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Proceedings of the Symposium on Ecology of Animal Population

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STUDIES ON SOME ASPECTS OF LARVAL ECOLOGY OF MOSQUITOES AROUND VISAKHAPATNAM

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INTRODUCTION

Although various ecological aspects of mosquitoes have been studied, comparatively very little attention has been paid to study the ecology of mosquito larvae, in relation to their tolerance to industrial effluents and other environmental conditions. Sehgal and Pillai (1970) made preliminary studies on the chemical constituents of mosquitoes breeding waters in Delhi. Hagstrum (1971) correlated the salinity, **PH** and organic nitrogen of water to the occurrence of mosquito larvae. Margalit (1971) has given some notes on larval ecology of five prevalent culicini in Israel. Studies have been carried out on the ecology of mosquitoes by Rajagopalan (1975), Pajot (1976) and Maire (1976).

The present investigation is aimed at understanding of the ecological characteristics of a small Hill stream water in relation to the survival of larvae to fluctuating conditions. The temperature, dissolved oxygen and **PH** vary seasonally. These parameters would appear to influence the distribution of the mosquito larvae to a marked extend.

Examination areas with high concentration of Industrial effluents reveals that no mosquito larvae could be supported in such polluted waters. The tolerance of larvae with respect to moisture content also was studied in the laboratory conditions.

DESCRIPTION OF THE AREA INVESTIGATED

The stream situated some mide about 6 Kilometers North of Waltair, Andhra Pradesh and runs along the foot of a hill and joins the sea three kilometers farther down. There are a large number of trees with branches overhanging the stream on either side. Bottom is muddy and marginal vegetation offers good shady habitat. Water

flows almost throughout the year and, rapidly flows during the months of August, September and October. The stream has floating as well as submerged vegetation like Lemna and Typha ect.

MATERIALS AND METHODS

Samples were taken from January, 1977 to January, 1978. Surface water temperature, dissolved oxygen and PH were noted once in a week between 9 A. M. to 11 A. M. White enameled culture dishes were used to collect the larvae from the stream. For quantitative analysis the number of larvae per hundred ml. of water was numerically counted and their relative percentages were calculated during the period of a year. The identification of the species was made only in the case of *Cules*. The experiment was repeated ten times and mean values were calculated.

Some experiments were carried out in the laboratory with the object of determining precisely the resistance of the larvae to desiccation under different conditions — namely ; on damp clay, on damp filter paper and on dry watch glasses. Since the mature larvae were very resistant, the 4th instar stages were exposed to desiccation for different duration and then replaced in water to study their revival.

RESULTS

The ecological conditions of the stream vary very much during the year. Surface water temperature and dissolved oxygen are known to change seasonally. A highest surface water temperature of 32°C has been noted in May corresponding to summer and a minimum of 25°C in January which correspond to winter. Dissolved oxygen content varied from 2.296 ml./litre to 6.160 ml./litre. The mean pH ranged from 8 to 10.

Species of *Anopheles*, *Aedes* and *Culex* were recorded, but with the studies of relative abundance it was found that the *Culex* species constitute the majority and as such the seasonal fluctuations in their distribution has been dealt with in this paper.

From seasonal study it was noted that the numerical abundance of larvae was greater during the period July to October. So the favourable temperature for larval development was 28 to 32°C. The causative factor is consider to be the monsoon which causes the flooding of

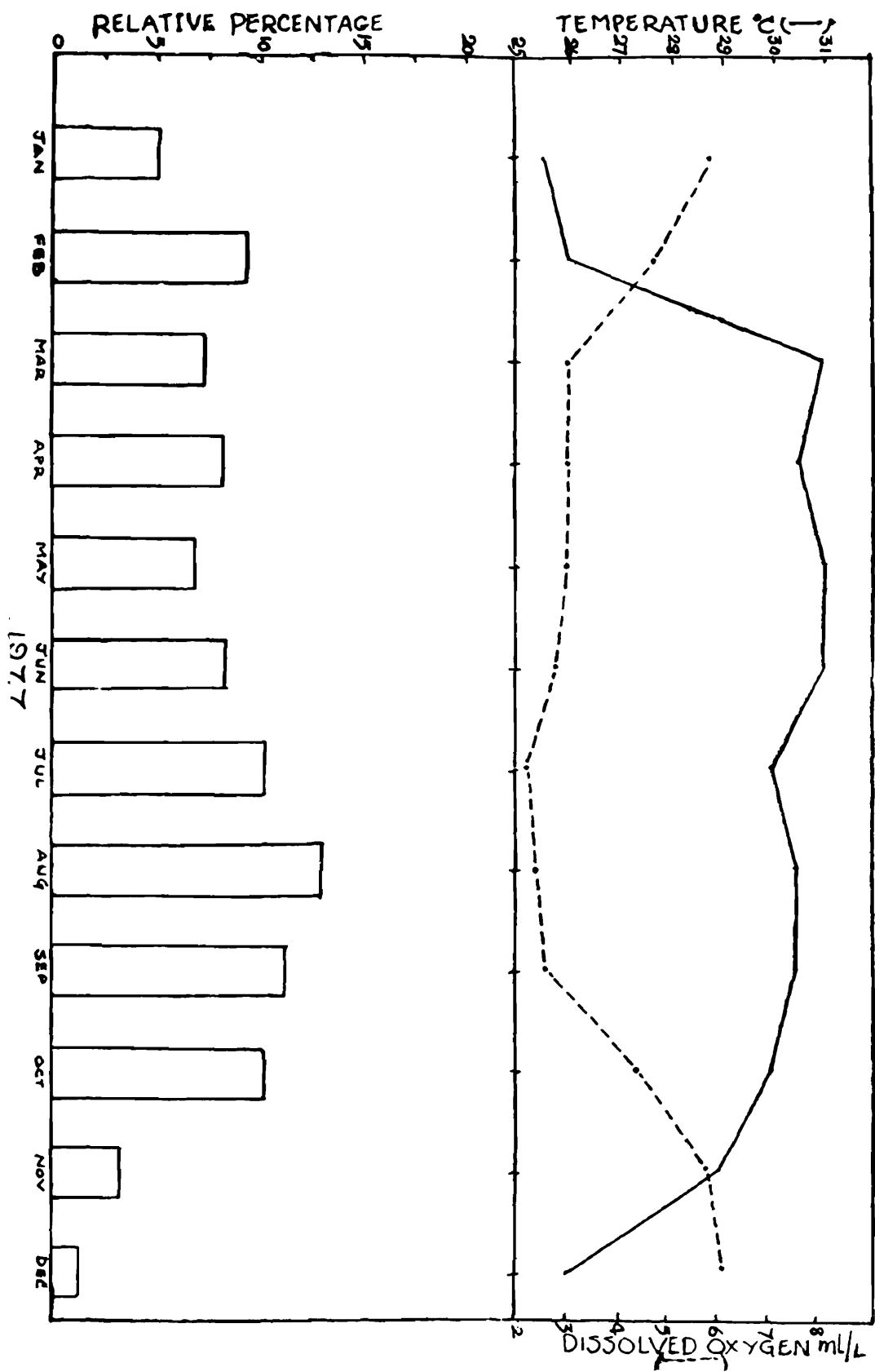


Fig. 1. Seasonal abundance of mosquito larvae.

stream with great influx of water from the catchment area. The number of larvae was very much reduced during winter months (December and January) due to low temperature of surface waters and high abundance of oxygen content (fig. 1). In the areas with high concentration of Industrial effluents the larvae were conspicuously absent.

In the study of survival rate and capacity it was possible to compare the results recorded for damp clay, damp filter paper, and dry watch glass. Variations were observed and it could not be attributed either to temperature or to relative humidity. On damp filter paper, damp clay and dry watch glass we get 100 percent mortality if we subject for desiccation for 5 days, 6 days and 8 hours respectively. It was noted that larvae can tolerate upto 5 hours for exposure on dry watch glass, 4 days on damp filter paper and 5 days on damp clay. When they are subjected to damp filter paper and damp clay for one day the mortality is less i.e., 16% and 14% respectively. On the whole, the experiments showed that the resistance of the larvae to dessiccation was very much restricted (Table-I).

DISCUSSION

De Meillon (1934) showed that, in the Transvaal, *Anopheles gambiae* larvae did not survive for more than six days on damp filter paper at the temperature of the laboratory, and that their resistance was less than 24 hours on drying mud. Soper & Wilson (1943) showed that 12% of the eggs hatched after being left for 10 days on damp filter paper at the temperature of the laboratory. The present results, however, are in accordance with the findings of Holstein (1954) who observed the tolerance capacity of *Anopheles gambiae* of 8 hours, 4 days and 4 days, on dry watch glass, damp filter paper and damp clay respectively.

The ecological parameters such as pH, temperature, dissolved oxygen observed in the present investigation clearly indicated that mosquitoes exhibit a certain specificity with regard to the chemical nature of the environment and it is difficult to isolate any single factor which is responsible for their distribution.

There appear to be a negative correlation between dissolved oxygen and larvae density as the stream which supported heavy natural

TABLE—1
Resistance of Larvae After Desiccation on Various Substrata

Substrata	Duration	No. of larvae (4th stage)	Pupae obtained	
			Number	Percentage
(1) Dry watch glass	3 Hours	82	1	1.2
	5 „	76	1	1.3
	8 „	80	0	0
(2) Damp filter Paper	1 Days	70	66	94.2
	2 „	72	60	83.3
	3 „	69	18	26
	4 „	66	6	9
	5 „	82	0	0
(3) Damp Clay	1 Days	81	78	96.2
	2 „	79	65	82.2
	3 „	75	24	32
	4 „	72	9	12.5
	5 „	85	1	1.2
	6 „	80	0	0

breeding water had relatively low amounts of oxygen. The same results were also found by Rajagopalan *et. al.* (1976).

Another parameter which influences species -- specificity is the PH. Peterson & Chapman, (1969) found 13 species of tree-hold-breeding culicids inhabiting waters with a pH range of 6.5 to 8.5. Laboratory studies on the ovipositional responses *Aedes aegypti* showed their preference for water with a pH range of 6.0 to 9.2 (Pillai & Madhukar, 1969). In the present study we found a pH range about 8 to 10.

In conclusion, it may be stated that the physical and chemical nature of the habitat seems to play an important role in determining the breeding habits of adult mosquitoes while selecting the breeding sites.

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MANIPULATION OF BIOLOGICAL ENVIRONMENT TO PREVENT MALARIA RESURGENCE

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INTRODUCTION

Spectacular success was achieved in the control of many vector-borne diseases with the introduction of DDT and other synthetic insecticides after the World War II. This as well as extensive use of pesticides in agriculture resulted in the development of insecticide resistance which is now widespread phenomenon (Brown and Pal 1971). The publication of Rachel Carson's "Silent Spring" in 1962 heralded the overall environmental awareness, and as a consequence in many European countries and America there was a partial or total discontinuance of the use of certain insecticides. Also, there was a growing disinclination of chemical industry to invest money in the development of new insecticides because of the enormous cost involved, uncertain marketing future and certain statutory restrictions (WHO 1975). It is now widely felt that there is an urgent need for a thorough review and re-assessment of the place of insecticides in vector control programmes. Even with many problems that are associated with the use of insecticides they would remain a main arsenal in our hand for the control of vectors during epidemics and in the integrated management of vector populations. With the growing awareness of the preservation of bio-eco-complex, increasing emphasis is now being placed on the alternate methods of vector control.

Recent resurgence of malaria has assumed alarming proportions e.g., the number of malaria cases in 1965 were reduced to 100,000 and in 1976 have increased to 7 million (a 70-fold increase). The Govt. of India has implemented a modified plan of operation from April 1, 1977 to contain malaria (NMEP, personal communication). The present paper is intended to project the role of integrated vector control methods in the containment of malaria.

MALARIA CONTROL IN RETROSPECT

Availability of DDT for use in public health in 1944-45, brought

about spectacular results in malaria control throughout the world. In April 1953, Government of India launched a National Malaria Control Programme (NMCP) with the objective "to bring down malaria transmission to a level where it would cease to be a major public health problem". Following the commendable achievements of NMCP, Government of India changed control programme to that of eradication (National Malaria Eradication Programme) with effect from April 1958.

Malaria eradication envisaged the reduction of parasite reservoir in human population to such a low level that resumption of transmission would not occur. This could be achieved through intensive spraying of residual insecticides in all roofed structures for 3 years, which would ensure interruption of transmission and consequent reduction of parasite reservoir. In addition it was also mandatory that human reservoirs of infection be sought out and subjected to radical treatment with 8-aminoquinolines resulting in the disappearance of parasite.

Operational activities of the NMEP were phased into (i) preparatory phase for initial surveys, planning recruitment and training of staff (about 1 yr.). (ii) attack phase for total insecticidal coverage till malaria transmission gets interrupted and thereafter surveillance system to be organized in the last year (about 3 yrs.). (iii) Consolidation phase for case detection and radical treatment, spraying to continue indefinitely with surveillance. This is all history now with the implementation of the modified plan of operation, but it may be mentioned that at one time about 3/4 of the entire country was under maintenance phase.

Out of a total of 45 Anopheline species found in India, 9 are vectors of malaria. Of these, six species have been considered principal vectors of malaria viz., *Anopheles culicifacies*, *An. stephensi*, *An. fluviatilis*, *An. minimus*, *An. philippinensis* and *An. sundaicus*. Three other species viz., *An. annularis*, *An. varuna* and *An. balabacensis* have been considered of local importance. In breeding habitats, *An. minimus*, *An. fluviatilis* and *An. varuna* breed in stream waters and all others breed in stagnant waters. In large cities, localized outbreaks of malaria may be due to *An. stephensi*, though

An. culicifacies might be transmitting malaria in the periphery of the urban zones but is a vector of rural malaria. In India *An. minimus* and *An. fluviatilis* have been associated with stable malaria and all other species with unstable malaria.

Anopheles culicifacies and *An. stephensi* have very wide distribution and account for most of malaria in the country. Also, the problem of insecticide resistance is confined to these vectors and also to *An. annularis* of malaria are a susceptible to insecticides.

Anopheline control under the malaria control/eradication programme was mainly achieved through the application of DDT. At that time there was no reported resistance to DDT in any of the vector species. By early 1960s malaria incidence was greatly reduced. At this time DDT failed to control mosquito populations in certain areas. Initial failures of DDT were attributed to poor quality of spray and lack of supervision etc. It was during mid sixties that DDT and later HCH failed to control *An. stephensi* and *An. culicifacies* populations, and malaria epidemics broke out in consolidation and maintenance phase. Malathion was used in such areas. Malaria incidence has since increased enormously and today about 75% of the union health budget is used for malaria control. There are many reasons for the resurgence of malaria which have been enumerated elsewhere (Sharma 1978 in press) but the development of insecticide resistance is foremost among the technical reasons.

MALARIA CONTROL PROSPECT

In view of the nation-wide resurgence of malaria, government of India has implemented modified plan of operation (through NMEP directorate) effective from April 1, 1977. The modified plan of operation has the following objectives :—

1. Prevention of death due to malaria.
2. Morbidity to be reduced to the minimum possible.
3. Industrial and green revolution of the country should not suffer.
4. Retaining the achievements gained so far.

In order to realize the objectives of the modified plan of operation, a three pronged strategy has been envisaged. Three components

of the strategy are (i) government's efforts (ii) peoples' participation and (iii) research and training. It is also spelled out clearly, that equal emphasis would be given to each component of the three pronged strategy.

As a first step, classical phasing of NMEP has been abolished. The entire country has been divided into 2 categories viz., (i) areas with 2 or more annual parasite index (API)* to be called high risk areas and (ii) areas with less than 2 annual parasite index (API)* to be called low risk areas.

The modified plan of operation in the area of vector control calls for emphasis on insecticidal spray and surveillance in the former areas ; whereas surveillance (mainly passive) and focal spray (indigenous cases only) in the later areas.

INTEGRATED CONTROL

Integrated control has been defined as a system of pest population management that utilizes all suitable techniques either to reduce pest population and maintain them at levels below those causing economic injury, or to so manipulate the populations that they are prevented from causing such injury. Integrated control achieves this ideal by harmonizing techniques in an organized way, by making the techniques compatible and by blending them into a multifaceted, flexible system (Smith and Reynolds 1966). This definition is typical in that it is intended to convey the idea that, in a successful integrated control programme, the desired control of a pest is achieved in the most intelligent and practical way that knowledge can devise (FAO 1971).

Integrated control has received increasing attention during the last 10-15 years largely because of 2 related circumstances : (i) man has become increasingly reliant on chemical pesticides, and (ii) at the same time he has become increasingly aware that such pesticides can have harmful effects (Corbet and Smith 1976). A set of guidelines have been devised for practitioners of integrated control (Smith 1968) and atleast two of these may be applicable to vector control.

- (i) Identify the environmental factors that permit a species to attain densities above threshold levels, and then try to manipulate these factors in an integrated way to prevent their abundance.

* API. Number of malaria cases per 1000 population per year.

- (ii) Surveillance of vectors and ecological change must be maintained to detect the need for reestablishment or modification of control procedures.

Anopheline control measures should be judiciously and harmoniously integrated to achieve the desired results. Methods of vector control which have been successfully used in the operational programmes of Anopheline control have been described below.

SOURCE REDUCTION

Source reduction is an effective method in the elimination of mosquito breeding and for this peoples' participation should be solicited. General environmental sanitation and engineering aspects of vector operations such as filling, drainage, removal of containers that may be the source of mosquito breeding, carefully planned water management, adequate and continued water supply and proper disposal of sewage water can lead to permanent control of mosquito breeding sites. These should as far as possible be worked out for each locality. However, cost of some of these methods may be steep and may require long term planning. Source reduction methods should also be practised on individual basis, and many corporations have imposed statutory restrictions on their residents to see that no mosquito breeding occurs in their premises.

In Bombay city, *Anopheles stephensi*, the vector of urban malaria was controlled mainly by the elimination of breeding sites and seeding of larvivorous fish in ornamental tanks, ponds and other water collections. Special squads were appointed to check mosquito breeding and take preventive measures (Covell, 1928).

A recent example of the application of engineering methods may be cited from Israel where water management policies resulted in the reduction of disease vectors. These policies included the development of water resources with extensive drainage systems, underground storage of water to eliminate surface water reservoirs, replacement of gravity irrigation by sprinkle or drip technique and regular supply of tap water to 98% of house-holds to eliminate domestic water storage. These measures resulted in the elimination of the majority of man-made mosquito breeding sites and the total cost of vector control operations was cut by 30-40% (WHO 1977).

BIOLOGICAL CONTROL

A number of biological agents to control mosquitoes are in developmental stages but the practice of biological control of mosquitoes is essentially limited to fish *Gambusia affinis*. Larvivorous fish are currently used by approximately 30 countries as part of their programmes for *Anopheles* control (WHO 1977). *Gambusia* has been credited with particular success in the permanent Anopheline control in several states of Southern US (Hildeb and 1921), Italy (Hackett 1931) and Iran (Tabizadeh *et al.* 1970). Massive releases of fish have been made in Iran since 1966 and in Argentina since 1971 (WHO 1977). The factors that contributed to the widespread use of fish in mosquito control are its small size (3-6 cm) and also its behaviour that enables it to negotiate pool, high survival, early maturity, ovoviviparity, high density distribution, seasonal brood repetition, voracity and omnivorousness. It has been found that 2-5 fish per sq. m. are generally required for effective control. Use of larvivorous fishes should be encouraged in tanks, ponds & other water collections. Sometimes use of *Gambusia* is discouraged because it eliminates small fish. The other fish Guppy *Poecilia reticulata* is only occasionally successful, and is especially useful in polluted waters (Bay *et al.* 1976).

INSECTICIDES

Insecticides are our main stay in malaria control/containment. DDT was the first insecticide used in malaria control and even today it is the most widely used insecticide in public health. Over the years, Anopheline populations became resistant to DDT. Populations resistant to DDT were controlled with HCH. In 1965-66 (in India) DDT and HCH spraying for the first time failed to control malaria epidemics that broke out in consolidation and maintenance phase. In such areas malathion was sprayed and gradually resistance developed to all the three insecticides (in Gujarat and Maharashtra). Today the problem of insecticides resistance and cross resistance is one of the most serious technical obstacle in the containment of malaria, and this is compounded by the fact that the choice of replacement insecticides is limited. few insecticides are in developmental stages and among these synthetic pyrethroids may hold promise. They show high toxicity mosquito larvae and adults. The photostability and residual toxicity of pyrethroids have been greatly improved. Mosquitoes resistant to OP or carbamates show little or no cross-resistance to pyrethroids.

and these chemicals may be useful against resistant populations. It may be mentioned that in areas where insecticide resistance has rarely precipitated and incidence of malaria is within tolerable limits, the insecticidal spraying may be withdrawn and malaria control may be carried out by larviciding and intensive chemotherapy. This will allow time for the Anopheline populations to revert to certain degree of susceptibility, so that the populations could be tackled with the available insecticides when the disease incidence is high. The application of insecticides should be determined on the urgency of situation. As a general rule, among the methods to be used in vector control, insecticidal application should be emphasized in high risk areas. In low risk areas, other methods of control including reduction/prevention of mosquitogenic conditions should be intensified to keep the vector populations below threshold levels and use of insecticides as far as possible be avoided/minimized.

CONCLUDING REMARKS

Use of preventive methods such as mosquito nets, meshing the doors, repellent creams etc. can provide effective protection from mosquito bites, and thus reduce malaria transmission. In fact, observance of these measures has become mandatory in malarious areas of defence establishments. Use of these measures should be given due publicity and encouragement.

Health education should constitute an integral part of malaria control operations. Educating the community on various aspects of malaria and its control, and mobilization of peoples' participation should receive greater emphasis. This fact has now been incorporated as one important component of the three pronged strategy of malaria control.

The newer emerging concepts of population replacement through interspecific or intraspecific displacements needs special mention. The former concept deals with displacing one species with another through competition. Aitken and Trapido (1961) gave a classical example from Sardinia where *An. labranchiae* the vector of malaria was replaced in nature by a non-vector *An. hispaniola*. Further observations revealed that *An. labranchiae* was ejected by nature and never returned. A similar displacement phenomenon between a malaria vector *An. funestus* and non-vector *An. rivulorum* was observed in East Africa (Gillies

and Smith 1960). The other concept of intraspecific displacement deals with the displacement of natural populations by desired genetic strain using the phenomenon of meiotic drive (Craig 1963) or increasing pesticide susceptibility (Whitten 1971) or replacement of vector species with refractory strains (Davidson 1974). It is hoped that in near future some of these concepts would be utilized in the replacement of vector populations with the non-vectors.

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**ADULT ECOLOGY OF *ANOPHELES STEPHENSI* WITH
SPECIAL REFERENCE TO DAY TIME RESTING PLACES AND
BITING RATES IN SALEM, TAMIL NADU.**

By

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Anopheles stephensi is an important vector of urban malaria in many parts of India, and a thorough knowledge of adult ecology is essential for any control measures to be carried out effectively. Among the most important factors to be studied are day time resting places and biting behaviour.

In Salem, malaria incidence increased after 1971 and in 1975, 3034 cases of malaria were reported in the town. The recognised vector species, *Anopheles stephensi*, was very scarce in hand catches and in biting collections also. Under these circumstances it was desirable to study its day-time resting places, man biting behaviour and comparative preferences for human or cattle blood.

In many parts of India it is difficult to locate the resting places of *A. stephensi*. Earlier many workers like Mulligan and Baily (1936) in Pakistan, Subba Rao and Appa Rao (1945) in Vishakapatnam, Rao *et al.* (1946) in Andhra and Rafi (1955) in Punjab (Pakistan) and recently Rehman and Menon (1975) near Delhi found no difficulty in day time collections. On the other hand in Calcutta, Knowles and Basu (1934), Ganguli (1935), Strickland *et al.* (1936) and Senior White (1940) found very few adults though this species breeds in large numbers in the area.

In Salem day-time resting places of *Anopheles stephensi* adults were studied by hand catches, first for 15 minutes per man per structure in various kinds of buildings of urban and suburban localities, but with poor results. However, when 30 minutes were spent per structure by two collections, using a ladder to search the ceiling, good results were obtained and a total of 16 males and 20 females were collected, generally resting in Pukka houses above $2\frac{1}{2}$ meters on walls, ceiling and the junction between the two. Adults were also collected

in dark, secluded corners of the room below $2\frac{1}{2}$ meters. One male was captured between overlapping coconut leaves and one semigravid female under a tape cot. The second method used to find out resting places was to space spray 1% Pyrethrum extract with diesel as base from a swing-fog machine. Motan SN 10, to knock down mosquitoes in houses, huts, cattlesheds, godowns and fire wood sheds after putting white cloth sheets on the ground. Wells were also fogged after first putting an umbrella like canvas structure above the water level. It was observed that *A. stephensi* was obtained only in certain wells, both breeding and non-breeding, where the water level was 8 metres below ground level.

Excluding collections from wells, altogether 16 males and 20 females were captured by conventional techniques in 224 houses, and 35 males and 49 females by fogging with pyrethrum extract after handcatching had been completed. As many of the structures fogged were completely or partially open some mosquitoes may have escaped so the actual numbes of *Anopheles stephensi* resting may have been higher.

Dissections of female *A. stephensi* show they were resting inside houses at all stages of the gonotrophic cycle. In wells it was very clear that newly emerged unfed mosquitoes predominated. However, a few blood fed and gravid specimens were also rest here to a certain extent.

Studies were also made of biting rates from 18.00 to 06.50 hours on human and cattle baits, weekly for a year from July 1976 to September 1977 in urban and semirural localities. Anophelines were often disturbed by the strong yellow light from a torch and could not therefore be collected. After red cellophane paper was placed in front of the torch, *A. stephensi* was consistently captured biting man.

Among anophelines, the most common species biting man and cattle was *A. subpictus*. *A. stephensi* was the second most abundant species biting man in the Salem urban area, where it wax also taken biting cattle. *A. stephensi* was consistently captured biting man in small numbers except for a few months in the cold season in an urban locality in which there was a high incidence of malaria. Maximum numbers of *A. stephensi* biting human were collected in

May, August and September months. Two infected specimens of *A. stephensi* were captured in May 1977 from an urban locality.

Altogether six specimens of *A. stephensi* were captured in 33 human-bait night collections made indoors. 29 female were captured in 60 collections on verandhas of houses, and nine specimens only in 105 nights of collection in the open air. This suggests that though *A. stephensi* will bite outdoors, it prefers to bite under a roof. Many people in Salem sleep outdoors and on the verandhas of houses, as well as indoors. About ten times as many mosquitoes were captured per cow-night, as per man-night, but as the total population of cattle was very low in this area high percentage of the total mosquitoes in the area feed on man. Macdonald in 1957 pointed out that in cities where *A. stephensi* is deviated to man due to non-availability of cattle a very low prevalence can cause severe endemic malaria. This appears to be the case in Salem Batra *et al.* (in preparation).

In the semi-rural area surprisingly very few *A. stephensi* were captured as compared with the urban catches, although there was more breeding in wells. Only two specimens were taken on human bait, in June 1977. Collections on cattle were somewhat higher, 4.0 per cow per night being captured in May.

A. stephensi was captured biting at all times of night. Nulliparous females showed a tendency to bite during the early hours of the night, from the proportions parous a survival rate of 0.85 per day was calculated assuming a gonotrophic cycle of 3 days as indicated by our laboratory studies. One specimen dissected had some old blood and faeces in its gut, and small nulliparous ovaries, showing that some individuals do come for a second feed-during the same gonotrophic cycle.

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POPULATION OF SOLDIERS IN TERMITE COLONIES (INSECTA : ISOPTERA)

By

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INTRODUCTION

Termite colonies are polymorphic comprising of different castes such as workers/pseudoworkers, soldiers and alates. Besides these, there are immature stages termed as nymphs or larvae by various authors. The main function of the soldiers in termite colonies, however, varies among different species of termites and even within a species at different seasons. In the foraging colonies, on the other hand, the proportion of soldiers largely depends on the volume or surface area of the infested wood and the number of openings required to be guarded (Nutting, 1970). In their reviews on the caste differentiation in lower and higher termites, Miller (1969) and Noirot (1969) have opined that the soldier and non-soldier castes are regulated in a characteristic ratio in colonies of certain species of termites. It is worthy of mention that soldier production is currently held to be regulated by externally secreted hormones or pheromones, although the evidence for the presence of soldier inhibitory substances is far from conclusive (Lüscher, 1961). Recent findings that excess soldiers can be produced in termite colonies by administration of juvenile hormone analogues (Chu *et al.*, 1974; French, 1974; Hrdy, 1972; Springhetti, 1974; Wanyoni, 1974; and Wanyoni and Lüscher, 1973) have created further interest in knowing the proportion of soldiers in termite colonies in nature, as this ratio is important in formulating hormonal control of termites. In this paper, results of investigations on the fluctuations of soldier population through the year in three species of termites viz. (i) *Neotermes bosei* Snyder, a wood-inhabiting termite, (ii) *Microcerotermes besoni* Snyder and *Nasutitermes dunensis* Chatterjee & Thakur, both subterranean carton nest building species, have been presented.

MATERIAL AND METHODS

Termite colonies (nests) were brought to the laboratory from the

field and the population of different castes including undifferentiated immature stages was counted by volumetric method. The proportion of soldiers in relation to total population was then calculated. Only mature colonies were used, excluding the incipient colonies, as the proportion of soldiers in the incipient colonies is always on higher side and is, therefore, not representative (Weesner, 1960 ; Haverty, 1977).

RESULTS AND DISCUSSION

A reference to Fig.1 shows that in wood-inhabiting termite species *N. bosei*, soldier proportion in a colony is higher (5.2% to 7.7%) during the winter months (November to February) and the proportion gradually declines subsequently and touches the minimum (1.3%) in May. However, reverse is the case in the subterranean termite, *N. dunensis*, where proportion of soldier progressively decreases (5.1% to 4.8%) in winter months (November to January). After January the soldier population in *N. dunensis* gradually increases until the maximum is reached in the month of May. In contrast, only a marginal decline in soldier population in winter months (November to January) was observed in case of *M. beesoni*, another subterranean termite species where a sharp gradual fall in the soldier proportion takes place from February onward till it reaches the minimum in the month of April (0.5%). This behaviour is puzzling.

If the ratio of soldiers and workers/pseudoworkers, is taken, a similar trend of soldier proportion becomes apparent (Fig. 2). This shows that the proportion of soldiers is not greatly influenced by the population of immature stages.

During winter months in Dehra Dun foraging activities of subterranean termites is the minimum (Chatterjee and Sen-Sarma, 1962). This may account for the the low proportion of soldiers during winter months in both the species of subterranean termites, as a high proportion of soldier will burden the colony on account of inadequate food resources. A high proportion of soldiers can, however, be maintained in wood-inhabiting colonies as is the case of *Neotermes bosei*, since no foraging outside the nest is required. It may be mentioned that there is also a decline in the proportion of immature stages during winter months. It has further been observed that a decline in soldier population is invariably associated with an increase in population of immature stages (Sen-Sarma and Mishra, 1969, 1972).

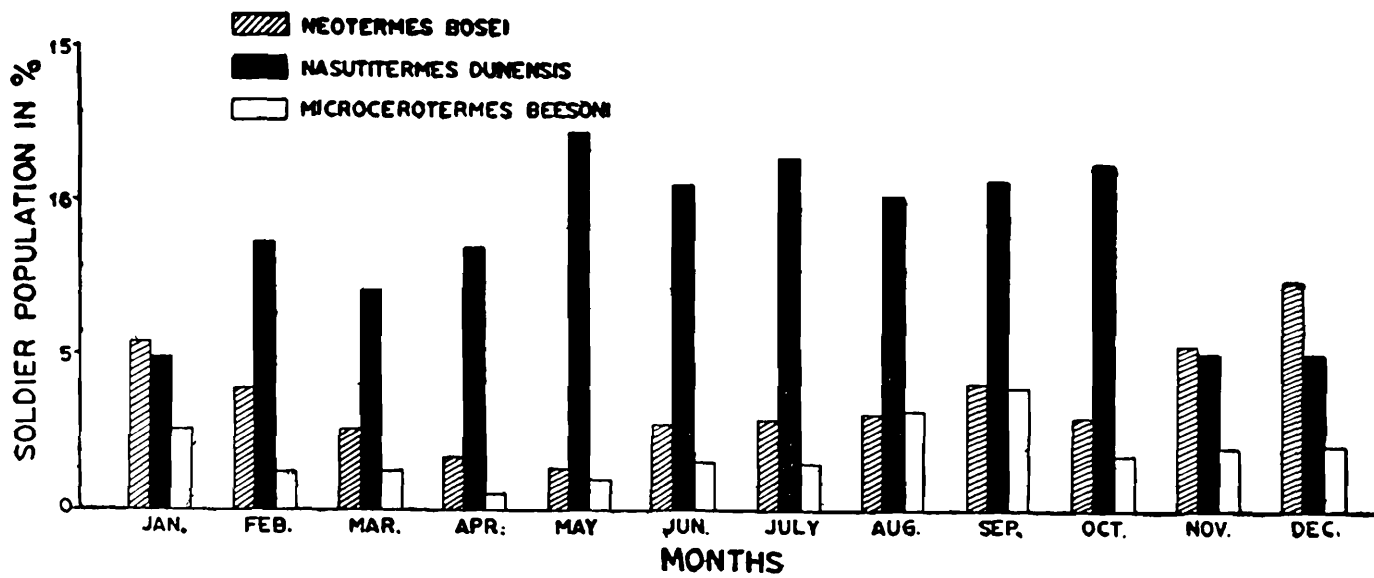


Fig. 1. Soldier population (%) in relation to the total colony population.

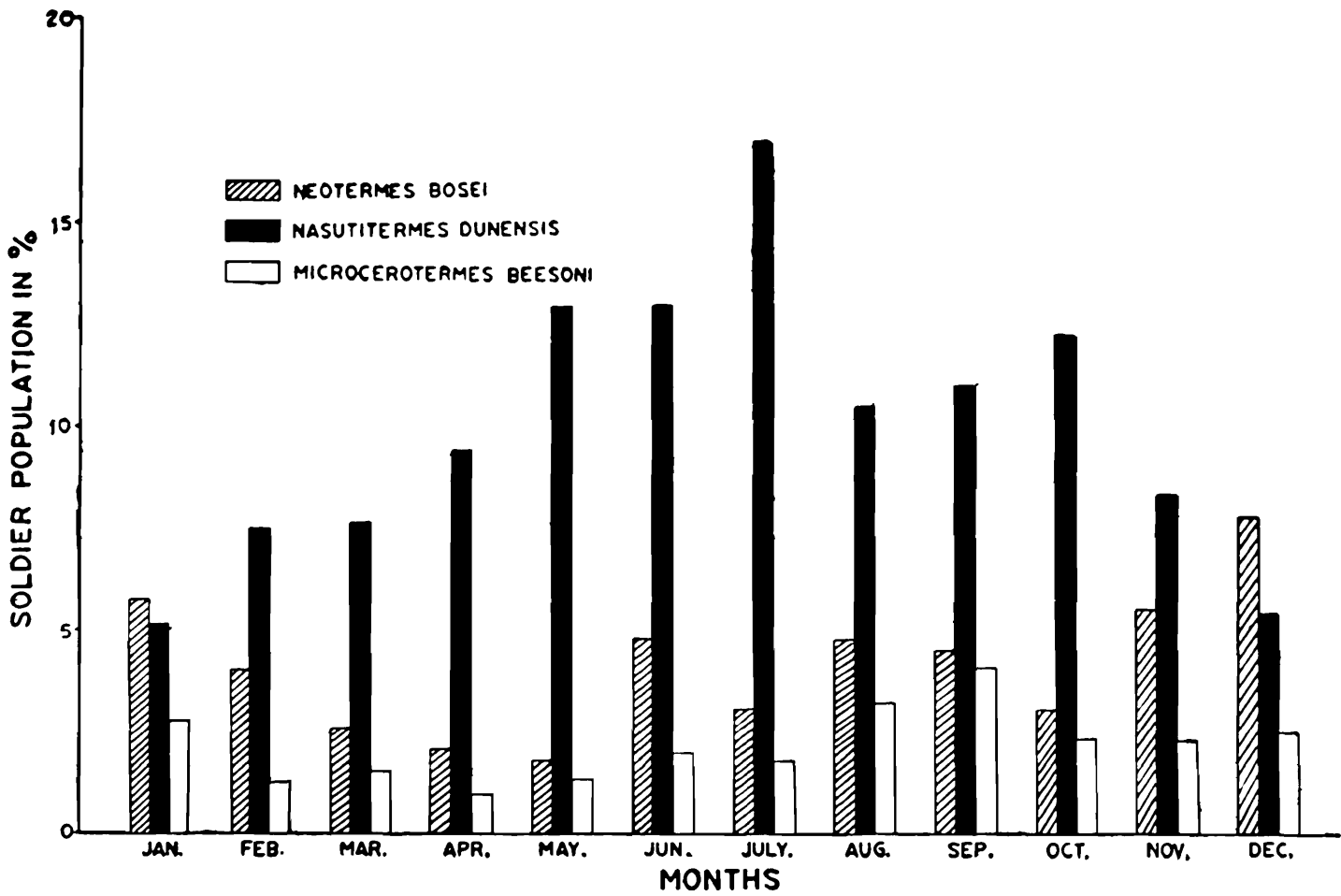


Fig. 2. Proportion of soldiers in relation to workers/pseudoworkers.

Mishra and Sen-Sarma, 1979). In *N. dunensis*, soldier population is high (Fig. 1) during active foraging period (April to October). Also, a high proportion (20.0% to 45.3%) of soldier population was observed accompanying the foraging group for protection against arthropod predators (Mishra and Sen-Sarma, 1979). For maintaining this ratio a higher proportion of soldiers is produced during active foraging in *N. dunensis*. Similar observations were also made by Nutting *et al.* (1974) in case of *Tenuirostritermes tenuirostris* which forages on exposed trails. In contrast to this, association of soldiers in foraging group is low (1.7% to 8.0%) in case of *M. beelsoni*.

It is interesting to note that soldier proportion suddenly increases

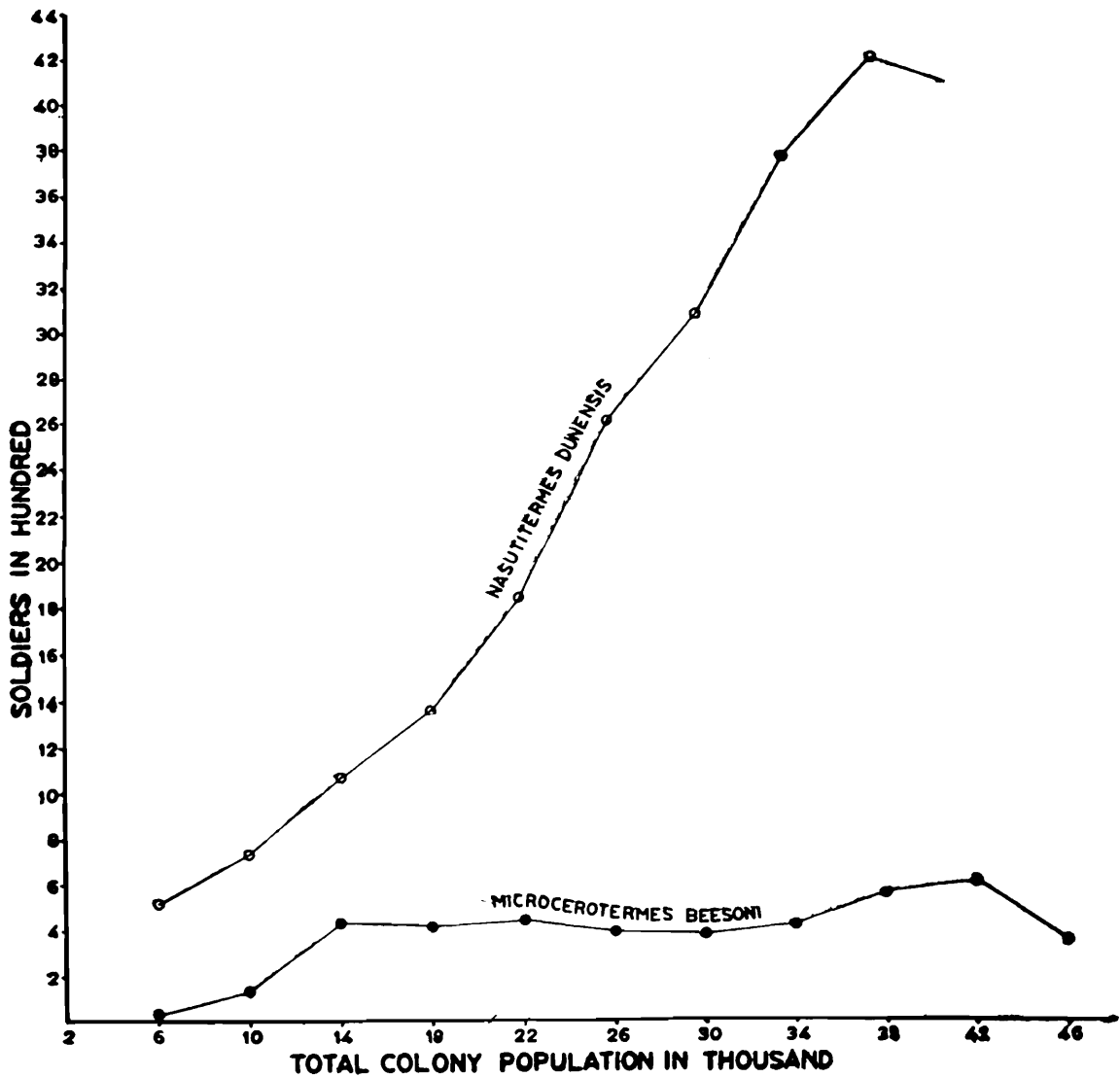


Fig. 3. Total colony population and maximum number of soldiers in *Microcerotermes beelsoni* Snyder and *Nasutitermes dunensis* Chatterjee and Thakur.

(Fig. 1) in the months of June and July when swarming takes place, in general. Castle (1934) has also observed similar trends of soldier population incase of *Zootermopsis*, a dampwood termite species. This sudden rise in soldier population can be explained by the fact that increased number of soldiers is required to guard the numerous exit holes through which alates swarm out.

Data were also collected in case of *M. beesoni* to find out if the soldier population increases corresponding with the increase in colony size. It has been observed that the number of soldiers in a nest decreases with the increase in colony size. For example, a carton nest weighing 550 gm contained 450 soldiers, while another nest weighing 1500 gm had only 280 soldiers. This observation is in agreement with that of Castle (1934), Bouillon (1964) and Nutting (1970).

