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Hui Lin

Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore

Brendan Luyt

Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore

Abstract

In order to analyse the development of a scientific journal in the academic periphery, a case study of the *Raffles Bulletin of Zoology* (RBZ), published in Singapore 1928–2008, was conducted. A combination of quantitative and qualitative methods was deployed. Quantitatively, statistics on various aspects of journal articles in RBZ were collected and analysed. Qualitatively, schematic structures of journal articles in the RBZ were coded and documented via Swales's move analysis. It was found that the development of the RBZ could be divided into three stages: a rudimentary period, transitional period and current period. Various factors that shaped the evolution of RBZ for the past 80 years are discussed, including the social and political context of Singapore, changes in scientific perspectives, the efforts of editors, information organization and retrieval, as well as changing scientific communities. It is argued that a longitudinal study of journal articles in the academic periphery enhances our understanding of: (1) the adaptive nature of knowledge production, organization, use and retrieval in various knowledge domains; (2) the importance of understanding the interplay between social factors in the scientific communication process; and (3) the increasing demand for the provision of efficient and effective information systems to meet the pressing need of information organization and retrieval.

Keywords

domain-analytic approach; genre studies; information organization and retrieval; move analysis; scientific communication; social factors; scientific journals

1. Introduction

As part of the domain-analytic approach, Hjørland [1] suggested the use of genre studies for a better understanding of the organization and structure of various documents in a domain. In his review of genre-related research in library and information studies, Andersen [2] pointed out the neglect of genre-related research within library and information studies and called for LIS to 'take up genre theory as a central research approach'. The gap that Andersen [2] noted is unfortunate because library and information science is interested in the organization of documented knowledge and genre theory provides a means for the systematic examination and study of the production, use and organization of documents [2]. This paper presents a genre study of the evolution of one scientific journal, illustrating the view of the scientific community at multiple points in time [3]. Through a genre study, this paper aims to show how scientific information and knowledge are codified, regulated and altered by scientists [2]. The result of the study can shed some light on knowledge organization and behaviours of scientific communities.

Corresponding author:

Hui Lin, Wee Kim Wee School of Communication and Information, Nanyang Technological University, Singapore.
Email: linh0017@e.ntu.edu.sg

2. Scientific journals

Since 1665, the year of publication of the first two scientific journals *Journal des Scavans* (in Paris) and *Philosophical Transactions* (in London), scientific journals have been in a state of constant change. As late as 1900, some of the most respected journals contained articles that would look very out of place today [4]. Research work has been undertaken to analyse such differences so as to better understand changes within the scientific community as a whole. Katzen [5] used *Philosophical Transactions* as a case study and analysed its change of appearance from 1665 to 1959, covering various aspects such as periodicity, accurate dating of issues (whether the publication date corresponded to the printed date), general features, content, index, text materials and presentation. Citing examples from various sources, Harmon [6] provided a historical overview of how various elements (for example, title, abstract, introduction, experimental details, results and discussion, conclusion, acknowledgments and references) of scientific and engineering papers evolved. Harmon [7] also reported on the development of the scientific paper, using a four-stage model that accounted for change over 300 years, documenting the changes in terms of audience, writing style, topical structure and use of language. In a study of articles from four leading medical journals during the period 1935–1985, Sollaci and Pereira [8] identified the point when the IMRAD (introduction, methods, results, and discussion) structure became widely used in medical scientific writing. Through a longitudinal analysis of references, Allen et al. [9] recorded changes in references in the *Philosophical Transactions of the Royal Society* from 1665 to 1990 in terms of style, materials cited, origin of cited materials, languages of cited materials, among other characteristics. Using the methods of statistics and close reading, Bazerman [10] conducted a historical study of articles in *Physical Review* and demonstrated how the evolution of the journal articles was strongly influenced by a common theory. In his study of the *Philosophical Transactions* of the Royal Society of London (PTRSL), Atkinson [11] demonstrated how the evolution of PTRSL was closely related to the development of its institution (The Royal Society) and scientific development in the UK. Through an analysis of short passages and whole articles in scientific journals from the seventeenth to the twentieth century, Gross et al. [12] studied the evolution of journal articles in terms of style, presentation and argument, and suggested selection theory to explain the development of journal articles over the years.

As one of the most privileged genres in the publishing world, the scientific journal article has captured attention and interest from researchers, especially in linguistics; however, LIS researchers have not paid much attention to this area yet. So far most of the research on the evolution of scientific journal articles focuses on journals published in European and North American countries (currently and for the past few hundred years the centre of the academic world). Little research has been done on the evolution of scientific journals published in the academic periphery, such as Asian countries, whose modern scientific development lagged behind Europe and the United States. This study examines the *Raffles Bulletin of Zoology* (RBZ), a journal published in Singapore, part of the academic periphery with a relatively short history in science. Basically the main research question addressed in this study is ‘How does the structure of journal articles in the *Raffles Bulletin of Zoology* evolve over the years?’

3. Method

The research method used here is a case study with a mixed-method design (a combination of quantitative and qualitative approaches) [13]. Statistics on various aspects of journal articles in the RBZ were collected and analysed, while the schematic structure of research articles in the RBZ was coded and documented via Swales’s move analysis. This study covered the journal articles for an 80-year period (1928–2008) divided into three periods derived from the various changes of name of the journal: *Bulletin of the Raffles Museum* (1928–1960), *Bulletin of the National Museum* (1961–1970) and *Raffles Bulletin of Zoology* (1988–2008) [14].

Kanoksilapatham’s [15] analysis of biochemistry research articles and Nwogu’s [16] analysis of medical research articles confirmed that the IMRD topical structure was the dominant form for contemporary research articles in natural science. For the present research, a hypothesis was made that journal articles in the RBZ would slowly evolve into the common IMRD topical structure. Current instructions to authors wishing to write for the RBZ require manuscripts to be arranged in sections such as introduction, materials and methods, taxonomy or systematics, results, discussion, acknowledgements and literature cited [17] (at first sight, taxonomy or systematics seems to be a unique section in zoology; however, a closer reading reveals that they are equivalent to results sections). Based on our hypothesis concerning the RBZ’s evolution and interpretation of its topical structure, articles in the RBZ were studied according to the common structure with three major parts: front matter (including title, author, abstract and keywords), main body (consisting of IMRD topical structure) and back matter (including acknowledgements and literature cited).

