Author Productivity and Citation Frequency in the Proceedings of the Oklahoma Academy of Science, 1921-2000

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This study measures author productivity and citation frequency in the *Proceedings of the Oklahoma Academy of Science* (*POAS*). Productivity is defined as the number of times an author published an article in *POAS* between 1921 and 2000. Citation frequency is the number of times a *POAS* article or author was cited in other journals between 1974 and 2000, as indexed in the citation database *SciSearch.* Author productivity approximated an inverse square distribution, as did citation frequency, as predicted by Lotka's Law of bibliometrics. Seventy-two percent of authors published once in *POAS*, while 1 percent of authors published 16 or more articles. Seventy-five percent of *POAS* authors were not cited, while 1 percent of authors were cited 9 or more times. Productive authors were not necessarily highly cited. Authors receiving the most citations per article published infrequently, but produced a highly cited article. The research has implications for bibliometric research methodology, for understanding state and regional scientific communication, and for measuring changes in citation rates since publication of *POAS* online.

INTRODUCTION

Bibliometrics is defined as the study of patterns in the publication and use of documents, while bibliometric laws define predictable relationships in those patterns (Diodato 1994). Citation analysis is a branch of bibliometrics that studies patterns in the references made from one document to another. Librarians and information scientists can use such studies for collection development, to better understand the creation and use of published works, and to develop qualitative measures to compare documents (Egghe and Rousseau 1990, Borgman and Furner 2000, Narin and Olivastro 2000, Dilevko and Atkinson 2002). Sociologists use bibliometrics to study scholarly communication and social networks of scientific collaboration (Garvey and Griffith 1967, Cole and Cole 1973, Bonzi and Snyder 1991, Davis 2002). Administrators and policy analysts use bibliometrics as a tool to evaluate the quality and productivity of researchers, institutions, or nations (Crane 1965, Gottfredson et al 1979, Cole 2000).

This study measures author productivity and citation frequency in the *Proceedings of the Oklahoma Academy of Science* (*POAS*). Productivity is defined here as the number of times a person has authored or co-authored an article in *POAS*, as indicated in *POAS* tables of contents published on the World Wide Web (Oklahoma State University Edmon Low Library Electronic Publishing Center 2003). Citation frequency refers to the number of times *POAS* has been cited in journal articles published from 1974 to 2000 as indexed in the citation database *SciSearch*® (Dialog Corporation 2003). The research also examines the extent to which author productivity and citation frequency exhibit inverse square distributions, as predicted by Lotka's Law of bibliometrics. This investigation is part of a larger study of state and regional scientific communication, and the effect that publishing *POAS* on the Web has on that communication.

The digitization of back issues of print journals creates opportunities for access beyond that available in print. In addition to potentially reaching a larger audience than print, retrospective digitization projects create opportunities for bibliometric studies that would be difficult and time-consuming using only print sources. Depending on the format, researchers can extract data from the electronic files of such journals using relatively simple techniques, allowing analysis of citation and authorship patterns. The method is particularly valuable for journals, such as *POAS*, that are not completely covered by citation indexing or other indexing and abstracting services. Scholarly journals that are freely available on the Internet, as opposed to proprietary journals requiring subscriptions to view online content, may be more thoroughly indexed by web search engines than by abstracting services. The effect of that access on small-circulation journals remains to be seen.

The *POAS* digitization project creates an opportunity to study state and regional aspects of scientific communication and communities, which have been largely neglected by researchers. A small number of researchers have written about the publishing activity of state academies of science. Skallerup (1955) published the first bibliometric studies of the publications of state academies of science. His analysis of the contents of 30 such publications revealed dominance by zoology and botany papers. Skallerup attributed that predominance to the adaptability of such research to local interpretation and to scientists working without institutional support. He also identified 12 abstracting services that index state academy of science journals, but noted the wide variation in subject and publication coverage. Finally, Skallerup advised researchers and state academies to consider the extent of indexing coverage for their journals and the role of that coverage in defining the journal's readership. Those observations are a reminder that indexing and abstracting are an important aspect of scientific communication.

