MUARIK BULLETIN, Vol. 2. pp. 71 - 77, 1999
Printed in Uganda.

The effect of plant architecture of open-pollinated and hybrid varieties of maize on their attractiveness to ant predators of termites

M. B. Sekamatte, M.W. Ogenga-Latigo[†] and A. Russell-Smith[††]

Namulonge Agricultural and Animal Production Research institute, P.O. Box 7084, Kampala, Uganda

[†] Department of Crop Science, Makerere University, P.O. Box 7062, Kampala, Uganda

[††] Natural Resources Institute (NRI), University of Greenwich, Central Avenue, Chatham Maritime ME4 4TB Kent, UK

Abstract

A field experiment was conducted at Namulonge Agricultural and Animal Production Research Institute during the short rains in 1998 to assess the effect of maize plant architecture on the activity of some termite predators. Nine varieties consisting of four Uganda hybrids, one local cultivar (Ekwakoit) from Serere, eastern Uganda, one Kenyan open-pollinated variety (Katumani), a Ugandan line (LP 16), Kawanda composite and Longe-1 were used in the study. The activity of two ant species *Odontomachus haematoda* and *Lepisiota* sp. was significantly higher ($P \leq 0.05$) in varieties characterised by an erect leaf system than varieties with decumbent leaf arrangement. The activity of *O. haematoda* had a positive correlation ($r^2 = 0.72$; $P \leq 0.05$) at mid-day sampling and during late evening sampling ($r^2 = 0.83$). Maize stem base wetness was observed to be a result of stem flow of water (accumulated dew) from the erect leaf axils to the soil at the base of the plant. Results of the study indicate the potential of exploiting indigenous predators in combination with host plant characteristics in the management of termites and possibly other soil pests of maize.

Key words: Decumbent leaf arrangement, erect leaf system, *Lepisiota* Sp., *Odontomachus haematoda, Zea mays*

Introduction

Since the early 1950's, persistent organo-chlorine insecticides were used to effectively control termites in annual crops. Following the restriction or banning of these substances on environmental and human health grounds, new and less persistent insecticides (Wood *et al.*, 1987), formulations of non-persistent insecticides (Majer, 1986) and baiting techniques (El Bakri *et al.*, 1989) have been developed for the control of termites. These, however, have not been widely used by smallholder farmers in developing countries due to high costs and, in some cases, poor availability (Logan *et al.*, 1990). Thus, alternative strategies are needed for the management of termites in smallholder agriculture where they can cause significant crop losses.

Host plant resistance and biological control are widely seen as providing both stable insect control and less environmental damage on non-target organisms than chemical pest control (Howarth, 1991, Thomas and Waage, 1996). Although the role of predators in regulating natural populations of termites is largely unknown (Wood *et al.*, 1987) termites are reportedly prey to a wide range of vertebrates and invertebrates (Wood and Johnson, 1986). Recent research reviews clearly indicate the important role of ants as predators of these pests (Grace, 1997).

Ants have frequently been used as biological control agents in the past (Claunsen, 1940; De Bach, 1974). In Uganda, *Odontomachus haematoda* and *Paltothyrus* sp. for example, are commonly seen attacking, killing worker termites and carrying away the dead bodies (Okwakol, 1991). Ponerine ants are also known to raid termite nests, causing extensive worker mortality (Sudd, 1970). Nests of *Myrmicinae* and *Componotinae* often occupy large portions of dead mounds, suggesting their ability to exterminate termite colonies and colonising the mounds (Okwakol, 1991). However, little is known about the impact of ants on termites under field conditions or the effects of plant architecture on predatory activity of ants. Habitat modification in perennial crops has in a few instances, effectively reduced pest populations by favourable habitat conditions for predatory ants (Majer, 1982, 1986) In this study, we examine the effect of different maize plant architectures associated with open-pollinated and hybrid varieties on the physical environment beneath the plants and on the activity of predatory ants in vicinity of the plants.