Table 1. Journal articles in the RBZ sampled for study under Section 3.1

Title of journal	Year range	Number of articles
<i>Bulletin of the Raffles Museum</i>	1928–1961	48
<i>Bulletin of the National Museum</i>	1961–1967	10
<i>Raffles Bulletin of Zoology</i>	1988–2008	137
Total		195

3.1. Quantitative approach

The total number of articles published in the RBZ from 1928 to 2008 stands at 1172. All were marked in number from 1 to 1172. Systematic sampling was deployed to gather 20% of the 1172 articles by using a sampling interval of 5, which produced a set of 235 articles. Within these 235 articles, there was a mixture of research articles, non-research articles (for example, book reviews or editorials), articles in languages other than English and articles in English with the error message ‘insufficient data for an image’ (the articles were retrieved from an online database). A further selection was conducted to make sure that the selected samples were research articles in English without errors in downloading, which resulted in a final total of 195 articles as shown in Table 1.

Statistics on FIMRDB were collected for the 195 articles (F: front matter, including title, author, abstract and keywords; I: Introduction section; M: Methods section; R: Results section; D: Discussion section; and B: back matter, including acknowledgements and literature cited). For those earlier journal articles in the RBZ without section headings, the headings were ‘assigned’ based on the content of paragraphs as well as their context. Non-textual information was also collected, including the number of the drawings, photos, microscope images, charts, maps and tables.

3.2. Qualitative approach

Swales’s move analysis was selected as a qualitative approach for this study. In his work, the general organizational patterns of texts are typically described as moves [18]. Essentially text segments are categorized or classified into different schematic moves depending on their communicative purpose. Swales’s move analysis is a very useful tool as it not only provides valuable insights into the nature of academic writing in terms of the schematic structure of research articles, as confirmed by previous research [15, 16, 19–22], but also facilitates the detection of changes for the study of the evolution of academic writing as noted by Dudley-Evans and Henderson [23].

The number of journal articles from the three periods of the RBZ varies greatly. To provide a representative picture of what each period looked like, systematic sampling was deployed to obtain journal articles from the previous batch of samples as per Section 3.1, resulting in 10 articles from each period and 30 articles in total, roughly evenly spread over 80 years from 1928 to 2008, as shown in Table 2.

Move analysis was conducted on the main body (IMRD topical structure) of these journal articles. In move analysis, text segments are classified into moves and each move is further categorized into the steps or sub-moves. In our approach, the steps or sub-moves were not analysed. Instead the steps or sub-moves mentioned by Swales [24],

Table 2. Journal articles in the RBZ sampled for study under Section 3.2

<i>Bulletin of the Raffles Museum</i>		<i>Bulletin of the National Museum</i>		<i>Raffles Bulletin of Zoology</i>	
Serial number	Year	Serial number	Year	Serial number	Year
1	1928	11	1961	21	1988
2	1931	12	1961	22	1992
3	1932	13	1963	23	1995
4	1934	14	1963	24	1997
5	1936	15	1965–1967	25	1999
6	1941	16	1965–1967	26	2001
7	1949	17	1965–1967	27	2003
8	1950	18	1965–1967	28	2005
9	1954	19	1966	29	2007
10	1956	20	1966	30	2008

Nwogu [16] and Kanoksilapatham [15] were used as semantic clues, which enabled the classification of text segments. In this regard, a functional-semantic approach as suggested by Kwan [25] was used to identify the moves themselves so that the researchers' cognitive judgment was used to divide the texts into the move segments [26]. This approach is in agreement with the theoretical assumption of a move in the sense that a move has both a local and overall rhetorical purpose in the text [25]. The moves identified by Swales [24], Nwogu [16] and Kanoksilapatham [15] were used as a starting point for analysis as shown in Table 3. New moves were developed when none of the existing moves could be applied to a particular text segment.

Table 3. Moves used as starting point in the study under Section 3.2

Moves in introduction (I)	Semantic clues
Move I1 Establishing a territory	Claiming centrality Making topic generalization Reviewing items of previous research
Move I2 Establishing a niche	Counter-claiming Indicating a gap Question-raising Continuing a tradition
Move I3 Occupying the niche	Outlining purpose Announcing present research Announcing principle findings
Moves in methods (M)	Semantic clues
Move M1 Describing material	Listing materials Detailing the source of the materials Providing the background of the materials
Move M2 Describing experimental procedure	Identifying equipment Documenting established procedures Detailing procedures Providing the background of the procedures
Move M3 Describing data-analysis procedure	Defining terminologies Indicating process of data classification Identifying analytical instrument/procedure Indicating modification to instrument/procedure
Moves in results (R)	Semantic clues
Move R1 Stating results	Highlighting overall results Indicating specific results Indicating consistent observation Indicating inconsistent observation
Move R2 Stating comments on the results	Explaining the results Making generalizations or interpretations of the results Evaluating the current findings Stating limitations Summarizing
Moves in Discussion (D)	Semantic clues
Move D1 Contextualizing the study	Describing established knowledge Presenting generalizations, claims, deduction, or research gaps
Move D2 Consolidating results	Restating methodology (purposes, research questions, hypotheses restated, and procedures) Stating selected findings Referring to previous literature Explaining difference in findings Making claims or generalization Exemplifying
Move D3 Stating limitation of the study	Stating limitation about the findings Stating limitation about the methodology Stating limitation about the claims
Move D4 Stating research conclusion	Indicating research implications Promoting further research

4. Findings

4.1. Evolution of journal articles in the RBZ in terms of the general structure, use of section headings and non-textual information

4.1.1. Changes in the general structure in terms of FIMRDB. Contributors to the *Bulletin of the Raffles Museum* used 10 different general structures, with the frequency of use of each ranging from 4.17 to 39.58%. Four different general structures were used by the contributors of the *Bulletin of the National Museum*, with the frequency of use of each ranging from 10.00 to 50.00%. The contributors of the *Raffles Bulletin of Zoology* used five different general structures, with the frequency of use of each ranging from 0.73 to 34.31%. Although many different structures were used by contributors of the RBZ over the years, there were four structures, namely FIMRB, FIMRDB, FIRB and FIRDB, that were consistently used from the early years of the RBZ. The usage rate of FIMRB and FIMRDB increased while the usage rate of FIRB and FIRDB decreased over time.

