properly discerned 'core' journals in line with Bradford's original approach.

Dividing the expected value of 6331 articles into 3 zones gave 2110 articles (expected) for each zone. The first two zones would then contain 4220 articles. Removing 4220 from 5139 which is the actual number of articles found would leave about 919 articles (found) for the third zone. When the 919 is added to the difference (1192) between the expected and actual number of articles found (i.e 6331 - 5139), it would give 2111.

When this hypothetical picture was translated into the actual figures as found in Appendix 1, the following was obtained.

Zone	No. of articles	No. of journals	bm
1	2118	10	
2	2118	107	10.7
3	905*	•556	10.7
	2118		
	1113+	1145+	

* found

\+ expected

This explanation seems plausible when related to the core of 11 journals from Fig. 8. It can be seen that with a bm of about 10.7, 3 ideal divisions will give a functional nuclear zone from the verbal point of view. This tends to agree with the graphical formulation.

Though only 905 articles were actually found for the least zone according to this division, it is expected that not less than 1113 articles are needed to bring the number of journals to the expected

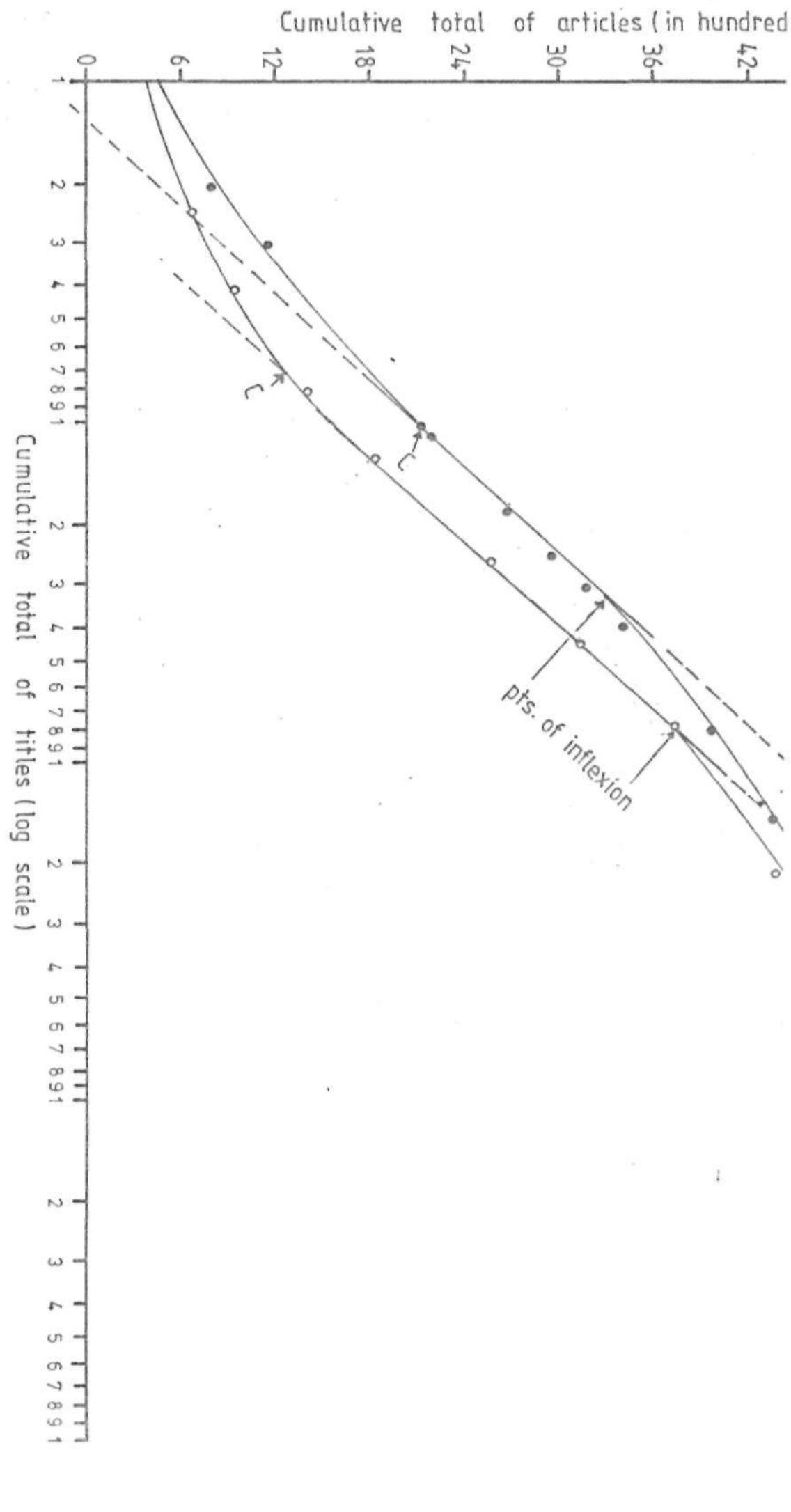
range of about 1100. The complete search totals seem to agree with this deduction having shown that 1192 articles will restore the droop to linearity.

