Reprint from:

ISSN 0165-0424
CODEN AQINDQ

Aquatic Insects

International Journal of Freshwater Entomology

SWETS & ZEITLINGER PUBLISHERS

Aquatic Insects, Vol. 22 (2000), No. 1, pp. 58–65

0165-0424/00/2201-0058$15.00

Silk Weave and Silk Glands in Aquatic Instars of Two Species of *Helicopsyche* von Siebold, 1856 (Trichoptera, Helicopsychidae)

Fernanda Cianficconi and †Giampaolo Moretti

Istituto di Zoologia, Università di Perugia, Perugia, Italy

ABSTRACT

Under SEM the silk weave in the snail-like cases of *Helicopsyche crispata* and *H. shuttleworthi,* the two species present in Italy consist of several types of meshes. The silk which connects the sand grains of the external wall is made up of multi-layered threads forming irregular meshes. The sand grains of the vertical pillars in the wall of the central columella are held together by very loosely woven silk and are supported by thick silken threads. The pupal silken membrane consists of concentric threads and the pupal case is attached to the substrate by a disordered mass of silken threads. The two glands which secrete the silk are long, double folded tubes.

KEYWORDS: Trichoptera, *Helicopsyche crispata, Helicopsyche shuttleworthi,* larval case, pupal case, silk weave, silk glands.

INTRODUCTION

Morphology and ultrastructure of the silk glands and silk weave have been investigated in several species of Italian Trichoptera. Free-living, net spinning and case-bearing larvae were observed. The latter build cases of various shapes (saddle, purse, tube) and of various materials such as sand grains, vegetable debris and silken secretion (Cianficconi & Moretti, 1991 b; Moretti & Cianficconi, 1992). The ultrastructure of the silk glands is similar in the larvae examined, but there are differences in length and shape, and the silk weave shows differences in the arrangement, thickness and length of the threads linked to different case-building behaviour (Cianficconi et al., 1993).

The research is still in progress and the aim of this paper is to provide a description of the silk weave of the larval and pupal cases, together with morphology of the silk glands of two species of *Helicopsyche, H. crispata (*Benoit, 1857) and *H. shuttleworthi* Siebold, 1856 (Johanson, 1995) present in Italy. These species are known for their characteristic helical cases made of sand grains, as in *H. bacescui* Orghidan et Botosaneanu, 1953 outlined by Botosaneanu (1956).

† Professor G.P. Moretti passed away on 9th April 1997 while this paper was still in progress.

Address correspondence to: Fernanda Cianficconi, Istituto di Zoologia, Facoltà di Scienze MM. FF.NN., Università di Perugia, Via Elce di Sotto, 06123 Perugia, Italy.

H. crispata (= *H. sperata* McLachlan, 1876) is found in the western Prealps (including Canton Ticino), the Apennines, Sicily and the Isle of Elba. *H. shuttleworthi* (= *H. revelieri* McLachlan, 1884) is found in Corsica, Sardinia and Capraia (Cianficconi & Moretti, 1991a).

A short note on this subject was presented at XX International Congress on Entomology held in Florence (Cianficconi & Moretti, 1996).

MATERIAL AND METHODS

The specimens of *H. crispata* were collected in a small spring with hygropetric habitats covered with moss *Palustriella commutata* (Hedw.) Ochira, in central Italy (Marche, Fonte Le Tarangole, Ancona, 450 m a.s.l.). The specimens of *H.shuttleworthi* were collected in Sardinia (Massiccio del Gennargentu, Nuoro) in small springs, with moss *Bryum mildeanum* Schimp, emerging from the banks of the streams Rio Pirastreddu, 680 m and Rio Flumineddu, 370 m (Cianficconi et al., 1997).

The aquatic instars of both species were reared in the laboratory on a substrate from the original habitats with mosses, bark and dead leaves, covered with a thin film of water.

Larval cases at different instars and pupal cases of both species taken from the mosses were sectioned, examined and drawn under light microscopy. The silk weave was studied by removing the external sand grains from the larval case one by one and then photographed with the Philips XL 30 scanning electron microscope.

The silk glands were stained with fuchsin and observed in light microscopy.