4.1.2. Changes in the components of the front matter. The front matter in the majority of articles (95.86%) in the *Bulletin of the Raffles Museum* consisted of title and author. The rest (4.17%) of the articles in the *Bulletin of the Raffles Museum* did not have title and author as part of the front matter. All articles (100.00%) in the *Bulletin of the National Museum* had title and authors as their front matter. The *Raffles Bulletin of Zoology* had 30.66% of articles with title, author and abstract and 69.34% of articles with title, author and keywords.

4.1.3. Changes in the components of the back matter. The *Bulletin of the Raffles Museum* had as many as 64.58% of articles without acknowledgements, 31.24% of articles with acknowledgements embedded in other sections and only 4.17% of articles with acknowledgements as an independent section. For the *Bulletin of the National Museum*, 60% of articles did not have acknowledgements, 10% of the articles had acknowledgements that were embedded in other sections and 30% of the articles had acknowledgements as an independent section. The majority of articles (98.54%) in the *Raffles Bulletin of Zoology* had acknowledgements as an independent section, leaving 1.46% articles without acknowledgements.

Different citation styles were used during the different periods of the RBZ. It was found that 10.42% of articles in the *Bulletin of the Raffles Museum* had no citation. Contributors of the *Bulletin of the Raffles Museum* formatted their citations in various ways: in-text citation (22.92%), footnote citation (10.42%), endnote citation (25.00%), a combination of in-text and footnote citation (14.58%), a combination of in-text and endnote citation (10.42%), a combination of footnote and endnote citation (2.08%), as well as a combination of in-text, footnote and endnote citation (4.17%). Contributors of the *Bulletin of the National Museum* formatted citations in two ways: endnote citation (90.00%) and a combination of in-text and endnote citation (10.00%). The majority (97.81%) of articles in the *Raffles Bulletin of Zoology* adopted endnote citations, while the rest (2.19%) of the articles used a combination of in-text and endnote citations. Over the years, endnote citation gained popularity, while the other approaches slowly disappeared.

4.1.4. Changes in the use of section headings. The use of section headings increased dramatically over the years. Only 18.75% of the articles in the *Bulletin of the Raffles Museum* included headings, compared with 70.00% of the articles in the *Bulletin of the National Museum* and 97.08% in the *Raffles Bulletin of Zoology*. The usage rate of various sets of section headings (for example, some articles used 'introduction, materials and methods, results, discussion, acknowledgement, literature cited' while other articles used 'introduction, methods, results, discussion, acknowledgement, literature cited') had the range from the lowest 0.75% to the highest 28.57%, which means that no particular set of section headings won the favour of the authors of the RBZ to become a conventional set.

4.1.5. Changes in the use of non-textual information. There were five types of non-textual information in the *Bulletin of Raffles Museum*, including drawings (30.80%), photos (20.91%), charts (6.46%), maps (4.56%) and tables (37.26%). Contributors of the *Bulletin of the National Museum* used two types of non-textual information: drawings (41.94%) and tables (58.06%). There were six different types of non-textual information in the *Raffles Bulletin of Zoology*: drawings (40.73%), photos (32.90%), microscope images (5.50%), charts (4.38%), maps (5.31%) and tables (11.18%).

4.2. Evolution of journal articles in the RBZ in terms of schematic structure

Table 4 shows the revised analytical framework based on a combination of the list of moves in Table 3, the newly identified moves (M4 and B1) as well as those moves in Table 3 that are not found in the move analysis of 30 articles (D1 and D3).

Table 4. Revised analytical framework used in the move analysis of the RBZ

Move	Semantic clues
Move I1 Establishing a territory	Claiming centrality Making topic generalization Reviewing items of previous research
Move I2 Establishing a niche	Counter-claiming Indicating a gap Question-raising Continuing a tradition
Move I3 Occupying the niche	Outlining purpose Announcing present research Announcing principle findings
Move M1 Describing material	Listing materials Detailing the source of the materials Providing the background of the materials
Move M2 Describing experimental procedure	Identifying equipment Documenting established procedures Detailing procedures Providing the background of the procedures
Move M3 Describing data-analysis procedure	Defining terminologies Indicating process of data classification Identifying analytical instrument/procedure Indicating modification to instrument/procedure
Move M4 Describing the illustration-making procedure	Identifying equipment Detailing procedure
Move R1 Stating results	Highlighting overall results Indicating specific results Indicating consistent observation Indicating inconsistent observation
Move R2 Stating comments on the results	Explaining the results Making generalizations or interpretations of the results Evaluating the current findings Stating limitations Summarizing
Move D2 Consolidating results	Restating methodology (purposes, research questions, hypotheses restated, and procedures) Stating selected findings Referring to previous literature Explaining difference in findings Making claims or generalization Exemplifying
Move D4 Stating research conclusion	Indicating research implications Promoting further research
Move B1 Expressing acknowledgements	Expressing acknowledgements

Appendices A, B and C show the detailed schematic structure of the 30 articles sampled in this study (see Table 2). The variety of moves changed over the years; however, some move patterns were found to repeatedly appear in the *Bulletin of the Raffles Museum*, the *Bulletin of the National Museum* and the *Raffles Bulletin of Zoology*, as shown in Appendix D.