5.5.6 Far back in time (FABIT) effect

The extent of bias resulting from FABIT analysis was considered. It is hypothesised that in ranking journals based on 'size' or 'productivity', analysing issues of journals far back in time would reduce the ranks of newer journals compared to older ones, thus creating a bias in favour of the latter (Lawani, (1972)). The focus of this study was on the core and representative journals in the field of African trypanosomiasis. Would there be prominent changes in the ranks as to invalidate the pragmatic value of the productivity ranking?

The FABIT list i.e rank of periodical titles 1900 - 1985 shown in Appendix 1 was compared to a rank list of the last two decades i.e. 1965 - 1985 (Appendix 1(A)). Bradford-Zipf bibliograph was drawn for each period as shown in Fig. 11. The two lists were examined for relatedness and changes that may affect acquisition.

Two measures of relatedness were employed in the comparison viz; the fraction number of titles in common in the first twenty, C and (2) Spearman's coefficient, R. The nearer each of these two is to 1, the greater is the link between the lists. If either is very low there is little link. Where the correlation is positive, the product of these two numbers gives a measure of the inter-relationship.


Cumulative total of articles (in hundred
0
6
12
18
24
30
36
42
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
7
8
9
1
Cumulative total of titles (log scale)
pts. of inflexion

The test measures were applied to the FABIT list (Appendix 1) and the 1965 - 1985 list. The first twenty titles in both were tested for relatedness to see what changes occured with FABIT analysis. Table 19 below shows the rank of periodicals in the 1965 - 85 list and the corresponding ranks in the FABIT list.

TABLE 19

Rank of First twenty titles in 1965-85 and FABIT List

	Title of Periodicals	Rank 1965-85	Rank FABIT (1900-1985)
1.	Trans. Roy. Soc. Trop. Med. & Hyg.	1	2
2.	Insect Science and its Application	2	5
3.	Bull. ento. Research	3	1
4.	Med. and Bioch. Parasitology	4	6.5
5.	Troponmed. Parasitology	5	6.5
6.	Ann. Trop. Med. and Parasit.	6	3
7.	Acta Tropica	7	6.5
8.	Expt. Parasitology	8	7
9.	J. of Protozoology	9.5	9
10.	Nature	9.5	8
11.	Ento, Med. Parasitology	10	10
12.	Infection and Immunity	11	11
13.	Nucleic acid Research	12	13
14.	Federation Proceeding	13	16
15.	Rev. Elev. Med. Vet. Pay. Trop.	14	17.5
16.	ISCTR	15	15

TABLE 19 CONTD.

17.	Ann. de la Soc. Belge de und Trop.	16	12.5
18.	Bull. WHO	17	17.5
19.	Bull. Ani. Hlth. and Prod. Afri.	18	21
20.	New Scientist	18	22.5

From this Table the overlap is 18 titles (in common) i.e. C = 0.90. The coefficient of correlation was found to be R = 0.93. Therefore RC = 0.84. These figures show high link between the two lists, RC of 0.84 is relatively very high and gives the measure of the inter-relationship. The degree of overlap is also high.