A reference to Fig. 3 indicates that the soldier population increases corresponding with the increase of non-soldier population in a colony up to a certain stage after which soldier population does not increase proportionately and may either remain more or less constant or may gradually decline. This is in agreement with the observations made by Castle (1934) in *Zootermopsis* and Bouillon (1964) in three species of *Apicotermes*. This is expected, as only an optimum number of soldiers is needed for protecting the colony and for accompanying the foraging groups. More than this excess soldiers will burden the food procuring members of the colony. This deduction is, however, not applicable to incipient colonies where a high proportion of soldiers is required to guard the greater environmental risks (Weesner, 1960).

CONCLUSION

From the above results, it is apparent that the proportion of soldiers in a colony varies with the season on which also depends the foraging activities of the subterranean termites. Since soldiers are to be fed by the food procuring caste, the proportion of soldiers is maintained at an optimum level in mature colonies and this phenomenon appears to have been evolved through selection of the mix of castes that will reduce the energy required in producing maximum number of alates for colony dispersal, without, of course, adversely affecting adequate defence of the colony (Wilson, 1971).

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STUDIES ON *Aedes aegypti* POPULATIONS OF INDIA

By

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INTRODUCTION

Aedes aegypti, a well known vector of many virus diseases is cosmopolitan in its distribution. In India, this species has been incriminated as a vector in outbreaks of dengue in Calcutta (Wattal, 1964), Vishakapattinam (Rao, 1964), Jabalpur (Seghal, 1967), Delhi (Balaya, *et al.* 1969), Nagpur (Wattal & Sen Gupta, 1966), Ajmer, (Ghosh, *et al.* 1974), Kanpur (Chaturvedi, *et al.* 1972), Bangalore (Samuel George & Soman, 1975), etc., and chikungunya in Barsi (Dhanda, *et al.* 1973), and Madras (Myers, *et al.*, 1965). It is being suggested that *Aedes aegypti* was introduced into Calcutta between 1907 and 1912.

Information on the population dynamics of a vector is an essential prerequisite before any control measures can be undertaken. Earlier studies on this species provide information on distribution, density, seasonal prevalence and biology of *Aedes aegypti* in the Indian sub continent (Barraud, 1934 ; Rao, 1967 ; Kalra, *et al.*, 1968 & Reuben, 1974). The present review aims at updating the information on *Aedes aegypti* in India.

DISTRIBUTION

Aedes aegypti, originally a tree-hole breeder in Africa, its native land, owes its wide distribution in other countries to its successful adaptation to human habitation by breeding also in artificial water containers and to travelling with man. The major factor governing its rapid spread to newer areas is the behaviour of man in moving materials like tyres and other metal scraps which are infested with dormant eggs of this species. In our country it is widely distributed in the coastal areas of peninsular India and along the Gangetic and Brahmaputra river basins. Even in interior places in Rajasthan (Reuben & Panicker, 1974) and Maharashtra (Mahadev, *et al.* 1978) where water problem is acute and people are forced to store water, they are found in high densities. The distribution and abundance of this species is greatly influenced by certain practices like storage of water and improper disposal of tyres and unwanted containers

which, when filled with rain water facilitate the breeding of *Aedes aegypti* in large numbers. A recent study in Maharashtra, showed that their distribution is rapidly on the increase (Mahadev, *et al.*, 1978). This species being highly susceptible to insecticides like DDT, had virtually disappeared in many cities like Poona (Rao & Rajagopalan, 1957 and Geevarghese, *et al.*, 1975), and Bangalore (Soman, 1977) during the malaria control operations. With the cessation of spraying after the initial success achieved in malaria control, this species has reappeared now, in many cities. There appears to be a centrifugal spread of this species from the urban areas to rural areas now as has been observed in many villages in states like Rajasthan and Maharashtra. This species has also been found to breed in domestic water containers in villages. Hence probably the most important single factor influencing the distribution of *Aedes aegypti* is man himself.

BREEDING BEHAVIOUR

It was reported for the first time that *Aedes aegypti* has reverted to its tree-hole breeding habit in South India and subsequently in many places (Soman, 1977; Rao, *et al.*, 1970; and Shetty & Geevarghese, 1977). The contribution of tree-hole especially of coconut trees, which are widely grown throughout the coromandel coast to the population of this species has been studied in Pondicherry (Panicker & Rajagopalan, 1968). Of a total of 2580 trees examined, the majority were found to have holes which supported mosquito breeding during the rainy season. These holes were bored by the plantation owners in the mistaken belief that it will prevent the attack of the major coconut pest, Red palm Weevil, (*Rhynchophorus ferrugineus*). *Aedes aegypti* was the most predominant species found breeding in such holes. This study also showed that no competitive displacement of *Aedes albopictus* by *Aedes aegypti* occurred in tree hole habitats as observed in gardens of Calcutta suburbs (Gilotra, *et al.*, 1967).

In many areas in the coromandel coast and possibly in the west coast also where coconut plantations abound, this species must be breeding in abundance but the seriousness of this problem has not properly been assessed because people in India in general, especially among the poorer sections have become quite used to mosquito bites. Unless an epidemic occurs, the problem does not invite official attention. Because of their short flight range and biting habits associated with man a reverse trend in the population dispersal from

the rural areas where practically no control measures exist, to the urban areas is unlikely in the present situation.

POPULATION STUDIES

A classical study of the seasonal changes, measurements of population and dispersal behaviour of this species has been made in Delhi and Sonapat in view of a genetic control programme of this mosquito. When a black jar ovitrap was used to measure the relative density it was found that their population is extremely low in the cold season and maximum in the post monsoon period (Reuben *et al.* 1978). Direct correlation of population density with rainfall was noticed in Vellore (Reuben, 1970) and also in Bangalore (Soman. 1977). However, an increased trend during the drier months was observed in one locality in Poona. (Geevarghese, *et al.*, 1975).

Estimation of adult population of *Aedes aegypti* was made in two tyre dumps in Delhi by six mark-release-recapture methods (Reuben, 1970). Estimates by Jackson's method, Bailey's corrected Lincoln index method and Jolly's method, Bailey's corrected Lincoln index methods and Jolly's method were found to give a fair picture of population in such habitats.

In a study on dispersal of both sexes of wild mosquitoes in a tyre dump in Delhi, it was found that during summer weather most mosquitoes were recovered within 50 meters of the point of release (Reuben, *et al.*, in press). In another study in Sonapat by making 5 releases of laboratory reared marked males in different seasons it was found that the dispersal is more rapid in hot weather than in the cold climate (Reuben, *et al.*, 1975).

In conclusion it would appear that *Aedes aegypti* continues to be a problem. Because of its high vectorial capacity for transmission of diseases like dengue, chikungunya etc., this species must be considered one of the major vectors of virus diseases. It is also the vector in the transmission of urban yellow fever, but fortunately this virus is not present in India. There may be many reasons for this. One of it might be the cross immunity in the Indian population conferred by the presence of other Group B virusses. However the problem exists. In other parts of the world especially in the developed nations in the west, species eradication is now being attempted. The least we can do in India is to realise the problem posed by the spread of this species to areas where they have not been recorded earlier.

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**POPULATION ECOLOGY OF TWO MAJOR FOREST
PESTS OF SAL (*SHOREA ROBUSTA*) : *HOPLO-
CERAMBYX SPINICORNIS* (COLEOPTERA)
AND *LYMANTRIA MATHURA*
(LEPIDOPTERA)**

By

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INTRODUCTION

During many years of study of forest insects at the Forest Research Institute, Dehra Dun, two insects, both pests of sal (*Shorea robusta* Gaerten f., family Dipterocarpaceae), proved to be the most outstanding for the study of population ecology. One is the Sal Heartwood Borer, *Hoplocerambyx spinicornis* (Newman) (Coleoptera, Cerambycidae), which is xylophagous and lives inside the tree most of the time. The other is the Sal Defoliator, *Lymantria mathura* Moore (Lepidoptera, Lymantriidae), which feeds on leaves in the open. Both undergo phenomenal eruptions in population and devastate large tracts of forests. While in the former, environmental ecology seems to play the major role in ordering the growth and decline of populations, in the latter disease is apparently more important. I shall discuss briefly both the beetle and the moth.

RESULTS

The Sal Hardwood Borer, *Hoplocerambyx spinicornis*

This is a large, dark brown, cerambycid beetle (Pl. I) (length c. 18-65 mm) with long antennae. There is enormous size variation in adults, larvae and pupae, due in part probably to varying quantities of nutrient woody material available as food. The beetle occurs from Eastern Afganistan, via North India, east to Borneo and the Phillipines. In India its distribution more or less coincides with that of its principal host, sal (*Shorea robusta*), whose forests are found from Himachal Pradesh to Assam, and south to Orissa (Fig. 1). Apart from sal, of which it is a serious pest, it has about half a dozen other host trees.

1. *Past epidemics* Since it first notice in 1897 as a pest of sal (Stebbing, 1899, 1914), some 17 epidemics, both severe and mild,

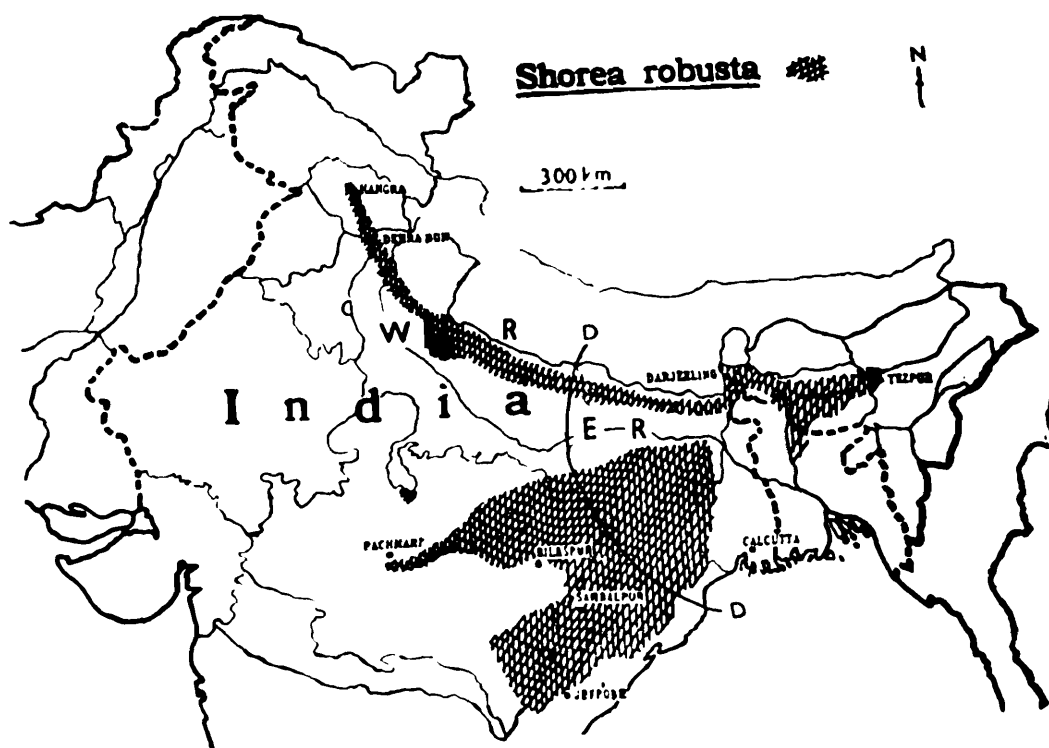


Fig. 1. Sal (*Shorea robusta*) belt of North India. The same also represents the epidemic areas of its heartwood borer, *Hoplocerambyx spinicornis*. Line D-D approximately separates the eastern (ER) and western (WR) breeding regions of the borer. (Ex Roonwal.)

have been recorded from all over the sal range (Roonwal, 1977, summary). The severe epidemic in Madhya Pradesh during 1923-28 killed seven million trees, resulting in a loss of Rs. 1.37 crores worth of forest capital. In many forests the beetle is there all the time, causing minor local epidemics which often escape attention. There is no regularity in either the duration or recrudescence of epidemics in an area; the duration may vary from 1 to 9 years and the interval between successive epidemics 3 to 55 years.

2. *Two breeding regions*: In north-western India (Dehra Dun) the beetles emerge from tress in early monsoon a few days after the first heavy shower of rain (early June) and emergence may continue up to mid-September. A beetle lives for three or four weeks. Soon after emergence, pairing occurs and eggs are laid on the bark of sal, a female laying up to about 300 eggs. The young larvae bore into the tree trunk and grow and migrate upward. With full growth and on reaching the heartwood, mature larvae excavate a prepupal chamber where they pupate by February and become beetles by May, to await emergence in June.

When data from all over the sal range are examined (Roonwal, 1977) it is seen that breeding is advanced in the Eastern Sal Region

(Bihar, West Bengal and Assam) by about a month as compared to the Western (Himachal Pradesh, Uttar Pradesh and Madhya Pradesh) so (Figs. 1 and 2). This advancement is evidently correlated with the early onset of the monsoon, by about a month, in the Eastern Region.

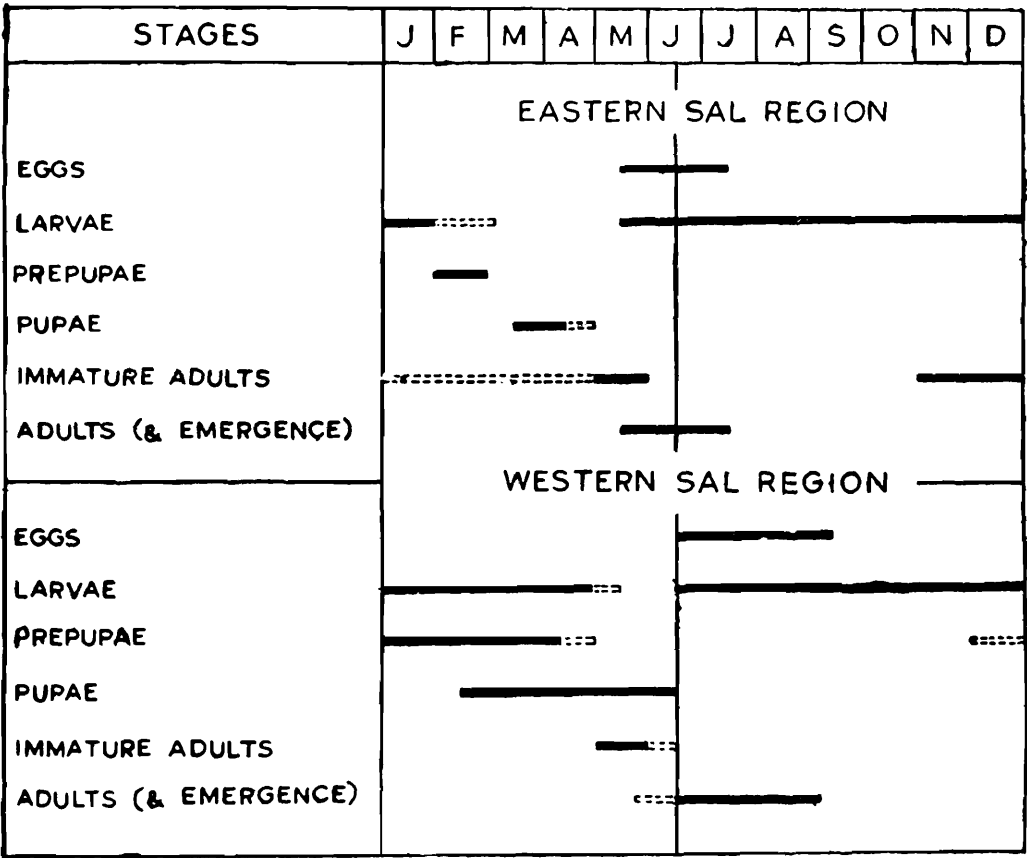


Fig. 2. Seasonal distribution of life-history stages of *Hoplocerambyx spinicornis* in the two breeding regions, eastern and western, in North India (cf. Fig. 1). Life-history is advanced by about a month in the Eastern Region, coincident with the early onset of the monsoon there by about the same period. (Ex Roonwal.)

3. Preferred tree sizes : Does the beetle prefer certain tree sizes for egg-laying ? This question is important for, should preferences exist, trees of the preferred sizes can be incorporated into the Forest Working Plan for felling, disposal and removal from the scene before they become foci of infection. The subject, however, is controversial, the entomologists generally opting for preference (Fig. 3) and the forest officers for its absence. After examining the available data from the Western Breeding Region, I have concluded (Roonwal, 1976) that real preferences are noticeable, as follows :-

- Girths below 30 cm (12 inches) : Not attacked as a rule.
- Girths 30-70 cm. (12-29 inches) : Attacked, but avoided if trees with larger girths are available.

Girths 71-125 cm (30-50 inches) : Preferred.
Girths 126-200 cm (51-84 inches) : Attacked at random (neither preferred nor avoided).
Girths above 200 cm (84 inches) : Avoided.

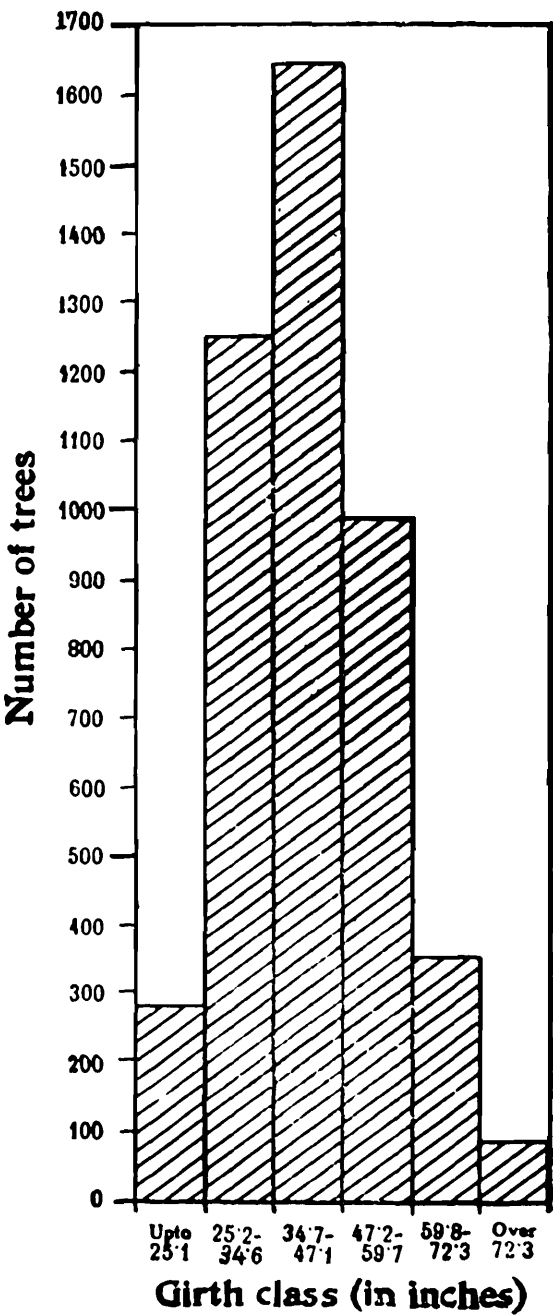


Fig. 3. Distribution of girth classes of 4,590 sal (*Shorea robusta*) trees attacked by *Hoplocerambyx spinicornis* in an epidemic in the Nahan forest, Himachal Pradesh. (Ex Roonwal.)

Two points must also be kept in mind : (i) These preferences are not universal and may vary with climate, soil and quality of sal. (ii) Changes in preferences may occur as an epidemic progresses. Only future data can clarify these points.

4. *Population inside trees and in forests :*

(a) *Inside trees :*

Populations subsist in two different habitats : the greater part of life is spent as larvae and pupae inside the sal trunk (Pl. 2); the beetle lives free in forest.

Data on population inside trees are not available in plenty because of the attendant difficulties. The splitting of large trees in forests and examining them section by section for larval and pupal population is an expensive and time-consuming operation, a single tree requiring at least three men for two to four days. In an epidemic in Nahan (Himachal Pradesh) in a poor quality sal forest, I obtained a maximum population of 310 larvae per tree (average 12-44 per cubic metre of timber volume). The population generally rose with bole volume, which was from 10-40.5 cu. ft. (c. 2.8-11.6 cu. m), but there was considerable fluctuation. In better quality sal, as in Madhya Pradesh, with larger trees, populations up to 450 per tree have been reported, and exceptionally up to 1378 (Beeson, 1961, pp. 141, 689).

In the Nahan forest the total number of attack holes made by larvae in all layers was 176-475 per bole. In the bark and bast region the intensity of attack was the heaviest (up to 17% of the total) in the bottom nine feet (c. 2.7 m) of bole, then slowly declined up to 25 ft. (c. 7.6 m), above which it fell abruptly. In the heartwood the attack was very low (0.7%) in the bottom one foot, and the zone of heavy attack had shifted upward, steadily rising to a maximum (8%) at 21 ft. (c. 6.4 m), declining to 4-5% up to 37 ft. (c. 11.2 m), and then falling still further (Fig. 4). The surface-density of attack (number of attack-holes per square metre of bole surface) at the concerned layers was as follows :

Bark and bast	: 8	31 (average 18)
Sapwood	: 0.4	2 (av. 1.7)
Heartwood	: 3	46 (av. 23.3)

Generally, the attack for egg-laying on the bark and bast (the initial points of entry) is heaviest in the bottom 13 feet (c. 4 m) or so, a feature which is probably correlated with the low-flying habits of the beetle. As the larvae proceed inward and upward to their final destination, the heartwood, the zone of heaviest attack, also moves up (to c. 13-21 ft.) and is substantial even at the top (40-50 ft.); the larvae mostly gather in the middle heights. Attack is the lowest in sapwood which is merely a passageway.

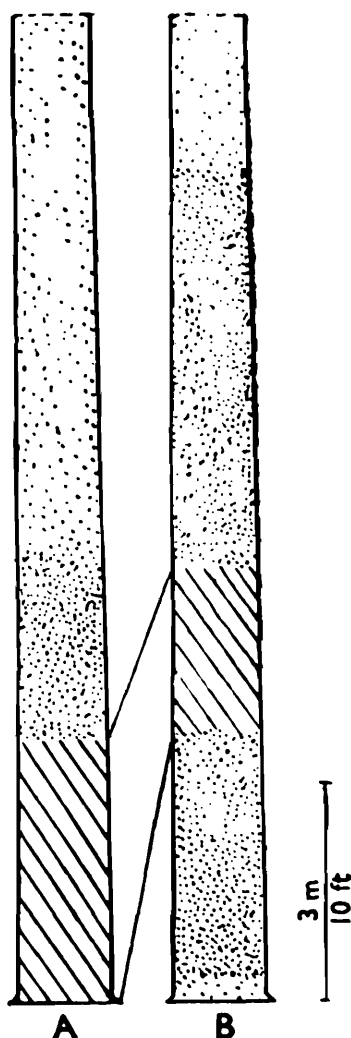


Fig. 4. Sal boles (*Shorea robusta*) to show the relative intensity of attack of *Hoplocerambyx spinicornis* at various heights and in different wood-layers. The height of maximum attack shifts from the bottom 3-4 m in bark and bast to middling heights (4-6 m) in heartwood. Diagrammatic. (A) Bark and bast (B) Heartwood.

All the larvae do not survive and many die on the wayside. On an average, about half the larvae fail to survive (34-32%, av. 49.9%), failure being heaviest in bark and bast (*i.e.*, among young larvae). Death results mainly by drowning in a resinous secretion (*ral* or *dammer*) which the host tree secretes in self-defence against borer attack; copious exudation indicates heavy attack. If the exudation is timely and adequate, most of the larvae die and the tree may recover; otherwise it is fated to dry up and die. Predators or parasites seem to play little or no part in reducing pest population.

(b) *In the forest :*

For the brief span of their free lives (3 to 4 weeks) after emergence the beetles fly about freely in the forest. They are diurnal and

are active in the hottest part of the day (afternoons). Beetles are attracted to fresh sap of sal*, and this habit is utilised for control purposes by attracting them to freshly felled sal and catching and killing them by the thousand, a performance called "trap-tree operation." Hundreds or thousands of beetles can thus be caught in a season, and the population reduced sizeably. The operation can also be used to obtain comparative information on beetle population. In the Nahan epidemic, 1 16, 264 beetles were caught and destroyed from 1,871 trap-trees in six operation-seasons. In more severe epidemics elsewhere, over 1,000 beetles were caught in 24 hours on one trap-tree.

The Sal Defoliator, *Lymantria mathura*

This is a white-and-pink-winged, moderate-sized moth (wing expanse : males 35-40 mm ; females 75-95 mm) (Pl. I) which occurs along the Sub-Himalayas from western Uttar Pradesh to Assam, and farther east to South-East Asia. It is an important defoliator of sal and a few other trees of the Indian forest.

1. *Population explosions in vast areas* : In normal years, *Lymantria mathura* occurs in small numbers and is hardly noticed, but occasionally it explodes in numbers. The most serious eruption occurred during 1953-54 in the Western Sub-Himalayas (the Doon Valley, etc.), and much of the information on the species now available is based on that eruption (Roonwal, 1953, 1957, and in press).

In the western Sub-Himalayas this eruption covered an extent of over 1,000 km² in the districts of Dehra Dun and Saharanpur. It also extended to West Bengal, some 1,200 km farther east (in the *terai* and *bhabar* forests of the Nimati Old Plantation of sal in the Buxa Forest Division), as reported by Chaudhuri (1962) who observed "millions and millions of larvae" defoliating sal in 1954.

2. *Widening of polyphagy and other preferences* : In normal years, the caterpillars feed on barely half a dozen species : sal (*Shorea robusta*, the principal host), jamun (*Syzigium cumini*, syn. *Eugenia*), two oaks (*Quercus indicana* and *Q. serrata*), and two terminalias (*Terminalia arjuna* and *T. myriocarpa*) ; eggs are also laid on these species.

But during the 1953-54 epidemic the moths laid eggs on the trunks of as many as 185 different species of trees and even on such objects

* The chemical nature of the sap constituent which attracts the beetles is not known and deserves study. The chemical can replace the expensive process of felling sal for control purposes.

as brick walls and wire-nettings. Moths fluttered about in abundance in the forest where none was seen before, and the tree trunks of hundreds of trees were rendered conspicuous by the presence of white, fluffy egg-masses (Pl. III). Though eggs were laid on a wide variety of plants, preference was noticeable, and the bulk of egg-laying was on some 30 species. Of these species, larvae survived only on 22. Thus, from the normal half a dozen, polyphagy was widened to 22 hosts.

Eggs are laid in large masses of 50 to 1,200 eggs, each egg-mass being covered over with a white matting of fine, long hairs (Roonwal, 1954). There are two annual generations : a summer generation (April to October) and a second or overwintering generation (September to June). Five moults and six instars occur. The fully grown caterpillar is hairy and about 60-84 mm long.

3. *Nocturnal feeding rhythm and protective coloration and behaviour* : Young caterpillars (fourth to six stages) feed entirely at night. During the day they sit absolutely still on tree trunks in large masses (Pl. IV). They are densely concentrated in the basal one-and-a-half metres of the trunk (average density 629/m²), and the entire trunk of a large tree may lodge seven or eight thousand larvae. Some have the head down, others have the head up or sideways ; most are nearly straight but some assume curved positions. All are still but for an odd individual or two which may, either on its own initiative or when touched with a stick, crawl up a few centimetres and then stop.

As dusk approaches some stirrings are noticeable, and there is remarkable regularity in the timing of what follows. At 6.25 p.m. all are still, but by 6.40 the smaller caterpillars (fully-grown males and younger females) show a peculiar activity. They turn and twist their bodies for a minute or so in a characteristic manner (as if toning up their muscles after the day-long stupor, like the yawning and stretching of a person on waking up). The middle part of the body remains attached to the tree surface by two or three of the prolegs, while the fore and hind moieties of the body repeatedly bend towards each other and move from side to side. The process over, the caterpillar starts on the upward march, but all caterpillars do not undergo this preliminary 'stretching' before climbing up. By 7 p.m. a mass movement of upward, sinuous crawling has developed, a caterpillar having an average speed of about 65.5 cm per minute. A caterpillar will thus take about 28 minutes to climb an 18 m (60 ft.) high bole. By 9 p.m. the majority of caterpillars are already actively feeding on the crown leaves, as

is evident by the incessant dropping of excreta on the dry leaves of the forest floor, like the 'trip' 'trip' of raindrops. However, here and there in patches, about one-fifth of the population remains unaffected by the mass movement, for reasons which are unknown ; possibly, these are individuals which have stopped feeding prior to pupation.

Feeding goes on vigorously throughout the night. At 3 a.m. in the morning the trunk is still deserted. Shortly before dawn, by 4 a.m., the downward march begins, first in twos and threes, and then, by 5 a.m., *en masse*, like an army marching down fast and purposefully. Some stop on the way and settle for the day, others come right down to the bottom. By 7 a.m. all are back, and the tree trunk is again clothed with a thick covering of caterpillars. Here they remain for the whole day, to begin their upward march again at dusk. Caterpillars are so cryptically coloured vis-a-vis the bark and remain so still throughout the day, that persons, even observant children, passing within two or three metres fail to notice them in the first instance. For this very reason, no bird or other predator was noticed feeding on them, except an odd bird which killed and ate a caterpillar.

4. *Parasites and diseases* : Caterpillars are fairly heavily parasitised by hymenopterous insects (chalcids and a braconid), and the pupae by a tachinid fly (Diptera). But their effectiveness in control is unknown.

During the epidemic caterpillars and pupae were severely affected by a polyhedral or 'liquefying' disease which decimated almost the entire population in the forest within three or four weeks. The infected caterpillars became sluggish and stopped feeding, and then died within 24 hours, the whole body liquefying and hanging limp by means of the crochets of one or two abdominal legs (Pl. V.). The organism responsible was a rod-shaped virus infecting the cell nucleus.

Ecology, Population and Control

1. *The Sal Borer* : The Sal Borer provides a good example of how ecology can be used to regulate pest population, and thus for economic control, both preventive and remedial. Preventive measures are essentially silvicultural, and modify the ecology of the sal forest so as to minimise chance of infection by means such as the following, keeping in view the fact that mild infection (below economic limits, *i. e.*, below one percent of the growing stock of sal), may be present all the time :— (i) Do not allow the forest to become dangerously dense.

(ii) Fell trees as they mature, rather than keep them too long. First exploit trees with the 'preferred' girths. (iii) Do the felling during October to March. (iv) Debark all fallen trees and logs immediately after felling, otherwise they may attract beetles for egg-laying in the bark. (v) Remove all refuse and dead trees from the forest. (vi) Run regular patrols in winter months to discover attacked trees, windfalls, etc. ; these should be removed. (Exudation of resin or *ral* from the trunk and the presence of heaps of wooddust at the base of a tree are early signs of attack. The drying up of epicormics and crown leaves are signs of advanced attack.)

When an epidemic is on, remedial measures have to be taken, as follows :— (i) Enumerate the infected trees from December onward ; earlier enumerations would miss late infections of the season. (ii) Suitably dispose of attacked trees by debarking, conversion or burning. (iii) Run trap-tree operations to reduce beetle population.

As far as we know, predators parasites and diseases do not play much part in reducing the Sal Borer population.

2. *The Sal Defoliator* : According to present information, flare-ups of Sal Defoliator population are less frequent than those of the Sal Borer, but are more intense and widespread when they occur.

Due to dearth of knowledge, the extent to which silvicultural or other methods can be used to alter the ecology and composition of the forest is not known. Parasitism is fairly heavy, but the biology and ecology of the parasites are unknown ; this knowledge is necessary before the parasites can be used for control. The caterpillars have practically no predators. Field experience shows that a polyhedral or 'liquefying' disease caused by a rod-shaped nuclear virus can quickly cause nearly complete extinction of an epidemic within a month, and it is worth while studying the possibility further. The source of this infection in nature is not known, but it could be latent (as is the case in some other lepidopterous larvae), the infection becoming virulent and conspicuous in periods of populations eruption.

Chemical methods have also been worked out and can be used if economically feasible (Roonwal *et al.*, 1962). Egg-masses when sprayed with 1% gamma B. H. C. (benzene hexachloride) in water suspension completely fail to hatch. Mature larvae are highly susceptible and are readily killed by dusting with either 0.6% gamma B.H.C. or 5% D.D.T. The caterpillar's habit of sitting in masses almost

motionless for the whole day and climbing up in the evening for feeding on the crown leaves can be exploited for placing sticky bands ('Ostico' bird-lime or other preparations) around tree trunks at the greatest practical height, between the hours of eight in the morning and six in the evening, to prevent the caterpillars going up.

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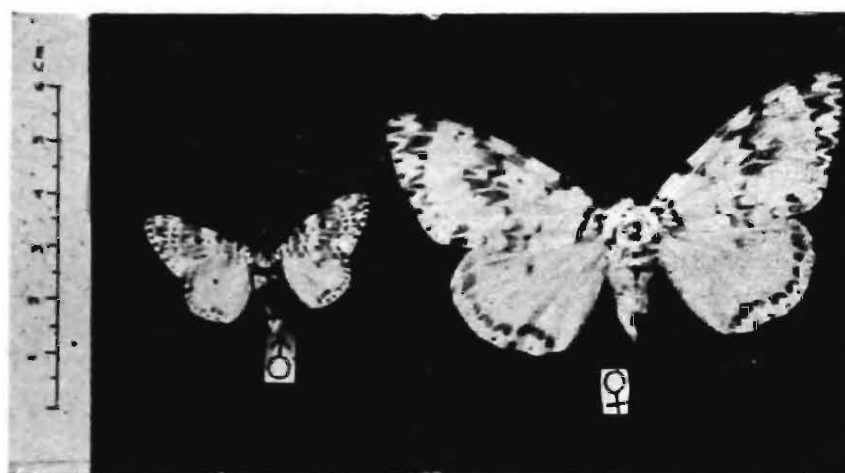
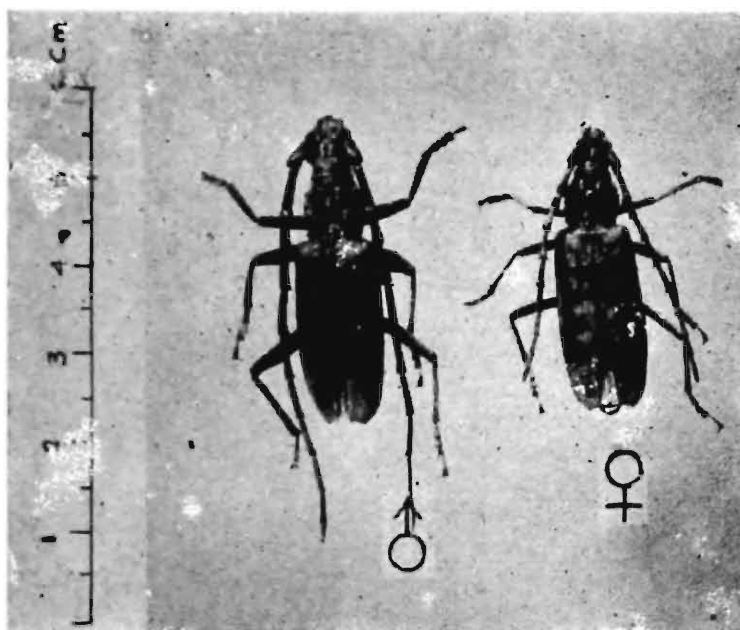
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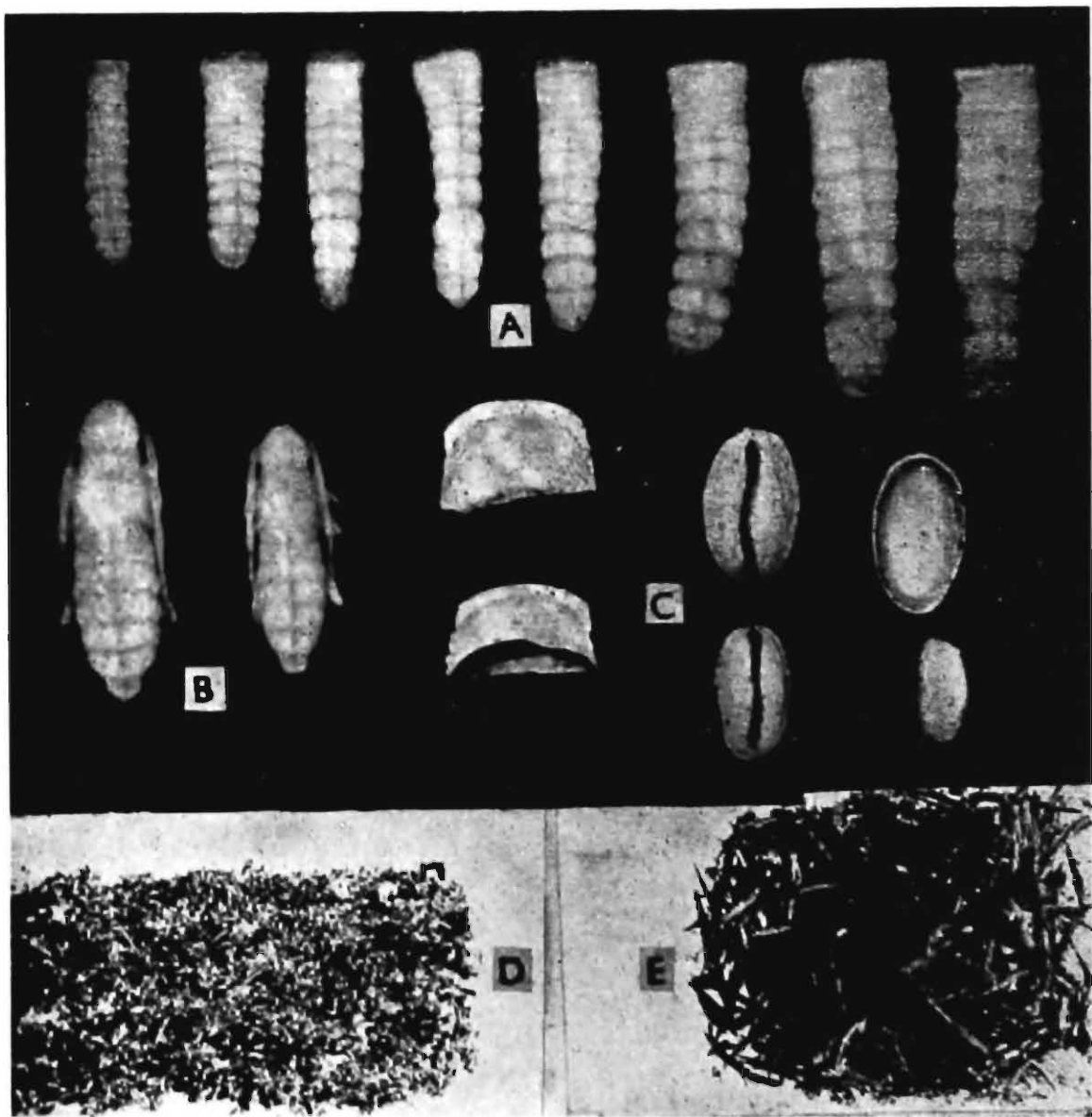
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Upper : *Hoplocerambyx spinicornis*. Antennae in male are longer than head and body, in female shorter. Lower : *Lymantria mathura*. Males are much smaller than females.



Hoplocerambyx spinicornis. Life-history stages, etc. (A) Mature larvae (note size variation). (B) Pupae. (C) Calcareous opercula of mature larvae and prepupae, in different views. (D) Woodfrass ejected from tree by larvae. (E) Wood-fibres from plug of pupal chamber.



Lymantria mathura. Left : Trunk of *Juniperus procera* Hochst., with ovipositing females and egg-masses during an epidemic. Right : Same, closer view. New Forest, Dehra Dun.



Lymantria mathura. Left : Caterpillars resting in day-time on trunk of *Acrocarpus fraxinifolius* Wight during an epidemic. Right : Same, closer view. New Forest, Dehra Dun.



Lymantria mathura. Dead Caterpillars (died from a virus disease) hanging limp from trunk of *Acrocarpus fraxinifolius* Wight during an epidemic. New Forest, Dehra Dun.

**OBSERVATIONS ON POPULATION ECOLOGY AND
SOCIOBIOLOGY OF THE PAPER WASP *ROPALIDIA*
MARGINATA MARGINATA (LEP.) (FAMILY
VESPIDAE)**

By

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INTRODUCTION

Wasps are remarkable amongst the social insects in exhibiting all stages of development of sociality from completely solitary to highly advanced colonial species with females clearly differentiated into reproductive and worker castes. The stage of greatest interest, to the student of social evolution in this series is that of truly eusocial wasps with multiple egg-layers morphologically indistinguishable from the non-laying workers. The tropical old world wasp genus *Ropalidia* is one of the few genera occupying this crucial stage in the development of social habits (Roubaud 1916, Wilson 1971, Gadgil and Mahabal 1974). A number of species of this genus occur on the Indian sub-continent, *Ropalidia marginata* being one of the commonest paper wasps of Peninsular India (vander Vecht 1962). It is a medium sized wasp measuring about 20 mm from the tip of the head to the end of the abdomen, with a well grown adult weighing upto 75 mgm. It builds a nest of carton with naked combs suspended by one or more pedicels in any dark, undisturbed corner of houses and buildings. The number of cells in a colony may go upto 500 while the number of adults may reach 100 or more. We have been investigating the population ecology and social biology of this species in Poona and Bangalore since 1971. This paper reports our preliminary findings on the cycle of population growth in the colonies of these wasps, and attempts to relate this population cycle to the social structure of the *R. marginata* colonies.

MATERIALS AND METHODS

We have observed and harvested *Ropalidia marginata* colonies

from the cities of Poona ($18^{\circ}30'N$ and $73^{\circ}53'E$) and Bangalore ($13^{\circ}00'N$ and $77^{\circ}32'E$) at various times over a period of five years from October 1971 to October 1976. Our population observations include records on the number of pupae and adults at a colony, maintained at roughly 8-10 day intervals. Such observations were maintained on 3 colonies in Poona for the period October 1971 to may 1973 and for 45 colonies in Bangalore for the period October 1974 to October 1976. In addition, we harvested a total of 28 paper wasp colonies from Poona over the period October 1972 to October 1975. While harvesting, attempts were made to collect entire combs along with all the adults and immature stages. The adults were sexed and the females dissected to ascertain the state of development of their ovaries. We also weighed all the adult and immature stages.

