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Volume 5 (Nos. 1 & 2) of *Vingnanam* has appeared six months after volume 4. Though a year behind the scheduled time of December 1990, we are now a little more hopeful of matching *Vingnanam* volume to year eventually.

Two papers deal with local problems in Jaffna peninsula. The paper by Kalawathy Kanagaratnam and K. Theivendirarajah describes the characteristics of four local cultivars of bananas: the paper by N. Selvarajah and Vanaja Rajaratnam deals with the limnology of two temporary ponds.

The paper by G. F. Rajendram describes the laboratory rearing of *Cyrtorhinus lividipennis*, a biological control agent of the planthopper pest of the rice crop.

K. Kandasamy presents further findings on diffusion of hydrogen in metals in Pd alloy membranes.

We also welcome a review paper from Andrew T. Chamberlain, University of Sheffield, England, on the evidence for human evolution, based on a seminar delivered at the University of Jaffna sometime earlier.

December 1991

Editor

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STUDIES ON FOUR CULTIVARS OF BANANA IN THE JAFFNA PENINSULA, SRI LANKA

KALAWATHY KANAGARATNAM AND K. THEIVENDIRARAJAH

(Department of Botany, University of Jaffna, Jaffna, Sri Lanka)

Vingnanam Journal of Science 5:1-6 (1990)

ABSTRACT: Studies on four cultivars of banana 'Mysore' (Kathali), 'Silk' (Kappal), 'Bluggoe' (Mondan-ash) and 'Watha palu' (Etharal) commonly cultivated in the Jaffna Peninsula, Sri Lanka, showed no significant difference among the cultivars with respect to their height and number of leaves/plant. Variation was observed in length of bunch, number of combs/bunch, total number of fingers/bunch and in the period of fruit maturation. Kathali showed the highest yield (number of fingers/bunch). Total sugar in ripe fruits varied from 20.21 to 28.33% (fresh weight) and showed no significant variation among the cultivars but % reducing sugar was much higher in 'Kathali' and 'Etharal'.

Introduction

The edible banana cultivars of importance in Sri Lanka are triploids and belong to AAA, AAB and ABB groups. The important cultivars are Gross michel and Dwarf cavendish belonging to AAA group; Mysore, Silk, Pome and Watha palu belonging to AAB group; and Bluggoe belonging to ABB group (Simmonds 1966). In Sri Lanka bananas are grown in the low country wet zone and in the dry zone including Jaffna peninsula in the north. It is grown under rain fed conditions in most places, but in the Jaffna peninsula it is cultivated under irrigation.

This paper describes the chief cultivars grown in the Jaffna peninsula. Mysore, Silk, Bluggoe and Watha palu cultivars dominate in Jaffna. These are referred under the following local names Kathali, Kappal, Mondan (Ash) and Ethari respectively. Of these, Kathali is cultivated extensively and it is highly resistant to Panama and leaf spot diseases (Simmonds 1966). Silk (Kappal) is susceptible to panama disease. Bunchy top disease is widely spread in Sri Lanka (Abeygunawardena, 1969) and this is the most common disease also among the cultivars in Jaffna.

No previous study has been reported on these cultivars and this paper deals with some morphological studies of the plant, fruit and biochemical analysis of the ripe fruits.

Materials and Methods

This project was conducted on well maintained banana cultivars at Urumpirai, Sirupiddy and Neervely in the Jaffna peninsula. The chemical status of the soils of the three places are similar; they are of the red latasols. The levels of the soil nutrients during the period of cultivation were within the range of adequacy for bananas. Sword suckers were used as propagules. Plants were spaced 2.5 m^2 at a depth of 30 cm. The normal cultivation practices were maintained throughout the study.

Growth parameters

Pseudostem height estimated as the distance from the base of the pseudostem to the point of intersection of the petioles of the youngest leaves was used as an index of growth. The heights of 50 plants at random for each variety were measured. Pseudostem girth was measured at different levels from the ground. The number of leaves at bunch emergence was counted in 50 plants selected at random for each variety. Time between flower initiation and harvesting was also measured.

Yield parameters

The length of the entire bunch, number of hands/bunch and number of fingers/bunch were measured as an index of yield. Length of the bunch was defined as the distance from the base to the maximum curvature when the bunch was kept straight. The above parameters were measured in 50 bunches selected at random for each cultivar.

Biochemical analysis

The ripe fruits of the four cultivars were analysed for moisture, mineral/ash, nitrogen, protein, reducing sugar and total sugar content. Fruits with good appearance, free from any disease and almost of the same stage of maturation, were selected for this analysis.

Moisture content was determined by drying a known weight of the sample at 105°C to a constant weight. A known weight of the dried sample was ashed at 480°C to a constant weight to determine the mineral/ash content. Percentage of reducing and total sugar was estimated by the Somogyi's semi-micro method (AOAC 1960). The percentage of total nitrogen in 1 g fresh sample was determined by the micro-kjeldahl method (AOAC 1950). The total nitrogen content was multiplied by 6.25 to obtain the total percentage protein.

Results and Discussion

The results of plant height, girth and number of leaves/plant are given in Table 1. The results show that there were no significant differences among the varieties in their height and in the number of leaves/plant. The mean height varied from 3.5 to 3.8 m. Girth size showed some variation, greatest girth size for Kappal and the least for Sambal mondan. The girth size variation was more significant at 50 cm from the soil.

Table 1. Growth parameters of the four cultivars of banana

(Sample size, $n=50$)

Cultivar	Height of the pseudostem (m) (Mean $\pm$ S.E)	Girth of final pseudostem at different levels from the ground (cm) (Mean $\pm$ S. E)			Number of leaves at bunch emergence (Mean $\pm$ S. E)
		25 cm from the ground	50 cm from the ground	100 cm from the ground	
Kathali	3.68 $\pm$.06	86.41 $\pm$ 2.32	76.08 $\pm$ 2.02	63.43 $\pm$ 1.66	13 $\pm$.64
Etharai	3.90 $\pm$.19	79.20 $\pm$ 3.80	71.06 $\pm$ 3.24	60.60 $\pm$ 2.62	11 $\pm$.62
Kappal	3.56 $\pm$.07	87.89 $\pm$ 2.50	81.16 $\pm$ 2.27	65.38 $\pm$ 1.69	13 $\pm$.68
Sambal mondan	3.80 $\pm$.36	79.03 $\pm$ 3.84	70.85 $\pm$ 3.28	60.62 $\pm$ 2.75	15 $\pm$.73

The results of yield parameters are given in Table 2. It shows that there is variation in length of the bunch, number of combs/bunch, total number of fingers/bunch and in the period of fruit maturation. Sambal mondan matures faster (nearly 2½ months) than the others. Etharai takes a longer period (nearly 4½ to 5 months) for the fruits to mature.

Table 2. Yield parameters of the four cultivars of banana

(Sample size, $n=50$)

Cultivar	Length of the bunch (cm) (Mean $\pm$ S E)	Number of hands/bunch (Mean $\pm$ S E)	Number of fingers/bunch (Mean $\pm$ S E)	Period of fruit maturation in days (Mean $\pm$ S E)
Kathali	60.8 $\pm$ 2.65	13 $\pm$.50	241 $\pm$ 12.92	100
Etharai	51.15 $\pm$ 4.0	8 $\pm$.42	99 $\pm$ 9.09	140
Kappal	59.03 $\pm$ 4.63	8 $\pm$.68	121 $\pm$ 14.30	105
Sambal mondan	50.93 $\pm$ 3.33	6 $\pm$.26	82 $\pm$ 5.58	70

Kathali produces larger bunches with more fingers. Among the four cultivars, Kathali is the best with regard to yield and also the fruits mature in reasonably short period of time. The above considerations may have led to the popularity of this cultivar among the growers in the Jaffna peninsula.

Moisture and mineral/ash content of the ripe fruits of the varieties are given in Table 3. The results indicate that the skin has more moisture content than the pulp although the pulp appears soft. The moisture content of the skin showed no significant differences among the varieties. It ranged from 85 - 87%. But the moisture content of the pulp varied among the varieties. Out of the three varieties Kathali, Etharai and Kappal which are commonly consumed as ripe fruits, the pulp of the varieties Etharai and Kappal are relatively dry and hard and this accounts for the lower moisture content as observed in our studies. The skin contains more mineral/ash content than the pulp. The ash content of the pulp ranged from 3 - 5% while the ash content of the skin ranged from 11-15%. There was no varietal difference in mineral/ash content of either the skin or the pulp.

Table 3 Comparison of moisture and mineral ash content of the ripe fruits of banana

Cultivar	Moisture %		Dry matter %		Mineral/ash content % of fresh weight		Mineral/ash content % of dry weight	
	skin	pulp	skin	pulp	skin	pulp	skin	pulp
Kathali	84.91	77.99	15.09	22.01	1.78	1.15	11.66	5.22
Ethari	85.45	71.18	14.55	28.82	2.26	1.11	15.54	3.83
Kappal	86.91	73.71	13.09	26.29	1.91	1.36	15.34	5.13
Sambal mondan	85.09	63.88	14.92	36.12	1.60	1.40	10.95	3.74

The analysis of reducing, total sugar and acidity of the ripe fruit pulp is given in Table 4. The total sugar content ranged from 16.75 to 28.33%. Except for the Kappal (28.33%), all other varieties did not show any significant difference in the amounts of the total sugar. However the proportion of reducing sugar and sucrose in the pulp showed significant variation. In Kathali and Ethari, the proportion of reducing sugar was greater while this was reversed in Kappal. This explains why Kathali and Ethari are generally sweeter in taste compared to Kappal. They have more reducing sugars in the form of fructose and glucose than Kappal, which accounts for the extra sweetness. Of these varieties Kathali has a pleasant sour taste due to the higher acid content. The same variety grown in other parts of Sri Lanka, is referred to as 'Ambul'. 'Ambul' in Sinhala means sour.