In general 78 journals have 10 or more articles in the FABIT list while 53 have 10 or more in the 1965-85 list. All the core journals in the 1965-85 list form part of the core in the FABIT list. Inspite of the appearance of such newer journals like Insect Science and its Application, Molecular and Biochemical Parasitology etc. the changes in rank appear only slight. Bull. ent. Res. which rank 1 in the FABIT list shifted to rank 3 in the 1965-85 list. However there were some significant changes. Bull. Soc. Path. Exotique, which ranked 4 in the FABIT list shifted to position 20 in the 1965-85 list and was not in the core journals of the latter list. This shows the journal is not being used as before.

It will be interesting to compare the FABIT list with a rank list based on the 1978-1988 decade, the lattest ten year period which depicts the current or prevailing state. The period, from Table 1,

seems the most active period of growth in the number of articles. Also some new journals such as Insect Science and its Application started during this period. Such a comparison will or should give a better picture of the effect the appearance of newer journals would have on older ones among others.

Some speculations concerning this effect in terms of journal ranking behaviour may not be out of place. One case is that in which new journals attract high number of articles relative to older ones especialyy when these newer journals are high quality ones. Insect Science and Its Application is one such journal. Part of the articles, which hitherto could have been exclusive to older ones, are now published in these newer ones. For example in a 1978-88 list, it is supposed or expected that Insect Science and Its Application may rank relatively higher than older ones like Bull. ento. Research. It is speculated that the 'John effect' may result i.e the increase and decrease phenomenon of newer and older ones respectively.

Another behaviour which may result from the multi-disciplinary nature of the biomedical disciplines is that multidisciplinary journals such as J. of Protozoology, Trans. Roy. Soc. Trop. Med. & Hyg.; Med. and Bioch. Parasitology etc. will tend to rank higher than such more specific ones like J. of Parasitology, J. of Insect Physiology etc.

A third possible ranking behaviour could be a trend of lower ranking for more general journals such as Nature, New Scientists,

Science etc.

. Some implications for biomedical libraries and Services.

The Bradford technique has been successfully applied to the data on African trypanosomiasis. The study have far-reaching implications for biomedical libraries particularly those supporting the work of tropical diseases research and services.

5.6.1 Bibliographic coverage and cost effective service

Research workers on all the tropical diseases including malaria, schistosomiasis, onchocerciasis, trypanosomiasis and other haemoparasitic diseases use almost the same collection of journals to disseminate information. What is characteristic of all these biomedical disciplines is that research involves a combination of a number of various disciplinese.g biochemistry, parasitology, microbiology, entomology etc. Expectantly one would think that each Scientist would prefer publishing in their respective subject journals. But it seems this is not the case (with few exceptions). The study shows that they publish more in a core of multi-disciplinary journals. The rank list can consequently be used as a guide for bibliographic coverage of periodical titles in the field of tropical diseases in general.

The study shows that 16 journals are representative of the field. It can also be implied from the discussion above that these journals are also representative of the field of all tropical diseases based on Bradford and Brookes graphical formulation.

These journals were shown to contribute a total of 2555 articles. Infact the first 12 titles published 50% of the total articles while 72 titles published 75%. This analysis shows that while 12 titles produced 50%, as many as 60 titles contributed only 25% while 168 titles barely 15%

Deriving from this one could say that only 72 of the total 673 titles seem ideal for cost-effective service in African trypanosomiasis and indeed the tropical diseases research. These 72 titles would provide 75% coverage in terms of actual physical acquisition of journals. To increase the coverage to 90% will require 168 titles, meaning an additional coverage of only 15%. Will this be justifiable for any biomedical library in terms of cost? Certainly not, even in terms of space.

Will the journals purportedly needed by the research scientists fall within these 72 titles? Moreover to what extent will their 'core' need fall within the Bradford productivity core as determined from the study? From sampled opinion of some scientists regarded as gatekeepers, some journals purported as 'core need' from their point of view were not among the 72 titles shown to contain 75% of the articles published in African trypanosomiasis. This was particularly prominent in biochemistry research in which 4 'core' journals were very low in rank, namely - J. of Biological Chemistry (r=36.5) Biochemical and Biophysical Res. Communication (r=44.5); Bioch. et Biophysica Acta (r=40.5) and European J. Biochemistry.