COLONY CYCLE

Colonies of *R. marginata* are founded and abandoned all round the year. They are initiated by 1 to 20 females, 3-4 being the commonest number of foundresses (Fig 1). All the females at the

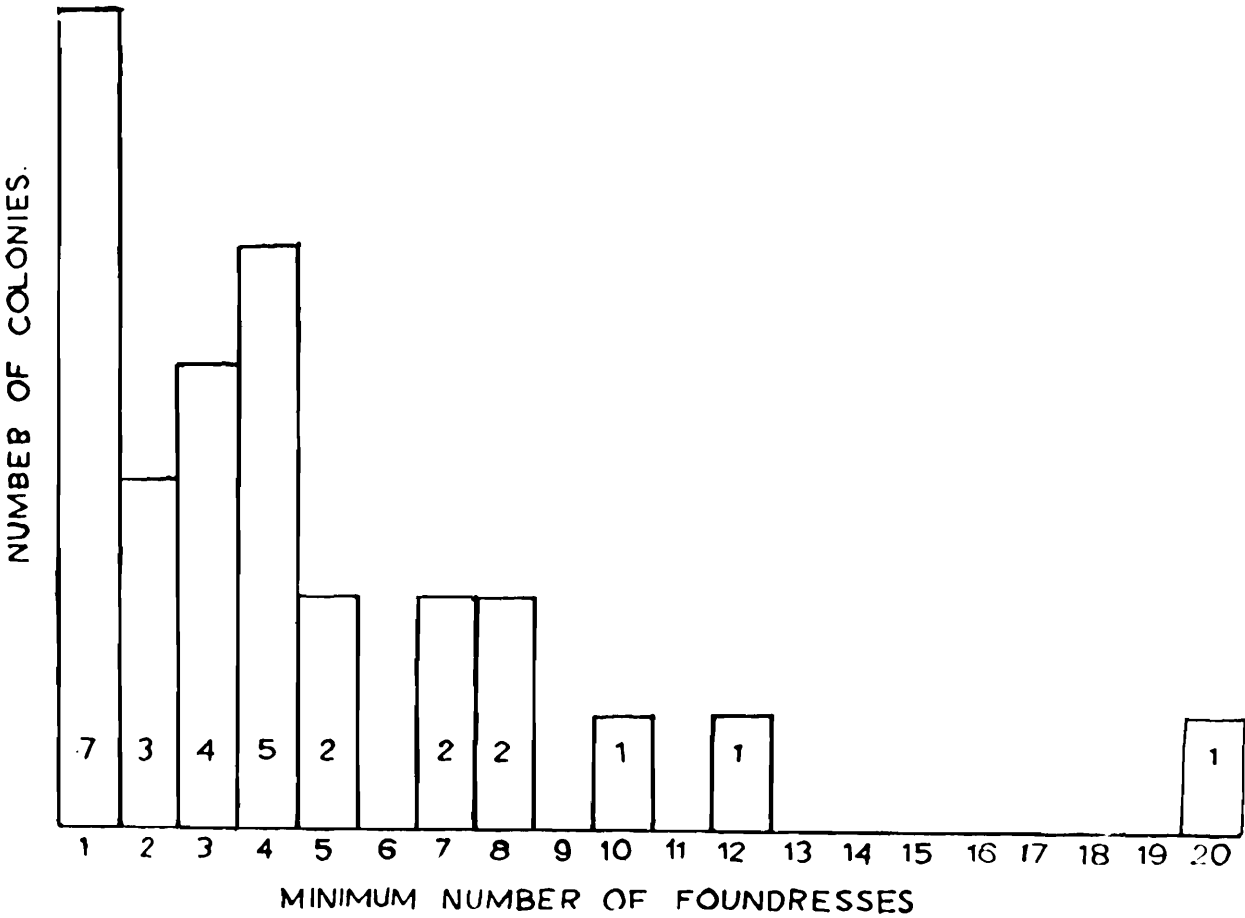


Fig. 1. Frequency distribution of number of foundresses of *R. marginata* colonies.

colony are morphologically indistinguishable, although only some of them have well-developed ovaries and are functional egg-layers. The egg, larval and pupal stages each take about 2 weeks for development, so that the first brood emerges about 6 weeks after the founding of the colony. Many of these stay on contributing to the colony labour, so that the rate of colony growth may accelerate at this juncture. Colonies may grow to sizes of up to 100 adults and over 200 immature individuals, although colonies with more than 60 adults are rare. Large number of adults seem to leave the colonies which have grown to these sizes, and these exoduses seem to set the upper limit to colony size in this wasp species. The males are not distinguishable from the females in the field ; hence we unfortunately lack definite evidence on the stage at which the males are produced. The colonies are perennial, and may last for more than two years, while individual adults are known to live for six months. Colonies may be abandoned at various stages of their growth, though most fail at the very early stages of establishment.

FOUNDING

New colonies of *R. marginata* are founded by 1 to 20 females, 3 or 4 being the commonest number (Fig. 1). In a number of cases the initial single foundress appears to be joined by other females within a few days of founding of the colony. We had marked a number of newly emerging females on colonies in the campus of the Indian Institute of Science. It was noticed that on these colonies the newly emerged individuals were not spending the night on the nest every night, but were occasionally missing for 2-3 days before returning to it. It is possible that these individuals may have been visiting other newly founded colonies on the nights that they were absent. There were emigrations of large number of adults from colonies which had grown to more than 40-50 adults in size. Groups of individuals from these exoduses probably constitute the initial set of foundresses for many colonies.

REPRODUCTIVE DIFFERENTIATION

Our dissections from the harvested colonies indicates that although there is no morphological differentiation amongst the females, there is a marked differentiation amongst them in terms of development of ovaries. In all the colonies, a majority of the females possessed rudimentary, completely undeveloped ovaries, while only 1 to 6 females

possessed moderately or well developed ovaries. In most of the cases, the females with well-developed ovaries tended to be heavier in weight than the other females (Fig. 2). This suggests that, as in the case of *Polistes*, there is a dominance hierarchy amongst the females

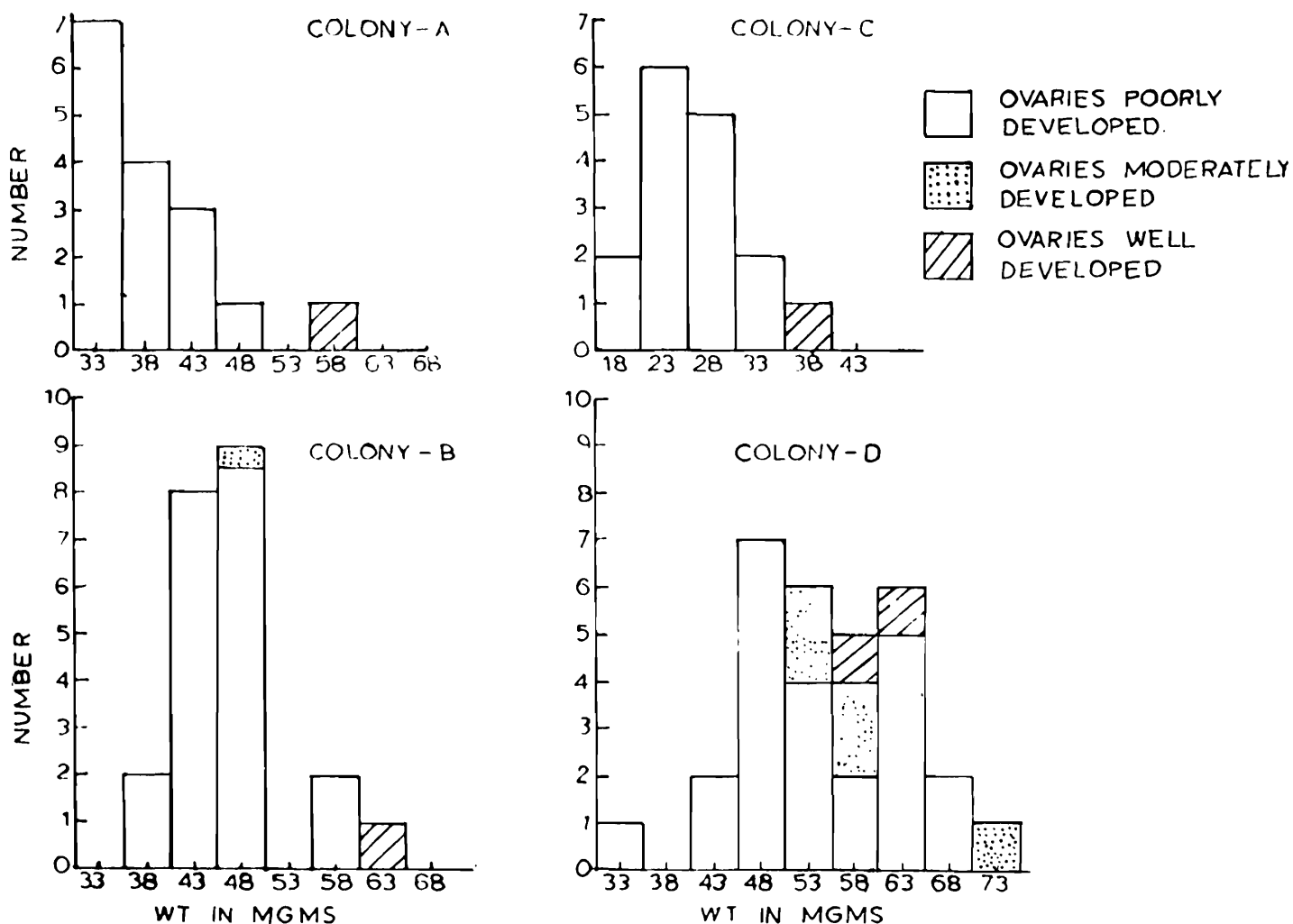


Fig. 2. The weight class and the extent of ovarian development in the total female population in four colonies of *R. marginata* (after Gadgil and Mahabal 1974.)

at a colony with the dominant females doing less of foraging and possessing better developed ovaries (Teanne 1972, West Eberhard 1969). There is extensive food sharing at the colonies of *R. marginata*, and it is quite plausible that the dominant individuals get a disproportionately greater share of the food, while expending less energy on foraging. They may thus be able to grow heavier and develop their ovaries, while the less dominant individuals, the workers suffer from 'nutritional castration'

The number of females with developed ovaries does not bear any clear relation to the total number of females on the colony ; while it

shows evidence of an increase with the number of cells in the comb (Fig. 3). With one exception, all the colonies with less than 80 cells had a single egg-layer, while all the larger combs had three or more. The number of cells in a comb is a good indicator of the age of the colony, while the number of females in a colony keeps constantly

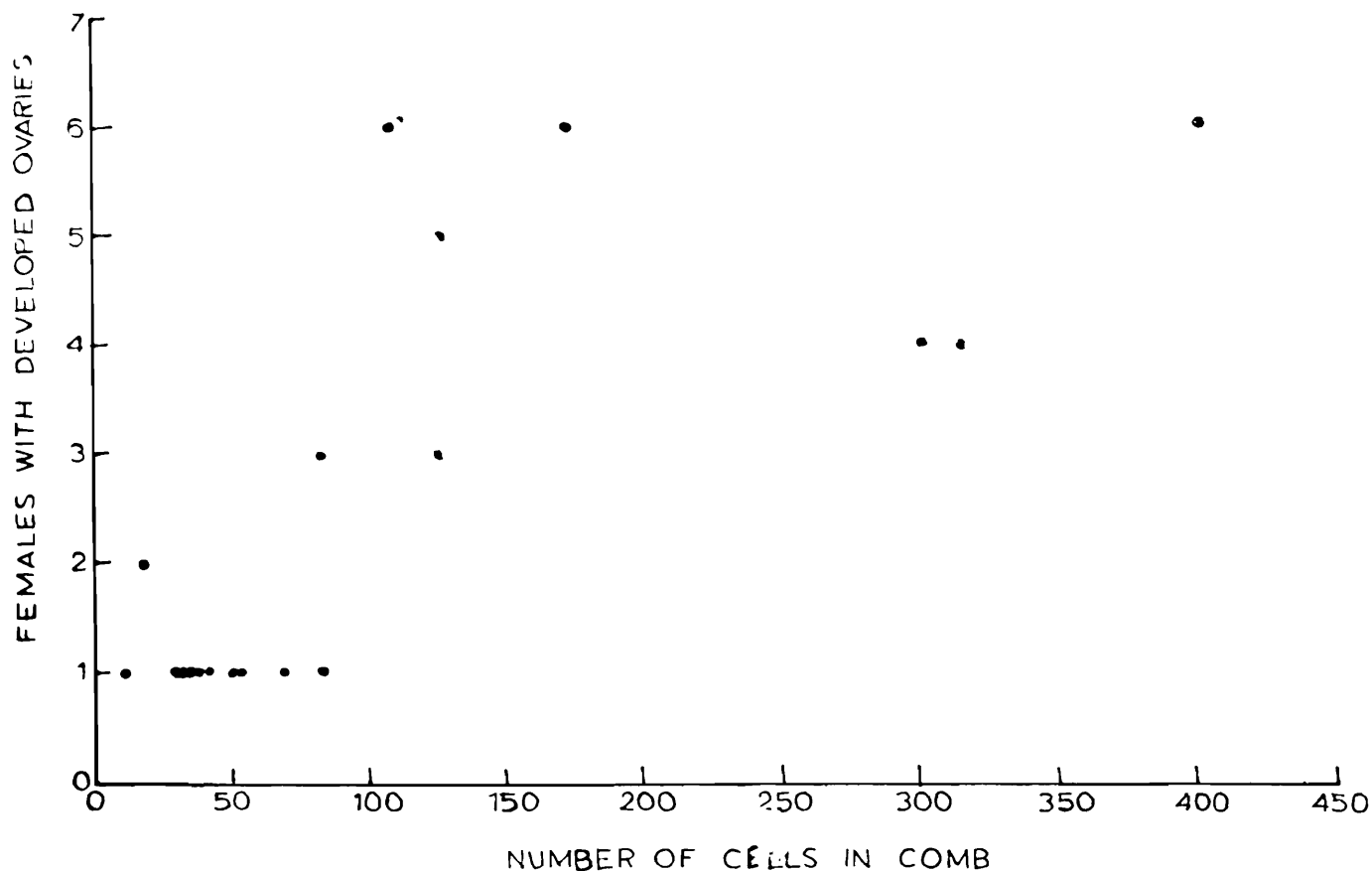


Fig. 3. The number of females with developed ovaries as a function of the number of cells in the colony comb.

fluctuating because of periodic large scale emigrations. We may therefore conclude that the number of egg-layers in a colony increases with the age of the colony. Initially, at the founding, a single female dominates and monopolises all egg-laying; as the colony develops, this monopoly is broken and other females, again the heavier, more dominant ones, also begin to lay eggs.

POPULATION FLUCTUATIONS

The number of adults at a colony of *R. marginata* rarely shows any smooth increase or decrease. Rather, it is characterized by continual fluctuations. Figures 4 and 5 represent the population changes at two of the colonies which grew to considerable

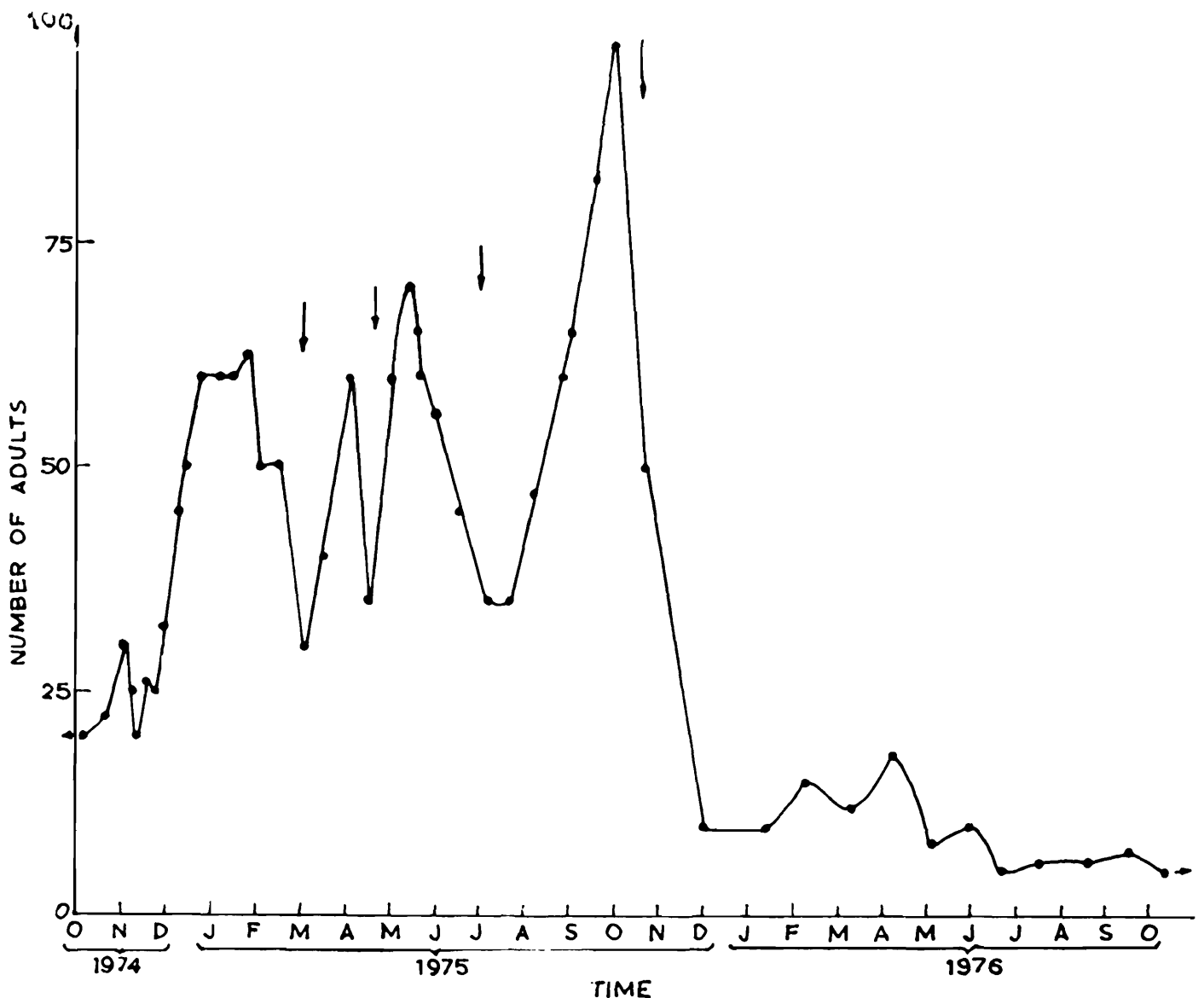


Fig. 4. Number of adults at a *Ropalidia marginata* colony in Bangalore. The arrows indicate mass exoduses.

size, and lasted for 2 years or more. In both these cases, the colonies grew initially, and following one or more mass emigrations, remained fluctuating for several months at less than 20 adults. In the case of the first colony, there were 4 clear cut instances of mass emigrations or exoduses (Fig. 4). These involved 30 or more adults apparently leaving the colony, perhaps to found other colonies nearby. In the case of the second colony, there was a single major exodus, apparently in direct response to predation on the colony by *Vespa tropica*. This large wasp feeds on eggs, larvae and pupae of *R. marginata*. The particular colony depicted in (Fig. 5) was under continual observation, and it is known that the mass exodus

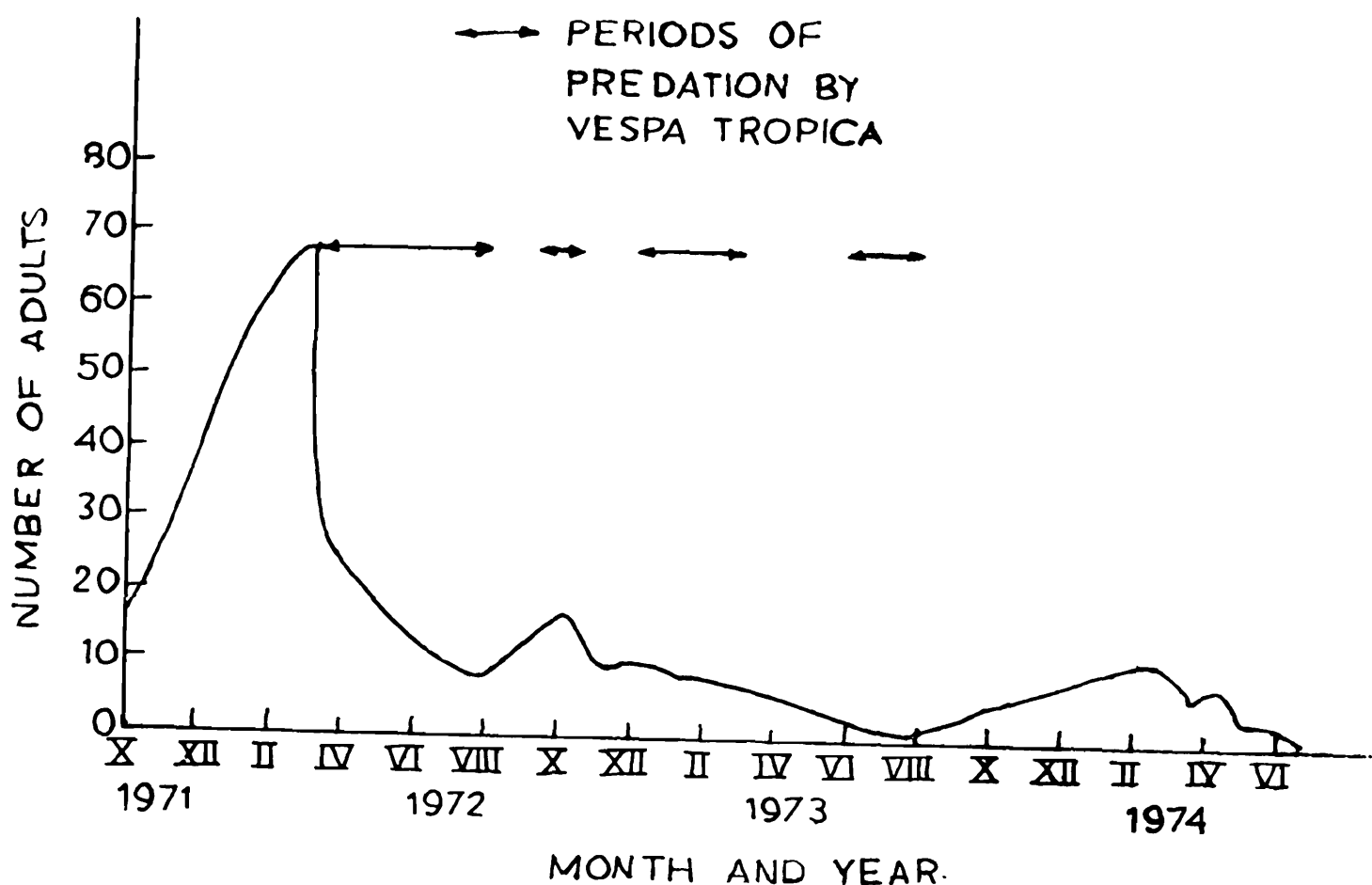


Fig. 5. Number of adults at a *R. marginata* colony in Poona. There was a single exodus following the first instance of predation on the colony by *Vespa tropica* indicate periods of regular predation by this wasp

followed the first-ever visit of the predator to the colony. The predator continued to regularly visit this colony thereafter, and apparently kept the population in check for a year or so. Beyond this period, the colony failed to grow further, although the visits of the predator apparently ceased.

These long-lived colonies however represent only a small proportion of the total colonies. Most of the colonies in fact had a much shorter life span. Fig. 6 plots the total life span of the 19 colonies which were observed from their inception till abandonment, while Fig. 7 plots the minimal life span of 19 more colonies whose founding and/or abandonment occurred before or after our period of observation. Although our observations continued over 150 weeks in Poona and 100 weeks in Bangalore, the colonies observed from founding to abandonment had life spans of 0 to 40 weeks only.

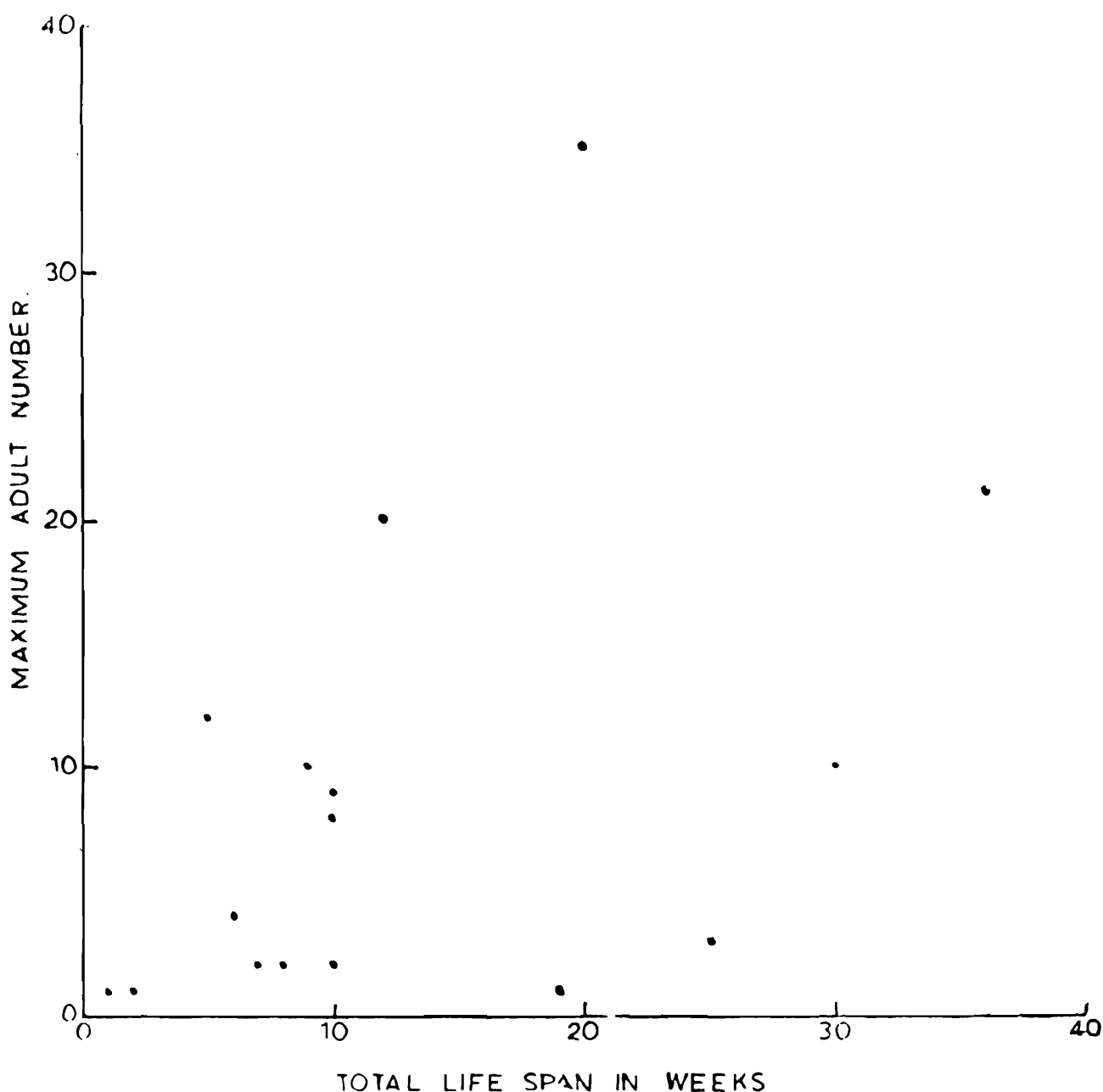


Fig. 6. The total life span of 19 colonies from Bangalore and Poona.

Even here, the shorter life spans are obviously under represented as many colonies which would be founded and abandoned in less than 10 days our observation interval - would not be recorded. As is evident from Fig. 6 and 7, there is obviously a clear-cut bimodality in the life spans of colonies, most being destroyed in 15 weeks or less, while those that persist beyond this having modal life spans of 50-100 weeks.

Fig. 8 presents further analysis of these population fluctua-

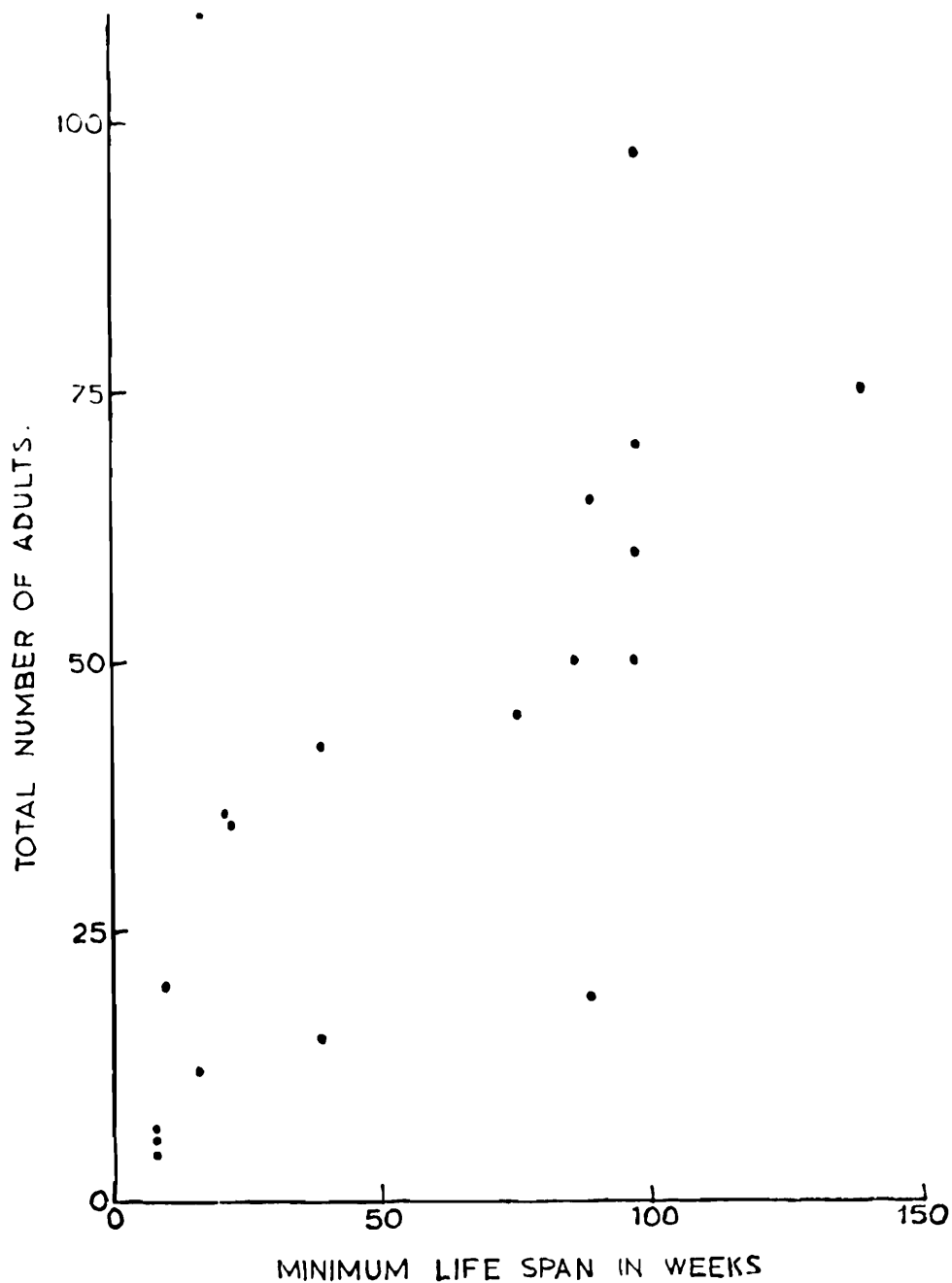


Fig. 7. Estimates of minimal life span of 19 colonies from Central College, Bangalore or Poona.

tions. Here we present the probability of increase in the number of adults at a colony as a function of the number of adults already present. These probabilities have been computed by pooling together our data for the 30-odd colonies monitored over more than 2 years, after correcting for the under representation of colonies which would have escaped detection by being founded and abandoned in between our

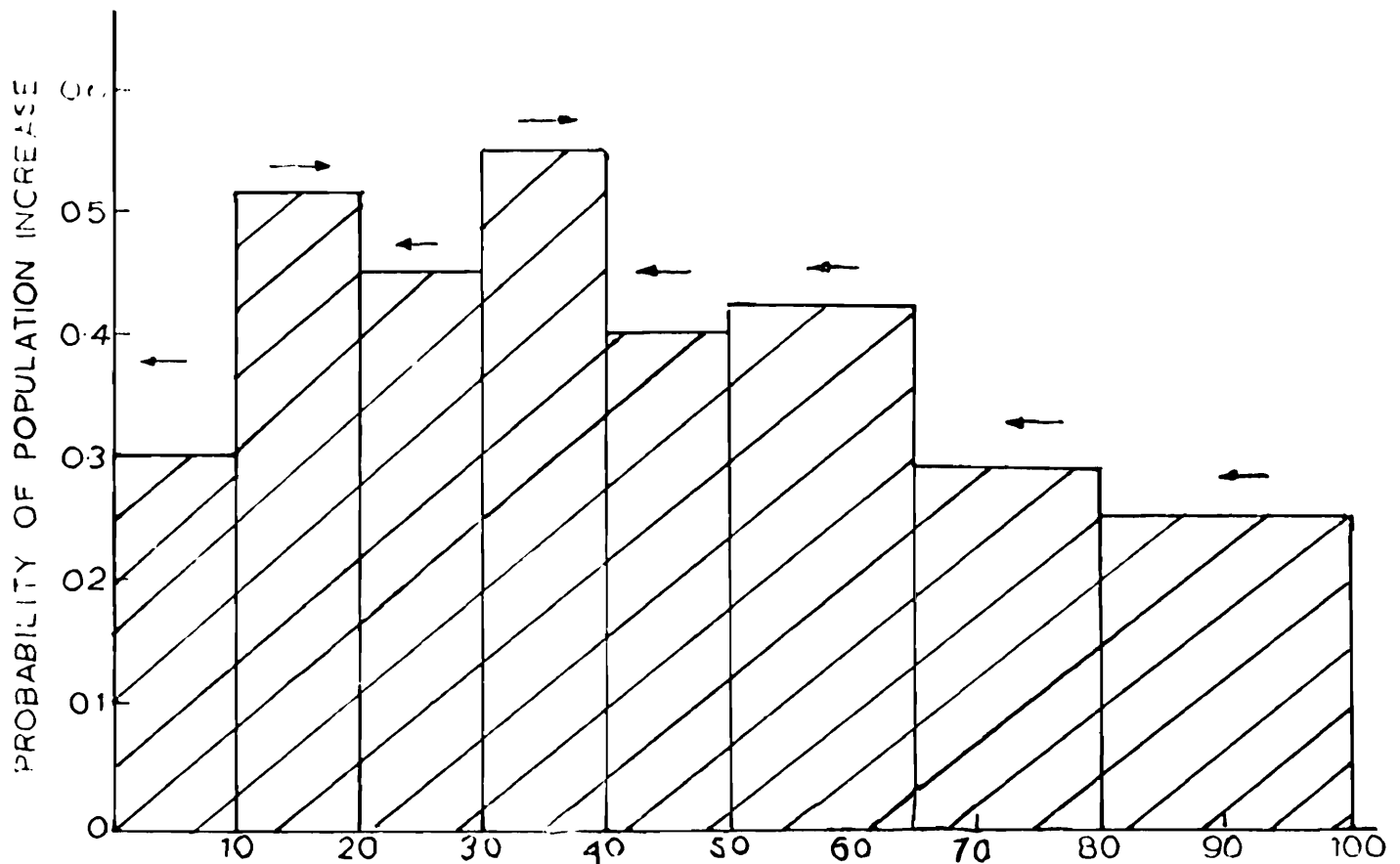


Fig. 8. Probability of increase in adult numbers as a function of number of adults already present. The arrows indicate the expected change on the mean in the number of adults in colonies of various sizes.

two successive observations. As can be seen, the smallest colonies have the lowest probability (only 0.3) of further increase in number. They are thus colonies most susceptible to extinction. The only sizes at which the colonies have near even or better than even chance of increase are between 10 to 40. Thus, a colony which has increased to this level may further increase rapidly till it crosses 40 adults. Beyond this, the colonies tend to have a high probability of decrease due to mass exoduses. The resultant size frequency distribution of colonies is presented in Fig. 9. The vast majority of the colonies have less than 10 adults, most go extinct without getting beyond this stage.

SOCIAL STRUCTURES

It is by now well-established that the rationale for the development of sociality in wasps, ants and bees lies in their haplodiploid system of sex determination. Because of this, a female wasp is genetically

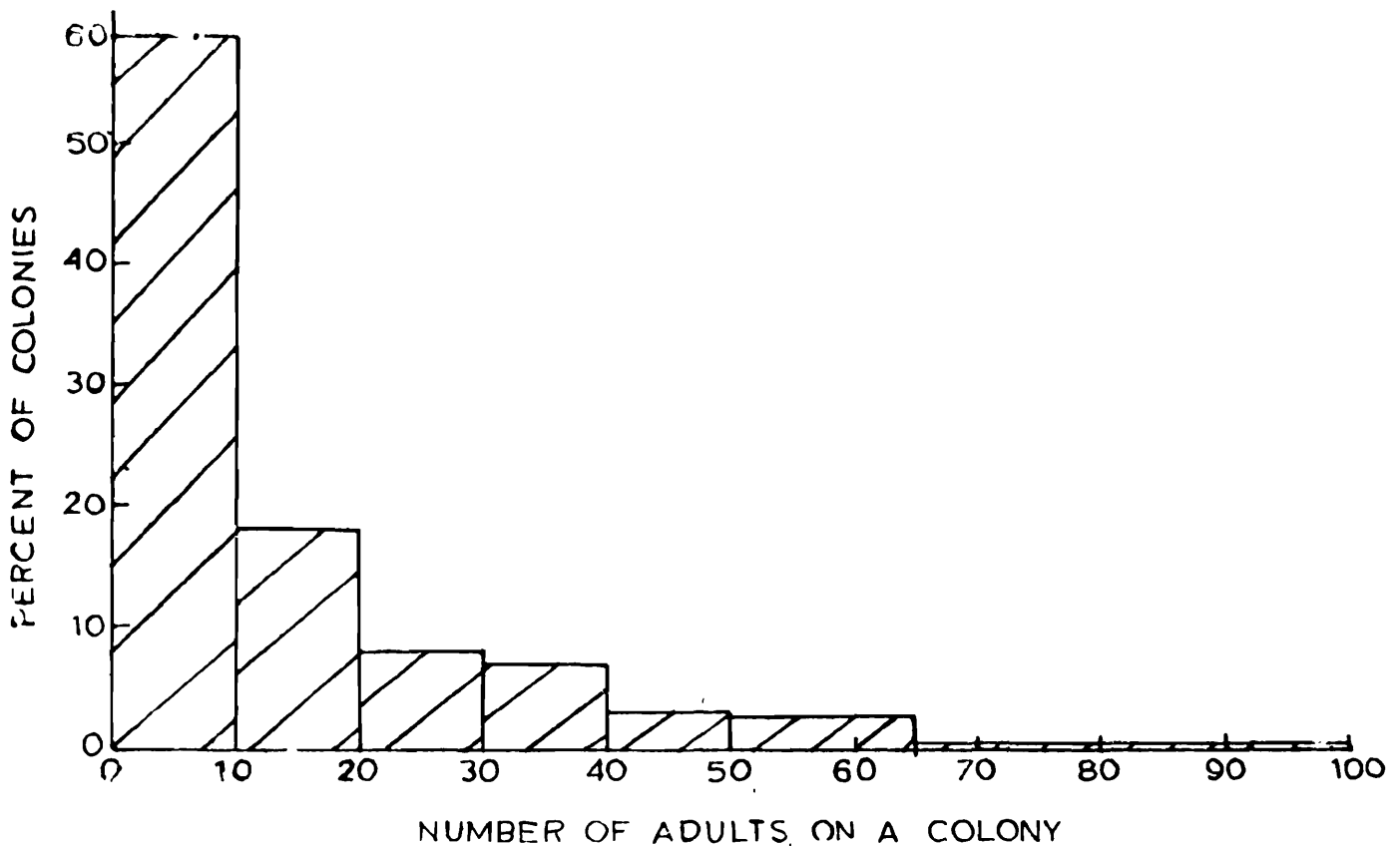


Fig. 9. Frequency distribution of the total population of *R. marginata* colonies in terms of the number of adults present on the colony.

more closely related to her sister than she is to her daughter, and it is therefore more advantageous for a female wasp to help her mother raise daughters which would be her sisters, than to attempt to raise daughters by herself. This is why wasps are selectively favoured to stay on with their mother and help her with the colony labour. At the same time, sons are more closely related to female wasps than brothers are; hence the workers would have a tendency to lay male eggs, and the males themselves would not share in the colony labour (Hamilton, 1964, Wilson 1971, Trivers and Hare 1976, West-Eberhard, 1975).

Wasp colonies with multiple foundresses and with multiple egg layers do not fall neatly in this scheme, particularly if the egg-laying females themselves were not close relatives. We, however, now know that in the case of Polistine wasps with multiple egg-layers, the foundresses do in fact tend to be sisters (West Eberhard 1969). This system of multiple foundresses can evolve if the colonies are highly susceptible to failure in the early stages of growth. Then, if the

coming together of several females increases the probability of success of a colony by a factor of 1.5 or more sisters may band together, and relinquish reproduction to the most dominant female as the female brood they are raising will be related to them as nieces with $k=0.375$. If a single female remains reproductive, the workers of the later brood will be raising their sisters with $k=0.75$.

If, however, more than one of the founding sisters starts to lay, the workers will now be raising a brood related at least in part to them as first cousins ($k=0.19$). At this point the workers may find it more advantageous to leave the colony and attempt to found one on their own. This tendency will increase with an increase in the number of egg-layers in the colony.

