TUBERCULOSIS AN IMPEDIMENT TO WILDLIFE CONSERVATION

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Introduction

Tuberculosis (TB) is a chronic infectious disease of great public health, economic and historical significance. In this country, the disease was reported as early as 4,000 years ago in elephants *(Elephas maximus).* Sanyal (1892) in his book on the Management of Captive Wild Animals has cited instances of the disease. The disease in England was recorded in many captive wild mammalian species between 1851 and 1860 (Crisp, 1860) i.e. even before the specific etiology of the disease was established in 1882 by Robert Koch. Presently tuberculosis is the greatest single problem among the specific infectious diseases of wild mammals affecting particularly deer and antelopes. There is no captive facility in the country said to be TB free. TB incidence is found also high in deer and antelope inhabiting certain natural habitats (Arora, 1994). The etiology, distribution, patho-genesis, diagnosis, treatment and control in certain native mammalian species are discussed hereunder.

Etiology

Mycobacterium tuberculosis (human type) and *Mycobacterium bovis* (bovine type) are important types causing the disease in primates and deer species. *Mycobacerium aviam* (avian type) is next to them. Two other types of tubercle bacilli were also recognised. The murine type—*Mycobacterium microti* from voles and from fishes, lizards, snakes, frogs and other cold-blooded animals. Recently *Mycobacterium lucknowi* has been isolated from frog *(Rana tigrina)* proved to be pathogenic (when was administered in heavy doses i/v) to common langurs *(Presbytis entellus).* Mention has often been made in the foreign published literature about the isolation of *Myco. chlonei, Myco, fortuitum, and Myco. scrofulaceum* particularly from the hooved animals.

Epidemiology

(a) *Artiodactilids*

All species are highly susceptible to disease. In captivity incidence of pulmonary form as well as generalized form of the disease is high in chitals *(Axis. axis),* sangai *(Cervus. eldi eldi),* barasingha *(Cervus duvauceli),* and black bucks *(Antilope cervicapra).* Of the 22.8 per cent (54/236) TB deaths that occurred during 1971-74 in Zoological Garden, Calcutta (WB), 53 per cent (29) cases occurred among artiodactylids: deer-25, Llama-I, wild sheep-1 and mouse deer-2 (Sen Gupta, 1974). During 1985, Zoological Garden, Lucknow (UP) experienced high incidence of TB among its black buck *(Antilope cervicapra)* population (Arora, 1994). Incidence of human type and bovine type in native artiodactylid species reported to be 42.4 (14/33) and 57.6 (19/33) respectively in Zoological Garden, Guwahati (Thakuria, 1996). In a herd of 34 black bucks of Van Prani Uddyan (VPU), I.V.R.I., Izatnagar (UP), intestinal tuberculosis was diagnosed in one case that had also extensive TB lesions in lungs, mesenteric glands, liver, and spleen (Arora, 1998). Earlier in 1994 similar type of TB lesions were recorded in one adult female chital *(Axis axis)* in this Uddyan. TB of spinal vertebrae in a captive black buck *(Antilope cervicapra)* in National Zoological Park, New Delhi. *Mycobacterium avium* has been isolated from captive chital *(Axix axis)* and hog deer *(Axix porcinus)* died of generalised tuberculosis (Arora, 1993 and 1998).

Necropsies of mouse deer *(Tragulus meminna)* on 31.5.83, at Zoological Park, Kanpur, and in gorals *(Nemorhaedus goral)* at various occasion in National Zoological Park, Delhi TB has been recorded. There appears to be no report of disease in musk deer *(Moschus chrysogaster), hungul (Cervus hunglu),* and pigmy hog *(Sus salvanicus).* In an outbreak of paramphistomosis among deer and antelopes that occurred during the hard summer 1981 in National Park, Ranthambore, Rajasthan, many of the chitals *(Axix axix)* and sambars *(Cervus unicolor)* during necropsy had shown extensive tuberculous lesions.

In captivity, introduction of an infected animal into the disease-free resident population will create focus for infection. Infected keepers are equally potential source of infection to their collections. Since the deer are maintained in open enclosures, introduction of infection from outside by free ranging infected animals such as rhesus monkeys *(Macaca mulatta)* and avian species

(Myco. avium infected and shedding the bacilli in their faeces) cannot be ruled out. In daily routines cleaning and disinfection of the enclosure substrate of deer and antelope is beyond scope, as their entire population normally remain in display area of the enclosure round-the-clock and there is no rotational adjacent built up facility for their migration. Hence, infected substrate of the enclosure itself can be a persistent source of infection to its new additions. Crowding and malnutrition is the major predisposing factors for causing rapid spread of disease in the population. The susceptible individuals contract disease by inhalation more frequently because of species herding nature. Ingestion is also an important route of acquiring infection.

(b) *Non-human primates*

Ten out of 57 monkeys died of TB at Zoological Garden, Calcutta during the years 1906 to 1910 (Mitter, 1910). Then after there have been many reports of disease in primate species besides other mammalian species dying in the captive facilities due to tuberculosis. TB deaths in 14 out of 15 rhesus monkeys *(M. mulatta)* occurred at all India Institute of Hygiene and Public Health, Calcutta. The source of infection was attributed to the infected guinea pigs housed in the same room (Krishnan, 1936). TB in endangered native non-human primate species claimed death in the golden langurs-Presbytis geei (8/33), capped langurs *Presbytis pileatus* (4/17), Nilgiri langur-*Preshytis johnii* (1/7), and lion-tailed macaque-*Macaca silenus* (1/2) in Zoological Garden, Guwahati, Assam (Thakuria, 1996), in lion-tailed monkey in Zoological Park, Madras and in Nilgiri langurs in National Zoological Park, New Delhi (Arora, 1994).

