Gross Assimilation Efficiency in Indian Rhinoceros

Dr. Amal Bhattacharya*

***Associate Professor, Department of Zoology, Raiganj University, Raiganj, W.B., India, 733134**

Abstract: A difference between the total amount of food intake and the total amount of voiding dung during 24 hours duration can be considered as the Gross Assimilation Efficiency. The assimilation efficiency may range from 20% to 90%. The large herbivores like rhinoceros have lower assimilation efficiency but higher net growth efficiency. The total weight of the food consumption in an adult rhino per day may be as high as 18.5 kg in the grassland habitat while in the mixed forest region it reaches up to 20 kg. The average total weight of defecation per day per adult was measured 10.5 kg (approx.) and 11 kg (approx) in the grassland and mixed forest habitats resulting in almost 8 and 9 kg gross assimilation respectively per day which is quite comparable to the zoo records. The daily consumption is about 1% of the animals' body weight. So in that respect, Indian rhinos consume more or less 1% of their total body weight. The weight at birth of Indian rhino is within 50 to 60 kg. But, it attains average 2200 kg when they become fully mature (range 1600 kg to 2800 kg). In the young ages, they may need more than 1% along with a high-quality diet as the growth factor is concerned and the nutritional requirement is high. This enormous increase in weight within a short period of time is obviously related to the huge consumption of food, as well as quality food, per day. So the national parks consisting of overpopulation of rhinoceros, as it happens in Gorumara, Jaldapara and also in Kaziranga, where rhino population is increasing, surely will have to face nutritional crisis sooner or later.

Keywords: Gross assimilation efficiency, Growth pattern, Rhinoceros, Vegetation.

Introduction:

The amount of food consumption and the amount of voiding dung in 24 hrs. is a measuring index of smooth maintenance of general physiology of animals including Great Indian one-horned Rhinoceros (*R. unicornis*, Linn). Though it is quite manageable in zoos, but it proves to be tough measuring in the wild, where the animals are living in a vast stretch of grassland or in a mixed forest. It is a time-consuming process and is also associated with a lot of risks while making a close observation. So, some indirect methods were applied which has already been discussed in the section Methodology. A lot of these type of works have been undertaken on elephants (Rees, 2008), herbivorous lizards and non-ruminants (Karasov, *et.al.*(1986), damselfishes (Cleveland and Montgomery, 2003) etc and all the authors have given stress on the amount of nutrients absorbed by the animals. Net growth efficiency is negatively correlated with assimilation efficiency and may range from 20% to 90%. It is calculated that gross growth efficiencies normally fluctuate between15% to 35% and demonstrate a nonlinear correlation with assimilation efficiency (Welch, 1968). Carnivores, in general, tend to have high assimilation efficiencies and low net growth efficiencies, while the herbivores have lower assimilation efficiencies and higher net growth efficiencies (Welch, 1968). The large herbivores like rhinoceros fall in the latter category.

The large herbivores consume a huge amount of fodder every day. If their population increases beyond its expected rate it may create fodder shortage within the smaller protected areas. The increasing population of Indian rhinoceros in the two small National Parks, Gorumara and Jaldapara, can face this problem. Their increasing population inspired the author to study on the rate of consumption according to the availability of fodder and whether the further increase of rhino population experiences fodder shortage or not.

Methods:

In my earlier working days I (accompanied by two or three forest guards and watchers) used to follow any particular adult rhino almost whole day and kept watching on their feeding types, duration of feeding etc. As they are very much fond of eating tall elephant grasses most of the rhinos congregated in those grazing areas where elephant grasses were predominant. After leaving of the rhinoceros from that area, I used to collect the un-grazed equal length of branches, leaves and twigs compared with those of the eaten portion and later they were taken to my camp for weighing those on a Barranger balance. I used to carry some big cellophane bags for collection of those portions of elephant grasses or tree leaves and small twigs. Those bags containing samples were tagged properly mentioning locations of the collection spot, date, time of the collections and the ID no. of the rhino (if possible). At the end of the day, the total weight was noted down in my field diary. In my absence on the spot, on some occasions, my fellow companions used to do this task. Sometimes after dusk, and at night, I used to follow any particular rhino (either male or female) from a treetop platform near the camp and after sunrise the same procedure was followed for collection of plant specimens. For observation, I used one 8x25 zoom binocular for clear viewing and for taking photographs I used an Ashahi Pentax, 1:1.4 camera. For weighing those plant specimens always fresh samples and their wet weight were taken into consideration.