Hill and Madarash-Hill (2000) provide the most thorough recent study of the relevance of the publications of the state academies of science. They examined 45 publications of state academies of science in the areas of subject coverage, subscription levels, library ownership rates, indexing and abstracting levels, and citation rates. They found that most are peer reviewed and multidisciplinary, although subject coverage is strongest in regional plant and animal studies. The authors also found that more than 100 abstracting sources indexed one or more publications of the state academies of science, although some publications are indexed more than others. They concluded that, despite being overshadowed by the larger journals, state publications remain an important vehicle to publicize the results of scientific research.[1]

MATERIALS AND METHODS

POAS has been published annually since 1921, 12 years after the founding of the Oklahoma Academy of Science (Shannon 1921).[2] *UlrichsWeb.com* listed *POAS* circulation as 800 in October 2003. The union catalog *WorldCat* (2003) listed *POAS* holdings in 196 libraries during that time. *UlrichsWeb.com* (2003) lists 16 abstracting services that have indexed *POAS* at some time. A recent study found six major abstracting services that had indexed 50 or more *POAS* articles. Together, those six indexed about 24% of *POAS* articles (Bremholm 2004).

The Oklahoma State University (OSU) Library Electronic Publishing Center has undertaken the digitization of a number of publications significant to Oklahomans, including *POAS*. The OSU Library Electronic Publishing Center has taken an incremental approach to the *POAS* digitization project. During this study, in 2002, the tables of contents of all volumes were online, with full text available for the issues published since 1976 (OSU Library Electronic Publishing Center 2003).

1 A new bibliographic database, *State Academies of Science Abstracts*, indexes forty state academy of science publications. See http://www.acadsci.com, accessed November 6, 2004.

2 Two volumes were published in 1948, and *POAS* was not published in 1958.

Data acquisition began by downloading *POAS* tables of contents for volumes 1 through 80 (1921-2000) using the freeware program URL2File, (Chami.com 1998). Each *POAS* table of contents was published online as a Hypertext Markup Language (HTML) file. Scripts written in the Perl programming language were then used to extract bibliographic information from the HTML files based on patterns in the markup tags (ActiveState Tool Corporation 2001).[3] Perl is able to extract text strings from between two other text strings that match a user-defined template. In this case, author names, volume, and page information was usually bracketed by the HTML tags <div class="smallfont"> and </td>, as the following example table of contents entry shows:

> <td bgcolor = "ffffff">Further Observations on the Effects of Alcohol on White Mice <div class = "smallfont"> L. B. Nice; 1 (1921); p. 31 </td>

Bibliographic information was extracted from articles and notes listed in the tables of contents, and from published abstracts. Beginning with volume 74, *POAS* started publishing abstracts of papers presented at the annual OAS meeting but did not list individual abstract titles or authors in the tables of contents. Because abstracts were cited by other journal articles, they were included in this study. That required copying bibliographic information from the full-text files of the individual volumes rather than from tables of contents. Papers listed in the tables of contents that were presented at the Oklahoma Academy of Science annual meeting but not published in that issue were not included.

The next step required manually evaluating the list of authors extracted from the tables of contents to determine if name variations were truly different people or just alternate spellings. Judgments were made based on the similarity of research topic, years in which they published, uniqueness of the name, location or institutional affiliation, shared initials, use of "Junior," or name changes due to marriage. As some of those ambiguous names remain unresolved, the number of authors who have been published in *POAS* is difficult to know with certainty. The assumption here is that in a large population of authors the errors will cancel out, allowing a close estimate of the number of unique author names.

In the second phase of the study, the citation database *SciSearch* was queried for references to *POAS* (Dialog Corporation 2003).[4] *POAS* is not indexed by *SciSearch*, but a search of the Cited Works field returns records of articles published in indexed journals that have cited *POAS*. The *SciSearch* records, which only listed the first author, volume, year, and page number, were then matched to the corresponding *POAS* articles. Because of the large number of articles and citations, Perl scripts were used to match the records (Bremholm 2003).

That automated matching was only partially successful, requiring substantial manual checking and correction of errors. That process also revealed a large number of erroneous citations, which usually involved a mismatch between the year and *POAS* volume. The erroneous citations were corrected manually when the intended article could be determined. The resulting list provides a sample that is close to the population of all *POAS* articles and authors that had been cited to that point (Bremholm 2003).