Table 4 Reducing sugar and total sugar content of the ripe banana fruits

Cultivar	Reducing sugar % (fresh weight)	Total sugar % (fresh weight)
Kathali	16.38	21.58
Ethari	17.33	23.04
Kappal	9.67	28.33
Sambal mondan	9.71	20.21

Nitrogen and protein content of the ripe fruits are given in Table 5. The results indicate that the skin and pulp of the fruits had almost equal amounts of protein and also there was no varietal difference. Only Sambal mondan and White mondan are used as vegetables and even there, in the traditional cooking in Jaffna, most of the skin is removed. Therefore from the point of nutrition, it is the pulp that is important in all these varieties. In our study we have only considered the reducing sugar and sucrose in estimation of the total sugars. There may be other disaccharides and polysaccharides in fruit which will contribute to the net caloric value of the fruit. Further studies on the starch, ascorbic acid and free amino acid content of these cultivars are in progress.

Table 5. Analysis of nitrogen and protein content of the ripe banana fruits

Cultivar	Total nitrogen % (fresh weight)		Protein % (fresh weight)	
	skin	pulp	skin	pulp
Kathali	0.32	0.29	2.01	1.88
Ethari	0.39	0.39	2.45	2.49
Kapal	0.21	0.25	1.31	1.61
Sampal mondan	0.25	0.19	1.575	1.225

The cultivars Kathali and Kappal show greater variability with regard to number of fingers/bunch which is one of the important yield parameters. This may be genetic or due to environmental factors. Further investigation on these cultivars to identify their variability will be useful in selecting better high yielding varieties.

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LIMNOLOGY OF TWO TEMPORARY PONDS IN THE JAFFNA PENINSULA, SRI LANKA

N. SELVARAJAH & VANAJA RAJARATNAM¹

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Vingnanam — Journal of Science 5: 7—13 (1990)

ABSTRACT : A limnological study was made of two temporary ponds namely Ariyakulam and Regal ponds in the Jaffna peninsula of Sri Lanka. This part experiences north-east monsoonal rains around December and this period is referred to as the 'rainy season'.

Of the two ponds, Ariyakulam pond dries up completely during the dry season and the other Regal pond does not dry up, since it is supplied by drainage water throughout the year. The study commenced with initial filling of the ponds and concluded when the ponds were dry or nearly so.

During the period of the study almost all the observed organisms, the phytoplankton such as members of chlorophyceae and zooplankton including crustacea and protozoa were found in both ponds, while considerable differences were observed in the two ponds regarding the chemical factors such as nitrogen, oxygen, salinity and pH which were higher in Regal Pond probably due to the accumulation of drainage water in this pond.

Introduction

Edible fresh water fish are an asset and a potential source for supplementing the protein shortage in our country. The successful inland management depends basically upon limnological aspects of water bodies.

In recent years the cultivation of fresh water fishes for food has been spreading throughout the country. Most work on limnology has been carried out in various water bodies of this peninsula to analyse the abundance of certain zooplankton (Fernando and Mendis 1962; Selvarajah and Costa 1979; Fernando 1980).

This study is mainly concerned with the abundance of zooplankton which especially play an important role in the food chain in ponds. The local species of fish, which are zooplankton feeders, are *Catla* and *Aristichthys nobilis* (big-head carp).

Zooplankton fulfil a vital role in the transfer of energy through the food chains since they are the intermediate step between the phytoplankton and most fishes.

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The Study Area

The two ponds selected for this study were Ariyakulam ($80^{\circ} 01' 05''$ E, $9^{\circ} 40' 00''$ N) and Regal, ($80^{\circ} 00' 30''$ E, $9^{\circ} 39' 45''$ N) both situated within the Jaffna municipality. Ariyakulam is located about one mile northeast to Regal pond. The area and maximum depths of these two ponds are 0.524 hectares and 2.94 meters for Ariyakulam and 0.920 hectares and 1.72 meters for Regal pond.

These two ponds receive water during the north-east monsoon extending up to February. In addition to this they are supplied with drainage water throughout the year. Particularly the drains that reach the Regal pond collect water from the adjacent hospital and motor service station.

During the end of the dry season (that is about August) Ariyakulam dries completely, but sometimes intermonsoonal rains provide certain amount of water. The Regal pond, since it collects the drainage from the town, does not dry up and has sufficient water to tide over the dry season.

Considering the boundary areas, Ariyakulam is surrounded by large trees *Terminalia arjuna*, *Thespesia populnea*, *Delonix elata* and *Ficus religiosa* and some bushes especially of *Calotropis*. The wide spreading branches of these were found to cover a considerable area of the pond, except its middle region, while the Regal pond is almost exposed, with only 2 or 3 large trees. A small area of the pond which is near the clock-tower situated close by is mostly covered with grass.

Materials and Methods

The study commenced with the initial filling of the ponds (October 1980) and was planned to conclude with the termination of the dry season (August 1981). From each pond, weekly plankton samples were taken at about 10.30 a.m. and 40 samples were obtained throughout the study period from each pond.

Physical parameters

Temperature and light are the main physical parameters that determine the distribution of pond water organisms. Temperature was measured using a thermometer which was placed at a point about one foot below the surface. The transparency of the water was observed using a sachchi disc.

Samples to determine water chemistry

To determine the oxygen content, water samples were taken monthly at about 30 - 40 cm below the surface. They were collected in 125 ml dark stoppered bottles which were filled until they overflowed once. To

determine the amount of oxygen, unmodified Winkler method was used. For this, oxygen of the samples was fixed in the field by the addition of manganous sulphate and potassium iodate solutions. The resultant precipitate was dissolved in concentrated sulphuric acid and titrated with sodium thiosulphate solution.

Since the pH is known to change in an isolated container of water it was measured in the field using pH paper and immediately upon arrival in the laboratory a more exact reading was taken using a Beckman pH meter.

Water samples for the determination of salinity and nitrogen content were obtained in one litre plastic bottles and analysed within four hours. Salinity was determined by titrimetry. Total nitrogen content was determined by Kjeldhal method converting nitrogen into ammonia.

Collection of plankton samples

Quantitative plankton sampling was performed on each pond at every observation period by pouring a measured volume of water through a plankton net of 64 μ mesh and concentrating to final volume. By prior trials, a 10 litre sample concentrated to 40 ml was found to be suitable. Water was poured through the net so that the filtered water was poured back into the pond. The samples were immediately preserved in 5% formalin.

Qualitative and quantitative analysis of plankton

Among the algal population the blue-green alga *Microcystis* species was not counted because of its high density. For quantitative purpose all other species of algae were considered collectively as "algae". Identifications of organisms was carried out mostly to the generic level.

One millilitre of the sample was withdrawn with a pipette, after thoroughly mixing to homogenize the concentrate, and transferred to a Sedgewick - Rafter counting cell and covered by a coverslip. Three counting techniques were used (Tribbey 1965). For larger organisms counts were made of the entire number within the counting cell under low magnification. Smaller and sparse forms were counted by traversing the width of the cell and counting all the types encountered. For very common smaller forms the number in one field was recorded. This was repeated for 5 fields and the average of these five counts was taken.

Bottom samples were first analysed for microfauna. Then they were dissolved in water and the resultant solution was examined under the microscope for microorganisms. Significance of correlation between biotic and abiotic factors was determined by the large sample approximation test for significance of correlation. The number of samples used was 40 (hence > 30).

Results and Discussion

The bottom of both ponds were found to be muddy, but that of the Regal pond was found to be much softer in nature than that of Ariyakulam.

The abiotic factors of the two ponds are given in figures 1 — 3.

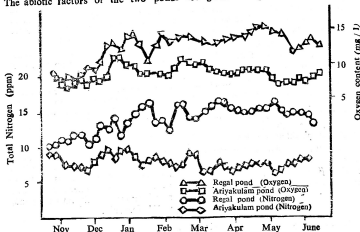


Fig. 1. Nitrogen and oxygen content in Ariyakulam and Regal Ponds.

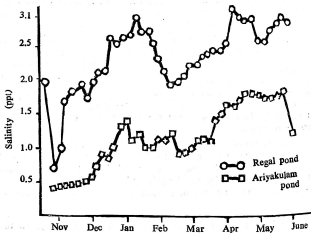


Fig. 2. Salinity in Ariyakulam and Regal Ponds.

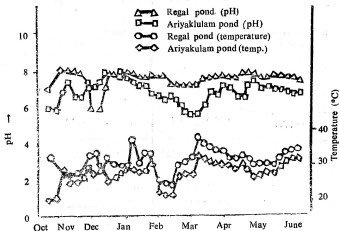


Fig. 3. pH and temperature in Ariyakulam and Regal Ponds.

The phytoplankton common to both ponds were species of *Chlamydomonas*, *Ulothrix*, *Pediastrum*, *Spirogyra*, *Volvox*, *Clavium*, *Navicula*, *Asterionella*, *Scenedesmus* and *Microcystis*. The zooplankton common to both ponds were species of *Daphnia*, cyclops, *Brachionus*, *Vorticella*, *Epistylis*, *Phyllodina*, *Euglena*, *Paramecium* and nauplius larvae.

Ariyakulam pond had *Nelumbium* and fish fingerlings, birds - Heron, tadpoles and mosquito larvae, while Regal Pond had shrimps and *Pistia*. Correlation matrix between biotic and abiotic factors in Regal and Ariyakulam ponds is given in Table 1.

It was found from this study, that both Ariyakulam and Regal ponds possess similar types of algae and mesofauna, but the larger organisms showed variation in types in these two ponds.