Tuberculosis in primates is caused mainly by 3 major types of *Mycobacteria: M. hominus, M. bovis and M. avium* in order of their mentioned. Mukunda (1996) reported that 60% of tuberculosis cases in primates caused by *Myco. hominus* type; 20% *Myco. bovis* type; 5%, by *Myco. avium* type and 15% by unidentified type. However, he has not substantiated veracity of his data and statement Thakuria (1996) reported high incidence of both human type (58.5%) and bovine type (41.5%) tuberculous infections in non-human primates dying between 1984 and 1992 in the Zoological Garden, Guwahati. On the other hand in the foreign country very high rate of avian tuberculous infection than bovine or human type tuberculous infections in primates has been reported by Theon and Himes (1980). *Myco, simiae* and *Myco. abscesses* are also reported to be pathogenic to simian species by them.

TB in free ranging primates is reported rather infrequently. 10.4% of 302 rhesus monkeys caught from the neighbourhood of Delhi and Mathura were found positive to tuberculin test. Within a month the number of reactors rose to 30.8% and after three months to 41%. Animals suffered from active TB and lungs were the main site of lesions Morbid anatomy of all these cases revealed that incidence of the disease increased progressively with length of their stay in captivity (Nair and Ray, 1954).

Author has necropsy examined two rhesus monkeys in the metropolitan cities and found affected with the generalized form of disease. The lesions in both the cases were generalised abscesses in the various organs besides the lungs. In one of the case spleen was almost completely damaged. In the primates species tuberculous lesions may vary from focal miliary lesions to large cavity lesions. The characteristic histological feature of tubercle as calcification, fibrosis, and Langhans giant cells may or may not be present. The lesions of *Myco, avium* infection in the intestine are marked for irregular thickness of small intestine and colon and enlargement of the mesenteric lymph nodes. Histologically the intestine mucosa and lymph nodes show diffuse infiltration of epitheloid cells containing acid-fast bacilli. The lesions lack necrosis, calcification and fibrosis (Sesline *et al.,* 1975; Smith *et al.,* 1973).

(c) *Carnivores*

Large felids are comparatively resistant to tuberculosis. Only few authentic case reports of the disease are on the published records. Darjeeling Zoological Garden appears to be the only captive facility in the country that has experienced mortality in its tigers *(Panthera tigris)* and also small felid species *(leopard cat—Felis bengalensis).* In free ranging carnivores there is hardly any authentic report of tuberculosis in any species except one case of tiger *(Panthera tigris)* died in Dudwa National Park, in 1987, in which hepatic abscess was diagnosed for the disease.

Myco, bovis has been isolated from a lion *(P. leo persica)* died of generalized tuberculosis in Zoological Garden, Bombay (Mumbai). (Das and Jayarao, 1986). The Zoological Garden, Darjeeling has also experienced death of leopard *(P. pardus)* due to TB. In his Garden TB has also caused a high mortality in Himalayan black bears *(Selenarctos thobetamus) (Zoo's Annual Report 1997-98).* Disseminated tuberculosis found in an 8 years old female sloth bear *(Melursus ursinus)* which died at Banarghatta National Park (Karnataka). General symptoms were anorexia, persistent cough, weakness and progressive loss of weight while in captivity (Sreenivas Gowda, *et al.,* 1983). Death of an adult male sloth bear on 26.5.1984 in Zoological Park, Kanpur (UP) and one female sloth bear on 7.2.1997 in National Zoological Park, New Delhi occurred due to TB. In case of former disease assumed pulmonary form and in case of later hepatic lesions to be the main.

Mortality has been reported in binturong *(Arctictis binturong)* and red panda/cat bear *(Ailurus fulgens)* in Zoological Garden, Bombay (Liston and Soparkar, 1924). In binturong generalized form of disease based on gross pathological lesions was diagnosed in 1 male died on 25 October, 1979, and 3 females died on different dates in span of 6 months between 1983 and 1984 in Zoological Park, Kanpur (UP). TB in members of families *Viverridae, Mustelidae* and *Hyaenidae* is poorly reported. Only one case is reported for small Indian civet cat *(Viverria indica),* otter *(Lutra lutra)* and hyaena *(Hyaena hyaena)* respectively in each family in Zoological Garden, Guwahati (Thakuria, 1996). There appears to be no report in species of family Canidae.

(d) *Proboscida*

Early Indian literature on the Hindu Mythology (2000 BC) furnishes evidence that tuberculosis was encountered in elephants *(Elaphas maximus).* Evans, G.C. (1910) has cited records of tuberculosis in elephants in his book 'Diseases of Elephants'. Pulmonary TB in elephants has been recorded by Narayan (1925), Chandrasekharan (1989), Vijayan *et al.* (1992) and generalized form by Bopayya (1928-29). Pus smears examined from the multiple abscesses developed on the hind and fore regions of the body in an adult working female elephant belonging to Corbett National Park, Ramnagar (UP) when examined showed presence of acid-fast organisms. The animal was marked for debility, tiredness and not responding to any treatment. Eventually it had died after about 6 months of severe illness and reportedly diagnosed for disseminated TB. Motomuria (1961) has reported isolation of *Myco. elephantis* as a separate species of *Mycobacterium* infection from an elephant, but any further report corroborating this finding is not traceable.

