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Tamil Nadu Veterinary and Animal Sciences University

Central Zoo Authority funded project on

"COMMON FOOT AILMENTS IN CAPTIVE ASIAN ELEPHANTS OF SOUTH INDIA"

FINAL REPORT

Tamil Nadu Veterinary and Animal Sciences University

Department of Wildlife Science

Madras Veterinary College, Chennai - 600 007.

2010

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"COMMON FOOT AILMENTS IN CAPTIVE ASIAN ELEPHANTS OF SOUTH INDIA"

FINAL REPORT

Submitted to

CENTRAL ZOO AUTHORITY OF INDIA
NEW DELHI

By

Dr. K. S. SUBRAMANIAN
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and

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TAMIL NADU VETERINARY AND ANIMAL SCIENCES UNIVERSITY
DEPARTMENT OF WILDLIFE SCIENCE
MADRAS VETERINARY COLLEGE
CHENNAI - 600 007.

2010

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COMMON FOOT AILMENTS IN CAPTIVE ASIAN ELEPHANTS OF SOUTH INDIA

1. Project title : Common foot ailments in captive Asian Elephants of South India

2. Date of Start : 18- 02 – 2008 (Scheme code : 22096)

3. Duration : Two years (February 2008 – February 2010)

4. a. Name of the Institute : Madras Veterinary College

   b. Division / Department : Department of Wildlife Science

   c. Location of work : Department of Wildlife Science, Madras Veterinary College, Chennai-600 007.

5. Technical personnel

S.No.	Name and Designation	Date of Joining	Total number of man months spent
	Principal Investigator		
1.	Dr. K.S. Subramanian, Assistant Professor	18-02-2008	24 months
	Co-Principal Investigators		
1.	Dr. T.G. Prabhakar, Professor	18-02-2008	24 months
2.	Dr. M.G. Jayathangaraj, Professor and Head	18-02-2008	24 months
	Junior Research Fellows		
1.	Tmt. S. Ranjani	20-03-08 to 12-11-09	20 months
2.	Dr. S. Roshini	24-12-2009 to 18-02-2010	2 ½ months

INTRODUCTION

Elephants are fascinatingly interlaced with Indian culture, tradition & mythology and India is blessed with more than 50 % of world's Asian elephant population. In south India, captive elephants are traditionally being maintained in the temples from time immemorial. Scientists working with elephants reported that foot problems constitute the single most important ailment of captive elephants and more than 50 % of the captive elephants suffer from some form of foot ailment in their life time.

Though the foot problems may not directly challenge the life of the elephant there will be serious economic loss in terms of productivity and utility of the animal and if the ailment is not handled properly in time, it may eventually lead to a painful death in due course. Hence considering the essential need for a preliminary study about the common foot problems and their management this research project has been formulated as a pilot study with the following objectives.

OBJECTIVES OF THE SCHEME

- To form a database about the common foot problems encountered in captive Asian elephants.
- To analyze the predisposing factors leading to foot problems in captive elephants.
- To identify the bacterial organisms in the foot lesions and to suggest appropriate treatment measures.
- To suggest proper foot care management practices for the captive elephants.

BUDGET AND EXPENDITURE : (TOTAL BUDGET :- RS. 5, 94, 420 /-)

A. BUDGET

SI. No.	Details	First year (Rs.)	Second Year. (Rs)	Total (Rs.)
1	Salary for Junior Research Fellow @ Rs.12,000/- and eligible HRA (10% of the pay) per month (Rs. 13,200 / pm)	1,58,400	1,58,400	3,16,800

2	Laboratory chemicals, reagents and other consumables	40,000	30,000	70,000
3	Traveling allowances	40,000	40,000	95,000
	Additional fund to cover Kerala & Karnataka	-	15,000	
4	Stationary, preparation of booklets and management guides	15,000	35,000	50,000
5	Medicines and Misc. expenditure	7,000	8,000	20,000
	Additional fund for Kerala & Karnataka		5,000	
6	Institutional charges	21,310	21,310	42,620
	Total	2,81,710	3,12,710	5,94,420

B. EXPENDITURE

Sl. No.	***Details***	***Total budget Allotment (Rs.)***	***Total Expenditure (Rs.)***
1	Salary for Junior Research Fellow @ Rs.12000/- and eligible HRA (10% of the pay) per month (Rs.13,200 / pm)	3,16,800	2,41,995
2	Laboratory chemicals, reagents and other consumables	70,000	70,000
3	Traveling allowances	95,000	95,000
4	Stationary, prep aration of booklets and management guides	50,000	50,000
5	Medicines and Misc. expenditure	20,000	19,996
6	Institutional charges	42,620	42,620
	Total	5,94,420	5,19,611

STUDY AREA: - CAPTIVE ASIAN ELEPHANTS MAINTAINED AT

- Aringar Anna Zoological Park, Vandalur (7).
- Anamalai Tiger Reserve, Pollachi (19).
- Mudumalai Tiger Reserve, The Nilgiris (23).
- Temple Elephants of Tamilnadu and Pondicherry UT (53).
- Guruvayur Devaswom (66)
- Bandipur Tiger Reserve, Karnataka (14)
- **Total No. of elephants covered : 182**

STUDY PERIOD

- February 2008 to February 2010.