Table 1

Correlation matrix between biotic and abiotic factors in Regal and Ariyakulam ponds

		C ₁ Cyclops	C ₂ <i>Daphnia</i>	C ₃ <i>Brachionus</i>	C ₄ Nauplius	C ₅ Algae
Regal Pond	C ₆ Nitrogen	-0.079	0.104	-0.644*	-0.524*	-0.040
	C ₇ Oxygen	-0.089	0.258	-0.736*	-0.560*	0.230
	C ₈ Salinity	0.065	0.185	-0.569*	-0.461*	0.448*
	C ₉ pH	-0.166	-0.124	-0.134	-0.298	0.191
	C ₁₀ Temperature	0.190	-0.307	-0.034	-0.014	0.069
Ariyakulam Pond	C ₆ Nitrogen	0.88*	-0.322**	0.196	0.038	0.171
	C ₇ Oxygen	0.148	-0.188	0.473*	-0.526*	0.031
	C ₈ Salinity	0.282	0.073	0.052	-0.744*	-0.092
	C ₉ pH	0.274	-0.321**	0.468*	-0.241	0.281
	C ₁₀ Temperature	0.375**	-0.040	-0.001	-0.422*	0.101

* Significant at 1% level.

** Significant at 5% level.

In the correlation matrix of the Regal pond the relationship between nitrogen and the rotifer *Brachionus*, nitrogen and the crustacean larva nauplius, oxygen and *Brachionus*, oxygen and nauplius, salinity and *Brachionus*, salinity and nauplius, and salinity and algae were found to be significant at one percent level while all other relationships were found to be not significant. In Ariyakulam pond, the correlation of nitrogen and the crustacean cyclops, oxygen and *Brachionus*, oxygen and nauplius, salinity and nauplius, pH and *Brachionus* and temperature and nauplius were found to be significant at one percent level. The correlation of nitrogen and *Daphnia*, pH and *Daphnia*, and temperature and cyclops were found to be significant at five percent level. All other correlations of the Ariyakulam were found to be not significant.

Burgis *et al.* (1973) have shown that the species of *Daphnia* found in the Limnetic region in the tropics are of small size and that high temperature limits *Daphnia* directly or indirectly.

Acknowledgements

We wish to thank Miss C. Rajendram of the Zoology Department, University of Jaffna, for helping us in the preparation of the manuscript. We also wish to record our thanks to Mr. C. Elankumaran of the Department of Economics who helped us with the statistical analysis.

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LABORATORY REARING OF *CYRTORHINUS LIVIDIPENNIS* (HEMIPTERA: MIRIDAE)

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ABSTRACT: Laboratory rearing of *Cyrtorhinus lividipennis* Reuter in three types of cages was compared — chimney cage, plastic sleeve cage, 30×25×25 cm, and large wooden cage, 105×75×60 cm. *C. lividipennis* cultures in the chimney cage diminished to 79% of the original population in the first generation. The population in the wooden cage showed peaks of 200% increase during a 7 month period. The plastic sleeve cage was the most successful, with population increases ranging from 300% to 500%. The plastic sleeve cage was also the most economical and easiest to handle. *C. lividipennis* adult females oviposited only in mature stems of 4—6 week old rice plants.

Introduction

Cyrtorhinus lividipennis Reuter is a predator of the planthopper and leafhopper pests of the rice crop in Southeast Asia and the Pacific (Chiu 1979, Yasumatsu *et al.* 1981, Liquido and Nishida 1985). Its increased importance in recent years as a biological control agent is due to the rise to pest status of the planthopper and leafhopper complexes, following the introduction of high yielding rice varieties (Smith 1972, Nickel 1973). In Sri Lanka, *C. lividipennis* has been reported from the districts of Amparai, Batticaloa and Kilinochchi (Rajendram 1982, 1984), Jaffna (Rajendram 1982, 1984; Rajendram and Devarajah 1990), Kandy and Kurunagala (Rajendram: Unpublished data). Rajendram and Devarajah (1987) also reported the results of laboratory studies on the effectiveness of *C. lividipennis* as a predator of *Nilaparvata lugens* (Stål) in Sri Lanka.

Studies on the biology of *C. lividipennis* have been forthcoming from different countries. Studies on the biology have been carried out on *C. lividipennis* reared in cages 45×50×50 cm in the Philippines by Reyes and Gabriel (1975) in cages 55×55×60 cm in Hawaii by Liquido and Nishida (1985) and in chimney cages in India by Samal and Misra (1977). In Sri Lanka, the biology of *C. lividipennis* was studied on cultures maintained in cages of smaller dimensions, 20×25×25 cm, made of clear plastic and provided

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with cloth sleeve on one side (Rajendram and Devarajah 1986). The present study compares the rearing of *C. lividipennis* in three types of cages – the chimney cage used by Samal and Misra (1987), the plastic sleeve cage used by Rajendram and Devarajah (1986) and a large wooden cage 105×75×60cm.

Materials and Methods

C. lividipennis cultures used in these experiments were collected from rice fields in Paranthan and reared on *N. lugens* cultured in the laboratory at the University of Jaffna on rice variety Bg 90-2. The temperature in the laboratory registered a range of 26–32° C and relative humidity 40–92%.

Chimney Cage

The chimney cage (Fig.1) was constructed as follows. A 500 ml plastic bottle was sawed off at a height of 10 cm, and a 4–6 week old rice plant from a garden plot was placed in it and covered with mud to a height of 8 cm. A 10 cm high chimney with a narrow base, 7.5 cm in diameter, fitted snugly into the plastic container. The height of the chimney above the level of the plastic container was 17 cm.



Fig. 1 Chimney cage: (a) Chimney; (b) Plastic container; (c) Cotton gauze.

The culture was set up by introducing a male-female pair of *C. lividipennis* adults and two male-female pairs of *N. lugens* adults into the chimney cage by means of an aspirator. The mouth of the chimney cage was covered with cotton gauze. Sixty-five chimney cages were set up during the course of this study.

Plastic Sleeve Cage

The second type of cage used was a clear plastic cage measuring $20 \times 25 \times 25$ cm, covered with fine mesh nylon at the sides, a plastic door in front, and a cloth sleeve fitted on one side (Fig. 2). Six plastic bottles with rice plants were placed in the cage.

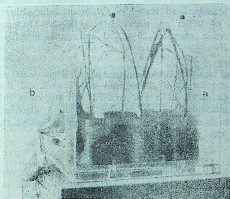


Fig. 2. Plastic sleeve cage : (a) Door; (b) Cloth sleeve.

The culture was set up by introducing three pairs of *C. lividipennis* adults into each cage along with three pairs of adults and 10 nymphs of *N. lugens*. Two adult pairs and 5 nymphs of *N. lugens* were introduced into each cage weekly. A total of 16 cages was set up in this experiment and a population count taken at the end of 30 days.

Large Wooden Cage

The third type of cage was a wooden cage measuring $106 \times 73 \times 60$ cm, made of a wooden frame, fitted with glass at the back, fine wire mesh on the top and the sides, and two sliding glass doors in front (Fig. 3). A cloth sleeve with a wooden frame could be fitted below a partially open door for use in transferring cultures. Rice plants grown in $25 \times 15 \times 9$ cm wooden boxes were placed in the cage for the host insects. Six plastic containers, with 4-6 week old rice plants, were introduced for oviposition by *C. lividipennis*.

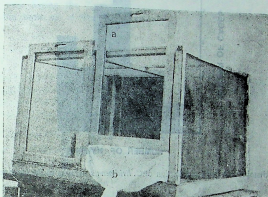


Fig. 3. Wooden cage: (a) Door; (b) Cloth sleeve in position.

The culture was set up as follows. Three male-female pairs of *C. lividipennis* were introduced into the cage, as well as four pairs of *N. lugens* adults and 10 nymphs. Only one large cage was used and the population fluctuation noted during 7 consecutive months.

Results

Chimney Cage

Of a total of 65 chimney cages set up, only 20 had nymphs, indicating an efficiency rate of about 29%. The number of nymphs produced in the cages ranged from 2 to 8, 5 being the median (Fig. 4). Although a total of 65 pairs or 130 individuals were used in setting up the chimney cages, only 103 nymphs hatched out. Hence the reproductive rate in the chimney cages was not sufficient to maintain the population.

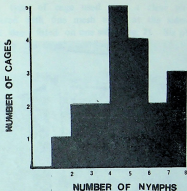


Fig. 4. Histogram showing distribution of *C. lividipennis* nymphs in the chimney cages.

Plastic Sleeve Cage

The number of *C. lividipennis* in the plastic sleeve cage at the end of 30 days ranged from 18 to 37, with a mean of 27.7 (Table 1). This represents a five-fold increase from the original 6 insects (3 males and 3 females) introduced into each cage.

Table 1. Number of *C. lividipennis* nymphs and adults in plastic sleeve cage after 30 days

Cage No.	Number of insects	Mean $\pm$ SD
1	37	
2	33	
3	23	
4	22	
5	18	
6	33	27.66 $\pm$ 6.96

Large Wooden Cage

The total number of *C. lividipennis* nymphs and adults in the large cage was 20 at the end of the first month, 35 at the end of the second month and 30 at the end of the 7th month (Fig.5). The maximum number of *C. lividipennis* at any time during the 7 month period was 35. The number is approximately the same as in the smaller plastic sleeve cage.

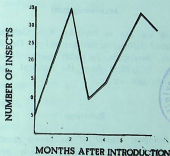


Fig. 5. Population fluctuation of *C. lividipennis* in the large wooden cage during a 7 month period.

Discussion

Of the three types of cages used in this study, the plastic sleeve cage was the most efficient. *C. lividipennis* reared in this cage showed an increase ranging from 300% to 500% at the end of 30 days. The cage was also easy to handle and required relatively few rice plants for the host insect.

C. lividipennis population in the large wooden cage showed an increase of up to 200%. Relatively more host plants were required to maintain the cultures of the host insect than in the plastic sleeve cage.

The chimney cage was the least effective, showing an efficiency rate of only 29%. Insects reared in these cages diminished to 79.2% of the original population in the first generation. Transferring of insects to cages with fresh plants was time consuming.