(e) *Perissodactylids*

The rhinoceroses *(Rhinoceros unicornis, Diceros bicornis)* have been observed to suffer from tuberculosis. Lesions in lungs and liver were described in an old sumatran rhinoceros (Sanyal, 1892). In Zoological Park, Hyderabad (AP) one of the three rhinoceroses *(R. unicornis)* which died of acute gastro enteritis caused by salmonellosis had pulmonary TB lesions (Arora, 1986). Nodules characterised by caseous centre, mononuclear cell infiltration and fibrous tissue encapsulation in liver and lungs were seen. On 23rd August, 1992 a 13-year old female African rhino *(Diceros bicornis)* fell ill in Zoological Garden, Mysore (Karnataka). Dyspnoea coughing and muco purulent nasal discharge reflecting bronchopneumonia were the clinical manifestations observed. Symptomatic treatment remained ineffective to alleviate the condition. On later dates clinical signs aggravated. Tuberculosis was suspected and treatment instituted. But, unexpectedly, the rhino expired on 11th September, 1992 at about 2.00 p.m. Gross necropsy examination showed trachea filled with an enormous quantity of pus and abscesses in the right and left lungs. Mediastinal and bronchial lymph nodes were found enlarged with abscesses containing creamy pus. Bacteriological examination of nasal discharge and pus and histopathological evaluation of lesions were suggestive of pulmonary tuberculosis as the cause of death of this female rhinoceros (DO MZP/700/92-93 dated 13th September, 1992, B.G. Mugadur). On 29.5.1994 the male partner died of Myco. tuberculosis infection. The nodular type caseated lesions were noticed in lungs and liver (vide No. MZAZH TB/94-95 dt. 7.12.94).

(f) *Rodents*

Sen Gupta, (1974) reported death of 3 porcupines, and 1 flying and I giant squirrel due to tuberculosis in ZG, Calcutta. Death of a porcupine (Histrix sp) in Garden was latter on recorded due to *Myco. bovis* infection (Basak *et al.* 1976). Necropsy examination of an adult female giant squirrel *(Retufa indica)* died on 6.11.1989 at Zoological Garden, Lucknow (UP) also evidenced extensive TB lesions in its lungs (Arora, 1994).

(g) *Marsupials*

Tuberculosis was recorded in a kangaroo, besides other animals (Anon. 1934-35). A kangaroo and 3 agouty with clinical history of coughing, dullness and emaciation had died of TB at Zoological Garden, Calcutta. Tuberculous lesions were confined to lungs in these animals (Sen Gupta, 1974). In Zoological Garden, Bombay, a kangaroo *(Megalaria rufa)* died with *Myco. tuberculosis* infection after prolonged wasting condition (Das and Jayarao, 1983). TB caused death of one bannet wallaby in Zoological Park, Kanpur, Morphologically acid fast organism isolated form lesions found in lungs and liver were indistinguishable form *Mycobacterium avium* bacilli (Arora, 1994).

(h) *Reptiles and Amphibians*

Mention has been made in the Proceedings of Zoological Society of London, 1939 and onwards about deaths due to TB in crocodiles, snakes and toads. In the generalized form of disease lesions involved liver, intestine, spleen with or without involvement of lungs. Thoen and Himes (1980) reported *Mycobacterium avium* from turtle and snake and also *Myco. chelonae* from snake, manatee toads. There are only few reports of disease in reptiles and amphibians.

Mycobacterium tuberculosis infection related lesions in the liver and lung in a python were recorded by Singh

et al. (1981). *Myco. lucknowi* isolated from a frog *(Rana tigrina)* proved to be pathogenic for langur *(Presbytis entellus),* when inoculated intravenously in very high doses (Tewari *et al.*, 1982). TB among monitor lizards in captivity is recorded very rarely.

Diagnosis

Specific diagnosis of TB in any animal species in antemortem examination is always complicated as the incubation period of the disease is prolonged and the specificity of the available diagnostic tests is at variance. TB bacilli grow slowly and disease assumes fulminating form only when affected host is severely exposed to a predisposing factor.

(a) *Clinical diagnosis:*

(i) Haematological and biochemical findings do not impart specific diagnosis. Emaciation rough hair coat and reduced food consumption are obviously marked only about 2-3 weeks before the terminal stage is reached. Any external abscess below the ear, thoracic and abdominal regions not responding to medical management must be investigated for TB. Such cases in deer are often related to generalized tuberculosis.

(ii) Chest X-ray is of diagnostic value for detecting advanced tuberculosis in primates that may be occasionally negative to tuberculin test.

(iii) Tuberculin testing with inoculation of PPD intradermally in palpebral of the upper eyelid or at the lower elbow skin in primates, in cervical region in deer and antelopes and at the base of ear or in the anal fold in case of elephants.

Case Reports

Report 1. Samantaray (1999) conductee TB testing in 6 common langurs *(P. entellus)* and 6 deer *(A. axis-3, C. unicolor-2 and Cervus eldi eldi-1)* belonging to Biological Park, Bhubneshwar (Orissa). His findings are cited as below (Personal comm.)

(i) In all 6 common langurs *(P. entellus)* normal skin thickness measured 0.1 mm. After 48 and 72 hrs. of inoculation of 0.1 ml. PPD i/d in each case no diffuse swelling developed at the site, hence all were declared to be TB negative.

(ii) The normal thickness of skin in the mid-cervical region measured 0.1 mm to 0.15 mm in chitals and sambars and 0.1 mm in sangai. In the mid-cervical of each animal 0.1 ml PPD was inoculated. After 48 hrs. and 72 hrs. all chitals and sambars showed diffuse oedematus, moderate swelling of 0.8 mm and 0.6 to 0.8 mm respectively. In sangai diffused oedematous swelling developed at site was 0.2 mm after 48 hrs. and 0.4 mm after 72 hrs. Based on the type of reaction and thickness of the site measuring above 0.4 mm all the deers were considered positive to TB.

Report 2. In Zoological Garden, Assam, Mahanta *et al. (1994) conducted TB testing in three Capped langurs (Presbytis pileatus),* 2-Golden langurs *(Presbytis geei),* I Nilgiri langur *(Presbytis johnii)* and 1 Lion-tailed monkey*) Macaca silemus).* Normal skin thickness behind the shoulder as 1.5 to 2.0 mm. After 48 and 72 hrs. of inoculation of 0.1 ml PPD i/d, the site measured from 2.5 to 3.0 mm in all except in one capped langur in which it was 2.2 mm. It was said that animals receiving isoniazid therapy have reduced sensitivity to tuberculin test.