Materials and Methods

The study was conducted at Namulonge Agricultural and Animal Production Research Institute (NAARI), Mpigi, Uganda. Previous observations from trials conducted in this region of the country have reported that ground foraging ants (Hymenoptera: Formicidae) are the most obvious insect predators in maize fields (Sekamatte, 1998 unpublish.). The experiment was established during the second cropping season of 1998, a period usually characterised by shorter rains than in the first season. The experimental plots were 13 m x 10 m, and maize was planted at a spacing of 75 cm between rows and 50 cm between plants within rows, to give a seedling density of approximately 53,000 plants per hectare. Plots were separated by 1.5 m wide alleys and weeds were managed by hand-hoe weeding. Weeding was done three times, at a monthly interval starting three weeks after seedling emergence. The treatments were arranged in a randomised complete block design with nine treatments (maize varieties) and three replicates. The 9 varieties consisted of four hybrid varieties developed by the Uganda National Cereals Programme (hybrids A-D), one local variety from eastern Uganda (Serere), one Kenyan open pollinated variety (Katumani), a line from Namulonge (LP16) and the open pollinated Kawanda composite and Longe-1.

Sampling for ants

Ants were sampled by visual observations on three middle rows of every plot. By inspecting every other hill in the 3 rows, a total of 50 plants were sampled per plot. Observations were performed on three occasions 4, 20 November and 3, December, 1999 (corresponding to 60, 75, 90 days after planting, respectively). The average maximum and minimum temperatures on the three data recording days were 27.9 and 16.0 °C, respectively. Also, observations were made at three intervals of each sampling day i.e. 6.00 - 7.00 hr, 11.00 - 12.00 hr and 17.00 - 18.00 hr. Because of the difficulty of counting the number of individual ants foraging or nesting at each hill, especially for the small species, a relative index of abundance was used where; < 5 ants = +, 6-10 = ++ and > 10 +++.

Moisture status of the soil at stem bases and degree of maize plant root exposure

It was casually observed during the previous cropping season that plants of the hybrid varieties collected dew during the night which later in the mid-morning dropped around the maize plant stem base, making the surrounding soil wet. Thus, during each sampling for ants, the moisture status (wet or dry) was recorded on each of the 50 sample plants per plot. For each of the 50 plants, the number of exposed root layers was also recorded. The proportion of plants with exposed roots was then expressed as a percentage and the frequency of occurrence of plants with a given number of root layers determined.

Termite damage to maize plants

All the sample plants in each replicate plot were examined for symptoms of termite damage. Damage on roots, stem base and leaves was recorded as a compound index (expressed as proportion of plants showing termite damage out of the sampled plants) for each treatment plot.

Statistical analysis

Data from the three sampling occasions were pooled to obtain seasonal means for the individual parameters. Statistical analysis for ant activity and moisture status of the soil around stem bases was done separately for each hour of sampling. The data for ant activity was arcsin transformed while that for soil moisture was square root transformed to normalise variances (Steel *et al.*, 1997). Analysis of variance (ANOVA) was performed and means separated by Tukey's honestly significant difference test (Steel *et al.*, 1997). A least squares regression analysis was also done to establish the relationship between ant activity and soil moisture at different hours of the day, root layers per plant, termite damage and percent plants with wet stem base.

Results

A description of the leaf system and variation in root exposure in the nine maize varieties used in the ant activity study is presented in Table 1. The erect leaf system is specific to the new hybrid varieties. Three of the hybrids (A,B & D) had a significantly higher ($P \leq 0.05$) number of exposed root layers than any of the other varieties (Figure 1). Hybrids B and D exhibited significantly more prop root layers than hybrids A and C. The open pollinated variety Katumani had significantly the lowest ($P \leq 0.001$) number of exposed root layers (Table 1).

Odontomachus haematoda and *Lepisiota* sp. were the dominant ants observed on maize plants during the growing season. Of the two species, however, *O. haematoda* showed greater activity in all the treatments, possibly because of its foraging behaviour. Ant activity in the early morning (6:00 – 7:00 h) was significantly lowest ($P < 0.05$) in Katumani plots (Table 2), a variety with the lowest root exposure (Table 1). Variety differences in respect to ant activity were more apparent, close to mid-day when temperatures rose above 25°C. At this time, significantly higher ($P < 0.05$) ant activity was

Table 1. Leaf architecture and degree of root exposure of the nine maize varieties used in the study