The third phase of the study consisted of calculating the exponents that describe

3 Perl is the Practical Extraction and Report Language, a flexible, powerful, open source language, useful for automating manipulation of text files.

4 *SciSearch*®: A Cited Reference Science Database produced by the Institute for Scientific Information® (ISI) contains all of the records published in the *Science Citation Index*® (SCI), plus additional records from the *Current Contents*® publications. At the time of access, March 2002, *SciSearch* indexed citations from articles published since 1974 in 3,800 journals. *Social SciSearch*, the social science citation index, was not queried for the current study, although social science articles comprise a substantial part of the *POAS*.

the distribution of author productivity, article citation frequency, and author citation frequency. Lotka's Law predicts a negative exponential relationship (Lotka 1926). That relationship has been affirmed in a number of studies since Lotka's original work (Pao 1986). Pao (1985) reminds readers that the relationship between authors and productivity varies with the discipline, and is close to, but not always, equal to an inverse square distribution.

Although Lotka's Law refers specifically to author productivity in terms of number of publications, citation frequency is used here as another measure of productivity. Because Lotka theorized a distribution in which the exponent depended on the discipline, the present study does not test the goodness of fit to an inverse square or other specific distribution. Instead, Pao's (1985) method was used to calculate the exponents. Pao discussed the desirability of considering Lotka's Law in the form

$$x^n \, y_x = c$$

where y_x is the number of authors making x contributions, n is the exponent that depends on the discipline, and c is a constant. The exponent, n, is calculated from the slope of the line that results from plotting the logarithm of y and the logarithm of x (Appendixes A-C).
The slope is calculated by using the least-square method, as

$$n = \frac{N\Sigma XY - \Sigma X \Sigma Y}{N\Sigma X^2 - (\Sigma X)^2}$$

where N is the number of data pairs; X is the logarithm of x, the number of contributions; and Y is the logarithm of the number of authors making x contributions (Pao 1985).

Lotka's exponent, n, could be determined from the average slope of the entire log-log distribution, but Pao (1985) warns that the linear relationship between log x and log y fails for the small number of prolific authors. For that reason, a cutoff must be determined, although there is no consensus as to what the cutoff should be. In some cases visual inspection may be as valid as any statistical determination. The slope was calculated here for the data points that did not strongly deviate from linearity based on visual inspection (Appendixes A-C).

RESULTS AND DISCUSSION

Author Productivity

POAS volumes 1 through 80 (1921-2000) include the work of 2,521 individual authors in 3,150 articles and 88 abstracts. Individuals published from 1 to 46 times (Table 1). The ten most prolific authors published in *POAS* between 24 and 46 times, with an average of one article per year (Table 2). Seventy-two percent of the authors have been published in *POAS* one time (Table 3). Lotka's Law indicates that, with an inverse square distribution, approximately 60% of authors would be expected to have published only one article (Pao 1985). The number of *POAS* articles produced by authors exhibits a negative exponential relationship to the number of authors, with an exponent of n = -2.42 (Appendix A and Fig. 1). Lotka proposed that the exponent varies by discipline, which suggests that the exponent here reflects the multidisciplinary nature of the work published in *POAS*.

Citation Frequencies

Overall, 14% of all *POAS* articles and 25% of all *POAS* authors were cited between 1974 and 2000 in journals indexed by *SciSearch*. There were 733 articles in the study that cited *POAS*. Articles and abstracts were cited from 0 to 12 times each (Table 4). The articles cited more than 10 times were all published between 1924 and 1985 (Table 5). *POAS* authors were cited from 0 to 30 times (Tables 6 and 7). Of those articles that were cited, 63% were cited just one time. Of the cited authors, 51% were cited just one time (Table 3).

Table 1. Frequency distribution of author productivity in *POAS* 1921-2000.