Report 3. There have been numerous reports that the animals with advance TB lesions become anergic to the tuberculin test. However, Verma (1999) in his report on tuberculin testing in rhesus monkeys mentioned that monkeys with advanced TB lesions did not become anergic to tuberculin test. Dille hay and Rudovsk (1998) have suggested that multidrug chemotherapy may not result in disease resolution. An adult rhesus monkey received isonazid and ethambutol prophylactically for 9 yrs. had 120 consecutive negative tuberculin tests. Miliary tuberculosis was diagnosed at necropsy.

(b) *Laboratory diagnosis*

(i) Culture of concentrated materials on specific medias which are very sensitive for detecting tubercle bacilli help in isolation and certain chemical tests in typing the isolate(s).

(ii) Transmitting infection into experimental animals (biological test) like guineapigs, rabbits by using concentrated material is practiced. However, in view of chemical tests use of biological test is no longer in vogue.

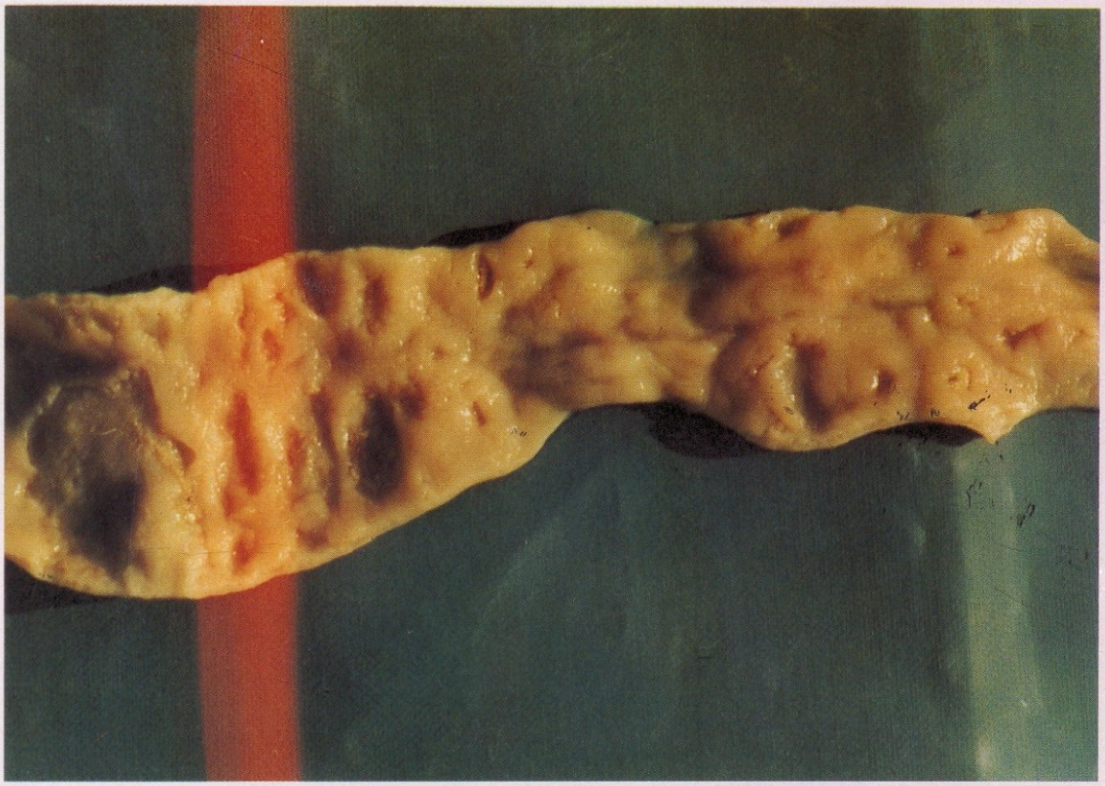
(iii) Radio culture of tissue biopsy (in avain also of faecal sample) and ELISA test for detection of serum antibodies are reported to be sensitive in early diagnosis of disease but they are still the primary research tools.

5. **Treatment, Prevention and Control**

(A) *Obstacles to tuberculosis control*

(i) —The organism is slow-growing
—Thick-walled-resistant to most antibiotics
—Able to develop resistance (can become incurable).

(ii) The disease is difficult to diagnose
—New technologies (field sensitive test) to diagnose preclinical stage of the disease are yet not available.



