

FLUORIDE TOXICOSIS IN IMMATURE HERBIVOROUS DOMESTIC ANIMALS LIVING IN LOW FLUORIDE WATER ENDEMIC AREAS OF RAJASTHAN, INDIA: AN OBSERVATIONAL SURVEY

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SUMMARY: Susceptibility to fluoride toxicosis in the form of osteo-dental fluorosis was observed among 435 immature herbivorous domestic animals living in areas with less than 1.5 ppm fluoride in the drinking water. These animals included 78 buffaloes (*Bubalus bubalis*), 89 cattle (*Bos taurus*), 30 donkeys (*Equus asinus*), 21 horses (*Equus caballus*), 23 camels (*Camelus dromedarius*), 96 goats (*Capra hircus*), and 92 sheep (*Ovis aries*). Except for the bovines and equines, none of the other animals appeared to have dental fluorosis. The highest prevalence of dental fluorosis was found in calves of buffaloes (52.56%), followed by calves of cattle (49.44%), donkeys (16.67%), and horses (14.29%). Thus the teeth of bovines were the most severely affected, and moderate lameness and stiffness in hind legs, wasting of body muscles, and bony exostoses as pathognomic signs of osteal or skeletal fluorosis were also found only in the immature cattle and buffaloes. The prevalence rate of these conditions among these animals was 8.99% and 10.26%, respectively. Other signs of chronic fluoride intoxication including colic, intermittent diarrhoea, and excessive urination were also seen. In the absence of airborne F contamination, the restriction of dental and skeletal fluorosis to the immature bovines and equines appears to be related primarily to their greater need to drink water containing even a low-level F compared to the much smaller need for water intake by the immature camels, goats, and sheep.

Keywords: Animal fluorosis; Buffaloes; Camels; Cattle; Donkeys; Fluoridated drinking water; Fluoride susceptibility; Goats; Horses; Immature domestic herbivores; Low-fluoride area; Osteo-dental fluorosis; Rajasthan, India; Sheep.

INTRODUCTION

Prolonged excessive intake of fluoride (F) through drinking water results in F accumulation predominantly in teeth and bones and causes various toxic effects in the form of dental mottling (dental fluorosis) and bone deformities (skeletal fluorosis) in man^{1,2} and in animals.^{3,4} The latter form of fluorosis is more dangerous and highly significant since it often diminishes the mobility of animals at a very early age by producing varying changes in the bones such as exostosis, osteosclerosis, osteoporosis, osteophytosis etc.⁵ Besides these osteal abnormalities, nonskeletal changes or fluorosis due to exposure to F have also been observed in the form of gastrointestinal disturbances, neurological disorders, reproductive dysfunctions, apoptosis, excitotoxicity, genotoxicosis, and teratogenic effects in domestic animals.⁶

In India, most studies on F toxicosis in domestic animals have been conducted on buffaloes (*Bubalus bubalis*), camels (*Camelus dromedarius*), cattle (*Bos taurus*), donkeys (*Equus asinus*), goats (*Capra hircus*), horses (*Equus caballus*), and sheep (*Ovis aries*) living in areas with high F (>3.0 ppm) in the drinking water.⁷⁻¹⁰ Among these animals, the prevalence of osteo-dental fluorosis varies

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greatly. On the other hand, in certain areas where the water is high in F, camels and sheep did not seem to show any sign of F toxicosis.^{3,4} However, such studies are lacking in immature herbivorous animals that are more sensitive and susceptible to F poisoning or less tolerant to F intoxication.¹¹ The present observational investigation was therefore undertaken to ascertain the relative susceptibility to osteo-dental fluorosis among immature domestic herbivores belonging to diverse species living in areas with a relatively low F content (<1.5 ppm) in the drinking water.