Number of Publications	Number of Authors	Percentage of Authors	Cumulative Percentage of Authors
1	1804	71.56	71.56
2	359	14.24	85.80
3	112	4.44	90.24
4	67	2.66	92.90
5	37	1.47	94.37
6	34	1.35	95.72
7	24	0.95	96.67
8	14	0.56	97.23
9	7	0.28	97.51
10	8	0.32	97.83
11	4	0.16	97.99
12	7	0.28	98.27
13	7	0.28	98.55
14	5	0.20	98.75
15	7	0.28	99.03
16	3	0.12	99.15
17	5	0.20	99.35
18	3	0.12	99.47
19	2	0.08	99.55
21	1	0.04	99.59
22	1	0.04	99.63
24	1	0.04	99.67
25	2	0.08	99.75
26	2	0.08	99.83
27	1	0.04	99.87
30	1	0.04	99.91
38	1	0.04	99.95
42	1	0.04	99.99
46	1	0.04	100.03
Total	2521		

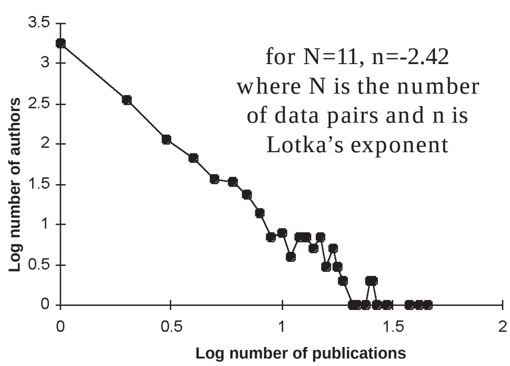

Figure 1. Logarithm of number of authors and number of publications in *POAS*, 1921-2000.

Authors with the highest citation rates had only one or two articles published in *POAS*, and were often coauthors on highly cited articles (Table 8). Authors such as K. O. Butts, F. B. Isely, and J. E. Scott published only one or two *POAS* articles, but those included some of the most frequently cited articles. It is also noteworthy that Jimmie Pigg was the only author who was prolific and highly cited, while K. O. Butts was the only author who was highly cited and had a high citation rate (Tables 2, 7, and 8).

Table 2. Ten most prolific authors published in *POAS* 1921-2000.

Author	Number of POAS publications	Active POAS years	Duration (years)	Average publications per year
Bragg, Arthur N.	46	1936-1969	33	1.39
Pigg, Jimmie	42	1974-2000	26	1.62
Evans, Oren F.	38	1922-1966	44	0.86
Tyler, Jack D.[a]	30	1970-2000+	30	1.00
Shead, Arthur C.	27	1922-1967	45	0.60
Gould, Charles N.	26	1921-1944	23	1.13
Wender, Simon H.	26	1947-1971	24	1.08
Drew, William A.	25	1962-1987	25	1.00
Harper, Horace J.	25	1927-1961	34	0.74
Gallup, Willis D.	24	1927-1951	24	1.00
Average	31		31	1.04

[a] Author active beyond volume 80 (2000)

Table 3. Predicted and measured percentage of authors and articles in *POAS* with one contribution.

	Calculated n, Lotka's exponent	Percentage of population with one contribution	
		Measured	Predicted[a]
POAS authors	-2.42	72	73
Cited *POAS* articles	-2.17	63	67
Cited *POAS* authors	-1.96	51	59

[a] Pao 1985.

The number of citations received by *POAS* articles exhibits a negative exponential relationship to the number of articles, with an exponent calculated as n = -2.17 (Appendix B and Fig. 2). The number of citations received by *POAS* authors exhibits a negative exponential relationship to the number of authors, with an exponent calculated as n = -1.96 (Appendix C and Fig. 3).

The average citation rate for all *POAS* articles was 0.27 citations per article, while the average citation rate for only those articles that were cited was 1.85 citations per article. Subsequent research indicates that geology, psychology, and social sciences ar-

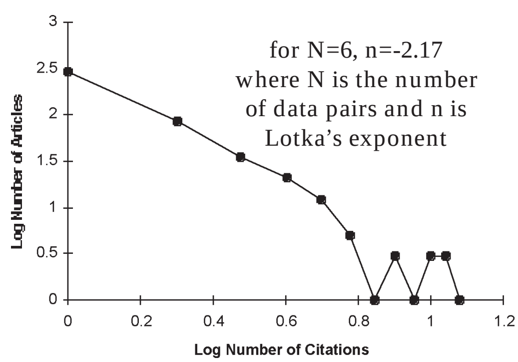

Figure 2. Logarithm of number of *POAS* articles and number of citations received.

Table 4. Frequency distribution of citations to *POAS* in articles published from 1974 to 2000 in journals indexed by *SciSearch*.