As discussed earlier the small colonies of *R. marginata* are in fact highly susceptible to failure, hence the banding together of several foundresses is expected. We have no evidence that these are sisters, though this is plausible as new colonies are very often founded close to old ones and the founders are likely to be sisters who leave together in an exodus from the colony.

We have also shown that there is a tendency for mass exoduses from colonies with over 40 adults. This may be related to these being older colonies with multiple egg-layers in which the average degree of relationship between the workers and the brood would tend to be low, making it less advantageous for the workers to stay on at the colony. Difficulties of sustaining a larger colony on the food resources of the home range could be ruled out as a major factor since the new colonies are often founded next to the parental colony and must therefore utilize much the same food resources.

We thus see in this paper wasp a beautiful example of interaction of ecological and social pressures determining the course of population growth of a colony. The ecological pressures rendering small colonies highly susceptible to failure dictate the banding together of several females. As the colony grows in size, a single female can no longer dominate it to the level of exclusively monopolizing all egg-laying. With multiple egg-layers becoming active, the workers are at less of an advantage in remaining on the colony and hence begin to leave in numbers producing the large population fluctuations. However an established colony has the ability to survive for a long time, retaining

some of the workers. Such colonies may persist for years providing examples of longevity unparalleled in the asocial insect world.

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**POPULATION DYNAMICS AND BIOLOGICAL STUDIES ON
OXYA FUSCOVITTATA (MARSCHALL) [ORTHOPTERA :
ACRIDIDAE] A MAJOR CROP PEST**

By

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INTRODUCTION

Life cycle of short horned grasshoppers has been studied by different authors (Latif & Haq, 1951 ; Katiyar 1955, 1956, 1961 ; Hunter-Jones and Ward 1959 ; Parihar, 1974 ; Venkatesh and Harjai, 1975 ; Mazeed *et al.*, 1975 ; Roonwal, 1976 etc.) but so far no attempt has been made in studying the life cycle of *Oxya fuscovittata* (Marschall). It is a major crop pest of U.S.S.R. (South West), Pakistan, Afghanistan, Mauritius and India (Mishchenko, 1952 ; Hollis, 1971). Present study deals the life history of the species in laboratory along with the fluctuation of population in the field at Narendrapur, 24-Parganas, West Bengal. Influence of temperature and relative humidity on the developmental stages of the species in the laboratory as well as on the population in the field are discussed.

MATERIAL AND METHOD

Oxya fuscovittata was collected from Narendrapur near Calcutta, and reared in separate cages designed for the purpose for pairing and egg laying in the laboratory. Each cage measured 8'' × 6'' × 10'' of wire gauge with wooden frame. The floor of cage was made of a sheet of wood and had one top glass side which could be slide out for observations, for changing the food and for cleaning the cage. Sufficient quantity of soil containing a mixture of sand and soil screened and put on the floor of the cages. Drops of water were also added daily to keep the soil moist. The layer of the soil was 3-4'' deep and it was searched out daily to find out the egg pods. Fresh grass and water were also kept daily inside the cages. The collected egg pods of known age were first washed thoroughly in plain water with the help of a fine sable hair brush to remove sand particles and dust and then gently rolled on a blotting paper to absorb free water. They were, then weighed in a physical balance. Measured egg pods were placed in glass jars having sufficient quantity

of screened mix soil (Sand + Soil), water drops were also added daily to keep the soil moist.

Laboratory temperature and humidity were also recorded 2 times in a day *i.e.* at 10 A.M. and 3 P.M. Maximum & Minimum temperature were also recorded during 24 hours of a day.

Population fluctuation of this species have been made in the experimental area at Narendrapur, where three plots of the size 150×80 , 100×50 and 80×30 meters were selected. Different crop and fodder plants were grown in three fields.

Collections were made during morning hours after every ten days interval for a period of 2 hours by sweeping and hand picking methods. Temperature and humidity were also recorded each time.

OBSERVATIONS & DISCUSSION

Pairing : Pairing was observed only during the day time and the duration of copulation was recorded from half an hour to three hours and it was of the "riding type" (Katiyar, 1956).

Oviposition : The oviposition behavior has been discussed by several authors (Künckel d'Herculais 1893-1905 ; Giardina 1901 ; Coleman, 1911 ; Grassé 1922 ; Fedorov 1927 ; Srivastava 1956, 1957 and Uvarov 1966) in short horned grasshoppers. During observation it was noticed that sexually matured females started moving on the surface examining the soil by their ovipositors and hind legs. After finding the proper site for egg laying, they started digging out the soil by their ovipositors. Abdomen is pressed into the soils by a series of jerks with the alternate opening and closing of the valves until the hole is sufficiently deep.

When the hole was completed in the soil, the female retracted its abdomen slightly and the frothy secretion of the accessory gland was emitted. The secretion filled the hole a little and hardened to form the wall of the egg pod. After 1 or 2 minutes bright yellowish eggs together with foam were expelled out through the valves of the ovipositor. When all the eggs were laid the mouth of the hole was sealed with more frothy secretion.

Hatching : Mechanism of hatching, and the emergence of Vermiform larva *i.e.* the real first instar (Uvarov, 1928)

is similar as described by Uvarov (1966). The time of hatching of egg pods depend upon the temperature and moisture *i.e.* humidity (Uvarov, 1966 ; Parihar, 1971a, b). During November to January the hatching time was recorded 28 to 38 days, while in May to September 22 to 32 days (Table 1). Hatching period also

Table 1 Hatching of egg pods of *Oxya fuscovittata* (Marschall)

Nos.	Date on which egg pod layed	Date on which egg pod hatched	Total days taken	No. of Nymphs
1	11.10.1977	11.11.1977	32	22
2	14.10.1977	10.11.1977	28	20
3	15.10.1977	18.11.1977	35	20
4	27.10.1977	30.11.1977	35	5
5	27.10.1977	31.12.1977	66	25
6	30.10.1977	28.11.1977	30	18—20
7	10.11.1977	7.12.1977	28	16
8	17.11.1977	16.12.1977	30	20
9	24.11.1977	31.12.1977	38	22
10	30.11.1977	2.1.1978	34	15
11	1.12.1977	30.12.1977	30	2
12	3.12.1977	4.1.1978	33	24
13	18.4.1978	16.5.1978	29	20
14	21.5.1978	12.6.1978	23	28
15	25.5.1978	—	—	—
16	28.5.1978	—	—	—
17	31.5.1978	—	—	—
18	4.6.1978	—	—	—
19	22.7.1978	19.9.1978	72	20
20	21.8.1978	21.9.1978	32	5
21	24.8.1978	14.9.1978	24	13
22	31.8.1978	21.9.1978	22	5
23	1.9.1978	24.9.1978	24	13
24	11.9.1978	2.10.1978	27	11

varied from 28 days to 72 days on account of different moisture conditions and sometimes egg pod does not hatch at all due to less or excess moisture.

Natality and Mortality: The minimum and maximum number of nymphs emerged from each egg pod was five and twenty eight respectively. Each female layed three to five egg pods in her life time. The life of adult female also varies from 30 to 50 days. Mortality rate of nymphs of laboratory reared mother is 70% and from field mother (Female collected from field) is 50% and this depends upon the temperature, humidity and food.

Hoppers and adults: Number of nymphal instars (after the vermiform larva) may be 4 to 8 as studied by different authors in 40 species (Dirsh, 1968). In this species also, there are six hopper stages, including vermiform larva, seventh being the adult. The duration of various stages at room temperature and humidity was as follows :

<i>Hopper stages</i>	<i>Duration</i>
I	5— 6 days
II	6--7 ..
III	6— 8 ..
IV	6—8 ..
V	8—9 ..
VI	10—13 ..

Growth of hoppers: Fig 1. shows that the rates of weight increase from instar to instar in *Oxya fuscovittata* and the total weight increase is higher in females than in males. The rate of growth in other parts in this study such as, the length of the pronotum, in comparison with head was less during 1st stage but it was increased from 3rd stage (Table 2). Hind femur was always bigger than hind tibia (Fig. 2). Growth was more from six stage onwards.

The total number of days taken for the completion of the life history from the egg laying to final moulting varies from 63 to 76 days during June to September and 71 to 86 days during December to February depending upon various ecological factors.

Table 2 Morphometrics of *Oxya fuscovittata* (Marschall) hoppers of I-VI Instar and the resulting adults, based on 10 specimens.

Weight & Measure- ments	MALE							FEMALE						
	I Instar	II Instar	III Instar	IV Instar	V Instar	VI Instar	Adults	I Instar	II Instar	III Instar	IV Instar	V Instar	VI Instar	Adults
Body weight in mg.	3	9	18	50	60	90	135	4	12	23	60	80	105	305
Body length in mm.	5.00	7.5	9.5	11.5	13.0	16.5	19.5	5.5	8.1	11.1	12.5	15.0	17.0	22.0
Head length in mm.	.8	1.1	1.4	1.9	2.5	3.3	3.5	.8	1.2	1.8	2.3	2.9	3.5	5.0
Pron. length in mm.	.8	1.1	1.7	2.5	3.5	4.3	5.0	.8	1.4	1.9	2.8	3.7	4.5	6.0
Hind femur in mm.	3.0	4.0	4.8	6.5	7.1	9.0	11.0	3.2	4.2	5.0	6.5	8.5	9.0	12.0
H. tibiae in mm.	2.5	3.2	3.7	5.5	6.7	8.0	9.5	3.0	3.5	4.0	5.2	6.5	7.5	10.9
Antennae left in mm.	1.0	1.5	1.8	2.5	3.2	4.3	9.4	1.1	2.0	2.5	3.2	3.6	4.6	9.5
Antennae right in mm.	1.0	1.5	1.8	2.5	3.2	4.3	9.3	1.1	2.0	2.5	3.2	3.6	4.6	9.5

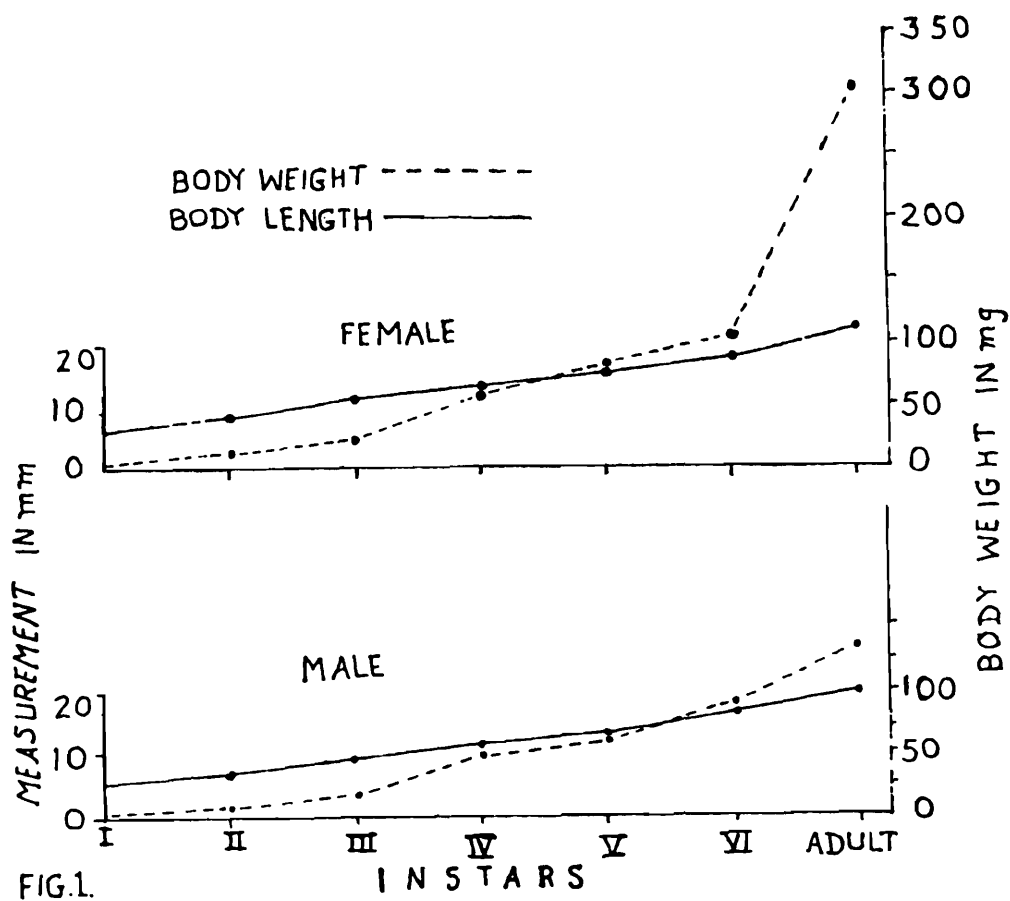


FIG.1.

Fate of adults : Newly emerged adults were sluggish upto one day then they have become very active. They start feeding vigorously on grass plants. Pairing was seen in female after become 10-15 days old. The life of adult female was 30-50 days and of male 20—35 days.

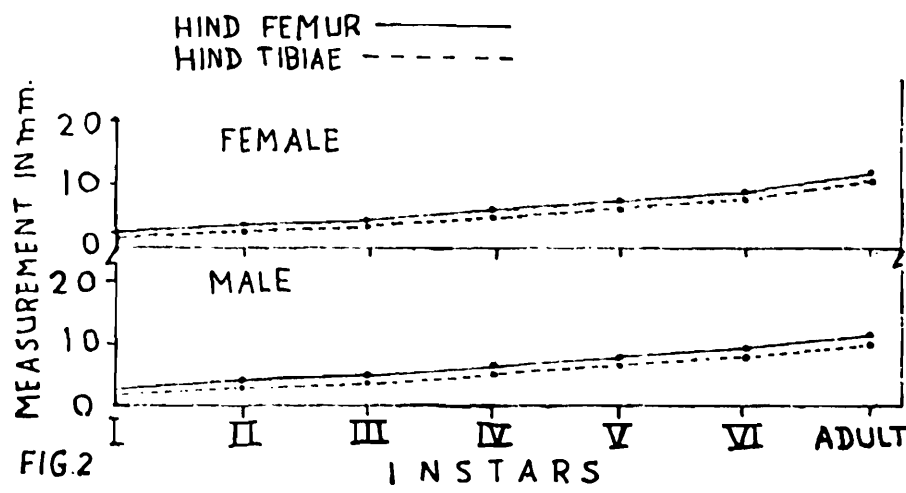
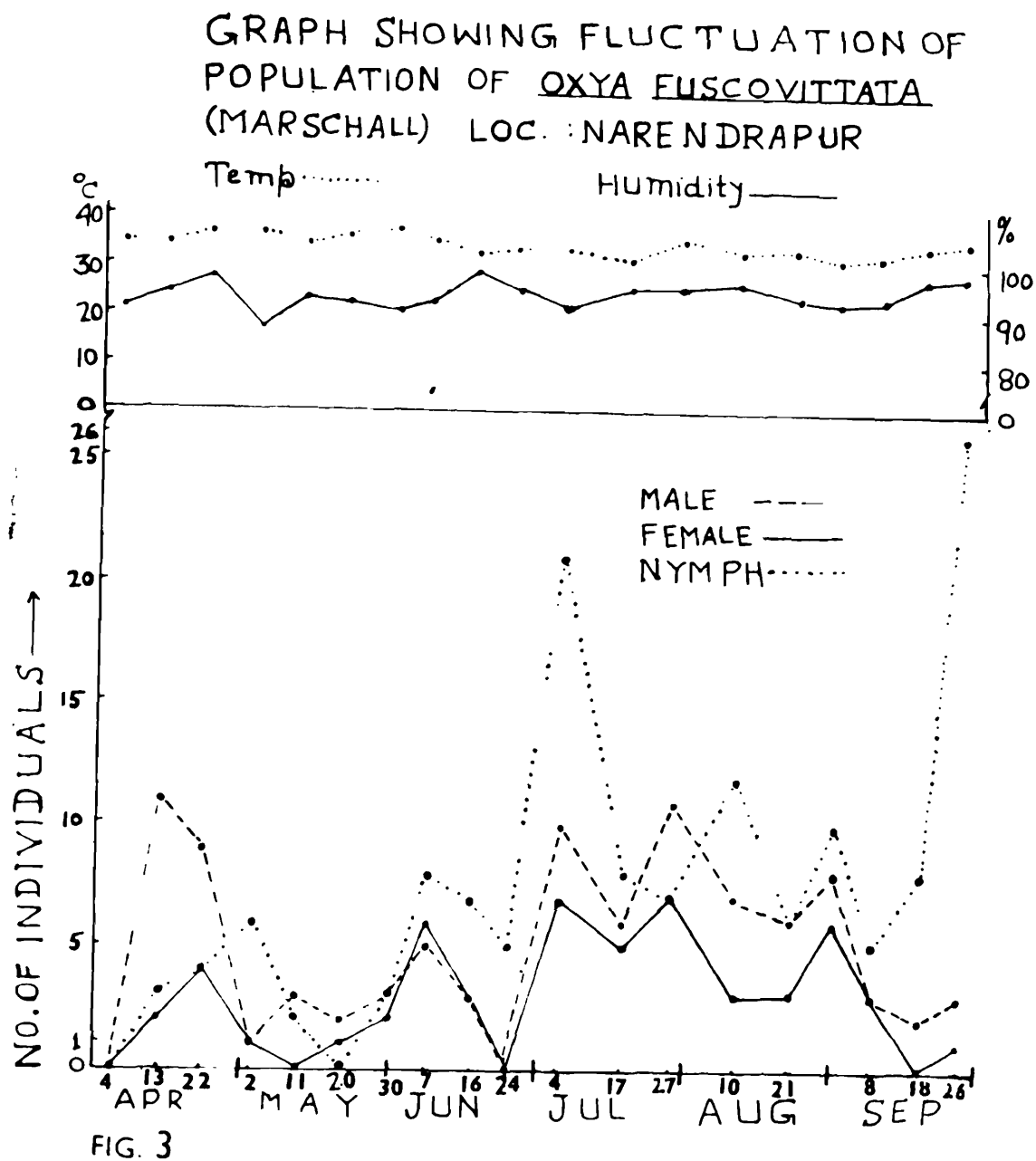


FIG.2



It is observed in the field that the occurrence of the species was less during the beginning of the month of April but started to increase from the month of June and was maximum during July-September depending upon the various ecological factors such as temperature & relative humidity (Fig. 3, and Table 3 & 4).

Eggs which were layed by female during June and July hatched in the month of July and August and the nymphs were at their peak during July and September when the paddy and maize plants were plenty. These nymphs after becoming adult in September may damage the crop a lot.

Table 3 Showing average monthly counts of *Oxya fuscovittata* (Marschall) [Male, Female and Nymph] at Narendrapur, 24 Parganas, West Bengal from the three fields.

	April	May	June	July	August	September
Male	20	9	8	27	21	8
Female	6	4	9	19	12	4
Nymph	7	11	20	36	28	39

Table 4 Range of temperature (°C) and Relative humidity on different dates of collection at Narendrapur

Temperature (°C)						
Month	April	May	June	July	August	September
	34. -- 36.4	34. -- 36.9	29.4—34.9	31 -- 35.4	26 -- 31	28.5—34.1
Relative humidity (%)						
Month	April	May	June	July	August	September
	54—76	69—97	64—99	51—96	70—93	60—97

SUMMARY

Oxya fuscovittata (Marschall) is very common around Calcutta. It feeds on most of the grasses of the family gramineae but always prefer paddy, maize, jowar and other important crops. Female lay eggs in soil. Egg pods hatch after 22-35 days. Generally six hopper stages occur. Favourable temperature and humidity for hatching and development is 30°C ($\pm$ 1°C) and 60-70% respectively. Fluctuations of the population of the species is directly related to temperature and humidity.

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CRYPTOSTIGMATID POPULATION OF SOME CULTIVATED AND UNCULTIVATED SOILS

By

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INTRODUCTION

Cryptostigmata are very important components of the microarthropod community of soil in most ecosystems. Until recently population and community studies of soil microarthropods have been largely neglected in India. Recently Choudhuri and Roy (1967), Singh and Mukharji (1971, 1973), Banerjee (1974), Choudhuri and Banerjee (1975), Singh and Pillai (1975), Prabhoo (1976) and Bhattacharya and Joy (1978) made some valuable contributions in this direction. Present paper deals with some qualitative and quantitative aspects of soil inhabiting cryptostigmatid mites in some cultivated and uncultivated soils at Santiniketan.

MATERIAL AND METHODS

The present investigation was done during February 1976 and January 1977. The sites selected for the purpose were a Grassland (GL), an *Acacia* forest (AF), a highland monocropped Paddy field (PF) and a Banana plantation (BP). From each site 9 soil samples of 5x5x10 cms. size were collected at monthly intervals. A total of 130 samples were studied for each site. Cryptostigmatid mites extracted from the soils by means of a battery of "Tullgren funnels" were identified upto generic level following Balogh (1972) and upto species wherever possible. Community analyses were done with reference to relative abundance, abundance, population density, species diversity on the basis of the species richness index of Menhinick (1964), micro-distribution pattern based on Fisher's coefficient of dispersion and mean crowding of Lloyd (1967), index of association (Southwood 1967) and Sorensen's (1948) quotient of similarity between sites. An attempt has also been made to correlate monthly changes in the abundance of common species with the moisture content and with the organic carbon of the soil.

OBSERVATIONS

Cryptostigmatid mite fauna of the sites under investigation accounted for more than 25% of the total soil microarthropods. Their relative abundance being maximum in the GL (36%) followed by PF (29%), BP (22%) and AF (20%) in that order (Fig. 1.). These mites constituted 55% of the total acarofauna in GL, 43% in PF, 38% in BP and 30% in AF. Prostigmata, Mesostigmata, and Astigmata together accounted for the rest of the acarofauna. In the present work cryptostigmatid mites were found to be the most predominant group of microarthropods in all the sites except AF where it was next in relative abundance to prostigmatid mites. Like relative abundance, abundance

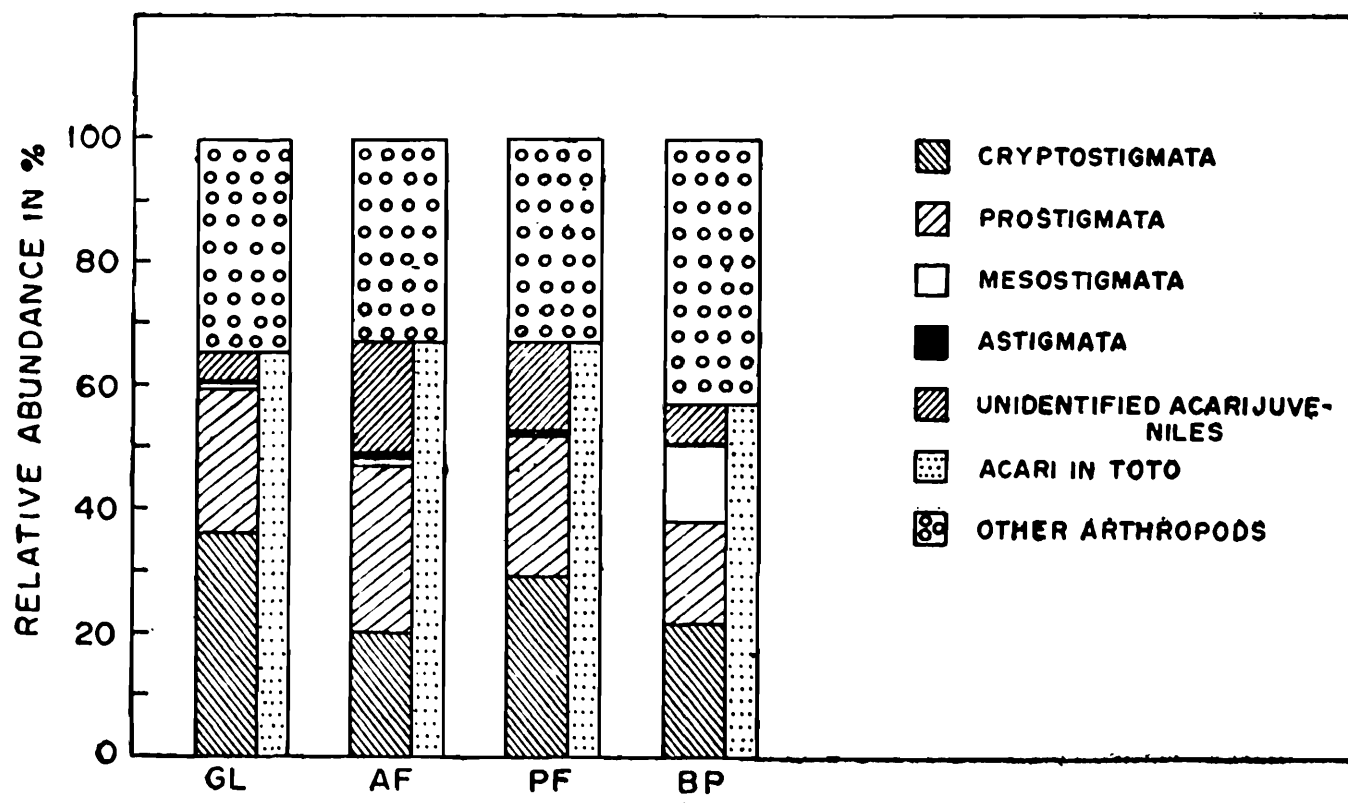


Fig. 1. Relative abundance of the major groups of Acari in relation to total microarthropods in different sites.

and population density of Cryptostigmata also varied from site to site (Table-1.), however, the picture being somewhat different from that of the relative abundance. These mites were most abundant in BP, followed by GL, AF and PF in that sequence. In all 37 species of Cryptostigmata could be recorded from the area during the survey. Of these 11 species had a relative abundance of more than 5% and were considered as dominant species. From AP 40 species could be collected, AF was next with 26 species followed by GL with 19 and PF with

only 9 species (Table-2). *Scheloribates albialatus* Hammer, was the most common and dominant species in all the sites. Next in relative abundance was *Eporibatula* sp. in PF, *Archegozetes longisetosus* Aoki, in GL, *Epilohmannia pallida pacifica* Aoki, in AF and *Oppia nodosa* Hammer, in BP. Species diversity on the basis of species richness index of Menhinick was greatest in AF (1.40) followed by BP (0.84), GL (0.60) and PF (0.56). All the dominant and subdominant species of the different sites with the exception of *Galumna* sp, in AF, had aggregated pattern of microdistribution. This was checked by both "Fisher's coefficient of dispersion" and "Mean Crowding" by Lloyd (Table 3 & Fig. 2.). Aggregation was found to be maximum in the

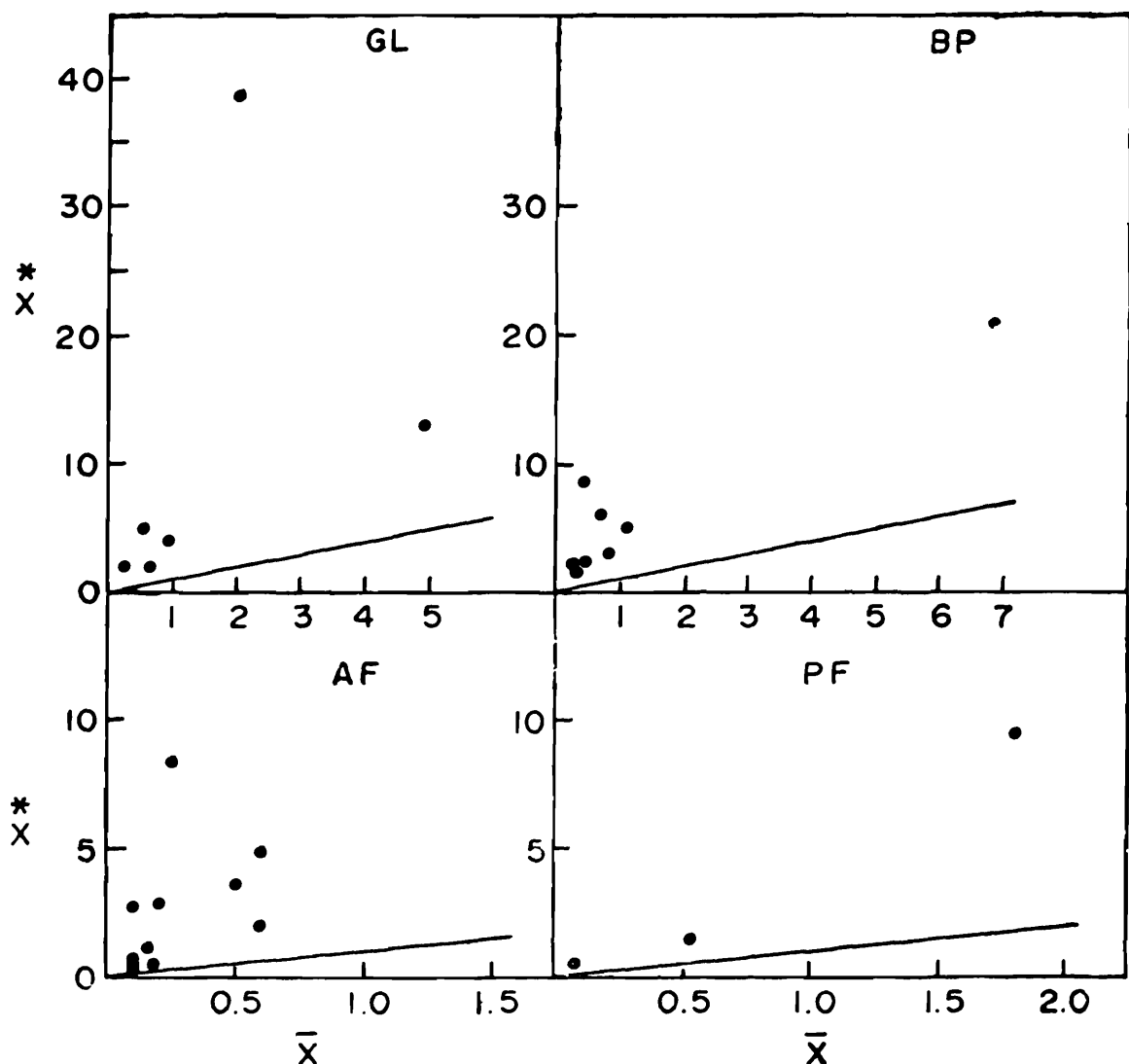


Fig. 2. Mean crowding ($\bar{X}^*$) plotted against abundance ($\bar{X}$) of cryptostigmatid mites with a relative abundance of $> 2\%$ in different sites. The straight line shows similar values for $\bar{X}^*$ and $\bar{X}$.

case of *A. longisetosus*. Fisher's coefficient of dispersion suggested a near random distribution also for *Paralamellobates bengalensis* in AF, since it was within the range of $+0.28$. Most of the dominant species had no association between themselves (Table-4). Only a weak association between *P. bengalensis* and *Galumna* sp. with *S. albialatus* in GL, *S. albialatus* with *O. nodosa* and *Eporibatula* sp. with *Pilobates* sp. in BP could be observed. Both the dominant species in PF namely *S. albialatus* and *Eporibatula* sp. had a strong association between

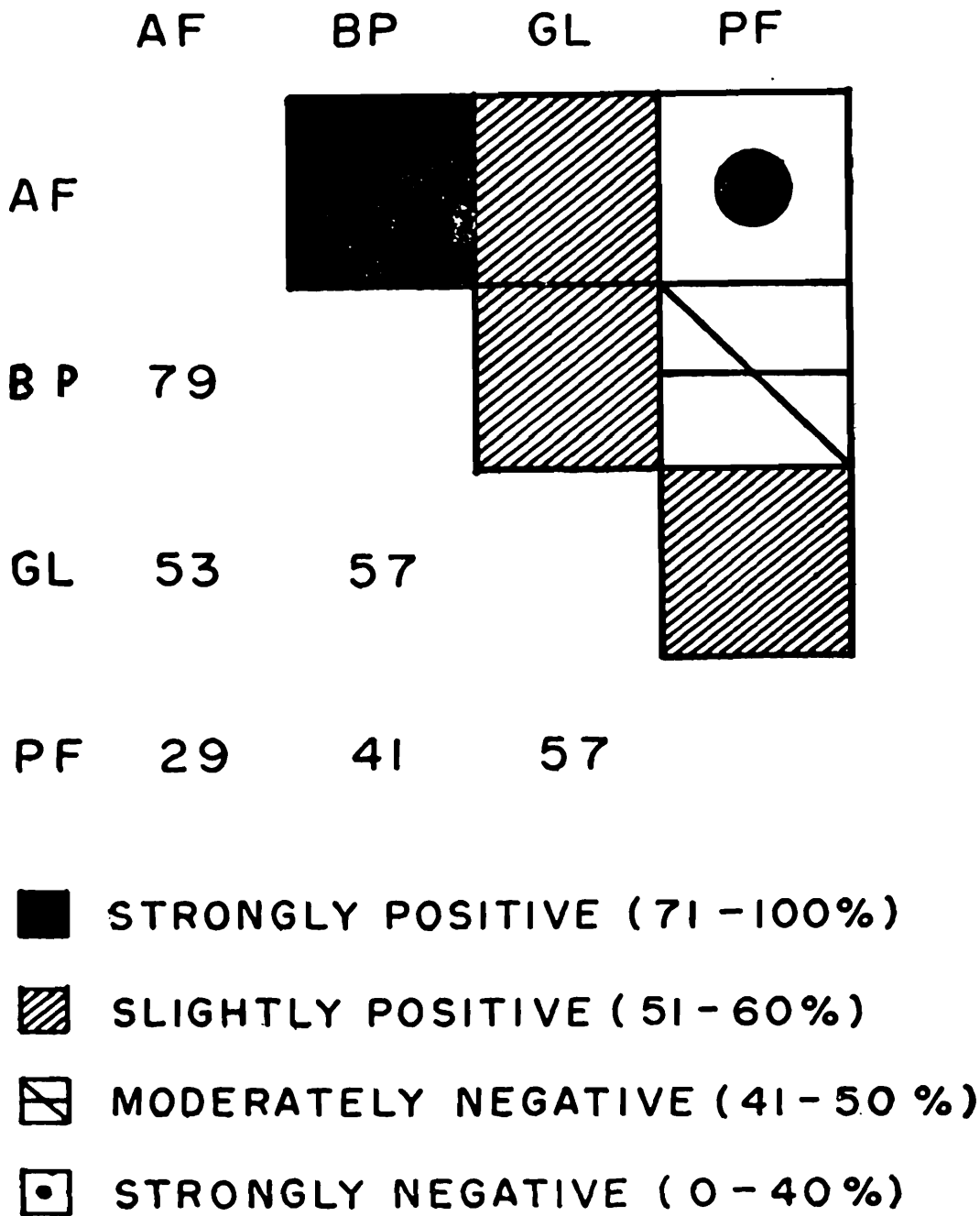


Fig. 3. Sorensen's quotient of similarity between different sites with respect to cryptostigmatid species.

themselves. In AF, only *E. pallida pacifica* and *Lanceoppia* sp. showed a very strong affinity ($I_{ai}=0.82$). From Sorensen's quotient of similarity between sites drawn on the basis of cryptostigmatid species present there (Fig. 3) it was observed that BP and AF were most identical in faunal composition. GL showed slightly positive similarity with the remaining three sites. On the other hand faunal make up of PF differed considerably from BP and AF, the quotient being negative, particularly so in the case of the latter. All the common species of cryptostigmatids showed a positive correlation with the moisture content and organic carbon of the soil. Although for most of the species correlation coefficient between moisture content of the soil and change in abundance was statistically significant, that between organic carbon and abundance was found to be insignificant in most of the cases (Table-5).

DISCUSSION

Various authors working in temperate areas have reported higher relative abundance for Cryptostigmata in comparison to what has been observed in the present investigation. Present findings are quite in accordance with the findings of Ryke and Loots (1967), Block (1970), Singh and Mukharji (1971), Singh and Pillai (1975) and Bhattacharya and Joy (1978) who worked in the tropical areas. This is because cryptostigmatid mites prefer the environment provided with undisturbed organic layer lying on the surface of mineral soil with mor type of humus formation (Wallwork 1970). However, figures obtained by Singh and Pillai (1975) were quite lower (12.2—17.7%) in comparison to that of the present findings (20.2—35.9%). In none of the sites they investigated, cryptostigmatid mites were the most dominant group, whereas in the present investigation cryptostigmatid mites were the predominant group in all the sites except AF. However, as in the present work Singh and Pillai (1975) also found highest population density of Cryptostigmata in Banana field in comparison to other fields at Varanasi although, they reported a lower population density (3365/m²) in comparison to what has been observed in the present findings (4998/m²). This might be due to the higher amount of organic matter in BP at Santiniketan. Sparsity of Cryptostigmata in cultivated soil as in PF has also been pointed out by Ryke and Loots (1967), Edwards and Lofty (1969), Singh and Pillai (1975) and Bhattacharya and Joy (1978). The reason for this might be due to the various agricultural practices which result into an unstable poorly structured

profile. Although population density of Cryptostigmata was noted to be highest in BP, the species diversity was greatest in AF. On the other hand both species diversity and population density were lowest in PF. Species diversity reflects complexity of the community and is directly proportional to the availability of ecological niche. Whittaker (1970), however, opined that species diversity show marked correlation with vegetation structure. From the present investigation it may be said that the species diversity of cryptostigmatids tends to be lower in simple, less stable ecosystem, for example PF and is higher in forest and perennial agricultural plantation such as AF and BP. The relative abundance of different cryptostigmatid species varied from site to site, perhaps depending on the microenvironmental conditions. *S. albi-latus* is the most common species in Santiniketan. Moreover this species could be collected almost throughout the year. This reflects to its extraordinary capacity of draught tolerance and adaptability.

Most of the dominant and subdominant species of Cryptostigmata seem to have an aggregated or contagious pattern of microdistribution. Haarlov (1960), Berthet and Gerard (1965), Gerard (1967), Wallwork (1972) and Lussenhop (1973) have also discussed the microdistributional pattern of soil oribatids and they have all found that the cryptostigmatids tend to be aggregated in distribution. Gerard (1967), however, is of the opinion that oribated mites are distributed not truly in well defined clumps but rather in quite diffuse zones of more or less high density. Haarlov (1960) has opined that better the locomotory organs are developed the less aggregated is the distribution of species of Collembola. Hale (1967) has, however, doubted this interpretation. Such non-random aggregated distribution for many soil microarthropods perhaps reflects oviposition pattern (Raw, 1967), or might be due to the fact that they aggregate at favourable feeding sites (Hale, 1967; Raw, 1967) or might be due to gregarious habit (Hale, 1967) or even due to microenvironmental conditions (Gerard, 1967).

Most of the dominant species do not show any sign of significant association among themselves. A positive association between two species may be expected if they require similar condition or if there exists any mutualism or predator-prey relationship. Lack of a strong association between most species may be explained by the competitive-exclusion principle of Hardin (1960) whereas existence of a weak positive association may be explained by the requirement of similar condi-

tion by the species concerned for their survival.

Analysis of Q/S values in the present investigation on the basis of cryptostigmatid mites revealed that most of the sites are quite similar in species composition. This is quite reasonable as the sites concerned are not situated very far from each other. Only PF showed a negative affinity with BP and with AF which suggests that the agricultural practices tend to decrease Q/S value between the sites. Strong positive similarity between BP and AF may be due to perennial vegetation and undisturbed nature of the soil profile.

Moisture content seems to play more important role in causing changes in the abundance of these mites compared to the organic carbon. Bhattacharya and Raychaudhuri (1977) also emphasised the importance of moisture content of the soil. Notwithstanding this it may be said that the relationship is not so simple, perhaps it is the cumulative effect of various environmental factors which is responsible for changes in the population size from time to time.

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Table 1 : Abundance, population density, and relative abundance in relation to Acari with moisture and organic carbon content of soil in different sites.

Groups		GL	AF	PF	BP
Cryptostigmata	Abundance	9.59	3.33	2.52	12.47
	Density/m ²	3836	1332	1008	4988
	R. A.	55.35	30.19	43.12	38.12
Prostigmata	Abundance	6.13	4.46	2.00	9.58
	Density/m ²	2052	1784	800	3832
	R. A.	35.35	40.40	34.16	29.31
Mesostigmata	Abundance	0.25	0.17	0.01	7.25
	Density/m ²	100	68	4	2900
	R. A.	1.46	1.58	0.17	22.18
Astigmata	Abundance	0.06	0.13	0.07	0.07
	Density/m ²	24	52	28	28
	R. A.	0.34	1.14	1.16	0.21
Unidentified Acari	Abundance	1.30	2.94	1.28	3.22
	Density/m ²	520	1176	512	1288
	R. A.	7.51	26.67	21.89	10.15
Total Acari	Abundance	17.33	11.03	5.85	32.70
	Density/m ²	6932	4412	2340	13080
Total microarthropods	Abundance	26.69	16.50	8.68	57.85
	Density/m ²	10676	6600	3472	23140
Organic Carbon %		0.435-0.272	0.390-0.164	0.308-0.159	0.608-0.456
Moisture content %		11.92-1.37	13.87-0.96	18.13-1.01	21.29-1.16

Table 2: Relative abundance and species richness of cryptostigmatids in different sites.

Sl. No.	Cryptostigmatid species	GL		AF		PF		BP	
		N.	R. A.	N	R. A.	N	R. A.	N.	R. A.
1.	<i>Gehvpochthonius</i> sp.	—	—	—	—	1	0.38	—	—
2.	<i>Eohypochthonius vilhenarum</i> Balogh	—	—	5	1.46	—	—	42	3.27 S
3.	<i>Brachychthonius crecoides</i> Weis-fogh	10	1.01	52	15.16D	—	—	4	0.31
4.	<i>Haplochthonius simplex</i> Willman	1	0.10	—	—	6	2.31S	11	0.86
5.	<i>Cosmochthonius emmae</i> Berlese	9	0.91	16	4.66S	—	—	9	0.70
6.	<i>Sphaerochthonius</i> sp.	—	—	1	0.29	—	—	—	—
7.	<i>Mesoplophora</i> sp.	1	0.10	—	—	—	—	2	0.16
8.	<i>Hoplophorella</i> sp.	—	—	2	0.58	—	—	10	0.78
9.	<i>Epilohmannia pallida pacifica</i> Aoki	—	—	63	18.37D	—	—	8	0.62
10.	<i>Papillacarus simplirostratus</i> Bhattacharya, Bhaduri & Raychaudhuri	1	0.10	—	—	—	—	—	—
11.	<i>Allonothrus russeolus</i> Wallwork	—	—	—	—	—	—	23	1.79
12.	<i>Archegozetes longisetosus</i> Aoki	208	21.05D	—	—	2	3.77	17	1.32
13.	<i>Malaconthrus</i> sp.	1	0.10	—	—	—	—	1	0.08
14.	<i>Cyrthermannia vicinicornata</i>	—	—	—	—	—	—	26	2.02 S
15.	<i>Daemeobelba</i> sp.	2	0.20	—	—	5	1.92	1	0.08
16.	<i>Hungarobelba</i> sp.	—	—	1	0.29	—	—	—	—
17.	<i>Conoppia</i> sp.	—	—	17	4.96S	—	—	4	0.31
18.	<i>Microzetes auxillaris</i> Grandjean	5	0.51	3	0.87	—	—	33	2.57
19.	<i>Eremaeus</i> sp.	—	—	5	1.46	—	—	—	—
20.	<i>Tricheremaeus</i> sp.	—	—	1	0.29	—	—	—	—

Table 2 Contd.

