CROP DEPREDATION AROUND JALDAPARA SANCTUARY BY *RHINOCEROS UNICORNIS* AN INDICATIVE TREND

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Introduction

Replenishing natural diet with agricultural crops is usually associated with bulk and roughage and mixed feeders, generally having a herd composition. Invariably with these animals are involved some kind of migration, either on a fixed long route (e.g. Elephant) or local on a much lower scale (e.g. Gaur) and most depredation takes place during such migratory movement. Others involve large herds multiplied beyond the carrying capacity of the holding forest tract (e.g. Spotted Deer) and unable to meet required energy demands from the resident area have proved a menace to agricultural crops.

Contrary to this general trend, the great Indian One Horned *Rhinoceros unicornis* an individualistic animal with fixed home ranges had never been a habitual crop raider. Contrary to this an incursion to one's field was considered an auspicious omen. Such was the rarity of its visit.

This belief is now a thing of past. Levels of crop depredation by *Rhinoceros* is now a menace, in Kaziranga, where special crop protection forces had to be compulsively created to prevent depredation of paddy fields around the park. If not to similar extents, the crop depredation by Jaldapara Rhinos are also on a sharp increasing trend and is already proving to be a menace in a few pockets.

Significant levels of crop raiding incidence has been noted in 'Torsa East Camp' and 'Moiradanga' specially in two males and one female with young calf from 1985 onwards and in 'Sisamara' since 1989 by two male and one female with a sub adult calf. Frequency of raiding incident is 2 to 3 times a week, unsually between 10.30 p.m. to 3.30 a.m. in the months of September, October and November. The most preferable crop is paddy, in the process of maturing, through the 'Monikarjee Ghat of Khawchang Para' constant raids of pulses have been noticed. Whereas the these animals have become habitual crop raiders, cursory visits by other Rhinos in the area is also on an increase.

Possbile Factors

Reasons for this anomalous behaviours cannot be attributed to one single factor. Various cause effects in itself and also often interdependent on each other have resulted in certain cumulative effects, crop damage being one of them.

Analysis of Cause Effects

(1) *Habitat* : The peculiar trouser shape of the sanctuary, densely populated villages along the periphery (Fig. 1) and subsequent habitat destruction in the forms of illicit felling of trees, firewood and fodder grass removal and cattle grazing in the past had altered the natural ecological balance of the sanctuary. Apart from the direct loss of

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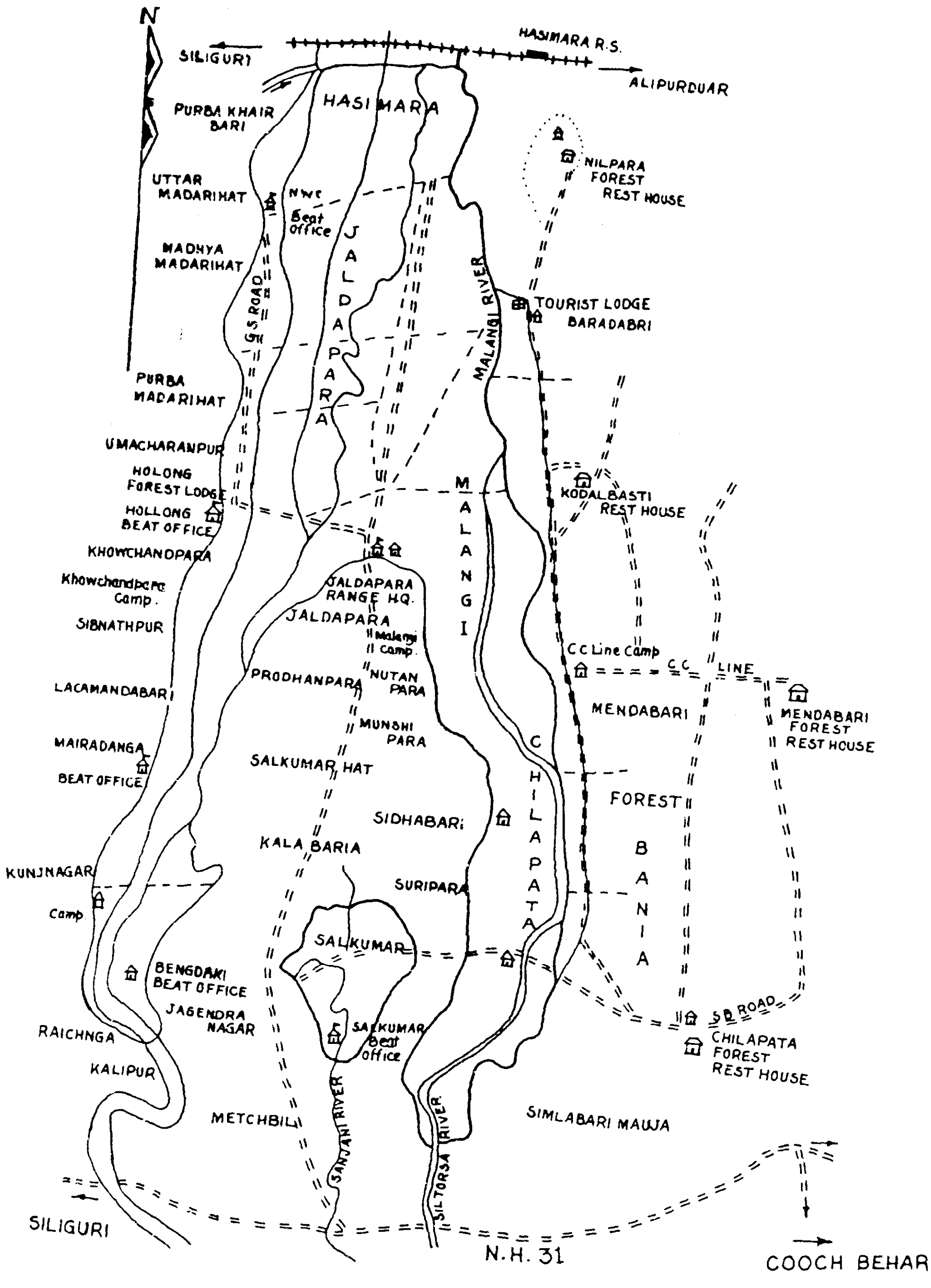
Fig. 1