The age of the rice plants was critical in rearing *C. lividipennis*. Mature rice stems with a minimum girth of about 1.5 cm were required for oviposition by *C. lividipennis*. The rice plants had to be 4-6 week old. *C. lividipennis* did not oviposit in young rice seedlings. This observation is in agreement with the findings of Samal and Misra (1977) and Liquido and Nishida (1985) who used 30 day old rice plants for rearing *C. lividipennis*.

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STRAIN INDUCED DIFFUSION OF HYDROGEN IN Pd ALLOY MEMBRANES

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ABSTRACT: An equation for the diffusion flux of hydrogen through thin slab shaped membranes is derived. The effect of an induced elastic field on the diffusion flux is demonstrated. A comparison of the published experimental result with the outlined theory is given.

Introduction

The behaviour of hydrogen in a metal lattice has been a stimulating study for many research workers. Very recently abnormal behaviour of hydrogen diffusion in Pd alloy membranes was reported and interpreted as uphill diffusion of hydrogen by Lewis and his co-workers (Lewis *et al.* 1983; Lewis *et al.* 1987). This conclusion was based on the observed diffusion of hydrogen in Pd alloy membranes towards high concentration regions from low concentration regions. The inclusion of hydrogen in a metal lattice is usually associated with lattice expansion (Kandasamy 1980 and Peisl 1978) which creates an elastic field in the lattice. The effect of lattice deformation, due to application of an external stress on diffusion of interstitial solutes, such as hydrogen, has been a long standing study for many scientists. Their studies have shown that the interstitial solutes preferentially diffuse from regions of relatively compressed interstitial sites to regions of relatively expanded sites (Wagner 1978; Kehr 1978). In this paper an expression for internally induced elastic stress on the inclusion of hydrogen during the diffusion process in a thin slab lattice is derived and its effect on the diffusion of hydrogen is discussed and compared with published results (Lewis *et al.* 1987).

Theory

- a) Derivation of an equation for elastic stress induced by the diffusing interstitials in thin slab lattice.

Consider a thin slab geometry with the space co-ordinates illustrated in figure 1. Assume homogeneous distribution of interstitials as a stress free reference state. A change in the distribution of interstitial concentration from homogeneity will result in the introduction of internal stresses. Assume a change Δc in the concentration of interstitial distribution from its homogeneous value due to the absorption of hydrogen through the YZ face at

$X=0$. In general Δc is a function of space and time t , since the absorption is controlled by the diffusion. The part of the lattice which absorbs interstitials is expanded. The internal stress that is responsible for the expansion comes from interstitials and it can be expressed as $\sigma_e = K \Delta c$ where K is a positive constant (Cermak and Kufudakis 1976). This expansion caused by the composition change will be opposed by the remaining part of the lattice by elastically developing an internal stress, σ_c .

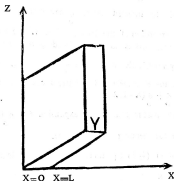


Fig. 1. Thin slab geometry with space coordinates (XYZ). The thickness L of the slab is very small compared to the width and the length.

Therefore the total internal stress σ_i is given by

$$\sigma_i = \sigma_c + \sigma_e = K \Delta c + \sigma_e \quad (1)$$

Assume the diffusion is only along the X direction. This is similar to assuming a constant concentration of interstitials in the YZ plane. Then in the slab material the component of the internal stress along the Y direction, σ_{yy} is the same as the stress component along the Z direction, σ_{zz} and the stress component along the X direction σ_{xx} is zero (Timoshenko 1934). The slab is under static equilibrium. Therefore the net force on the slab and the momentum about $X = L/2$ should be zero.

From zero net force
$$K \int_0^L \Delta c \, dx + \int_0^L \sigma_e \, dx = 0 \quad (2)$$

From zero momentum about $X = \frac{1}{2} L$
$$K \int_0^L \Delta c \left[x - \frac{L}{2} \right] dx + \int_0^L \sigma_e \left[x - \frac{L}{2} \right] dx = 0 \quad (3)$$

In general the elastically induced stress, σ_e can consist of two parts. One part is due to the expansion of the lattice. This will be the same everywhere in the slab. The other part is due to the bending of the lattice. This should vary linearly and symmetrically about $X = \frac{L}{2}$ (assuming constant Young's modulus). Therefore the elastically induced stress could be expressed as

$$\sigma_e = \sigma_o + \sigma_b \left(X - L/2 \right) \quad (4)$$

where σ_o represents the part responsible for expansion and $\sigma_b \left(X - L/2 \right)$ represents the part responsible for bending of the lattice.

Substitution of equation (4) in equations (2) and (3) will lead to the following:

$$\sigma_o = -\frac{K}{L} \int_0^L \Delta c \, dx \quad (2a)$$

$$\sigma_b = -\frac{K}{L} \frac{12}{3} \int_0^L \Delta c \left[x - \frac{L}{2} \right] dx \quad (3a)$$

Therefore the internal stress components σ_{YY} , σ_{ZZ} can be given by

$$\sigma_{YY} = \sigma_{ZZ} = K \left\{ \Delta c - \frac{1}{L} \int_0^L \Delta c \, dx - \frac{12}{L^3} \left[X - \frac{L}{2} \right] \int_0^L \Delta c \left[X - \frac{L}{2} \right] dx \right\}$$

The hydrostatic (external) stress components which have an equal effect on the lattice are equivalently given by

$$\sigma_{YY} = \sigma_{ZZ} = -K \left\{ \Delta c - \frac{1}{L} \int_0^L \Delta c \, dx - \frac{12}{L^3} \left[X - \frac{L}{2} \right] \int_0^L \Delta c \left[X - \frac{L}{2} \right] dx \right\} \quad (5)$$

For the problem considered here, that is with equal tensile stresses in the Y and Z directions and zero stress in the X direction, the strain ϵ and stress σ can be related by

$$\sigma = \frac{E\epsilon}{(1-\nu)}$$

where E is the Young's modulus and ν is the Poisson's ratio. If we assume Young's modulus and Poisson's ratio to be constant then

$$K = \frac{d\sigma}{dc} = \frac{E}{(1-\nu)} \frac{d\epsilon}{dc}$$

Using Vegard's law for interstitials, (Cermak and Kufudakis 1976), $\frac{d\epsilon}{dc}$ can be replaced by $\frac{1}{3}\bar{V}$ where $\bar{V}$ is the partial molar volume of interstitials

$$\text{Therefore } K = + \frac{E\bar{V}}{3(1-\nu)}$$

From this it follows that the stress components are

$$\sigma_{YY} = \sigma_{ZZ} = - \frac{E\bar{V}}{3(1-\nu)} \left\{ \Delta c - \frac{1}{L} \int_0^L \Delta c dx - \frac{12}{L^3} \left[X - \frac{L}{2} \right] \int_0^L \Delta c \left[X - \frac{L}{2} \right] dx \right\}$$

and $\sigma_{XX} = 0.$ (6)

The above expressions for stress components are exactly identical to the expressions deduced by Larche and Cahn (1982) from the theory of thermo-elasticity.

b) Derivation of equation for diffusion flux in the presence of induced internal stresses

In general the diffusion flux of hydrogen J_H could be written as (Volkl and Aleffeld 1978 and Wipf 1976)

$$J_H = -Mc \text{ grad } \mu \quad (7)$$

where M is mobility, c is concentration and μ is the chemical potential of hydrogen in the solid. The chemical potential of hydrogen in a solid which is under a tensile stress $\mu(c, \sigma)$ could be expressed as (Flanagan and Lynch 1976)

$$\mu(c, \sigma) = \mu(c, 0) - \bar{V}_H \sigma \quad (8)$$

Where $\bar{V}$ is the partial molar volume of hydrogen in the solid and $\mu(c, 0)$ is the chemical potential in stress free state. If μ_H^0 is the standard chemical potential of hydrogen atom then

$$\mu(c, \delta) = \mu_H^0 + RT \ln c \quad (9)$$

Where R and T have their usual meaning. Since the chemical potential of hydrogen is a function of c and δ equation (7) can be expanded as,

$$\begin{aligned} J_H &= -Mc \{ \text{grad } \mu(c, \delta) + \frac{d\mu}{d\delta}(c, \delta) \text{ grad } \delta \} \\ &= -Mc \frac{d\mu}{dc}(c, \delta) \text{ grad } c - Mc \frac{d\mu}{d\delta}(c, \delta) \text{ grad } \delta \end{aligned} \quad (10)$$

But from equation (8) $\frac{d\mu}{d\delta}(c, \delta) = -\bar{V}_H$ and the quantity

$Mc \frac{d\mu}{dc}(c, \delta)$ could be defined as the diffusion coefficient, D_H

Equation (10) can then be written as

$$J_H = -D_H \text{ grad } c + \frac{c D_H \bar{V}_H}{\frac{d\mu}{dc}(c, \delta)} \text{ grad } \delta$$

But from equation (9) $\frac{d\mu}{dc}(c, \delta) = \frac{RT}{c}$

Therefore $J_H = -D_H \text{ grad } c + \frac{c D_H \bar{V}_H}{RT} \text{ grad } \delta$

Chen Min Li (1978) has suggested a similar equation to explain the possibility of enhanced diffusivity of isotropic solute in solid lattice. In a previous paper the author (Kandasamy 1989) has used the Chen Min Li formalism to explain the experimental result of Lewis *et al.* (1987). Here the equation has been derived from basic principles. On substitution for grad δ from expression (6) for the stress components, the flux J_H is given by

$$J_H = -D_H \left\{ 1 + \frac{2 \bar{V}_H^2 c E}{3 R T} \right\} \frac{dc}{dx} + \frac{8 \bar{V}_H^2 E c D_H}{L^3 R T} \int_0^L \Delta c [x - L/2] dx \quad (11)$$