21. <i>Eremulus flagellifer</i> Berlese	—	—	1	0.29	—	—	8	0.62
22. <i>Fosseremus quadripertitus</i> Grandjean	—	—	—	—	—	—	8	0.62
23. <i>Tectocephus sarekensis</i> Tragardh	—	—	2	0.58	—	—	6	0.47
24. <i>Oppia nodosa</i> Hammer	—	—	4	1.17	—	—	113	8.80 D
25. <i>Oppia</i> sp.	24	2.43 S	11	3.21 S	—	—	11	0.86
26. <i>Brachioppia</i> sp.	15	1.52	27	7.87 D	1	0.38	16	1.25
27. <i>Ramusella</i> sp.	—	—	5	1.46	—	—	15	1.17
28. <i>Lanceoppia</i> sp.	1	0.10	22	6.41 D	1	0.38	1	0.08
29. <i>Fortuynia</i> sp.	3	0.30	—	—	—	—	—	—
30. <i>Multioppia</i> sp.	—	—	2	0.58	—	—	1	0.08
31. <i>Suctobelba elegantula</i> Hammer	—	—	1	0.29	—	—	2	0.16
32. <i>Paralamellobates bengalensis</i> Beaduri & Raychaudhuri	58	5.87 D	10	2.92 S	2	0.77	38	2.96 S
33. <i>Galumna</i> sp.	89	9.71 D	9	2.62 S	—	—	8	0.62
34. <i>Eporibatula</i> sp.	49	4.96 S	11	3.31 S	57	21.92D	67	5.22D
35. <i>Scheloribates albialatus</i> Hammer	500	50.61 D	64	18.66D	185	71.15D	702	54.67D
36. <i>Chaunoproctus clavisetosus</i> Bhaduri, Bhattacharya & Chakraborti	6	0.61	5	1.46	—	—	13	1.01
37. <i>Pilobates</i> sp.	6	0.61	3	0.87	—	—	84	6.54D
Total Cryptostigmata	988	343	343		260		1284	
No. of species present	19	26	26		9		30	
Species richness index of Menhinick	0.604	1.403	1.403		0.557		0.337	

D = Dominant (> 5) ; S = Subdominant (5-2).

Table 3: Fisher's coefficient of dispersion (F) and mean crowding

(X)^{*} for species with a relative abundance of $> 2\%$.

[illegible]

Table 4 : Index of Association between dominant species in various sites.

SITE	Name of the species (vide table-2)		Iai
	Species I	Species II	
GL	<i>A. longisetosus</i>	<i>S. albialatu</i>	—0.138
	..	<i>Galumna</i> sp.	—0.218
	..	<i>P. bengalensis</i>	—0.226
	<i>S. albialatus</i>	<i>Galumna</i> sp.	+0.114
	..	<i>P. bengalensis</i>	+0.093
	<i>Galumna</i> sp.	..	—0.320
	<i>B. crecoides</i>	<i>E. pallida pacifica</i>	—0.270
	..	<i>Brachioppia</i> sp.	—0.165
	..	<i>Lanceoppia</i> sp.	—0.595
	..	<i>S. albialatus</i>	—0.172
AF	<i>E. pallida pacifica</i>	<i>Brachioppia</i> sp.	—0.288
	..	<i>Lanceoppia</i> sp.	+0.824
	..	<i>S. albialatus</i>	—0.134
	<i>Brachioppia</i> sp.	<i>Lanceoppia</i> sp.	—0.347
	..	<i>S. albialatus</i>	—0.495
	<i>Lanceoppia</i> sp.	..	—0.721
PF	<i>S. alhialatus</i>	<i>Eporibatula</i> sp.	+0.504
	<i>O. nodosa</i>	<i>Eporibatula</i> sp.	—0.211
	..	<i>S. albialatus</i>	+0.102
BP	..	<i>Pilobates</i> sp.	—0.371
	<i>Eporibatula</i> sp.	<i>S. alhialatus</i>	—0.230
	..	<i>Pilobates</i> sp.	+0.100
	<i>S. albialatus</i>	..	—0.033

Table 5 : Correlation coefficient between monthly variation in the population size of species with > 2% relative abundance and moisture content and with organic carbon of the soil.

Sl. No. os species — (vide table-2)	Moisture content %				Organic carbon %			
	GL	AF	PF	BP	GL	AF	PF	BP
2	—	—	—	0.301	—	—	—	0.418
3	—	0.520	—	—	—	0.604*	—	—
4	—	—	0.586*	—	—	—	0.476	—
5	—	0.753**	—	—	—	0.587*	—	—
9	—	0.723*	—	—	—	0.436	—	—
12	0.677*	—	—	—	0.530	—	—	—
13	—	—	—	0.492	—	—	—	0.366
17	—	0.730**	—	—	—	0.455	—	—
18	—	—	—	2.345	—	—	—	0.511
24	—	—	—	0.515	—	—	—	0.480
25	0.713**	0.604*	—	—	0.426	0.382	—	—
26	—	0.314	—	—	—	0.210	—	—
28	—	0.790**	—	—	—	0.325	—	—
32	0.749**	0.690*	—	0.621*	0.539	0.554	—	0.571
33	0.793**	0.587*	—	—	0.437	0.589*	—	—
34	0.675*	4.783**	0.662*	0.865***	0.392	0.434	0.711*	0.396
35	0.687*	0.507	0.912''	0.582''	0.596	0.468	0.546	0.574
37	—	—	—	0.543	—	—	—	0.536

* Significant at $P < 0.05$

** Significant at $P < 0.01$

*** Significant at $P < 0.001$

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CROCODILE POPULATION ECOLOGY AND MANAGEMENT

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I. INTRODUCTION

The work described below on the three Indian species of crocodilians was carried out since I came to India in 1974, and mostly since I was charged, early in 1975, with the task of developing a project, under the UNDP/FAO programme of India, to save the gharial (*Gavialis gangeticus*) from extinction, and to rehabilitate it in the wild in a network of specially created and managed sanctuaries/National Parks. For the purposes of this paper-which is to shed light on the population ecology and resultant management possibilities of an archaic reptilian group even to day little known to science-except where reference is made to a particular crocodilian species, the information may be composite, always, however, with Indian crocodilians in mind unless otherwise stated.

This project resulted from Indian and international concern over the plight of the gharial which seemed to be rapidly disappearing but without any precise data. Its rapid disappearance was confirmed by the first mission (FAO, 1974). This situation was further complicated by the fact that the gharial had remained one of the least known crocodilian species despite its uniqueness and little of substance had been written about it since the time of Smith (1931).

Because of the very rarity of the gharial, and restricted number of other Indian crocodilians, ecological work was extremely difficult and it was not possible to find an undisturbed natural population of any species to utilise for a long-term population ecology study. Such populations had first to be created and feasible ecological studies carried out in the meantime. This means that scientific data on such facets of the population as natural recruitment (to a stable unhunted population) and age/size class composition (again of a natural population) could not be directly observed.

Crocodiles are an integral part of the tropical wetland ecosystem.

Until comparatively recently (at least the 1950's) they were numerous in all suitable habitat in Africa, the Americas, Asia and Australasia and an important part of the ecosystem with a sizeable share in biomass terms. Unfortunately, commercial hunting for their skins by shooting or spearing light-blinded animals at night, and later netting or baiting with shark hooks, resulted in their virtual extirpation before they were the subject of scientific ecological study.

Twentyone-Twentytwo living species are recognised worldwide in the Order Crocodylia. The Order is divided into two families the Gavialidae and the Crocodylidae, the latter subdivided again into the Crocodylinae (true crocodiles), Alligatorinae (alligators and caiman) and (by some authors) Tomistominae (the false gharials included in the Crocodylinae by some authors). The gharial (*Gavialis gangeticus*) is the only surviving member of its family making it an animal of immense scientific interest. In addition to the gharial, India has two species of true crocodiles, one a freshwater, swamp, tank, or river-dwelling species, the Indian mugger (*Crocodylus palustris*) restricted to the Indian region, the other an enormous estuarine species inhabiting the mangrove ecosystem and formerly distributed from Cochin in the West to South China in the East and down through Indonesia, the Philippines, to Papua New Guinea and northern Australia. This is the so-called saltwater or estuarine crocodile (*Crocodylus porosus*).

II. LIFE HISTORY

Crocodiles are archaic reptiles and like all archaic reptiles all species lay numerous eggs and the hatchlings are very minute compared to the parents.

Crocodiles belong to either of two nesting types—those which dig a nest in an exposed sandbank and lay their eggs in the bottom of the pit—and those which build a mound nest rather similar to Megapodes and lay their eggs within this mound. Clearly the former have to nest in the lean season when the water level is low and the sandbanks are exposed. Similarly the eggs have to complete their incubation prior to the monsoon or the nests will be flooded and the eggs drowned (incubating eggs cannot withstand even several days submersion). Crocodiles which build mound nests on higher ground face no such restrictions as to their nesting season and the saltwater crocodile actually nests during the monsoon.

Sandbank laid nests rely on the heat of the sun beating down on the huge mass of sand to maintain incubation temperatures. At a depth of even 30 cm (the approximate level of the top of the nest) the day-night temperature variation has virtually disappeared. The huge mass of sand is extremely temperature stable except for the immediate surface layers (Bustard, 1972) and temperature of between 30-34°C. (the preferred incubation range) are readily maintained.

Mound nest builders rely on the decomposition of moist rotting vegetation to generate heat and also on the high ambient temperature of the habitat to maintain incubation temperatures.

India has species adopting both types of nesting strategies. The gharial and the mugger are sandbank hole nesters and the saltwater crocodile is a mound nest builder. The 'closed' mangrove environment of the latter provides a 'greenhouse effect' idea for incubation. When nests are removed from the immediate mangrove forests, yet kept within the same general habitat, it becomes difficult to maintain viable incubation temperatures. Mangrove forest prevents virtually all wind effects and the high humidity therein virtually eliminates evaporative cooling effects.

As with that other archaic reptile group the Chelonians, the habit of laying nests in sandbanks makes them extremely vulnerable to predation. A clear track from the water to the nest and back again remains for some days under normal conditions, indicating the location of the eggs, a problem countered to some extent by digging up a large area in the vicinity of the nest in sea turtles (Bustard, 1972) and by nest guarding in crocodilians.

Parental care in crocodilians (Cott, 1971 ; Singh and Bustard 1977) has only been recognised scientifically within the last decade but was, of course, well known to people living within the crocodiles' habitat. Parental care extends far beyond nest guarding to excavation of the nest at time of hatching, guiding the young to the water and remaining to protect them for periods of weeks/months. I have myself observed a female gharial in Rajasthan with her brood of thirtythree hatchlings on several occasions. The young when first observed were lined up on the bank facing the edge of the nulla and the mother was guarding them from the water her head and snout protruding. Two baby gharial were basking on her head. Following human disturbance all

hatchlings, jumped into the water and reassembled, like a school of fish, in midstream, where the mother also surfaced beside her brood. Such care must tend to reduce neonatal mortality but perhaps only insignificantly. Unfortunately no quantitative studies have as yet been published. The important point here is to stress the difficulties of maintaining constant guard on either a clutch of eggs throughout the two to two and a half month incubation period or on the members of a brood of siblings, the latter extremely small and vulnerable, numerically large and inhabiting muddy water where a predator such as a large fish, snake or monitor lizard can approach unseen. Hatching size of archaic reptiles is extremely small in relation to the adult. The ratio may be as divergent as 1 : 6000 in crocodiles (*c. f.* approximately 1 : 16 in humans).

Furthermore any field scientist knows that actual predation is extremely difficult to observe due to the very short time interval occupied. Further information of these topics, treated only generally here, is given in the section dealing with Population Ecology.

Crocodiles mate in the water, often floating at the water's surface. Fertilisation, as in all other reptiles is internal. Males are generally associated with several females, the figure of 1 : 2.5 ($\sigma \sigma$: ? ?) having been observed both in the wild (Cott, 1961) and in a commercial stocking situation in a crocodile farm (Yangprapakorn, 1971) and for different species.

Despite belief to the contrary crocodiles can grow rapidly if maintained under suitable conditions or left in the wild. Because all growth data was captive and was based on zoo-reared individuals often poorly housed, there has been a widespread belief that crocodiles grow slowly. The figure of 'a foot a year' has often been quoted. There is no substance for this belief. Immature crocodiles can and do grow rapidly. However, larger (older) individuals show slow growth rate which presumably continues, albeit extremely slowly, throughout life. Extrapolation of this data for one individual of the African nilotic crocodile (*C. niloticus*) (Cott, 1961) led him to state that at sixteen feet length crocodiles of this species must have crossed the century mark in longevity. No one who has an intimate knowledge of crocodiles in the wild will be surprised at this. Extremely large individuals still occur in certain localities despite hunting pressure and from known growth rates for adults, scanty as these are, must be extremely old (see

also Part II, B.). For some species at least it may be quite reasonable to postulate a potential breeding life of at least one hundred years. In this regard crocodilians seem to parallel the gigantic land tortoises which are known to attain great ages (several hundred years for certain famous individuals for which data has been maintained). On the contrary sea turtles do not appear to attain such ages (Bustard, 1972).

Crocodilians are predominantly fish eaters but such a statement hides much interesting information (see Part II. C).

As crocodiles grow other vertebrates also become important in the diet. Although fish are taken throughout life the proportion (by weight) in the diet may drop dramatically as other reptiles, birds and mammals are increasingly and progressively preyed upon with increase in crocodile size (these remarks do not apply to the gharial).

Snout shape in the Crocodylia has followed two main evolutionary lines—short broad snouts, well adapted for pulling down large vertebrates, and long narrow snouts (of which the gharial is the ultimate example) ideally suited for catching fish by a sudden sideways sweep of the jaws as the thin elongated jaws offer little resistance to the water. The short broad snouts are seen in the Alligatorinae (alligators and caiman) and in some of the crocodiles such as the Indian mugger which has the shortest and broadest snout of any true crocodile. The elongated snouts, more specialised for fish eating occur in the West African slender snouted (*C. cataphractus*), Johnson's (*C. johnsoni*) from Australia, the so called false gharial (*Tomistoma schlegelii*) from Malaysia/Indonesia and developed to its ultimate in the Indian gharial.

B. GROWTH

Growth at the Indian project sites has been rapid, even better than anticipated. Gharial, which are about 37 cm in total length at hatching, reach release size of 1.20 metres, weight 5-6 kg after about eighteen months. Growth in mugger has been even more spectacular. Best growth rates were obtained from a strain from Tamil Nadu. At hatching these mugger measured 30 cm, weight about 80 g; at one year 71 cm, weight 1.59 kg and at two years 1.5 m, weight 18.4 kg. At three years old when they could no longer be weighed length was almost 2 metres. Such individuals had already exceeded size at first breeding quite substantially and (the group was unfortunately all male)

had at the age of two years 7 months lured a wild female out of the adjacent river to approach their pool complex.

Growth of saltwater crocodiles shows an increase from about 32 cm and 112 g at birth to 84 cm and 2.1 kg at one year old and 1.26 metres and 7.5 kg at two years old.

C. FOOD

When very young insects appear to form an important part of the diet of at least some species such as *C. niloticus* (Cott, 1961) and *C. palustris* in India (unpub. project data). (In specialised fish-eating species like the gharial these are unlikely to be taken to any significant extent). Selection of the fish taken may also reduce harmful effects to a human-oriented fishery since crocodile prey predominantly on bottom-dwelling species of low human palatability themselves important predators on valuable commercial species. Further more, the juveniles eat carnivorous water bugs which prey extensively on fish fry fingerlings. The combined effects of these dietary habits may have an overall beneficial effect on a fishery (Cott, 1961).

Although crocodiles of large size (such as adult saltwater crocodiles, (*C. porosus*) are capable of pulling down extremely large mammals, such as adult sambhar in India, and occasional domestic stock, and I have records of large males tackling fully grown cross-poll Hereford bullocks in Northern Australia, they rarely attack man. Gharial are considered harmless to man because of their specialised jaw structure and mugger attacks are exceptional, large mugger often inhabiting a bathing ghat where scores of people take their bath daily for many years with no reported incidence of attack.

III. POPULATION ECOLOGY

Although parts of the life table are still incompletely known for any species of crocodilian, considerable information has been collected in the last decade or so on a number of species. Survival in the wild, natural growth rate and age at first breeding in the wild and natural longevity are not known with any certainty. However, the production end is well known.

The known parameters are briefly discussed so that a tentative life table can be elaborated and the management implications of this discussed.

A. PRODUCTION : In the gharial at present the clutch is approximately forty eggs (observed range in 55 nests 16-98 eggs), this figure is reduced by about five eggs for the mugger and increased by about five eggs for the saltwater crocodile. I have written "at present" since clutch size in crocodilians, as in most reptiles which have been studied in detail, increases with increase in female size. Since growth continues throughout life these larger females are usually older. Hunting pressure greatly depresses average size/age, as the animals do not survive long enough to grow large. There has been intensive hunting pressure throughout India with the result that clutch size has also been depressed.

All crocodilian species which have been studied lay only a single clutch each year and the female nests annually. The mean clutch size is, therefore, the annual level of egg production.

Age at first nesting for the gharial is unknown. However, much data has been collected for the saltwater crocodile at the Samutprakan crocodile farm within the natural range of the species in Thailand. There breeding commences at an age of between 8 and 12 (exceptionally 14) years. For illustrative purposes we will assume gharial commence breeding at age 10 (it is unlikely to be later than this and may even be one or two years earlier). In contrast, the smaller freshwater species start breeding much sooner at about 5 to 6 years old or perhaps even earlier (e.g. Indian mugger).

Similarly, longevity of crocodilians in the wild is not known and the poor conditions given to them, particularly when they become large, in most western zoos makes zoo data highly questionable. Indications from maximum size attained and tentative growth rates (see Cott, 1961) would tend to indicate extremely long lifespan certainly for members of the population I am thinking in terms of several hundreds of years and an average breeding lifespan of perhaps between fifty and one hundred years for the larger species.

This long lifespan combined with the fact that since adults grow throughout life, the territory holding male may be two to three times the length of young sexually mature challengers and about ten times their weight, will result in an extremely conservative society dominated by old bulls and their equally old cows. Large crocodiles, like large forest trees, are virtually indestructible and have no enemies other than man.

B. LOSSES : Despite maternal care (nest guarding) nest losses to a range of mammalian and reptilian predators is substantial. Unfortunately, because of our management techniques (see Part III) no qualitative data exists for the gharial or other Indian crocodilians and it is not valid to infer this from other species. However, it may be noted that in the saltwater crocodile in Australia (same-*C. porosus*-as in India) the present author observed nest losses averaging approximately fifty per cent in an average year. These nest losses resulted from flooding in wet years as well as from predation.

This latter situation is relevant to the gharial which certainly loses a proportion of nests from flooding. Ideal steeply-inclined high sand-banks are frequently scarce or unavailable with the result that nesting takes place in low banks susceptible to inundation with fluctuations in water level during the incubation period such as result from melting snow in the catchment area. While this does not affect all gharial populations (e.g. Orissa), many of the populations of this species, which predominantly inhabits rivers rising in these Himalayas, are susceptible.

Everyone who has studied crocodilians is agreed that neonatal losses are extremely large. However, quantitative data is again lacking. Collection of such data has been prevented in India by our management techniques in which all nests are removed as laid for secure hatchery incubation. However data collection in future will still be difficult since hatching of both gharial and mugger siblings coincides with onset of the monsoon. With the first floods all traces of juveniles are frequently "lost" It has been suggested that this is a means of dispersal of young throughout the habitat. Clearly this is an area where future work is required.

Many survival figures have been bandied about such as one per cent or one hatchling per nest. However, brief consideration of the problem indicates that were such a level of recruitment to occur on a sustained basis all the rivers would be jammed with crocodiles (in the absence of hunting by man).

It may well be that predation losses take the survival figure by the end of the monsoon down to the order of five per cent survival or less. However, as the crocodiles grow and approach sexual maturity they must find a home range and within this a territory or 'station' for

themselves. If they are unable to do this they will be lost from the population either as a result of direct fighting with territory holders or due to enhanced incidence of disease at least partly the result of psychological factors.

Long-term studies on ecology and population ecology of Australian lizards (see for instance Bustard 1968a ; 1968b, 1969) indicated that the populations were regulated through intraspecific competition and maintained at levels well below those at which food supply would become a limiting factor. These data were in agreement with the theory proposed by Wynne-Edwards (19.2). The above studies together with concurrent work on sea turtle population ecology (Bustard, 1972) indicated that reptiles always breed maximally and that regulation (from a population stabilising viewpoint) always takes place subsequently. It is important to realise that predation by itself will be a most unsatisfactory means of stabilising population size in most situations and that some method of 'finer tuning' will be required if populations are not to fluctuate widely.

It is instructive to look at the available data/indications for crocodiles in order to obtain insight into the required level of recruitment in order to maintain a stable population. The following example for the gharial is intentionally kept simple for illustrative purposes. Assumptions : first breeding at age 10 ; 3 females associated with each male ; average clutch size throughout the breeding life 40 eggs, adult breeding lifespan (two models) (a) 50 years (b) 100 years. In example (a) the total egg production by the breeding group will be 6000 of which four individuals are required to recruit eventually to replace the parents, this is a required survival rate of only $1/1500$ or 0.00067 . In example (b) it is $1/3000=0.000335$. A model for the mugger associating 2 females with each male would be as follows : first breeding age 5, average clutch size 30 eggs, adult breeding lifespan 30 years (intentionally very conservative), required survival $1/600=0.00167$. It is clear that the required levels of recruitment to maintain a stable (unshot) crocodile population are extremely meagre. It is for this reason that any sustained level of hunting rapidly wipes out the population (see Part III).

III. EXPLOITATION & MANAGEMENT

The high fecundity of crocodilians together with the enormous natural wastage singles them out as a prime species for management.

Clearly traditional methods of exploiting this resource—as by shooting adults by spotlight at night—are extremely wasteful. Culling off the top of the pyramid in a species with a life table of this form can never provide a substantial sustained yield. It is the very failure of crocodile populations everywhere to provide this sustained yield that has led to their virtual extinction.

The simplest way of harvesting crocodiles in nature is nature is to provide total protection to the entire breeding population and to harvest individuals of below first breeding size. In species such as *C. porosus*, where breeding does not commence until a size of at least 2.5 metres (8 feet), excellent commercial skins can be obtained from pre-breeding stock. This was the policy that I recommended to Papua New Guinea as their adviser in 1966 (Bustard, 1967). In practice this maximum size needs to be complemented by a minimum size limit, on purely commercial grounds, so that juveniles are not slaughtered before they have attained a good commercial skin size. Since crocodiles are shot at close range, so that they can be gaffed before they sink, judging the size is not at all difficult. Indeed one quickly learns to do this at distance of a furlong or more. For legislative purposes the size limits can be expressed as belly skin widths. However, this also does not cause a problem as a well-known relationship exists between total length and belly skin width. Although it was fairly easy to pass the maximum size limit into law, the lower limit was not accepted, as traders feared they would lose much/most of their income.

The above method of exploitation will not give a large harvest but it has the advantage that it will be sustainable since all the breeding stock is protected at all times and, if the size limits are set sufficiently close together, as sound commercial practice would dictate to protect subcommercial stocks, then sufficient will escape the relatively short period when they can be legally hunted and so recruit to the breeding population. Since, as shown above, the requirement is so very low populations subjected to such a regimen might even build up and reattain optimal levels. The problem comes not at the scientific end but at the political and—the need to pass the necessary legislation into law and then to effectively enforce it. Failure at this level has been a major reason for the destruction of wild life in many parts of the world, resulting in it often becoming so rare that it is no longer a commercial resource—a resource for sustained yield harvesting.

A substantial improvement on the crocodile harvesting situation set out above would result from protection of all nests (by collection of eggs and incubation in safe hatcheries) and captive rearing of hatchlings for 6-12 months to take them past the main predation phase. Using simple facilities and "building in" considerable mortality effects it should be possible to release just over one half the number of eggs collected as yearling crocodiles. If one assumes that at this age in nature 5% remain (an optimistic estimate) then one has increased the survival tenfold (to 50%) and since such crocodiles have a very high survival potential in the wild, this method will raise the future annual commercial crop at least eight times.

From this it is a small further step to crocodile farming either for conservation purposes (as in India at the present time) or for commercial reasons. The success of this approach can be seen in the gharial and related crocodile projects of Government of India/FAO/UNDP together with selected State Governments. Since 1975 about two thousand gharial have been produced under this scheme increasing the world population of this species some fifteen times (details of the project will be found in FAO, 1975 and Bustard, 1976 a & b). Using these proven techniques of egg collection, hatchery incubation, rearing of first and second year juveniles in captivity, it is possible to increase survival by around one thousand times over that occurring in nature. This technique is invaluable for conservation purposes (as has been done so very successfully for the gharial, and is being done for the two crocodile species) but it also the way that crocodiles should be commercialised for their skins. Furthermore, skins obtained from such a farm cannot possibly bring down the wrath of true conservationists as they are being produced independently of the wild population.

In Government farms I have recommended that the breeding stock be left in the wild and all eggs harvested for the farm against a return of the very small required number of three year olds to maintain the populations. This approach obviates the need for the expensive large holding compounds for breeding stock and also their feeding costs. However, a completely closed farm (in the I.U.C.N. sense that all product is produced from eggs laid by a captive breeding herd) is also possible and an excellent one has operated at Samutprakan near Bangkok for many years.

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**SOME OBSERVATIONS ON THE GROUP SIZE OF
THE SAMBAR *CERVUS UNICOLOR* KERR, WITH
REFERENCE TO THEIR BIOMASS AT
HAZARIBAGH NATIONAL
PARK, BIHAR**

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INTRODUCTION

The Sambar (*Cervus unicolor* Kerr) has been one of the most coveted game in India. Knowledge gathered during encounters with the Sambar, though of little scientific value, have been published from time to time by several authors. Some useful general accounts given by Jerdon (1874), Forsyth (1889), Blanford (1888-91), Baker (1890), Lydekker (1898), Fletcher (1911), Brander (1923), Pocock (1933), Prater (1934), etc., concerning the distribution, herd size, and feeding and drinking behaviours of Sambar are available. Recently, Schaller (1967) based on his field studies in the Kanha National Park (Madhya Pradesh) made substantial contribution to the study of the ecology of the Sambar. Simultaneously, Spillett (1967) and De and Spillett (1967) have briefly commented on its population structure and fawning period from different parts of India. The account of the Sambar by Eisenberg *et al.*, (1972) based on their study at Wilpattu National Park (Sri Lanka) is of considerable interest. Krishnan (1972 and 1973) has dealt briefly with the ecology of the Sambar with reference to the feeding and breeding behaviours in different parts of the country.

It is apparent that systematic studies on the Sambar in India are few and far between. Therefore, our knowledge is inadequate concerning the population dynamics of this species. The conservational measures are dependent on such studies which can throw light on the sex ratio, age at maturity, breeding condition, peak period of dropping of the young ones, size of the litter, natality and mortality in different parts of the country, since different parts of India has different ecological conditions.

The author has made some observations during 1972-1975, on the Sambar of Hazaribagh National Park, with a view to developing a

comprehensive ecological knowledge of this species in Chota Nagpur plateau.

Environment : The Park is situated on the north of Hazaribagh town between 11 and 18 km away on the Patna-Ranchi National Highway. Ara (1960) has given details of the layout, topography, geology, etc., of this area. However, it may be stated that in August, 1954, the State Government created this sanctuary over an area c 112 square kilometers in extent with the object of eventually converting it into a National Park. In strict legal parlance, however this area is still a sanctuary as it has not been constituted into a National Park either by the State or the Central Government Act. The Park is about 25 years old now and in all official and non-official descriptions it is called a 'National Park'. The reasons for the delay in the enactment with regard to this Park has been discussed by Shahi (1977). The Park occupies the north-eastern portion of Chota Nagpur plateau. This plateau is highly undulating and its height towards the south-west exceeds 600 m. But the north-eastern portion which embraces the Park constitutes the lower region having a maximum elevation of 300 m. The surface is never level, but the undulations are usually gentle. This plateau is chiefly formed of granite and gneiss, and partly of softer rocks like schist.

A few villages are still in existence inside the Park and domestic livestock graze in small herds all the year round. Besides, there are also tiny patches of cultivation within the Park.

Climate : There is no reliable climatological data available for the Park. However, the climate of the Park is much the same as that of Hazaribagh town. The day temperature of Hazaribagh does not rise beyond 107°F and never falls below 40°F. The average day temperature for the whole year is about 75°F and the relative humidity is approximately 51 per cent. The annual precipitation varies from 900 mm to 1400 mm. The monsoon breaks in June and succeeding two months are quite temperate. From the middle of September the mornings indicate the onset of winter. But November to the middle of February is quite cold, and occasional excessive cold as a result of occasional showers. In February, 1972, the Park received a good rain fall which kept the area cool till the middle of March. During April to June, the day temperature is comparatively high, but the nights are never oppressive.

Flora : Both Ara (1960) and Krishnan (1972) have deals with the flora of the Park. But here it will be enough to mention only those species of plants that have considerable importance for the Sambar.

The Park is mainly a Sal forest, but the plant associates of the Sal (*Shorea robusta*) vary greatly in different parts of the Park. The vegetation is a combination of distinct types ranging from tropophilous to moist deciduous type.

The western part of the Park around the Bahimar area where exploitation of the forest has occurred, shrubs of *Lantana camara* have taken over. These shrubs are of little use to birds and mammals as a source of food, but these bushes prevent soil erosion and provide a site for nesting of some birds and cover to wild pigs, wild dogs and even to larger cats. At places *Dendrocalamus strictus* (Bamboo) has replaced *Boswellia serrata* (Salai) and occurs in widely scattered small patches.

On the southern portion, dry deciduous trees and shrubs are commonly met with. They consist, besides Sal, of *B. serrata* (in pure patches), *Anogeissus latifolia* (Dhan), *Nyctanthes arborescens* (Harsinghar), *Gardenia latifolia* (Ghogar), *Lannea coromandelica* (Jingan), *Adina cordifolia* (Haldu), *Garuga pinnata* (Garuga), *Butea monosperma* (Tesu), *Ougeinia dalbergioides* (Sandan), etc. Further, away from the Sal, *Acacia catechu* (Khir), *Zizyphus xylopyrus* (Khatti Ber,) *Emblica officinalis* (Amala) and *Bauhinia vahlii* (Jallur, as a common climber). *Ficus glomerata* (Gular, very scarce), *Aegle marmelos* (Bel), and *Feronia limonia* (Kath Bel) are few and scattered elsewhere.

On the northern slopes, the damp flora is represented by a number of Cucurbitaceae, Apocynaceae, Asclepiads, Acanthaceae, Labiatae, Liliaceae, Cammelinaceae, etc., are short-lived vegetation which grow as understory of the forest. and during monsoon Rubiaceae, Compositae and Leguminosae are abundant. The Sal is the predominant species and almost all the trees are in patches rather than in continuous belt. They are in regeneration phase and in the majority of the plants the girth does not exceed over a meter. In some patches where the Sal is in the process of forming canopied forest, discourages the growth of other trees or shrubs as its understory. However, other trees, shrubs and climbers which are of considerable importance for

the Sambar are :— *Diospyros melanoxylon* (Kendu), *Eugenia* sp. (Kat Jamun), *Pterocarpus marsupium* (Bijasal), *Bridelia retusa* (Gondui), *Bombax ceiba* (Simul), *Lagerstroemia parviflora* (Bakli), *Mallotus philippensis* (Roini, scarce in distribution), *Madhuca latifolia* (Mahuwa), *Terminalia tomentosa* (Asaina), *T. bellerica* (Bahera), *T. chebula* (Choti Harra), *Schleichera trijuga* (Kusumi), *Bauhinia variegata* (Kachnar), *B. retusa* (Kanloo), *Gmelina arborea* (Gamhar), *Indigofera pulchella* (Sakena), *Wendlandia exserta* (Chilkiya), *Croton oblongifolious* (Ganasur), *Stereopermum suareoleus* (Paral), *Flemingea chappar* (Salpan, at places abundant), *Vitex negundo* (Nirgundi) etc.

In the low-lying open areas, along the banks of the nullahs which have not been encroached upon by the Sal, are occupied by grasses, such as *Andropogon muricatus* (Khus), *Cynodon dactylon* (Dub), *Cyperus rotundus* (Motha) and *Heteropogon contortus* (Shurval). Such areas are visited by the Sambar during July-October.

On the eastern side, the forest across the National Highway is being developed and the movement of wildlife is not much.

Fauna (Mammalian): The mammalian fauna of the Park as observed during the course of studies, consists of Rodentia, Lagomorpha, Carnivora and Artiodactyla (Table I). Though not observed but stated also to be found within the park are - Smooth Indian otter (*Lutra perspicillata* Geoffroy), Ratel [*Mellivora capensis* (Schreber)] and Indian wolf (*Canis lupus* Linnaeus), in *per. com.* Shri S. N. Sinha, Assts. Wildlife Warden of this Park, had stated that he had seen wolf several times in the north of Pokheria sector near Pipra chalka village, (ii) South-west of Dumri village on New loop road, and (iii) in Bahimer sector on Katkamsari Road. Shahi (1977) does not mention its occurrence in this Park. Ara (1960) has reported gaur (*Bos gaurus* H. Smith) from this Park, but it is all together absent at present.

During the course of study it was not possible, for the author to conduct the census of mammalian fauna due to obvious reasons.

The census conducted by the Forest Department for its major fauna in May 1970 by "Sample area counts" method in a portion of Rajdarwa sector was the basis for them to estimate the probable population of each species in all over the Park. Besides the above wildlife, about 250 domestic cattles are also grazing all the year round,

inside the Park. The calculations in term of density and biomass per square kilometers of the *Artiodactyla* are presented here (Table IV) from the above figures.

METHOD

However, studies on group size and breeding biology were confined in this Park within an area of about 15 sq. km., around the canteen lake. The study area was subdivided into four compartments (i) Dam No. 1 & 2, (ii) Bagjobra, (iii) Pipra chalka and (iv) Kaile, each being approximately 3.5 sq. km. in extent. Each compartment has a water hole to support the wildlife of its area. The animals of Dam area are partly dependent on canteen lake besides Dam No. 1 & 2. The Bagjobra and Pipra chalka nullahs are exclusively used by the animals of their respective areas. The Kaile population, besides nullah No. 5 near Tower no 5 of its own area is also dependent on Bhatra munda. The Bhatra munda is further shared by the animals of Danai area.

The other important water sources are nullah No. 3 (near Tower No. 3) which is frequented by the animals of Pokharia area. Amba Jharna (near Tower No. 7) is used by the Dumri and Raibar populations. Nullah No. 8 (near Tower No. 8) is used by the animals of Rahea area.

The method followed for the study consisted of grouping the Sambars observed into three categories: (i) Fawn (infants upto one month in age), (ii) Young (above one month in age to below two years of age including yearling males) and adult animals, based on developmental stages and reproductive status.

The Sambar has a wide tolerance for different habitat types being found in the thorn forests of Gujarat, Rajasthan and other states, in the dry and moist deciduous forest throughout peninsular India, in the pine and oak forests of Himalayan foot-hills and in the semi-evergreen and evergreen forest regions of eastern India as summarized by Schaller (1967) from the available records of Jerdon (1874), Baldwin (1877), Lydekker (1898), etc.

The Sambar is the dominant species in numerical abundance at the Hazaribagh Park. They are magnificent in body development and are impressive in size (Figs. 1 & 2). Antlers development is

considerable, reaching a length of 100 c.m. in curvature (Text-fig. 3), stout and rugose. Stags are nearly 150 c.m. at the shoulder hinds are about 30 c.m. shorter (Eisenberg & Lockhart 1972), newly born fawns in captivity are about 48 to 58 c.m. in height according to Acharjyo (1970).

OBSERVATION

Group tendencies: According to Jerdon (1874) average group size in Sambar is 4 to 5. Lydekker (1898) states 4 to 5 to about a dozen and similar is the view of Prater (1965). Schaller (1967) held the opinion that the typical herd is small, numbering fewer than 6 individuals. Eisenberg & Lockhart (1972) observed group size ranging from 2 to 8. They further mentioned that the hinds typically forage accompanied by a juvenile and or a fawn of the year. Krishnan (1973) reported that the Sambar is often seen alone, especially the stags or in family groups of fawn and its mother.

However, during the studies on the social organization among the Sambar at the Hazaribagh Park, a total of 306 individuals were observed, out of which 51 were adult males, 181 adult females and 74 immatures (*i.e.* 35 young and 39 fawns; *vide* Table VI, Fig. 4). Normal group size appears to be one to three and rarely four. The adults, either male or female are solitary and move independently from one another except during rutting season. A female and her immediate offspring constitute the most cohesive social unit. Such a family group generally persists for about a period of two years in the case of female offspring and a little less in the case of male's. In rutting season either adult female or a female with her immediate offspring (having an approximate height of 90 c.m. and about a year in age) will join an adult male. Very rarely a female with two offsprings of two different ages (*i.e.* one of the young about 100 c.m. and the other above 75 c.m. in height having an age, above one year and the other above 3 months) may also associate with an adult male. The latter group were observed only twice one in Baghjobra and the other in Kaile areas during November, 1974. Usually a female with a fawn of around 70 c.m. in height (estimated age nearly two to three months) will not associate with an adult male. Group size ranging from five to nine were usually observed in their escape flight from the feeding ground due to disturbances caused by our approach. Similar grouping tendencies were observed, besides Hazaribagh at Mudumalai Wildlife

Sanctuary (Tamil Nadu) as well, during April 1976, when a total of nine (A ♀ 5, I_s, F₁), eight (A ♀ 5, I₁, F₂) and six (A ♀ 3, I₁, F₂) were sighted in their escape flight. Solitary adult males in hard antlers were found, both at Bandipur Tiger Project area (Karnataka) and Mudumalai (Tamil Nadu) during March-April, 1976 respectively. Further females and immatures numbering eighteen were observed twice inside the canteen lake of the Hazaribagh Park at about 22.30 hours in November, 1974, being the unusual colder nights.

However, this suggests that any grouping beyond four is the result of mixing up of more than one group. This usually occurs either in the feeding ground or on the water holes. (Table VI, Fig. 4.)

Breeding biology: The rut season has generally been correlated with the antlers condition. Schaller (1967) has reviewed the published comments of Forsyth (1889), Blanford (1888-91), Lydekker (1898), Russell (1900), Comber (1904) and Stockley (1913), Brander (1923) and Prater (1934) which are unanimous in stating that the time of rut in peninsular India runs from October to December. Whereas the Sambar in the Himalayas mate in the spring (*i.e.* February to April *vide* Comber 1904 and Blanford 1888-91). But Schaller (1967) observed that the rut in the Sambar at Kanha does not appear to be discrete, but it is spread over a period of seven months. Spillet (1967) on the basis of information received from the staff of Kaziranga wildlife sanctuary states that the rut occurs in November and December. Krishnan (1973) held the view that there is no definite season for the shedding of antlers in the South India. But my observation suggests that the casting off and regeneration of antlers may take place at any time of the year. The percentage of hard antlers gradually increases from September to January and 100 per cent hard antlers are found in February and March, which indicates that the rut is not confined to any particular period of the year (Table III, Fig. 8).

The Sambar stags grow their first set of antlers when they are around a year in age. The first year antlers are short almost straight like spikes and this form is retained upto the age of 2 years. These antlers after their first shedding acquire three times in succeeding years, and continue to grow larger with a regular annual increase in size. The growth of antlers is dependent on the food conditions of the habitat and the age of the stag. Baker (1890) is of the opinion

that Sambar does not attain its full development of antlers until it is ten years old. In an individual, the antlers of both sides are shed at the interval of several hours or days from one another. The shedding may take place at any time of the year. It was further observed, contrary to Prater (1965), that younger stags retain their hard antlers for a longer period than the older ones. A new set begins to regenerate within two weeks of the shedding (Figs. 5 & 6). The growth of antlers are completed within a period of four and five months, thereafter the colour of the velvet changes and dries up, followed by longitudinal cracks in the velvet. The stag at this stage develops a rubbing tendency against trees for peeling off the velvet. The tree generally used by the Sambar for the purpose at Hazaribagh Park is *B. serrata*. The dried velvet falls in pieces and very rarely some portion of velvet may also be seen hanging from the antlers. The process of peeling off the antlers generally takes about three to four weeks. The younger stag takes approximately half of the total duration to that of the older stag in developing the hard antlers. The stag free from velvet in its hard antlers is again ready for rut Text fig. 1. It also develops other secondary sexual characters like swelling of the neck and enlargement of preorbital glands, which are external manifestations during breeding phase, besides the rut call. There is no apparent external manifestation in the hinds. A stag during its breeding phase maintains a small breeding territory of approximately 1.5 square kilometer. The presence of rubbing trees, at regular intervals on the periphery of such area the secretion of preorbital glands are rubbed on the foliage or trunks of the tree and the rut calls a loud metallic sounding bellow of the stag (territorial advertisement) is the indication of the breeding territory. The agonistic behaviour of stag towards other eligible male is also another indication of the breeding territory.

Since the gestation period is about eight months (*vide* Asdell, 1946), the fawning period appears to be synchronising well with the above rut in this park. The fawning period was observed to be at its peak in October and November. During December more fawns are born than September but a declining tendency begins from January reaching to a minimum in March and April. (Table-III, Fig. 9). A female attains maturity at an approximate age of two years (Fig. 7.) and normally drops her first fawn in the third year of her age. It appears that they breed generally once in two years, rarely annually, contrary to the

belief of Schaller (1967). The nedit follows the mother from the first week of its birth, contrary to the statement of Eisenberg *et al.* (1972).