Location of villages in and around the Jaldapara Sanctuary biomass, after effect of illicit felling has altered the modes of aerophilic seed disposal, thereby resulting in colonization of tree species of short and medium grass beds. Abandoned tops and discarded logs of illicitly felled trees in various stages of decay had resulted in greater accumulation of water and nitrogenous nutrients resulting in wood pockets.

(2) *Stages of Decay* :

(a) *Standing dead* : Trees girdled or half cut, no photosynthetic capability.
(b) *Sound felled* : Recently cut, left lying on ground (upto 1 month)
(c) *Diseased felled* : Pathological condition revealed (Heart rot pocket rot etc.) on felling or left as suchi Invertebrate community present.
(d) *Colonization conditioning Class-I* (residence time 1-2 yrs). Wood moist, Diplopods and other surface inhabiting invertebrates present, blue stain fungi, mycelia of imperfect fungi present.
(c) *Channelization Class-II* (3-4 yrs. residence time). Colonization by channelizing invertebrates, termite, carpenter ants and battles.
(f) *Succession and Secondary channelization Class - III* (4-yrs residence time). Colonization by large number of channelizing invertebrates, others without channelizing mouth parts, soil dwelling microarthropods, earth worm, large amount of faecal material contaminated soil, high diversity of microbial community within channels.
(g) *Maceration Class-IV* (6-7 yrs. residence time). Extensive fungal rizomorphs, root invasion, soil and feacal material clogging chamber, secondary colonizing invertebrates and fungal dominance obvious.
(h) *Incorporation Class-V* (7-8 yrs. residence time). Wood no longer recognizable by species 20-30% soil mixed with wood, mass of mycelia fibrous, and woody rot system colonizing throughout.

Discarded woody material of all these categories are found to the extent of 100-160 ha in the prime Rhino habitat in Jaldapara. The channeling and gradual decomposition of these decayed wood increases the water holding capacity in the form of capillary water, where as the fungal hyphaes concentrates necessary nutrients like N, P, K, Ca, S etc. preventing them from leaching in the otherwise sandy porus soil. High rates option exchange sites are provided along with necessary water once the hyphse decay percentage of water by weight and nitrogen content(x) in different decomposition classes being as follows (Table 1).

Table 1

Water and Nitrogen content % in log classes

Log class/ Decomposition class	Water by weight (%)	Nitrogen content (%)
I	37.62	0.07
II	43.79	0.10
III	57.82	0.13
IV	66.68	0.16
V	69.81	0.28

The high nutrient status of those pockets immediately attract and help settling down of the weed "*Mikenia (M. cordata, M. scandens* and *M.* hybrid*)*, and act as seed banks from which farther propagation takes place. Large tracts of prime Rhino habitats has been oblitered by profuse growth of *Mikenia* spp. (Fig. 2) completely altering the nature of the original habitat in the form of cover and modification of organic matter content and soil pH.