Treatment	Maturity days	Leaf system	% plants with exposed roots	Number of plants wth exposed root layers	Number of plants with wet stem bases
Longe - 1	118	decumbent	74.7a	0.89abc	0.71c
Serere	150	decumbent	83.1a	0.55bc	1.18bc
Katumani	95	decumbent	27.3b	0.03c	0.71c
LP 16	105	decumbent	87.3a	0.89abc	0.88bc
Kawanda	150	decumbent	67.3ab	0.90abc	0.71c
Hybrid A	125	erect	85.3a	1.15ab	2.59abc
Hybrid B	125	erect	95.3a	1.43a	3.53a
Hybrid C	125	erect	78.0a	0.15ab	2.67ab
Hybrid D	125	erect	86.7a	1.64a	2.67ab

Means within a column followed by the same letter(s) are not significantly different based on Tukey's test at $P < 0.05$.

recorded in plots with hybrid maize varieties (Table 2). The hybrids A, B and C characterised by an erect leaf system also showed a higher level of ant activity than the rest of the varieties, but the difference was only significant for hybrid B (Table 2).

No statistically significant differences among varieties were observed for *O. haematoda* activity during the evening sampling although their activity around hybrid varieties was always greater than that around open-pollinated varieties. *Lepisiota* sp. was most active during the evening in plots of hybrid A although this was not significantly different from 5 others (Table 2). The activity of this ant

Table 2. Mean percentage of maize plants with predatory ants in plots with different maize varieties in the early morning, mid-day and evening of 4th and 20th November and 3rd December 1998 at Namulonge.

Variety	Early morning		Mid - day		Late afternoon	
	Odont[2]	*Lepisiota.*	*Odont*[2]	*Lepisiota .*	*Odonto*[1].	*Lepisiota*
Longe-	112.75b	2.86a	11.08b	2.49a	15.19a	2.29abc
Serere	12.40b	3.04a	11.25b	1.44 a	12.19a	1.18c
Katumani	7.67b	3.21a	8.85b	2.58a	11.38a	2.46b
LP 16	23.67ab	2.97a	18.10ab	2.41a	14.03a	2.41abc
Kawanda	22.43ab	3.55a	18.73ab	2.21a	15.88a	3.68abc
Hybrid A	22.53ab	3.92a	30.57a	2.83a	16.63a	4.72a
Hybrid B	34.23a	3.06a	37.03a	4.12a	19.00a	4.19abc
Hybrid C	25.33ab	3.51a	33.97a	1.58a	10.70a	3.14abc
Hybrid D	21.93ab	3.16a	31.17a	3.28a	11.43a	4.70ab

[1]Means within a column followed by the same letter are not significantly different at $P \leq 0.05$, Tukey's honestly significant difference test. [2]*Odontomachus haematoda, Lepisiota* sp. [3]Pooled data for the recordings on 4, 20 November and 3 December.

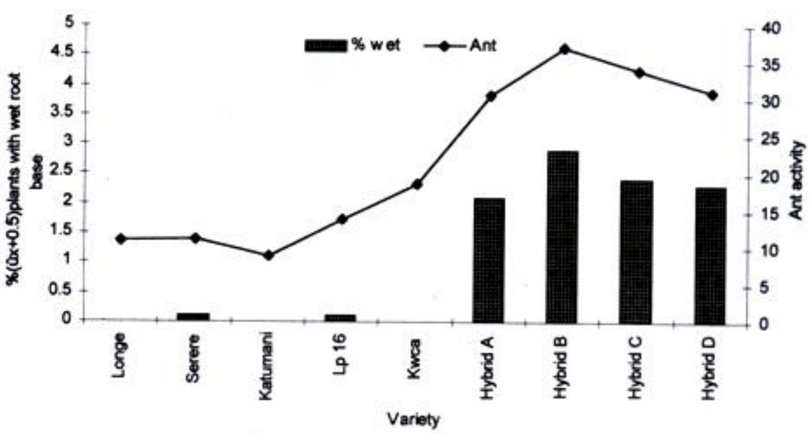

Figure 1. Effect of maize varieties on activities of O.haematoda and Lepisota ants in maize.

was greatest in the evening, possibly coinciding with the reduced activity of *O. haematoda* (Table 2).

There was no significant correlation between *Lepiosta* sp activity and the proportion of plants with wet soil at the stem base during the period from 6.00 to 7.00 h., between 11.00 and 12.00 h and between 17.00 and 18.00 hrs across all varieties. However, there was a significant positive correlation between activity of *O. haematoda* and the proportion of plants with wet soil at the stem base ($r^2 = 0.7205$, $P < 0.05$) (Figures 2 and 3).