5. Discussion

Over the past 80 years, how has the RBZ evolved? What are some of the factors that have contributed to the evolution of the RBZ? The following sections discuss the findings of the study of the RBZ, presenting a three-stage model of its development as well as a number of potential factors likely to have shaped its evolution.

5.1. Three-stage development of the evolution of the RBZ

Over the period of time under consideration here (1928–2008) the RBZ underwent dramatic changes. The following sections elaborate on the nature of these changes.

5.1.1. Stage one (1928–1960): rudimentary period. During this stage the journal was named *Bulleti of the Raffles Museum*. The major features of the articles in this stage were simplicity and eclecticism.

- Most (87.50%) of the articles used a simple general structure, among which included FIR, FIRB, FR, FI, FIMRB, FIRD, FIRDB, FRB and I.
- Front matter consisted of only the title and author, but a little over 4% of the articles did not have even these elements. Abstracts and key words were entirely absent.
- The move analysis showed that authors developed their thoughts in a simple and unsophisticated manner. Authors did not provide much background information in the introduction section; as a result, many articles either did not have moves in the introduction section or only used simple moves with a combination of other moves that were supposed to appear in other sections instead of the introduction section. For example, Article 7 used I3-B1-I3 in its introduction. These findings are similar to those of Sollaci and Pereira [8], who discovered in their study of early medical journals that the order in which sections appeared and their content were different from modern medical journal articles; in their words, ‘information, which today is highly standardized in one section, would be absent, repeated, or dispersed among sections in earlier articles’. Most authors in the RBZ in this stage also seemed to list results without detailed discussion about their new species findings as only one out of 10 articles had a specific section devoted to more detailed discussion. The authors in this stage paid more attention to description than explanation when writing their journal articles, a situation very similar to the very first scientific journal articles (1665–1765), as observed by Harmon [7], who noted that: ‘by and large, authors of these papers describe their, or someone else’s research results and observation ... report straightforward observation such as ... descriptions of exotic flora and fauna ...’.

The eclecticism of journal articles in stage one can be seen from the following:

- The authors of the RBZ used as many as 10 different types of general structures.
- The authors used different citation styles, including in-text citation, footnote citation, endnote citation, and so on. The citations could be found throughout the articles.
- Most (81.25%) of the articles did not use any section headings. Section headings are important in that they give the readers a sense of position within the overall structure of the article as well as providing hints of what will happen next. Without the guidance of section headings, readers may become confused and lost within the long accounts in the article. They are also forced to read the article from beginning to end, without the choice of skipping certain sections and going straight to important or interesting parts, which greatly slows down the overall reading process.
- The results of the move analysis showed that authors used different strategies to compose a single section (for example, introduction or results section) in the article. For example, the author of article 6 used 10 different move patterns for the results section. Move patterns show how the author organized their fluid thoughts into fixed words. Such variety of move patterns reflects a lack of systematic approach to composition. This way of composing articles might have seemed convenient for writers during the period and readers at that time would also have viewed them as natural. But it is a daunting and confusing experience for modern readers to handle the variety of move patterns used in the same article and from one article to another as it violates their expectations.

5.1.2. Stage two (1961–1970): transitional period. The journal was named *Bulletin of the National Museum* during this period. Compared with journal articles in stage one, the journal articles in stage two start to show signs of modern sophistication and order.

Signs of sophistication in the journal articles of stage two are found in the following:

- In this stage, the authors of the RBZ only selected four out of the original 10 general structures. These chosen general structures were also more complex. The authors seemed to favour two general structures (80% for FIRB and FIRDB) and seldom used FIMRDB (10%).
- All the articles provided titles and authors in the front matter; however, abstract and keywords were still not in use.
- Compared with seven different citation styles in the first stage, the majority of the journal articles (90%) adopted endnotes as the citation style of choice.

- The majority (70%) of journal articles used section headings, a 52.25% increase compared with journal articles in stage one.
- The authors tended to use fewer move patterns in their journal articles. This showed that the authors became more skillful and professional in the sense that they started to think more systematically. As a result it reduced the variation of moves used in the articles, which helped readers easily digest the information. Unlike the orientation towards description found in stage one, authors during this period started to focus on explanations as shown from the increased use of moves in the discussion section, which reflected the increased complexity of the authors' thoughts.

Signs of order in journal articles in stage two could be found in the following:

- Only four out of 10 general structures adopted in the previous stage were used in stage two. Furthermore, two (80% for FIRB and FIRDB) out of the four general structures were much more widely used. Such a reduction in general structures produced a more homogeneous appearance; as a result, it created an impression that the articles in this period were more organized than those that came before.
- Endnote citation became the major citation style widely used by authors, imposing an increased uniformity on the physical appearance of the articles.

5.1.3. Stage three (1988–2008): current period. Compared with the previous two stages, the journal articles in stage three showed an increased degree of sophistication, order and professionalization.

The sophistication of journal articles in stage three can be gauged from the following:

