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DIFFERENTIAL GROWTH OF VARIOUS BODY PARTS OF THE RED-WATTLED LAPWING *VANELLUS INDICUS* IN DESERT ECOSYSTEM OF THE THAR DESERT, INDIA

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ABSTRACT

Red-wattled Lapwing is one of the most common bird species of the arid ecosystem of India. This precocial species is widely distributed in almost every habitat of Thar desert except sand-dunes. The hatchlings of the species are feathered and start moving around soon after hatching. Morphometric measurements of various body parts were taken on every alternate day for 31 days. The growth patterns of various body parts are quite different and coincide with the requirement of the species. Tarsus, middle toe and beak develop faster during early part of growth to meet out the 'fast moving' and 'feeding on its own' requirements. The growth pattern of these parts almost perfectly correlates with the overall body growth. The growth of tail and wings start during later half of development. At the age of 34 days the young is able to take the flight.

Key words: Red-wattled lapwing, morphometry, desert ecosystem, growth patterns, differential growth

Introduction

Birds have two types of developmental behavior. Young of many species are hatched naked, which are unable to take care of themselves and are known as altricial. On the other hand precocial species though have delicate hatchlings, these are feathered and can start moving around soon after hatching (Maier, 1997). Most of the ground nesting bird species are precocial and Red-wattled lapwing is one of them. Though better developed, chicks of precocial species also need protection of the parents. These have different growth patterns of body parts as compared to altricial species. In comparison to altricial species, parents of precocial do not feed young directly but they take them to places with abundant food and where predator pressure is minimum. As a consequence of this, growth of various body parts in precocial species is different from that of altricial species. Growth and development in any organism is a cumulative effect of increment in different body parts. Various body components grew at different rates which are determined by functional priority of each organ (Ricklefs, 1975). Each species should vary in differential growth patterns according to their adaptive reproductive strategy (Ricklefs, 1968, 1969 and 1973).

Red-wattled lapwing is one of the most widely distributed bird species of Indian subcontinent (Ali and Ripley, 1989). The Thar Desert is one of the smallest yet most populated deserts of the world. Avian diversity of the Thar is quite rich and as many as 371 species have so far been recorded from here (Idris *et al.*, 2009). Many ecological changes are being now observed due to perpetually available good quality canal water and due to changes in ecological conditions; the flora and fauna of this fragile ecosystem are also rapidly changing. The Red-wattled lapwing is most widely distributed species of the Thar Desert and is successfully thriving under the hostile climatic conditions of the desert. The chicks of Red-wattled lapwing are precocial. The growth of chicks is influenced by various intrinsic and extrinsic factors (Ricklefs, 1968, 1973). Within a brood, hatching order influences the growth rate. Asynchronous hatching produces initial size differences among brood members. Due to that a general hierarchy in growth is observed, in which the senior most chick achieves faster growth than the juniors (Zach, 1988). Moreover, in case of shortage of food, the smaller and weaker young are not given food and thus fail to survive.

In present study we focus on adaptive aspects of differential growth on various parameters like body length, wing, beak, tarsus and middle toe of Red-wattled lapwing chicks at different stages.

The growth and development of individuals of a species is an important aspect of its breeding biology. The altricial species tend to have faster growth rates than precocial species of equivalent size (Ricklefs, 1968, 1973). Growth and development of the Northern lapwing *Vanellus vanellus* has been studies in some detail by Jackson and Jackson (1975, 1980), Redfern (1983) and Fuller (1983).

Soikkeli (1967) reported that the Dunlin *Calidris alpina* gained little weight during first two days of life. Mean growth rate of the Red-wattled lapwing till fledging at 38 days was 2.44± 0.01 gm/day as observed by Kalsi and Khera (1990). Jackson and Jackson (1980) reported mean growth rate of 3.26±1.48 gm/day in the Northern lapwing. The observed growth rates in some other Charadriiformes have been 3.7-4.2 gm/day in Red Knot *Calidris canutus canutus,* 2.9 gm/day in Ruddy Turnstone *Arenaria interpres interpres* ,1.8-2.0 gm/day in Ringed Plover *Charadrium hiaticula* and 2.1 gm/day in Sanderling *Calidris alba* (Green, 1978).