RESULTS

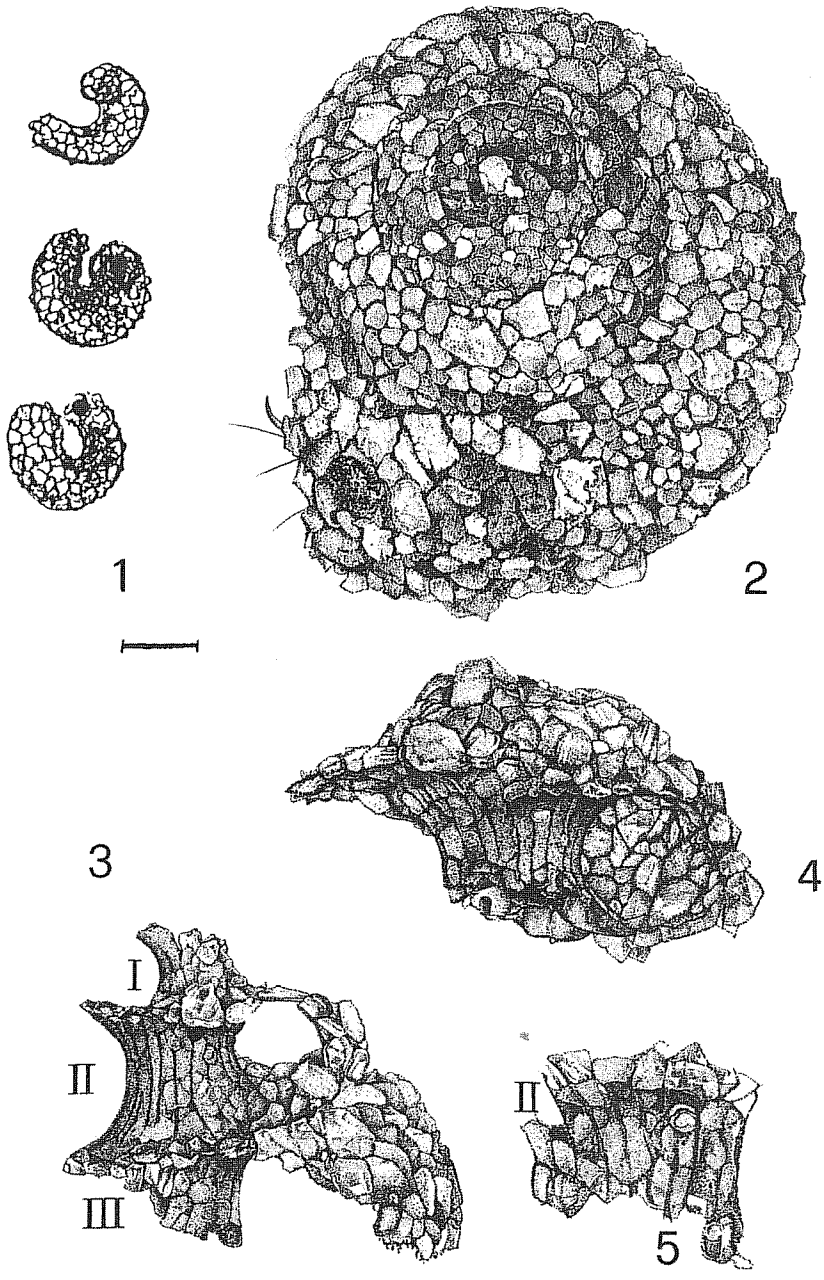
Silk Weave

Larval case – Laboratory rearing allowed us to observe the phases of case building described by Moretti (1958).

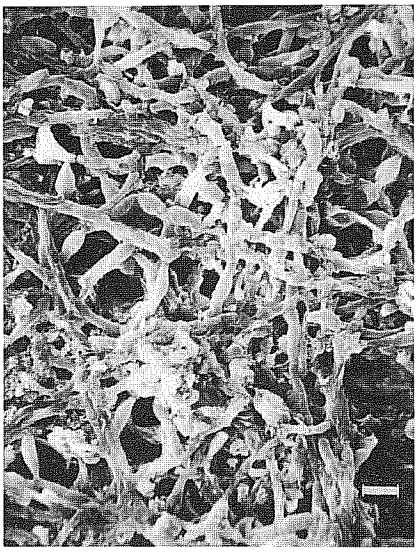
At the early instars (30–40 days after hatching) the larval cases of both species are curved tubes of sand grains which later become helical cases and then a closed spiral (Fig. 1). At the last instar, the case is coiled three times around a central columella (4–4.5 mm in diameter in *H. crispata*; 3–3.5 mm in diameter in *H. shuttleworthi*). The upper spiral, the first one to be built, and the upper sand grains are smaller. The other spirals are larger, more pronounced and separated by a deep groove (Fig. 2). Under SEM, the external sand grains of the cases at different instars seem to be connected by loose, twisted silk threads (0.5–1 μm in diameter) forming a 2–3 layered web with irregular meshes (up to 30 × 40; 10 × 20 μm) (Fig. 6).

