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Is the Water Buffalo Species (*Bubalus bubalis*) Relatively more Sensitive to Fluorosis than other Species of Domestic Animals? Still, there is a Need for more in-depth Research on this

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Abstract

Endemic fluorosis in domestic animals is the resultant of chronic fluoride intoxication. Animals that are repeatedly exposed to fluoride for a long-time through drinking fluoridated water, fluoridated food, and industrial fluoride pollution or air-borne fluoride emissions tend to suffer from this dangerous disease. In this disease, almost all types of teeth, bones, and soft organs of animals are affected or damaged. Brown striped stains and abrasions of teeth (dental fluorosis) and lameness or bone deformities (skeletal fluorosis) are the main symptoms or clinical signs of fluorosis. However, its severity and prevalence vary greatly among different species of animals living in the same area, even if fluoride levels in drinking water are approximately the same. It has been observed in different species of domesticated animals including water buffaloes (*Bubalus bubalis*), cattle (*Bos taurus*), horses (*Equus caballus*), donkeys (*E.asinus*), dromedary camels (*Camelus dromedarius*), sheep (*Ovis aries*), and goats (*Capra hircus*) living in the areas having low (< 1.0 ppm) and high (>3.0 ppm) fluoride level in drinking waters. Among these domestic animals, water buffalo species was found to suffer more severely from chronic fluoride intoxication or fluorosis than other species. Similarly, the prevalence of fluorosis has also been found to be relatively higher in buffalo species as compared to cattle, donkey, horse, camel, sheep, and goat species. This pattern is also seen in immature or juveniles of these animals. It is clearly evident and accepted that water buffalo species is relatively more sensitive or susceptible to fluorosis and have lower tolerance to fluoride intoxication than other species of domestic animals. It is also acknowledged that juveniles or immature animals are found to be most sensitive or susceptible to fluoride intoxication in the form of dental fluorosis as compared to adults or mature animals. Therefore, these

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are also ideal bio-indicators of chronic fluoride toxicity. Apart from fluoride concentration and its duration and frequency of exposure, 'genetics' of various species of animals is also an important factor in variation in fluoride tolerance and sensitivity to fluorosis, which is the focus of the present communication. Along with this, the research gaps are also highlighted for researchers or veterinary scientists to do some advance research work on chronic fluoride toxicity in different species of animals.

Introduction

Endemic fluorosis in different species of wild and domestic animals is the resultant of repeated fluoride exposure for prolonged period through fluoridated water and food as well as airborne fluoride emissions or industrial fluoride pollution [1-25]. This disease is more prevalent in those areas where drinking water sources, whether these may be groundwater or fresh water sources, have fluoride beyond the standard level of 1.0 ppm or 1.5 ppm [26-28]. In fact, both fluoridated ground and fresh waters have the potential to cause fluorosis in both animals and humans [29, 30]. Thousands of ruminant and non-ruminant domestic animals, including bovines (cattle and buffalo), flocks (sheep and goats), equines (horses and donkeys), and camels are found to suffer from this dangerous disease in many countries. But accurate country-wise statistical data on fluorosis in domestic and wild animals is not yet available. On the other hand, the reported findings are also insufficient to reveal the complete scenario of the disease in any endemic country.

In this disease, almost all types of teeth, bones, and soft organs of animals are affected. Brown striated stains and scratching or abrasions of the teeth (dental fluorosis) and lameness or various bone deformities (skeletal fluorosis) are the main symptoms or clinical signs of this disease (**Figures 1 and 2**) [31]. Chronic fluoride intoxication or fluoride exposure in animals also causes many health complaints such as intermittent diarrhea or constipation, abdominal pain, polyuria, polydipsia, infertility, recurrent miscarriage, stillbirth, reluctance to perform reproductive functions, erectile dysfunction, etc. (non-skeletal fluorosis) [31]. But all these health problems are not found in any one fluorosed animal. The worst thing about this disease is that not only the animal becomes lame for life but this disease also causes financial loss to the animal farmers [16-18]. Chronic fluoride intoxication through drinking of fluoridated water and/or industrial fluoride pollution not only affects the health of animals but it also affects the health of humans [32-44] and various species of agricultural crops [45-52].