Materials and Methods

The study was undertaken at Bikaner city of Thar Desert, it lies in between 28°01'00"N latitude to 73°18'43"E longitude of Rajasthan state, India.

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(breeding season of 2018). After field survey we located the nests by monitoring the activities of incubating Red-wattled lapwing, the nests were visited at regular intervals during incubation period. Various methods for ethological studies have been suggested by Altman (1974) and for present study we stuck to focal sampling method and took measurements of three chicks belonging to one brood. Upon hatching, we marked the neonates with water proof ink on their tibio-tarsus and classed them as age 0 day. A specific number code was used to identify different chicks during recapture. Those chicks which could be recaptured were marked again for convenience of observation. The sites were visited alternate day and measurements of various morphometric parts were taken using vernier caliper and a ruler (Plate 1).

At each capture middle toe length, tarsus length, bill length, tail length and wing length were measured for comparative study of morphometrical development. A fully grown adult Red-wattled lapwing's length of different body parts was taken from Kalsi and Khera (1990). For the study of differential growth patterns in various morphometrical parts like Middle toe, Tarsus, Bill, Tail and Wings, increment in the growth of various body parts were plotted against age (days) of chicks and growth curves were obtained.

To investigate whether the growth of various body parts varies according to days of growth, Spearman rank correlation coefficient test between body parts and time (days) was calculated. We used Microsoft excel to draw the graphs and calculate the correlation coefficient, mean and standard error. Since we have morphometry of adult individuals, daily growth was plotted for middle toe, tarsus, bill, tail and wing lengths till the adult lengths were achieved (Fig.1).

Results and Discussion

The following full grown measurements were used for comparison with the measurements of Red-wattled lapwing chicks at different stages of development like length of Middle toe 36.00 mm, Tarsus 76.50 mm, Bill 35.30 mm, Tail 112.00 mm and Wings 226.00 mm (Table 1). Various body parts of chicks of Red-wattled lapwing *Vanellus indicus* developed at different rates. The middle toe and tarsus grew at fastest rate in early stages of development and attained approximately adult size before the fledging time.

At the time of hatching the leg parts of chicks are at a more advanced stage than the bill. As we observed average middle toe length is 52.44% of adult size, average tarsus length is 35.60% of adult size and average bill length is 29.68% of adult size in one day old chick. Middle toe acquired 90% of adult size in 21 days and tarsus acquired 90% of adult size in average 25 days. Tarsus gain their full length *i.e.* 100% development within 29 days of age (Table 1).

Bill was the fastest growing structure in precocial chicks of Red-wattled lapwing and gained 100% of adult size approximately at age of 23 days. In Red-wattled lapwing maturation of structures that help, in flight, like wings and tail, was relatively slow in early stages of development but soon reached at adult size near to fledging period. Tail did not begin to grow until day 10-12, at beginning the tail is fur like and approximately 14.46% of adult size. After age of 10-12 days tail begin to develop and reached 75% of adult size in average 29 fledging time.

Wing was next to tail in terms of growth, in neonate average wing length was 8.7% of adult size. Their development is very slow and they gain 55% of adult size up to 31 days of age. Probably remaining development occurs between next 5-10 days.

Some body parts of Red-wattled lapwing showed faster growth during early period of development and others attained faster growth during later period of development. Middle toe length (R^2=0.952) and tarsus length (R^2=0.950) showed almost perfect correlation with the overall body growth (Fig.2 and 3). These two body parts grow faster during early part of development and later growth became steady. Bill length also grew faster during earlier development period and was closely correlated (R^2=0.899) with body growth patterns (Fig.4). Wing length and tail length were relatively slow in development. Wing length (R^2=0.705) had spurt in growth around day 27 and the bird took flight around day 34 (Fig. 6). Tail length also had two quick growth peaks (R^2=0.661) first around day 13 and second around day 25 (Fig. 5). Tail length and wing length were not closely correlated with the overall growth of the body.

Middle toe, tarsus and bill which reached 90% of adult size approximately within 21, 25 and 15 days, respectively, indicates that, these morphometrical parts develop in early stages of development than other morphometrical parts. Long Tarsus and Middle toe of the ground nesting bird helps their precocial chicks to run on the feeding grounds with their parents and feed on their own. The early development of bill and well developed leg parts are very effective in their run, peck and probing type of feeding habit.