Habitat utilization, density and biomass : The Sambar makes a major contribution to habitat utilization in the thicker forest and also make use of discontinuous open habitat to certain extent Table-II. The Barking deer has similar habitat preference like Sambar but differs in trend of utilization which includes both browsing and grazing in discontinuous open habitat far from water resources. The other associates like Nilgi, Four-horned antelope and Chital are grazers and stick to the grassy plains with patches of coverts. The Wild Boar is the animal of discontinuous scrub or grass patches but also utilize the forest floor, besides the cultivated fields, both within and outside the park.

The density and biomass of the wildlife as well as domestic live-stock has been presented in the Table-IV, Fig. 10. It is worth while to mention that the biomass of approximately 580 kg per square kilometer for the Sambar at this park is much higher than Kanha (*vide* Schaller, 1967), Wilpattu Park (*vide* Eisenberg & Lockhart, 1972) and Keoladeo Ghana (*vide* Schaller and Spillet, 1966) Table-V The available data suggest that Hazaribagh Park can support a biomass of around 1200 kg per square kilometer for its wildlife if the domestic live stocks are prohibited from grazing inside the park.

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Table—I Mammalian fauna as observed during—1972-1974

Sl. No.	Species	Comments
I.	Rodentia :	
	<i>Funambulus pennanti</i> Wroughton (Five-striped Palm squirrel)	Thinly distributed
	<i>Golunda ellioti</i> Gray (Indian Bush Rat)	Moderately abundant in certain parts
	<i>Rattus rattus</i> (Linnaeus) (Common House Rat)	
II.	Lagomorpha :	
	<i>Lepus nigricollis ruficaudatus</i> (Indian Hare)	Abundant all over the park in scrub and grassy patch
III.	Carnivora :	
	<i>Panthera tigris</i> (Linnaeus) (Tiger)	Rare. Seen only pug marks near nullah No. 2 and 3
	<i>P. pardus</i> (Linnaeus) (Leopard)	Thinly distributed all over the park
	<i>Felis chaus</i> Guldenstaedt (Jungle cat)	Moderately abundant in certain part
	<i>Viverricula indica</i> (Desmarest) (The small Indian civet)	
	<i>Herpestes edwardsi</i> (Geoffroy) (Common Mongoose)	
	<i>Hyaena hyaena</i> (Linnaeus) (The striped Hyena)	Thinly distributed all over the park
	<i>Canis aureus</i> Linnaeus (The Jackal)	Rare.
	<i>Vulpes bengalensis</i> (Shaw) (The Indian Fox)	Rare.
	<i>Cuon alpinus</i> (Pallas) (Indian Wild Dog)	Thinly distributed in 1974 it was abundant in the study area
	<i>Melursus ursinus</i> (Shaw) (The Sloth Bear)	Rare.

Table—I Mammalian fauna as observed during—1972-1974 (Contd.)

Sl. No.	Species	Comments
IV. Artiodactyla :		
	<i>Carvus unicolour</i> Kerr (The Sambar)	Abundant in study area and thinly distributed elsewhere
	<i>Muntiacus muntjak</i> (Zimmermann) (The Barking deer)	Moderately distributed
	<i>Axis axis</i> (Erxleben) (The Chital)	Thinly distributed in Pokheria and Bahimer area
	<i>Boselaphus tragocamelus</i> (Pallas) (The Nilgai)	Moderately distributed in Pokheria
	<i>Teracerus quadricornis</i> (Blainville) (The Four-horned antelope)	Rare. Restricted near Bhatramunda
	<i>Sus scrofa</i> Linnaeus (The Wild Boar)	Seasonally abundant in all over the Park

Rare = less than 5 Thinly = less than 20 Moderately = less than 50 ;
Abundant = above 50

Table—II Plants eaten by Sambar at Hazaribagh Park

Sl. No.	Species (Hindi name)	Comments
1.	<i>Anogeissus latifolia</i> (= Dhau)	Leaf. Round the year
2.	<i>Gardenia latifolia</i> (= Ghogar)	Leaf. Rarely
3.	<i>Adina cordifolia</i> (= Haldu)	Bark. Occasionaly
4.	<i>Nyctanthes arbortrists</i> (= Harsinghar)	Leaf. Round the year
5.	<i>Garuga piunata</i> (= Garuga)	Fruits. June-July
6.	<i>Ougeinia dalbergioides</i> (= Sandan)	Leaf. Round the year
7.	<i>Bauhinia vahlii</i> (= Jallur)	.. ..
8.	<i>Ficus glomsrata</i> (= Gular)	.. ..
9.	<i>Aegle marmelos</i> (= Bel)	Leaf. Round the year & fruit in March-April
10.	<i>Feronia limonia</i> (= Kath Bel)	.. ..
11.	<i>Acacia catechu</i> (= Khair)	Leaf. Round the year
12.	<i>Zizyphus xylopyra</i> (= Khatti Ber)	Leaf. Round the year & fruits Nov. to January
13.	<i>Emblica officinalis</i> (= Amala)	.. ..
14.	<i>Shorea robusta</i> (= Sal)	New leaves in Feb.-March Flower in June-July
15.	<i>Terminalia tomentosa</i> (= Asaina)	Leaf. Round the year & fruit Feb. to March
16.	<i>T. bellerica</i> (= Bahera)	.. ..
17.	<i>T. chebula</i> (= Choti Harra)	.. ..
18.	<i>Diospyros melanoxylon</i> (= Kendu)	Fruit. Feb. to April
19.	<i>Pterocarpus marsupium</i> (= Bijasal)	Leaf. Round the year
20.	<i>Lagerstroemia parviflora</i> (= Baklai)	Rarely in summer
21.	<i>Mallotus philippensis</i> (= Roini)	Leaf. Round the year
22.	<i>Madhuca latifolia</i> (= Mahuwa)	Fruit. Feb. to April
23.	<i>Schleichera trijuga</i> (= Kusumi)	Leaf. Round the year
24.	<i>Bauhinia variegata</i> (= Kachnar)	Leaf. ..

Table—II Plants eaten by Sambar at Hazaribagh Park (Contd.)

Sl. No.	Species (Hindi name)	Comments
25.	<i>B. retusa</i> (= Kanloo)	.. .. .
26.	<i>Gmelina arborea</i> (= Gamhar)	Leaf. Round the year & fruits in March-Apr.
27.	<i>Indigofera pulchella</i> (= Sakena)	Leaf in winter and flower in Summer
28.	<i>Wendlandia exseria</i> (= Chilkiya)	Leaf. Round the year
29.	<i>Croton oblongifolius</i> (= Banasur)	.. .. .
30.	<i>Stereopermum suareoleus</i> (= Paral)	Leaf. Rarely
31.	<i>Flemingea chappar</i> (= Salpan)	.. .. .
32.	<i>Vitex negundo</i> (= Nirgundi)	.. .. .
33.	<i>Dendrocalamus strictus</i> (= Bamboo)	Occasionally
34.	<i>Andropogon muricatus</i> (= Khus)	June to October
35.	<i>Cynodon dactylon</i> (= Dub)	.. .. .
36.	<i>Cyperus rotundus</i> (= Motha)	.. .. .
37.	<i>Heteropogon contortus</i> (= Shurval)	June to Oct., at times even after drying of this grass during Feb. to onwards.

Table III. Population structure

Months	Approx. No. of indi- duals obser- ved	Percentage of					Natality 100 A Female : Fawn Male : Female
		A Male	A Female	Immature			
				Young	Fawn	Total	
January	25	19.4	58.2	16.0	6.4	22.4	11.3
February	31	26.6	53.4	15.0	5.0	20.0	9.3
March	30	26.0	55.2	14.4	4.4	18.8	7.9
April	32	17.0	64.0	14.0	5.0	19.0	7.8
May	32	16.5	62.5	16.0	5.0	21.0	8.0
June	38	18.0	62.0	14.0	6.0	20.0	9.6
July	35	21.0	57.0	15.5	6.5	22.0	11.4
August	39	21.8	59.7	11.8	6.7	18.5	11.2
September	40	20.6	56.0	12.6	10.8	23.4	19.2
October	45	19.5	50.5	16.6	13.4	30.0	26.7
November	48	16.0	53.0	17.0	14.0	31.0	26.4
December	46	17.0	53.7	17.9	11.4	29.3	21.2
Total (Average)	36.7	18.2	57.1	—	—	23.4	14.1
monthwise (Average of three years)							

of Sambar.

Approx. Sex ratio Male : Female	Percentage of antlers Condition in A male			Remarks
	H	V	S	
1 : 3	94.6	5.4	—	A = adult
1 : 2	100.0	—	—	Younge = includes fawn above one month of age to below two years of age including yearling males.
1 : 2	100.0	—	—	Fawn = Young below a month in age
1 : 4	87.0	6.5	6.5	H = Hard
1 : 4	67.3	2.7	30.0	V = Velvet
1 : 3	22.2	50.0	27.8	S = Shed
1 : 3	17.3	61.3	21.4	
1 : 3	19.0	74.0	7.0	
1 : 3	31.7	61.0	7.3	
1 : 3	48.8	43.9	7.3	
1 : 3	57.6	35.8	6.6	
1 : 3	81.4	15.1	3.5	
1 : 3				

Table IV. Density and Biomass of *Artiodactyla* in Hazaribagh Park
Approximate Area of the Park 112 Sq. Km.

Species	Estimated population in the Park	Density per Sq. Km.	*Average body weight in Kgs.	Biomass in Kgs. per Sq. Km.	
<i>Cervua unicolor</i>	450	4.01	145	581.45	*Average
<i>Muntiacus muntjak</i>	140	1.24	18	22.32	body weight
<i>Boselaphus tragccamelus</i>	60	0.53	181	95.93	has been
<i>Axis axis</i>	40	0.35	46	16.10	adopted vide
<i>Tetracerus quadlicornis</i>	35	0.31	18	5.58	Schaller
<i>Sus scrofa</i>	370	3.30	27	88.10	(1967)
Total	1095	9.70	—	809.48	
Domestic livestock	± 250	2.2	186	409.20	
Grand Total	1345	11.94	—	1218.68	

Table VI. Group tendency in Sambar

No. of Groups	Sambar per group	Individuals	Total No. sighted
11 | 23	Solitary	A Male	11
12 |	Solitary	A Female	12
2 | 18	Two	A Male (in velvet)	4
16 |	Two	A Male + A Female	32
18 | 25	Three	A Male + A Female + J	54
7 |	Three	A Female + Y + F	21
2	Four	A Male + A Female + Y + F	8
6	Five	A Male ₃ + F ₂	30
5	Six	A Male ₄ + F ₂	30
4	Eight	A Female ₈	32
4	Nine	A Female ₇ + Y ₁ + F ₁	36
2	Eighteen	A Female ₁₄ + Y ₂ + F ₂	36
89		A Male ₅₁ , A Female ₁₀₁ , Y ₃₆ , F ₃₀	306

Table V. Density and Biomass of Sambar in different Park

Parks	Area of the Park in square kilometer	Estimated popu- lation in the Park	Density per square Kilo- meter.	Average Body weight in Kilograms.	Biomass in Kilograms per square Kilogram/ square Kilometer.	Total Biomass of the Park in Kilograms per square Kilometre
Hazaribagh National Park (Based on the present study)	112	450	4.01	145	581.45	1,218.68
Keoladeo Ghana Sanctuary Schallar & Spillet (1966)	28.5	15	0.52	145	75.40	2,609.0
Kanha National Park Schaller (1967)	319.6	300	0.94	145	136.30	4,103.0
Wilpattu National Park Eisenberg & Lockhart (1973)	580	700	1.2	135	162.0	770.4

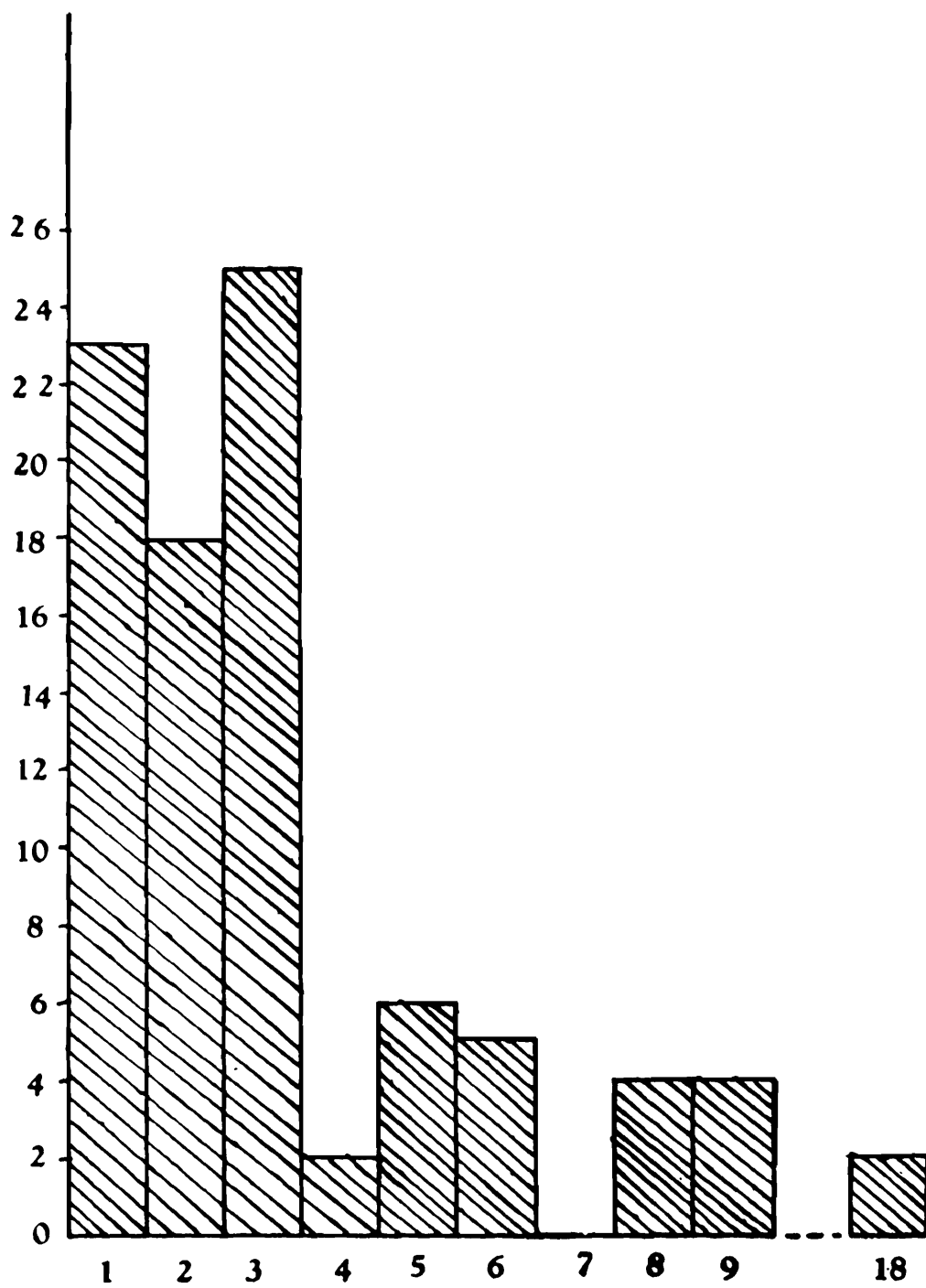


Fig. 4. Frequency diagram of group size of Sambar at Hazaribagh.



Fig. 1. A stag in hard antlers at Hazaribagh in November.



Fig. 2. Adult doe at Hazaribagh.



Fig. 3. Head showing antlers development of a stag at Hazaribagh, right antler 100 cm. and the left 95 cm. in curvature.



Fig. 5. A new set of antlers in initial stage of development in Orissa during late June.



Fig. 6. Antlers development at Hazaribagh during July.



Fig. 7. A stag in rut with a captive born 26 months old doe, at Bannerghatta National Park (Karnataka) in March, 1976.

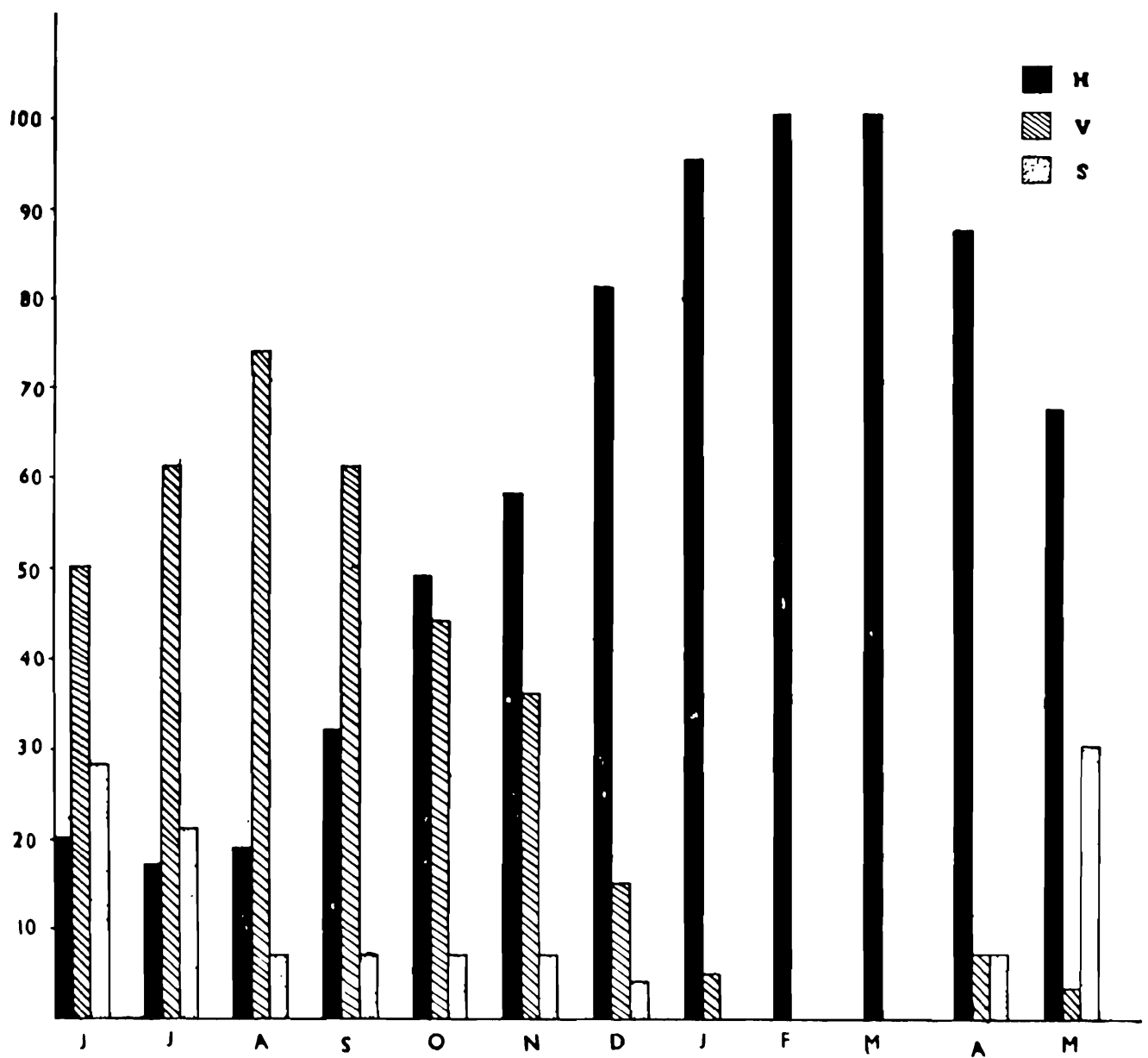


Fig. 8. Monthwise percentage of comparative antlers development, at Hazaribagh.

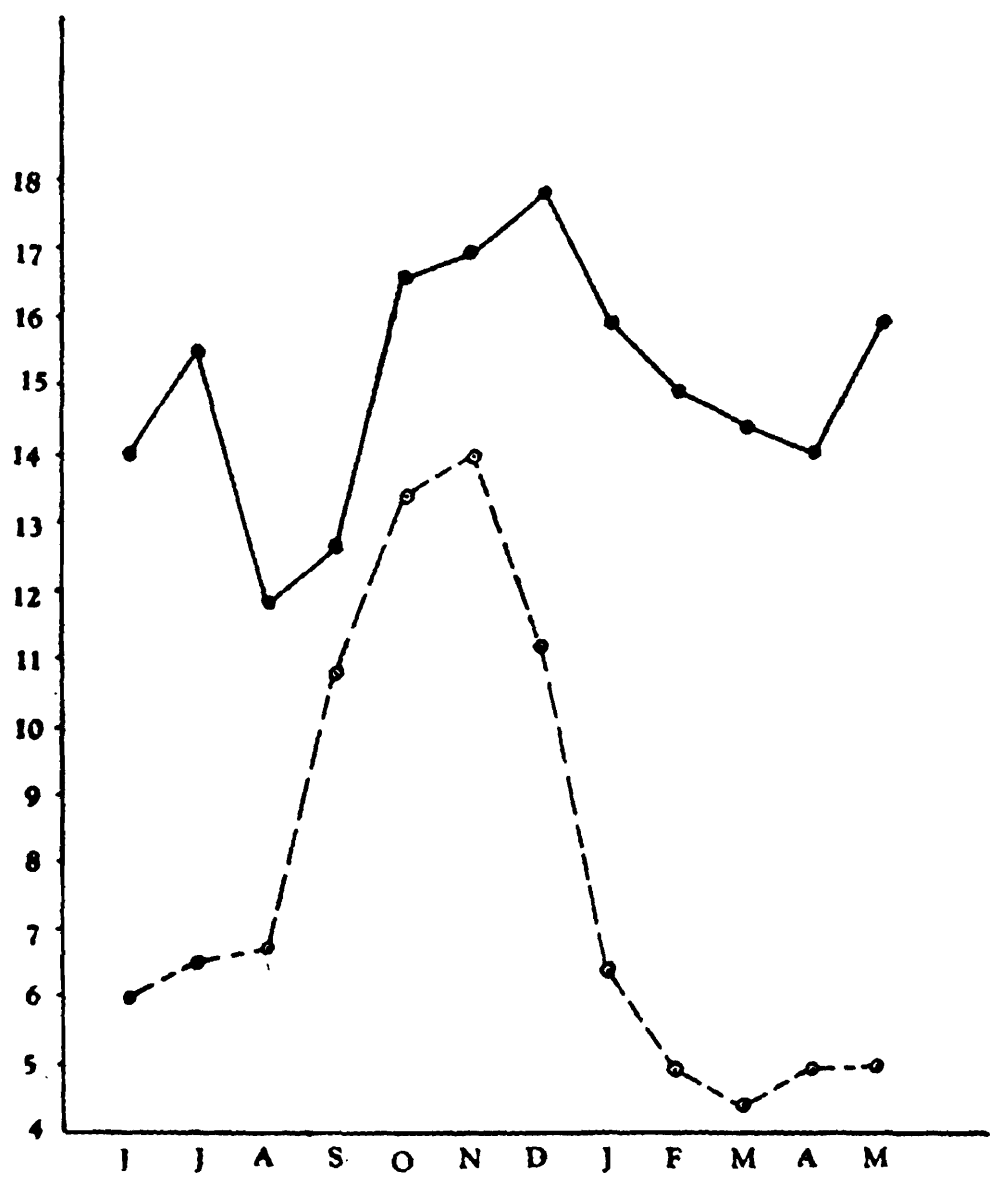


Fig. 9. Breeding season data showing percentage of fawn (broken line) and young (solid line).

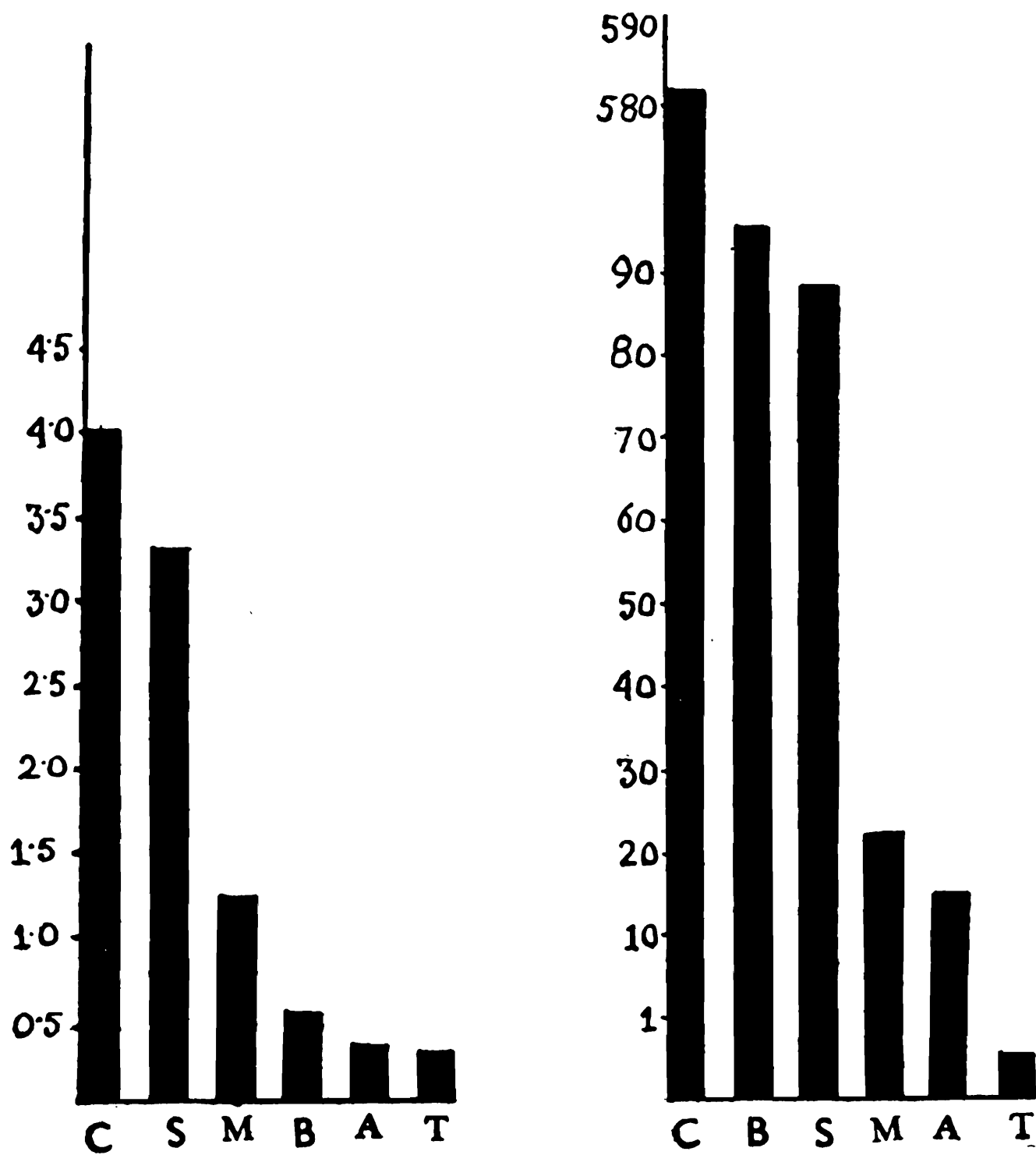


Fig. 10. Density and biomass of *Artiodactyla* at Hazaribagh.

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ECOLOGICAL FACTORS IN RELATION TO CHEETAL (CHITAL) POPULATION AT CORBETT NATIONAL PARK

B. S. LAMBA AND P. C. TAK

While working on the MAB Project "Impact assessment of Bio-ecological changes in the faunal patterns (Selected groups) brought about by the partial submersion of Corbett National Park as a result of Ram Ganga multipurpose Hydel Project Dam ; especially in the areas contiguous to the proposed water line," at the Corbett National Park the authors were intrigued by the year round variation in the formation pattern, size, distribution and disintegration of cheetal herds. The fluctuations in the type, size and location of the herds during the different season were so marked that we decided to study the ecology of cheetal herds in the park. Observations were made at the Dhikala chaud area from September 1977 to August 1978.

The following 5 types of herds (Fig. I) were observed.

1 *Male-Female-Fawn Herds :*

This herd-type was sighted maximum number of times in April. The number of sightings fell slightly in May and then remained almost constant till August, it decreased abruptly in September. From December onwards there was a gradual increase till April (Fig. IA).

2. *Female-Fawn Herds :*

Optimum sighting of Female-Fawn herds occurred in December, thereafter it registered a sharp fall in January and remained almost constant up to July (IB).

3. *Male-Female Herds :*

These herds were sighted throughout the year except in months of April and July. The maximum number of herds were seen in October (IC).

4. *All Male Herds :*

These herds appeared in January, reached their peak in March and disappeared after May (ID).

5. *Female-Yearling Herds :*

These herds were observed from September to February, with the peak in November, and were almost absent from March to August (IE).

6. Lone pregnant females were sighted in November-December.

The composition of these herds varied greatly. Ratio of bucks to does varied from $\cdot 09 : 1$ (minimum) in December, to $\cdot 90 : 1$ (maximum) in June ; while the ratio of fawns to females ran between $0 : 1$ in October-November and $\cdot 20 : 1$ in December (Table II).

From (Fig. III) it can be seen that the ratio of bucks to females increases gradually, from, $\cdot 1$ in January to its peak *i.e.* females $\cdot 9$ in June. When the rut commences, the ratio fluctuates between $\cdot 4$ to $\cdot 9$ till October, the time when the rut is over. Thereafter the ratio declines and is minimum *i.e.* $\cdot 09$ in December (III A). Whilst the ratio of fawns to females is maximum in December *i.e.* $\cdot 2$ when the fawning beings. It declines to $\cdot 05$ in February, the fluctuates between 0.09 to 0.2 , touching the lowest *i.e.* nil in October-November (III B).

These variations and fluctuations of ratios of various herd components are governed by a number of physiological-cum-behavioural and ecological factors. The Physiological factors are responsible for growth of antlers in males. The males start growing the antlers soon after shedding of the older set sometimes in October-November. When antlers are in velvet, and being developed *i.e.* from November-May it was noticed that the males developed a tendency to remain slightly, if not much, apart from other members of the herd. This results in a decline in the male ratios as seen in Fig. (III A). These males preferred the company of other such males often resulting in the formation of "All-Male" herds, 'Stag-Parties' or "Bachelor-Herds" By the commencement of rutting season in May-June the antlers of most of these males became hard and fully developed. At this time the males with hard antlers, started joining the Female-Yearling-Fawn herds, resulting in the formation of typical mixed herds. As a component of the mixed herds the males showed aggressive behaviour to seek receptive females. A single male often mounted three to four times a day. The pregnant females remained with the herd till an advanced stages of pregnancy, when they dropped out of the herds to seek shelter in thickets of tall grass. While thus secluded and hidden, the pregnant females dropped the fawn after the completion of gestation period.

Most fawns were laid in December.

The ecological factors involved are mostly : availability of food and predator pressure. The predators like Tigers, Panthers, Foxes and Jackals are present in the Park in good numbers and are mainly responsible for the high fawn mortality rate, bringing down the fawn female ratios as seen in Fig. (III B).

The year round climatic changes in the area influence the ecology of the area which in turn effects the herds. For example, just after rains when the grazing is good alaround small size herds (3 to 5, Fig. IV) are found in abundance. With the commencement of cold-dry season the grazing area starts shrinking and becomes highly localised. The smaller herds start congregating in these patches of the park where the food by way of sprouting grasses like *Apluda mutica*, *Arundinella bengalensis*, *Chrysopogon serrulatus*, *Eragrostus tenella*, *Heteropogon contortus*, *Saccarum bengalensis* etc. are available. This gives rise to the formation of larger herds of 35 or so. The largest herds of 500+ are met with during the driest season in April to June. At this time most of the grasses go dry. The water level of the reservoiur receds laying bare large portions of the river bed where succulents like *Glinus lotoides*, *Panicum ramosum*, *Fimbristylis squarosa* etc., Sprout. The herds of cheetal move into this area from surrounding grassy and forested areas thus forming the largest herds (Fig. IV).

In 1977 when the water of the lake receded considerably denuding a large area of the river bed in which fresh succulents sprouted, the largest herd was observed to be composed of 526 individuals (Fig. V). In the year 1978 the lake water did not reced much and only 50% of the area denuded in 1977 was available for grazing, also the quantity of succulent sprouts was much less. Consequently the size of largest herds observed in July 1978 was 42 individuals only.

These larger herds start disintegrating in smaller herds from July-August onwards when the onset of rains augments the grazing and brosing till the lowest herd size is reached in October-November. At this time the Cheetal were observed to spend comparatively much more time in browsing leaves of the plants like *Murraya koenigii* and *Murraya panilated* (family-Rutaceae) etc., which occur in and along the ecotone. And also leaves of fallen trees like *Syzygium cumini*, *Terminalia*, etc., and *ficus* species (*Ficus retusa*, *Ficus arnottina*, *Ficus bengalensis*, and *Ficus religiosa* etc) which are broken by elephants or used as elephant fooder.

FIG. I-HERD TYPES OBSERVED

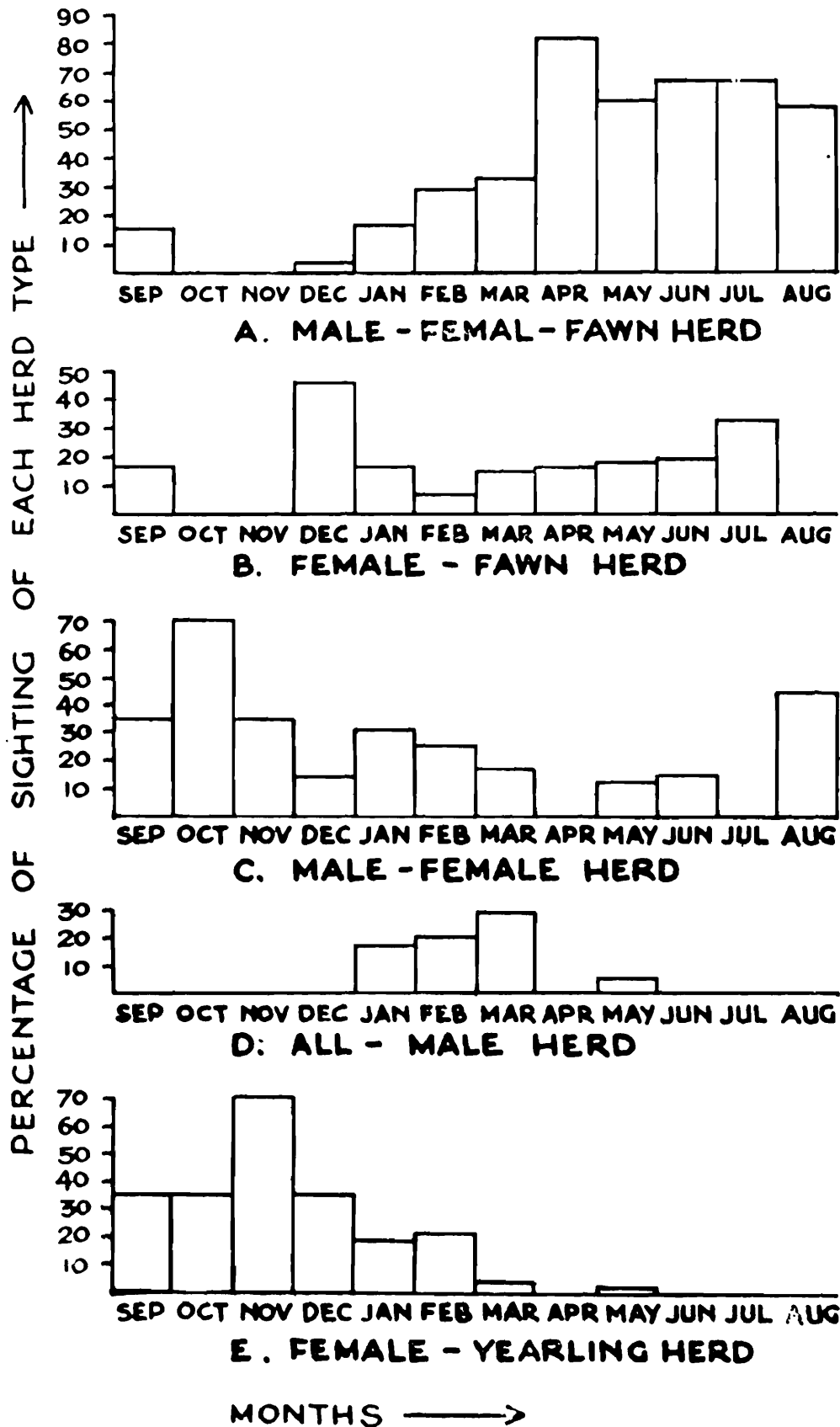


**TABLE II — REPRESENTING THE HERD COMPOSITION
OF THE CHEETAL OBSERVED AT DHIKALA
CORBETT NATIONAL PARK**

MONTHS & YEARS	NUMBER OF INDIVIDUALS CLASSIFIED	BUCKS	DOES	FAWNS
1977 SEP	60	40.00	100	10.00
OCT	34	88.88	100	0.00
NOV	18	38.46	100	0.00
DEC	97	9.33	100	20.00
1978 JAN	144	10.08	100	10.92
FEB	491	22.02	100	5.18
MAR	1140	45.03	100	14.40
APR	1112	44.79	100	9.43
MAY	1300	49.30	100	18.75
JUN	656	90.40	100	12.69
JUL	80	40.0	100	20.0
AUG	57	57.57	100	15.15

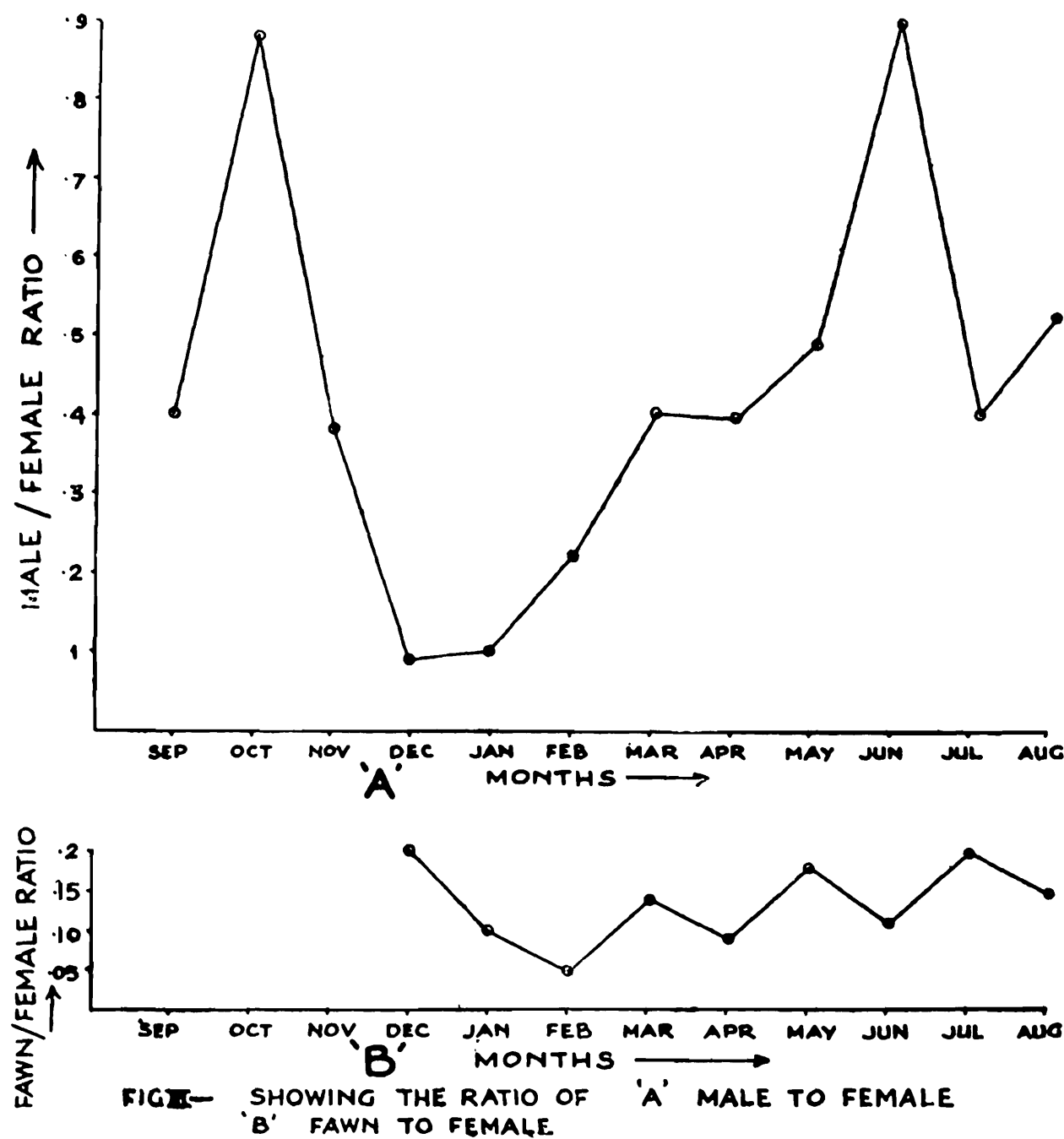
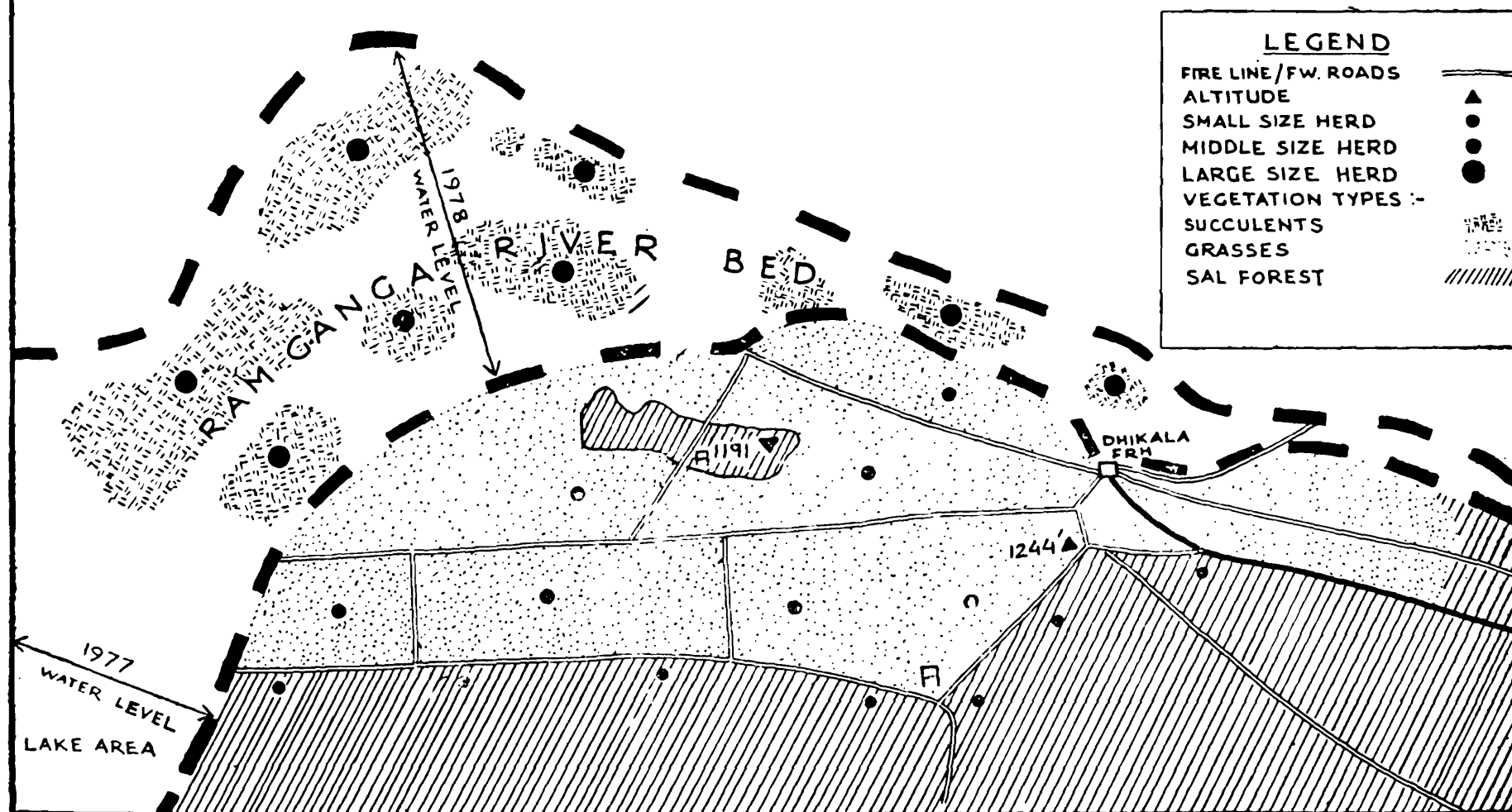


TABLE IV – REPRESENTING SIZE OF THE SMALLEST AND LARGEST HERD OF THE CHEETAL OBSERVED FROM JAN, 1977 TO AUG, 1978

MONTHS		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
YEARS													
1977	SMALLEST	3	5	10	10	10	10	35	55	4	3	3	3
	LARGEST	70	60	98	200	200	171	526	526	18	8	6	11
1978	SMALLEST	3	5	3	7	6	6	3	5				
	LARGEST	21	52	93	291	134	138	42	12				

FIG.V - VEGETATION TYPES - HERD SIZES



POPULATION ANALYSIS OF THIRTY GROUPS OF HANUMAN LANGUR (*PRESBYTIS ENTELLUS*) WITH RESPECT TO THEIR SOCIAL LIFE

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INTRODUCTION

Animal shows definite preference for association and there preferential association leads to the substructuring of the groups. In macaque (*Macaca mulatta*) monkey it is well known and reported up to a recognizable level, for which, Southwick *et al.* (1965) gave the term 'subgroup'. He defined it as 'fairly large assemblage of individuals within a social group that displayed recognizable affinity from day to day'. But here the term 'party' refers to functional associations, in which, members of the group allow other members in each others social space. Attention was paid not to the particular individual but to the participation of age and sex classes in 173 parties, observed in the field.

