

## Parakeratosis: Hypozincemia and its therapeutic management in captive Asian Elephants (*Elephas maximus*)

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### ABSTRACT

Three captive Asian elephants presented with chronic skin lesions characterized by thickened, crusty and scaly growth on the ears and limbs. Clinical examination, blood sampling, mineral profiling and skin biopsy were carried out to investigate the underlying cause. Histologically skin biopsy revealed hyperkeratosis and marked parakeratosis. Serum analysis showed reduced zinc levels. Based on the clinical signs, histopathology and biochemical findings, zinc deficiency was identified as a contributing factor.

**Keywords:** Asian elephant, hypozincemia, keratinization, parakeratosis, skin

India has a long and intriguing history of domesticating elephants from the wild. The religion, mythology and cultural legacy of India have been intricately linked to captive Asian elephants for years<sup>1</sup>. As they are voracious feeders due to its large digestive tract, they need enormous source of feed for its growth and maintenance. Elephants are prone to a variety of infectious and non-infectious diseases, but recognizing that they are even sick may be difficult and challenging<sup>2</sup>. Elephants often do not manifest clinical signs of illness until disease is well advanced. Such masking of clinical signs makes identifying and treating diseases in elephants is very challenging for veterinarians and zoo managers. Among these, micro-mineral deficiencies, though often overlooked compared to more acute infections or major metabolic imbalances can have insidious yet significant long-term effects on health and physiology<sup>3</sup>. Iron, zinc, copper, selenium and other trace minerals are essential for immunological function, enzyme functioning, antioxidant defence systems and epithelial integrity. In elephants, deficits in these micronutrients may not show up as obvious symptoms at first, but they can progressively affect the function of the skin barrier, wound healing, infection resistance and reproductive performance<sup>4</sup>. Among those, zinc is a vital trace mineral for many different kinds of metabolic, enzymatic and regulatory functions, including growth, immunological response and tissue integrity Zinc also form a component of several enzymatic systems<sup>5</sup>. Its role in cell division, keratinisation, gene expression and protein synthesis accentuates its significance in both healthy and diseased conditions<sup>6,7</sup>. Although zinc deficiency is often subclinical, it can cause a variety of disorders that impact the skin, reproductive organs, gastrointestinal tract and immune system. These disorders usually show signs such as dermatitis, growth retardation, alopecia, impaired wound healing and increased susceptibility to infections<sup>3,8</sup>. In captive

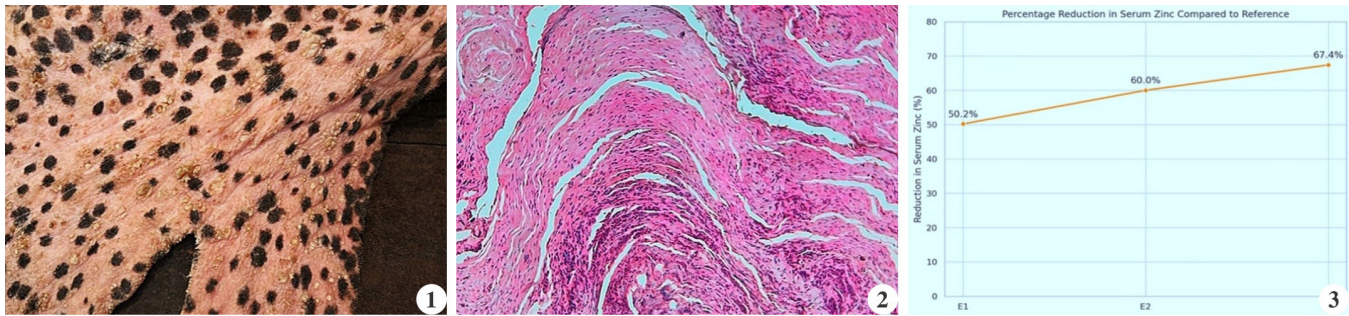
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Asian elephants, trace mineral imbalances such as zinc deficiency may go unrecognized due to a lack of standardized reference ranges and species-specific diagnostic tools. The present study reports the occurrence of parakeratosis in Asian elephants with its diagnostic approach.