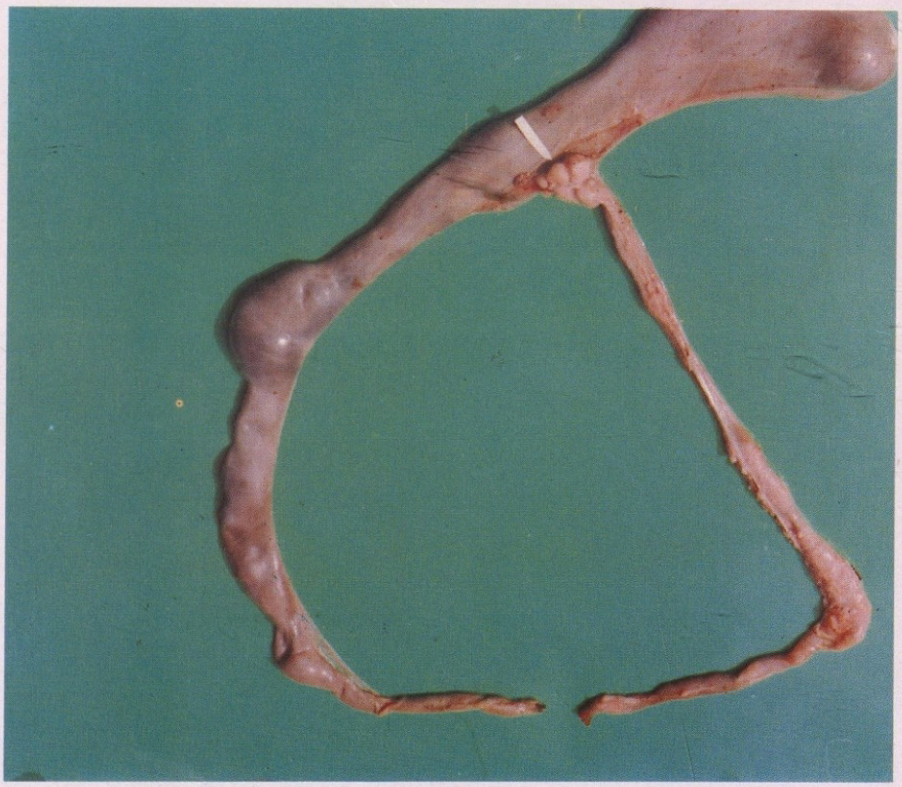


Fig. 1.(a and b): Tuberculous enteritis in an adult black-buck *(A. cervicapra)* died of generalized TB.

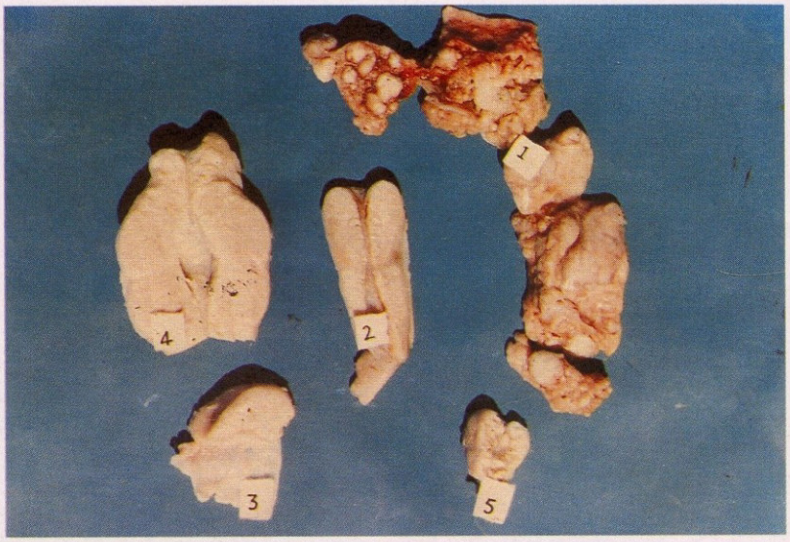


Fig. 2.TB lesions in lungs and lymph nodes—mediastinal, bronchial, etc. in black-buck *(A. cervicapra)*

Fig. 3. Showing subcutaneous abscess in the thoracic region and also involvement of mandible in an adult chital died of generalized TB

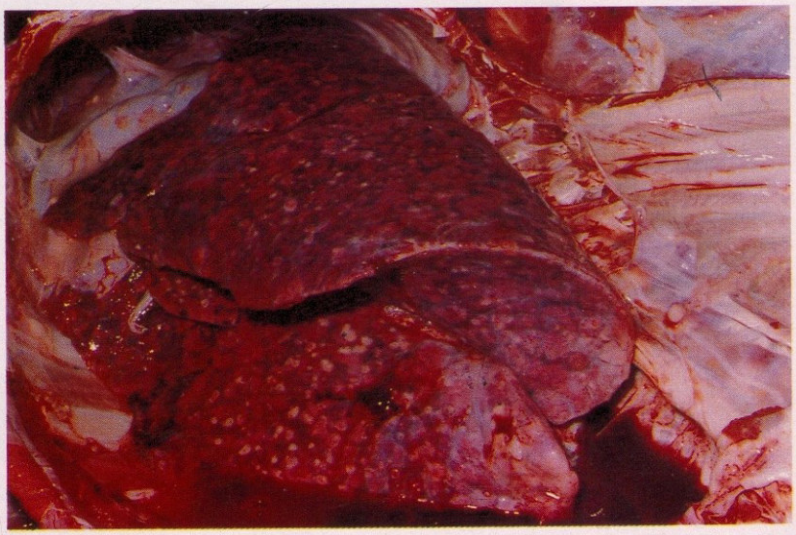


Fig. 4. TB affected lungs of chital *(A. axis)*

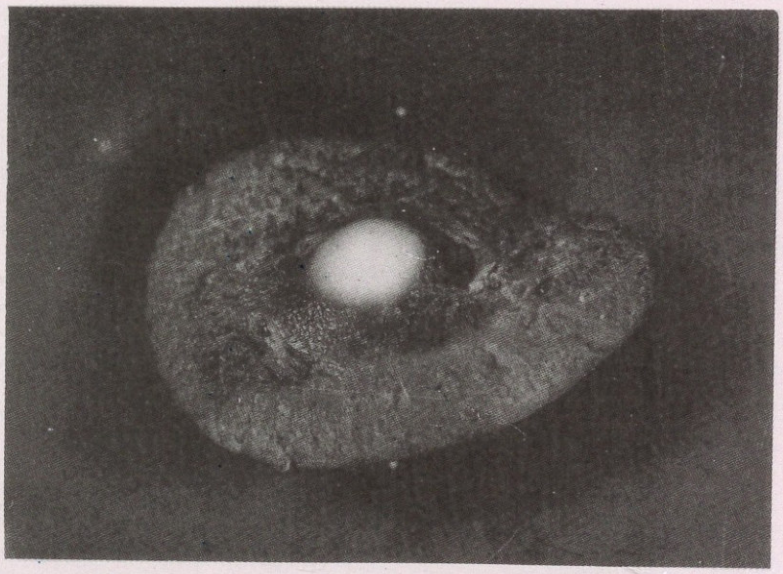


Fig. 5. TB abscess in medulla of kidney in chital *(A. axis)* died of generalized TB