Simultaneously I was always in search of fresh defecation spots. Whenever and wherever those were found in the Park, the total weight of the single fresh defecation was taken on the spot by a smaller hanging balance by weighing each dung ball, multiplied by the number of dung balls, as well as scattered fragments of dung in that spot (Bhattacharya and Chakraborty, 2016a). I also inserted those dung balls in polythene packets by a spatula and took the weight. The weight, along with location, date, time and possible ID number (mostly known by their footprints) were recorded in my field notebook. Usually, I searched those places, where communal dung piles were deposited. Sometimes I was informed by the forest guards and watchers of the other camps about fresh defecations. In every case, the fresh defecation of an adult was considered for this study. In the latter stages, I used to follow the footprints which became familiar to me, (Bhattacharya and Acharya, 1993) near the dung piles and realised which particular rhino defecated there.

Results and Discussions:

Gross Assimilation Efficiency: In continuation of my earlier works the second phase of the study included the work on gross assimilation efficiency by the rhinos in different areas of Gorumara and Jaldapara National Parks, W.B., India and a distinct regional variation in the gross assimilation was recorded in those two areas. The rhinos permanently inhabiting the Malangi, Sissamara, Jaldapara 3 and Torsa blocks of Jaldapara

National Park had shown a higher rate of efficiency than the other surrounding blocks like Bengdaki, Hollong, Dhaidhaighat, Bardabri and new CC Lines. The former blocks consist of a stretch of high-quality grasslands and the estimated average of daily consumption by adults confined within 18.5 kg (Table 1). The quality fodders in those blocks could fulfil their hunger by providing sufficient energy to them. Although a considerable amount of roughage fodders were also a part of their diet in those blocks and the total ingested fodders underwent long retention and bacterial fermentation processes as by the law of large ceacum animals' digestive mechanism. The amount of average weight of defecation per adult per day was estimated 10.446 kg, which means that the rate of gross assimilation amounted to be 18.5 – 10.446 = 8.054 kg which they managed to burn daily through various activities. On the other hand, the blocks containing a bulk of low-quality vegetations, the daily consumption most often exceeded 19.5 kg and sometimes reached 20 kg and estimated defecation per day per adult was recorded to be 10.953 kg., that does mean that 20-10.953 = 9.047 kg assimilation proved to be equivalent or might be to some extent less than 8.054 kg in terms of energy input. The Juveniles and calves were not considered for this study. It is also to be taken into account that most of the adult rhinos were not the permanent residents of the best areas. Many of them had wider home ranges during their daily activity cycles. Only one or two dominant adult bulls and three adult cows remained constantly in the best blocks.

A similar situation happened at Gorumara. The rhinos inhabiting Dhupjhora, Jaldhaka and a small part of South Indong blocks are considered to be the best habitat zones for rhinos. And the gross assimilation recorded there was 8 kg ± 0.235kg. Whereas, the other 8 blocks consisting of 24 compartments are considered to be very poor in respect of the rhino habitat zone. Not a single rhino was a permanent resident over those blocks. Not much data could be possible to collect from those blocks and compartments for statistical analysis.

My findings were latter compared with the resident rhinos of Kolkata zoo. As per verbal communication with the rhino caretakers, they reported that they used to give them nutritious fodder consisting of green grass, hay, some leaves amounting maximum up to 18 kg per day per adult which almost corresponds to our study. Defecations per day per adult were also calculated during 36 to 48 hours duration after assimilation and were estimated to be 10.02 kg ± 0.3 kg. So the assimilation was calculated to be 18.0 kg – 10.02 kg = 8 kg (approx.).

Being a perissodactyl and hindgut fermenter (Sinclair *et.al.*, 2006), Indian rhino has the capability of digesting less nutritious food items (Bell, 1971; Jarman,1974),such as, tall elephant grasses which have much amount of cellulose, hemi-cellulose and lignin content but less nutritious plant material. Since Indian rhino is a large herbivore, the average weight is about 2000 kg, their basal metabolic rate is lower than smaller animals (Clutton-Brock and Harvey, 1983). Greater the surface area lowers the rate of metabolism, for this reason, they can manage on roughage fodders. It has been estimated that the nutritional requirements often vary disproportionately with body size. It is again dependent on the seasonal food availability with fluctuation of their general biology.