Table 2

Organic matter content(x) and soil pH in heavily affected Mikenia areas

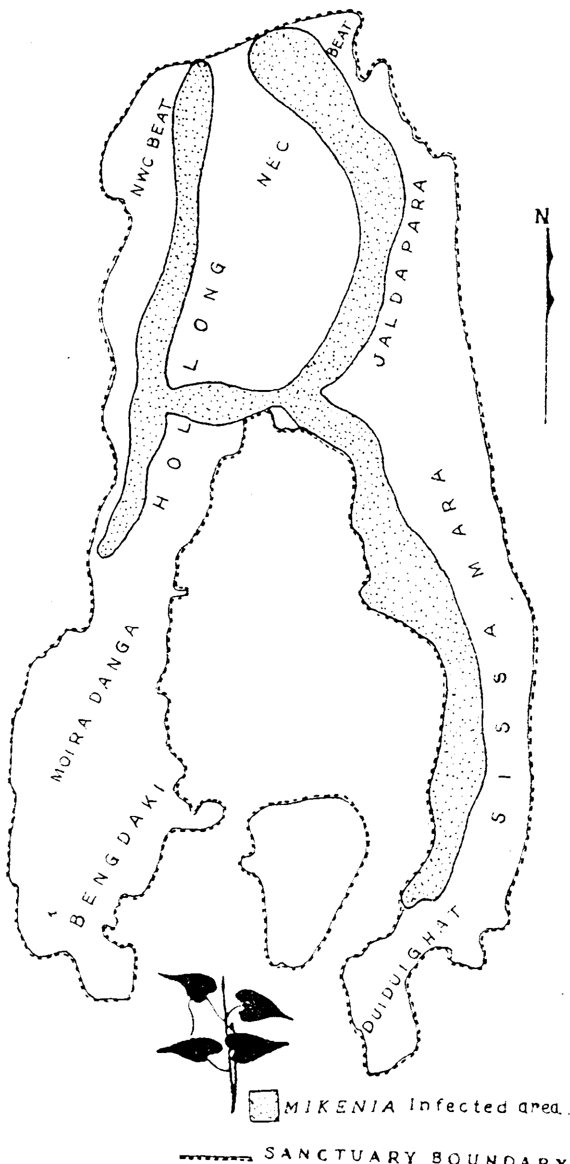
Site No.	Organic matter	pH
1.	37	5.2
2.	42.8	5.6
3.	41.8	6.1
4.	57	5.5
5.	33.6	5.5
6.	35.6	5.6
7.	54.4	5.1
8.	48.8	5.2
9.	56.2	5.6
10.	47.8	5.5
	Av % = 45.48%	Av pH = 5.49

Whereas a weakly alkaline pH (7-7.5) is suited for grassland development, change to weakly acidic soil pH prohibits the proliferation of grass in *Mikenia* affected areas, without soil treatment. *Mikenia* propagation to the extent of almost 20% of the prime Rhino habitat is recorded (Fig. 2).

The overall effect of disturbances and the trend of the habitat pattern has been studied by means of a plot less system, "Bitterlicks point quarter method". Based on the actual pattern of random vegetative distribution of Jaldapara, in which individual plants/trees are widely spaced, and with the underlying assumption that individuals of all species together are randomly dispersed this system was adopted as it does not produce any significant error. Thirty (30) sample plots were selected covering the present and possible Rhino areas and at each site 50 readings taken at 10 m interval over 3 years readings averaged for the deduction of :

(a) Relative density of each species.
(b) Frequency of each species.
(c) Relative frequency of each species.

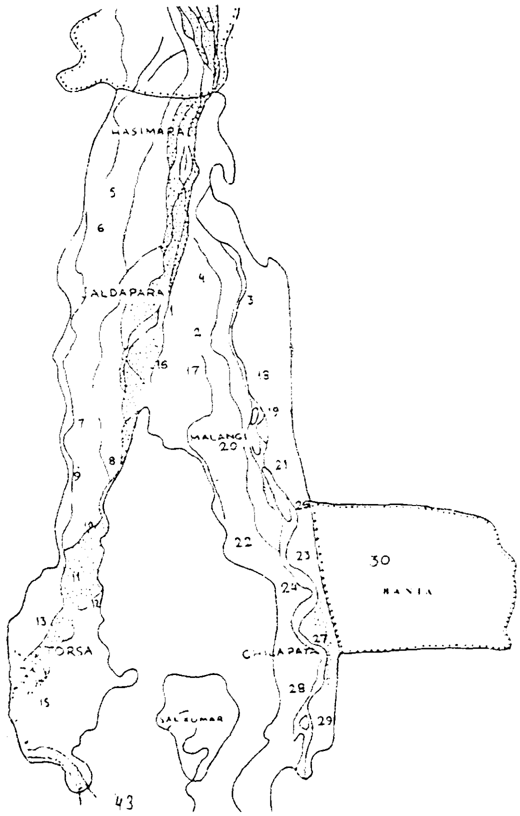
Fig. 2



Mikenia infested area in Jaldapara Sanctuary

From these data inferences were drawn regarding
(i) Importance value
(ii) Ecological sequence number.
(iii) Continuum index.

Fig. 3



Relationships of several dominant species

Importance Values

Highly heterogeneous nature of plant community at Jaldapara makes any classification on the basis of dominance or co-dominance impractical.