SCHEDULE OF TECHNICAL WORK

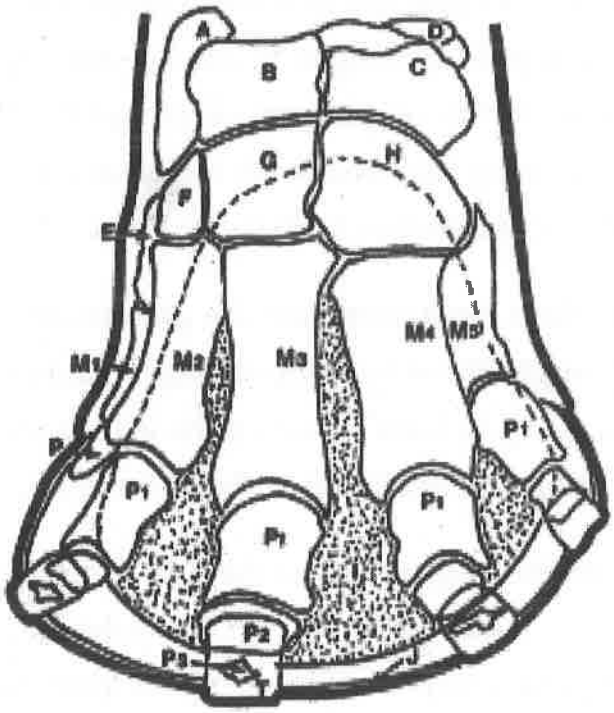
Technical work	Status of completion
➢ Getting permission from Tamilnadu Forest department and Temple authorities to carryout the study.	Completed
➢ Collection of technical information and literatures regarding foot problems in elephants.	Completed
➢ Carrying out field work with captive elephants of Mudumalai tiger reserve, Anamalai Tiger reserve, Arignar Anna Zoological Park, Chennai and Temples maintaining elephants in Tamil Nadu.	Completed
➢ Carrying out the field work with captive elephants of Guruvayur Devaswom, Kerala and Bandipur Tiger Reserve , Karnataka.	
➢ Laboratory analysis of samples collected from the foot ailments of elephants.	Completed
➢ Preparation of management guides for mahouts and Veterinarians associated with the health care of the captive elephants	Completed

ELEPHANT FOOT

The foot of an elephant is a masterful piece of evolutionary development, designed to support the weight of the largest terrestrial mammal. Asian elephants usually have five toe nails on each front foot and four on each hind foot. Basically they have five digits which are not at all identifiable externally, but some digits are represented by variable numbers of phalanges and toe nails. In general, two, three and four digits have three phalanges each.

The foot has an integumentary covering consisting of skin, toenails and a cornified but flexible sole (slipper). Elephants leg are massive and lack a marrow cavity. The marrow cavity is replaced with a network of dense cancellous bone which provides hematopioesis but remoulds the bone much stronger.

The bones of the front foot includes the phalanges, metacarpal and eight carpal bones arranged in two rows. The hind foot is smaller than the front foot and has an oval shape. The tarsus consists of seven bones arranged in three rows.



Courtesy - Murray E. Fowler

Diagram of a front view of the bones of an elephant forefoot. A) radial carpal; B) intermediate carpel; C) ulnar carpal; D) accessory carpal; E) carpal 1; F) carpal 2; G) carpal 3; H) carpal 4; I) sole (slipper), M1-5 metacarpal 1-5, P1-3 phalanx 1-3.

Elephant toe nail has a cuticle similar to the human fingernail and they are not weight bearing unlike those of hoofed animals. Elephant toenails grow approximately 0.5 – 1cm per month.

The front foot has an unique cartilage structure (propollux) attached to carpal bone and metacarpal bone by ligamentous tissue. It extends into the digital cushion and attaches to the sole slightly medial to the midline. Its function is presumed to be to stabilize the carpus and digits over the digital cushion. The hind foot has a similar structure called as prehallux. Lack of ability to flex the foot is an indication of either pain or ankylosis with in the foot.

Elephants are semi – digitigrade in the front foot with the digits on the cranial and lateral aspects of the foot surrounding an extensive fibro elastic digital cushion. The hind foot is semi-plantigrade. The metacarpal and metatarsal bones of the foot maintains a relative – vertical angulation during weight bearing but the phalanges compress the digital cushion and lie nearly horizontal when supporting the weight of the body.

PHYSIOLOGY OF THE FOOT

Both captive and free-ranging elephants when standing and not otherwise engaged in some activity, move back and forth, alternating putting weight on one leg then the other. This is called swaying, and some people equate this only as stereotypic behavior. It is a natural behavior and in the process of swaying back and forth the elephant is facilitating the circulation of blood from the distal extremities back to the heart.

Blood flows peripherally easily but return flow must overcome the gravitational stagnation of blood in the long limbs. This is brought about by compressing the digital cushion in the foot, which acts as a peripheral pump to force blood up the leg. As the elephant alternates stepping on each foot, it facilitates circulation in the feet and legs.