Discussion

Equation (11) for the diffusion flux of hydrogen can be written as

$$J_H = -D_H^* \frac{dc}{dx} + \frac{8 \bar{V}^2 E c_D}{L^3 R T} \int_0^L \Delta c [x - L/2] dx \quad (12)$$

$$\text{where } D_H^* = D_H \left\{ 1 + \frac{2 \bar{V} c_E}{3 R T} \right\}$$

The first term of equation (12) is identical to Fick's flux term but with an enhanced diffusion coefficient due to elastically induced stress (extension part). The variation of this term with time could be represented by the characteristic break through nature (Crank 1972) as illustrated by plot (a) in figure (2). The second term also represents the effect of an elastically induced stress (bending part) due to the inhomogeneity of hydrogen distribution during diffusion process. We can show that this effect generates a hydrogen flux in the negative X direction, that is a flux against the concentration gradient. To illustrate this consider the second term of equation (12) at short times, that is when

$$D_H t/L^2 \ll 1 \text{ then the integral } \int_0^L \Delta c [x - L/2] dx \text{ can be approximated by } - \int_0^L \Delta c dx$$

which is equal to $-\frac{L^2}{2} \frac{\Delta c}{D_H} (D_H t/L^2)^{1/2}$ where Δc_0 is the concentration change

at $x=0$. Therefore the second term of equation (12) is

$$-\frac{4 \bar{V}^2 c_E D_H}{R T} \frac{\Delta c_0}{L} (D_H t/L^2)^{1/2}$$

which represents a flux in the negative direction. After a very long time, that is when $D_H t/L^2 > 0.45$ say, we could assume the establishment of a steady state of diffusion (Crank 1972). At steady state of diffusion we could assume linear variation of the concentration across the slab thickness. At this state the

$$\text{second term of equation (12) is } \frac{-2 \bar{V}^2 c_E D_H}{3 R T} \frac{\Delta c_0}{L} \text{ This also represents}$$

flux in the negative X direction. Therefore the variation of the second term of equation (12) could be represented by plot (c) in figure (2). This is in qualitative agreement with the published results of Lewis *et al.* (1987) which are reproduced in plot (d) of figure (2).

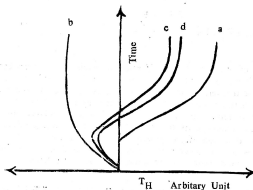


Fig. 2. Plot (a) Variation with time (t) of the first term of equation (12) for hydrogen flux J_H

Plot (b) Variation with time (t) of the second term of equation (12) for hydrogen flux J_H

Plot (c) Variation with time (t) of the diffusion flux J_H given by equation (12)

Plot (d) Experimental diffusion flux J_H with time (Lewis *et al.* 1987).

Conclusion

An expression for the stress induced by compositional inhomogeneity can be derived from simple Vegard's law. The observed abnormal behaviour of hydrogen diffusion can be accounted for by including the effect of stress induced by the compositional changes in the diffusion process.

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ABSTRACT: The main sources of evidence for human evolution are reviewed. The pattern of diversification of primates from their origins at the beginning of the Cenozoic era has been reconstructed using a combination of morphological evidence from fossil and living species together with measures of biomolecular similarity. Hominids evolved from a common ancestor shared with the living African apes, and throughout the Pliocene and much of the lower Pleistocene hominids were confined to their continent of origin. The earliest identifiable fossil hominids are less than 6 million years old and the origin of our own species ('anatomically modern' *Homo sapiens*) probably occurred with the last few hundred thousand years. Recent hypotheses concerning the evolution of the unique hominid adaptation of bipedalism are discussed.

Introduction

During the second half of the 19th century following the publication of Charles Darwin's "The Origin of Species" (Darwin 1859) the theory of evolution by natural selection became widely accepted among natural scientists. Interest and speculation about human ancestry was stimulated by Darwin's work, although Darwin himself was initially cautious about discussing human evolution. In his later book "The Descent of Man" (Darwin 1871) he was more forthcoming on the issue and assembled "three great classes of facts" which he held to demonstrate conclusively that humans had evolved from 'lower' animals. Darwin's evidence consisted of the homologous anatomical structures and physiological processes in humans and other animals; the similarities between humans and animals in patterns of growth and mode of development; and the presence in humans of rudimentary structures and organs that were best explained by gradual evolution from animals in which the same structures were fully functional. This body of indirect evidence was considered by Darwin to demonstrate that humans had evolved under the same constraints and mechanisms of natural selection as had other organisms, despite the absence (at the time he was writing) of any evidence for intermediate forms, either fossil or living, that could bridge the gap between humans and their closest relatives among the primates.

The evidence available today to students of human evolution is augmented by two major sources of data that were undiscovered in Darwin's lifetime. There are now a large number of fossil hominids, dating from about 6 million years ago (6 Ma) up to the end of the Pleistocene, which allow some of the intermediate stages of human evolution to be identified

and investigated. Secondly there is a new source of comparative data generated by the recently developed methods of molecular biology which provides an objective means of comparing the biological affinities of living species of primates, thus allowing independent corroboration of phylogenies derived from morphological evidence. This article summarises the position of the hominoids within the phylogeny of the primates; reviews the fossil remains *Australopithecus* and early *Homo*; and discusses the origins of the uniquely human adaptation of bipedalism. The term 'hominid' is used throughout in its cladistic sense of referring to the monophyletic group that includes all taxa more closely related to *Homo sapiens* than to any other living primate.

Primate Evolution and the Molecular Clock

Modern primates occupy forest, woodland and grassland biomes that broadly fall within the tropical region. Their present-day distribution is also constrained by their historical biogeography (Hoffstetter 1974), and by the pressures of human predation and modern changes in land-use (Harcourt 1990; Box 1991). Together with other modern orders of mammals, primate origins can be traced back to the beginning of the Cenozoic (Tertiary) era, to about 65 Ma (Szalay and Delson 1979; Martin 1990). Recent discoveries in Algeria have shown that anthropoid primates, the group that includes modern monkeys and apes, had evolved by at least 45 Ma (Godinot and Mohboubi 1992). The divergence of the anthropoids into their two major existing infraorders, the New World (Platyrrhine) and Old World (Catarrhine) faunas, is now estimated to have occurred before 40 Ma, after which the widening of the Atlantic Ocean in the late Eocene would have rendered faunal interchange between Africa and South America improbable (Martin 1990).

The pattern of diversification of the Old World monkeys and apes (including humans) has been established by combining the evidence from well dated fossils with the results of morphological and biomolecular comparisons between living representatives of the different catarrhine lineages (Martin 1990). After two lineages become separated the DNA and protein sequences of species diverge as random genetic mutations steadily accumulate in each lineage. In nuclear DNA, over 90 percent of which appears to be non-functional, most of this evolutionary change is selectively neutral since it neither benefits nor disadvantages the organism. Most mutations in mitochondrial DNA are also either in non-coding regions or are 'silent' substitutions that do not cause changes in the amino acid sequences coded by the molecule. Thus the rate of DNA evolution is largely determined by internal factors that are remote from environmental influence, such as the efficiency of DNA repair mechanisms and the time between germline replications.

Protein and DNA comparisons have yielded a highly corroborated sequence of branching among the extant catarrhine primate lineages (Goldman *et al.* 1987; Jeffreys 1989; Miyamoto and Goodman 1990). This branching pattern (Figure 1) can be converted into a 'clock' for determining the time of individual branching events by calibrating at least one speciation event against reliably dated fossil evidence. The molecular phylogeny for hominoids

is usually calibrated at two points, by the fossil evidence for the emergence of the cercopithecoïd (Old World monkey) lineage at 25 - 35 Ma, coupled with a date for the origin of the lineage leading to the orang-utan which diverged from the African ape and human lineage before 13 Ma (see below). Interpolation of the dates of the other branching points shown on Figure 1

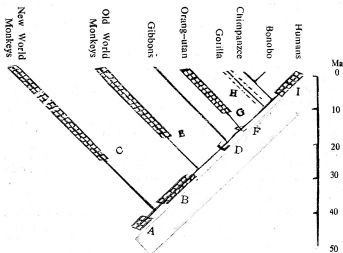


Fig 1. Phylogenetic tree for living anthropoid primates, based on the branching sequence established from biomolecular and morphological evidence. The hatched regions indicate the extent of the fossil record for each of the groups of living primates. Fossil evidence for the first appearance of these lineages is as follows: A. Anthropoids (*Algeripithecus*); B. Catarrhines (*Aegyptopithecus*, *Proplioptithecus*); C. Platyrrhines (*Branisella*); D. Hominoids (*Proconsul*); E. Cercopithecoïds (*Victoriapithecus*); F. Great Apes (*Afropithecus*); G. Pongines (*Sivapithecus*); H. ?Gorillines (Samburu Hills); I. Hominids (*Australopithecus*).

might conceivably be affected by changes in the rate of molecular evolution, which may have slowed down as generation lengths have increased during primate evolution (Li and Tanimura 1987). In fact generation length is relatively stable among the living apes, ranging from about 11 years in gibbons to between 12 and 14 years in great apes, and developmental timing in early hominids appears to resemble that of living apes, rather than modern

humans (Beynon and Dean 1988). It is probable therefore that generation length in apes, and by inference the rate of neutral molecular evolution, has changed significantly only in the terminal phase of the evolutionary history of modern *Homo sapiens*.

One prediction of the 'molecular clock' is that humans diverged from the African apes in the late Miocene, less than 10 Ma and perhaps as recently as 7 Ma. The Asian middle Miocene genus *Ramapithecus* was formerly classified as a close relative of the hominids (Pilbeam 1972; Szalay and Delson 1979), but following the synonymy of *Ramapithecus* with *Sivapithecus* (Greenfield 1979), and the identification of derived characters linking *Sivapithecus* to the living orang-utan (Andrews and Cronin 1982; Ward and Pilbeam 1983), the origins of the hominid clade are now thought to lie outside the Asian continent. The divergence of the human and chimpanzee lineages must have predated the earliest known fossil hominids, which occur in Africa later than 6 Ma (Table 1). An estimated date of 8 Ma for hominid origins can be obtained from the molecular phylogeny by interpolation from a date of 16 Ma for the origin of the orangutan clade, which in turn is bracketed by the appearance of the earliest known fossil great ape *Afropithecus*, dated to 17 Ma (Leakey and Leakey 1986) and the occurrence of *Sivapithecus* (a fossil relative of the orang-utan) in Asia at about 13 Ma (Kappelman *et al.* 1991).