An opening at the top of the columella may facilitate water circulation through the case. The columella is empty or sometimes filled with a whitish amorphous substance. A vertical dissection of the case shows that the walls of the columella, in the 3 spirals (Figs. 3, 4, 5), consist of rectangular pillars of vertically-stacked sand grains joined together by a loose silk weave (Figs. 7, 8), bordered by thick, straight silk threads (2.5 μm in diameter) (Fig. 9).

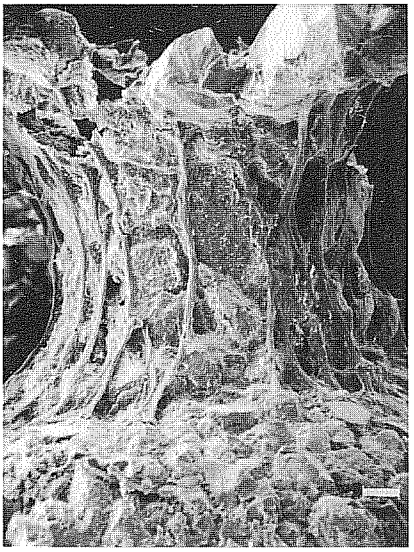
Pupal case – Before pupation, the larvae build a circle of larger, protruding sand grains around the anterior (lower) opening (1.5 mm in diameter) and, between



Figs. 1–5. *Helicopsyche crispata,* larval case: (1) the early instars (bar = 230 μm); (2) last instar (bar = 460 μm); (3) a vertically dissected case showing the inner wall in three contiguous coils (bar = 307 μm); (4, 5) inner wall of the second coil (bar = 307, 230 μm) (drawn by A. Speziale).