In Immunological studies, part of their core need' was also found low in rank and infact not in the representative list at all except Ann. de Soc. Belge Med. Trop. (r=12.5). Others are J. of Immunology (r=33.5), Am. J. Trop. Med. & Hyg. (r=38.5); European J. Immunology (r=4.5); Immunology (r=40.5); Vet. Immunology & Immunopathology (r=46.5) and Vet. Research Comm. (r=47.5)

When the subject representatives were confronted as to why they chose these journals as very important inspite of the very low quantitative coverage, they said the journals are very reliable in making them know current research techniques or methods being used in their respective subjects. These findings have reseachin implications for acquisition policies and effective biomedical information services. Basic parameters must be established in forecasting journal needs of scientists with respect to efficient and relevant acquisition of information sources. Absolute reliance on Bradford ranking would not yield absolute effective coverage especially when specific information need of scientists are taken into consideration.

We also saw shown above that using FABIT list for Bradford study affects affects the efficiency of bibliographic coverage for special libraries. This further gives support to the fact that several factors interplay in making final decision.

Chapter six

6.0 Summary, conclusions, and recommendations

6.1 The study was conducted for the following reasons.

1. To determine the growth of the articles and examine the pattern of such a growth as a typical biomedical discipline.

2. To identify core or representative journals in the field of African trypanosomiasis based on the productivity of the journals through the application of Bradford's law. Further to ascertain whether this numerical approach to identify core journals agreed with the opinion of users (Representative researchers were asked to identify their key journals which were then compared with the rank list).

3. To critically examine the effect Far-Back-In-Time (FABIT) analysis would have on the position of core or representative journals and what changes in rank would result.

4. And finally to look into the pattern of co-authorship and research collaboration. Lotka's law was applied to see whether or not the productivity fits the law.

The data analysed are the abstracts contained in Tropical Diseases Bulletin (TDB) 1900-1977 and Tsetse and Trypanosomiasis Information Quarterly (TTIQ) 1979-1986. Five thousand one hundred and thirty nine (5139) articles covering 1900-1985 were analysed.

Counting method was employed throughout the study. To reveal the growth and the exponential increase pattern, graphical methods were further invoked. And to discover if the data corroborates Bradford's law, Bradford-Zipf bibliographs were applied.

6.2 Summary of findings and concluding comments

6.2.1 Growth characteristics

African trypanosomiasis literature was characterised by fluctuating and undulating growth pattern. The average papers per year rose and fell for most part of its growth. However there were two epidemic peaks, the first in the second decade and another started by the sixth decade. At present a very high level infective growth has set in which has not yet declined. (Fig. 1). These findings show that African trypanosomiasis research is still an active field and research interest is very high. Also the literature is not saturated. This means that the levelling off suggested by Sandison (1975) is not found to occur in the literature of African trypanosomiasis at least as of now.

If the above is correct, then a geometric increase sequence i.e exponential growth behaviour is expected with a natural doubling pace. This indeed was the case for African trypanosomiasis. The result found indicates about 53 year doubling on a ten-fold order of magnitude. This seems a rate that does not spell fear in the minds of those concerned with information service in the field of African trypanosomiasis. The rate is relatively slower than that of whole science.

African trypanosomiasis literature is a typical biomedical discipline. It is made up of several components viz; Entomology, Parasitology, Biochemistry, Therapy and Prophylaxis, Epidemiology, Physiology, Pathology among others. These are major disciplines on their own. How does the pattern of growth of each of these relate to the whole? In the first place entomology contributed most to the literature followed by parasitology, immunology, biochemistry, (chemo)therapy, epidemiology, physiology, pathology respectively. It was found that the growth pattern of the main stream of data is an extended sameness with those of the two major components, entomology and parasitology. As indicated by the profile of exponential increase, entomology has a 70-year doubling pace while parasitology was a 60-year doubling. From these it can be deduced that in a situation of monotonic similitude, while it may not be possible for all the components to exhibit the same doubling rate, the major components as in this case should reflect the same pace with the main data. These then could be regarded as the 'control components.'

Control components reflect the overall growth behaviour of the biomedical discipline. An analysis of the resources of libraries of such disciplines should also show a relatively high percentage of the control components (or 'core' components). It does appear that the overall exponential growth was derived by super-imposing the growth of each component on and above each other to give rise to the overall pattern. This implies a compoundment of exponential growth.