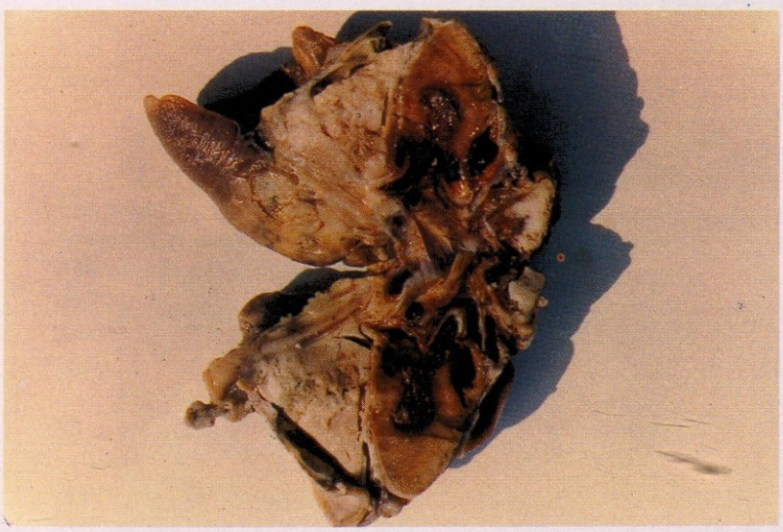


Fig. 7. Pulmonary TB in a giant squirrel *(Rtufa indica)*

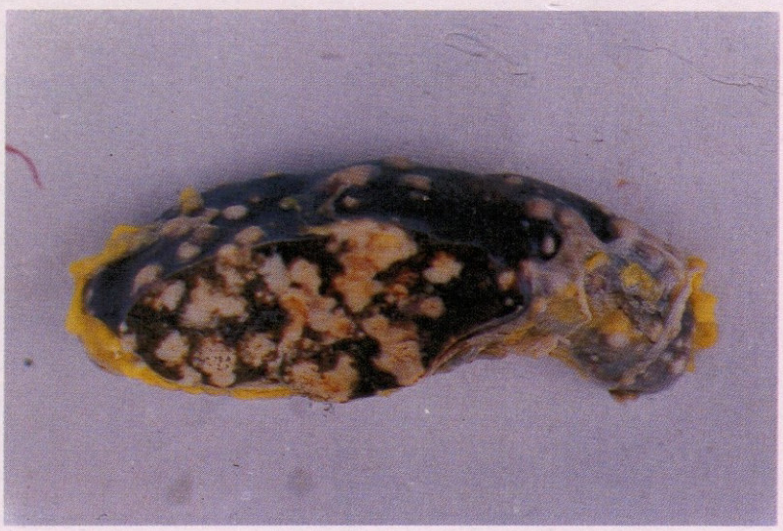


Fig. 8. TB affected spleen belong to a rhesus monkey *(M. mulatta)* died of generalized TB in a temple in Bareilly City

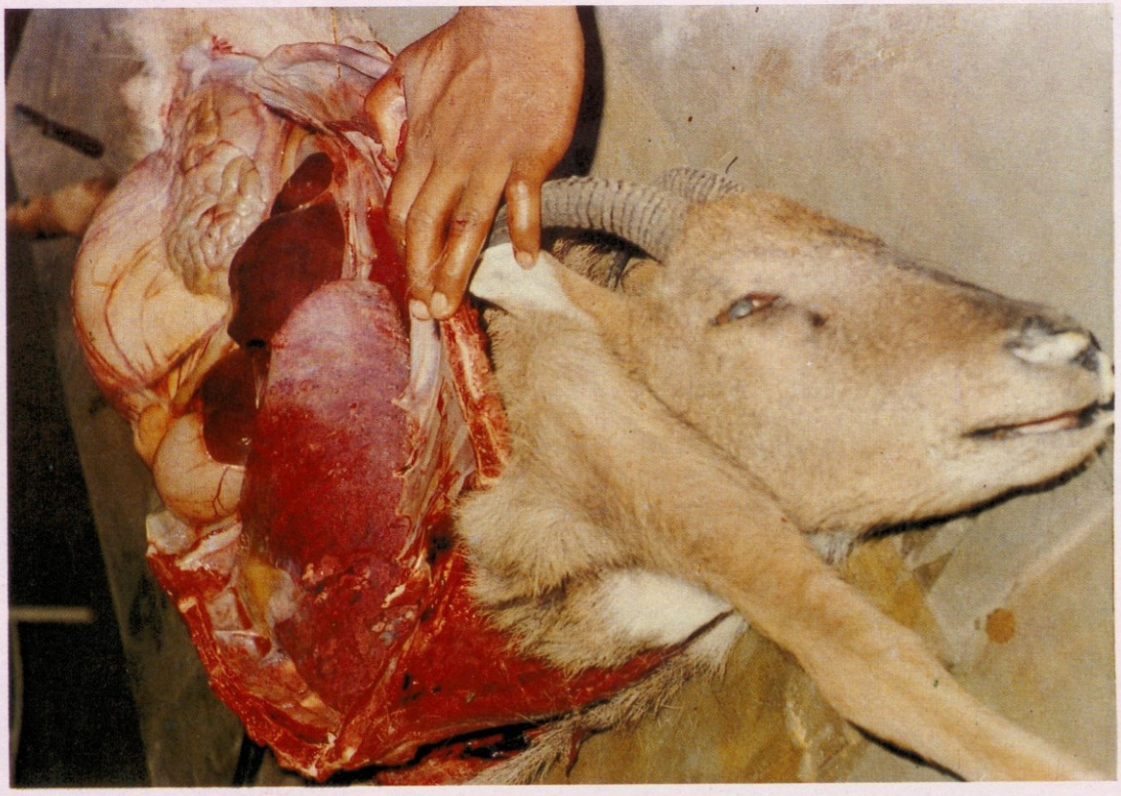


Fig. 6. (a) Tuberculous lungs and nasal exudate in goral (N. goral)