Discussion

The results presented here are preliminary, as they cover observations of a single maize growing season, and will therefore require replication at different sites and season, and perhaps with more cultivars. Nonetheless, the results clearly indicate significant differences in the behaviour of predatory ants and termite infestation in phenotypically different maize varieties. The hybrid varieties in this study showed a significantly higher frequency of plants with exposed roots and a larger number of prop

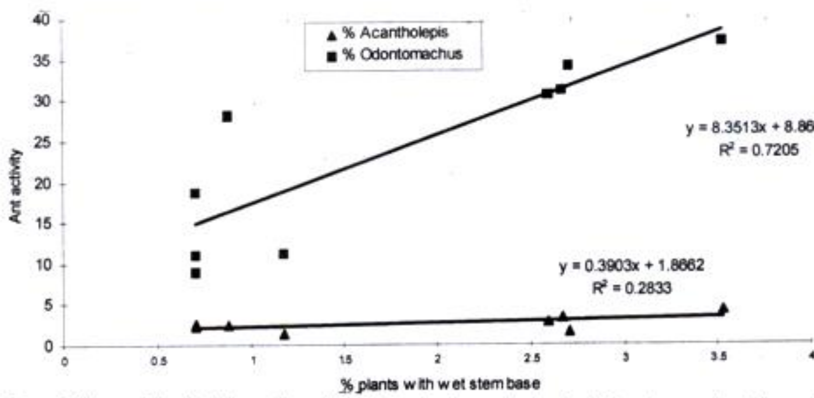

Figure 2. Linear relationship between the moisture status of soil around maize plants stem bases and predatory ant activity at mid-day.

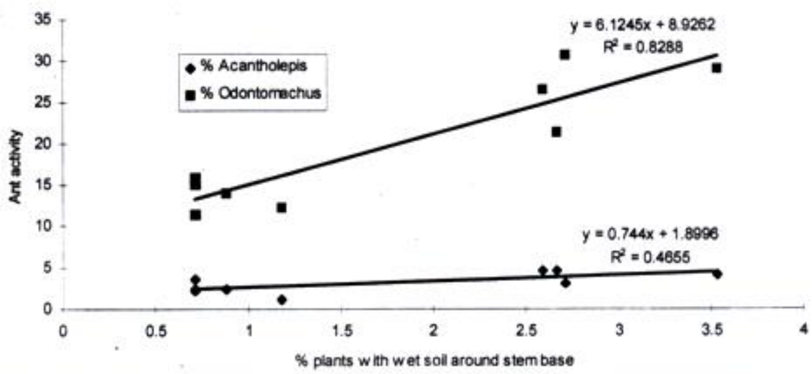

Figure 3. Linear relationship between the moisture status of soil around maize plants stem bases and predatory ant activity in the evening.

root layers as well as a more erect leaf architecture.

The latter feature appeared to result in greater amounts of stem flow of water from the leaf axils to the soil at the plant bases . These two features provide a generally more humid and shaded environment at the stem base of the hybrids as opposed to the open-pollinated maize varieties which we speculate is particularly favourable to the activity of the ant species studied. The strong positive relationship ($P < 0.01$, $r^2 = 0.72$) between plants with wet stem base at mid-day and ant activity (Figure 2) appears to be a result of the combined effects of the erect leaf system and well developed prop root system on ant activity. An even stronger relationship ($P < 0.01$, $r^2 = 0.83$) was obtained in late evening sampling (Figure 3). These features of hybrid varieties may be very important if the natural ant community is to be used as part of an integrated pest management programme. The use of ants as biological agents has a long history (Perfecto, 1990).

The preference for moist conditions for foraging by these species is revealed by the high level of activity observed immediately following rains (Sekamatte, pers. observation). Some evidence exists that plant architecture can influence dispersion of herbivores and searching by natural enemies (Thomas and Waage, 1996) but as yet, little is known about the effects of plant architecture on herbivore/natural enemy interactions (Price, 1986).