Genetic investigations of living human populations using a range of different gene frequency and nucleotide sequence data offer strong support for an African origin of modern *Homo sapiens* within the last 400 thousand years (Cann *et al.* 1987; Cavalli-Sforza *et al.* 1988; Vigilant *et al.* 1989; Long *et al.* 1990; Bowcock *et al.* 1991). Some biologists, however, have criticised their colleagues' interpretations of the mitochondrial DNA data (Spuhler 1988; Excoffier and Langaney 1989; Maddison 1991), and palaeoanthropologists are divided over the implications of the DNA results for theories of human evolution (Mellars and Stringer 1989; Brauer and Smith 1992). Some anthropologists continue to advocate in situ evolution of *Homo sapiens* in every area of Africa, Asia and Europe rather than in Africa alone (Thorne and Wolpof 1992).

The Earliest Hominids

The late Miocene primate fossil record in Africa is exceedingly sparse (Pickford 1986), and the period of hominid evolution from 8 to 4 Ma is thus poorly known. The earliest fossils that can be assigned with confidence to the human lineage are attributed to the primitive hominid genus *Australopithecus*, which is present in East Africa from about 6 Ma (Hill and Ward 1988; see also Tables 1 & 2). The oldest fossil hominid yet discovered is a mandible from Lothagam in Kenya. This fossil was found in sedimentary

Table 1: Earliest fossil evidence for hominids in Africa

Date (Ma)	Site	Specimen	Taxonomic Attribution
3.0	Hadar, Ethiopia	AL 288-1 'Lucy' skeleton	<i>A. afarensis</i>
3.35	Koobi Fora, Kenya	ER 2602 cranial fragments	<i>A. afarensis</i>
3.4	Omo, Ethiopia	Omo 20-1886 tooth	<i>Australopithecus</i>
3.5	Laetoli, Tanzania	LH 4 mandible	<i>A. afarensis</i>
<4.0	Maka, Ethiopia	MAK VP 1.1 femur	<i>A. afarensis</i>
4.0	Belohdelie, Ethiopia	BEL VP 1.1 cranial fragments	<i>A. afarensis</i>
c. 4.0	Fejej, Ethiopia	FJ 4 SB 1,2 teeth	<i>A. afarensis</i>
4.0	Kanapoi, Kenya	KP 271 humerus	<i>A. afarensis</i>
>4.2	Chemeron, Kenya	BC 1745 humerus	<i>Australopithecus</i>
4.9	Tabarin, Kenya	TH 13150 mandible	<i>cf. A. afarensis</i>
>5.5	Lothagam, Kenya	LT 329 mandible	<i>cf. A. afarensis</i>
c. 8.0	Samburu Hills, Kenya	SH 8531 maxilla	Hominoid (<i>cf. Gorilla</i>)

deposits between volcanic layers with radiometric dates of 3.8 and 8.5 Ma; faunal correlations suggest that the specimen is older than 5.5 Ma. Although White (1986) expressed reservations about the attribution of the Lothagam mandible to *Australopithecus*, Hill and Ward (1988) present a convincing case

Table 2: First and Last Appearances of Hominid Taxa in Africa

Taxon	First Appearance (Ma)	Last Appearance (Ma)	Maximum Geographical Range
<i>A. aethiopicus</i>	2.6	2.3	E. Africa
<i>A. afarensis</i>	> 5.0	2.8	E. Africa
<i>A. africanus</i>	3.1	2.3	S. Africa
<i>A. boisei</i>	2.3	1.4	E. Africa
<i>A. robustus</i>	1.9	1.2	S. Africa
<i>H. habilis</i>	2.4	1.5	Africa
<i>H. erectus</i>	1.75	0.4	Africa, Asia
<i>H. heidelbergensis</i>	0.4	0.1	Africa, Asia & Europe
<i>H. sapiens</i>	0.1	—	Worldwide

The taxonomic classification adopted in this Table follows Delson (1987) for species in the genus *Australopithecus* and Stringer (1984) for species of *Homo*. The species '*Homo heidelbergensis*' has been substituted in place of Stringer's informal taxon 'archaic *Homo sapiens*'.

for its assignment to that taxon. An earlier fossil jaw from late Miocene deposits at Samburu Hills in Kenya is non-hominid, having closest affinities with the extant great ape *Gorilla* (Hill and Ward 1988). Confirmation of this taxonomic attribution for the Samburu Hills fossil, which is dated to around 8 Ma, would provide a minimum date for the divergence of the gorilla lineage and would therefore further constrain the timing of the origin of the human lineage.

Hominids are better represented in the early Pliocene with at least ten African fossil hominid sites now identified in the interval from 5 to 3 Ma (Table 1; Figure 2). Most of the fossils from these sites have been attributed to *Australopithecus afarensis*, a species which is best known from the samples recovered at Laetoli in Tanzania and Hadar in Ethiopia. The postcranial fossils at Hadar and the fossilised hominid footprints at Laetoli provide clear evidence of bipedalism in *Australopithecus afarensis*, although this species also retained some anatomical adaptations for arboreal locomotion (Susman *et al.* 1984).

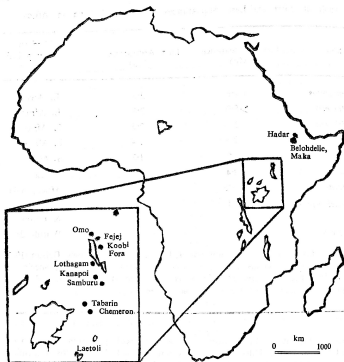


Fig 2. Map of early hominid sites in Africa.

The earliest fossil skeletal evidence for the genus *Homo* appears in East Africa before 2.0 Ma. Three isolated teeth from Member E of the Shungura formation at Omo, Ethiopia, dated to about 2.4 Ma have been attributed to the genus *Homo* (Howell *et al.* 1987). At Koobi Fora in Kenya the genus *Homo* first appears in the upper part of the Burgi Member, dated to 1.9 Ma (Wood 1991). The type series of *Homo habilis* from Olduvai Gorge in Tanzania includes specimens from Bed I, dated to 1.85 Ma, and from the lower part of Bed II, dated to 1.7 Ma (Tobias 1991). Specimens that have been attributed to *Homo habilis*, particularly the cranial remains of early *Homo* from Koobi Fora, are heterogeneous in their morphology (Chamberlain

and Wood 1987; Lieberman *et al.* 1988; Chamberlain 1989) and there is currently no clear consensus on the taxonomic status of this species (Tobias 1991; Wood 1991). The species *Homo erectus* which first appears at 1.75 Ma in the KBS member at Koobi Fora, Kenya, subsequently occupied a wide region of the Old World, persisting until 0.4 Ma in North Africa and 0.25 Ma in China (Rightmire 1990). A summary of the first and last appearances of conventional fossil hominid species in Africa is given in Table 2.

The earliest stone tools have been found in deposits dated to 2.7 Ma at Kada Gona in the Hadar region of Ethiopia (Harris 1986). All sites in Africa yielding the remains of *Homo habilis* have also produced evidence of stone tool manufacture or use, and many anthropologists view the manufacture of stone tools as the exclusive prerogative of *Homo*. This assumption has been challenged by Susman (1988) who argues that the fossil hand bones of *Australopithecus robustus* show that this species may have possessed a precision grip as sophisticated as that of *Homo habilis*. The fossil remains of 'robust' australopithecines are frequently found at the same sites as *Homo habilis*, and it is thus impossible to exclude *Australopithecus* as a potential maker or user of stone tools.

The evolution of bipedalism

Although a variety of modes of locomotion have been adopted by primates (Martin 1990), the immediate ancestors of hominids were large bodied hominoids that were probably adapted to climbing and suspensory postures (Susman *et al.* 1984). Several theories have been advanced to explain the evolution of upright posture and bipedal gait, a form of locomotion that among primates is unique to hominids (Day 1986). Hominoids have been considered to be preadapted to develop bipedalism, but a large number of anatomical and physiological changes are implicated in the change from habitual quadrupedal to bipedal locomotion (Aiello and Dean 1990). This suggests that considerable advantages in energy saving or in enhanced reproductive success must have accrued when hominids adopted this form of locomotion. Skeletal modification for bipedalism are found in the earliest fossil hominids, and the occurrence of fossilised footprints of hominids at Laetoli in Tanzania shows that the australopithecines were capable of walking fully bipedally.

Rodman and McHenry (1980) showed that when a bipedal animal walks it consumes less energy than a quadruped of the same body size, although this advantage is reversed at higher speeds. Adaptive advantages in long distance bipedal walking might have included scavenging opportunities (from being able to follow migrating animals; Sinclair *et al.* 1986), or the ability

to carry food in order to provision mothers who had dependent infants (Lovejoy 1981). However, recent models of early hominid social structure (Foley and Lee 1989) exclude the monogamous group structure on which Lovejoy's provisioning hypothesis is founded, and there is no evidence of the widespread adoption of hunting or substantial meat eating by hominids prior to the appearance of *Homo*.

Wheeler (1984, 1991a, 1991b) has shown that by adopting a bipedal posture early hominids would have been able to reduce the heat load from incident solar radiation in the middle of the day. Further efficiency in thermoregulation would have stemmed from the loss of body hair in hominids, which would have allowed effective heat removal through convective cooling augmented by sweating. Since windspeeds are higher and air temperatures and humidity are lower away from the ground surface, the bipedal posture also enhances evaporative cooling. Wheeler (1991b) argues that the combination of bipedalism with loss of body hair enabled early hominids to maximise the time spent on foraging for low density or scattered resources in equatorial grassland habitats.