However, fluorosis has been reported in various species of domestic animals from different geographical provinces by several workers [53-59]. But which species has relatively lower tolerance or greater sensitivity to fluoride toxicity is not yet clear. Therefore, in the present communication, based on the available findings on the prevalence of fluorosis in different species of domestic animals, it is highlighted that the water buffalo species (*Bubalus bubalis*) is found to be relatively more sensitive or susceptible and vulnerable to fluorosis as compared to other species of domestic animals, such as cattle (*Bos taurus*), horses (*Equus caballus*), donkeys (*E. asinus*), dromedary camels (*Camelus dromedarius*), sheep (*Ovis aries*), and goats (*Capra hircus*). Along with this, the research gaps were also highlighted for researchers or veterinary scientists to do some advance research work on chronic fluoride toxicity in different species of animals.

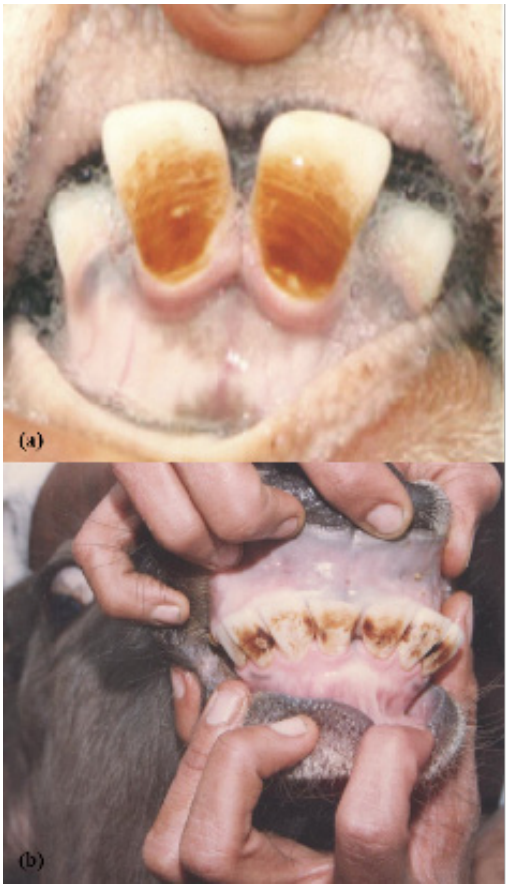

Figure 1: Severe dental fluorosis in one-month-old cattle **(a)** and < 6 months buffalo **(b)** calves. Note bilateral stratified horizontal deep brownish yellow staining on newly erupted incisors.

Figure 2: Moderate skeletal fluorosis in emaciated one-month-old cattle **(a)** and < 6 months buffalo **(b)** old calves. Note wasting of body muscles, bulging of bony lesions on legs and intermittent lameness in hind legs.

Fluoride exposures and forms of fluorosis

In general, fluoride enters animals' bodies through oral and/or respiratory routes. This is possible only when drinking water and food, and air, respectively, are contaminated with fluoride toxic substance. Groundwater in many countries is naturally contaminated with fluoride to varying degrees. At many places, fluoride in groundwater exceeds the standard limits (1.0 ppm or 1.5 ppm) as per the guidelines of World Health Organization (WHO), Indian Council of Medical Research (ICMR), and Bureau of Indian Standards (BIS) [26-28]. In addition to groundwater, many sources of lentic and lotic fresh waters (ponds, ponds, rivers, springs, dams, lakes, etc.) in many geographic regions or countries have also been found to be contaminated with fluoride with varying amounts [26,30]. In most rural areas, ground water sources (hand-pumps, bore-wells, and deep-dug wells) as well as freshwater sources are commonly used for drinking by domestic animals. Agricultural crop fodder and green grass cultivated in fluoridated soils and by irrigation with fluoridated water are also potential sources of development of fluorosis in animals [26,49]. Besides these sources of fluoride exposures, industrial fluoride pollution is also anthropogenic potential source of fluoride exposure for animals. In fact, certain industries, such as coal-burning power stations and brick kilns and the manufacture or production plants of steel, iron, aluminum, zinc, phosphorus, chemical fertilizers, glass, plastics, cement, oil refineries, etc. are the most common sources of fluoride emission or pollution [26]. Fluoride from these industries is released into the surrounding environment in both gaseous and particulate/dust form which pollutes not only the air, soil, and fresh water sources but also herbs, vegetation, and agricultural crops [19,26].