Our observations show that bill growth is rapid and it completely grow in average 24 days in relation to that of tarsus, which took on average 29 days, during stages of natal development. However, in neonates tarsus is more advanced than the bill. Rapid growth of leg parts and bill are adaptation for chicks as they confer ability to walk or run at an early stage of life and significantly help in feeding. According to Soni *et al.*

Table 1: Morphometric measurements of various body parts in Red-wattled Lapwing *Vanellus indicus*

Age in (Day)	Middle Toe (mm) $\bar{x}$±S.E.	Tarsus (mm) $\bar{x}$±S.E	Bill (mm) $\bar{x}$±S.E	Tail (mm) $\bar{x}$±S.E	Wing (mm) $\bar{x}$±S.E
1	18.88±0.10	27.24±0.42	10.48±0.25	16.20±0.21	20.20±0.43
3	20.00±0.63	27.57±0.32	11.11±0.12	16.20±0.21	21.10±0.45
5	26.15±0.66	32.20±1.30	90.96±0.54	16.20±0.21	23.25±0.21
7	27.90±0.48	37.59±1.26	23.90±0.57	16.20±0.21	26.19±0.21
9	28.25±0.35	43.12±0.95	27.15±0.68	16.20±0.21	27.95±0.18
11	28.79±0.69	52.25±6.34	29.80±0.72	16.20±0.21	29.38±0.12
13	29.43±0.71	58.00±1.04	30.95±1.02	16.70±0.17	31.29±0.18
15	30.00±0.66	61.50±2.22	31.85±0.89	22.50±0.70	35.20±0.22
17	30.60±0.75	63.21±2.48	32.09±0.89	29.09±0.48	42.17±0.07
19	31.18±0.97	64.90±2.87	33.53±0.82	36.18±0.65	50.28±0.16
21	32.40±1.68	65.02±2.91	34.59±0.94	43.57±0.71	53.19±0.49
23	32.70±1.71	67.20±1.71	35.30±0.59	49.91±0.66	59.10±0.70
25	33.10±1.56	68.85±1.29	35.30±0.59	54.88±0.46	61.02±0.59
27	33.95±1.29	74.81±1.20	35.30±0.59	71.29±0.57	72.19±0.85
29	34.26±1.22	76.50±0.77	35.30±0.59	84.00±0.51	92.25±0.89
31	35.28±0.63	76.50±0.77	35.30±0.59	100.80±0.65	124.30±1.02
Adult	36.00	76.50	35.30	112.00	226.00

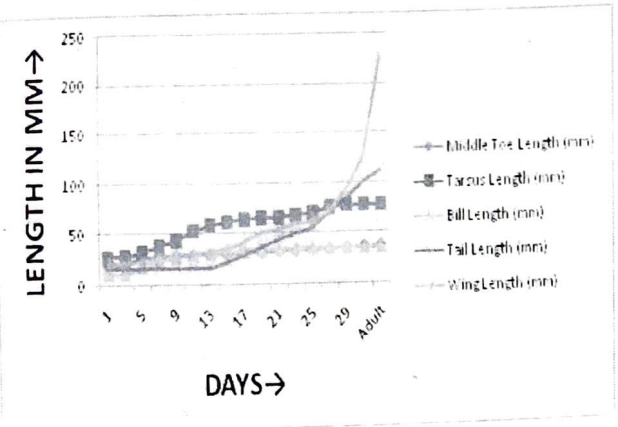

Fig. 1: Growth of various body parts till adulthood measurements are achieved

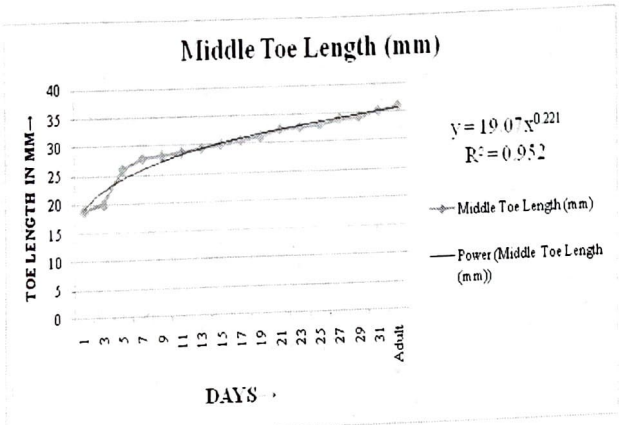

Fig. 2: Linear regression analysis of middle toe length in relation to period of days.