Based on the fact that most species do not normally reach a high level of importance in the community but those that serves as an index guiding species Importance Value is derived by taking a sum of relative density and relative frequency of each species involved (Curtis and Meintosh, 1951). Importance value thus obtained for species in stand enables grouping of stands by leading dominance and groups can be placed in an logical order based on the relationships of several dominant species.

Ecological Sequence Number

Based on the figures of frequency, relative frequency and relative dominance 'Ecological sequence number' is obtained by first assigning ecological adaptation to various species.

For this a 10 part scale has been established for Jaldpara Sanctuary as follows (Table 3).

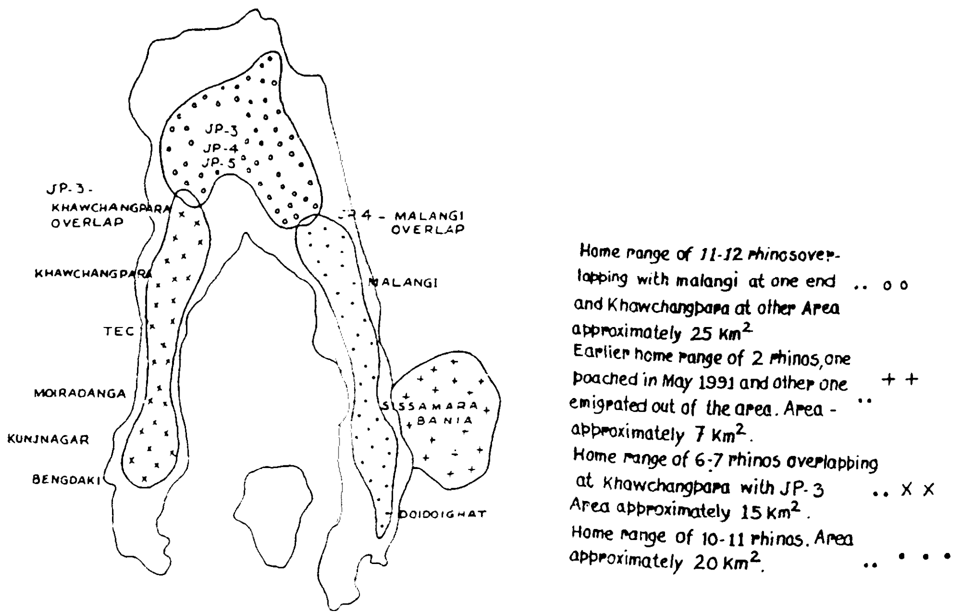
Continuum Index : The importance value has further been expanded into a composite figure "Continuum Index" for comparison of a large number of stands observation that each species reaches it best development in stands whose position bears a definite relation to that of other species, varying continuously along a gradient. continuum Index is obtained by multiplying the importance value of each species with its ecological sequence number and values of all species in the stand added. The sum is the stand continuum index. This is used to place that stand on continuum scale that runs from 300 to 3000 (Curtis and Meintosh, 1951). After the stand indices has been calculated the position of the individual species can be plotted in relation to the position of the stand on the index (Fig. 5).

Inference

Mikenia spp : Highest continuum index indicates prolific increase and further increasing trend, affecting and obliterating mainly the short and tall grasslands the primary grazing ground of the Rhino.