Now the point is that the rhinos are to ingest more (in this case 1.5 kg approx.) in the areas other than grasslands to fulfil their nutritional requirements, on the other hand, the nutritious grasslands provide them more nutrients with less intake. This 1.5 kg difference per day is, presumably equivalent to the nutritional requirement compensation per day (Table 1)

Regarding egestion the average difference in the two habitats is nearly 500 gm per day in two habitats (10.953 kg – 10.446 kg = 0.507 kg). More fibrous materials are seen in their dung in the mixed forests or the habitats which are not very desirable to them.

Table 1:Gross Assimilation Efficiency per day per adult rhino in the wild and in the Zoo

FUNCTIONS	PER DAY GROSS ASSIMILATION EFFICIENCY IN WILD	
	VEGETATION TYPES	GROSS WET WEIGHT IN KG.
Ingestion	Grassland	18.5
Egestion	-Do-	10.446
Gross Assim. Eff.	-Do-	8.054
Ingestion	Other Areas (Mix. Forest)	20
Egestion	-Do-	10.953
Gross Assi. Eff.	-Do-	9.047
PER DAY GROSS ASSIMILATION EFFICIENCY IN CAPTIVITY (IN KOLKATA ZOO)		
Ingestion	----------	18.0
Egestion	----------	10.02±0.3 (Approx.)
Gross Assim. Eff.	----------	8.0 (Approx.)

A comparison between wild and captive rhinos regarding ingestion, egestion and assimilation has been shown

The gross assimilation is slightly higher (approximately 1 kg per day per adult) in the habitats other than grassland (9.047 kg – 8.054 kg = 0.993 kg), but, since very few adult rhinos were the permanent residents in those areas it proved difficult to collect sufficient data. Many of the subordinate adults could manage to stay in the fringe areas adjacent to grasslands or ecotonal zones, where some of them used to feed on grass diets but used to move to the mixed forest zones bordering the grasslands.

The voracious eater like rhinoceros can pose a serious problem on the availability of quality fodders in the two National Parks, Gorumara and Jaldapara. Thought these parks cover the area of 79.8 sq.km and 216 sq.km respectively but their prime feeding area, the grassland habitats are quite smaller comprising of only 8 sq.km and 30 sq.km. In order to maintain the general health of the rhinoceros, the area of the grassland must be extended.

The large herbivores like rhinoceros evolved a much longer small intestine with a side pocket, known as caecum at the distal end of the small intestine just to ferment a fairly large amount of cellulose, hemi-cellulose and lignin or other undigested food residues. The small intestine is associated with an increased retention time (Sinclair *et. al.*, 2006) which takes a complicated fermentation process in the hindgut. For doing this they have also been adapted using microorganisms such as bacteria, protozoa and fungi to digest non-digestible matters by fermentation (Chivers and Langer, 1994). Food materials must be retained in a fermentation chamber long enough for the microorganisms to cause fermentation before moving into the large intestine. The calculated mean retention times of fluids and particles in the whole gastrointestinal tract averaged 42 and 61 h, respectively, and were the longest ever recorded in a monogastric ungulate (Clauss, *et.al*, 2005). The small intestine plays a major role in breaking down of foods by enzymatic actions followed by absorption into the bloodstream.

The large intestine plays two main roles,1) absorbing most of the remaining water into the body again to get rid of dehydration and 2) at the end of the fermentation in caecum, the short-chain fatty acids produced are absorbed and utilized, thereby providing energy. An anatomical case study of African white rhinoceros (who are also grazers), has shown that the cecum may be functionally replaced by the well-developed colon which may act as the main fermentation tank in this animal (Endo, *et.al.*, 2000). The same feature has also been observed by Stevens and Hume (1995). The absorption of microbial protein is little known. However, the hindgut fermenter like rhinos are to some extent less efficient than the ruminants who can digest high fibrous foods, but since only indigestible parts are fermented in the cecum of rhinos they do not experience the loss of energy.

