"Sources of information on specific subjects" by S.C. Bradford

1. Introduction

On returning to the paper published in 1934 in which Bradford first announced his 'law', one brings to its re-reading the insights slowly acquired during the past 50 years of bibliographical studies. Bradford clearly appreciated that his data conformed with some simple logarithmic function because he adopted a log scale for his unconventional ranked distribution. But he refrained from expressing that function explicitly. Instead, faced by uncertainties about the exact form of the 'nucleus', he expressed his law as a verbal conundrum which took years to resolve. But he also presented a diagram in his Fig. 2 which clearly displays the form of the nucleus as he then saw it.

To clarify the difficulties Bradford faced at that time it is necessary to analyse his data to reveal what they show in the light of subsequent studies.

2. Bradford's data

In 1967, Leimkuhler [1] solved the conundrum and showed that the law could be expressed in the form

$$G(r) = k \ln(1 + br) \qquad (1)$$

where $G(r)$ is the cumulated total of papers in the first r of the ranked journals and where b and k are parameters to be evaluated from the data.

With a logarithmic scale of ranks (1) represents a straight line from the origin. Here I use it simply to find the equation of the straight line joining the two end-points of each of the two bibliographical distributions in order to present their form more clearly than Bradford's own graphs do.

We therefore put

$$G(1) = k \ln(1 + b) = 92$$

and

$$G(326) = k \ln(1 + 326b) = 1332$$

for the data on Applied Geophysics. On eliminating k we have the following equation for b:

$$93 \ln(1 + 326b) - 1332 \ln(1 + b) = 0$$

which is most simply solved by an iterative process to give $b = 0.40763$ with $k = 272.0033$.

Applied to the Lubrication data, the same technique gives $b = 0.22415$ with $k = 108.777$.

It is now possible to compare the results obtained from the above calculations with those given in Bradford's tables. The two comparisons are shown in Tables 1′ and 2′. It can be seen that the Lubrication data fit the calculated line remarkably well and that the Applied Geophysics data fit much less well though they still conform overall with the calculated 'log-linearity'.

3. The graphs

For drawing the graphs of the two calculated lines it is helpful to rescale the ranks to give unit intervals for ranks on the log scale of ranks, i.e., to put $a = 1/b$ so that

$$G(r) = k \ln(1 + rb) = k \ln(1 + r/a)$$
$$= k \ln(a + r) - k \ln a.$$

For the Applied Geophysics data $a = 1/0.40763 \approx 2.5$ and for the Lubrication data $a = 1/0.22415 \approx 4.5$—approximations which suffice for the drawing of the graphs.

The two graphs which, I emphasize, merely join the two end-points of their distributions with no

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Table 1′
The Applied Geophysics bibliography

r	1	2	3	4	5	6	7	8	9
$G(r)$ calc	93	162	217	263	302	337	367	394	419
$G(r)$ obs.	93 [a]	179	235	283	329	364	392	412	429
	13	**20**	**27**	**28**	**56**	85	108	157	326
	501	602	676	**762**	862	972	1036	1135	1332
	493	590	662	753	868	996	1065	1163	1332 [a]

[a] Datum points.

Table 2′
The Lubrication bibliography

r	1	2	3	5	7	8	11	14	15	22	24	37
$G(r)$ calc	22	40	56	82	103	112	135	154	160	194	202	242
$G(r)$ obs.	22 [a]	40	55	81	101	110	134	155	161	196	204	243
	62	164										
	294	395 [a]										
	293	395 [a]										

[a] Datum points

attempt whatever to find the 'lines of best fit', are shown in Fig. 1′. They reveal no nucleus of the form displayed in Bradford's diagram.

4. Bradford's nucleus

Neither set of data, plotted as Bradford plotted them in his Fig. 1, could produce a rising curve which runs into a linearity at some point P_1, as he indicates in his Fig. 2; they would continue to rise as curves of ever decreasing curvature as r increases. But, within the finite limits of any bibliography, they could never run into a linearity. My own guess is that when Bradford wrote his paper he had already plotted the graph of other bibliographies produced by the SML staff but which are not mentioned in his paper and that some of these produced the nuclear form of his diagram. When mechanized databases became operational in the 1960s, print-outs from MEDLARS that I examined, and plotted as Bradford plotted his graphs, revealed the form of his diagram.

About four years ago I went to the SML to ask whether any of the bibliographies produced in Bradford's time as Director had survived the War, the move to a new building and the sharing of its stock with the Playfair Library of Imperial College. I was shown *two*—the only two then found among Bradford's papers—the two he cites in his paper.

So I can only guess that Bradford had already noted what I noted 30 years later— that *some* bibliographies have no nucleus at all but that others do. When, however, a nucleus does occur, it may consist of 1, 2, 3, or more journals up to many. Facing the uncertainties presented by this variety of nuclear possibilities, I well understand the difficulty Bradford found in formulating his law as a simple logarithmic function. His 'conundrum' was most ingeniously contrived to cover all possible eventualities.