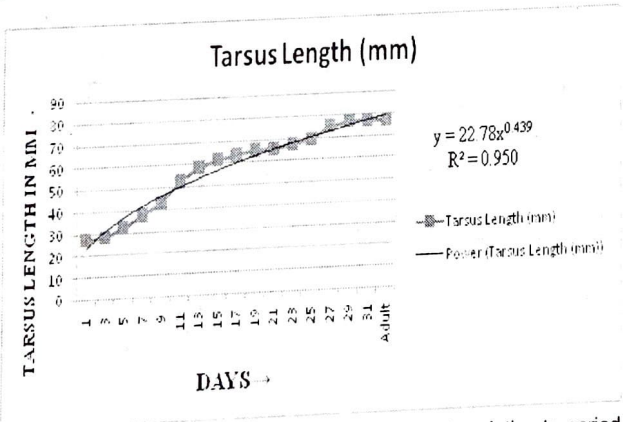

Fig. 3: Linear regression analysis of tarsus length in relation to period of days.

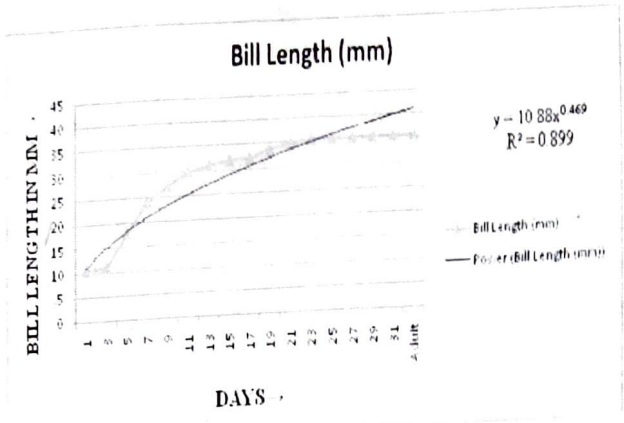

Fig. 4: Linear regression analysis of bill length in relation to period of days

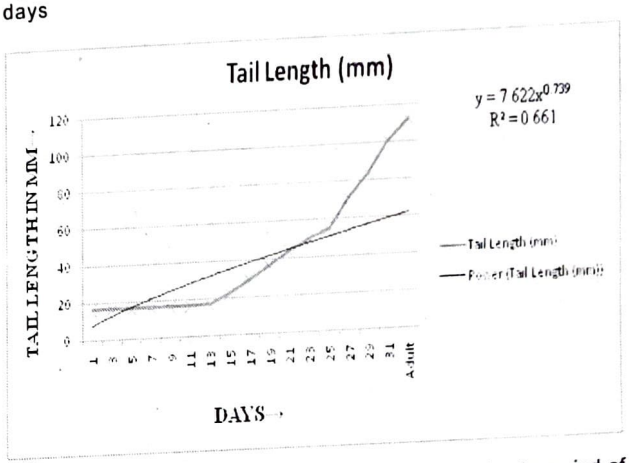

Fig. 5: Linear regression analysis of tail length in relation to period of days

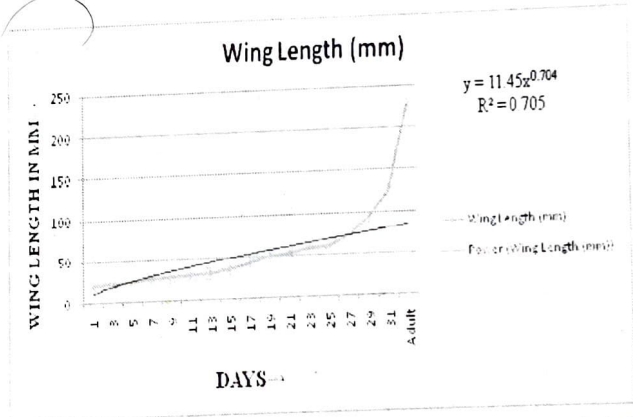

Fig. 6: Linear regression analysis of wing length in relation to period of days

(1989), full development of locomotory organs at fledging in Black Ibis is essential to achieve foraging proficiency. Similar cases of early development of locomotive organs have been observed in Sacred Ibis (Urban, 1974) and in White Ibis (Kushlan, 1977). Early development of locomotion ability in Black Ibis is important for nestling survival during sibling aggression, particularly at the time of food delivery (Werschkul, 1979). Early development of middle toe and tarsus in Red-wattled lapwing is absolutely essential for survival as hatchlings of this precocial species have to move soon after hatching for food and to avoid predation.

Differential growth patterns during morphometrical development were also studied by Urban (1974) in Sacred Ibis, by Kushlan (1977) in White Ibis and by Dhandhukia (2014) in Common Myna. Bill is fastest growing structure in chicks of Red-wattled lapwing because of their self feeding nature.