Times Cited	Number of *POAS* Articles	Total Citations	Percentage of Total *POAS* Articles	Cumulative Percentage
0	2771	0	85.58	85.58
1	296	296	9.14	94.72
2	86	172	2.66	97.38
3	35	105	1.08	98.46
4	21	84	0.65	99.11
5	12	60	0.37	99.48
6	5	30	0.15	99.63
7	1	7	0.03	99.66
8	3	24	0.09	99.75
9	1	9	0.03	99.78
10	3	30	0.09	99.87
11	3	33	0.09	99.96
12	1	12	0.03	99.99
Total	3238	862		

Table 5. Times cited and self-citations for *POAS* articles cited 10 or more times.

Article	Times Cited	Self-citations
Butts KO, Lewis JC. 1982. The importance of prairie dog towns to burrowing owls in Oklahoma. Proc Okla Acad Sci 62:46-52.	12	0
Howell DE. 1948. A case of DDT storage in human fat. Proc Okla Acad Sci 29:31-32.	11	0
Francko DA. 1983. Dissolved cyclic adenosine 3':5'-monophosphate (cAMP) in a eutrophic reservoir lake. Proc Okla Acad Sci 63:9-11.	11	10
Waller GR. 1967. Description of the Oklahoma State University mass spectrometer-gas chromatograph. Proc Okla Acad Sci 47:271-292.	11	3
Isely FB. 1924. The fresh-water mussel fauna of eastern Oklahoma. Proc Okla Acad Sci 4:43-118.	10	0
Civan F, Sliepcevich CM. 1985. Application of differential quadrature to solution of pool boiling cavities. Proc Okla Acad Sci 65:73-78.	10	4
Namminga HE, Scott JE, Burks SL. 1974. Distribution of copper, lead, and zinc in selected components of a pond ecosystem. Proc Okla Acad Sci 54:62-64.	10	0

Table 6. Distribution of number of citations received by *POAS* authors from articles published 1974 to 2000 in journals indexed by *SciSearch*.

Times Cited	Number of Authors	Percentage of Authors	Cumulative Percent
0	1898	75.29	75.29
1	316	12.53	87.82
2	130	5.16	92.98
3	60	2.38	95.36
4	31	1.23	96.59
5	28	1.11	97.70
6	15	0.60	98.30
7	10	0.40	98.70
8	6	0.24	98.94
9	4	0.16	99.10
10	5	0.20	99.30
11	6	0.24	99.54
12	2	0.08	99.62
13	1	0.04	99.66
14	1	0.04	99.70
15	1	0.04	99.74
17	1	0.04	99.78
18	1	0.04	99.82
21	1	0.04	99.86
22	2	0.08	99.94
23	1	0.04	99.98
30	1	0.04	100.02

Table 7. Ten *POAS* Authors cited most frequently in articles published from 1974 to 2000 in journals indexed by *SciSearch*.

Author	Times Cited	*POAS* Articles	Cites / Article
Pigg, Jimmie	30	42	0.71
Lewis, J. C.	23	9	2.56
Seto, Frank	22	8	2.75
Waller, G. R.	22	10	2.20
Berlin, K. Darrell	21	15	1.40
Hill, Loren G.	18	13	1.38
Butts, Kenneth O.	17	2	8.50
Rice, Elroy L.	15	7	2.14
Echelle, Anthony A.	14	8	1.75
Howell, D. E.	13	8	1.63

Table 8. *POAS* authors with highest average number of citations per publication.

Author[a]	*POAS* Publications	Times Author Cited	Average Citations Per Publication
Isely F. B.	1	10	10.0
Scott Jerry E.	1	10	10.0
Butts Kenneth O.	2	17	8.5
Bakshi J. S.	1	8	8.0
Mangiafica S.*	1	7	7.0
Ritchey C. R.*	1	7	7.0
Clark Peter E.**	1	6	6.0
Schroeder Jack T.**	1	6	6.0
Walker Jerome W.***	1	6	6.0
Estes Richard L.***	1	6	6.0
Miller Helen C.	1	6	6.0

[a] Authors with the same number of asterisks were co-authors on the same paper.