Further, if Bradford had not seen the nuclear form displayed in his diagram, it is difficult to understand why he introduced the term *nucleus* at all; he could simply have referred only to the first, second, third... *zones*.

I also find it difficult to imagine how specialized the topics of Applied Geophysics and Lubrication were regarded in the 1930s but Bradford's note on the diagram states that the nucleus embraces those journals "more particularly devoted to the subject". If the topic is so widely dispersed or too novel yet to have attracted a journal "more particularly devoted" to it, we need not expect to find a nucleus in its bibliography.

5. Bradford's application of his law

At the time he wrote his paper, Bradford's primary interest was to make accessible to poten-

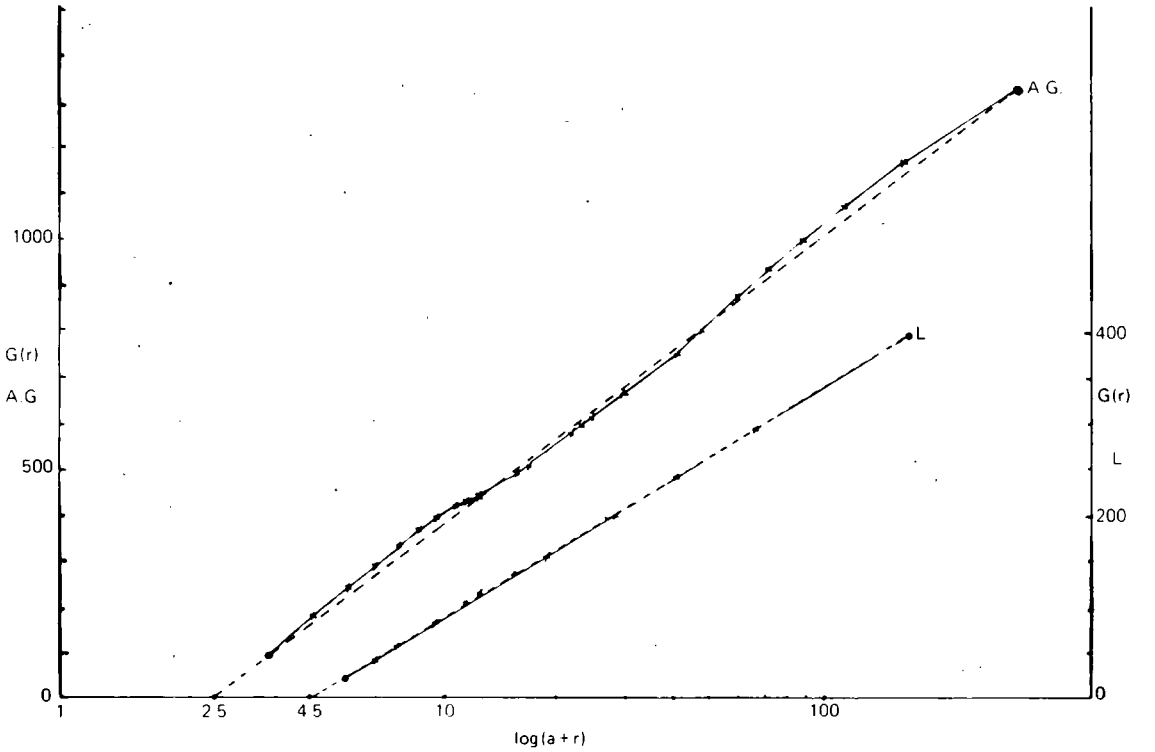

Fig. 1'.

tial users *all* the scientific literature relevant to any specified topic. In the second part of his paper he estimates that in the 1930s only about one third of all the papers published in the scientific journals were actually indexed. So he was less concerned with the exact form of the law than with using it as a means of estimating how many relevant papers could be expected to be found in the large set of peripheral journals beyond the immediate reach of his bibliographers.

The computer has since come to help solve Bradford's problem but the fact that he chose to illustrate his method of estimating the totalities by means of the law may also help to explain why he chose the two particular non-nucleated bibliographies to make his point: the presence of a nucleus would have seriously complicated his estimations. The inclusion of the diagram thus serves as a warning that a nucleus might affect his method of estimating the totalities.

6. Other comments

(a) The fact that Bradford published his paper in the journal *Engineering* suggests that he was seeking support for his advocacy of comprehensive information services for science and technology from the potential users of those services rather than from the library profession of his time.

I also note that his paper was reprinted as 'Publication No. 1' of the British Society for International Bibliography, which, founded in 1927, became the British National Committee for the FID before amalgamating with Aslib in 1948 [2].

The primary objective Bradford had in mind in 1934 was eventually realized—at least in part—by the founding of the NLLST at Boston Spa with Dr. D.J. Urquhart as its first Director some 30 years later.

(b) The graphs of Fig. 1 show no trace of the 'Groos droop' and therefore bear witness to the patience and 'manual' skills of the SML staff of the 1930s.

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References

[1] F.F. Leimkuhler, The Bradford distribution, *Journal of Documentation* 23 (3) (1967) 197–207.
[2] Herbert Coblans, *Librarianship and Documentation* (Deutsch, London, 1974).