6.3 Comparison of parameters of different literatures

The intent was principally to further examine the relationship of the parameters which Hoffman and Warren first found for mast cell and schistosomiasis. They proposed, based on their analysis, that the relationship found between mast cell and schistosomiasis may be the same for mast cell and such other literatures e.g trypanosomiasis, leishmaniasis, malaria ecc. having similar dissimilarities as mast cell and schistosomiasis. The ratio of journals to authors, W, is 0.27 for mast cell and schistosomiasis literatures. This study found 0.22 value for African trypanosomiasis. The difference is not statiscally significant. Furthermore the ratio of schistosomiasis authors to that of African trypanosomiasis $a_c/a_t = 0.73$ to 1; while the ratio of journals with one article for schistosomiasis is to journals with one article in African trypanosomiasis, $Z_c/Z_t = 0.82$ to 1. These figures show that there are as many schistosomiasis authors as trypanosomiasis authors and as many journals having one article each in schistosomiasis as in African trypanosomiasis.

To establish this knowledge claim may require further studies based on such literatures as malaria, onchocerciasis, leishmaniasis etc. in relation to mast cell.

6.4 Authors Productivity Pattern

African trypanosomiasis data does not fit Lotka's theoretical model in its original form. In his case the exponent, n = 2. The data was further tested for the basic assumption that only a few authors contribute the most and most of them contribute few number of papers. The hypothesis is true for African trypanosomiasis research. The exponent in this case was found to be 2.03.

What was implied further was that the proportion of single authors is a function of the exponent; the greater the exponent the greater the low productivity of scientists (Gupta 1987). With highly productive number of scientists, the exponent is expected to be large. The values of these exponents can consequently be used as an index of comparative analysis of various productivity patterns of different scientific research. The 'fertility' of the authors could be regarded as an exponentially decaying property (Fig.7). The number of scientists, S, with n articles to their credit is approximately:

$$S(n) \propto n^{-2} \qquad S(n) = C/n^{2}$$

6.5 Authorship and Collaboration

About thirty-eight (38.51) percent of the papers were single author while 61.49% (3160) were multiple author. In all two and three author papers were predominant. The extent of collaboration extended up to 11 authors especially towards the latest period covered by the research. The average number of authors per paper is between 2 and 3 for the period.

The degree of collaboration, as indicated by the weighted average is 2.19. The weighed average for 1978-1985 was 2.54 while that for 1900-77 was 1.85. The trend is one of increasing collaboration. This study again, like some others, does not support Price's hypothesis of a likelihood that single author papers would disappear as time went on.

6.6 Bradford's law and reference scattering co-efficient

The Bradford-Zipf bibliograph was successfully applied to the literature. The core journals are the first 11 titles (Appendix 1A); consequently 16 are the representative journals in line with Brookes formulation (i.e core + 5). The extent of journals title dispersion and bibliographic scatter was illuminated. The scattering co-efficient for African trypanosomiasis was 0.56. This was reflected in the dispersion order as shown in appendix 1. Twelve titles contributed 50% of the articles. Seventy-two titles published 75% while 240 titles contributed 90%. Seventy-eight journals have 10 and above articles in the FABIT list while 53 have 10 or more in the 1965-85 list. Core journals in the 1965-85 list were also among the core in the FABIT list.

Bradford hypothesised that by reading only the core journals of one's specialty, one would miss 40% of articles relevant to it. It is even morese in the field of African trypanosomiasis. This study shows that the researcher would miss about 50%. When this was reconciled with the demand of the scientists, it was seen that this missable percent may contain part of their need. Though it is enhancing that only 12 titles would provide 50% of the requirements, the aspect of research technique factor would seem to make it inevitable to fall back on journals lower in rank to meet this need.

The degree of overlap between the FABIT list and the 1965-85 list, C, is 0.90. The co-efficient of correlation is given by R = 0.93. This shows a high degree of relatedness.