Data were analyzed here with respect to (i) attraction (which leads to formation of the parties) and (ii) degree of attraction (which is a mathematical value of comparative cohesion).

Data for this paper were collected during my field trip to Kanha National Park, M. P. in the months March-April 1977. Distribution and ecological conditions together with studies on social life of langur of the park have already been provided in a previous paper (Kankane, 1980).

METHODS

Observations on the composition of groups were recorded on the special sheets designed for the purpose (Fig. 1). There has been the sub-structuring of the groups arising out of inter-individual relations. This leads to the formation of different kinds of parties. Here the term party refers to feeding parties, resting parties, playing parties etc. or individuals of the group which have certain preferences of association in certain activities or when members of the group allow other members in each other's social space. This also includes those

* Present address : Zoological Survey of India, Calcutta

DATE :- 5th Nov '77

SHEET No 7

TIME :- 0715

GROUP No

LOCALITY :- Shramanfal

SY/Y/LS/21

COUNT :-

	MALE	FEMALE	JUV.	INS.
I			1	
II			1	
III		2		
IV	1		1	
V		1		1
VI		2	1	3
VII		1		
VIII				
IX				1
X				
	1	6	2	4

15

COMMENTS :-

1) 2-1 was found alone

2) 4-1 Jammu, Sauri and Mahab. were

Fig. I. Specimen observation sheet.

individual which do not participate in any party and prefer to perform their activities alone but within the group. Nineteen kinds of possible parties based on age and sex composition were as follows :

<i>Composition of party</i>	<i>Abbreviation</i>
Male/s Female/s Juvenile/s Infants/s	MFJI
Female/s Juvenile/s Infant/s	FJI
Juvenile/s Infant/s Male/s	JIM
Infant/s Male/s Female/s	IMF
Male/s Female/s Juvenile/s	MFJ
Juvenile/s Infant/s	JJ
Infant/s Male/s	IM
Male/s Female/s	MF
Female/s Juvenile/s	FJ
Female/s Infant/s	FI
Juvenile/s Male/s	JM
Males	MM
Females	FF
Juveniles	JJ
Infants	II
Male	M
Female	F
Juvenile	J
Infant	I

Visibility was quite good during the study period as many trees were leafless. The groups were approached regardless of time and party position was recorded. Observations were recorded with having this point in mind : attraction which cause the formation of parties and participation of different age and sex classes in different parties may throw some light on their social life. This is, why data were collected in terms of parties and further age and sex composition of the parties.

To find comparative degree of attraction or cohesion it was calculated, how many parties of that kind would have been there if the total number of langur was 100 for each kind of party : the fewer the number of parties the higher the attraction within that kind of party.

POPULATION

During the study period a total of 599 langurs were counted in 40 groups. Out of forty, thirty were bisexual groups, nine male groups and one solitary male, their total population was 524, 74, and 1 respectively. Crook (1970) writing about nature of primate social system stated that the key social unit of each species is that within which normal social and reproductive activities occur, and it usually consists of females and young with at least one adult male. Imanishi

(1960) once termed such groups ‘oikia’ The present author too agrees with Crook (1970) and only bisexual groups were taken into account.

The average of group size and some indexes of age-sex composition of the groups are as follows :

Average group size	17.47
Adult male/Adult female	0.15
Infant/Adult female	0.32
Juvenile + Infant/Total	0.4
Adult male/Total	0.08
Adult female/Total	0.53

A total of 524 langurs of bisexual groups were counted in 173 parties of nineteen kinds. Figure 2 shows the distribution of male, female, juvenile and infants among such parties, two kind of parties

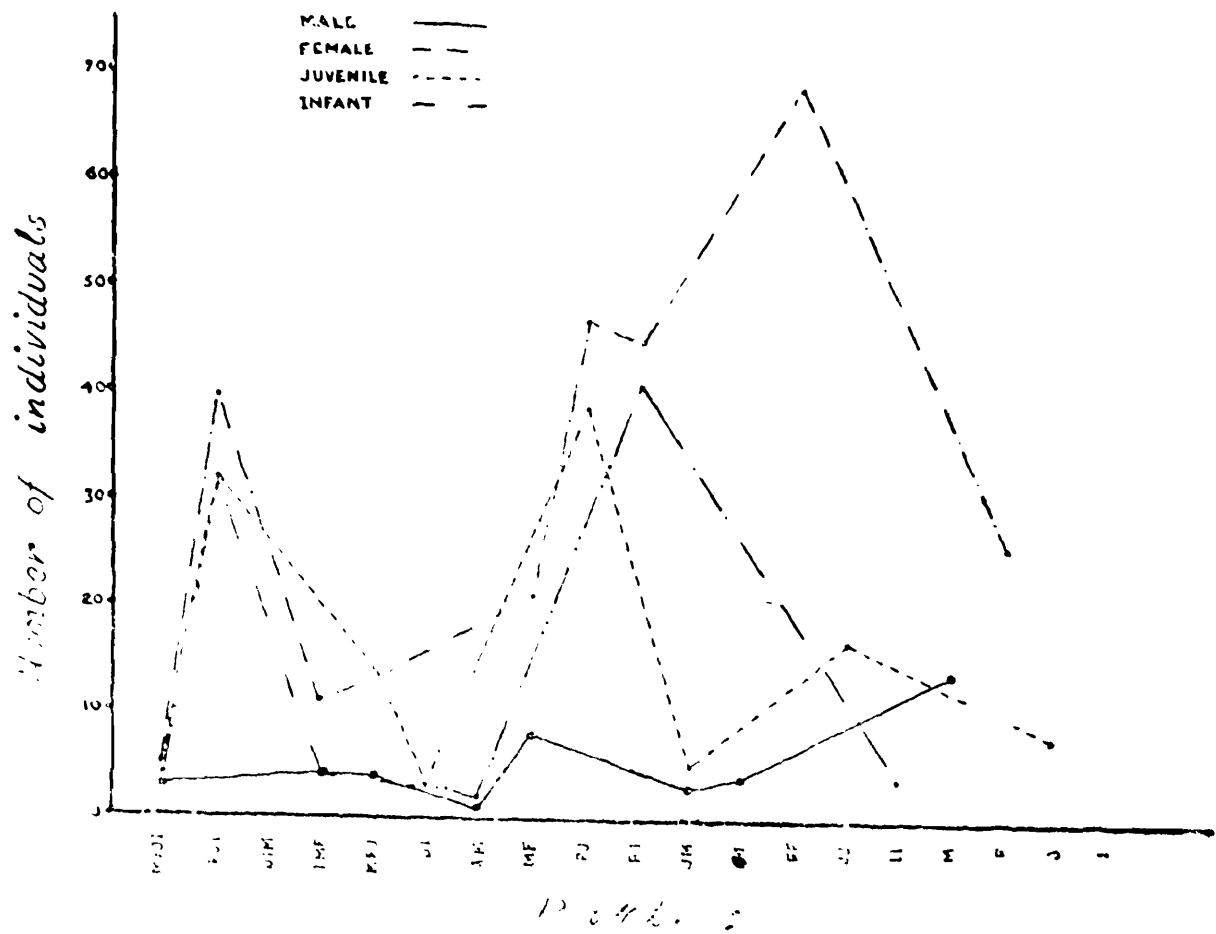


Fig. 2. Distribution of male, female, juvenile and infants in the different kinds of parties.

namely Juvenile/s Infant/s Male/s (JIM) and Infant (I) were never recorded. Comparative degree of attraction or cohesion (see methods) was calculated and the highest degree of attraction was found in Infant/s Male/s Female/s (IMF) party (15 parties per 100 langurs) while the lowest in three parties namely Male (M), Female (F) and Juvenile (J) (100 parties per 100 langurs).

a) *Male* : Out of 41 male langurs (table 1) the highest percent (34%) was present in the male (M) party. Next to this (20%) in Male/s Female/s (MF) and then nearly equal percent (10%) male in the

Table 1 : Percentage of the total number, male, female, juvenile and infant in the different kinds of parties of langurs,

Parties	Total	Male	Female	Juvenile	Infant
	524	41	277	116	90
MFJI	3.2	7.0	1.8	4.3	4.5
FJI	20.0	—	14.4	27.5	35.6
JIM	—	—	—	—	—
IMF	3.6	10.0	4.0	—	4.5
MFJ	4.6	10.0	4.7	6.0	—
JI	1.1	—	—	2.5	3.3
IM	0.7	2.0	—	—	2.2
MF	5.6	20.0	7.6	—	—
FJ	16.3	—	17.0	33.6	—
FI	16.3	—	16.2	—	45.5
JM	1.5	7.0	—	4.3	—
MM	0.8	10.0	—	—	—
FF	13.2	—	25.0	—	—
JJ	3.2	—	—	14.8	—
II	0.8	—	—	—	4.4
M	2.6	34.0	—	—	—
F	5.0	—	9.3	—	—
J	1.5	—	—	7.0	—
I	—	—	—	—	—
	100	100	100	100	100

parties of Males (MM), Male/s Female/s Juvenile/s (MFJ) and Infant/s Male/s Female/s (IMF). The lowest number (2%) of the males were recorded with Infant/s Male/s (IM) party.

b) *Female* : Out of 277 female langurs (table 1) the highest numbers (25%) were recorded with Females (FF) party. Next to this comes the parties Female/s Juvenile/s (FJ) (17%), Female/s Infant/s (16.2%), Female/s Juvenile/s Infant/s (FJI) (14.4%) and Female (F) (9.3%). Only 7.6% of the total number of females were noted with males in Male/s Female/s (MF) party.

c) *Juvenile* : Out of 116 Juveniles (table 1) the highest percent (33.6%) was counted in the party composed of Female/s Juvenile/s (FJ), Next to this were the parties Female/s Juvenile/s Infant/s (FJI) (27.5%), Juveniles (JJ) (14.8%), Juvenile (J) (7%) and male/s Female/s Juvenile/s (MFJ) (6%). Equal distribution (4.3%) was noted in two parties composed of Male/s Female/s Juvenile/s Infant/s (MFJI) and Juvenile/s Infant/s (JI). The lowest representation (2.5%) of juveniles was noted in the Juvenile/s Infant/s (JI) party.

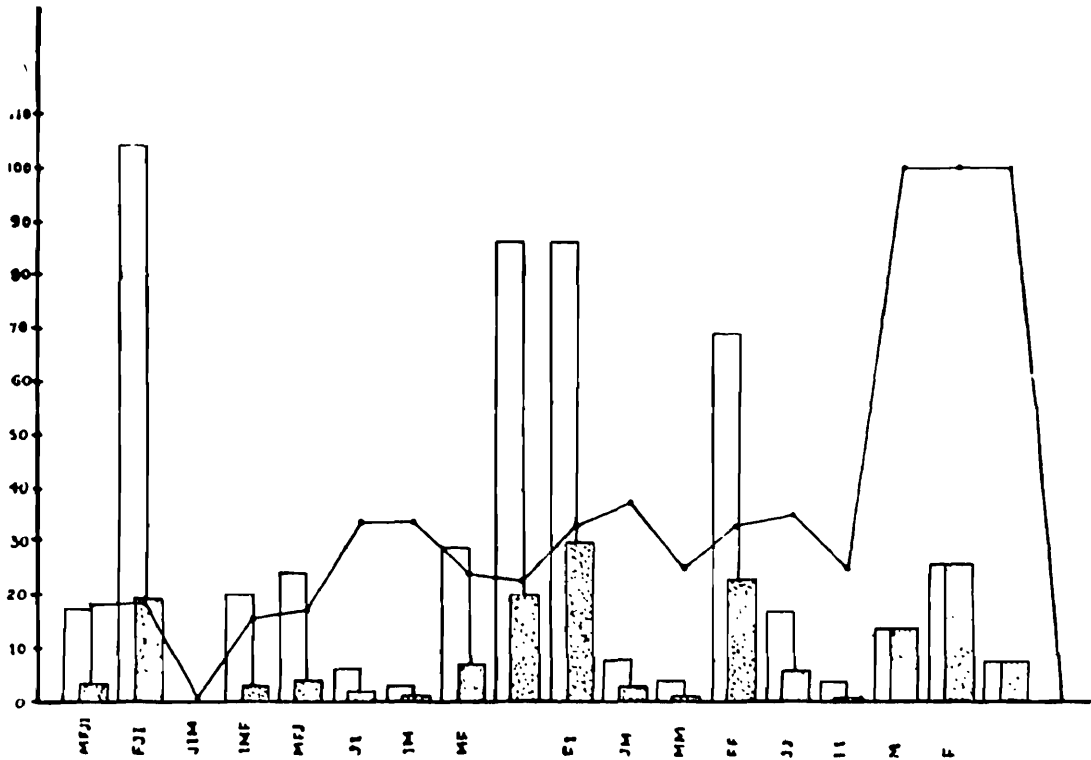


Fig. 3 Distribution of 524 langurs in different kinds of parties. Blank bars indicate total number of langurs in kind of party ; dotted bars indicate number of parties in which population of that kind of party condensed. Graph indicate comparative degree of cohesion.

d) *Infant* : Out of 90 infant (table 1) recorded the highest percent (45.5%) was counted in the party composed of Female/s Infant/s (FI). Next to this Female/s Juvenile/s Infant/s (FJI) (35.6%). Equal distribution (4.5%) was noted in the parties namely Male/s Female/s Juvenile/s Infant/s (MFJI) and Infant/s Male/s Female/s (IMF). Then comes Infants (II) party (4.4%), Juvenile/s Infant/s (JI) party (3.3%) and the lowest number of infants (2.2%) were noted in Infant/s Male/s (IM) party.

CONCLUSION

It was noted that langurs prefer to form a kind of party composed of Female/s Juvenile/s Infant/s (FJI), which constitute the highest number of the total langur population. The lowest of the total was recorded for Male/s Infant/s (MI) party. It was interesting to note that male prefers Male (M) party, female, Females (FF) parties while juvenile and infants were mostly recorded with females (in FJI, FJ, and FI parties). The highest degree of attraction was calculated in Infant/s Male/s Female/s (IMF) party which constitute only 3.6% of the total langur population.

Association of 47% of females with juveniles and infants as well as heavy (81%) representation of infants in two parties FJI and FI indicates that there had been the concentration of new born individuals (or birth season) and comparatively lower reproductive activities during the study period. This argument is also supported by presence of the highest percent (25%) of female in Females (FF) party, the highest percent of male in Male (M) party and merely 7.6% of the females with male in Male/s Female/s (MF) party. Jay (1965) also reported April and May birth season for the langurs of central India which agree, with the present author's observations. Sugiyama *et al.* (1965) noted December to March as active birth season though the study area was near Dharwar in South India. The highest percent of juveniles were noted with females; more than half of the total population was female langurs; and their representation in nine out of nineteen parties indicate that females play an important role in the formation of parties and to some extent functional structure of the group dependant upon females. But it requires more data with respect to different seasons and physiological conditions of females.

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A STATISTICAL INVESTIGATION ON WILD LIFE CENSUS AND MONITORING

By

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INTRODUCTION

Any method of estimating wild animal population is based on two basic assumptions :

1. Recruitment and mortality during the period of collection of data are negligible or the estimates are corrected accordingly. Movement out of the population and movement into the population are considered synonymous to mortality and recruitment respectively.
2. All individuals in the population of wild animal have an equal probability of being enumerated in the wild animal census.

The word "census" is defined as a count which includes the detailed data on age and sex classification for a given species in a given area. There are two basic steps in estimating the size of an animal population. The first is to obtain the data and second is to derive the result of it. Visual counts, enumeration of signs and symptoms, ratio of the number seen per unit to a known ratio of animals per unit etc. are some of the steps that are necessary in getting in the desired data on animal population in one species or the other. Any "census" method employed in making the estimate must be chosen for the particular species, time, place, area and purpose.

Determination of number of animals - methodology thereof :

The methods for wild life census fall in the following three categories :

- a) a true census (complete enumeration)
- b) a sampling estimate
- c) an index.

A true census is a count of all individuals present on a given area. It is the total and complete enumeration of all animals present in the area. It can be inaccurate because of errors that may occur because of recording in a larger area and larger number. A sampling estimate is derived from counts made on sample plots and standard deviations are attached to it. An index is a count of some object related in some quantitative manner with the animal to be censused. Several techniques of estimating wild animal populations may be classified as follows :

(A) Direct count of animals :

a) Direct count of all animals present in a given area.

- 1) no statistical presupposition involved
- 2) it is a true census and not an estimate

b) Sample count :

- 1) There is a basic hypothesis that the samples are drawn at random.
- 2) The statistical estimate on count depends upon required precision.
- 3) it is an estimate and not a census in the true sense of the term.

c) Index count or ratio :

- 1) Basic assumption involved is that samples are randomly obtained.
- 2) It depends upon statistical precision.
- 3) it is an estimate and not a census.

(B) Count of animal signs and symptoms (tracks, cells etc.)

- a) Direct count of all signs in a given area.
- b) Sample count of signs.

(C) Index counts or ratios :

CENSUS

This involves either to count or to capture all of the individuals of the population. If the population can be counted completely then a true census is possible but such cases are not very practical ones. Such population can be described in time, distance or area units, In cases

of territorial species, the result of enumeration is described as animals per unit area of enumeration (acre, hectare etc.)

SAMPLING ESTIMATE

It is necessary to determine the number of samples that may be required to give reliable information in sampling any ecological habitat. Number should neither be too large nor too small and should be optimum. The following formula is employed to determine the optimum number which is :

$$n = \frac{S^2 t^2}{d^2}$$

where n = number of samples required

S = standard deviation

t = normal deviate at requisite confidence limit level and at given degrees of freedom (from t table)

d = margin of error (arithmetic mean times designated accuracy).

The following two methods are recognised in the case of sampling estimate : (1) method dependent on direct observation and counting of the animal or its 'sign' (2) method based on determining ratios to some sign such as tracks, fecal matter, call counts etc.

Counts on sample plots :

The strip census (or king method) is employed usually to estimate wild animal populations which is

$$P = \frac{AZ}{2YX} \quad \text{where } P = \text{population for the area under study.}$$

A = Total area under study.
 Z = number flushed
 Y = average flushing distance
 X = length of line

This method however does not allow for area actually sampled beyond the animals observed.

Frequency method :

The data on frequency can be employed to estimate mean number of animals per quadrat. If the number per unit (of time, space etc.)

has a poisson distribution then $\bar{e} \bar{x} = q$ where q is the proportion

of units that lack individuals, X is the mean individuals per unit and e is the base of natural logarithm.

$$\text{or } \log q = -\bar{x}.$$

Counts of Related objects and estimation :

Estimation techniques for sample survey work are rather restricted in scope and use. Two techniques are considered : (1) Ratio estimate (2) Linear regression method.

In the ratio method an auxiliary variate X_i , correlated with Y_i is obtained for each unit in the sample. The population total X of the X_i must be known. The aim is to obtain increased precision by taking advantage of the correlation between Y_i and X_i . At present simple random sampling is assumed.

The ratio estimate of Y , the population total of Y_i is

$$\hat{Y}_R = \frac{Y}{X} \bar{x} = \frac{\bar{Y}}{\bar{X}} \bar{x} \text{ where } Y \text{ and } X \text{ are the sample totals of } Y_i \text{ and } X_i \text{ respectively.}$$

Like the ratio estimate, the linear regression estimate is designed to increase precision by the use of an auxiliary variate X_i which is correlated with Y_i . Supposing that Y_i and X_i are each obtained for every unit in the sample and the population mean $\bar{X}$ of the X_i is known. The linear regression of $\bar{Y}$, the population mean of the Y_i is

$$\bar{Y}_{lr} = \bar{Y} + b (\bar{X} - \bar{X})$$

subscript lr denotes the linear regression and b is an estimate of the change in Y when X is increased by unity.

Rather a simple procedure evolved is based on two captures. The population

(N) is given as :

$$N = \frac{Y_1^2}{Y_1 - Y_2}$$

Where N = Population in the area under study

Y_1 = Number caught during the first day

Y_2 = Number caught the second day.

Three basic assumptions are to be fulfilled before this method is employed. Those are : (1) immigration and emigration are negligible

(2) probability of capture remains constant during the period of collection of data. For various reasons like trap shyness, change in weather, food supply etc. the probability may vary. (3) The catch is proportional to the population.

Estimate based on changes in Ratio :

If the change in number of tracks per unit area ($T_1 - T_2$) is due to n number of wild animals, then

$$\frac{T_1 - T_2}{n} = \frac{T_1}{N_1} = \frac{T_2}{N_1}$$

where N_1 is the population before removal

N_2 is the population after removal

T_1 = number of tracks due to wild animal before removal per unit area

T_2 = Number of tracks due to wild animals after removal per unit area.

Obviously the standardization of the conditions is a pre-requisite for application of this method since time of day, weather and other features must be similar.

Estimates based on Recaptures :

The population (N) may be calculated as follows :

$$\frac{N}{M} = \frac{n}{m} \quad \text{where } M = \text{number marked and released}$$

the confidence limits 95% may be calculated from :

$$S. E = \sqrt{\frac{M^2 n (n - m)}{m^3}}$$

n = total marked and unmarked that were captured at a subsequent time ;

m = number marked out of the total recaptured,

This method is known as "Peter Jackson method" or "Lincoln index" etc.

Present day estimation techniques have low precision. For example if the population estimate has precision of only 10% then we cannot detect the effect of say predation unless its effect is more than

p%. The number of basic methods is also quite a few. A problem in population dynamics is to determine the density of a population where the density is the number of animals per unit area. Density relates the population, ecologically to habitat. So the density should be expressed in terms of its limiting factor, limiting the population into time and place. But the terminology of density per unit area makes a tacit assumption that the limiting factor is proportional to the size of the area, which fact is perhaps based on not too accurate assumptions.

CONCLUSION

The methods of population dynamics in the field of wild life ecology are still passing through various stages of experimentation and no method is universally applicable to all animals in all time and place and as such proper behavioural knowledge of wild animal species and intimate experience of its environment is prerequisite in the field of biometrical studies, without which any application of any method of census and monitoring is liable to give inaccurate results.

STATUS OF THE GAUR (*BOS GAURUS*) IN KANHA NATIONAL PARK MADHYA PRADESH

J. J. DATTA,¹ D. K. BELSARE,² S. S. CHANDIRAMANI³

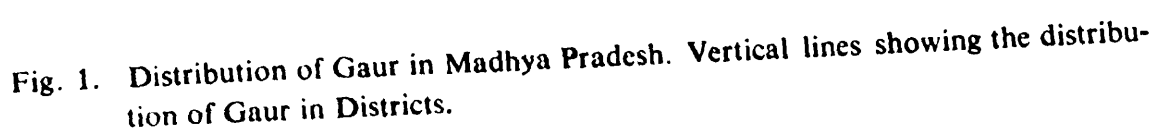
INTRODUCTION

The Gaur, *Bos gaurus*, is a massive bovine also referred to as the bison and is found in India, Burma and the Malaya Peninsula. The gaur belongs to the family Bovidae of the order Artiodactyla which includes hoofed animals. The Indian species is known as *Bos gaurus gaurus*, whereas its species in Burma and Malaya are *B. gaurus readei* and *B. gaurus hubbacki*. These three species share certain morphological features such as massive built body, white feet, ridge along the back and dewlap in two parts.

In Madhya Pradesh, the gaur is distributed in the districts of Khandwa, Hoshangabad, Betul, Chhindwara, Seoni, Balaghat, Surguja, Shahdol, Bilaspur, Jabalpur, Bastar, Ambikapur, Sidhi, Raipur, Mandla and some parts of Durg, Rajanandgaon, Damoh, Sagar and Narsinghpur (Fig. 1).

Its population in Kanha National Park is considerably higher than in other areas because of the conservation measures adopted in the National park. However, there is fluctuation in its population all over the State, and one of the reasons given for such fluctuation is the outbreak of epidemics such as rinderpest. In 1976 the rinderpest epidemics took heavy toll of gaur in Kanha National park (Census Report, 1976). Besides ecological observations on gaur in Kanha by Schaller (1967), no scientific study has been made on this magnificent wild animal so that better methods of conservation and management could be worked out. This was the primal aim of the investigation on the biology of gaur and the present paper reports the interim observations on the status of gaur in Kanha park.

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PLACE OF INVESTIGATION

The Kanha National Park is a part of the Central Indian highlands which are stretched across the State of Madhya Pradesh from west to east (Fig. 2). It is situated between the Latitude 22°00'N & 22°30'N and Longitude 80°25'E & 81°07'E.

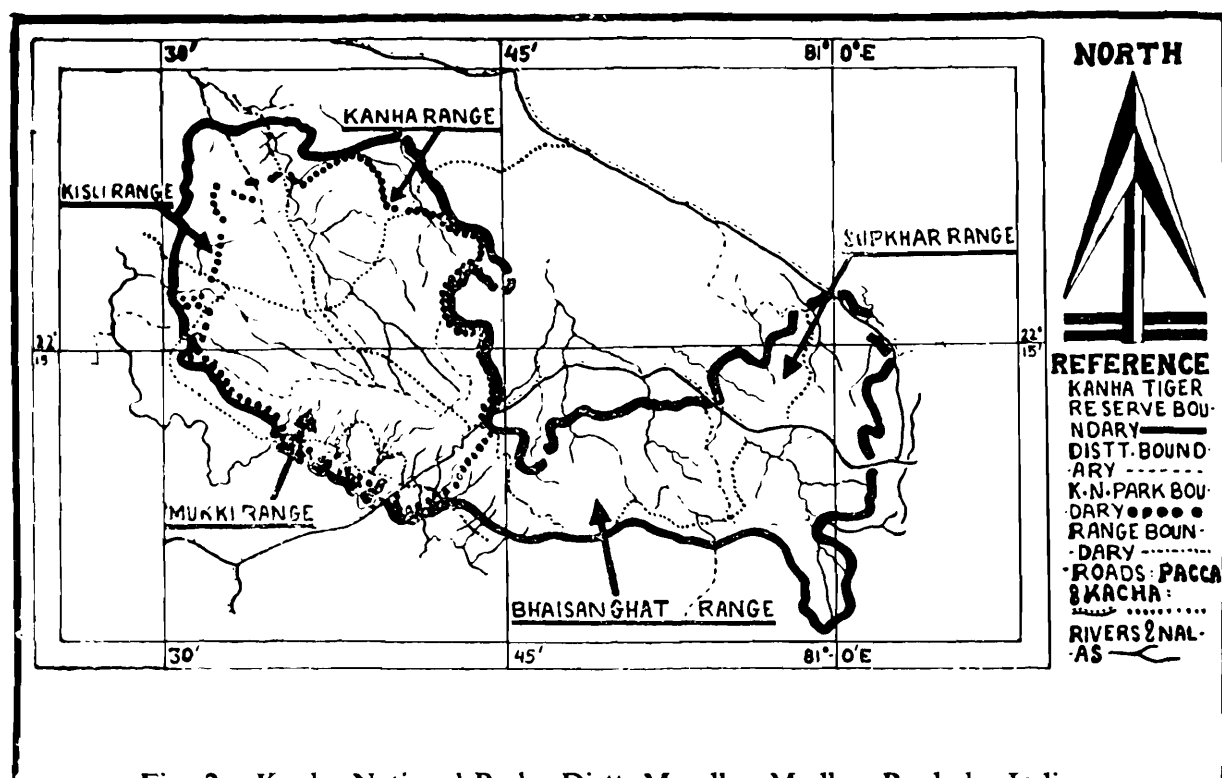


Fig. 2. Kanha National Park, Distt. Mandla, Madhya Pradesh, India

Kanha National Park with its 940 sq. kms. of expanse, cradles in the Maikal range of hills in the eastern Satpuras. The Park also has a 1,005 sq. kms. buffer zone surrounding it which is closed to hunting forever. The whole conservation unit thus occupies an area of 1,945 sq. kms. and falls into the southern part of the Mandla district and the north eastern part of the Balaghat district at altitudes between 502 and 802 metres. The area drains into the Banjar river and its tributaries. The Banjar flows into the Narmada near the district town of Mandla 40 kms. northwest of the park's centre. The forest of Kanha is mixed type and consists of tropical moist and dry deciduous types. The average rainfall is 150 cms./year.

The typical topographical features are the extensive plateau-capped hills with steep slopes in the upper reaches and sprawling slopes in the

lower reaches that finally terminate into valleys of varying extents between the branching spurs and the main ridge system. The plateaus tend to have sparse or little tree growth and plenty of grasses. The typical landscape in the valleys comprises rolling grassy meadows interspersed with groves of stately sal. The lower slopes carry dense stands of sal with plenty of bamboo which also occur in the mixed stands that clothe the upper slopes. The grassy meadows in the valleys and on the plateaus are the mainstay of the herbivores. Enormous fodder resources also exist in the form of bamboo, leafy plants and shrubs and a host of flowers and fruits.

CONSERVATION HISTORY OF KANHA NATIONAL PARK

An area of 250 sq. kms. from a part of the Banjer valley (Kanha area) lying in Mandla district was first constituted into a sanctuary as early as 1933. Further an area of about 300 sq. km. in the Halon valley in Balaghat district (Supkhar area) was also likewise constituted into a Sanctuary in 1935. In the sanctuary of Banjer valley, the wildlife remained protected, albeit with fluctuating fortunes. At one time 250 deer were allowed to be shot every year in the sanctuary for reasons of damage to sal regeneration and nearly 30 tigers were allowed to be shot between 1950 and 1952 to a favoured Shikari under a special licence. The latter occurrence caused great public resentment and this brought about the conversion in 1955 of the sanctuary into the Kanha National Park (250 sq. kms.) under a special statute. By two expansions in 1962 and 1970, the park assumed a size of 446 sq. kms. until 1972, however, the wildlife conservation effort was restricted to protection of the central part around Kanha. Stock grazing both from cattle camps and the adjacent villages was heavy. The central part nevertheless had teeming herbivore population and a fair density of predators. An adjoining sanctuary in the Halon valley was, however, disbanded shortly after its constitution on public demand for reasons of damage to cattle living in camps inside the forest by the carnivores. The latter treatment meted out to the Supkar forests was highly detrimental to both the tree crop and the wildlife in that forest village settlements were allowed to grow beyond rational limits and permanent cattle camps were allowed to mushroom in the area. As a result the habitat degenerated considerably, tiger and leopard population succumbed to elimination by poisoning of cattle kills, so much so that as per the 1972 Tiger census none were left in the Supkhar area. This was of course

preceded by a far reaching decline in the status of prey herbivores. In 1972 the State Government sanctioned an independent Forest division for the management of this park. This was thus the beginning of the intensive conservation effort in the park. Protection and developmental management was also extended to the part (Mukki valley) added in 1970 to the park from across the ridge in Balaghar district. The Park came under the project Tiger in 1974 when the Supkhar area was again included in the newly formed Kanha Tiger Reserve to give it, its present extent.

In all, there were 40 villages in the National Park in 1974 of which atleast 20 were situated in the interior of the Park. Not only these caused a serious disturbance but the cattle from villages caused a heavy grazing pressure in the vicinity. These interior villages also occupied a large part of the potentially capable wildlife habitat which also carried the perennial water holes. The existence of these villages was therefore, a significant limiting factor in the development of habitat and wildlife. A programme of reallocation of villages was initiated in 1975-76 but only 5 villages were moved out during that year. Thus, at the beginning of the period under review 15 interior villages still remained inside the park. These domestic cattle take part to spread epidemic in wild animals specially in herbivores.

The park carries the typical fauna of the peninsular sal forest. The main herbivores are the Chital, the Sambar, the Barasinga, the Muntjac, the Black Buck, the Chousinga, the Gaur, the Nilgai and the Wildpig. Apart from tiger, the main predators are the leopard and wild dog. Hyena and Jackal are the chief scavengers whereas sloth bear is an omnivore.

PHYSICAL CHARACTERISTICS OF THE GAUR :

The Gaur is the largest amongst the world's wild oxen. In appearance the gaur is dark brown to black animal with a bulky body and huge shoulders. The legs and feet appear small considering the weight they have to carry. A bull gaur has a massive yet rangy body. Adult bulls have a shiny black, short-haired pelage, except for white stockings, a grey boss between the horns, and rust-coloured hair on the inside of the thigh and forelegs. The hair is seen to be dark chestnut brown, sometimes a deep purple brown or almost brown. The hair about the armpits and groins is golden brown, and the legs

from above knees and the hocks to the hoofs are white or ashy grey. Young bulls are dark brown like the cows. There is a conspicuous dorsal ridge, formed by the extension of the spinous processes of the third to eleventh vertebrae, which terminates abruptly near the middle of the back. A small dewlap hangs below the chin, and a large one drapes down between the fore-legs. The heavy horns sweep sideways and upwards. The horns of young bulls are smooth, yellow-orange in colour, and tipped with black and pointed, whereas those of old bulls are corrugated, a dull olive in colour, and sometimes frayed at



Fig. 3. Gaur-group : Kanha National Park : Note—Two culves in the middle, one yearling at extreme right. Head at extreme left is probably young Bull whereas left foreground is a young or sub-adult cow. Photo—H. S. Panwar

at the tips. The males are about one fourth larger than females. The horns in the males especially are strong and at the base are slightly curved downward, they bent backward and up with the tips inward. In old males the horns often are considerably shorter from wearing out by use. There is a high bulging fore-head ridge between the horns. The face is stretched with a long muzzle which appears to be indented in upper part, and a nose bent forward. In adult males the dewlap consists of two parts at the chin and throat and there is a huge hump over the withers.

Cows are considerably smaller than the bulls, and their dorsal ridges and dewlaps are not prominently developed (Fig. 3). The pelage of cows is dark brown in colour and the horns are slenderer, more upright and with a more inward curve than those of bulls. A tuft of brown-black hair forming a 'goatee' was seen in the lower jaw of one adult cow in Supkhar recently. Sub-adults and (Figs. 3 & 4) yearlings are brown-black in colouration as well as young calves have a light brown coat and lack the conspicuous white stockings, which do not appear until they change into a dark brown pelage at the age about



Fig. 4. Sub-adult Gaur. Sex undetermined. Photo—S. M. Hasan

three months. The hair of the gaur is short and close fitting, and in old bulls is often scanty. The colouration on the body is due to the pigmentation of the skin itself and is independent of the hair. The tail is comparatively short and furnished with black tassel.

MEASUREMENTS

General measurements of the HRL (Head Rump Length) from nose to base of tail or end of body) is 260-330 cms. The TL (Tail

length) is about 85 cms. the height at the shoulders is 165-213 cms. length of horns, 60-75 cms. distance between the tips of horns upto 120 cms. The horn length of one of the largest bulls seen at Kanha which was killed by a tiger was 60 cms. (Schaller, 1967) ; the world record is $31\frac{1}{2}$ " or 79 cms. (Ward, 1922). Recorded weights of bull, shot in the wild are as follows :

1,297 ; 1,720 ; 1,908 ; 2,049 and 2,071 pounds.

(Meinertzhagen, 1939 ; Moris, 1947). One cow weighed 1,546 pounds (Meinertzhagen, 1939) ; another cow which was found dead at Kanha weighed 969 pounds excluding blood and one light brown young, just killed by a tiger, weighed 95 pounds (Schaller, 1967).

POPULATION DYNAMICS

Gaur are shy creatures and extremely wary of man. It is seldom possible to approach within 150 metres unobserved. Closer approach is possible only unobserved and the animals react with a loud snort when alarmed by man and disappear in no time in dense cover where observations are not possible. Even on elephant back a much closer approach is not possible.

Ageing of individual animals is not possible except to the extent of the year's calves which are light tan colour, the yearlings which assume the darker colour. Sub adults marked by incomplete growth of the body and the dorsal ridge and adults. Adulthood comes in 4-5 years.

In the adult the sexes are clearly discernible. The males have a massive build, a higher dorsal ridge, a wider head and higher born boss. The horns are also wider and thicker. In the sub-adult stage the identification of the sexes possible only after close approach. In yearlings and fawns it is not possible to determine the sex from a distance.

Our estimates of the Gaur population in Kanha are based on observations *i.e.* visual sightings in the various of the study area (Fig. 5) from January to June 1978. It was found that April to June are the best month for observation as the herd come down to the valleys in search of grazing and water and migrate to the uplands after the first few showers of monsoon.

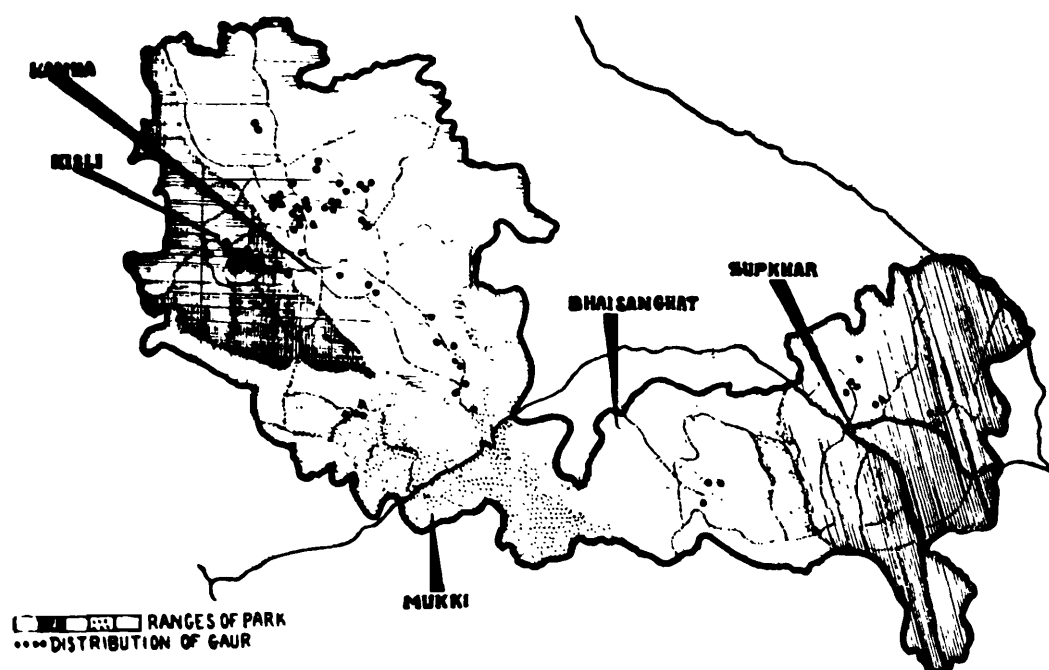


Fig. 5. Distribution pattern of Gaur in Kanha National Park.