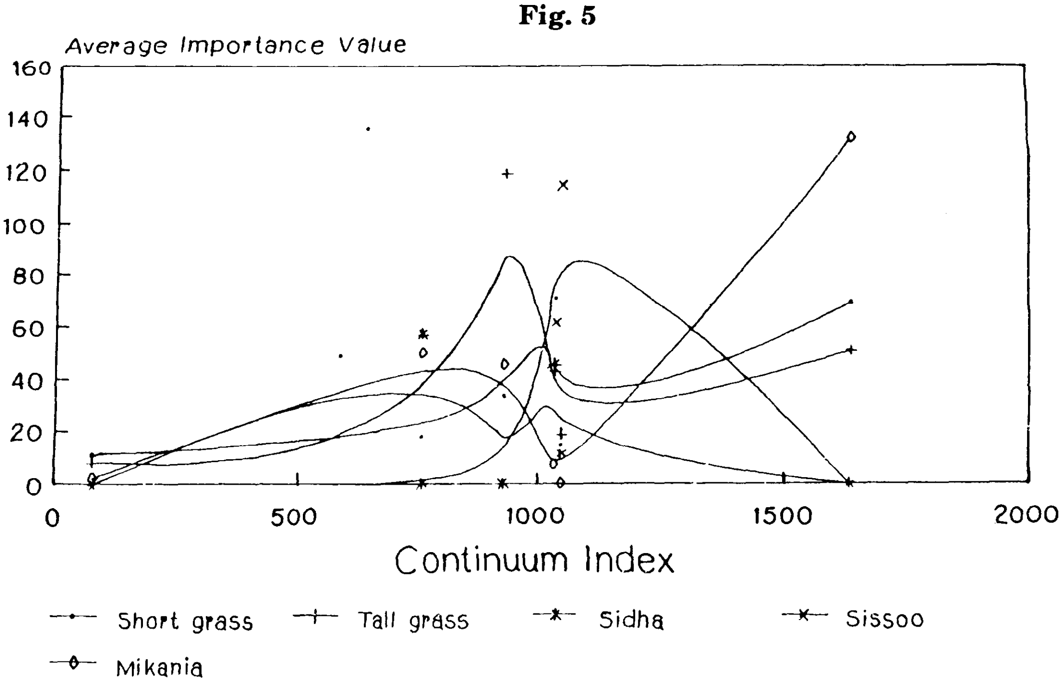
Dalbergia sissoo : Secondary colonizing

Fig. 4



Rhino home ranges in Jaldapara WLS (not to scale)

Fig. 5



Distribution of 5 forest species on a Continuum Index (after Curtis and Mcintosh, 1951)

Table 3

Ecological sequence number of various spp.

Species	ESN	Reason
Mikenia cordata, Scardass hybrid	10	Highly tolerant, rapidly, propagating and extremely well established, no co-relating successional order.
Dalbergia sissoo (Sissoo)	8	Major coloniser, climax spp. of reverine succession.
Bombax ceiba (Semal)	6	Major coloniser, less frequent than sissoo, climax spp of reverine succession.
Lagerstroemia parviflora (Sidha)	4	Major coloniser, less frequent than Semal, climax spp of reverine succession.
Tall grassland (*Themeda* spp.) *Phragmites* spp etc.	3.5	Less tolerant, grass cereal stage climax.
Short grassland	2	Most intolerent, highly susceptable to biotic disturbance, grass cereal stage climax.

Table 4

Average importance value of leading dominant species and respective ecological sequence number

Species	Short grass	Tall grass	Sidha	Semal	Sissoo	*Mikenia*	ESN
Short grass	70.34	42.66	45.69	-	61.29	7.30	2
Tall grass	33.46	118.26	-	-	-	45.06	3.5
Sidha	17.89	-	56.75	-	-	49.57	4
Semal	11.49	8.41	-	-	-	2.44	6
Sissoo	14.74	18.76	11.12	-	113.90	-	8
Mikenia ssp.	69.05	50.80	-	-	-	132.01	10

Table 5

Continuum Index (Adapted from Curtis and Mcintosh, 1951)

Stands	Short grass	Tall grass	Sidha	Simul	Sissoo	*Mikenia*	Continuum index
Short grass	140.68	149.31	182.76	-	490.32	73	1036.07
Tall grass	66.92	413.91	-	-	-	450.60	931.43
Sidha	35.78	-	227	-	-	495.70	758.48
Semal	22.98	29.40	-	-	-	24.40	76.78*
Sissoo	29.48	65.66	144.48	-	911.20	-	1050
Mikenia ssp.	138.10	177.80	-	-	-	1320.10	1636

* Eliminated from illustration because of zero importance value.

species with massive propagation and further increasing trend affecting mainly the short grasslands, converting them into monocultural sissoo stands.

Short grasslands : The most important and vulnerable biotic component from Rhino forage point of view is on a sharp and steady decline with further declining trend.

Tall grasslands : The second most important biotic component from Rhino forage and cover point of view is also steadily and sharply declining, with trends of further decline.

Lagerstroemia parviflora : Another bulk colonizer of the short and tall grasslands, having a much more closer canopy than sissoo, has degenerated large portions of Rhino foraging grounds and is on an increasing trend.

The general conclusion from the habitat analysis shows a major reduction of the Rhino habitat within the sanctuary grossly altering the forage, cover ration and contracting the Rhino use area to a considerable extent. The future trends predicted shows further construction of such habitat.

Foraging Strategies

The optimal foraging strategy of Rhinoceros in Jaldapara includes time and energy expenditures for persuit, handling and ingestion of food increased thermoregulatory cost risks of predation, reduced reproductive and home range maintenance activities and the potential consumption of toxic or inhibitory compounds. Ultimately, the solution of the cost benefit functions are related to the biological fitness of the forager.

Food Selection

Food selection by Rhino at Jaldapara was done adopting the Dinerstein (1975) method, for estimating the order of abundance of the plant species eater and two indices calculated.

(i) *Utilisation Index* : A measure of the contribution of the type of diet is the number of minutes during which the type was eaten expressed as % of the total number of minutes under observation.
(ii) *Preferability Index* : Is the number of minutes during which food of a certain type was eaten expressed as a number of minutes the type of food was available. Using these two indices and close examination of all browsing, grazing, preferential grazing, differential grazing and substantial grazing a seasonal diet list was prepared at 4 months interval.