- FIMRDB was used in 34.31% of the articles, which is a 243.10% increase compared with articles with the same general structure in stage two. When compared with Sollaci and Pereira's [8] study of medical journal articles, this is a rather slow transition. According to them [8], the standardized structure, i.e. introduction, methods, results and discussion, was fully adopted by the four leading medical journals during the 1980s.
- During this stage, the components of the front matter were not limited to title and author. From 1988 to 1996, the abstract became part of the front matter together with title and author. The appearance of the abstract in the RBZ is more than 20 years late compared with Harmon's [7] observation that abstracts were widely used in scientific papers in the 1960s. Starting from 1997, keywords were added to the front matter. With the new components, especially the abstract, the front matter became more and more important in the sense that it started to play an important role in the organization of the information inside the body of the article as it is the main section that attracts the attention of potential readers and helps them decide whether to continue reading [6]. With the help of concise information in the front matter, readers could decide the relevance of the article in a timely manner, which would greatly increase the effectiveness and efficiency of their literature search, especially when facing the ever-increasing amount of literature in their field.
- Section headings achieved popularity during this stage as the majority (97.08%) of journal articles in this stage used them. Although there is criticism that the modern scientific paper is monotonous and uninteresting, or, in Harmon's [7] words, 'it's about as stylized and dull as a police report', the headings used by authors at this stage showed great diversity. For example one article uses the headings 'introduction, materials and methods, examination and comparisons, discussion, acknowledgement, literature cited' while another uses the headings 'introduction, materials and methods, observation and results, discussion, acknowledgement, literature cited'. That the practice of including section headings became a norm for the RBZ suggests their popularity, perhaps, as Gross et al. [12] note, because they possessed the ability to 'facilitate the tracking of intellectual content' [12]. Unlike readers of articles during the first stage of the journal's existence, who had to read from beginning to end, now equipped with the section headings, readers could skip sections when they wanted to or go directly to a particular desired section, greatly improving the speed of the reading process.
- The results of the move analysis during stage three revealed that authors started to systematically transform their thoughts into words in a more sophisticated manner. Unlike the simple move pattern used in earlier stages, long and complex move patterns started to appear. For example, the introduction section of article number 21 used the move pattern of I1-I2-I1-I2-I1-I2-I1-I3. Differing from the variety of move patterns used in the results section during the previous two stages, authors at this stage started to use fewer move patterns, which showed that the authors organized their thoughts more systematically.

The imposition of order among the articles in stage three can be seen in the following:

- Although scientists started to express their acknowledgements in their papers regularly in the middle of the nineteenth century [6], only a small number of the early articles of the RBZ had acknowledgements. The percentage of such acknowledgements as an individual section was low in stage one (4.17%) and stage two (30%). In stage three, the majority (98.54%) of the number of articles had acknowledgements as a section with heading, which showed an increased level of organization leading to an increasing degree of orderliness.
- Except for the occasional appearance (three articles or 2.19%) of a combination of in-text and endnote citations, endnote citation has been the conventional citation style for the authors of the RBZ since 1996. A change from in-text and footnote citation to endnote citation was also found by Harmon [6], who attributed it to the rise in the number of references per article. In Allen et al.'s [9] longitudinal analysis of references in the *Philosophical Transactions of the Royal Society*, the endnote citation was found to achieve 100% dominance as early as 1940. They suggested that such changes were the result of a growing persuasive community [9].

The professionalization of journal articles in stage three is indicated by the following:

- As an integral part of reporting research results, non-textual information, especially images, act as a complement to the text, often providing more concise detail [5]. Similar to Harmon's [6] observation on how researchers changed from drawing to various clever ways of visual representation of the technical information in their experimental papers, the non-textual information used by the authors of the RBZ changed during the different periods. In earlier stages, the images – one type of non-textual information – consisted of drawings and photos. In stage three, a new type of image, that is, microscope images, appeared in the articles. The microscope images were far more detailed than simple drawings and photos. The use of the microscope images enabled the study and understanding of the natural world in a much more refined and specialized way. The detailed microscope images created a divide in terms of interpretation because the specialized knowledge needed for understanding these images made it difficult for amateurs to participate in scientific work in the same way that professionals did. Thus, they drove further a wedge between amateurs and those capable of devoting their careers to scientific work.
- In his study of the evolution of American ornithology discourse, Battalio [27] noticed the increasing use of an acknowledgements section over the years and attributed it to a self-awareness of collegiality and professionalism by the ornithologists. The use of acknowledgements in the RBZ as an individual section dramatically increased from 4.17% in stage one to 30% in stage two and then 98.54% in stage three. Such a dramatic increase can be similarly interpreted as suggesting the growth of a scientific community in zoology in terms of size and professionalization.
- In the previous two stages, the authors tended to neglect the methods section. A minority of the articles in earlier stages (one article in stage one and two articles in stage two) devoted an individual section to methods. In stage three, the number of articles with methods section dramatically increased to seven. Beside the increase in quantity, the move pattern became much more complicated. For example, article number 27 used M2-M3-M1-M3 in its methods section. The complexity of move patterns in the methods section during this stage reflected that the authors started to pay more attention to the methods of research. In other words, methods, or scientific methods to be exact, became more and more important for the authors of the RBZ in their research area, which was a good indication of the specialization of the research work. The same phenomenon was observed in the evolution of American ornithological discourse [27].

5.2. Factors that have shaped the evolution of the RBZ

The following section will discuss a number of possible contributory factors to the evolution of the RBZ over the years, including the social and political context of Singapore, changes in scientific perspectives, the efforts of editors, information organization and retrieval, as well as changing scientific communities.

5.2.1. The social and political context of Singapore. The social and political context is an important factor in understanding the development of the RBZ. Launched in 1928, at the peak of the British Empire, the RBZ was initially a vehicle to publish the findings of the museum staff working in different areas of zoology. As such it belonged to the complex of

institutions established by the Empire to further its own economic and geo-strategic interests in creating knowledge about the territories under imperial control as well as demonstrating this knowledge to local people.

With independence (first as a part of Malaya) and later as a separate country, Singapore's need for this kind of knowledge rapidly dissipated. The museum quickly altered its focus to ethnology, history, and art in line with the new nation's need to understand itself rather than the natural world. The RBZ was, as a result, given up to the University of Singapore's Department of Zoology, which itself maintained a precarious existence, as the needs of economic nation-building took precedence over the esoteric pursuit of knowledge. However, all was not bleak, for the expansion of secondary and tertiary education in Singapore at this time provided the seeds for future growth of the RBZ from the early 1990s onwards. Those were the years that the environmental movement came of age around the world and with that a renewed focus on the natural world in Singapore.