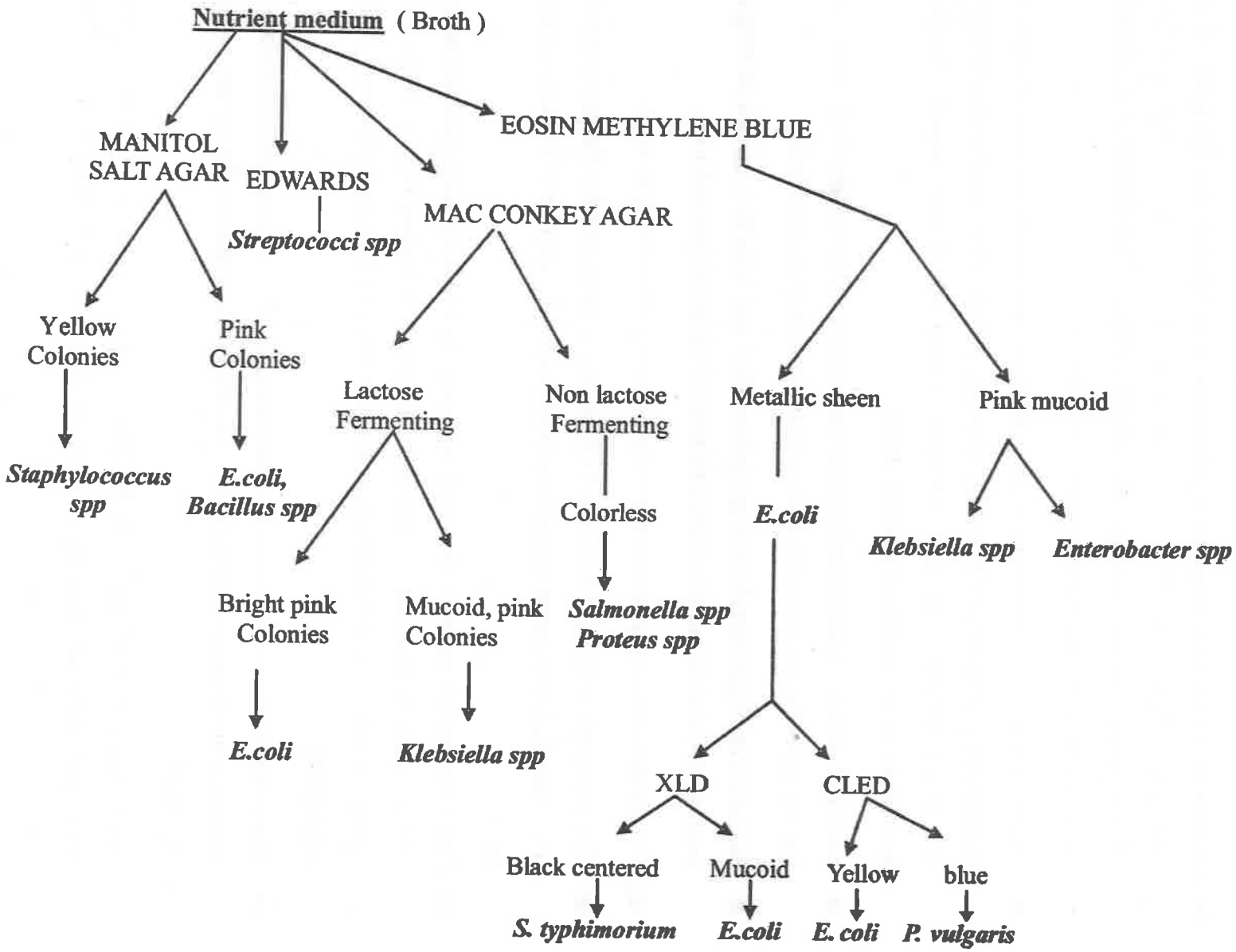
Murray E. Fowler (2006) reported that weight bearing increased the circumference of the elephant foot just above the nails from 5. 0 - 11. 4 cm or by 7. 0 – 9. 7 %. As weight is applied, the digital cushion compresses and pushes peripherally, causing the increase in circumference and at the same time compressing the veins in the foot.

RESEARCH METHODOLOGY

- A total of 182 captive elephants belonging to Aringar Anna Zoological Park (7), Mudumalai Tiger Reserve (23), Anamalai Tiger Reserve (19), Temples of Tamilnadu (53), Guruvayur Devaswom (66) and Bandipur Tiger Reserve, Karnataka (14) were examined for the presence of foot ailments.
- During the process of examination of all these elephants, the details regarding the husbandry practices like housing, flooring, details of enclosure and tethering site, use of leg chains, foot care practices carried out if any., general hygiene and sanitation were observed and recorded.
- Materials from various foot lesions encountered during the study were collected for microbiological examination in a sterile transport medium.
- Isolation of organisms based on differential and selective media plating method was carried out as per the standard microbiological procedures.
- The Anaerobic organisms were isolated using Anaerobic system.
- The materials collected from the foot lesions were tested for the presence of fungal and yeast isolates using selective mycotic culture medium (Sabouraud's dextrose agar).
- The impression smears obtained from the foot lesions were stained using Lacto phenol cotton blue stain (fungal staining), Schefers Fulton stain (Bacterial Spore staining) and Gram stain for identification of morphology of bacterial organisms.
- The isolated organisms were further tested for their susceptibility towards various selective antibiotics (Kirby-bauer method) and the antibiogram results were reported.

  (Ref:- Bauer, A.W, Kirby, W.M, Sherris, J.C and Turk, M. (1966). Antibiotic susceptibility testing by a standardized single disc method, *American Journal of Clinical Pathology*. **45** :493)
- The species identification of these isolated organisms were carried out based on different biochemical tests and fermentation of different sugars.

MICROBIOLOGICAL EXAMINATION - FLOW CHART



PROTOCOL *FOR SPECIES IDENTIFICATION OF MICROBIAL ORGANISMS USING BIOCHEMICAL TEST KIT*

1. The pure culture of the organism to be identified is isolated using selective medium.
2. A single well isolated colony is inoculated in 5 ml Brain-Heart infusion broth and incubated at 37 ^{0}C for 4 – 6 hours or a homogenous suspension made in 2 - 3 ml sterile saline was used.
3. The biochemical test kit was opened aseptically.
4. Each well was inoculated with 50 micro liter of inoculum by surface inoculation method.
5. The kit was incubated at 37 ^{0}C for 24 hours.
6. After 24 hours of incubation specific reagents for varies tests were added in to the respective wells such as Kovac's reagent (Indole test), Andrade's reagent (Methyl red test) and Barrit's reagent (Voges -Proskauer test). The changes in colour reaction were recorded and the organisms were identified based on the standard reference chart as given below.