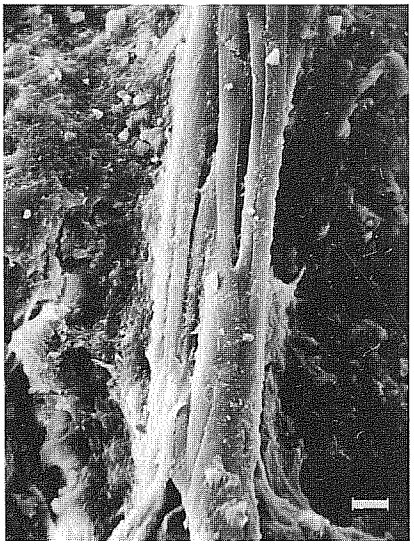


6



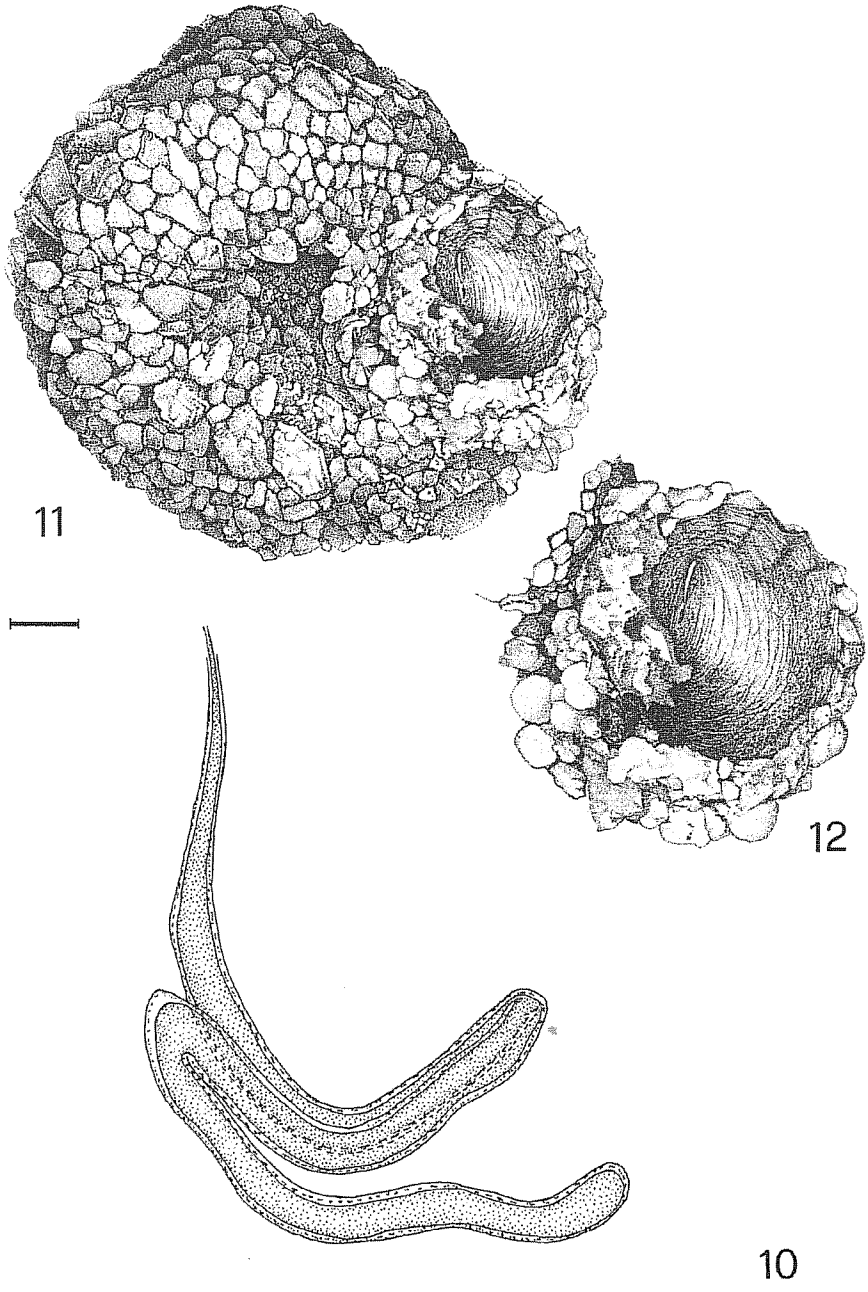
7

8

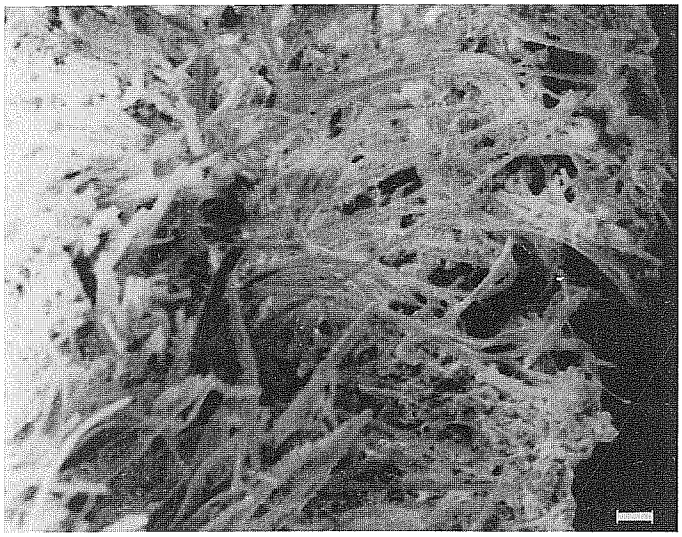


9

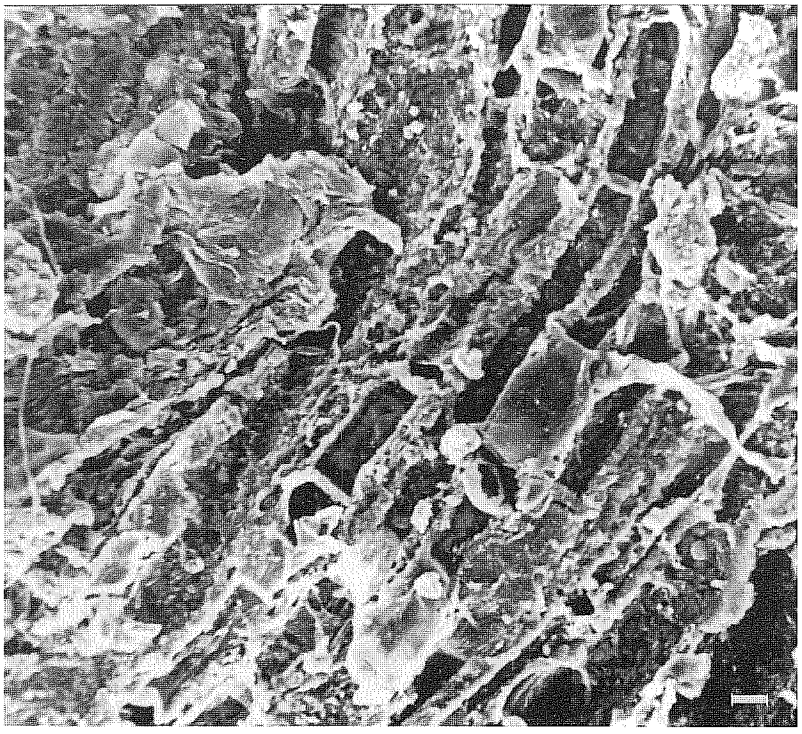
Figs. 6–9. *Helicopsyche crispata* (under SEM); (6) silken threads connecting the sand grains together (bar = 30 μm); (7) wall of the columella (bar = 30 μm); (8) pillars of sand grains (3 μm); (9) silken threads bordering the pillars (bar = 610 nm).