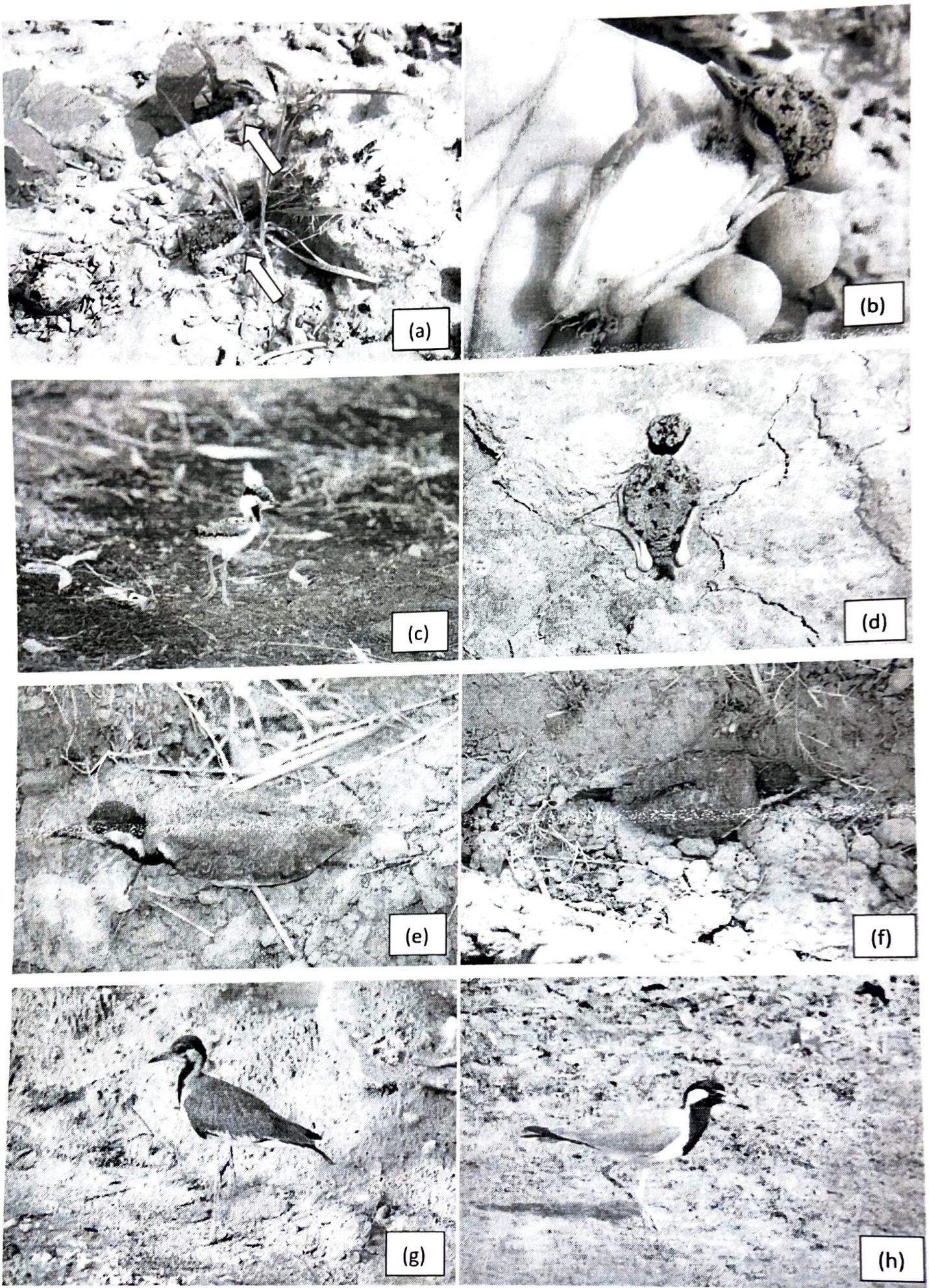

Plate 1: Various stages of development of *Vanellus indicus*, (a) Newly hatched chicks lying close to nest (marked by arrow) while one egg is still unhatched, (b) A day old chick with prominent egg tooth, (c) A day three chick, (d) A day five chick, (e) A day 17 chick, (f) A day 21 chick, (g) A day 34 young which has just started flying, (h) A full grown Adult.

According to Kristan *et al.* (1996) in the birds like Spotted Owl *Strix occidentalis* where requirement of bill is early, it develops early. Bill is slowest growing structure in Black Ibis as observed by Soni *et. al.* (2009). Initial small size of bill in these birds may facilitate a nestling to gape into parents' mouth for feeding. The early development of beak in *Vanellus indicus* can be attributed to the fact that hatchlings have to survive by feeding on their own whereas altricial species are fed for four to five weeks by both the parents.

Both the structures associated with flight show faster growth after that the leg parts and bill gain their maximum length. Functions of these organs are important after fledging. In common Myna tail growth began later and proceeds faster than wing but reached at similar stage of development at the time of fledging as both are essential for flight (Dhandhukia, 2014). According to observation of Kalsi and Khera (1990) the growth rate of wings and remiges was faster than that of a beak and tarsi and the rate of increase in body weight. Our studies, however, contradict this and the tail and wings start a faster rate of growth only during last half of development. They also observed that the Red-wattled lapwing attained a capability of free flight *i.e.*, were fledged at an age of 38 days when its mean weight was 106.5 gm. During this study we found that the fledglings take flight at an age of 34 days.