In 1992, when the Earth Summit took place, Tommy Koh from Singapore was appointed as Chairman of the preparatory and main committees, resulting in Singapore's commitment to nature conservation arousing much attention [28]. The Singapore Green Plan with a vision of a Singapore as a model Green City was presented at the Earth Summit, promising 5% of the land for nature conservation [28–30]. The inclusion of nature conservation as part of environment policy by the Singapore Government fostered a greater research focus and interest in taxonomy, ecology and conservation biology. The editorial board of the RBZ was reorganized in 1996, bringing in new members with a background in ecology and conservation biology [31, 32]. With the reorganization of the editorial board for the promotion of animal ecology, more and more papers on conservation and ecology were published in the RBZ from 1996. Starting from 2007, the table of contents in the RBZ was grouped into three main categories, including taxonomy and systematics, conservation and ecology, and book reviews. Over 80 years after its inception, the RBZ changed from beginning a journal on the study of zoology and natural history of Malaya [33] to a peer-reviewed journal on taxonomy, ecology and conservation geology of animals from Southeast Asia and its adjacent areas [34]. It was in the forefront of the green movement, encouraged by the government environmental policy, that the RBZ found its identity and mission and was successfully transformed.

5.2.2. Changes in scientific perspectives. To explain the relationship between natural history and theoretical science, Killingsworth and Palmer [35] developed a continuum from natural history to theoretical science divided into six sequential stages: observing in [the] field (the extreme of natural history), observing and measuring in [the] field, manipulating in [the] field, manipulating in semi-natural conditions, bringing system[s] into the laboratory, and finally theoretical systems, manipulation with numbers and computer models (the extreme of theoretical science). Based on his study of the evolution of American ornithological discourse, Battalio [27] confirmed the stages in Killingsworth and Palmer's [35] continuum but with a slight change, introducing a new stage, namely 'collecting specimens', between 'observing in [the] field' and 'observing and measuring in [the] field'.

Similar to Battalio's [27] observation of how the changes in scientific perspectives on nature influenced the development of American ornithological discourse, study of the RBZ shows that the change from natural history to theoretical science has played a part in the evolution of journal articles in the RBZ. In the early years, many contributors to the RBZ were staff of the Raffles Museum and journal articles of the RBZ tended to report the results of their collecting expeditions. As discussed in Section 5.1.1, most authors in the RBZ during stage one wrote up their results without detailed discussion. There was only one out of 10 articles with a specific section devoted to more detailed discussion. It would seem that these early years of the RBZ inclined towards the natural history end of the spectrum with journal articles documenting such activities (for example, observing, collecting and measuring specimens) in the field with the main focus on the results section. The institutional change from the Raffles Museum to the National University of Singapore saw a change in scientific perspective, from natural history to theoretical science. The students in the Zoological Department at the National University of Singapore were also contributors to the RBZ. These students followed the dominant paradigm of the time [36] as a result of the rigorous education they were exposed to in the University. With the professionalization and dominance of theoretical science in zoology, the writing of the RBZ also became more professionalized in terms of the development of a standardized article structure, use of headings, acknowledgements and citations. As discussed in Section 5.1.3, there was an increased number of articles with moves in the method section in stage three compared with the previous two stages. With the increased emphasis on method as a result of the movement towards the theoretical science, more space was devoted to methodology in the later years in the journal articles of the RBZ. The changing approach from natural history to theoretical science in zoology influenced how journal articles in the RBZ were written; in return, the changing appearance of journal articles in the RBZ documented such influence.

5.2.3. The efforts of editors. The editorial function is very important in shaping a definitive public version of a work as the editor is ideally intimately connected with the author right from the submission of the manuscript to the final published

article [5]. For example, in their analysis of why medical articles completely adopted the full topical structure in the 1980s, Sollaci and Pereira [8] attributed their findings to Huth's (as cited in Sollaci and Pereira [8]) claim that, for the benefit of the reader as well as effective and efficient peer review, the editors required that all papers should be clearly formatted.

Similar to Sollaci and Pereira's [8] finding on the role of editors in shaping the formal structure of medical articles, continuous editorial efforts from the RBZ editorial staff clearly have left their mark on the journal articles of the RBZ. When the Department of Zoology in the National University of Singapore started to fund the RBZ in 1991, editorial staff revised their policy, aiming to publish the RBZ as a top-quality international scientific journal [34]. In the following years, the editorial staff took various actions [17, 34, 37] in order to improve the quality and impact of the RBZ including:

- Regular review of editorial structure and invitation of international experts to sit on the editorial board.
- Mandatory practice of peer review of manuscript by international experts.
- Inclusion of the RBZ in the Institute of Scientific Information (ISI) database in 1995 as well as other international scientific abstract services, for example, Cambridge Scientific Abstracts.
- Transformation of the RBZ into an open access online journal so as to reach a wider audience and increase its influence and impact.
- Detailed instructions on the RBZ website for the authors who submit their manuscripts for publication. For example, the website gave instruction in great detail to the authors on how to present their manuscripts with 11 sections in total, including (1) manuscript preparation, (2) title, authors and abstract, (3) citations in the text, (4) taxonomic papers, (5) material and methods, (6) material examined, (7) literature cited, (8) tables, (9) illustrations, (10) special requirements for corrected manuscripts, (11) long manuscripts.

Clearly, the involvement of the editorial staff in publishing the journal articles of the RBZ from manuscript submission to peer review to final publication must have played an important role in getting authors to adopt a more conventional presentation format.

5.2.4. Information organization and retrieval. Besides being a medium for recording research results, the journal also provides the means for the organization and retrieval of scientific information [5]. Over the years, scientific journal articles have rapidly grown in numbers. At the same time, the number of scientists is still growing, which suggests an even higher number of articles in the future. Facing the difficulty of getting the desired information from the mass of scientific literature, scientists have been using abstracts and indexes since the nineteenth century, which has helped overcome the difficulties caused by a growing number of articles [38].

The journal articles published in the early years of the RBZ only used authors and titles for identification of their publications. The use of abstracts and keywords started in 1988 and 1997, respectively. One reason for the lack of abstracts in the early years of the RBZ may be due to the fact that there was no demand for them since the number of articles in the RBZ was still manageable from an information retrieval perspective. The early RBZ aimed to publish papers whenever there were enough to form a volume and it had a problem accumulating the necessary number [33]. The changes in the institution eventually resolved the problem of insufficient papers in 1993 [34]. With the increasing number of articles in the RBZ, the use of abstracts and keywords became a necessary part of the RBZ as conventional devices for effective and efficient information organization and retrieval. In a way, the history of these conventional devices built into primary journals over the years can be viewed as a history in which various tools were constructed for the purpose of effective and efficient description, organization, navigation and retrieval of scientific information [5].

