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TOWARDS A BIBLIOGRAPHY AND INDEX OF GRAPTOLITES

A pilot survey has been conducted in order to assess the feasibility of compiling a 'Bibliography and Index of Graptolite species and literature'. Initially it is necessary to ascertain as accurately as possible the size of the problem; i.e. how much literature is there, how many species have been described?

A poll of graptolite specialists indicated that there has probably been several (but less than ten) thousand publications on the subject and only a few (possibly less than five) thousand species described. Such a crude assessment is, however, hardly an accurate enough base from which to embark on a potentially time consuming and, if not completed, time wasting exercise. Consequently an attempt has been made to carry out a more rigorous survey.

The problem has been tackled in more than one way. Initially a card index file of graptolite literature was compiled over the last few years from as many different sources as possible, too numerous to cite fully here but primarily based on Elles and Wood (1901—18), Přibyl (1948), Přibyl and Spasov (1955), Ruedemann (1944), Strachan (1971) and some seventy other graptolite publications with extensive bibliographies. In addition references have been extracted from various general geological serialised bibliographies, particularly the 'Bibliography and Index of Geology' and its precursors.

At present this file consists of some four thousand titles (it would be nearer five if complete) including articles on all aspects of graptolite study from systematics, morphology, palaeoecology and stratigraphy to preparation techniques. The primary listing is in chronological order.

The problem of estimating the total number of graptolites species from published descriptions had to be approached in a different way since no separate species list had been compiled. It was, therefore, necessary to find some rapid method of obtaining the best possible estimate of the total number of species and the chronology of their description. Fortunately that invaluable work, The Elles and Wood 'Monograph of British

Graptolites (1901—18)' again provided the basic information in a readily retrievable form; i.e. the annual production of descriptions of new graptolite species in chronological order until 1900. The record is continued until 1926 in the same style and with the same thoroughness by Bulman in the historical account of previous research which introduces his 'Monograph of British Dendroid Graptolites'. I consider that these two sources represent the most complete published record of graptolites for the period.

The only comparable work, the Zoological Record, did not seriously attempt to list graptolites until the early 1900's. However, since the monographic information on new taxa only extended until 1926 the Zoological Record was used to bring the cumulative total up to date. In order to evaluate the comparative completeness of these two sources an overlap period of ten years (1916—1925) was counted.

	Monograph		Zoological Record			
1916	4	3	1921	0	1	
1917	0	0	1922	17	1	
1918	3	3	1923	32	12	
1919	0	1	1924	14	27	
1920	2	0	1925	29	21	
Total	9	7	Total	92	62	
5 year average	1.8	1.4	5 year average	18.4	12.4	
			Total for decade	101	69	

It can be seen that over the decade the Zoological Record listed about seventy per cent of the species found in the Monograph. This is not very satisfactory but is the best that can be achieved at present. It must be borne in mind when comparing the data.

The histogram of new taxa in chronological order of description (fig. 1a) emphasises individual authors' contributions and therefore consists of separate peaks of productivity. It is easy to identify major systematic works such as Barrande 1850; Hall, J. 1858 and 1865; Lapworth 1876 and that extraordinary 1947 memoir by Ruedemann, in which single work he described some two hundred new species and subspecies. In order to elucidate trends in description and to facilitate comparison of new taxa and the overall production of the literature, the data has been presented as five year averages (fig. 1b) for the histograms and five year totals for the cumulative curves (fig. 2).

These show, as would be expected, a close correlation between new taxa and the literature. This applies particularly to the pre 1885 period when most of the contributions to the literature contained systematic descriptions of new species. After this time the increasing importance of graptolites as stratigraphic indices led to a growth of papers on this subject alone.