The 1965–85 list had seven core journals (Appendix 1A). The FABIT list has eleven core journals. Analysing far back in time brought Bull. ent. Research to position one instead of the third position in the 1965–85 list. Trans. Roy. Soc. Trop. Med. Hyg. also assumed position one instead of the second place in the 1965–85 list. A more significant change occured in the place of Bull. Soc. Path. Exotique. It is 4th in the FABIT list but shifted to 20 in the '65 - 85 list.

6.7 Recommendations

One main motive for this study is to provide factual information in support of information service in the field of African trypanosomiasis research.

Rank list of periodicals have been presented as shown in Appendix 1. It is highly recommended that the list shown be used as a guide in selecting and acquiring journals. The most current list of 1965–85 is recommended. Though there were only shuffling of rank position when analysis was done 'FABITEY', the study shows that newer journals assume higher positions in the '65–'85 list. Their chances are enhanced, though not lost in the FABIT list. The high relatedness of the two lists shows that information will not be lost when the FABIT list is used however.

The study shows that there are 'core' component parts in making up the main data. Such 'core' components (cc) should be established and these should form the major acquisition component of the policies of such biomedical libraries. The trailing component should then be acquired in line with their ratio of composition.

It is highly necessary that the top ranking core sub-set or representative journals be examined in relation to the idiosyncratic need of the scientists. For example there are some needs which are specific and peculiar according to the specialities of the scientists. This specialty factor prompts inter-or intra-search linkages. A search for specific biomedical research methods that the scientist can apply in trypanosomiasis research may lead a searcher or a librarian to journals that publish articles highly exclusive to biomedical work and not related to trypanosomiasis per se. Productivity ranking does not establish such journals because if they occur at all in the list, their rank positions are usually considerably low. A way must be established to incorporate this need as a basis of acquisition.

Though FABIT analysis does not significantly affect the [illegible] of most of the very important journals, 'NOFABIT' (i.e not far in time) analysis is highly recommended especially for the purpose of dynamic and current awareness service.

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APPENDIX 1

AFRICAN TRYPANOSOMIASIS LITERATURE

RANK LIST OF PERIODICAL TITLES

1900 - 1985

	Total of Periodicals	No. of Articles	Rank
1.	Bull. Ent. Research	454	1
2.	Trans. Roy. Soc. Trop. Med. Hyg.	381	2
3.	Ann. Trop. Med. and Parasit	329	3
4.	Bull. Soc. Path. Exotique	182	4
5.	Insect. Science and its Application	144	5
6.	Tropenmed. Parasit.	130	6.5
7.	Acta Tropica	130	6.5
8.	Molecular and Biochemical Parasit.	130	6.5
9.	Experimental Parasitology	122	7
10.	Nature	116	8
11.	J. Protozoology	80	9
12.	Ento,. Med. Parasitology	78	10
13.	Infection and Immunity	77	11
14.	Report Sleep Sick. Comm. Roy. Soc.	68	12.5
15.	Ann. Soc. Belge Trop. de Med. Trop.	68	12.5
16.	Nucleic Acid Research	66	13
17.	Ann. Trop. Med. Hyg.	65	14
18.	ISCTR	62	15
19.	Federation Proceeding	53	16
20.	Bull. WHO	50	17.5
21.	Rev. Elev. Med. Vet. Pays Trop.	50	17.5

	Total of Periodicals	No. of Articles	Rank
22.	Parasitology	49	18.0
23.	Biken Journal	45	19.0
24.	Ann. de la Soc. Belge de Med Trop.	44	20.0
25.	Bull. Ani. Hlth & Production Afr.	39	21.0
26.	Trop. Ani. Hlth & Prod. Afr.	38	22.5
27.	New Scientist	38	22.5
28.	Ento. Expt. et Appl.	37	23.0
29.	Zeitschrift fur Parasititenkunde	35	22.5
30.	Med. Tropicale	35	22.5
31.	East Africa Medical Journal	28	23
32.	American J. Trop. Med. and Hyg.	27	24
33.	Veterinary Record	26	25.5
34.	Journal of Parasitology	26	25.5
35.	Proc. Ento. Soc. London Series B	25	26.0
36.	Ztschr. F. Immunitatst U. Expt. Therapy	23	27.5
37.	Arch. Schiffse U. Tropenhyg.	23	27.5
38.	J. Trop. Med. & Hyg.	22	28.0
39.	Science	21	29.0
40.	Proc. Roy. Ento. Soc. Lond. Series A	21	30.0
41.	Biochemical Journal	20	31.0
42.	J. Insect Physiology	17	32.5
43.	Brit. J. Pharm. & Chem.	17	32.5
44.	Contribution to Microbiology and Immunology	16	33.5
45.	First Symposium Tsetse breeding	16	