5.2.5. Changing scientific communities. As members of the scientific community, scientists highly value journal articles. It is the scientists who shape the journal articles but at the same time, by conforming to the conventional rules of the scientific community, scientists are also shaped by the journal articles. The writers of the RBZ belong to the same scientific community and hence share interpretive strategies for writing texts as defined by Fish [39]. Interpretive strategies can be viewed as the collective agreement of the community so that it is conventional for the members to see 'everything in relation to the community's assumed purpose and goals' [39]. They involve conventional ways of thinking by the members of the community in a particular context in a particular time period. Owing to their nature as social constructs, interpretive strategies change as a result of the interplay of various social factors. By using the same interpretive strategies, the writers of the RBZ could compose similar prose at during the same period of time, but also change the articulation of their prose over time because of the influence of the various factors mentioned previously.

On one hand, interpretative strategies play a part in helping writers of the RBZ compose journal articles in a specific way; on the other hand, the writers themselves have changed over the years, which also contributed to the changes in the articles of the RBZ. Similar to Battalio's [27] observation that the early contributors to American ornithological discourse were a mixture of amateur and professional ornithologists, writers of the RBZ during its early years consisted of both amateur and professional zoologists. Staff of the Raffles Museum frequently contributed papers to the RBZ and papers prepared by the former directors of Raffles Museum are found in the RBZ, including C. Boden-Kloss, F. N. Chasen M. W. F. Tweedie and C. A. Gibson-Hill. However, besides professional zoologists, papers from amateur zoologists, for example, F. F. Laidlaw, could also be found. In his early life, F. F. Laidlaw studied Zoology at Trinity College but later he turned to the study of medicine and qualified for Membership of the Royal College of Surgeons and Licentiate of the Royal College of Physicians from St Bartholomew's Hospital, starting a practice at Uffculme 1911–1945 [40]. While working as a general practitioner, Laidlaw carried out research on natural history in his spare time and published many papers in various scientific journals, including the RBZ [40]. As an amateur zoologist, Laidlaw contributed as many as 11 articles to the RBZ. The change of institution from Raffles Museum to the National University of Singapore resulted in quite a number of quality papers from the staff and students in the Department of Zoology [34]. The contributors to the RBZ in later years are mainly professionals from universities, museums and other zoological and research institutions, for example, National University of Singapore, Field Museum of Natural History (USA), and the Institute of Zoology (China), among others. Comparing 10 randomly selected articles in stage one with 10 articles from stage three (using the samples in Table 2), we can see that two out of 10 articles were written by the amateur zoologists in stage one while all 10 articles were written by the professional zoologists in stage three.

The writers of the RBZ in its early years tended to create prose with a focus on description (as discussed in Section 5.1.1). In contrast, the writers of the RBZ in later years tended to create more complicated prose and write in an analytical manner (for example the increased number of articles with headings and with moves in the discussion section in stage three). The simple prose with a focus on description in the early years of the RBZ and the complicated and analytical prose in the later years of the RBZ may be viewed as two different ways of writing used by those writers who are a mixture of amateur and professional zoologists writing from a natural history perspective in the early years of the RBZ and by those writers who become more and more professional with a more theoretical perspective later on. Thus the change in the writers of the RBZ over the years from a mixture of amateur and professional zoologists to professional zoologists contributed to the emergence of professional writing in the RBZ in terms of complicated and analytical prose. The shift from a mixture of amateur and professional zoologists to professional zoologists is not the sole cause for the change of genre form of the article but is one possible factor that might have contributed to the change in the genre form. We do not claim that the shift from a mixture of amateur and professional zoologists to professional zoologists only produces the change in the genre, but we suggest that it is a possibility.

6. Conclusion

Through a genre analysis of the journal articles in the RBZ over the past 80 years, this study has outlined the evolution of a scientific journal in the academic periphery. The appearance of certain features in the RBZ took place much later than those in the academic centre. For example, the first appearance of the abstract in the RBZ was in 1988, more than 20 years after the date Harmon [7] suggests that abstracts were widely used in scientific papers. It was only in 1996 that the vast majority (97.81%) of articles in the RBZ adopted endnote citations, while endnote citation achieved 100% dominance as early as the 1940s according to Allen et al.'s [9] study of the *Philosophical Transactions of the Royal Society*. In his historical study of the *Physical Review*, Bazerman [10] highlighted the impact of the movement towards theoretical science in shaping the evolution of journal articles from 1893 to 1980. Similar to Bazerman's study [10], the change of scientific perspective from natural history to theoretical science is one important factor that has contributed to the change in the evolution of the RBZ over the years. According to Bazerman [10], there was a reduced emphasis on the methods description in the *Physical Review* over the years; however such a trend was not found in our study of the RBZ. In their study of scientific articles from the seventeenth century to the present, Gross et al. [12] used selection theory to explain the evolution of scientific journals articles. The result of our study neither supported nor refuted Gross et al.'s [12] claim. Despite the differences in certain features in the RBZ as discussed, similar to the evolution of scientific journals in the academic centre documented in previous studies [5–7], the RBZ has undergone dramatic changes inside and out, developing from a simple and eclectic way of writing in its rudimentary period to a more orderly, sophisticated and professional way of writing in its current period. Darwin [41] claimed 'natura non facit saltum' [nature does not leap] as an old canon of natural history in his book *The Origin of Species by Means of Natural Selection*. A similar concept can be applied to the historical development of journal articles in the sense that changes in articles do not just happen suddenly; instead they are adaptive by nature and take place in a continuous and progressive manner over a period of time. As a

vehicle or channel for scientific communication, changes in journal articles adapt to the needs of the scientific community and reflect the changes in that community over time.