MATERIALS AND METHODS

The survey study was conducted, in 2011–2012, in nine villages of the Udaipur district (Aklingpura, Banjariya, Dhalena, Jagat, Jamar-Kotada, Kheda, Parola, Rajol, and Umarda) and seven villages (Amaliya Fala, Fatehpura, Kankudi, Meharwada, Munged, Navagaon, and Ratanpura) of Dungarpur district of Rajasthan, India. In these villages the average F concentration in drinking water is reported to be below 1.5 ppm.^{12,13} Signs of dental and skeletal fluorosis were surveyed among 435 immature native herbivorous animals, all of which had lived in the villages since birth. Included were buffaloes (*B. bubalis*), camels (*C. dromedarius*), cattle (*B. taurus*), donkeys (*E. asinus*), goats (*C. hircus*), horses (*E. caballus*), and sheep (*O. aries*). Animals below the age of 3 years in cattle, buffaloes, horses, and donkeys, 5 years in camels, and one year in goats and sheep were considered immature.

To derive estimates of the relative prevalence of dental and skeletal fluorosis in bovines (cattle and buffaloes), equines (horses and donkeys), flocks (sheep and goats), and camels, house-to-house surveys were conducted in the morning and evening hours when the animals were generally available. The herds in the fields were also examined during the daytime. For dental fluorosis, the teeth of the immature domestic animals were carefully examined for any signs of dental mottling; for skeletal fluorosis, poor body condition, lameness, reluctance to move or stiffness, skeletal deformities, bony exostoses, muscle wasting, and a snapping sound from the feet during walking were looked for.¹⁴⁻¹⁶ Simultaneously, owners were also asked about common illnesses in their animals such as colic, allergy (urticaria), intermittent diarrhoea, constipation, bloating, etc. Similar surveys have also been conducted on healthy immature domestic herbivores in other fluoride and nonfluoride areas.¹³ In those surveys, chronic F intoxication assessments of osteo-dental and nonskeletal fluorosis were likewise based on clinical examination.

OBSERVATIONS AND DISCUSSION

Dental fluorosis: Out of 435 immature herbivorous domestic animals examined, 93 (21.38%) were afflicted with varying grades of dental fluorosis. These were all bovines and equines; no other species of animals showed signs of fluorotic dental mottling (Table). However, some of the bovine calves had relatively severe forms of dental fluorosis (Figures 1 and 2) with a prevalence varying between 49.44% and 52.56%. Incisors of these animals had deep dark-yellowish discoloration on their enamel surface. In a few cases, recession of gingiva and irregular wearing of

teeth were also seen. Although equines were also affected with dental fluorosis, it was mild, and only light yellowish staining was found on the enamel surface. The prevalence of dental fluorosis was also low among the equines and varied between 14.29% and 16.67%.

Table. Prevalence of dental fluorosis (DF) and skeletal fluorosis (SF) in immature animals of different species living in areas with low fluoride (<1.5 ppm) in the drinking water

Animals (spp)	No. of animals investigated (age yr)	No. of animals with DF (%)	No. of animals with SF (%)	Total with DF or SF (%)
Buffaloes (<i>B. bubalis</i>)	78 (<3)	41 (52.56)	8 (10.26)	49 (62.82)
Cattle (<i>B. taurus</i>)	89 (<3)	44 (49.44)	8 (8.99)	52 (58.43)
Donkeys (<i>E. asinus</i>)	30 (<3)	5 (16.67)	– (0.00)	5 (16.67)
Horses (<i>E. caballus</i>)	21 (<3)	3 (14.29)	– (0.00)	3 (14.29)
Camels (<i>C. dromedarius</i>)	23 (<5)	– (0.00)	– (0.00)	– (0.00)
Goats (<i>C. hircus</i>)	96 (<1)	– (0.00)	– (0.00)	– (0.00)
Sheep (<i>O. aries</i>)	92 (<1)	– (0.00)	– (0.00)	– (0.00)
	435	93 (21.38)	16 (3.68)	109 (25.06)

χ^2 testing shows a highly significant variation of the dental, skeletal, and total fluorosis scores between the animal groups ($p < 0.001$).