As the aerial flight enables a bird to effectively avoid terrestrial predators, rapid development of wings and remiges takes place while gaining weight at a slower rate confers an early and effective wing loading capability (Redfern, 1983). This is probably an adaptation for chick. Study on *Vanellus vanellus* chicks by Fuller (1983) also suggests that close to hatching the legs of chicks are at a more advanced stage than the bill, but by fledging stage these two components are equally developed and are relatively more advanced than weight attainment and especially feather growth.

In Red-wattled lapwing maturation of structures that help in flight like wings and tail was relatively slow but thay soon attained adult size near to fledging stage. Development of tail start after 10-12 days of hatching, shows it is of less important during early age. During morphometrical development first 10 to 15 days are crucial for growth of those morphometric structures associated with feeding. Therefore metabolic energy can be utilized by other important growth processes, essential to sustain at early stages of development. Underdevelopment of wing and tail are the most adaptive feature of differential growth patterns in chicks of Red-wattled lapwing. In our study we observed that at the age of 25th day average development of tail is 49% of adult size and of wings, it is only 27% of adult size.

The patterns of growth shown by various body components in passerines have been discussed by O'Connor (1977). He argued that the differential growth rates displayed by various parts of the body are adaptive. During growth, the significance of body components to the survival of the nestling will vary. At any one time resources are, therefore, directed towards those body components which are of highest functional priority.

Conclusion

Differential growth in various body parts are determined by current functional priority of each organ. Faster development of leg and bill in early stages enables the chick to self feeding and is thus a feeding adaptation. Maturation of flying structure just after fledging is essential and is an anti-predatory tactics to ensure the survival of Red-wattled lapwing as a species.

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