Alternative scenarios in which there might have been a selective advantage for bipeds include the need to detect and defend against predators (Kortlandt 1980), enhancement of the efficiency of tool use (Marzke 1986), or the ability to move across steep and sparsely vegetated terrain (Jaanusson 1991). The process by which adaptations end up serving a useful function additional to the function for which they were originally selected has been characterised by Gould and Vrba (1982) as 'exaptation'. It is likely that regardless of the initial impetus for bipedalism in early hominids, other benefits and opportunities emerged to contribute to the success of this radical change.

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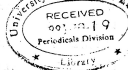
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இதழ் 5

1-ம், 2-ம் வெளியீடு

விஞ்ஞானம்

விஞ்ஞான சஞ்சிகை

'விஞ்ஞானம்' இதழ் 5 (1-ம், 2-ம் வெளியீடு) ஆனது இதழ் 4 வெளிவந்து ஆறு மாதங்களின் பின் வெளியிடப்படுகிறது. 1990ம் ஆண்டு வெளிவர வேண்டிய இவ்விதழ் ஒரு வருடம் காலதாமதமாகியுள்ள போதிலும், படிப்படியாக 'விஞ்ஞானம்' இதழ் ஒவ்வொன்றும் அதற்குரிய ஆண்டின் வெளிவரும் என நம்பிக்கை கொண்டுள்ளோம்.

இரண்டு கட்டுரைகள் வாழ்ப்பாண-குடாநாட்டுப் பிரச்சினைகளைப் பற்றியவை. கனாவதி கனகசெட்டியம், K. தெய்வேந்திரராஜா ஆகியோரின் கட்டுரை நான்கு வாழை வகைகளின் சிறப்பம்சங்களைக் குறிக்கும். N. செல்வராஜா, வனஜா இராஜ ரட்னம் ஆகியோரின் கட்டுரை இரண்டு தற்காலிக நன்னீரிக் குளங்களின் நன்னீரியவை விபரிக்கின்றது.

G.F. இராசேந்திரம் தெற்குமீர்ப்பிடைவாண கபிலிதத் தத்தியை உயிரியல் முறையில் கட்டுப்படுத்தும் *Cyrtorhinus lividipennis* இனுவடைய ஆய்வுகூட வளர்ப்பு முறைகளை விபரிக்கிறார்.

K. சுந்தராமி உலோகங்களில் (Pd) அமல்கச் சவ்வின் ஐதரசன் பரவல் மேலான கண்டுபிடிப்புகளை வெளிப்படுத்துகின்றார்.

இங்கிலாந்திலுள்ள செபி(ரி)மட் பல்கலைக் கழகத்தைச் சேர்ந்த அன்று T. சேம்பலின் மனித உர்ப்பிக்கான ஆதாரங்களை மீளாய்வு செய்கின்றார். இவ்விடயம் சில காலத்துக்குமுன் வாழ் பல்கலைக் கழகத்தில் நடந்த ஒரு கருத்தரங்கில் விவாதிக்கப் பட்டது. இதை நாம்கள் வரவேற்கின்றோம்.

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ஆசிரியர்

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இழ்விதழ் கட்டுரைகளின் சுருக்கங்கள்

யாழ் குடாநாட்டில் நான்கு வாழை இனங்களைப்பற்றிய சில படிப்புகள்

ஆசிரியர்கள்:

கலாவதி கனகரத்தினம் & K. தெம்பேந்திரராஜா

(தாவரவியல் பீடம், யாழ் பல்கலைக்கழகம், யாழ்ப்பாணம், இலங்கை.)

Vingnanam J. Sci. 5: 1-6.

சுருக்கம்:

யாழ் குடாநாட்டில் சாதாரணமாக பயிரப்படும் 4 வாழை இனங்களாகிய கதலி, உப்பர், மொத்தன், இதரை என்பவைப்பற்றிய பழப்பிரிவுத்து வாழையில் உயரம், இலைகளின் எண்ணிக்கை / தாவரம், நான்கு வாழை இனங்களிடையே பொருளுள்ள வேறுபாட்டைக் காட்டவில்லை என அறியப்பட்டது. வேறுபாடானது பின்வருவனவற்றில் காணப்பட்டது. குளவியின் நீளம், சீப்புகளின் எண்ணிக்கை / குலை, மொத்த வாழைகளின் எண்ணிக்கை / குலை, கதலி மற்றும் எடுக்கும் காலம், கதலி உயர் விளைவை (மொத்த கனியின் எண்ணிக்கை / குலை) கொடுக்கிறது. பழுத்த கனியின் வெவ்வு அளவானது 20-21 % இலிருந்து 28-33 % வரை (உடலின் திறை (fresh weight)) வேறுபடுவதுடன் இனங்களிடையே பொருளுள்ள வேறுபாடு எதனையும் காட்டவில்லை, ஆனால் தாழ்த்தும் வெவ்வுத்தின் நூற்றுத அளவானது கதலி, இதரை ஆகிய இரண்டிலும் கூடுதலாக காணப்படுகிறது.

இலங்கை, யாழ்ப்பாணக் குடாநாட்டிலுள்ள

இரு தற்கால குளங்களின் நன்னீரியல்

ஆசிரியர்கள்: N. செல்வராசா & வனஜா இராஜரெட்டினம்

(விவசாயத் துறை, யாழ் பல்கலைக்கழகம், யாழ்ப்பாணம், இலங்கை)

Vingnanam J. Sci. 5: 7-13.

சுருக்கம்:

இலங்கையின் வடபிராந்தியத்தில், யாழ்ப்பாணக் குடாநாட்டிலுள்ள, நீகல் குளம், ஆரியகுளம் எனப் பெயர்கொண்ட தற்காலிக குளங்களின் நன்னீரியலுக்குரிய ஆய்வு மேற்கொள்ளப்பட்டது. இப்பகுதி மாரீகழி மாதங்களில் வட-கீழ் பருவ மழையைப் பெறுவதால் அக்காலம் "மழைக்காலம்" என அறியப்படுகிறது.

இவ்விரு குளங்களில் ஆரிய குளமானது வறண்ட காலங்களில் முற்றாக வற்றும் மற்றைய நீகல் குளமானது வருடம் முழுவதும் வடிநீர் வழங்கப்படுவதால் வற்றுவதில்லை. இவ்வாய்வு இக்குளங்களின் தொடக்க நிரம்புதலுடன் ஆரம்பிக்கப்பட்டு, அவற்றின் அளவான அல்லது முற்றான வற்றலுடன் முடிவெடுக்கப்பட்டது.

இவ்வாய்வுக்காலத்தின்போது அனேகமாக அவதானிக்கப்பட்ட தாவர அழைப்பிர்களான குளோரோபைசியே அழைப்பிற்களும் விலங்கு அழைப்பிற்களான கிரெந்தேசியா, புரோட்டோசோவா என்பனவும் இரு குளங்களிலும் காணப்பட்ட போதிலும், இரகாயனக் காரணிகளான நைதரசன், ஒட்சிசன், உவர்த்தன்மை, பி. ஏச் என்பவற்றில் இரு குளங்களிடையேயும் பெருமளவு வேறுபாடு காணப்பட்டது. இவை நிகல் குளத்தில் கடுதலாகக் காணப்பட்டதன் காரணம் கழிவுநீர் இங்கு சேர்க்கப்பட்டமையேயாகும்.

Cyrtorhinus lividipennis (Hemiptera : Miridae) இன் ஆய்வுகூட வளர்ப்புமுறை

ஆசிரியர்கள்:

G. F. இராஜேந்திரம், பிரகாசின்கா R. தேவராஜா

(விவசியல் துறை, யாழ். பல்கலைக்கழகம், யாழ்ப்பாணம், இலங்கை)

Vingnanam J. Sci. 5: 14-21.

சுருக்கம்:

Cyrtorhinus lividipennis இன் ஆய்வுகூட வளர்ப்புமுறை மூன்றுவகைக் கூடுகளில் ஒப்பிடப்பட்டுள்ளது. மிமினி கூடு. மென் இரப்பர் கூடு, 30×25×25 cm, பெரிய மரக்கூடு, 105×75×60 cm. மிமினி கூட்டில் உள்ள *C. lividipennis* வளர்ப்புகள் முதல் சந்ததியில். ஆரம்ப சனத்தொகையின் 79.2% ற்கு முறைந்தது. மரக்கூட்டில் உள்ள சனத்தொகை ஏழுமாத கால இடைவேளையில் 200% வளர்வு அதிகரிப்பைக் காட்டியது. மென்ரப்பர் கூடு அதிக வெற்றியுள்ளதாக 300% இல் இருந்து 500% அளவு அதிகரிப்புடையதாக இருந்தது. மென்ரப்பர் கூடு அதிக பொருளாதாரமுடையதாகவும் கையாணச் சுலபமாகவும் இருந்தது. *C. lividipennis* திறைவுடலிப் பெண்கள் 4—6 மிழைமை வயதுடைய தெத்தாவரங்களின் மூலிர்த்த தண்டுகளில் மட்டுமே முட்டைபிட்டன.

பலேடிய (Pd) அமல்கச் சங்ரில் தகைப்பால் தூண்டப்பட்ட ஐதரசனின் பரவல்

ஆசிரியர்:

K. கந்தசாமி

(பெளதிகவியல் துறை, யாழ். பல்கலைக்கழகம், யாழ்ப்பாணம், இலங்கை)

Vingnanam J. Sci. 5 : 22-29.