Three elephants of different age group, sex and setting (Table 1) presented with chronic dermatological lesions since two months were examined as a part of health assessment. Cutaneous lesions were predominantly distributed over the caudal pinna (Fig. 1), forelimbs and caudal

**Table 1.** Details of Elephants under study

ELEPHANT	AGE (YEARS)	SEX	LOCATION
E1	61	Male	Mudumalai Tiger Reserve, Udhamandalam
E2	45	Male	Mudumalai Tiger Reserve, Udhamandalam
E3	35	Female	Private Elephant, Trichy



**Fig. 1.** Rough, thick and scaly skin with prominent crusts and flakes in auricular surface - Hypozincemia - Parakeratosis - Skin - Ear; **Fig. 2.** Abnormal keratinization with retention of nuclei in the stratum corneum - Hypozincemia - Parakeratosis - Skin (H&E stain x400); **Fig. 3.** Line Plot displaying the percentage reduction in serum zinc levels for each elephant relative to the reference.

surface of hind limbs. Affected areas exhibited thick, rough, scaly skin with crust and exfoliation on the ears and cobblestone-like plaques with deep fissures and cracks on the limbs. Crusty and exfoliated skin lesions were collected and fixed in 10% formalin for histopathological studies. The tissue samples were processed as per standard paraffin embedded technique. The tissue sections of 3-4  $\mu\text{m}$  thickness were processed and stained with haematoxylin and eosin (H&E) stain<sup>9</sup>. Blood samples were collected for haematological analysis, serum biochemistry and mineral profiling. Serum from blood samples were separated for estimation of biochemical parameters such as zinc and cobalt using Atomic Absorption Spectrometry (AAS).

Grossly, cutaneous lesions were characterized as thick, irregular with broad base, crusty and measured 0.7-3.0 cm in width and 3-12 mm in height. Microscopically, cutaneous lesions revealed marked epidermal changes consistent with abnormal keratinization. The stratum corneum appeared thick, compact and irregular with dense eosinophilic keratin layers, hyperkeratosis (Fig. 2). It showed prominent parakeratosis, evidenced by retention of pyknotic nuclei within the stratum corneum. The epidermis beneath the layer of hyperkeratosis showed moderate acanthosis with elongation and thickening of the rete ridges. Serum biochemistry showed decreased zinc concentration ranged from 66.1 to 101.2  $\mu\text{g/dL}$ , indicating a 50-70% reduction compared to the standard reference range of 203-275  $\mu\text{g/dL}$ . Specifically, elephant E1 showed a 50.2% reduction (101.2  $\mu\text{g/dL}$ ), E2 showed 60.0% (81.3  $\mu\text{g/dL}$ ) and E3 had a 67.4% reduction (66.1  $\mu\text{g/dL}$ ) (Fig. 3). Cobalt levels were assessed to rule out any contributory deficiency. While zinc concentrations showed a substantial reduction consistent with clinical manifestations, cobalt levels remained within a normal range.

Zinc plays a crucial role in maintaining the structural integrity and function of epithelial tissues, particularly the skin<sup>6</sup>. Zinc deficiency generally arises, when dietary sources are inadequate due to low zinc content in soil and

water which in turn leads to reduced zinc availability in forage crops<sup>10</sup>. In ruminants and other herbivores, it can be exacerbated by high dietary levels of calcium, phytates or iron, which interfere with zinc absorption from the gastrointestinal tract<sup>11</sup>. In the present study, all three elephants demonstrated significantly reduced serum zinc levels, accompanied by gross dermatological changes such as thickened, crusty and exfoliative lesions with fissures. Histopathologically, parakeratosis was evident, characterized by abnormal keratinization with retention of nuclei in the stratum corneum. The pathogenesis of parakeratosis in zinc deficiency involves disruption of normal keratinocyte proliferation and differentiation<sup>12</sup>. Zinc is a cofactor for numerous metalloenzymes and transcription factors (including zinc-finger proteins) that regulate gene expression during epidermal maturation. In the absence of adequate zinc, there is impaired protein synthesis, delayed cell turnover and faulty keratinization resulting in a hyperplastic epidermis with parakeratotic changes. The present observations were in parallel with the findings of earlier documented evidence from elephant of the Zoological Society of London, where an adult female Asian elephant developed parakeratosis, alopecia and dermatitis due to dietary zinc insufficiency following changes in feed quality<sup>13</sup>.

Reduced zinc levels were correlated well with the clinical presence of hyperkeratotic skin lesions and the histopathological findings of parakeratosis suggesting that suboptimal zinc status played a contributory role in the skin pathology observed. A strong association between hypozincemia and cutaneous pathology of the present study highlighted the importance of adequate trace mineral nutrition in elephant health management.

The findings of the present study highlight the significance of zinc deficiency as a potential cause of chronic dermatological conditions such as parakeratosis in captive elephants. Based on clinical signs, serum mineral analysis and histopathological findings a targeted therapeutic approach was implemented. Dietary supplementation included zinc sulphate syrup

(200 ml once daily), multivitamin syrup (100 ml once daily) and a region-specific mineral mixture (150 g/day) was followed to address the underlying nutritional deficiencies. Additionally, topical application of zinc oxide ointment combined with antifungal cream and olive oil was performed twice daily to promote skin healing and prevent secondary infections. Dietary care was taken to avoid administering zinc syrup concurrently with mineral supplements, as calcium can interfere with zinc absorption and bioavailability.

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