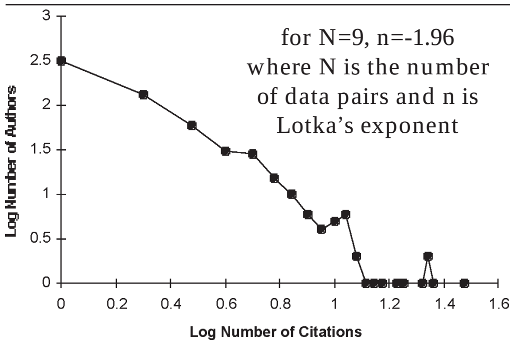

Figure 3. Logarithm of number of *POAS* authors and number of citations received.

ticles in *POAS* were cited much less frequently than articles in other disciplines (Bremholm 2004). *POAS* data compare to average 10-year citation rates of 8.31 citations per article for all sciences, with disciplinary averages ranging from 2.27 citations per article for computer science to 23.99 for molecular biology and genetics (Thomson ISI 2004a).

The ISI journal impact factor provides another comparative measure of citation rates for journals. Impact factor is calculated as the number of citations received during the year of interest by articles published in the two previous years, divided by the total number of articles published during that period. For example, the impact factor for 2001 for 102 ecology journals indexed in *Science Citation Index* was 1.56 citations per article, compared to 0.94 citations per article for 110 zoology journals (Thomson ISI 2004b). By comparison, the 38 *POAS* articles published in 1999 and 2000 received 1 citation in 2001 (as indexed in the ISI database), which would be equivalent to an impact factor of 0.026. That suggests that *POAS* articles are not cited soon after publication, which may be related to the limited indexing and small circulation.

The number of citations received by *POAS* varies greatly by year, with the fewest citations received by the newest and the oldest articles (Fig. 4). That distribution reflects the lag time between publication and citation, what ISI calls the immediacy index, and the durability of the literature, or its ISI half-life (Thomson ISI 2004b). Although articles from the earliest volumes were cited during the study period, the data are almost certainly skewed by not having citation data from 1973 back to 1921. In addition, citation frequencies for *POAS* may be distorted by not including data from *Social SciSearch*, the social sciences citation database. Subsequent research has addressed that by examining

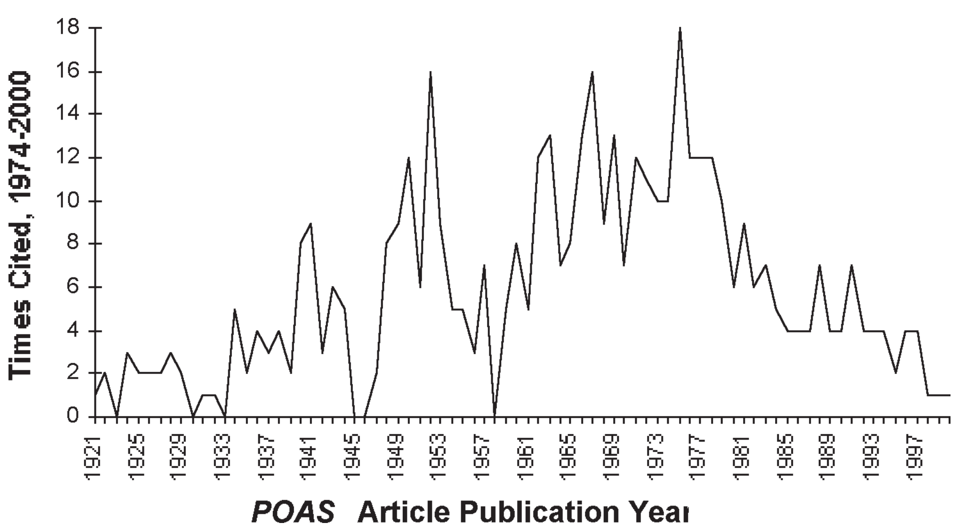

Figure 4. Frequency distribution of publication years for *POAS* articles and abstracts cited 1974-2000.

citations in the social science literature (Bremholm 2004).