BIOCHEMICAL TEST

	Test	*Proteus mirabilis*	*Proteus vulgaris*	*Salmonella entiritidis*	*E.coli*	*Klebsiella aerogenes*
IMVIC TEST	Indole	-	+	-	+	+
	Methylred	+	+	+	+	+/-
	Voges Proskauer	+/-	-	-	-	+
	Citrate	+/-	+/-	+	-	+

SUGAR FERMENTATION TEST						
	Glucose	+	+	+	+	+
	Adolase	-	-	-	-	+
	Arabinose	-	-	+	+	+
	Lactose	-	-	-	+	+
	Sorbitol	-	-	+	+	+
	Manitol	-	-	+	+	+
	Rhamnose	-	-	-	+/-	+
	Sucrose	+/-	+/-	-	+/-	+

\+ : Positive reaction.

\- : Negative reaction.

+/- : Weakly positive reaction.

SUGAR FERMENTATION TEST

1. The organism to be identified was isolated in pure culture.
2. Tubes containing 2 ml of Peptone water along with the sugar discs were sterilized by autoclaving.
3. The pure culture of the individual organism was inoculated into each sugar tubes.
4. The inoculated tubes were incubated at 37 ^{0}C for 24 to 48 hrs.
5. After incubation 2 – 3 drops of Andrade's indicator solution was added to each tube and the results are observed after 2 – 4 min.
6. Tubes showing bright pink colour indicates positive results which indicates the utilization of the sugar as the key carbon source.

7. Tubes showing light pink colour indicates weakly positive reaction indicates partial utilization of the sugar as the carbon source.
8. Based on the colour change due to the addition of the indicator solution (Andrade's Indicator) the results were predicted.

ANTIBIOTIC SENSITIVITY TEST

1. Keep the required number of Muller and Hinton agar plates , properly labeled after checking for the sterility by the absence of any visible growth.
2. A sterile swab was dipped into the standardized suspension (prepared test sample) of bacterial culture and excess fluid is removed by pressing the swab on the sides of the test tube.
3. The swab was streaked over the entire surface of the agar in different direction with an aim of getting uniform inoculation. A final sweep with the swab can be made around the rim of the petridish.
4. In the case of testing Streptococci 5 - 10 % sheep blood agar is used for inoculation.
5. The inoculated plates are allowed to stand for 3 - 5minutes but no longer than 15 minutes for any excess of moisture from the inoculum to be absorbed by the agar before applying antimicrobial discs.
6. The discs are placed on to the agar surface using disc dispenser or sterile forceps, not closer than 24 mm (center to center), 14 mm (periphery).
7. Each disc is gently pressed on the agar with the help of forceps to get complete contact with the agar.
8. The plates were incubated within 15 minutes of applying the disc at 37 °C for 16 - 18 hours. Plates must not be incubated under increased concentration of CO_2, as this will alter the zone of inhibition.

READING AND INTERPRETATION OF RESULTS

The zone of inhibition is defined as complete absence of any visible growth of bacteria around the disc. After incubation, the zone of inhibition is read with the help of standed scale. The diameter of the zone is read from the back of the plate as it is

clear in the case of Muller and Hinton agar and over the surface of the agar in the case of blood agar plates (for *Streptococci*). The transmitted light can be used to see any faint growth of colonies in the margin of the zone of inhibition.

According to the degree of inhibition, the antibiotic susceptibility results are interpreted as Sensitive, Intermediate and Resistant.

Sensititve : If the zone of the inhibition is equal to or above the prescribed limit for the respective antibiotic, then the concerned antibiotic can be declared as sensitve. Then the infection may respond to the treatment at the normal dose level.

Intermediate: Here the result is equivocal. If the infection could not be controlled with the prescribed antibiotic, then the test should be repeated.

Resistant : If the level of inhibition falls equal to or below the prescribed limit for resistant category then the concerned drug is said as resistant and such a drug may not be effective in controlling the infection.

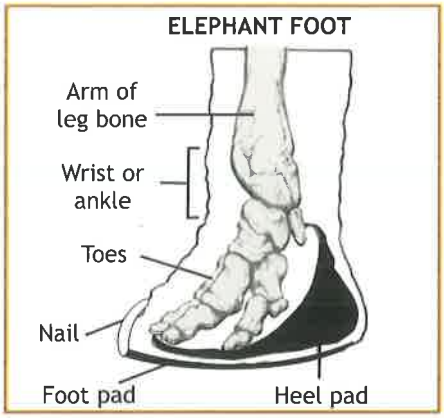
(Ref:- Bauer,A.W., Kirby,W.M., Sherris,J.C.and Turk,M. (1966). Antibiotic susceptibility testing by a standardized single disc method. *American Journal of Clinical Pathology*. **45** :493).