Figs.10–12. *Helicopsyche shuttleworthi*; (10) double folded silk gland (bar = 430 μm); (11) pupal case (bar = 6 μm); (12) circle of large sand grains (bar = 33 μm) and silken membrane with an oblong slit (bar = 30 μm) (drawn by A. Speziale).



13



14

Figs.13–14. *Helicopsyche shuttleworthi* (under SEM): (13) silken attachment of pupal case to substrate (bar = 5 μm); (14) concentric silken threads of pupal membrane (bar = 1.5 μm).

these grains, they weave a thick silken membrane with an oblong slit that presumably allows the passage of water into the case for the gaseous exchange needed in respiration (Fig. 12). The membrane consists of concentric silken threads (Fig. 14) which are pale when just secreted and darker before insect emergence, taking place in summer (from July to mid September) in both species. The pupal case (Fig. 11) is fixed to the substrate (stones or mosses) by a mass of silken threads anchored to the inner margin of the silken membrane (Fig. 13).

Silk Glands

The silk is secreted by two long tubular glands (10–12 mm), double folded, and symmetrically located in the abdomen, ventrally to the alimentary canal (Fig. 10). The glands, which occupy a good part of the larva body, are large and closed at the posterior end. They are thin anteriorly and join together in a short common duct just before the opening into the labium. The posterior secretory portion is about 80% of the whole length and the anterior conducting portion is about 20 % of the whole length.

CONCLUSION

This study shows that the two species of *Helicopsyche* present in Italy seem to differ only in the size of the case and there are no clear distinguishing characteristics in the silk weave and morphological aspects of the silk glands.

ACKNOWLEDGEMENTS

We thank Angelo Speziale for the drawings, the Doctors Olla, Pau, Terenzi for providing the material and Mary Kerrigan for reviewing the text.

REFERENCES

Botosaneanu L (1956): Le développement postembryonnaire, la biologie et la position systématique d'un des Trichoptères les plus interéssants de la faune européenne: *Helicopsyche bacescui* Orghidan et Botosaneanu. *Acta Soc Zool Bohemoslov 20 (4):* 285–312.

Cianficconi F, Moretti GP (1991 a): The second list of Italian Trichoptera (1980-1989). In C Tomaszewski (ed.): *Proc 6th Int Symposium on Trichoptera* A.M.U., Poznan, pp. 265–274.

Cianficconi F, Moretti GP (1991 b): Biologia, morfologia e geonemia di *Catagapetus nigrans* McL. *Mem Soc Ent Ital Genova 70 (2):* 225–238.

Cianficconi F, Moretti GP (1996): Morphology and coleobiosis of two species of *Helicopsyche* von Siebold, 1856 present in Italy (Insecta, Trichoptera Helicopsychidae). *Proc XX Int Congr Entom Firenze:* p. 359.

Cianficconi F, Bicchierai MC, Moretti GP (1993): Silk glands and silk weave in trichopteran larvae. In: C Otto (ed.): *Proc 7th Int Symposium on Trichoptera,* Backhyus Publ, pp. 33–38.

Cianficconi F, Corallini C, Moretti GP (1997): Trichopteran fauna of the Italian springs. In L Botosaneanu (ed.): *Studies in Crenobiology*, pp. 125–140.

Johanson KA (1995): Revision on the European *Helicopsyche* (Trichoptera: Helicopsychidae). *Ent Scand 26:* 321–338.

McLachlan R (1874-80): *A monographic revision and synopsis of the Trichoptera of the European fauna*. Incl 1 Supplement (1884). Reprint 1968. Hampton (Classey).

