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Studies on rickets and osteomalacia in Bactrian camels (*Camelus bactrianus*)

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Abstract

Epidemiological studies have indicated incidences of 32.9% and 27.8% for rickets and osteomalacia, respectively, in Bactrian camels (*Camelus bactrianus*), but there is an increased incidence under drought conditions, sometimes reaching 75%. We have found that concentrations of phosphorus and copper in forage and soil samples in a drought affected area were significantly lower than in a control area or normal reference values ($P < 0.01$); the mean Ca:P ratio in the forages was 50:1. The phosphorus content of blood and hair from affected camels was significantly less than that in controls ($P < 0.01$) and concentrations of copper in the liver and kidney were significantly lower in affected camels than control animals ($P < 0.01$); the concentrations of triiodothyronine (T_3), thyroxine (T_4) and parathyroid hormone (PTH) in the serum from affected animals were significantly higher than those from healthy controls ($P < 0.01$); serum inorganic phosphorus and ceruloplasmin levels were lower than those in the controls ($P < 0.01$ or $P < 0.05$); the concentrations of serum α-globulin and β-globulin were significantly higher in the affected camels than in the healthy controls ($P < 0.01$).

The pathological changes seen in camels affected with rickets included porous, brittle, light, osteoporotic bones that were susceptible to fractures and had less resistance to cutting and sawing. Wrist joints were enlarged with an apparent bowing of the long bones in forelimb and with typical broadening of the epiphyses. In adult female camels, many enlarged scars were often seen in ribs indicating earlier fractures. The disease could be cured with supplementary bone meal, phosphate or mineral mixtures and in field investigations clinical signs disappeared within 15 days. Over the same period, the concentrations of phosphorus and alkaline phosphatase in blood returned to normal. The disease may be effectively prevented by use of mineral blocks (block salt licks) or dosing orally with copper, selenium and cobalt soluble glass boluses. We conclude that rickets and osteomalacia are mainly caused by phosphorus and copper deficiencies in the pasture.

Keywords: Bactrian camel; Rickets; Osteomalacia; Phosphorus deficiency; Tissues; Minerals; Biochemical values; PTH; Copper

1. Introduction

Bactrian camels (*Camelus bactrianus*) are vital to the production system of the Chinese desert and semi-desert areas where feeding resources are generally scattered and poor. The animals have adapted well to the harsh climatic conditions and poor feeding resources, not only providing hair, wool, meat and hides for local farmers and herdsmen, but also acting as an indispensable means of transport in this arid zone.

Despite the cruel hard environment, there has been little evidence to date of clinical mineral deficiencies in camels (Faye et al., 1992a,b; Liu et al., 1994; Zhang et al., 1986), although rickets and osteomalacia have been recently discovered in the Badanjiling and Tengeli deserts in China. As in other animals, rickets is a disease of the young growing Bactrian camel and is characterised by stiffness in the gait, enlargement of the costochondral junctions and abnormal curvature in the long bones, especially in the forelegs. Osteomalacia on the other hand usually occurs in mature Bactrian camels and is characterised by fragile bones, general weakness, lameness, emaciation and stiffness; affected animals often are seen chewing bones, rocks and other objects.

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In the region under study, animals are grazed throughout the year and rickets and osteomalacia usually occur between February and June. The disease has caused major economic losses and has become a serious scourge.

Although rickets and osteomalacia have been reported in cattle (Blood et al., 1989; Huang et al., 2001; McDowell, 1992), water buffaloes (Heuer and Bode, 1998), sheep (Blood et al., 1989; McDowell, 1992), pigs (McDowell, 1992) and dogs (Zhang et al., 1989), there are no data for Bactrian camels. We therefore decided to study the epidemiology, aetiology and pathogenesis of these diseases, with a view to helping to control them and improving local camel production.