Although the importance of either ant species studied as predators of termites has not been quantified as yet, we have observed workers of both species attacking, killing and carrying workers of the three dominant genera of termites at Namulonge (*Pseudacanthotermes, Macrotermes* and *Microtermes*) on many occasions. It was particularly surprising that groups of the small *Acantholepis* sp. preyed on *Macrotermes* workers some several times their own body size. Individual *O. haematoda* were commonly seen carrying worker termites into large nests up to the time of harvesting. Ponerine ants are specialist termite predators but little work has been done on their effects on termite abundance in agro-ecosystems. However, the connection between ant abundance and reduced termite damage to maize was previously observed in a survey of farmers fields in 5 maize growing districts of Uganda where a strong negative correlation ($r^2 = -0.57$; $P < 0.05$) between numbers of ant nests at the base of maize plants and termite damage to the plants was established across all sites (Sekamatte, 1998 un publ.). In eastern Uganda, ants appear to play an important role in reducing termite damage to maize. Ants have been used for hundreds of years in Yemen to control date palm pests (Claunsen, 1940), and in China to control citrus pests (Groff and Howard, 1924) and have been found to be effective biological control agents in temperate forests and perennial crops (Room, 1973; Majer, 1982). Studies in cotton (Jones and Sterling, 1979; Sterling *et. al.*, 1984; Fillman and Sterling, 1985) and in soybean (Whitcomb *et al.*, 1972) in the tropical and subtropical zones of USA emphasise the role of ants as natural control agents.

Other authors however, have cast doubts on whether ant species could be used in pest termite control (Grace, 1997). Indeed the use of ants alone may not offer satisfactory termite control to maize below an economic threshold. Their use however, in combination with other methods of biological and cultural control has potential for stable regulation of pest termites at a level below which would otherwise cause economic damage under conditions of smallholder maize producers in Uganda and probably elsewhere in sub-Saharan Africa. Preliminary studies on the use of proteinaceous and sugary baits to increase ant activity and thereby reduce termite damage to maize have given promising results in both on-station and on-farm trials (Sekamatte *et al.*, Unpublished).

Acknowledment

The United Kindom Department for International Development (DFID) and the National Agricultural Research Organisation (NARO) funded this study. We deeply thank them. The views expressed in this paper are not necessarily those of DFID/NARO project R6653, Crop Protection Research Programme.

References

Claunsen, C.P. 1940. *Entomophagous Insects*. McGraw Hill, NewYork, USA.

De Bach, P. 1974. *Biological Control by Natural Enemies*. Cambridge University Press, Cambridge, England.

El Bakri, A., Eldein, N., Kambal, M.A., Thomas, R.J. and Wood, T.G. 1989. Effect of fungicide-imprignated food on the viability of fungus combs and colonies of *Microtermes* sp. nr. *albopartitus* (Isoptera:macrotermitinae). Sociobiology 15 : 175 - 180.

Fillman, D.A. and Sterling, W.L. 1985. Inaction levels for the red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formiciae): a predator of the bollweevil, *Anthomonas grandis* (Coleoptera: Curculionidae). Agricultural Ecosystems and Environment 13 : 93 - 102.

Grace, J.K. 1997. Biological control strategies for suppression of termites. Journal of Agricultural. Entomology 14 : 281 - 289.

Groff, G.W. and Howard, C.W. 1924. The cultured citrus ant of south China. Lingnan Agricultural. Review 2 : 108 - 114.

Howarth, F.G. 1991. Environmental impacts of classical biological control. Annual Review of Entomology 36 : 485 - 509.

Jones, D. and Sterling, W.L. 1979. Manipulation of the red imported fire ants in a trap crop for boll weevil suppression. Environmental Entomology 8 : 1073 - 1077.

Logan, J.W.M., Cowie, R.H. and Wood, T.G. 1990. Termite (Isoptera) control in agriculture and forestry by non-chemical methods: a review. Bulletin of Entomological Research 80: 309 - 330.

Majer, J.D. 1982. Ant manipulation in agro and forest ecosystems. Pages 166 - 188. In: Breed, M.D., Michener, C.D. and Evans H.E.(Eds.). *The Biology of Social Insects*. Westview, Boulder, Colorado, USA.

Majer, J.D. 1986. Utilising economically beneficial ants. Pages 1-68. In: Vinson, S.B. (Ed.). *Economic Impact and Control of Social Insects*. New York Praeger.

Okwakol, M.N.J. 1991. Fauna associated with *Cubitermes testaceus* mounds (Isoptera: Termitinae). Insect Science and its Application 12 : 511-514.

Perfecto, I. 1990. Indirect and direct effects in a tropical and agro-ecosystem: The maize- pest -ant system in Nicaragua. Ecology 71 : 2125-2134.