Growth Pattern: The daily intake of southern species of white rhino has been estimated 35 kg (Anonymous, 2009), which means if a white rhino bull weighs 2400 kg (average) it consumes 1.45% of its body weight. It seems to be much high in comparison to Indian bull rhino. The consumption depends entirely on the metabolic activity, growth rate, quality of fodder and so on. The data from the Zookeeper, Kolkata Zoo reported that a newborn calf of the Indian rhino weighs only 55-60 kg, but within six weeks the calf attains up to 158 kg, i.e., per day increase in weight is 3.4 kg (approx)! So, during the growing period, the metabolic activity remains too high and until attaining full maturity (6-7 years for cow and 7-9 years for bull) the food

consumption level, whatever it is, gets absorbed its most part and helps to grow the animal. After attaining full maturity the food consumption becomes lower and roughage fodder gradually takes place in their diet but during young stages, nutritious fodder is required to keep up the assimilation efficiency high.

Winberg (1956) has brought together much of what is known about the bioenergetics and growth of animals. The energy budget of an animal may be represented (Winberg, 1956; Richman, 1958) as below:

$I = G + R + E$ ..... (1)

Where I = Ingestion, G = Growth, R = Respiration and E = Egestion

Further: $A = G + R$ = Assimilation and A/I = Assimilation efficiency..... (2)

G/I = Gross Growth Efficiency (Ivlev, 1939) .....(3)

and

G/A = Net Growth Efficiency .....(4)

As the percentage of dry undigested part found in dung is lowest in calf and highest in adult (Bhattacharya and Chakraborty, 2016a), it is obvious that assimilation efficiency is highest in calf and lowest in adult. The assimilation must be high in young ages because the growth is an important factor associated with the assimilation in the individuals. When the individuals attain full maturity, i.e., no growth occurs, the assimilation or absorption of nutrients is only necessary to maintain the metabolic activities and daily normal functions of the huge body. So the adults are able to survive on roughage fodders, no extra nutrient for growth is needed.

If an Indian male rhino weighs 2000 kg and consumes 20 kg (approx) per day, i.e., 1% of its body weight and a newborn weighs 55 kg it does not mean that it will consume only 0.5 kg per day. As the growth is concerned it may need either 2 to 3% consumption of its body weight or high-quality diet with high nutrient content. According to Silberman and Fultor (1979) the weight range matrix of black, white and Indian rhinos are as below (Table 2):

Table 2: Average weight range matrix of black, white and Indian rhino (Silberman and Fultor, 1979) and from other sources

Species	New born (in kg)	Adult (in kg)
Diceros bicornis (black)	30 -35	1000-1050
Ceratotherium simum (white)	55-65	2000-3200
Rhinoceros unicornis (Indian)	50-60*	1600-2800

*Reported from Zookeeper, Kolkata Zoo

From the above table it is evident that a newborn Indian rhino calf, whose average weight is 55 kg, gains weight 2200 kg within 7 – 9 years (average 8 years) in case of bull while in case of the cow, it gains 1600 kg within 6 – 7 years. This means that net gain of weight in case of the bull is 2200 kg – 55 kg = 2145 kg in 8 years, i.e., 2145 ÷ 8 = 268.13 kg per year. In the case of the cow, it becomes 1600 kg ÷ 6 = 266.66 kg per year. The heaviest rhinoceros ever recorded up to 4,000 kg (www.indianrhinocerosfacts.com, 2017).

An enormous increase in weight within a short period of time is obviously related to the huge consumption of food, as well as quality food, per day. So the national parks consisting of a healthier population of rhinoceros, as it happens in Gorumara, Jaldapara and also in Kaziranga, surely may have to face nutritional crisis sooner or later.

There is ample scope of study on the aspect of assimilation according to age and bodyweight of the individuals relating to the consumption of food and voiding of dung in every stage of life which can throw light on the carrying capacity of the parks.

Conclusions:

The rhinoceros is known to be a voracious consumer. As per the present study each rhino consumes at least 1% of its total body weight. If the rhino population increases abruptly in these two small national parks, where their preferred grassland habitat is even smaller, in near future the overpopulation can create a serious threat to their survival. In that case, the grassland habitat should be extended in both the National Parks sufficiently. Though the Assistant Wildlife Warden of Jaldapara National Park, Mr Bimal Debnath expressed his view to the author that Jaldapara National Park can harbour thirty more rhinos in the present situation (Pers. Com., 2018).