If animals develop fluorosis from drinking fluoridated water it is called "hydrofluorosis", which is most common in both domestic and wild animals throughout the world. When fluorosis occurs due to consumption of fluoride-containing supplements and contaminated food (forage, hay, etc.) it is called "food-borne fluorosis" which is generally rare. However, "industrial fluorosis" in animals caused by industrial fluoride emissions or pollution is usually confined to the vicinity of fluoride emitting industries. In animals, "dental fluorosis" and "skeletal fluorosis" are irreversible while "non-skeletal fluorosis" is reversible or disappears after the source of fluoride exposure is removed or the animals are moved from fluoride endemic areas to non-fluoride endemic areas [60].

Sensitivity to fluorosis in domestic animals

Though, the prevalence and severity of dental and skeletal fluorosis at different fluoride concentrations in diverse drinking water sources have been studied in various species of domestic animals including water buffalo (*B. bubalis*), cattle (*B. taurus*), horses (*E. caballus*), donkeys (*E. asinus*), dromedary camels (*C. dromedarius*), sheep (*O. aries*), and goats (*C. hircus*) from different geographic provinces [1,53-59]. But studies on the prevalence and severity of fluorosis in different species of domestic animals living in the same geographical area with approximately similar fluoride levels in drinking waters are too scanty. However, few such studies with large sample sizes of mature and immature (juveniles) domestic animals have been conducted in certain areas in the fluoride and fluorosis endemic state of Rajasthan (India)with low (<1.0 ppm) and high (>3.0 ppm) fluoride concentrations in drinking groundwater sources (**Tables 1 and 2**) [61,62].

At high (>3.0 ppm) concentrations of fluoride in drinking water, the highest prevalence, 96.8% of dental fluorosis and 34.3% of skeletal fluorosis, was found in immature buffaloes followed by 80.7% and 26.9% in immature cattle, 48.4% and 18.1% in immature donkeys, 43.7 % and 18.7% in immature horses, 22.2% and 11.1% in immature camels, 9.5% and 0.0% in immature sheep and 7.4% and 0.0% in immature goats, respectively (**Table 2**) [62]. Similarly, a similar pattern of prevalence of dental and skeletal fluorosis was also found in mature animals of these species as shown in **Table 2**. Among these animal species, the maximum severity of fluorosis is also manifested in water buffaloes. Interestingly, at low fluoride levels (<1.5 ppm) in drinking water, the highest prevalence of dental and skeletal fluorosis was also observed in juvenile buffalo, followed by juveniles of cattle, donkeys, horses, camels, sheep and goats [61]. The prevalence of dental and skeletal fluorosis in juveniles of different animal species is shown in **Table 1.**

In another study conducted in areas with 1.5 -1.7 ppm fluoride levels in drinking waters, the highest prevalence of fluorosis was also observed in buffaloes compared to other species of domestic animals (**Table 3**) [63]. Additionally, the prevalence and severity of fluorosis was higher in buffaloes than in cattle living in villages in three different districts of Rajasthan (India) where fluoride is found in drinking water sources ranging from 1.5 to 4.0 ppm [4]. But research studies also conclude that there is not much difference in the effect of fluoride on cattle and buffaloes. On the other hand, the effect of fluoride in them is more than that of other species of animals. These findings revealed that among different species of domestic animals, the water buffalo species is relatively more sensitive or susceptible to fluoride toxicity or fluorosis. In other words, buffaloes have relatively lower tolerance to fluoride or fluorosis compared to their counter parts. The sensitivity or susceptibility of fluorosis in animals can be presented as buffalo> cattle > donkey > horse > camel > sheep > goat. However, the prevalence and severity of fluorosis is more dependent on multiple determinants, including fluoride levels in drinking water and its duration and frequency of exposure, age, sex, chemicals in the water, food, nutrients, environmental factors, etc. [63-69]. It is also acknowledged that immature animals are found to be most susceptible or sensitive to chronic fluoride intoxication in the form of dental fluorosis as compared to mature animals. Therefore, they have also been considered as ideal bio-indicators of chronic fluoride toxicity [70].

Table 1: Prevalence (%) of dental fluorosis (DF) and skeletal fluorosis (SF) in immature animals of different species living in areas with low F (<1.5 ppm) in drinking water. Source: [61].