However, while the diet chart simply lists food injested quantifications of relative amounts injested, are extremely difficult. Significant co-relations between preference ranking of a food and its nutrient or chemical content are almost impossible to evaluate since many plant components are reflections of each other e.g. plant parts high in protein are often low in fiber and high in digestible dry matter and energy. When nutrient constraints and secondary plant compounds are included in the foraging model, the complexity mushrooms because value of each food item is no longer independent of all others but rather each food item subsequently has an absolute value as well as a relative value that is dependent on the dieting composition of all other dietory components. For Rhinos exposed to many different foods the avoidance of toxins, while meeting the necessary requirements are accomplished by the foraging.

Increased Foraging Effort

Feeding and the search for food are the predominant activities of Rhinos, their activity patterns, daily energy expenditures and overall fitness reflects the costs and efficiencies with which food can be gathered. Rhino in Jaldapara exhibit the following behaviourial trends.

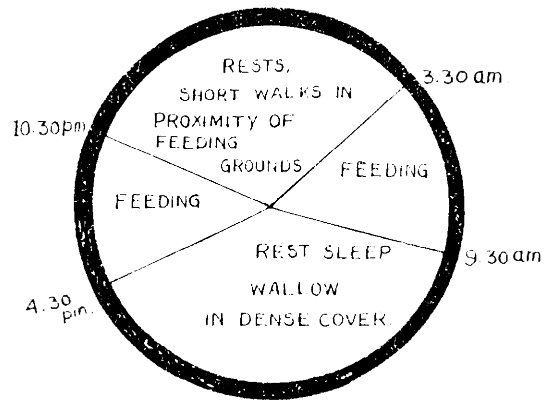
Increased foraging movements and clustering in particular pockets : Though Rhinos do not have fixed territoriality they do have very exacting and specified home ranges. The movements and activities of each animal is confined to an area only and even if dispersal takes place due to some biotic disturbance the animal ultimately comes back to the same area after the cause for dispersal removed or reduced.

Depending on the quantum of degradation of the habitat, the home ranges of Rhinos at Jaldapara are much larger than in comparison to other sanctuaries or natural parks. The defined home ranges for Rhinos in Jaldapara is depicted in (Fig. 4).

Whereas previously Rhinos were known to make a maximum movement of 2-3 km day with which sufficient food in quality and quantity was available, thereby minimizing time and energy expenditures for food gathering while maximizing digestible energy intake, an increased rate of movement ranging between 5 to 15 km per day is noticed in almost all Rhinos under observation since 1988. During these movements Rhinos have been observed to be constantly grazing or frequently browsing, according to the habitat, to finally reach some selected pocket having better quality and quantity of fodder.

These pockets are under heavy pressure of grazing as evident in at least two pockets.

Fig. 6



General Rhino time plot

One such area is Khejurbari at Jaldapara-3 Compartment and the other Khachubari at Sissamara adjoining the Malangi Watch Tower. In both of these pockets 9-10 Rhinos can be located within a radius of 2-3 km from any set point.

Thus as food density decreases, foraging effort increases. Rhinos alter foraging strategies by becoming less selective and choosing more favorable food patches in the total environment. Foraging efficiency ultimately decreases as the animal is forced to expend more time and energy in acquiring necessary food. A co-relation between forage consumption and foraging effort was attempted during study of these metabolic movements and feeding (Fig. 7).

Utilisation of Weeds by Rhinos

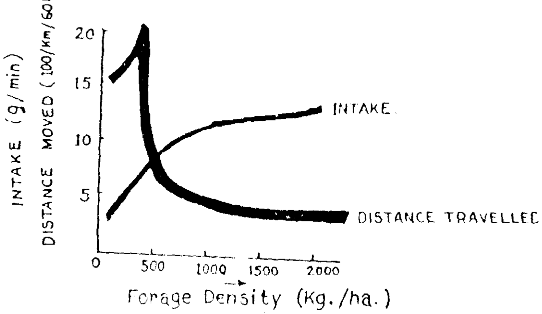
Rhinos are basically grazers as is also demonstrated in the construction of molars and pre-molars. The tall grasslands mainly plays the role of thermal, hiding, and fawning covers mostly and is utilized little for feeding in Jaldapara. Large tracts of prime small grasslands have been covered by *Mikenia* species, and with this conversion of prime fodder areas, Rhinos are compelled to add considerable amounts of *Mikenia* spp. in their regular diet menu. During analysis and direct observation have shown about 30-35% of the food consists of *Mikenia,* in the younger Rhinos below 10 years and 15-20% in case of older Rhinos. The older age groups attempts to find as much grass forage before switching over to *Mikenia.* Invariably the tender growing shoots are taken.

Versatility

Due to a decreased level of food availability, the mode of behaviour of the Rhinos in Jaldapara is oriented in the following ways.

(1) Having the capacity to seek out and eat plants containing highly specific classes of nutrients and to balance nutrient ingestion relative to the spectra of nutrient requirements.
(2) Having to ingest a number of different sample foods over a short period of time and to indulge simultaneously in a continuous food sampling programme.
(3) Preferentially feeding on the foods with which they are familier and continuing to feed on them as long as possible.
(4) Preferring to feed on foods that contain only minor amounts of toxic secondary plant compounds.