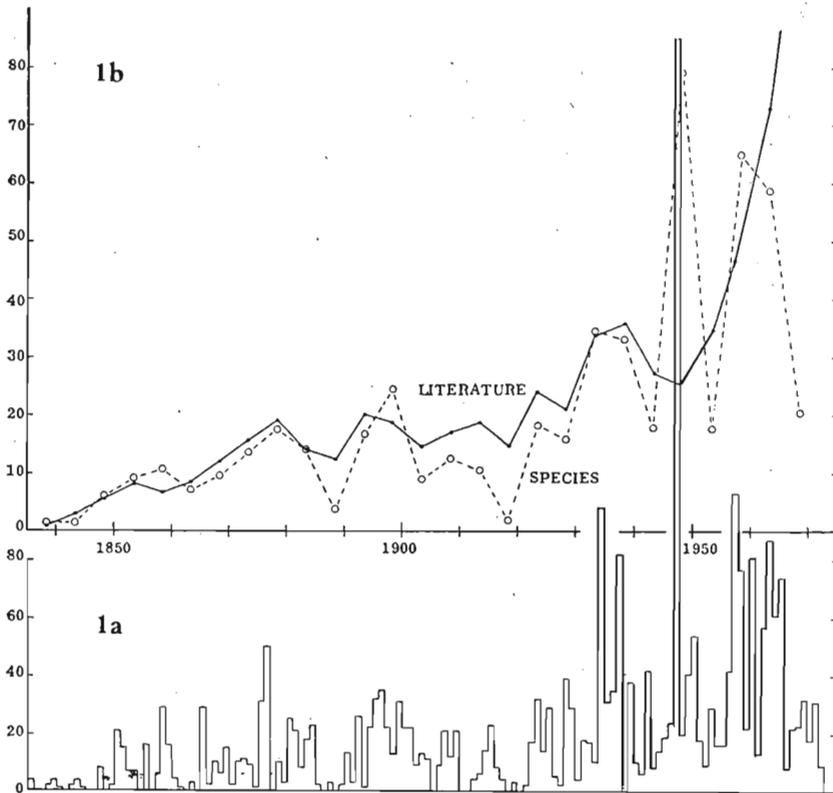


Fig. 1. *a*—histogram of chronology and frequency of new graptolite species descriptions; *b*—comparative production of graptolite literature and new species descriptions. Plotted as five-year averages against “monographic” time.

A fairly close parallelism of the two growth curves did continue until 1910 but there was increasing divergence thereafter. That this divergence started prior to 1926 shows that it is not a function of the change in bibliographic sources.

Originally it was hoped that a comparison of the growth curve for the literature with that for new taxa would allow a projection of the latter beyond 1926 to give an up-to-date estimated total. This would have to be based on the close correlation of the two curves, which existed up until 1910, but since they then become increasingly divergent there can be little confidence placed in such an estimate. Even with the data replotted on a log linear scale to demonstrate the exponentials more clearly (fig. 3) it is difficult to make an accurate projection. The result is an estimated total of 2000 ± 300 , which is too low. This is confirmed by the subsequent addition of data from the Zoological Record which gives a cumulative total of 2704 (1972). This includes subspecies and does not take synonymy into account.