Price, P.W. 1986. Ecological aspects of host-plant resistance and biological control:Interaction among three trophic levels: In: Boethel, D.J. and Eikenbary, R.D. (Eds.). *Interactions of Plant Resistance and Parasitoids and Predators of Insects*. Wiley andSons, Chichester, U.K.

Room, P.M. 1973. Control by ants of pest situations in tropical tree crops: a strategy for research and development. Papua New Guinea Agriculture Journal 24 : 98-103.

Steel, R.G.D., Torie, J.H. and Dickney, D.A. 1997. *Principles and Procedures of Statistics: A biometrical Approach*. 3rd Edn. McGrawhill NewYork. 666pp.

Sterling, W.L., Dean, D.A. Fillman, D.A. and Jones, D. 1984. Naturally-occurring biological control agents of the bollweevil (Coleoptera:Curculionidae). Entomophaga 29 : 1-9.

Sudd, J.H. 1970. *An Introduction to the Behaviour of Ants*. Edward Anorld, London.

Thomas, M. and Waage, J. 1996. *Integration of Biological Control and Host-Plant Resistance Breeding: A Scientific and Literature Review*. CTA.

Whitcomb, W.H. A., Denmark, A.P., Bhalkar and Green, G.L. 1972. Preliminary studies on the ants in Florida soybean fields. Florida Entomology 55 : 129 - 142.

Wood, T.G. and Johnson, R.A. 1986. The biology, physiology and ecology of termites. Pages 1-68. In: Vinson, S.B. (Ed.). *Economic impact and control of social insects*. New York, Praeger.

Wood, T.G., Bednarzik, M. and Aden, H. 1987. Damage to crops by *Microtermes najdensis* (Isoptera: macrotermitinae) in irrigated semi-desert areas of the Red Coast. 1. The Tihama region of Yemen Arab Republic. Tropical Pest Management 33 : 142 - 150.

MUARIK Bulletin

INSTRUCTIONS TO AUTHORS

1. Manuscripts presented for publication should describe original work and are accepted on the understanding that they are not published elsewhere.

2. The articles should deal with original research, surveys, reviews, short notes, new methods and techniques. Research investigations conducted outside Uganda but with relevance to the African context will be considered.

3. Each article should be submitted in triplicate (original and 2 copies) to:

The Editor
MUARIK Bulletin
Makerere University
Faculty of Agriculture
P. O. Box 7062
Kampala, Uganda

4. Manuscripts are submitted in English (original and two copies), double-spaced, and on one side only. Articles should be limited to 12 quarto pages including tables, figures and photos. The spelling should be that of the Oxford English dictionary. Tables should be self-explanatory. Data presented in tables should not be duplicated in figures, nor discussed extensively in the text.

5. Articles are arranged in well defined sections: Title, Authors' names and addresses, Abstract, Introduction, Materials and Methods, Results and Discussion, Acknowledgement (if desired), References.

6. References should be arranged in alphabetical order, by family name of the first author and year of publication. Each reference should include authors last name, initials, year of publication, title of paper, name of Journal, volume and pages, for example,

Osiru, M.O., Rubaihayo, P.R. and Opio, A.F. 1999. Screening tomato accessions for resistance to bacterial wilt. MUARIK Bulletin 2:65-69.

Majer, J.D. 1982. Ant manipulation in agro and forest ecosystems. Pages 166-188. In: Breed, M.D., Michener, C.D. and Evans, H.E. (Eds.). *The Biology of Social Insects*. Westview, Boulder, Colorado, USA.

7. Authors cited in the body of the article should be indicated as follows: e.g. (Burton, 1970). If publications of one author (in the same year) are cited several times in the article, they should be indicated in a chronological order in the text with the letters "a", "b", "c", etc. e.g. (Odelola, 1969a) and should be listed similarly in the Reference list.

8. Each table and figure should be presented on separate a sheet and numbered Table 1, Figure 1, etc. The number of tables and figures should be limited as much as possible.

9. Authors shall be responsible for the accuracy and originality of the articles published in the Journal.

10. Ten copies of reprints shall be made available free of charge to the principal author. Extra copies may be purchased.

11. Articles submitted to the Journal will be subject to the usual editorial review procedures.

12. The Journal is published once a year except when special issues are produced.