This case study of evolution of journal articles in the periphery via the lens of genre emphasizes the importance of the following for an understanding of scholarly communication:

- Adaptive nature: the study of the evolution of journal articles shows that change is constant in the communication process. It is a slow and gradual process, not a sudden shift. Such changes have a direct impact on various aspects of knowledge production, organization, use and retrieval. As a result, knowledge production, organization, use and retrieval in various disciplinary domains will evolve over time, adapting to various factors.
- Social and historical factors: as social animals, human beings construct their social world. To understand human behaviour fully, it is necessary to understand humans in their social context as well as the impact of the social context on humans. Meadows [3] vividly termed the scientific paper an 'archaeological artifact'. The genre study of evolution of journal articles provides a chance to study the marks of those social impacts left on such 'archaeological artifacts'. Such a longitudinal study highlights the importance of understanding the interplay between social factors in the scientific communication process or knowledge communication process in general over a period of time.
- Information organization and retrieval: in his study of journal layout, Meadows [38] attributed the evolution of journal content to 'a response to the need for maintaining information flow when the volume of communication is constantly growing'. This case study of the evolution of journal articles in the periphery shows that the need for information organization and retrieval is one of the factors that have shaped the changing appearance of journal articles over time. With the increasing amount of information available, it is a challenging task for users to keep up with the pace of information as well as to find the desired information. The pressing need shows the increasing demand in the provision of information systems that are efficient and effective in information organization and retrieval so as to guide the users in the labyrinth of information sources.

If Andersen [2] is right about his assumption of library and information studies as 'the study of how and with what means professional, scholarly, cultural and social knowledge as materialized in documents (print or electronic) is communicated in society and what function libraries and other similar knowledge organizing institutions or activities have, or are supposed to have in these communication processes', it seems that much work needs to be done by library and information science professionals to play an effective and efficient role as knowledge professionals in the communication of human knowledge. Genre analysis would seem to be a fruitful avenue to explore as they undertake this task.

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Appendix A. Schematic structure of the *Bulletin of the Raffles Museum*

Serial number	I	M	R	D
1	II-MI-II-MI-II-I2-II-MI	NA	NA	NA
2	II-MI	NA	NA	NA
3	I3-II-I2	NA	R1-MI or R1-MI-R2 or R1-R2 or R1-MI-R1-MI-M4 or R1-MI-R1-MI-R1-MI-R1 or R1 or R1-MI-R1-R2 or R1-MI-R2-R1	NA
4	MI-I3-BI	NA	R1	NA
5	N.A.	NA	R1-MI-R1-MI-R1 or R1-MI-R1 or R1-MI-R2	NA
6	II-I3-II-I3 or II-I3	NA	R1-R2 or R1-MI-R2 or R1-R2 or R1-R2-MI or R1 or R1-R2-MI-R2 or R1-MI-R1-R2 or R1-MI-R1 or R1-MI or R1-R2-R1	NA
7	I3-BI-I3	NA	R1 or R1-MI-R1-R2 or R1-MI-R1 or R1-R2-MI-R1-R2 or R1-MI-R1 or R1-MI-R2 or R1-R2-MI or R1-R2 or R1-MI	NA
8	I3	NA	R1-MI-R1-D2 or R1-MI-R1-D2-R1-D2 or R1-D2-R1-D2 or R1-D2-MI-R1-D2-MI-R1-R2-R1 or R1-D2-R1-D2-R1-R2	NA
9	MI-I3	NA	R1-MI or R1-MI-R1 or R1-MI-R2 or R1-R2 or R1-MI-R1-R2	NA
10	II	II-M3-MI	R1 Or R1-R2	D2

Appendix B. Schematic structure of the *Bulletin of the National Museum*

Serial number	I	M	R	D
11	M1	NA	R1-R2	NA
12	I1	NA	R1-R2	NA
13	I1-I3	M1-M2-M4	M2-R1-R2-R1 or M3-R1-R2-R1 or R1-M2-R1 or M2-R1 or M2-R1-R2-R1-R2-R1	D2-D4
14	I1-I3	NA	R1-M1-R1 or R1-M1	NA
15	M1	NA	R1-R2-M1	D2
16	I3	NA	R1-M1-R1	NA
17	I1	M1-M2-M3	R1-M1-R1 or R1-M1-R1-M1 or R1-M1-R1-R2 or R1-R2	NA
18	I3	NA	R1-M1-R1-R2	NA
19	I1-M1-I3 or I1	NA	R1-M1-R1-R2 or R1-M1-R1 or R1-M1-R1-R2-R1-R2 or R1-M1-R2	D2
20	I3-M2-B1	NA	R1	D2

Appendix C. Schematic structure of the *Raffles Bulletin of Zoology*

Serial number	I	M	R	D
21	I3 or I1-I2-I1-I2-I1-I2-I1-I3	I3-M3-M1-M2-M3	R1-M1-M2-R1-R2 or R1-R2-R1-M1 or R1-R2	NA
22	I1-I3	NA	M1-R1-R2	NA
23	I1-I2-I3	M3-M1	R1-M1-R1-R2	NA
24	I3-I1-I3-M3-M1	NA	R1-M1-R1-R2	NA
25	I1-I3-I1-I3	M1-M2-M3	R1	D2
26	I2-I3	M3-M4	R1-M1-R1	D2
27	I1-I3	M2-M3-M1-M3	R1 or R1-M1-R1	NA
28	I1-I2-I1-I2-I1-I2-I1-I3	M1-M2-M3	R1	D2-D4
29	I1-I2-I3-M1	NA	R1-M1-R1 or R1-M1-R1-R2	NA
30	I1-I3	M1-M2-M3-M4-I3-M3	R1-M1-R2 or R1-M1-R1-R2	NA

Appendix D. Same move pattern found in the *Bulletin of the Raffles Museum*, the *Bulletin of the National Museum* and the *Raffles Bulletin of Zoology*

Section	Move pattern
I	I1-I3 I3
R	R1 R1-M1-R1 R1-M1-R1-R2 R1-M1-R2
D	R1-R2 D2