Self-Citation

Sixteen percent of the citations to *POAS* in journals indexed by *SciSearch* were self-citations in which an author cited his or her own *POAS* article. That rate is within the range of that found in other studies, generally 10 to 20% in the sciences (Tagliacozzo 1977, Snyder and Bonzi 1998). Those studies found little difference in authors' motives for citing self and others. The major reasons they found for citing one's own work rather than that of someone else involved establishing priority, authority, and referring to earlier work that led to the current work (Bonzi and Snyder 1991). Given the iterative nature of scientific research, it would be unusual if scientists did not cite their own work. The incomplete indexing and small circulation of *POAS* suggests a role for self-citation in bringing *POAS* articles to the attention of colleagues reading other journals. Further research could clarify the place of *POAS* articles in an author's entire publishing record and the role of self-citation in linking scientific literature.

Multiple Authorship

In the present study, each author of a multi-author paper was given full credit for publications and citations received. There is no consensus in the bibliometric literature whether to credit only the senior author, credit all authors equally, or give proportional credit to each author (MacRoberts and MacRoberts 1989). Some findings indicate that Lotka's Law no longer holds for proportional authorship (Rousseau 1992). The justification used here is that each author of a multi-author paper would count the publication or citation as his or hers, whether he or she was the first or last, senior or junior, author. Because there is no evidence that each author contributed in equal proportion to the others, fractional credit makes no more sense than crediting only senior authors. In addition, it appears that Lotka's Law held in this case by giving equal credit to all authors.

Limits to the Method

The goal of the research methodology was to automate data extraction and processing as much as possible, enabling research on large samples, long journal runs, and large text files. Without that automation, data extraction and processing fall back to the manual methods that make bibliometric analysis of print journals difficult and time-consuming. Perl scripting is useful for automating comparisons and counting occurrences of text strings in large text files or simply for extracting and formatting text for export into a database. However, variations in format or spelling of author names, irregularities in the HTML tags, and erroneous citations required manual intervention to make comparisons or count occurrences. Although citation error rates were not quantified in this study, other authors have found errors rates ranging from 11 to 50% of citations in published articles (Pandit 1993, Sweetland 1989). These errors could be serious impediments to automated data extraction and processing. In addition, many journals publish their contents online using file formats that make extraction of text difficult or impossible.

Subsequent and Future Research

Subsequent research found that journals with a regional emphasis, or that had a wildlife, ecology, or natural history emphasis, were highly cited in *POAS* and also cited *POAS* frequently (Bremholm 2004). In addition, queries of six major bibliographic databases found that 24% of *POAS* articles published between 1976 and 2002 were indexed. About 15% of those articles that were indexed were cited, while 14% that were not indexed were cited, suggesting that indexing does not have much influence on whether *POAS* articles are cited or not. Those findings suggest that models of scientific communication that are based on national or international communities do not adequately describe regional scientific communication (Bremholm 2004).

One unique feature of the web version of *POAS* is that it is indexed almost entirely by the Google search engine, including full-text indexing for articles available in that format. That coverage far surpasses indexing of the print edition by bibliographic databases (Bremholm 2004). The overriding question remains whether publishing *POAS* on the Internet will result in more citations in the scholarly literature. Given the time lag between publication and citation, that question may not be answerable for several years. However, unless authors cite the web version of *POAS*, it would be difficult to attribute any increase in citations to the web presence.

CONCLUSION

The results of this study indicate that a small number of prolific authors have used *POAS* as a major outlet for communicating their work, while the largest group of authors have published in *POAS* infrequently. While that is not surprising, it is not simple to explain. Determining why so many authors publish only one time and others publish more than 30 times is beyond the scope of this study and would likely require biographical or demographic research. This study is a reminder that neither productivity nor citations alone indicate fully the impact an author has on a discipline. Longevity, recognition from peers, editorial positions, professional service, teaching, and training graduate students are all indicators of influence that cannot be measured in studies of citation and productivity.

It is also a reminder that science is practiced in many forms and in many settings. The state academy journals have their place in the spectrum of scientific practices and practitioners. They fulfill a particular need as an outlet for science with a regional scope. In addition, while many *POAS* authors are academic researchers, others may have limited access to other scholarly publishing outlets, often because they work outside of academia. The challenges for many *POAS* authors are to make their regional studies relevant to a larger scientific audience and to make others aware of their findings. Harnessing the communication power of the Internet could have a lasting effect on the practice and communication of regional science.