Fig. 7



Forage consumption and forging effort in Rhino at Jaldapara during Metabolic movements

All these effects were observed in the analysis of habitat of Rhino on the utility pattern and based on this a Versatility Index Rating was made for Rhino and other associated species of Jaldapara Sanctuary, in that the number of plant communities and successional stages the species uses for feeding and reproduction.

The sensitively of each species to habitat change is directly related to versatility. The most versatile species are least sensitive to habitat manipulation and the least versatile are the most sensitive.

Versatility Score : (V) = (Cr + Sr) + (Cf + Sf)

Where Cr = Number of communities used by spp for reproduction.
Sr = Number of successional stages used for reproduction.
Cf = Number of communities used for feeding.
Sf = Number of successional stages used of feeding.

The versatility score was calculated by quantifying the land use pattern of each animal taken on account in the respective communities and successional stages. Pellet count, dung count and browsing and grazing signs were considered (Fig. 8).

In case of Rhino increase in the % versatility score from 1985 had been 42.1.

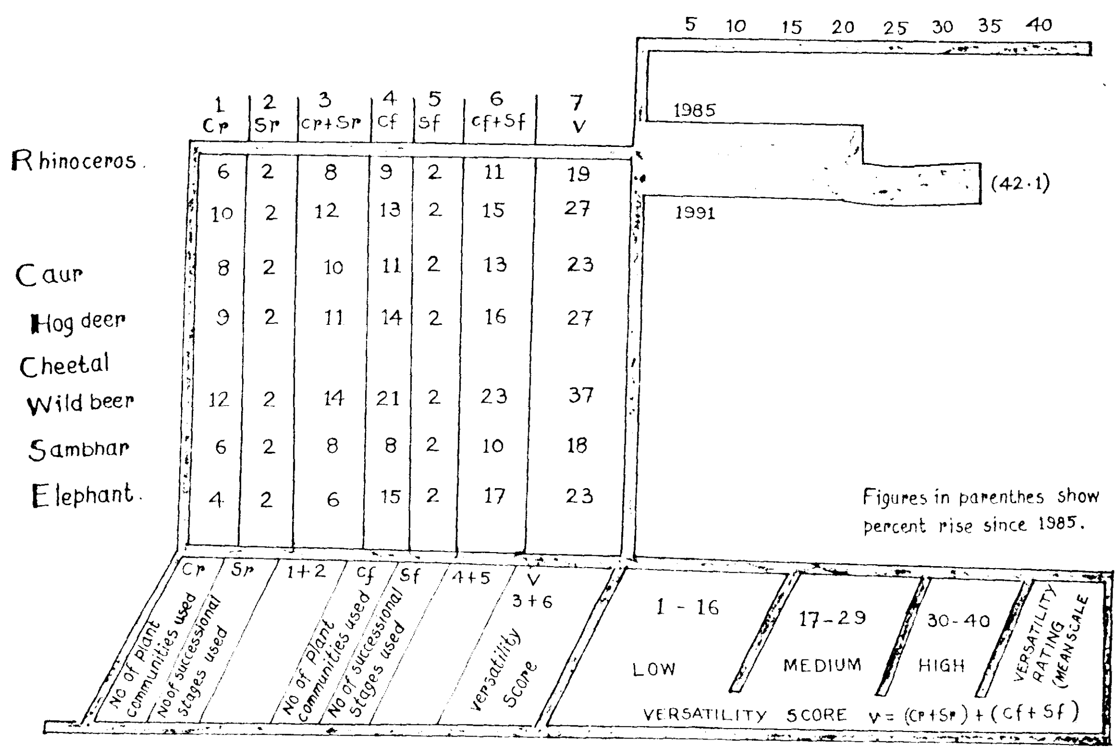
The Rhinos which had a medium

versatility rating till 1985 have now a high versatility rating. Where as the versatility rating in case of reproductive uses has been much lower in the scale, the rating in case of feeding has considerably increased. Basically grazers, Rhinos of Jaldapara has extensively taken up browsing on various shrub and tree species available as well as utilization of a large quantity of weeds like *Mikenia, Eupatorium, Clerodendron* etc. to cater to their energy requirements involved.

Extended Food Resource Utilisation

Evaluation of the animals versatility index rating shows a considerable % rise in the versatility rating (42.1%) form 1985 to 1991. Whereas till 1985 rating for Rhino at Jaldapara was in the medium category of versatility rating mean scale, in 1991 the rating has approached the high level of the scale. With the rating for the reproductive factor going down, this indicates, a much broader spectrum of plant species incorporated in the menu of the Rhino. Rhino has also extensively taken upto browsing from tree and scrubby growth, thereby increasing the intake of primary and secondary plant compounds, effects of which upon the gastrointestinal efficiency of the animal is yet to be quantified. However, the known effects of these

Fig. 8



Versatility Index Rating for Rhinos in Jaldapara Sanctuary compounds have been corroborated with the Metabolic Feacal Nitrogen (MFN) analysis to make an attempt.