OBSERVATIONS

A) COMMON FOOT AILMENTS ENCOUNTERED

In this study,

- The foot ailments / lesions which need immediate microbiological examination and treatment are classified as **Major ailments**, which include abscess in different parts of the foot, necrotic wound, lesions in the nail, footpad and cuticle, foot rot, Podo-dermatitis, arthritis, ankylosis of joints, degenerative joint disease etc.,
- Husbandry oriented foot ailments which do not need culture examination at that point of time were incorporated in **Minor ailments** such as crack nail, split nail, excess cuticluar growth, uneven / over grown nails, nail damage, abrasion / uneven wear and tear of foot sole, excessive foot pad growth / hyperkeratosis etc.,



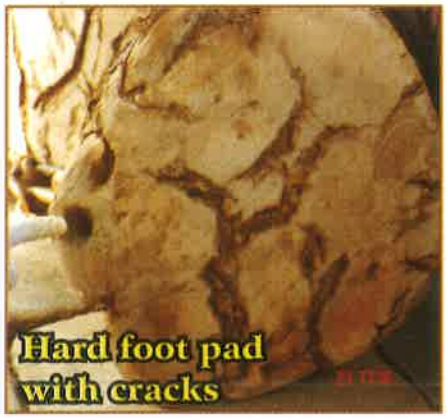


Photo : K.S. Subramanian

FOOT AILMENTS ENCOUNTERED AND THEIR PRE-DISPOSING FACTORS

MINOR FOOT AILMENTS

- Crack nail / Split nail / Broken nail condition.
- Excess cuticular growth / Hang nail
- Uneven / Over grown nails / Deformed nails
- Nail damage.
- Abrasion of sole / Uneven wear and tear of foot pad.
- Excessive foot pad growth / Hyperkeratosis.

PREDISPOSING FACTORS

- Absence of regular foot care & management
- Unnatural substrate – Stone / Cement / Concrete
- Continuous standing on the same substrate
- Lack of exercise / Nutrition - Minerals
- Lack of awareness – Mahouts / Temple officials.
- All put together

MAJOR FOOT AILMENTS

- Foot rot
- Podo-dermatitis
- Abscess (Nail, Cuticle, Nail and Pad, Pad & sole)
- Necrotic wound
- Specific ailments like Hyper-extension of leg / Ankylosis of joints, Degenerative Joint Disease etc.,
- Combined foot lesions / all the above ailments together.

PREDISPOSING FACTORS

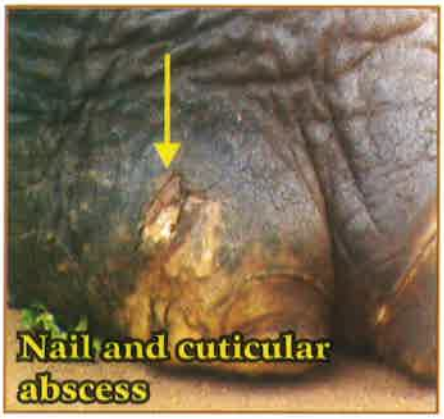
- Absence of regular foot care & management
- Unhygienic and Unsanitary tethering conditions
- Minor foot lesions / Foreign body
- Negligence of lesions at the early stage
- Incomplete treatment
- Unscientific approach – making the problem BIG.
- All put together.

RESULTS

- Out of **Seven** elephants maintained at **Aringar Anna Zoological Park**, Vandalur, **three** were found to be affected with minor foot ailments and one having major foot ailment.
- Out of **23** camp elephants examined at different camp sites of Mudumalai Tiger Reserve, minor foot ailments were revealed in **15** camp elephants and one elephant had nail abscess.
- Out of **19** camp elephants examined at different camp sites of Anamalai Tiger Reserve revealed the presence of one or more of minor foot ailments in **12** the camp elephants and major foot ailment in one captive elephant.
- Out of **53** elephants (maintained in different Temples of Tamilnadu) examined, **48** temple elephants revealed the presence of one or more of minor foot ailments and **23** elephants showed one or more of major foot ailments.
- Out of **66** elephants maintained at Guruvayur Devaswom **8** were found to be affected with major foot ailments and **21** elephants with minor foot ailments.
- Out of **14** camp elephants examined at Bandipur Tiger Reserve **3** revealed minor foot ailments and no major foot ailment was observed.