I think that palaeontologists, indeed probably all scientists, would

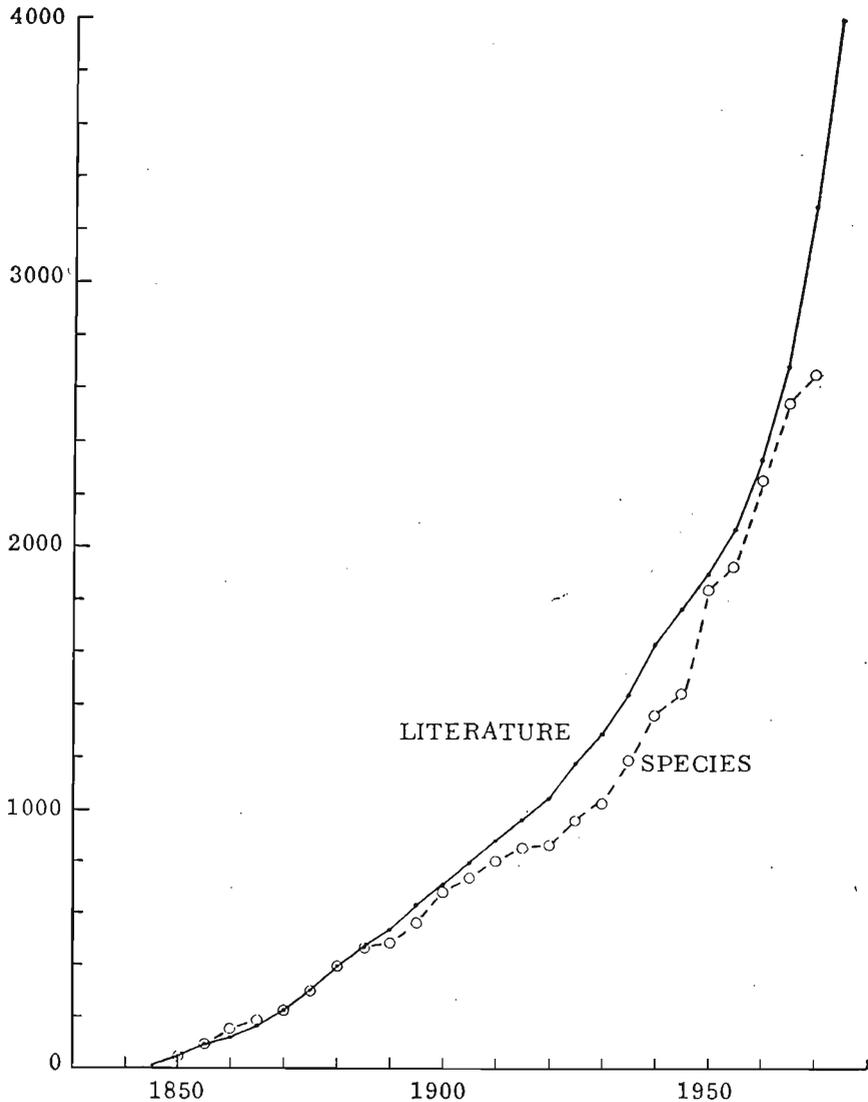


Fig. 2. Growth curves for graptolite literature and new species descriptions. Plotted as cumulative five-year totals against "monographic" time.

suspect that there has been an exponential growth of some rate, especially over the past World War 2 period, in the literature. Any such suspicions can be easily confirmed. For instance the graptolite literature is currently increasing at a rate of more than 150 articles a year and is doubling every 15 years. Although the implications of this are a matter of some concern, it is not as alarming as it might seem. Nevertheless, we might well ask ourselves if this accumulation of over 4000 articles (it would be nearer 5000 if complete) is manageable for us today and if it is, then for how long will it remain so?

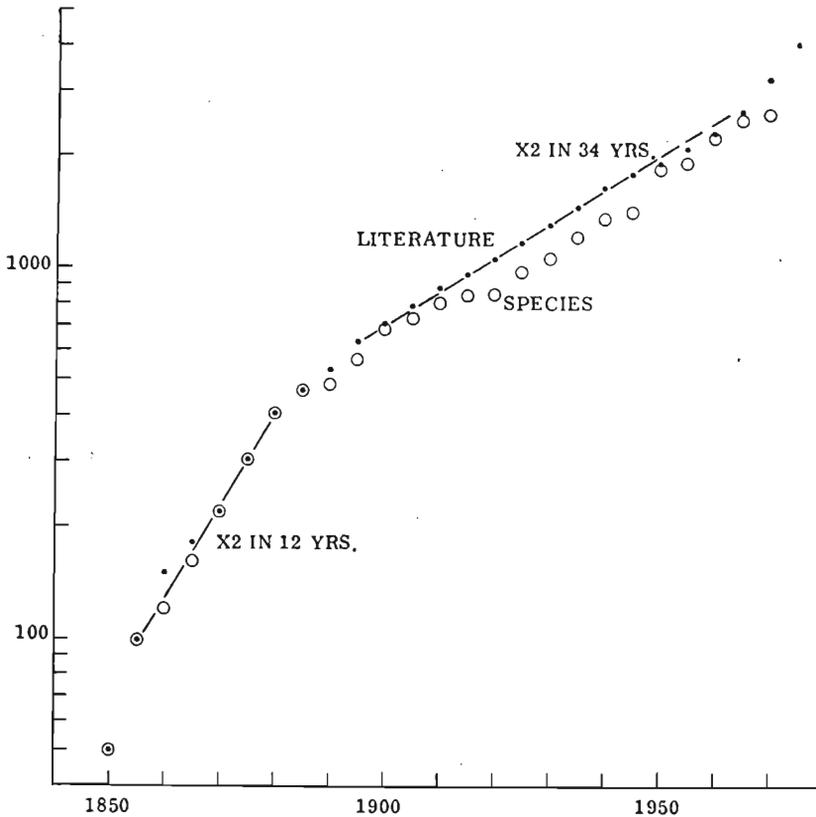


Fig. 3. Comparative growth of graptolite literature and new species descriptions. Plotted as cumulative five-year totals against "monographic" time on a log-linear scale.