சுருக்கம்:

மெக்னிய தகடுபோன்ற வடிவிலமைந்த சங்வினாடு ஐதரசனின் பரவற் பாயத்தில் காண சமன்பாடொன்று பெறப்பட்டுள்ளது. தூண்டிய மின் சத்திப் புனமொன்றினால் பரவற் பாயத்தில் ஏற்படும் விளைவு காண்பிக்கப்பட்டுள்ளது. பிரகரிக்கப்பட்ட பரிசோதனை முடிவுகளினதும் இங்கு விபரிக்கப்பட்ட அறிமறையினதும் ஒப்பிடுகை தரப்பட்டுள்ளது.

மனித கூர்ப்பிற்கான சான்றுகள்

ஆசிரியர்:

அன்று T. சேம்பலின்

(புதைபொருள் ஆராய்ச்சி, ஆரம்ப சரித்திரத்துறை, செபீ (F) ஸ்ட் பங்களவுக்ஹம், செபீ (F) ஸ்ட், இங்கிலாந்து)

Vingnanam J. Sci. 5: 30—42.

சுருக்கம் :

இக்கட்டுரையில், மனித கூர்ப்பிற்கான சான்றுகளின் பிரதான காரணிகள் மீள் ஆராயப்படுகின்றன. ஆரம்ப சிஸ்டோசோமிக் காலத்தில், பிறைமேற்றாக்கள் அவற்றின் வழித்தோன்றல்களிலிருந்து வேறுபாடடையும் அமைப்பானது, உயிர்ச்சவட்டு, உயிர் வாழ் இனங்கள் இரண்டின் உருவவியலுக்கான சான்றுகளையும் உயிர் மூலக்கூறு ஒத்த தன்மை அளவீடுகளின் சான்றுகளையும் பயன்படுத்தியே, மீள் அமைக்கப்படுகின்றது. தோறாமினிடாக்கள், உயிர்வாழ் ஆபிரிக்க வாலில்லாக் குரங்குகளுடன் பங்கிடு செய்யும் ஒரு பொது மூதாதையலிலிருந்து கூர்ப்படைத்தவை, பிளியோசீன் முழுவதிலும் அதின் சீழான பெருமனவான பிலிஸ்ரோசீனினும் தோறாமினிடாக்கள் உற்பத்தியான கண்டத்தில் வாழ்ந்தன. ஆரம்ப, இனங்காணக்கூடிய உயிர்ச்சவட்டு தோறாமினிடாக்கள், 6 மில்லியன் வருடத்துக்குள்ளானவை. எமது இனமாகிய (உடமைப்பியல் நவீன "Homo sapiens") கடந்த சில தூறாயிரம் ஆண்டுகளிலேயே பெரும்பாலும் உற்பத்தியாயின. விந்தையான தோறாமினிடாக்களின் உற்பத்தியைப் பற்றிய நவீன கருதுகோள்கள் இருபாதவியலுக்குரிய இசைவாக்க கூர்ப்பை தொடர்புபடுத்தியே விவாதிக்கப்படுகின்றன.

Instructions to Contributors

GENERAL

Submission of a manuscript to the editor involves the assurance that it is original and that no similar paper, other than an abstract, has been or will be submitted for publication elsewhere without the consent of the Editorial Board.

Research papers from original investigations and reviews which are critical evaluations of existing knowledge in a specialised field are accepted for editorial consideration. Short communications of sufficient importance to merit publication in advance of a full paper are also accepted by the journal.

The language of publication is English. A translation of the abstract in swabasha should be submitted with the manuscript. Every paper will be referred to at least one referee familiar with the field of research covered by the paper, who will be nominated by the Editorial Board. Papers are edited to increase clarity and ease of communication.

PREPARATION OF MANUSCRIPTS

No restriction is laid on the length of the manuscript, provided it is written clearly and concisely. All unnecessary descriptions, figures and tables must be eliminated. The impersonal form should be used in the text.

The style of setting out, sub-division of text and lay out of tables in the manuscripts should in general be organised in the form adopted in this issue.

Manuscripts should be submitted in triplicate including the original typewritten copy, typed throughout in double spacing on one side of the paper only. Adequate margins (4 cm) should be left with liberal spacing at the top and bottom of each page. The typescript should be free of corrections.

Each page of the manuscript should be numbered in the upper right hand corner. The title page should include the name and mailing address of the author to whom the proofs should be sent, a proposed running title of not more than four words and a short list of key words to be used in rapid scanning of the contents of the manuscript. The last page should contain a not indicating the number of manuscript pages, figures and tables.

ILLUSTRATIONS

All illustrations are considered as figures and each graph, drawing or photograph should be numbered in sequence with Arabic numerals. Authors must submit the original and two duplicates of each figure. Figures should be planned to fit the proportions of the printed page. The maximum space available on a page is 140 x 190 mm.

the same in the text as in the reference list. In the text refer to the author's name (without initial) and year of publication, followed, if necessary, by a short reference to appropriate pages. E.g. "Since Peterson (1967) has shown that..." "This is in agreement with results obtained later (Kramer, 1969, pp. 12-16)". If reference is made in the text to publications written by more than two authors, the name of the first author should be used, followed by "*et al.*". This indication, however, should never be used in the list of references, where the name of authors and co-authors should be mentioned instead. The list of references should be arranged alphabetically on authors' names, and chronologically per author. If an author's name in the list is also mentioned with co-authors, the following order should be used. Publications of the single author, arranged according to publication dates, publications of the same author with one co-author and publications of the author with more than one co-author. Use the following system:

JOURNAL

Selman, I. W. and Kujasegaram, S. (1967) Development of the stem tuber in Kohlrabi. *Journal of Experimental Botany*, 18, 471 - 490. Journal name should not be abbreviated.

BOOK

Slatyer, R. O. (1967) *Plant Water Relationships*. Academic Press, London. 366 pp.

SECTIONS OF BOOK

Skoog, F. and Miller, C.O. (1957) Chemical regulation of growth and organ formation in plant tissue cultured in Vitro. pp. 118 - 131. In: *Symposia for the Society of Experimental Biology XI. The Biological action of growth substances*. University Press, Cambridge.

In referring to a personal communication the two words are followed by the year, e.g. (J. McNary, personal communication, 1968).

CROSS-REFERENCES

The cross reference cannot be finally inserted until the page proof is available. Type them: "see page 000". In the margin pencil the page number of the cross reference in the manuscript.

FORMULAE

Formulae should be typewritten, if possible, leaving ample space around the formulae. Subscripts and superscripts should be set off clearly. Greek letters and other non-Latin or handwritten symbols should be explained in the margin when they are first used. Take special care to clearly show the difference between zero (0) and the letter O, and between one (1) and the letter l. Give the meaning of all symbols immediately after the equation in which they are first used. For simple fractions use the solidus (/) instead of a horizontal line.

Figures must be drawn in Indian ink on plain white paper or board tracing paper, not larger than twice the linear dimensions desired. Drawings should be lettered with a lettering set; lettering should be kept large enough to be clearly legible after a reduction of 50 to 60%; if this is not possible all letters and numerals must be inserted clearly and lightly in blue pencil and not in ink. Wherever possible small figures should be grouped to fill a page.

Each figure should carry a legend so written that the general meaning of each illustration can be understood without reference to the text. The amount of lettering on drawing should be reduced as far as possible by transferring it to the legend. Figure legends should be typed on a separate sheet and placed at the end of the manuscript.

Graphs should be plotted on white or bluelined graph paper or tracing cloth; grid lines that are to be shown in the engraving should be inked in black. The caption of each axis should be lettered parallel to its axis. Each figure should be identified in the margin with figure number. The preferred position of all illustrations should be indicated in pencil in the manuscript.

PHOTOGRAPHS

Good glossy prints with *sharp contrasts between black and white areas* should accompany the manuscripts. The size should be such that when the print is reduced to the normal size for reproduction (140 × 190 mm maximum) the detail is still clear. Magnification should be indicated with a scale line on the photograph. Figure number should be given on the back of each photograph.

TABLES

Tables should not repeat data which are available elsewhere in the paper. Each table should be typed on a separate sheet with due regard for the proportions of the printed page. They should be numbered consecutively with Arabic numerals. Tabulated matter should be clearly set out and the number of columns in each table kept as low as possible. Tables should have legends which make their general meaning clear without reference to the text and all table columns should have explanatory headings. Units of measure should be indicated in parentheses in the heading of each column. Vertical lines should not be used and horizontal rules used only in the heading and at the bottom. Footnotes to the tables are to be placed directly below the table. Each table should carry on the back of the sheet the author's name and figure number. The preferred position of tables should be indicated in pencil in the manuscript.

REFERENCES

All references to publications made in the text should be presented in a list of references following after the text of the manuscripts. The manuscripts should be carefully checked to ensure that the spelling of authors names and dates are exactly

e.g.: $I_p/2_m$ rather than $\frac{I_p}{2_m}$.

Parentheses and square brackets are preferred in formulae. Accolades should be used only when they are absolutely necessary. Equations should be numbered serially in the right-hand side and in parentheses only equations explicitly referred to in the text need in general be numbered. The use of fractional powers instead of root signs is recommended. Also power of e are often more conveniently denoted by exp. In the chemical formulae, valence of ions should be given as Ca^{2+} and CO_3^{2-} , not as Ca^{++} or CO_3^{--} . Isotope numbers should precede the symbols, e.g. ^{18}O . Use of superscripts added to superscripts and subscripts added to subscripts should be avoided, if possible.

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The journal may include a limited number of short communications. Authors should submit short communications only when they believe that rapid publication of their result is of the utmost importance. A short communication must not exceed 1200 words, should be complete in its own right and suitable for citation.

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Corrected galley proofs must be returned to the editor without delay. Failure to do so will result in delay in publication. Correction of proofs by authors must be restricted to the printer's and similar errors. They should be marked in pencil. Any modification of the original text is to be avoided. Responsibility for correcting proofs rests entirely on the authors though editorial assistance will be provided.

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