Skeletal fluorosis: Careful examination of mandibular regions, ribs, metatarsus and metacarpus bones revealed diffuse to well-marked periosteal exostoses (bony lesions) in 3.68% (16/435) of immature bovines apparently afflicted with skeletal fluorosis (Table). In these animals, mild to severe intermittent lameness or restricted movements in their hind legs, stiffness of tendons in the legs, wasting of main mass



Figure 1. Severe form of dental fluorosis in one-month-old cattle calf seen in Figure 3. Note bilateral stratified horizontal deep yellowish staining on newly erupted central incisors and swelling of gingiva. Light yellowish staining also appearing at the base of erupting lateral incisors.

of hind quarter and shoulder muscles, snapping sounds and lowering of neck during walking were also observed (Figures 3 and 4). With advancing age, these signs become more conspicuous and severe. Other signs of chronic F intoxication

such as colic, intermittent diarrhoea, polydypsia, and polyuria were also noted. In general, these animals had weak bodies, were indolent, and were reluctant to stand. Interestingly, no other domestic animal species besides the calves of cattle and buffaloes appeared to be afflicted with overt signs of skeletal fluorosis.

It is well known that immature animals are more sensitive and susceptible to F intoxication and are less tolerant to F compared to mature animals.¹¹ However, in the present investigation, with relatively low F in the drinking water, immature camels (calves) and flocks (kids/lambs) did not show any pathognomic signs of osteo-dental fluorosis, whereas equines exhibited only mild forms of dental fluorosis (Table).



Figure 2. Severe form of dental fluorosis in a <6-month-old buffalo calf shown in Figure 4.

However, calves of cattle and buffaloes were severely affected with dental and skeletal fluorosis. Such findings have also been reported from high F endemic areas where the F concentration in drinking water is >3.0 ppm.^{9,10} In other studies where water, rather than pastures from F air pollution, is



Figure 3. Emaciated one-month-old cattle calf afflicted with moderate skeletal fluorosis. Note lameness in hind legs.

involved, goats and sheep likewise did not show any appreciable signs of chronic F intoxication.^{3,5} Thus, the present findings clearly indicate that calves of bovines are relatively more sensitive and highly susceptible to F toxicosis from waterborne F and are therefore less tolerant to F in drinking water compared to other domestic animals. These findings are also in agreement experimentally with evidence that

fluorosis in goats and sheep appears only at relatively high levels of F exposure and intake.^{17,18} Sheep are also reported to be less susceptible to fluorosis than cattle.¹⁹

It is a fact that F never spares any animal from its toxic effects. These effects, however, are influenced by various biological and nonbiological factors other than F concentration.²⁰⁻²²

Nevertheless, the frequency of F intake has a highly significant role in the occurrence and extent of F toxicosis. Actually, the severity of fluorosis is generally directly proportional to the frequency of F intake.

In well-adapted desert

animals like camels and even goats and sheep, the frequency of F intake from water is very low.²³ Hence these animals are less afflicted with fluorosis from water-borne F. By contrast, cattle and buffaloes are not desert animals and therefore require more frequent water intake for their survival and biological makeup and processes.²⁴ Accordingly, these domestic herbivores are often observed to be severely affected by osteo-dental fluorosis from F in their drinking water.

In summary, because calves of both cattle and buffaloes are very susceptible to toxicosis from drinking F water, clinical examination of their teeth for dental fluorosis provides a useful way for identifying F endemic areas that meets all the necessary requirements for being a good bio-indicator of such areas.^{25,26} Results of the present investigation also add significant insight into the causes of chronic F intoxication and F ecotoxicosis.

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Figure 4. Emaciated <6-month-old buffalo calf afflicted with less severe skeletal fluorosis. Note wasting of body muscles and bulging of bony lesions on legs.

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