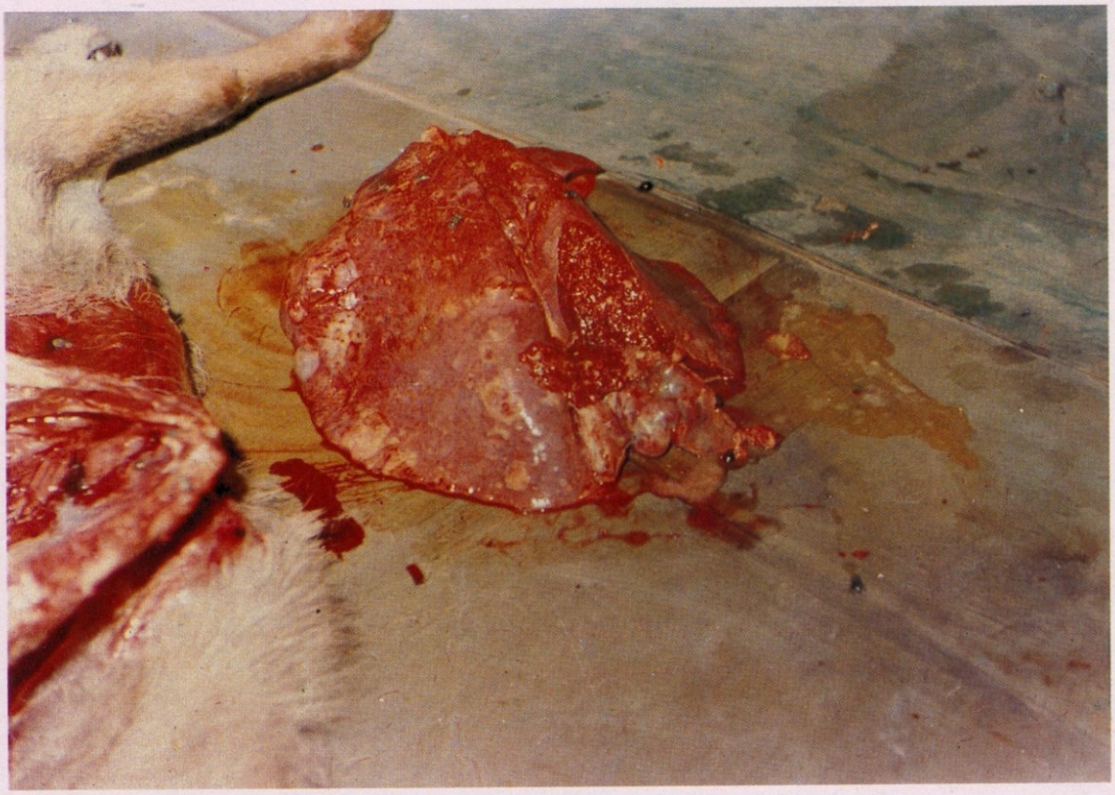


Fig. 6. (b) Gross tuberculous lesions in the lung

(iii) The treatment
—Multiple drug therapy is choice. Which is relatively expensive need regular prolong monitoring.
—No effective vaccine.

(iv) Control programmes
—Require proper planning by the technical persons.
—Require prolonged effort and funding on the part of Government.
—To practice BCG or other vaccine need policy programme.

(B) *Treatment*

Tubercle bacilli is a formidable enemy. It grows slowly and its impervious wall is making it hard to expose effectively to the bactericidal effect of the drugs administered, hence require prolong treatment. Another problem is of acquired drug resistance owing to pool and interrupted course of tuberculosis treatment regimen or faulty prescription.

(a) *Artiodactylids*

(i) Zoological Garden, Calcutta in 1960 started treatment of its deer and antelope populations with isoniazid @ 4-5 mg/kg b.w mixed in concentrate feed. A gap of 3 months was given after each course of three months of treatment. This schedule has been followed for about 3 decades (Das *et al.*, 1994). However, there is no report for disease-free states of the zoo.

(ii) *Study*

Thakuria (1996) practiced the following therapeutic approach to cure the disease in artiodactylid species belonging to Zoological Garden, Guwahati (Assam).

First Trimester

For large animals: Tibnex 450 tab 2 + Becosules cap 2 daily for 90 days

For small animals: Tibnex 450 tab 1 + Becosules cap 1 daily for 90 days

Second Trimester

Inabutol forte (Themis chemicals isoniazid 300 mg. Ethambutol Hcl 800 mg tabs)+ Becosules

For large animals: Inabutol forte tab 2 + Becosules cap 2 daily for 90 days

For small animals: Inabutol forte tab 1 + Becosules cap 1 daily for 90 days.

Third Trimester

Themibutol (Themis chemicals ethambutol Hcl 200 mg, 400 mg, 600 mg, 800 mg 1000 mg tab)+ Becosules.

(b) Non-human Primate

The disease has been a problem since the first primates were maintained in captivity, continues to be a significant problem, and all likelihood will remain a potential problem as long as primate species are maintained in Zoological Parks. Policy for stamping out of the infected stock is yet not adopted in this country.