Excess cuticular growth / Hang Nail

Nail abscess



Nail and cuticular abscess

Necrotic wound

Foot rot with cuticular abscess

Nail & cuticle abscess

Nail and pad abscess

Foot rot with Pododermatitis

Nail abscess

Foot rot with abscess

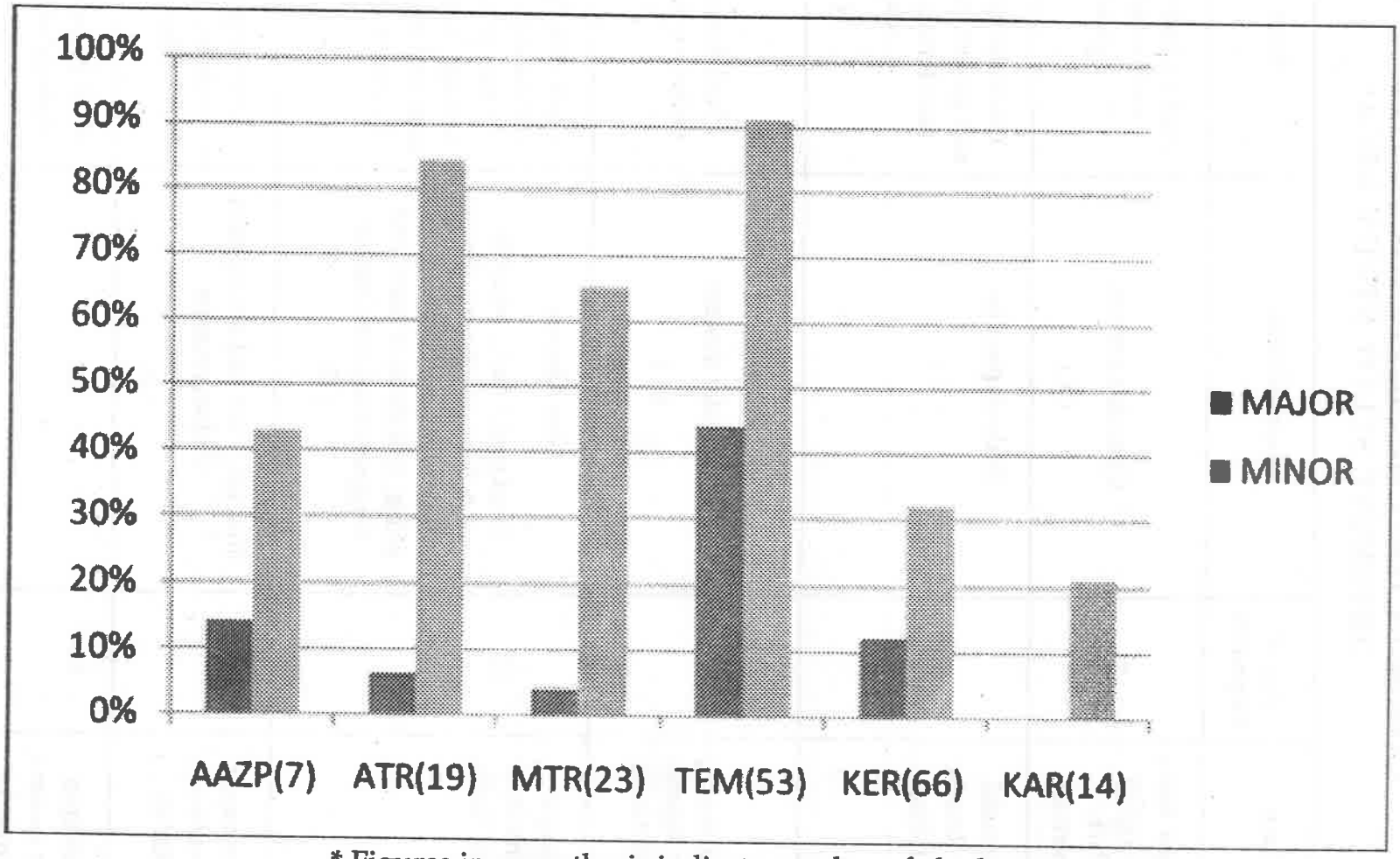
Formalin foot bath

Photo : K.S. Subramanian

COMMON FOOT AILMENTS ENCOUNTERED IN DIFFERENT STUDY STUDY AREAS

Place	No. of Elephants	Major ailments	Minor ailments
Aringar Anna Zoological Park, Chennai	7	Cuticular abscess (1)	Nail / Crack nail conditions and excessive cuticular growth (3)
Anamalai Tiger Reserve Tamil Nadu	19	Podo-dermatitis (1)	Cuticular growth, un-even nail growth, mild to moderate nail damage and split nail condition (16)
Mudumalai Tiger Reserve Tamil Nadu	23	Cuticular abscess (1)	Nail damage, split nail, excessive cuticular growth (15)
Temple elephants of Tamil Nadu.	53	Foot Abscess (foot pad / nail), Necrotic wound, Foot rot, chronic abscess, Podo-dermatitis, Hyperextension of leg, Ankylosis of joints and Degenerative Joint Disease (23)	Crack nail, Split nail, Excess cuticluar growth, Uneven / Over grown nails, Nail damage, Abrasion / Uneven wear and tear of foot sole and Excessive foot pad growth. (48)
Guruvayur Devaswom, Kerala	66	Foot rot, Foot pad abscess and Pododermatitis (8)	Uneven growth of nail & cuticle, Split nail, Nail damage (21)
Bandipur Tiger Reserve, Karnataka	14	Nil	Over grown nails, mild nail damage and cuticular over growth. (3)

Status of Foot Ailments in Captive Asisan Elephants of South India



* Figures in parenthesis indicate number of elephants.