	Total of Periodicals	No. of Articles	Rank
46.	J. Arid Environment	16	
47.	Veterinary Parasitology	16	
48.	J. Immunology	16	
49.	J. General Microbiology	16	
50.	British Medical Journal	15	34.5
51.	Experienta	15	
52.	J. Animal Ecology	15	
53.	J. Infectious Diseases	14	
54.	East African Agric. J.	14	
55.	Trop. Pest Management (formerly PANS)	14	
56.	Kenya Veterinary Physiology	14	
57.	Applied Microbiology	14	
58.	Comp. Biochemistry and Physiology	14	
59.	Ind. Vet. Journal	14	
60.	Bull. Epizoot. Diseases Africa	14	
61.	Zeitschrifts fur Angel Wandfe Zoologie	13	36.5
62.	Cell	13	
63.	Parasite Immunology	13	
64.	J. Biol. Chemistry	13	
65.	Jap. J. Parasitology	13	
66.	Proc. Soc. Exp. Biol. Med.	12	37.5
67.	Intern. J. Parasitology	12	
68.	Embo Journal	12	
69.	Ann. Parasit. Humaine Comparee	12	
70.	C. R. Soc. Biol.	12	

	Total of Periodicals	No. of Articles	Rank
71.	Physiological Entomology	11	38.5
72.	Rev. Trimestiellede Inform. Tech. et Cytology	11	
73.	British Veterinary Journal	11	
74.	Ann. Ist. Pasteu	11	
75.	C. R. Acad Science	11	
76.	Biochemical Pharmecology	10	
77.	J. Comparative Pathology	10	
78.	Bull. Sleeping Sickness Bureau	10	
79.	7 Journals with 9 articles each	63	40.5
	5 Journals with 8 articles each	40	41.5
	13 " " 7 " "	91	42.5
	16 " " 6 " "	96	43.5
	24 " " 5 " "	120	44.1
	23 " " 4 " "	92	45.5
	47 " " 3 " "	141	46.5
	80 " " 2 " "	160	47.5
	380 " " 1 article "	380	48.5

APPENDIX 1A

AFRICAN TRYPANOSOMIASIS LITERATURE

RANK LIST OF PERIODICAL TITLES

1965 - 1985

	NAMES OF JOURNALS	No. OF ARTICLES	RANK
1.	Trans. Roy. Soc. Trop. Med. and Hyg.	230	1
2.	Insect Science and its Application	144	2
3.	Bull. Ent. Research	139	3
4.	Med. and Bioch. Parasitology	130	4
5.	Tropenmed Parasitology	123	5
6.	Ann. Trop. Med. and Parasitology	114	6
7.	Acta Tropica	113	7
8.	Expt. Parasitology	86	8
9.	Journal of Protozoology	80	9.5
10.	Nature	80	9.5
11.	Ent. Med. Parasitology	77	10
12.	Infection and Immunity	72	11
13.	Nucleic Acids Research	66	12
14.	Federation Proceedings	53	13
15.	Rev. Elev. Med. Vet. Pays. Trop.	47	14
16.	ISCTR	44	15
17.	Ann. de la Soc. Belge de und Trop.	44	16
18.	Bull. WHO	40	17
19.	Bull. Ani. Hlth and Prod. Africa	39	18
20.	New Scientist	38	18
21.	Trop. Ani. Hlth and Prod. Afr.	38	18