Primary plant compounds

(a) *Lignin* : A high molecular weight aromatic non-saccharide polymer that adds structural rigidity to the plant cell wall and is confined to higher plants, lignin concentration increase with advancing cellular maturity constituting 15-20% of the cell wall.

Since lignin degradation is dependent on oxidation, it is resistant to gastrointestinal fermentation.

(b) *Cutin, Suberin* : Closely related chemical compounds, cutin is the structural component of plant article and suberin occurs between cell wall and cytoplasm and is a major constituent of the bark. These as percentage dry matter are quantitatively insignificant in grass but constitutes 15% in browse cell walls. These physically block the digestibility of more readilly available cell wall polysaccharides.

(c) *Biogenic Silica* : Incorporated in plant tissue as distinct localized concretion, in medium and tall grasses (*Themeda phragmites* etc.), physically prevent their degradation.

Secondary plant compounds: Secondary plant compounds are an extremely diverse assemblage of anti harbivory chemicals ranging from feeding deterroney to antibiosis. Three most prevalent group of plant secondary compounds are soluble phenoloids, alkaloids and tereponoids.

(d) *Soluble Phenolics* : Soluble plant phonolics include flavonoids, isoflavonoids and hydrolysable and condensed tannins. The antiharbivory properties of these compounds are primarily due to their abilities to bind with proteins and other macromolecules thereby precipitating cellular proteins, in cultivating digestive enzymes, and possibly forming indigestible macromolecules with cell wall carbohydrates. Several isoflavonoids (e.g. coumestrol and genistein) are similar in configuration to estrogen and hence are capable of reducing or altering reproductive patterns in the animal.

Tannins occur in about 17% of the non-woody perennials, 14% of herbaceous perennials, 79% of deciduous woody perennials and 87% of evergreen woody perennials. Tennins are effective in their ability to precipitate proteins and preventing fungal, viral and bacterial attacks as well as harbivory by vertebrates.

(e) *Alkaloids* : Alkaloids are more common to plants growing in nitrogen rich environments (*Mikenia* spp.) and effects antiharbivory by incurred metabolic aberration when ingested. It also results in depletion of gastro intestinal enzymes and bacteria.

Through perrisodactyla (*Rhinoceros*) and other odd toed ungulates has developed an extensive lower tract fermentation (cecum) capable of digesting plant fiber as also the capability to conserve and synthesize microbial protein from non protein nitrogen, synthesize vitamins and detoxify many secondary plant compounds inferior to the normal site of host enzymatic digestion and absorption, constant intake of secondary plant toxins drastically reduces this capability due to depletion of enzymatic microbial population.

Conclusion

High levels of grains (cereals and pulses) required by *Rhinoceros* and is frequently obtained by increased incursion into agricultural fields is a gastro intestinal demand to replenish the reduced secretion of digestive enzymes and microbial population generated by high intake of secondary plant products, rather than casual intake of such crops for taste or smell. From the combination of various factors and their resultant effect on the ecostatus of *Rhinoceros,* leading to such depredations, it seems to be one way traffic, unless drastic well calculated measures are taken to remove the ecological imbalances and repair the habitat of the animal, so as to lessen its dependence on such forage high in secondary plant produce.

SUMMARY

Crop depredation by *Rhinoceros unicornis* differs in nature from other animals. Feeding habits of this Perrissodactyla with a capability of extensive lower tract fermentation, enables it to synthesize microbial protein from nonprotein nitrogen, synthesize vitamins and detoxify many secondary plant compounds replenishing of which is done by adding high levels of grains, to its fibrous diet, by "Crop Raiding".

जलदापाड़ा अभयारण्य के आस-पास *रहायनोसेरस युनिकार्निस*

(एक शृंग गेंडे) द्वारा फसल विनाशन - एक दिग्सूचक प्रवृति

दीपक के० घोष

सारांश

रायनोसेरस युनिकार्निस (एक शृंग गेंडे) द्वारा किया जाने वाले फसल विनाश अपनी प्रकृति में उन अन्य पशुओं द्वारा किए गये विनाश से भिन्न है। इस पोरिस्सोडैक्टाइल पशु की भोजन आदतें इसकी सघन अघोक्षेत्र किण्वन कर सकने की क्षमता से मिलकर इसे गैर-प्रोटीनी नाइट्रोजन से अणुजीवी प्रोटीन संश्लिष्ट करने, विटामिन संश्लेषण करनें, अन्य बहुत से गाँव पादप यौगिकों को पोषी विकरात्मक पाचन एवं अवचूषण की सामान्य स्थली से नीचे ही अविषाक्त बनाने में समर्थ बना देते हैं।

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