It has been argued quite reasonably by Loeblich and Tappan (1964: 370) that we should not be alarmist about these seemingly indomitable literature 'mountains'. No single research project will need more than a very small part of the total bulk and every few workers attempt to cover all taxa or the whole span of their fossil record. Therefore specialists can more easily develop specialist bibliographies. Although this is undoubtedly correct, are we in a position to make rapid literature surveys to recover even that relatively small portion that we require? I think not, especially as ours is a historically based subject operating on the principles of priority with a literature extending back over more than 150 years.

The growth exponentials for both new taxa and the literature show some striking features. Over the twenty-five years from 1855 to 1880 there was a very rapid growth with the cumulative totals doubling every twelve years. Subsequently the growth rate fell quite sharply and for seventy years (1895—1965) had a fairly constant rate of increase doubling every

thirty-four years. This is more clearly shown by the increase in literature; in comparison the production of new taxa has shown considerable fluctuation. There was a marked decline after 1910, which deepened during the First World War followed by a short-lived recovery before a similar decline associated with the Second World War. The overall production of literature was apparently less affected. Despite these oscillations, the overall rate of increase in new taxa has nevertheless paralleled the literature curve. Recently, however, there has been a marked divergence with the literature growth almost regaining its pre 1880 rate of increase, whilst the production of new taxa has dropped quite sharply.

These are not isolated phenomena peculiar to graptolite studies. To take the last feature first: Raup has recently tabulated (1976: fig. 1) the production of all new fossil taxa from the Zoological Record. It appears that there has been a general decline in systematic palaeontology since 1961. Although, as Raup points out, (*op.cit.*: 288) it may also be the product of a more conservative approach to the species concept or a failure of sampling. Indeed recent changes in the sampling methods of the Zoological Record may well be a contributory factor but cannot be wholly responsible. As long ago as 1958 Cooper was deploring "the wane of the descriptive, taxonomic and morphologic phase" of invertebrate palaeontology in general.

The most remarkable feature of the overall growth is the clear change in growth rate since 1880. This appears, quite surprisingly, to be a not uncommon feature in the growth of geology as a whole. Newell illustrated (1959: fig. 1) fluctuating growth rates for several important groups of fossils based on description of new genera and subgenera. Both the ammonoids and mammals had declined in their rates of publication post 1890. Loeblich and Tappan plotted similar data for foraminifera (1964: fig. 5) with a similar but less marked effect. Even the membership of the Geological Society of London (Cohen *et al.* 1954: fig. 3) showed a steady decline after 1880 and only regained and overtook its previous maximum membership after the Second World War. Geographical science was similarly affected; Stoddart has shown (1967: fig. 1, 2) that the growth rate of geographical periodicals declined slightly after 1880. Similarly the foundation of world geographical societies has had two quite separate growth periods. Prior to 1880 they were doubling every eight years or so and subsequently doubled every 40 years. Cohen *et al.* (1954: fig. 2) showed that this trend can be seen also in the growth of chemical, physical, mathematical and anthropological societies. Price (1962: 105) underlines this in his plot of the number of papers published in the field of the theory of determinants and matrices (*op. cit.*: 105) and the rate of discovery of chemical elements (Price 1963: 29, fig. 11). Finally the rate of foundation of scientific journals of the world peaked around 1880 and declined slightly thereafter (Price 1962: 97).

All this demonstrates that exponential increase cannot be prolonged indefinitely at a single rate without rapidly reaching absurd proportions. A saturation level is reached after which there is a period of decline and readjustment followed by a new lower rate of increase. Thus the growth pattern follows a stepped logistic curve. It appears that graptolite studies reached such a saturation level around 1885—90 as a reflection of a general trend in science.

Despite contemporary concern (eg. Watts 1904) about the state of geology at the beginning of this century, it was not until much later, in Britain at least, that the full extent of the drop in popularity and interest in the subject was fully realised (Boswell 1941; Hollingworth 1962).

In conclusion it would appear that with a total species list of around three thousand including subspecies and synonyms, the Class Graptolithina, one of the more important fossil groups in geology, is one of the few, if not the only one of class rank for which a complete bibliography and index could be achieved at present. Given the lull, however, undesirable it may be, in contemporary systematic work now is a good time to attempt such a project and catch up on the last hundred and fifty or more years of graptolite studies and encapsulate its history.

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