Animals (spp)	No. of animals (age)	No. of animals showed		Total
	investigated	DF	SF	
Buffaloes (*B. bubalis*)	78 (< 3 years)	41 (52.56)	8 (10.25)	49 (62.82)
Cattle (*B. taurus*)	89 (< 3 years)	44 (49.43)	8 (8.98)	52 (58.42)
Donkey (*E. asinus*)	30 (< 3 years)	5 (16.66)	- (0.00)	5 (16.66)
Horses (*E. caballus*)	21 (< 3 years)	3 (14.28)	- (0.00)	3 (14.28)
Camels (*C. dromrdarius*)	23 (< 6 years)	- (0.00)	- (0.00)	- (0.00)
Sheep (*O. aries*)	92 (< 1 year)	- (0.00)	- (0.00)	- (0.00)
Goats (*C. hircus*)	96 (< 1 year)	- (0.00)	- (0.00)	- (0.00)

Table 2: Prevalence (%) of dental fluorosis (DF) and skeletal fluorosis (SF) in domestic animals living in areas with high F content (>3.0 ppm) in drinking water. Source: [62].

Animal (species)	Immature animals		Mature animals		Lameness
	DF	SF	Lameness	SF	
Buffaloes	62/64 (96.8)	22/64 (34.3)	209/312 (66.9)	188/312 (60.2)	+++
Cattle	63/78 (80.7)	21/78 (26.9)	328/518 (63.3)	267/518 (51.5)	+++
Donkeys	16/33 (48.4)	6/33 (18.1)	39/106 (36.7)	28/106 (26.4)	++
Horses	7/16 (43.7)	3/16 (18.7)	23/70 (32.8)	17/70 (24.2)	++
Camels	4/18 (22.2)	2/18 (11.1)	13/67 (19.4)	12/67 (17.9)	+
Sheep	12/126 (9.5)	–/126 (0.0)	112/544 (20.5)	54/544 (9.9)	+
Goats	8/108 (7.4)	–/108 (0.0)	102/538 (18.9)	47/538 (8.7)	+

+, mild; ++, moderate; +++, severe

Table 3: Prevalence (%) of dental fluorosis (DF) and skeletal fluorosis (SF) in ruminants living in areas with 1.5-1.7 ppm F in their drinking waters. Source: [63].

	Mature ruminants		Immature ruminants	
Ruminants Species	DF	SF	DF	SF
Buffaloes	161/288 (55.9)	139/288 (48.3)	23/37 (62.2)	8/37 (21.6)
Cattle	188/392 (48.0)	156/392 (39.8)	22/43 (51.1)	8/43 (18.6)
Camels	2/38 (5.3)	2/38 (5.3)	–/12 (0.0)	– /12 (0.0)
Sheep	18/248 (7.3)	14/248 (5.6)	–/28 (0.0)	– /28 (0.0)
Goats	38/356 (10.7)	30/356 (8.4)	–/34 (0.0)	– /34 (0.0

However, apart from these determinants, "genetics" of the species or individuals is the most important factor that plays a vital role and is responsible for variation in fluoride tolerance and susceptibility to fluorosis. It is also observed in various human populations in India such as Scheduled Tribes (ST), Scheduled Castes (SC), and General Castes (GC). The study revealed that the prevalence of dental and skeletal fluorosis was found to be higher in tribal subjects (69.0% and 27.7%, respectively) compared to subjects of SC (57.2% and 20.8%, respectively), and GC (38.6% and 9.3%, respectively) population [71,72]. Variation in fluorosis susceptibility and severity and fluoride tolerance in different populations is also due to variation in genetics [72]. Therefore, the genetics of the individual or species is one of the most important factors responsible for variation in sensitivity or susceptibility to fluorosis in both animals and humans. Nevertheless, to confirm it and accept it unanimously, more intensive research is needed on this topic in different species of animals, both wild and domestic.

Conclusion

Fluorosis in various species of domestic animals including buffalo, cattle, donkey, horse, camel, sheep, goat, etc. is the result of chronic fluoride intoxication due to prolonged exposure to fluoride through fluoridated drinking water and food and/or industrial fluoride pollution or air-born fluoride emissions. In this disease, teeth and bones generally become damaged or deformed. Thousands of animals suffer from dental and skeletal fluorosis where fluoride exposure is found. Several studies have shown that among various species of domestic animals, water buffaloes are found to be more sensitive or susceptible to fluorosis compared to other species of domestic animals. In fact, it is possible that in buffaloes have low fluoride tolerance. Therefore, the prevalence and severity of fluorosis has been found to be high in buffalo species. However, many factors influence fluoride tolerance or susceptibility to fluorosis but genetics is the most important determinant among them which is responsible for the variation in fluoride tolerance and sensitivity to fluorosis in different species of animals. However, more epidemiological or scientific studies are needed to support and confirm this.

Declarations

Conflict of interest statement

The author declares that there is no conflict of interest in relation to this work.

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