	NAMES OF JOURNALS	NO. OF ARTICLES	RANK
22.	Biken J.	38	18
23.	Ent. Exp. et Appl.	37	19
24.	Bull. Soc. Path Exot.	36	20
25.	Med. Tropicale	35	21
26.	Parasitology	35	21
27.	Zeitschrift fur Parasititenkunde	35	21
28.	Contribution to Microbiology and Immunology	16	
29.	J. Arid Environment	16	
30.	Veterinary Parasitology	16	
31.	East African Medical Journal	14	
32.	Trop. Pest Management (formally PANS)	14	
33.	Kenya Veterinary Physiological	14	
34.	Appl. Micro. Biol.	14	
35.	Comp. Biochem. Physiol.	14	
36.	Science	14	
37.	Jl. Insect. Physiology	15	
38.	Jl. Immuno	13	
39.	Zeitschrifts fur Angel Wandte Zoologie	13	
40.	Cell	13	
41.	Vet. Rec.	13	
42.	Amr. J. Trop. Med. and Hyg.	13	
43.	Jl. Biol. Chem.	12	

	NAMES OF JOURNALS	NO. OF ARTICLES	RANK
44.	Ind. Vet. Jl.	12	
45.	Jl. Parasit.	12	
46.	Inter. Jl. Parasit.	12	
47.	Embo Jl.	12	
48.	Experimentia	12	
49.	Revenue Trimestiellede Information Technique Cytology	11	
50.	Physiological Entom.	11	
51.	Bull. Epizoot. Dis. Afr.	11	
52.	Biochemical Pharmacology	10	
53.	Jl. Comp. Path.	10	
54.	Biochem. Biophys. Acta	9	
55.	Biochem. Jl.	9	
56.	Jap. Jl. Parasit.	9	
57.	Zentralblantt fur Veterinermedizin	8	
58.	Jl. Gen. Microbiol.	8	
59.	Jl. Med. Ent.	8	
60.	Anti-Microbiol. Agents and Chemotherapy	8	
61.	Folia Parasitologica	7	
62.	Brit. Vet. Jl.	7	
63.	Meditzinskaya Parazilogoya and Parazitonye Bolengni	7	
64.	Comparative Biochemistry and Physiology	7	
65.	Nigerian Jl. Ent.	7	
66.	Brit. Med. Jl.	7	

	NAMES OF JOURNALS	NO. OF ARTICLES	RANK
67.	Jl. of Biochem.	7	
68.	Cana. J. of Zoology	7	
69.	Zetschrift fur Angewandte Entomologie	7	
70.	Biochem. Soc. Trans.	7	
71.	Journal of Cellular Biochemistry	7	
72.	Zentralblatt fur Bakteriologie, mikrobiologie und-Hygiene	6	
73.	Insect Biochemistry	6	
74.	J. of Economic Entomology	6	
75.	Vet. Path.	6	
76.	First Symposium tsetse-fly breeding, Lisbon	6	
77.	Ann. Esc. Nac. Saude Publica Med. Trop. Lisbon	6	
78.	Jl. Appl. Scol.	6	
79.	Soc. Sci. Med.	6	
80.	Trop. Geogr. Med.	6	
81.	Annales D' Immunologie	6	
82.	Brit. Jl. Pharm. and Chem.	6	
83.	Jl. Med. Chem.	6	
84.	Gene	6	
85.	Ann. Soc. Belge Trop. de Med. Trop.	5	
86.	Proc. Roy. Ent. Soc. Lond. Ser. A.	5	
87.	Arzneimittelforschung	5	
88.	Jl. Ent. Soc. S. Afri.	5	
89.	Advances in Parasit.	5	

	NAMES OF JOURNALS	NO. OF ARTICLES	RANK
90.	Barlin Munden Tieratzl Wschr.	5	
91.	Biochem. Biophys. Res. Commun.	5	
92.	Ind. Jl. Ani. Sci.	5	
93.	Ethopian Medical J.	5	
94.	Tropical Information Leaflet	5	
95.	J. Invert. Path	5	
96.	J. Of Zoology (London)	5	
97.	Praktisch Tierarztlide	5	
98.	J. Of Chem. Ecology	5	
99.	Environmental Polution	5	
100.	Hoppe-seyleru's Zeitschrift fur physiologisde chemie	5	
101.	Preventive Veterinary Medicine	5	
102.	Current Topics in Microbiology and Immunology	5	
	15 Journals have 4 articles each		60
	42 " " 3 " "		126
	54 " " 2 " "		108
	229 " " 1 " "		229