Moretti GP (1958): Tappe iniziali nella coleobiosi della larva di *Helicopsyche sperata* McL. (insetti Tricotteri). *Boll Soc Ital Biologia sperimentale 34 (21):* 1–3.

Moretti GP, Cianficconi F (1992): Un caso di colonizzazione ipogea nelle Alpi Orientali sostenuta da *Philopotamus ludificatus* McL. *Mem Soc Ent Ital Genova 71 (2):* 637–648.

NOTICE TO CONTRIBUTORS

1. Two copies of the complete text, tables, legends and illustrations should be submitted. Submission of a paper will be taken to imply that it is unpublished and is not being considered for publication elsewhere. Papers published in Aquatic Insects may not be reprinted or published in translation without permission. Reproduction of illustrations requires similar permission.
2. The receipt of manuscripts will be acknowledged. They will be reviewed by referees, and a decision on their acceptance, or a request for modification, will normally be made within three months.
3. The Editor reserves the right to refuse any manuscripts submitted, whether invited or otherwise, and to make suggestions and modifications before publication. Submitted papers should be in a final form ready for publication. All corrections in the proofs other than printing errors are at the author's expense.
4. Papers should be concisely written in English. Authors who are not native English speakers are strongly urged to have their manuscripts checked for linguistic correctness before submission. All papers should start with an abstract, giving a synopsis of the paper with sufficient information about methods and results. Summaries in other languages may be added at the end of the paper.
5. Papers should be typed with double spacing on single sides of A4 paper, leaving top and left hand margins of at least 2.5 cm (one inch). Simple roman print must be used, except for scientific genus and species names, which will be printed in italics. The use of italics for chapter headings is at the discretion of the Editor. Please avoid bold, capital, and spaced lettering. Measurements must be in international units.
6. Papers should be headed by a title, the initial(s) and name(s) of author(s). Then a block should follow containing: name(s) and initial(s) of author(s); title; journal reference; up to five key words; initial(s) and name(s) of author(s) and full address(es). Please compare a recent issue for details of format. Manuscripts not conforming to the requested format will be returned for revision.
7. Bibliographical references should be listed in alphabetical order at the end of the paper.
8. References to periodicals should include the following elements: name(s) and initial(s) of author(s): year of publication; title of the paper; name of the periodical; volume number (Arabic numerals); first and last page number. For periodicals, the recognized abbreviations laid down in the "World List of Scientific Periodicals 1900-'60" (London, 1965) should be used. Example: Halberg F (1973): Periodicity analysis. A potential tool for biometeorology. *Int J Biometeor 7:* 61–191.
9. References to books should include: name(s) and initial(s) of author(s); year of publication; exact title; name(s) of publisher, town of publication; page number (where pages are specifically cited). Example:
   Sollberger A (1965): *Biological Rhythm Research,* Amsterdam, Elsevier.
10. References cited in the text should be in parentheses, and given as author name(s) followed by the year of publication, e.g. "(Jones, 1961)" except when the author's name is part of the sentence, e.g. "Jones (1961) has shown...". If there are more than two authors, "et al." may be used behind the first name, e.g. "Smith et al., 1961".
11. Each table should be typed on a separate sheet of paper. Tables should be numbered consecutively in Arabic numerals, e.g. "Table 1, Table 2", etc., and attached to the end of the text. Should a table not be an original, the exact reference should be quoted. Tables should be supplied with headings and kept as simple as possible, and should be referred to in the text as "Table 2", etc.
12. Figures (including photographic prints, line drawings in black indian ink on strong white or transparent paper, and maps) should be numbered consecutively in Arabic numerals, e.g. "Fig. 1", etc. and attached to the text behind the tables. Graphs and diagrams should be suitable for reduction to page width (11.7 cm) or page size (18.5 x 11.7 cm) and mounted on plates, where appropriate. Illustrations must be ready for print, accurate lettering and symbols are required; legends must not be included in the figures. Legends for figures should be listed consecutively on a separate sheet of paper. Photographs can be easily reproduced in offset print and should be unmounted, glossy prints, capable of being reduced to a size of 10 x 10 cm without affecting legibility.
    Authors will be asked to contribute to the cost of excessive illustrations and elaborate tables. The cost of reproducing coloured plates must be met in full. Estimates may be obtained in advance.
13. It is expected that the revised paper, if accepted, will be delivered on floppy disk. Please ask the editor or the publisher for full instructions.