Although Gaur are widely peripatetic, our observations indicate that the herds can be identified by their composition especially the number of cows. The number of bulls and yearlings/calves varies due to difficulties of observations, straying of bulls and/or predation in case of the younger individuals. This coupled with the home ranges of the herds, which overlap to some extent gives a fairly reliable estimate of the herds indigent in an area.

Table 1 depicts the number of observations recorded and the number of observations included in totalling the count. Some observations of the same herd which were repeated on a different date have been eliminated (Cols. 2, 3, 4).

Herd size : Fig. 6 shows the frequency distribution of the observations by herd size. A total of 104 observations are considered of which 18 are of solitary bulls. The graph shows an unusual depression for herd sizes of 7, 8 and 9 individuals and two smaller depressions at 4 and 5 and 11 individuals. These depressions are probably due to insufficient observations. The dotted line in the figure represents the theoretical expected frequency distribution and indicates that the most frequent herd sizes at this time could be of 6 to 7 individuals. Larger herds of 16, 22 and 24 animals have been observed just once and are probably conglomeration of smaller herds which separate soon after

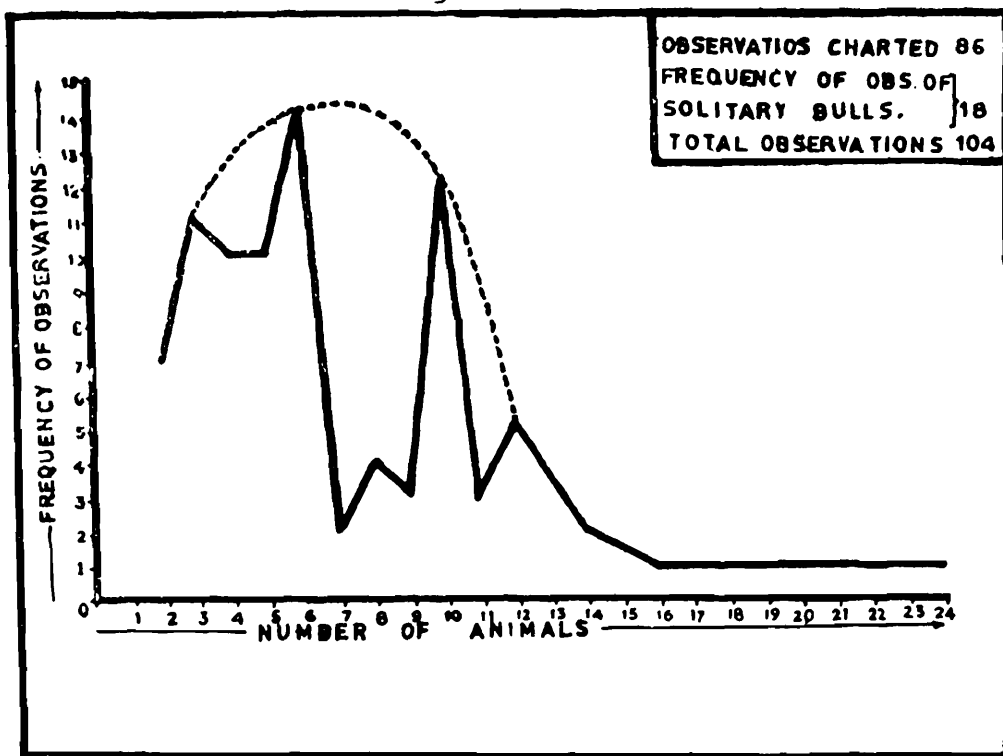


Fig. 6. Frequency distribution of numbers of Gaur in herd.

into their smaller units. It is to be noted that the total of the herd observations is far above the total estimated population of gaur. This figure only indicates the herd-size tendencies.

Schaller's observations on herd size in Kanha in 1964 indicate average size of herds varying from 5.5 to 10.5 animals, the size increasing from January to May 1964 and remaining at the higher level from June to December that year. The maximum sizes of the herds varied from 10 to 29 animals during the same period. Schaller does not indicate the frequency of the herd sizes but our observations do not go contrary to his and indeed supplement them. This also indicates that the rinderpest epidemic that took a heavy toll in 1976-77 (Fig. 7) did not cause any change in the herd-size is determined at the lower end by the minimum strength needed to defend against predators and on the higher end by the availability of fodder and forage at one place for the herd. Further observations on this point will be recorded in the course of our future work.

Herd Composition : A total of 69 herds have been identified and 397 individuals are counted as Gaur population of the study area. Of these 18 are usually solitary bulls. 73 bulls are in herds and cows are

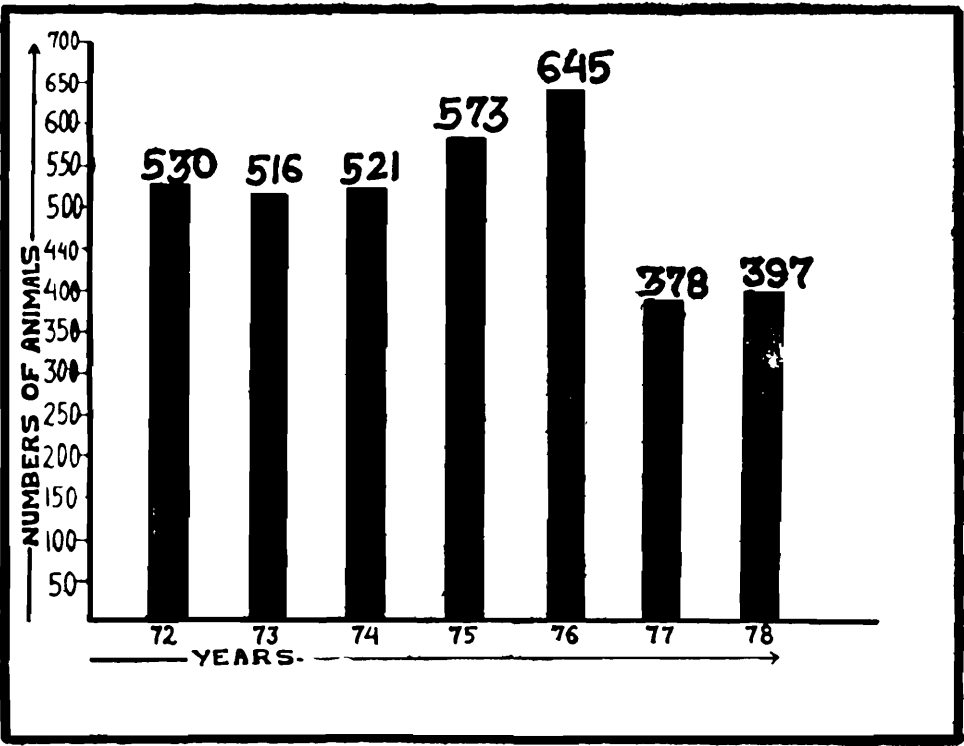


Fig. 7. Gaur population trend 1972-78.

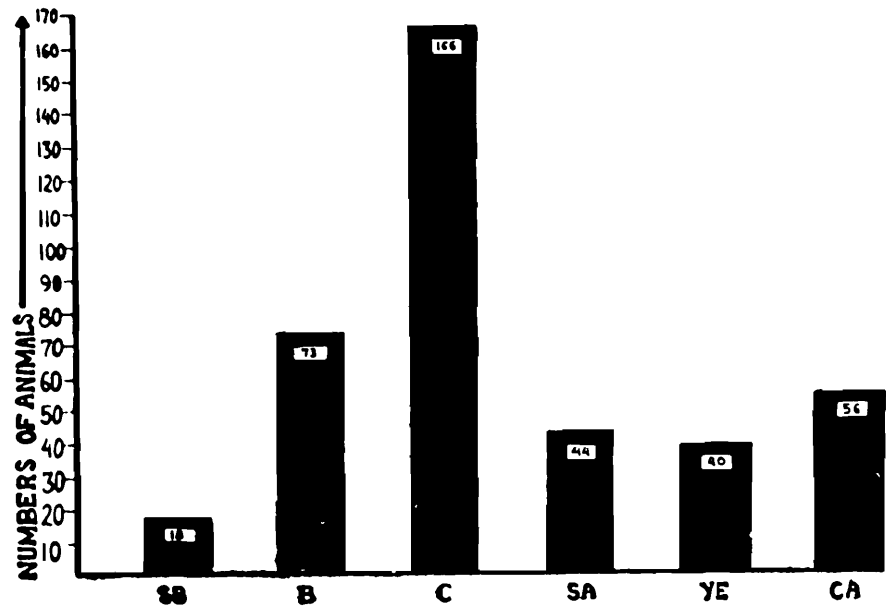


Fig. 8. Proportions of solitary bulls (SB), Bulls (B), Cows (C), Sub-adults (SA), Yearlings (YE) and Calves (CA).

166 with 44 sub-adults, 40 yearlings and 56 calves of the year (See Fig. 8) giving a ratio of 45 bulls to 100 cows. Gaur are polygamous and the low ratio of bulls to cows is not likely to adversely affect

growth of the herd. However, Schaller states that the percentages of males to females amongst calves is half and half, and therefore, the causes of reduction of the adult male : female ratio in herds needs further investigation. Selective predation on males being an unlikely possibility, poorer resistance to other decimating factors, notably disease suggests itself as a likely cause.

Solitary Bulls : The general impression is that the solitary bulls are outcasts from the herds. The solitary bulls of Gaur all appeared to be of full growth and heavy build and often of advanced age as judged from the condition of the horns. We have not observed the process of separation of any individual from the herd. Fights between males have been reported by field staff of Kanha but the reasons and the conclusion of the fight have not been observed. Fights are apparently not very frequent. Whether the separation from the herd is sexual rivalry and defeat or temperament of the older animals is not certain. It is well known that the solitary bulls are often vicious. They are apparently unafraid of any predators and they retire to very dense cover for their daytime siesta, and are difficult and dangerous to observe on foot.

Sub-Adults and Yearlings : In yearlings we have considered the calves of the previous season's birth, and sub-adults are the births of the two years prior to that. The Gaur seem to reach maturity in their fourth year. Mortality among calves is mainly due to predation by tiger. Predation by wild dogs could be expected but has not been observed by us or even the field staff of Kanha though packs of wild dogs (*Cuon alpinus*) are indigent in Kanha. The sub-adults are early the most alert and most timid of all the individuals as they are no longer in the protection of their mothers and are not yet confident of their might against enemies. It is they who move away first at the sight of man.

REPRODUCTIVE POTENTIAL

The wet udder ratio seems to be 33% in 1977 and 1978 counts of calves born. It is higher in 1976 apparently because that was the year of the epidemic in the herds and the count could be biased on that account.

Schaller however, gives a calf percent of 39 to 45 for January to June which is higher than our observations. As our observations were

recorded from January to June, whereas calving season is at peak from September to March, there is a chance that some calves were not born in the earlier phases of our observations. Our calves, however, were all under one year of age whereas the age of Schaller's calves probably spread over the second year also.

The Gaur population of Kanha (Fig. 7) shows an uncanny stability between 1972-1974 (530, 516, 521). The reasons for this stability could only be that the habitat was incapable of supporting any more. There are, however, no visual indications that this is the cause. Unfortunately the analyses of the population by age in these counts by the forestry staff are not complete or reliable and no inference is possible from these data.

The count of 1975 shows a 10% increase over the total population of the previous year, and that of 1976 shows a 13% rise. This census was followed by the rinderpest epidemic of 1976 and the population suffered a loss of 41.4% of its numbers, as shown in the 1977 count. There is a 5% rise in the population in the year between the 1977 and 1978 count.

The Supkhar area was added to the park in 1974 but the area was apparently unstocked as far as Gaur is concerned. The count after 1974 include the added area and it is apparent that the improved conditions of the grazing range are attracting the Gaur as they have been found in the new areas quite frequently.

The herds were visible most frequently between the hours of 5 A.M. to 6 A.M. and 5 P.M. to 7 P. M. from usual human movement routes, as they returned to heavy cover in the morning and came out in the evenings to graze. The maximum frequency of observations was in May 1978 when water scarcity forced the animals to move to the lower reaches where water was available in the streams.

Inter Specific Relationships : Gaur share their habitat with Sambar, Barasingha, Cheetal and Smaller Deer *e.g.* the Muntjac and Chevrotain (See also Fig. 7). Though large numbers of Gaur succumbed to rinderpest, none of the deer were affected. Table 2 (Fig. 9) shows the ratio of growth of the associated species. The 139% increase in Sambar population in 1973 is the result of addition to the park area which was apparently well stocked with Sambar, though not Gaur. In subsequent

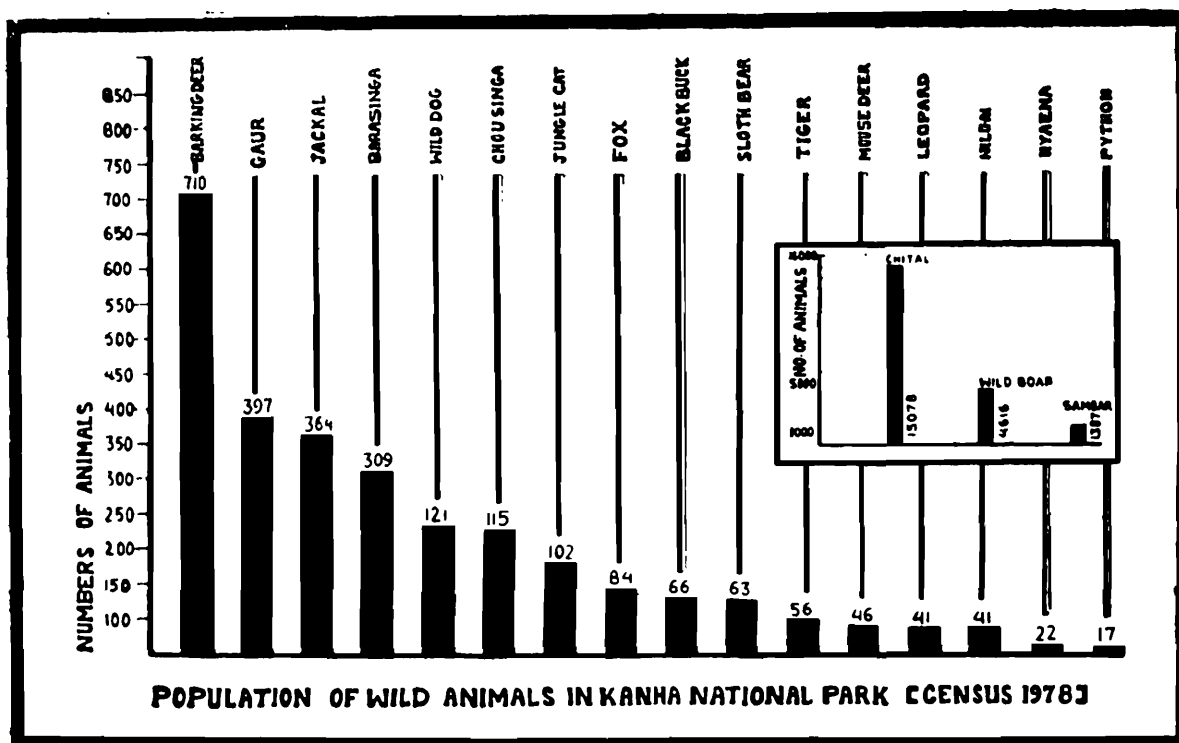


Fig. 9. Population of Wild animals in Kanha National Park (Census 1978).

years the rate of growth is 22%, 12%, 3.6%, 9.1% and 11.6% respectively. The Cheetal show a rise of 26%, 16% and 28%, in 1973, 1974 and 1975 probably due to addition of area. The growth rate of the Cheetal shows a remarkable decline to 7.9%, 8.8% and finally 1.9% from 1976 to 1978. The decline is too steep to be attributed to census errors. The Barasingha show a rising trend of growth in percentage until the 1978 census when the growth drops from 30.3 and 31.6 of two previous years to 9.18%.

Leopards and Tigers show continuous increase in percentages of accrual.

No instances were seen of Gaur trying to exclude older associates from their grazing land. The reaction of two adult male Gaur to a calling tigress about 25-30 metres from where they were grazing, was of supreme indifference, though all lesser creatures like Cheetal, Sambar and Langur were voicing their alarms. The two Gaur calmly continued with their grazing while the tigress called and proceeded to her destination. On one occasion a barking deer called in alarm at the sight of a solitary gaur. Sambar are frequently associated with Gaur, the latter probably act as a safety cover for the Sambar against predators.

MORTALITY

Mortality among Gaur is mostly due to old age infirmity when adults are targets the lesser predators and scavengers a short while before death. Predation is an important factor only in the earlier stages upto sub-adults when tigers and leopards take an occasional toll. Poaching in Kanha is at a minimum and only rarely does an adult or sub-adult fall a prey to poachers when they move out of the park. Accidental deaths are unknown. By far the most important cause of mortality is disease, and rinderpest has been repeatedly found to decimate Gaur populations in all parts of the state including Kanha. As no regular censusing of wild life is carried out in other parts of the state a wider study of effects of disease on Gaur populations has not been attempted.

CONCLUSION

As given earlier, this is an interim report of our continuing observations on the Gaur in Kanha National Park, M.P. We have found that observations on gaur are rendered extremely difficult due to the very shy nature of the wild animals and limited to daylight hours so far. Night observations will be done on moonlit nights on specific herds in future to determine other aspects. The population trends will now be studied at time and period most suited for elimination of errors. This, first year has given us experience of how to deal with this animal in the wild.

ACKNOWLEDGEMENTS

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We are also grateful to Dr. Ravi Prakash, Vice-Chancellor, Bhopal University, Bhopal, for encouragement.

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Table 1 : Estimated Population of the Gaur in Kanha National Park—Jan. to Jun. 1978

RANGE	Frequency of observations			No. of herds observed.	Total	Number of animals (Gaur) in Herds						Remarks
	No. of observations Cited	Calculated	Omitted			Solitary Bulls	Bulls in herds	Cows in Herds	Sub-adults in Herds	Year-lings in Herds	Calves in Herds	
KANHA	59	41	18	41	234	11	45	100	25	19	34	The range boundaries are administrative only and do not represent ecological units. Migrations between Ranges are frequent.
KISLI	18	10	8	10	70	1	9	27	9	10	14	
MUKKI	13	9	4	9	36	2	7	15	6	1	5	
BHAISANGHAT	2	2	0	2	10	1	3	4	2	—	—	
SUPKHAR	13	7	5	7	47	3	9	20	2	10	3	
Total for the Park	104	69	35	69	397							
					Number	18	73	166	44	40	56	
					%	4.4	18.4	41.8	11.1	10.0	14.2	

Table 2: Total Number of Animals/Percentage Increased/Decreased over Previous Year Since 1972-78.

Species	1972	1973		1974		1975		1976		1977		1978		Remarks
	No.	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Gaur (<i>Bos gaurus</i>)	530	516—2.6		521+1.0		573+10		645+12.6		378—41.4		397+5		The decline in 1977 is due to rinderpest in August 1976.
Sambar (<i>Cervus unicolor</i>)	336	803+139		981+22.1		1099+12		1139+3.6		1242+9.1		1387+11.6		The steep rise in 1973 is due to accretion from other areas.
Chital (<i>Axis axis</i>)	6728	8477+26		9837+16		12596+28		13597+7.9		14800+8.8		15078+1.9		The rate of rise seems stemmed due to holding capacity of deital habitats.
Barasinga (<i>Cervus duvauceli branderi</i>)	96	118+23		138+17		165+19.5		215+30.3		283+31.6		309+9.18		The reason for low rate of increase in 1978 is not clear.
Wild Dog. (<i>Cuon alpinus</i>)	33	54+63.6		49—9.3		84+71.4		111+32.1		108—2.7		121+12		Temporary decreases in 1974 and 1977 are due to either migration or counting errors.
Leopard (<i>Panthera pardus</i>)		24				30+25		36+20				41+14.6		Percentages refer to increase since last figures and not annual increase.
Tiger (<i>Panthera tigris tigris.</i>)		40						48+20				56+16		

Additional areas were added to the Park in 1974 and first counted in 1975, but count + INCREASED
indicates that the areas were not well stocked with game. — DECREASED

POPULATION STUDIES ON INDIAN DEER (Artiodactyla : Cervidae)

By

H. KHAJURIA

INTRODUCTION

The Indian Cervidae include eight species with fourteen subspecies and is considered as one of the most important group of game animals. They include such magnificent species as sambar, one of the largest of the existing deer ; the swamp deer with one of the most beautiful antler ; Cheetal with one of the most attractive coat among the tribe ; the Kashmir stag and the shou, the representatives of the famous European red deer ; the highly specialized musk deer, and the ancestral deer species, the barking deer. The brow-antlered deer and the hog deer appear related to the swamp deer and cheetal respectively. The mouse deer belongs to separate family and is not discussed.

Because of excessive exploitation mainly by poaching and destruction of their habitats, many species have become very rare and at least three subspecies (*Cervus eldi eldi* McClelland), *C. duvauceli branderi* Pocock and *C. elaphus* Warrge are on verge of extinction. The need for detailed population studies on these animals has long been keenly felt for the purpose of proper management. The paper discusses the present position of the subject with special reference to author's original work on Central Indian Swamp deer.

There has been apparently no attempt to study the population of the barking deer.

II. Remarks on methods of investigation

In any population study, it is necessary that census figures available should be fairly accurate. The best procedure to achieve this objective appears to be to devise as many reliable census methods as possible for a particular species and apply them through different parties to compare the results obtained. If the error in figures obtained by different parties is too such, the method should be rejected but if it is low the mean values of the figures should be obtained. If it is not possible to devise morethan one reliable census method, the same

method should be used repeatedly (repeat census) by at least three parties independently and mean values should be obtained. The census can also be used to locate limiting factors by censusing the population frequently at least once in each season to pin point the time where abnormal increase or decrease in population has taken place. After locating the period, the limiting factors can usually be found in three principal activities of the organism: (1) protection against enemies both living and non living, the latter including abiotic factors; (2) procurement of food including water; and (3) reproduction. The fourth important activity is rest and recreation but this need is usually fulfilled if first three are satisfied. It is also necessary to obtain advice of a biometrician before obtaining census figures so that pertinent data is collected. During our study swamp deer census was taken independently by two parties by drive census and direct counts. The result more or less tallied. It is generally not possible to obtain accurate pertinent biological data in the wild. It is advisable to keep the animals in large enclosures near their habitat to obtain data on sex ratio at birth, age of maturity, frequency of births, number of young in a litter, breeding age, etc. This data is necessary in calculating potential and actual increase in size of population, etc. In Kanha National Park such an enclosure exists at present and was used for intensive study of the swamp deer. In the absence of such an enclosure the study can be carried in Zoological park/garden.

I have not been able to find out any equation which will give potential increase in deer population in a fenced enclosures when all adverse factors have been eliminated. A figure of potential increase should be the target of wild deer manager as the excess population can be harvested before the pinch period even in National Parks and sanctuaries by using attractants such as food and water during pinch period outside the boundaries of such areas and by other measures (Giles *et al.* 1971).

It is further necessary to harvest individuals which have passed the peak of breeding activity. Such individuals could be distinguished by tying suitable bands to the young after tranquilization (Herbert, 1972). The great economic value of deer will, it is hoped, will fully compensate for labour spent on such techniques.

A figure approximating to potential increase may be possible by

manipulating different factors (Giles *et al* 1971). However, population of the swamp deer in Kanha National Park has not reached the stage where its harvesting can be advised. Potential increase is possible only if the enemies of the species in question have minimum density. The minimum density which needs definition, appear to be that below which the population automatically goes on decreasing because of insufficient gene pool, reproductive difficulties, etc. This minimum density appears different in different species. There does not appear to be any harm if a dangerous parasite is totally eliminated gradually after proper ecological study after the manner of natural elimination so that its place in ecosystem is occupied by some other organism, without disturbing the ecosystem. Such enemies of the swamp deer are still under study.

The natural proportionate carrying capacity in pinch period can be modified by increasing the number of a species at expense of less useful one. For example swamp deer can be increased at expense of cheetal in Kanha National Park but this is not being done at present.

I am grateful to the Director, Zoological Survey of India, and Forest Department, M. P. for facilities during the work.

III POPULATION STUDIES

The Central Indian swamp deer or hard-ground barasingha *Cervus duvauceli branderi* Pocock

Pertinent biological data :

The Central Indian swamp deer originally occupied a very large area mainly south of the Narbada and North of the Godavari rivers from Orissa coast to Gujarat in the west. Its presence in Gujarat is indicated by prehistoric remains.

The deer obviously belong to the group of animals which migrated south during glacial periods (Hora, 1949) but was unable to reach more humid areas of western ghats as the aridity appeared ; but got adapted to more arid conditions by evolving into a distinct subspecies.

The range of this deer gradually shrunk and at present it is apparently confined to Kanha National Park, Madhya Pradesh, as there are no authentic records of its occurrence elsewhere in the last few years. The animal is mainly a graser and most of its food consists of grasses, e.g., *Bragros is gangetion*, *Saccharus spontancum* and *Veliveria ziga-*

nioides and water weed, *Naias* a., (Schaller, 1967). It also feeds on leaves. Its preferred habitat is tall reed grass.

The peak of breeding session starts in winter in December and continues upto January. A single young is dropped usually after rainy season with a gestation period of about $8\frac{1}{2}$ months on alternate years. The age of maturity of female is about 3 years. The sex ratio at birth is about 50 : 50. Besides man, the chief enemy of the adult deer is the tiger. The fawns may be preyed upon by a number of smaller carnivores. The chief protection against these enemies is the tall thick grass as the deer inhabits open places. Some parasites have also been reported by Schaller (1967). The mature stags are found of bathing and wallowing in water particularly during the rutting season and thus plenty of water is a necessity. The animal lives in hards of varying sizes.

Population studies :

The figures obtained by drive census and direct counts are given in Table I. for seven years as available in forest records.

However, Shaller (1967) who censused the population very carefully in 1964 and 1965 gave the following figures :

1964 — Total population ; 84 : ad. ♂, 37% ; yearling ♂, 7% ; ad. ♀, 44% yearlings ♀, 5% ; fawn, 7%.

1965 — Total population ; 55, ad. ♂, 41%, yearling ♂, 6% ; ad. ♀, 40% yearling, ♀, 6%, fawn, 7% ;

Our figures for the year 1971 during which the study was carried out is 82 for total population and this along with age and sex composition more or less tallies with figures given by forest department.

The important points to be noted is very small population, low fawn production and sex ratio favouring females.

Limiting factors with remedies

i) *Poaching*—Because of beautiful antler of the stag, the habit of the species to collect in large hards in open, and tribal population, poaching appear to have played considerable part in reducing the population to verge of extinction. That poaching can considerably be stopped by proper measures is evident from the example set by

Table 1: Analysis of census figures of the swamp deer in Kanha National Park.

Year	1965				1966				1967				1968				1969				1970				1971			
	Population	Male	Female	Fawn	Population	Male	Female	Fawn	Population	Male	Female	Fawn	Population	Male	Female	Fawn	Population	Male	Female	Fawn	Population	Male	Female	Fawn	Population	Male	Female	Fawn
Number	109	26	69	14	116	29	69	18	181	47	112	22	98	19	56	23	70	16	34	20	66	13	46	7	88	26	43	19
As Percent- tages of total population	—	23.9	63.3	12.8	—	25.0	59.5	15.5	—	26.0	69.1	12.2	—	18.4	57.1	23.5	—	22.9	48.6	28.6	—	19.7	69.7	10.6	—	29.5	48.9	21.6

staff attached to Kanha National Park whose strict vigilance appears to be responsible for increase in population of this deer. Selective poaching and predation on stags appears to be responsible for uneven sex ratio. Stags are preferred by poacher because of large size and antlers and by predators because they get injured during fights. They also appear to be less vigilant.

ii) *Burning of tall reed grass*—This grass was burnt every year to promote fresh tender growth but it is the real habitat of this deer which is indispensable for giving it protection particularly to the young because of its herding habits in the open. The burning operation has now been greatly reduced.

iii) *Concentration of predators in preferred habitat*—To attract tiger for visitors, the baits used to be tied in the preferred habitat of the deer. Many smaller predators also fed on the remains of kills and also the deer, particularly the young. Predators have now been dispersed by tying baits elsewhere.

iv) *Herd pinch period*—The pinch is during summer when there is scarcity of fodder and water. This can be overcome by providing artificial reservoirs of water in different places. The feeder can be tied at suitable height so that competition with Cheetal is avoided.

v) *Collection of detailed data*—This was not available in the wild but now a large enclosure has been constructed inside the park and the study is underway.

vi) *Cattle menace*—Large number of cattle used to graze in the park. Besides reducing fodder, they were source of spread of disease. This menace has now been reduced by shifting forest villages outside the park.

vii) *Wild dogs*—There is a wild dog menace in the park. Their number has to be reduced by offering suitable reward by shooting only with .22 gun so that other animals are not much disturbed.

viii) There is too much disturbance in the park not only from the visitors but also from construction work. The latter should be spread over the whole year.

ix) There is no regular research unit and veterinarian attached

to the park. These should be provided.

x) To avoid risk of fire inside the enclosure and elsewhere adequate fire lines should be cut.

xi) There should be proper publicity in form of posters particularly in villages and centonment areas to obtain co-operation of villagers and army.

The Brown-antlered Deer
Cervus C. eldi

Pertinent biological data :

At present the animals occupies very curious habitat, a floating mass of aquatic vegetation locally called 'phusdi' with reeds growing upto about 3 mts. near the shallow shores of a large lake called Logtak near Manipur city, in Lamjao sanctuary. The animal is reported to occupy scrub jungle or area between hills and rivers devoid of high hills over a large area in Manipur state. It appears to feed on aquatic vegetation found in its peculiar habitat. Sankhala and Desai (1971) has given an account of its breeding habits in captivity. Because of its great rarity and inaccessable habitat, it is very difficult to obtain its accurate data in the wild. Mating takes place in March-April. The gestation period is 240 days. A single young is usually born every year. At present its principal enemy is man. The age of maturity of females is about three years.

Population study :

Singh (1975) estimated only 14 deer, 5 males, 6 females, 3 fawns. Gee (1960) gave a rough estimate of 100. The deer in fact was reported to be extinct in fifties. The principal limiting factors are poaching and destruction of habitat.

The Kashmir stag or hangul
Cervus elaphus hangul Wagner

Pertinent biological data :

The deer is a race of European red deer and is a typical high altitude animal seldom descending below 1800 mts. It is confined to Western Himalayas to the north of valley of Kashmir and in some nearby areas. Its strengthhold is the Dachigan sanctuary. It feeds

mainly on high altitude vegetation mulberry and haw thorn leaves are reportedly preferred in captivity. This deer can be kept only in semi-captivity in large enclosures and, thus, detailed data on its breeding habits is not available. The rut starts in October to November and fawns are born in May-June. The gestation period is 230-240 days. The age of maturity appears to be about three years as in the red deer.

Population study :

The forest department figures which are mere rough estimates are as follows :—

<i>Year</i>	<i>No. of deer in Kashmir state</i>	
1900	3000-5000?	
1947	1000-2000?	
1954	300?	
1957	400?	
1958	550*	
1960	250*	KEY ? Indicates my own estimate
1962	360*	* Indicates official 'census' figure
	200?	
1965	280*	

There appears to be a large percentage of error in these figures. It is better to quote Schaller (1969) who states as follows :

I am unable to give an accurate population estimate, but agree with Gee (1966) that there are probably 180 or fewer hangul left in existence.

Of the 86 deer observed, 44 were stags, 29 were hinds, and 13 were fawns, giving ratios of 151 males : 100 females ; 45 young. Thrity-eight of the stags were large (antlers with 8 to 12 points), 2 were small (6 points), and 4 were yearlings (2 points). The male to female ratio probably does not reflect the population composition accurately because roaring stags are more easily spotted by the observer than the silent hinds. Males and females appeared to be present in about equal numbers. Stockley (1936) noted a male to female ratio of 30 : 100, and a census in 1965 gave one of 9 : 100 (Gee 1966), but the accuracy of the latter figure is questionable. Nearly half of the hinds were accompanied by young, indicating good fawn production and survival. Red deer hinds give birth to

their first young when 3 or 4 years old and then either breed each year or in alternate years (Darling 1937), a pattern probably followed also by the hangul. Some hinds in my sample may have been yearlings and had not yet given birth to their first young, so the percent of fawns in relation to adult hinds would be somewhat higher than indicated.

Limiting factors : Poaching mainly by nomadic herdsmen who carry fire-arms for self protection.

4. The sambar (*Rusa unicolor* Kerr)

Pertinent biological data :

The sambar is widely distributed in South-east Asia and occurs practically in whole of India excluding high altitudes, Sri Lanka, Nepal, Bhutan, Bangladesh, Burma, Malaya, Thailand, Indo-china, Phillipines and East Indies. Three races have been recognised. It is a wary forest animal and one of the few animals which has been able to hold its own again man despite large scale destruction of its habitat. Forest near cultivation and water is preferred. It is mainly nocturnal and a browser. It feeds on great variety of grasses, leaves, fruit, Schaller, 1967. Rut starts in November-December. Fawn, usually one is dropped in May, July each year. The age of maturity appears to be about two years. They associate in small herds.

Population studies :

The census figures of M. P. forest department Kanha obtained by driver census over a number years are given in table II.

Table II. Forest department census figures for Sambar in Kanha National Park.

Year	1938	1958	1959	1960	1961	1962	1963	1964	1965
Number of animals	324	36	52	96	87	194	126	77	139

Schaller (1967)'s figures are given in table III.

Table III. Age and sex composition of 363 Sambars in Kanha National Park.

Ad. O	Yearling O	Ad. O	Yearling O	Fawns
14.9%	3.5	51.4	9.8	20.0
(29.7%)			(33.7%)	
of ad. O			of ad. O	

The figures shows adverse sex ratio in favour of males from yearling stage, good fawn production and survival. The disproportionate loss of males from yearling stage appears due to predation and poaching possible because of holder behaviour of males as shown by data provided by Schaller (op. cit) who recorded 20% more kills of males than females in a population in which males were only 30% while in case of cheetal and Barasingha the kills were proportionate.

Limiting factors : Poaching & habitat destruction.

5. The Chital or the spotted deer *Axis axis* (Erxleben)

Pertinent biological data :

The chital is also widely distributed in Indian subcontinent from Himachal Pradesh to Assam along the Himalayas upto 100 mt. alt., India, Nepal, Bhutan, Bangladesh in the South upto Sri Lanka. It is absent in desert areas. It prefers fringes of forest, generally moist deciduous and dry deciduous with water and grass. The food consists of a variety grass, leaves and wild fruit and is obtained by grazing and browsing (for details see Schaller 1967). The rutting continues intermittently throughout the year with peaks in certain season which appear to vary in different localities (May in Central India, winter in North India).

They associate in herds of various sizes ranging from a few individuals to several hundreds. They continue feeding during day also. The age of maturity appears to be about one year. The young usually 1-2 are dropped generally once in a year.

Population studies :

Forest department figures are given in table IV and Schaller's figures are given in table V.

Table IV. Forest department census figures for cheetal in Kanha National Park.

1938	1958	1959	1960	1961	1962	1963	1964	1975
2844	1726	1579	1259	1253	1292	1471	623	1196

Table V Population composition of cheetal in Kahna in May-June.

Total	Population	ad. O	Year-	ad. O	Year-	Fawns
Population	density		ling O		ling O	
900-1000	7.5% per sq. 60% per sq. miles in actual area occupied	19%	10%	32%?	10%?	29%

Sex ratio : 70.5 : 100

These figures compare well with those obtained in other localities : Ghana, Vanvihar sanctuaries Corbett national park and from a free ranging population in Hawai.

The following points need emphasis :—

1. The percentages as given by Schaller appear to be reasonably accurate as they are supported by figures in several localities and a free ranging population.
2. There is very good fawn production and survival.
3. The sex ratio is disproportionately in favour of females. The reason for this does not appear to be poaching or predation but due to some genetic factors.

Limiting factors : Poaching and habitat destruction.

6. The hog deer
(*Axis porcinis* Linn.)

Pertinent biological data :

It ranges over the Indo-gangetic plain from Sind (Pakistan) to Burma and Malaya in suitable localities with good high grassy cover near water. It occurs in Sri Lanka also but is absent in South and

Central India. They also occur in scrub jungle and mangroves. The brouse and graze and mainly feed on tender grasses. The rut appears to spread from September to October over about six months with a peak in September-October and usually one fawn is dropped after a gestation period of eight months. In captivity they breed throughout the year with peaks as indicated above. They are found singly or in pairs but in grazing ground e.g. burnt patches of grass as many as 50 have been counted in a plot by the author in Keziranga National Park but these appear to be a temporary association. Age of maturity appear to be 2 years.

Population study :

According to Schaller (1967) sex ratio is about 50 : 50 with 20% fawns.

Limiting factors : Poaching and habitat destruction.

7. The musk deer
(*Moschus m. moschiferus* Linn.)

Pertinent biological data :

It is distributed generally above the pine forest from Kashmir to upper Burma. Their favourite haunt is forest of birch, juniper, spruce, fir and bush rhododendron with proximity of alpine grass lands. In autumn they appear to rest higher up without forest cover in the caves and small protective cavities. They feed in the morning or evening : Each individual appears to have a territory. The food habits are not clearly understood but they do feed on moss, lichen, laurel, rhubarb, celery flowers, buds and roots. They defecate on particular spots and the males whose droppings are scented can be traced by dogs. Important natural enemy is snow leopard. They appear to rut in January-March and usually one fawn is born after a gestation period of about five months. Age of maturity appears to be one year. They are found singly or pairs.

Population study :

Dang (1968) gave very rough estimate of 2000-4000 individuals. The males being under strong hunting pressure and because of the musk easily falls prey to both man and possibly to some carnivores

because of the scented droppings the sex ratio appears to favour strongly females in adults.

Limiting factors : Poaching and habitat destruction.

IV. SUMMARY

The information available on the population dynamics of Indian deer comprising eight species and fourteen subspecies is reviewed particularly in relation to three vanishing subspecies ; the Manipur deer, *Cervus eldi eldi* McClelland, the Central Indian swamp deer, *C. duvancelli branderi* pocock ; and the Kashmir stag, *C. elaphus hanglu* and with special reference to author's own work on Central Indian swamp deer. The information, it is hoped, will help in the sound management of these important game animals which are keenly sought after for their meat, hides, antlers, trophies and recreature values.

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Fig 1. Sambar stag in its prime (Renuka) ;
Fig. 2. a herd of Sambar (Renuka) ; deer in Kufri High Altitud Zoological Park.



Fig. 3. The musk deer in Kufri High Altitude Zoological Park.



Fig. 4. A herd of central Indian swamp deer in Kanha National Park.

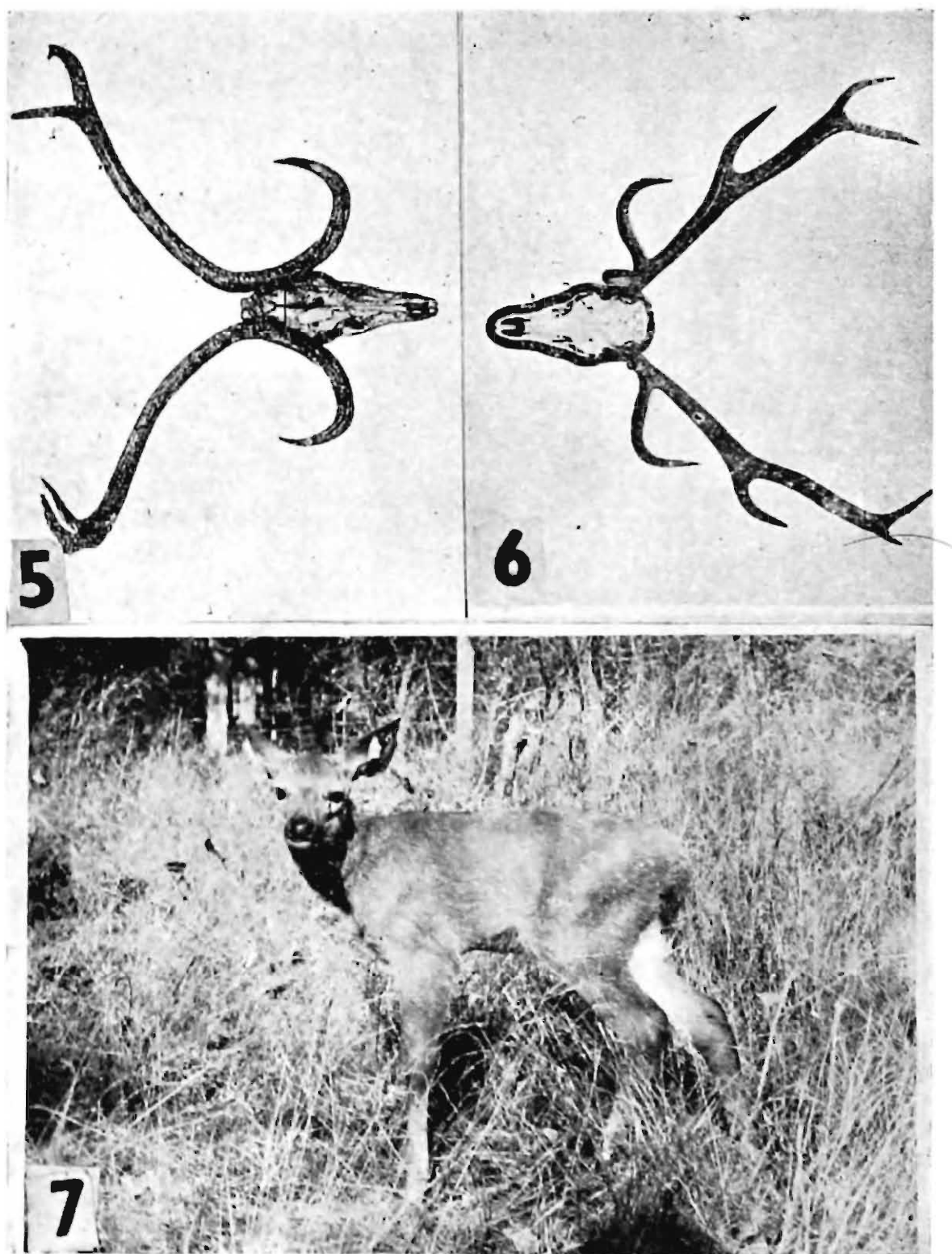


Fig. 5. Antelers with skull of brow-antelared deer. Fig. 6. Same of Kashmir stag.
Fig. 7. The fawn of sambar in Bandogarh National Park.