Anti-tuberculosis treatment in case entire stock is affected has limited scope for cure with any treatment. In case where extremely valuable and endangered primate species are involved, they do require specific diagnosis and institution of treatment at the very early stage. Confirmed cases of tuberculosis should be treated in isolation wards.

Case Study 1: Das *et al.* (1994) described prophylactic treatment with isoniazid @ 4-5 mg per kg b.w. in primate species maintained in Zoological Garden, Calcutta. The powdered medicine was mixed with rose syrup and offered to the animals after spreading the same over the sliced bread. A gap of 3 months was given after each course of 3 months of treatment. This practice remained continue throughout the year.

Case Study 2: Mukunda (1996) recommended the following regimen.:

			Dosage:	
(a)	12 months regime		Isonicotinic acid	
(i)	INH+S+T/E	2 months	Hyderazide (INH)	3.5 mg/kg bw
	INH+T/E	9 months	Streptomycin (S)	10 mg/kg bw
(ii)	INH+S	1 month	Thiacetazone (T)	2 mg/kg bw
			Ethambutol (E)	15-20 mg/kg bw
(b)	8 months regime		Rifampicin (K)	10 mg/kg bw
			Pyrazinamide (PZA)	20-30 mg/kg bw
(i)	INH+R+PZA+T	2 months		
	with INH+T	6 months		
(c)	6 months regime			
(i)	INH+R+PZA+SE	2 months		
	with INH+T	4 months		

The above regimen should be supplemented with pyridoxine to counter adverse reaction.

First Trimester

Tibinex 450 tab 1/2 + Becosules cap 1/2 daily for 90 days.

Second Trimester

Inabutol tab 1/2 + Becosules cap 1/2 daily for 90 days.

Third Trimester

Themibutol 15 mg/kg body wt + Becosules cap (as before) daily for 90 days.

(c) *Proboscida*

Case Study 1: Chandrashekharan (1989) treated tuberculosis in and adult elephant (*E. maximus*) by administrative of streptomycin @ 100 g i/m on alternative day for a period of 4-5 weeks. Supportive drugs like herman @ 200 ml i/v and 10@ of dextrose i/v were also found useful.

Case Study 2: Foreign workers have tried rectal suppository dosage regimen for administration of isoniazid and rifampin in case of Asian elephant that refuse to take oral medicine. The animal undergoes conditioning for this practice, found effective (Dunker and Rudovsky, 1998).

(d) *Marsupials*

Multiple anti-tubercular drugs such as amikacin, rifafutin, myambutol, enrofloxacin and newer drugs—azrithromycin and immunotherapy with Myco. vaccae vaccine are being tried in Australia in marsupialsagainst *Myco. avium.*

(C) **Prevention and Control**

(a) *Preventive measures*

Many facilities maintaining non-human primates and deer and antelope species must maintain an active, vigorous, tuberculosis surveillance programme in both their animal and human populations to attempt to prevent entry of the disease or to eradicate it as soon as possible it gains entrance.

(i) Inter and intra-deer and antelope species dwelling together eill establish a persistent disease focus in the facilities. Therefore, each species shall be maintained separately. Segregation of all the juveniles aged 3 to 6 months to be maintained sexwise separately. All the juveniles males (except 2 to 3 nos. to be retained for breeding) shall be vasectomized. The juvenile stock shall be accinated with BCG vaccine.

(ii) Water moat of the enclosures housing infected deer/antelopes shall not flow into moat of any other herbivore enclosures.

(iii) No exchange or introduction of animals from the infected deer population be commissioned.

(iv) Animal staff shall regularly be got screened for TB. Only healthy staff is to conduct daily routines of the animal stock.

(b) *Control measures*

(i) Once TB in deer and antelope herds is established it is difficult to eradicate by any treatment practice. Then it is always necessary to depopulate the entire herd. In such instance the empty enclosure shall not be used until it is thoroughly cleaned and decontaminated using a 3% cresylic compound or a derivative of phenol such as orthophenyl. If possible the enclosure should be disinfected two times in a week interval.

(ii) At one year of age the representative numbers shall be tuberculin tested and after 45-55 days that positive or doubtful in first testing be retested. The confirmed cases be eliminated. Rest all stock provided daily anti-tuberculosis combined therapy treatment for 60-90 days.

(iii) It should be ensured that number of animals in one hectare of the enclosure area shall not be more than 7 to 8 animals in any case.

(iv) Animals required for addition to a collection should come from TB-free accredated herds.

Avizendum: There is no approved national programme to eradicate tuberculosis from the Zoological Gardens/ Parks. There is also no mandatory reporting systems of disease in endangered species such as sangai (*C. eldi eldi*), barasingha (*C. duvances*), golden langur (*P. presbytis goei*), red panda (*A. fulgens*), rhinoceros (*R. unicornis*), etc. Raisen d'etre could be shortage of technical staff and risk of handling the animals for the purpose. And sometimes also to avoid mentioning intentionally about the disease to attract public criticism and departmental quaries. Most of the necropsy reports describe pulmonary TB lesions as suppurative pneumonia or bronch pneumonia and cases of generalized suppurative lesions in the visceral organs and lymph glands related to organ abnormality such as hepatitis, spleenitis and nephritis. Therefore, accurate data are not available related to kind of *Mycobacteria* infections affecting animals in our captive and free facilities. It is advisable that whenever tuberculosis lesions are found on necropsy attempts should be made to subject the specimen for cultural examination to determine whether *Myco. bovis, Myco. tuberculosis, Myco. avium* or atypical mycobacteria are involved. All these agents have been reported in zoo collections and the difference is critical for analysis of the problem and prediction of the outcome. The type infection based data are likely to be useful in treatment and for animal exchange programmes between the zoos or surplus stock releasing into wild natural habitats. The handlers as well as visitors need to be educated about zoonotic importance of the disease.

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