References:

- **Journal Articles:**

1. Bell,R.H.V. (1971) A Grazing Ecosystem in the Serengeti, *Scientific American* ,**225***:* 86- 93.

2. Bhattacharya, A and Acharya,S.(1993): Identification of great Indian one horned rhinoceros (*R.unicornis*) by foot impression. *Proc.Zool.Soc.*,**Vol. 46 (2)**, pp. 125-130.

3. Bhattacharya, A. and Chakraborty, K.(2016a) Defecation Behaviour of Great Indian One Horned Rhinoceros (*Rhinoceros unicornis,* Linn.), *IJRS,* **5 (7),** pages 923-928,

4. Clauss, M., Polster, C., Kienzle, E., Wiesner, H., Baumgartner, K., Von Houwald, F., Ortmann, S., Streich,W.J., and Dierenfeld, E.S. (2005) Studies on digestive physiology and feed digestibilities in captive Indian rhinoceros (*Rhinoceros unicornis*), *J.Anim.Physiol. Anim. Nutr.*(Berl.), **89 (3-6):**229-237.

5. Cleveland, A and Montgomery,L.(2003) Gut characteristics and assimilation efficiencies in two species of herbivorous damselfishes (Pomacentridae: Stegastes dorsopunicans and S. planifrons)., *Marine Biology*, **Vol.142 (1):** 35-44.

6. Endo,H., Morigaki, T., Fujiswa, M., Yamagiwa, D., Sasaki, M. And Kimura, J. (2000) Morphology of the Intestinal Tract in the White Rhinoceros (*Cerato thorium simum*), *Anat. Histol. Embryol.*,**28:**303-305.

7. Ivlev,V.S.(1939) Energy balance in the carp. *Zool. Zh*. **18**: 303-318 [In Russian Google Scholar. Transl.]

8. Jarman, P.J. (1974) The seasonal organisation of antelope in relation to their ecology, *Behaviour*, **Vol.48,** pp. 215-267.

9. Karasov, W.H, Petrossian, E, Rosenberg L, Diamond J.M.(1986) How do food passage rate and assimilation differ between herbivorous lizards and non ruminant mammals. *J Comp. Physiol. B.* 1986; **156(4)**:599-609.

10. Rees, P.A. (2008) Gross assimilation efficiency and food passage time in the African elephant, *African Journal of Ecology*, **Vol.20 (3):** 193-198.

11. Richman, S. (1958) The Transformation of Energy by Daphnia pulex, *Ecological Monographs* (Ecological Society of America), **28 (3),** pages 273-291.

12. Silberman, M.S and Fulton, R.B. (1979) Medical problems of captive and wild rhinoceros – A review of the literature and personal experiences., *J. Zoo. An. Med.*, **Vol. 10,** 6-16.

13. Welch, H.E.(1968) Relationships between Assimilation Efficiencies and Growth Efficiencies in Aquatic Consumers. ,*Ecology*, **Vol.49(4):** pp. 755-759.

14. Winberg, G.G. (1956) Rate of metabolism and food requirements of fishes. Nauchnye Trudy Belorusskovo Gosudarstvennovo Universiteta im. V. I. Lenina, Minsk. 253 pp. (*Fish. Res.* Bd Can. Transl. **Ser. 194**.)

- **Books:**

1. Chivers, D.J. & Langer, P. (1994) *The Digestive System in Mammals: Food, Form and Function.*, **Cambridge University Press, Cambridge**.

2. Sinclair,A.R.E., Fryxell,J.M. and Caughley G.(2006) *Wildlife Ecology, Conservation and Management,* Second Ed. **Blackwell Publishing, USA,** 450 pp.
3. Stevens, C.E. and Hume, I.D. (1995) *Comparative Physiology of the Vertebrate Digestive System.* 2nd ed., **Cambridge University Press, N.Y.**

- **Book Chapter:**

1. Clutton-Brock,T.H. and Harvey, P.H. (1983) The functional significance of variation in body size among mammals. In. Eisenberg,J.F. and Kleiman,D.G., eds. *Advances in the Study of Mammalian Behaviour*, pp. 632-663.

- **Online document:**

1. Anonymous (2009): White Rhino (*Ceratotherium simum*), Wildlife Ranching.com
2. Indian Rhinoceros facts (2017):Anatomy, diet, habitat, behaviour...animalstim e.com/indian-rhinoceros-facts