2. Materials and methods

2.1. Epidemiological investigations and clinical examination

Detailed investigations on the epidemiology of the disease in local Bactrian camels were carried out in the affected area. These included ascertaining the history, incidence, character and regularity of the diseases, the natural ecological environmental conditions, and the effects on local animal husbandry. We interviewed many local herdsmen, including both the owners of Bactrian camels severely affected by the disease, and older herdsmen who had lived in the area for many years, asking for their advice and opinion and gathering background information on the diseases. Data on the ecological and environmental conditions and on the effects of the diseases were obtained from local records and annual reports provided by local government. Clinical signs were recorded by direct observation while following the herds on the pasture. Bone hardness was assessed by needle puncture of the rib, skull, vertebra and hip bone.

2.2. Aetiology and pathogenesis

2.2.1. Affected animals

Fifteen cases of osteomalacia were studied in camels aged 4–13 years, and 10 cases of rickets in animals aged less than two years. The animals were selected from Badanjiling desert in Alashanyouqi county of Inner Mongolia. All animals had shown obvious clinical signs, including emaciation, lameness, weakness, stiffness in the gait, enlargement of the costochondral junctions, abnormal curvature in the long bones, especially in the forelegs, sometimes showing a typical knock-kneed condition. Affected animals were frequently seen chewing bones, rocks, soil and other objects.

2.2.2. Healthy controls

Ten young camels and 10 adult camels were selected from Mingqing county of Gansu province, where the diseases had not been reported previously. All of these animals were judged to be in good health after clinical examination.

Blood samples (15 mL) were obtained from the jugular vein using 1% sodium heparin as anticoagulant. Samples were stored at −20 °C for analysis of trace elements. Serum samples for biochemical values were taken in tubes without anticoagulant and were refrigerated until they arrived at the laboratory within 5 h of collection. The serum was separated by centrifugation (1000*g*, 10 min) and stored frozen in plastic vials. Hair samples were taken from the neck of all animals, washed and de-greased as described by Salmela et al. (1981) and then kept in a desiccator over silica gel until analyzed.

All the animals were slaughtered by exsanguination. Routine post-mortem pathological examination (Zhu and Zhu, 1988) was carried out by naked eye examination of tissues. Samples of liver, renal cortex and medulla, heart, spleen, lung, cerebrum, cerebellum, rib, ovary, pancreas and a gluteal muscle were taken from each animal for mineral determination. Tissue samples were dried at 80 °C for 48 h, ground, passed through a 0.5 mm sieve and stored in a desiccator over silica gel.

Multiple small samples of forage, mainly common reed (*Phragmites communis*), saxoul (*Haloxylon ammodendron*), desert wormwood (*Artemisia desertorum*), common ceratoides (*Ceratioides lateen*), were cut from pasture and mixed. To reduce soil contamination, the herbage samples were cut 1–2 cm above ground level. Forage samples were dried at 60–80 °C for 48 h and ground to facilitate chemical analysis (Wang, 1991). Soil samples were taken from the surface layer (0–30 cm) of the pasture, using a 30 mm diameter cylindrical corer. Four cores per paddock were bulked and placed in polythene bags. The soil samples were dried out at 60–80 °C for 48 h and passed through a 10 mm sieve. Six samples of soils, 10 samples of forage for control were also collected from Mingqing County in Gansu province.

The serum content of ceruloplasmin (Cp), lactate dehydrogenase (LDH), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (AKP), γ-glutamyl transferase (γ-GT), creatinine (Crt), urea nitrogen (BUN), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), inorganic phosphorus (IP), total protein (TP), albumin (Alb) and globulin (Glob) were determined on an automatic analyser using commercial test kits (Nanjing Medicine University Biochemical Co.). Quality control serum (Shanghai Biochemical Co.) was used to validate the blood biochemistry data. Serum protein electrophoretic studies were performed on cellulose acetate (Shi, 1990). Serum triiodothyronine (T_3), thyroxine (T_4) and parathyroid hormone (PTH) concentrations were determined by radioimmunoassay (RIA) using commercial