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Appendix A: Author productivity. Calculation of Lotka's exponent, n, *Proceedings of the Oklahoma Academy of Science* 1921-2000.

x Publications	y Authors	X log x	Y log y	N Data points	n $n = \frac{N\Sigma XY - \Sigma X\Sigma Y}{N\Sigma X^2 - (\Sigma X)^2}$
1	1804	0.000	3.256		
2	359	0.301	2.555	2	- 2.329
3	112	0.477	2.049	3	- 2.508
4	67	0.602	1.826	4	- 2.426
5	37	0.699	1.568	5	- 2.421
6	34	0.778	1.531	6	- 2.306
7	24	0.845	1.380	7	- 2.247
8	14	0.903	1.146	8	- 2.265
9	7	0.954	0.845	9	- 2.356
10	8	1.000	0.903	10	- 2.353
11	4	1.041	0.602	11	- 2.419
12	7	1.079	0.845	12	- 2.366
13	7	1.114	0.845	13	- 2.304
14	5	1.146	0.699	14	- 2.275
15	7	1.176	0.845	15	- 2.204
16	3	1.204	0.477	16	- 2.213
17	5	1.230	0.699	17	- 2.166
18	3	1.255	0.477	18	- 2.158
19	2	1.279	0.301	19	- 2.173
21	1	1.322	0.000	20	- 2.220
22	1	1.342	0.000	21	- 2.253
24	1	1.380	0.000	22	- 2.268
25	2	1.398	0.301	23	- 2.231
26	2	1.415	0.301	24	- 2.196
27	1	1.431	0.000	25	- 2.199
30	1	1.477	0.000	26	- 2.189
38	1	1.580	0.000	27	- 2.148
42	1	1.623	0.000	28	- 2.100
46	1	1.663	0.000	29	- 2.048
Sum	2521			Average	- 2.252

Appendix B: Article citation frequencies. Calculation of Lotka's exponent, n, *Proceedings of the Oklahoma Academy of Science* 1921-2000.

x Citations	y Articles	X log x	Y log y	N Data points	n $n = \frac{N\Sigma XY - \Sigma X\Sigma Y}{N\Sigma X^2 - (\Sigma X)^2}$
1	296	0.000	2.471		
2	86	0.301	1.934	2	- 1.783
3	35	0.477	1.544	3	- 1.926
4	21	0.602	1.322	4	- 1.927
5	12	0.699	1.079	5	- 1.980
6	5	0.778	0.699	6	- 2.165
7	1	0.845	0.000	7	- 2.588
8	3	0.903	0.477	8	- 2.512
9	1	0.954	0.000	9	- 2.615
10	3	1.000	0.477	10	- 2.457
11	3	1.041	0.477	11	- 2.316
12	1	1.079	0.000	12	- 2.332
Sum	467			Average	- 2.236

Appendix C: Author citation frequency. Calculation of Lotka's exponent, n, *Proceedings of the Oklahoma Academy of Science* 1921-2000.

x Citations	y Authors	X log x	Y log y	N Data points	n $n = \frac{N\Sigma XY - \Sigma X\Sigma Y}{N\Sigma X^2 - (\Sigma X)^2}$
1	316	0.000	2.500		
2	130	0.301	2.114	2	- 1.281
3	60	0.477	1.778	3	- 1.487
4	31	0.602	1.491	4	- 1.650
5	28	0.699	1.447	5	- 1.594
6	15	0.778	1.176	6	- 1.676
7	10	0.845	1.000	7	- 1.755
8	6	0.903	0.778	8	- 1.860
9	4	0.954	0.602	9	- 1.959
10	5	1.000	0.699	10	- 1.953
11	6	1.041	0.778	11	- 1.895
12	2	1.079	0.301	12	- 1.976
13	1	1.114	0.000	13	- 2.098
14	1	1.146	0.000	14	- 2.174
15	1	1.176	0.000	15	- 2.217
17	1	1.230	0.000	16	- 2.226
18	1	1.255	0.000	17	- 2.222
21	1	1.322	0.000	18	- 2.188
22	2	1.342	0.301	19	- 2.098
23	1	1.362	0.000	20	- 2.070
30	1	1.477	0.000	21	- 2.000
Sum	623			Average	- 1.919