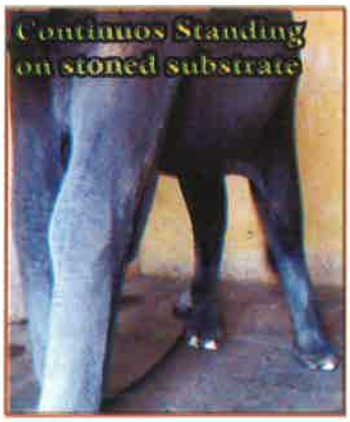

Collection of samples


Treatment

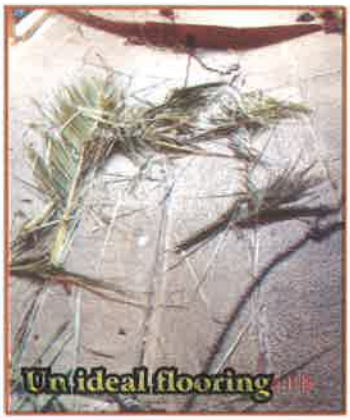

Ethno-Veterinary therapy


Degenerative joint disease with multiple foot ailments


Treatment & Application of sandal type protective cover for the foot lesion


Continuous Standing on stoned substrate

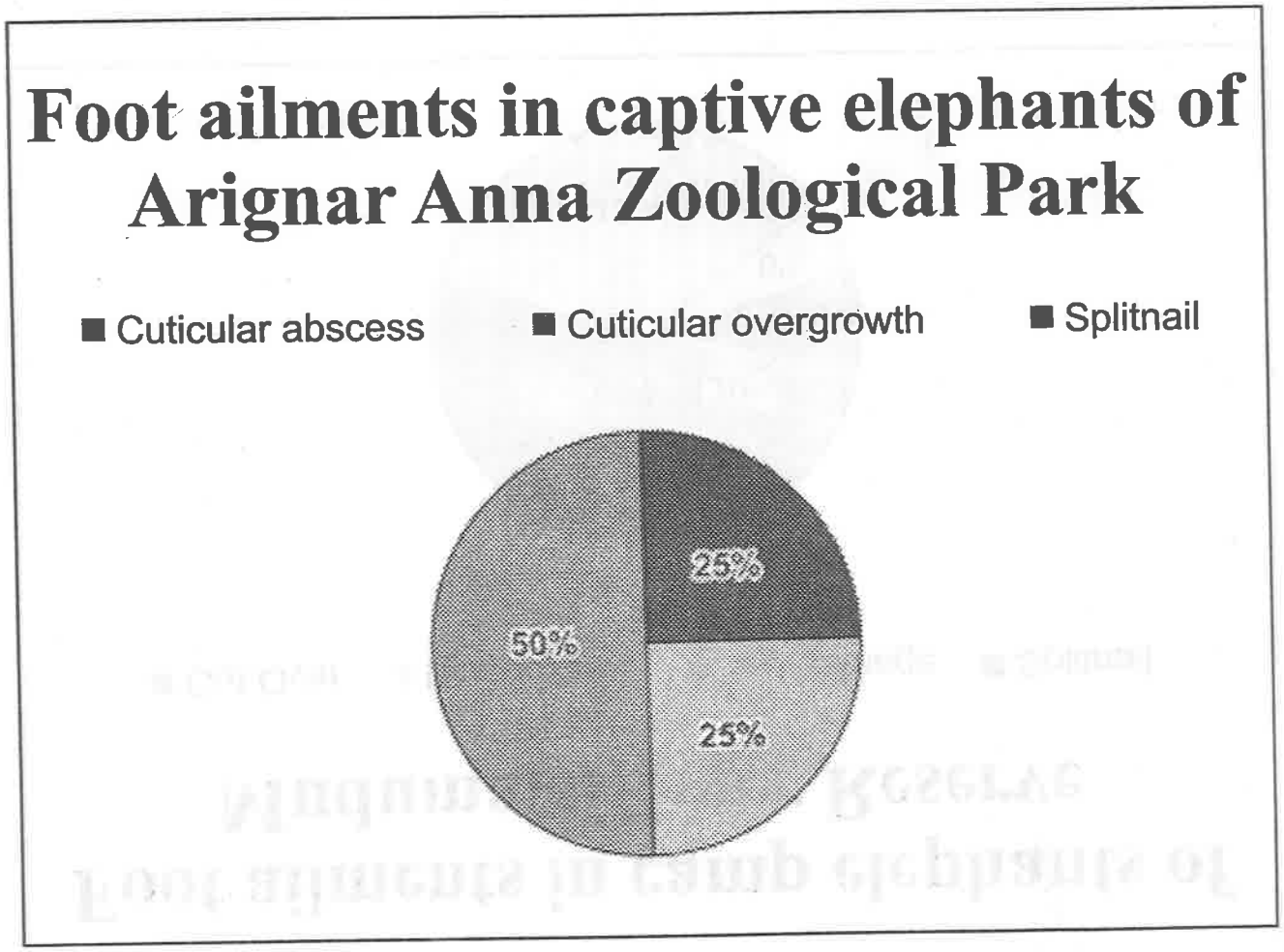

Unhygienic tethering site

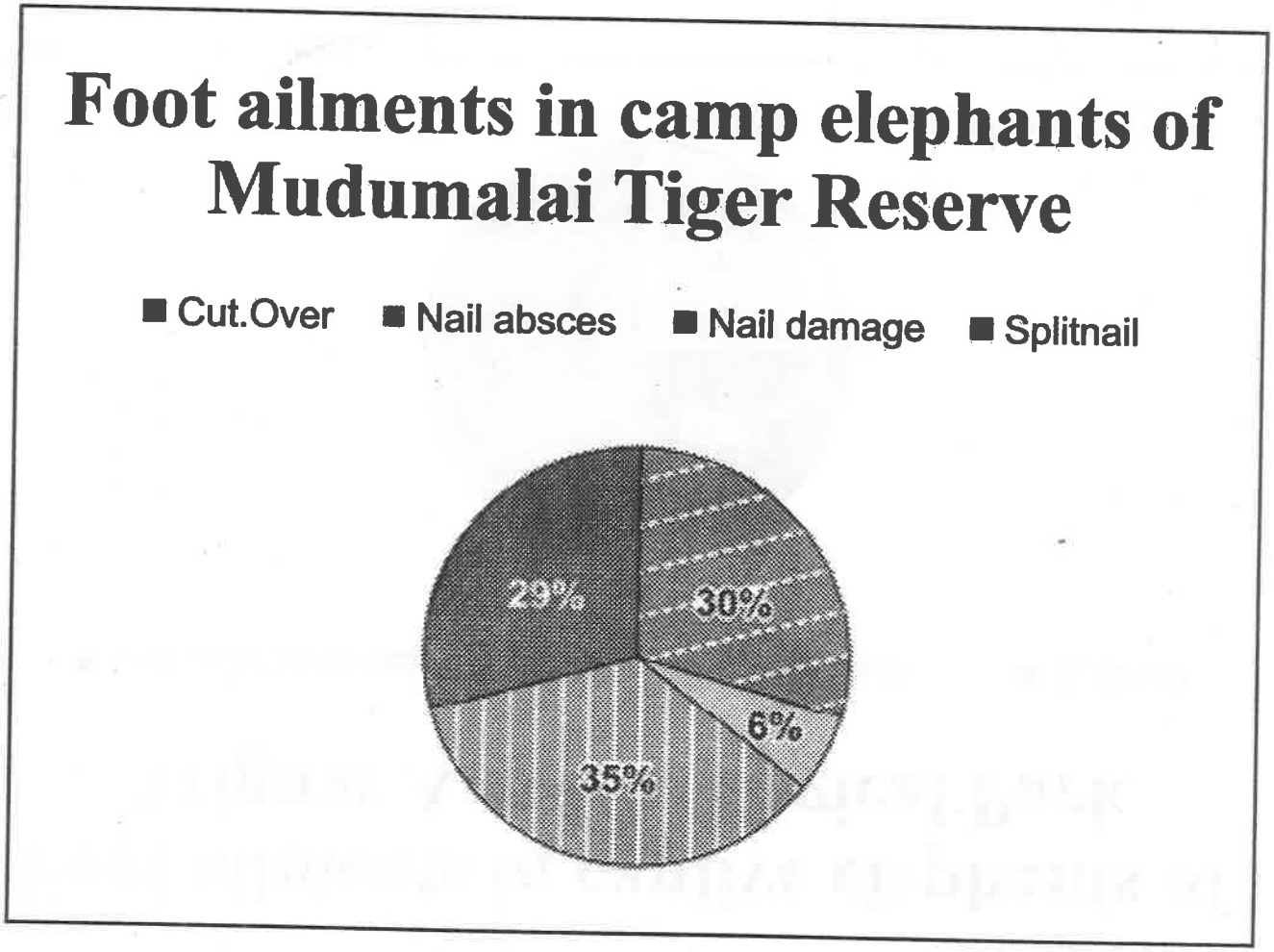

Un ideal flooring


Natural substrate

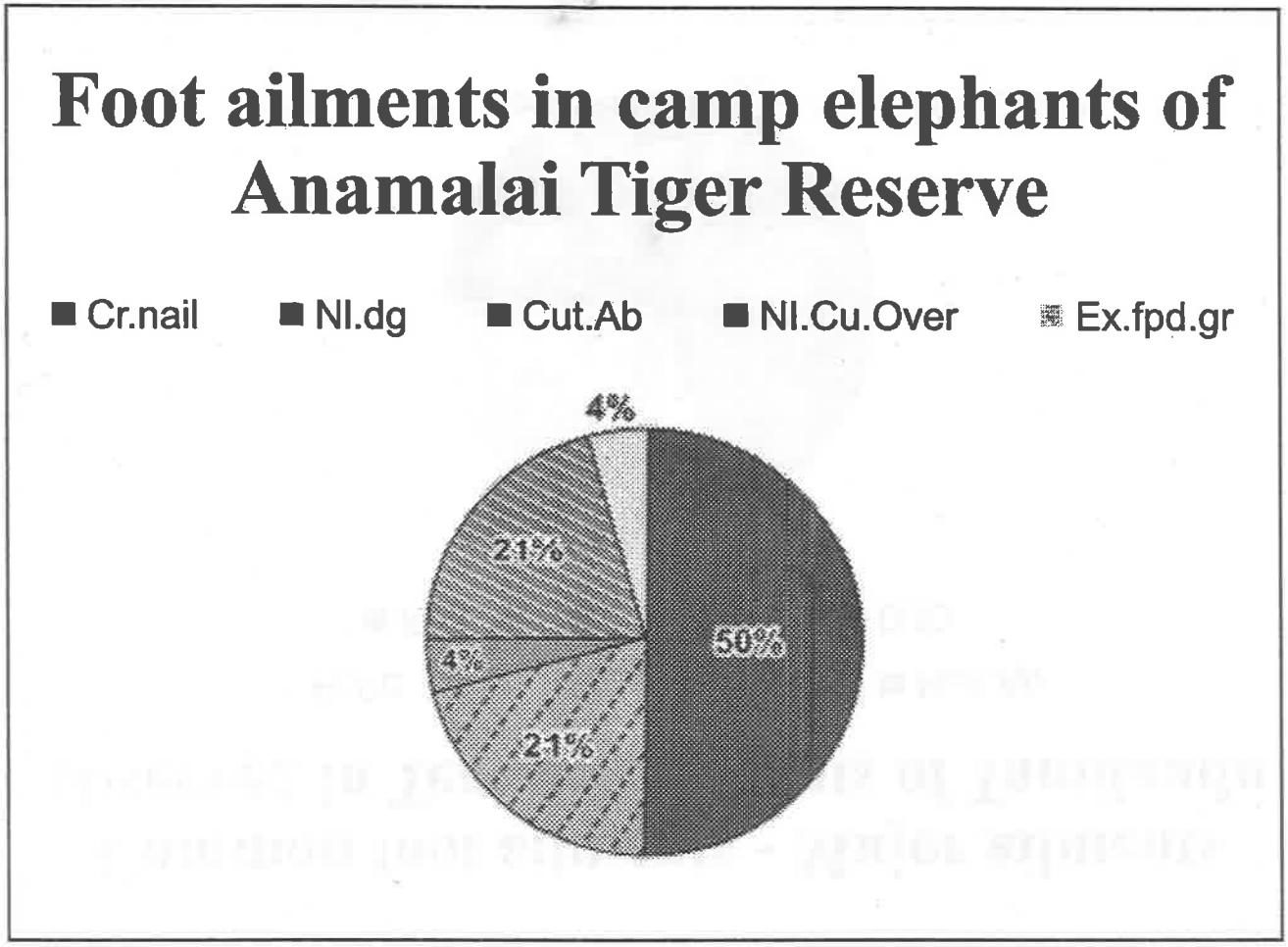

Demonstration of nail rasping technique to mahouts

Photo : K.S. Subramanian

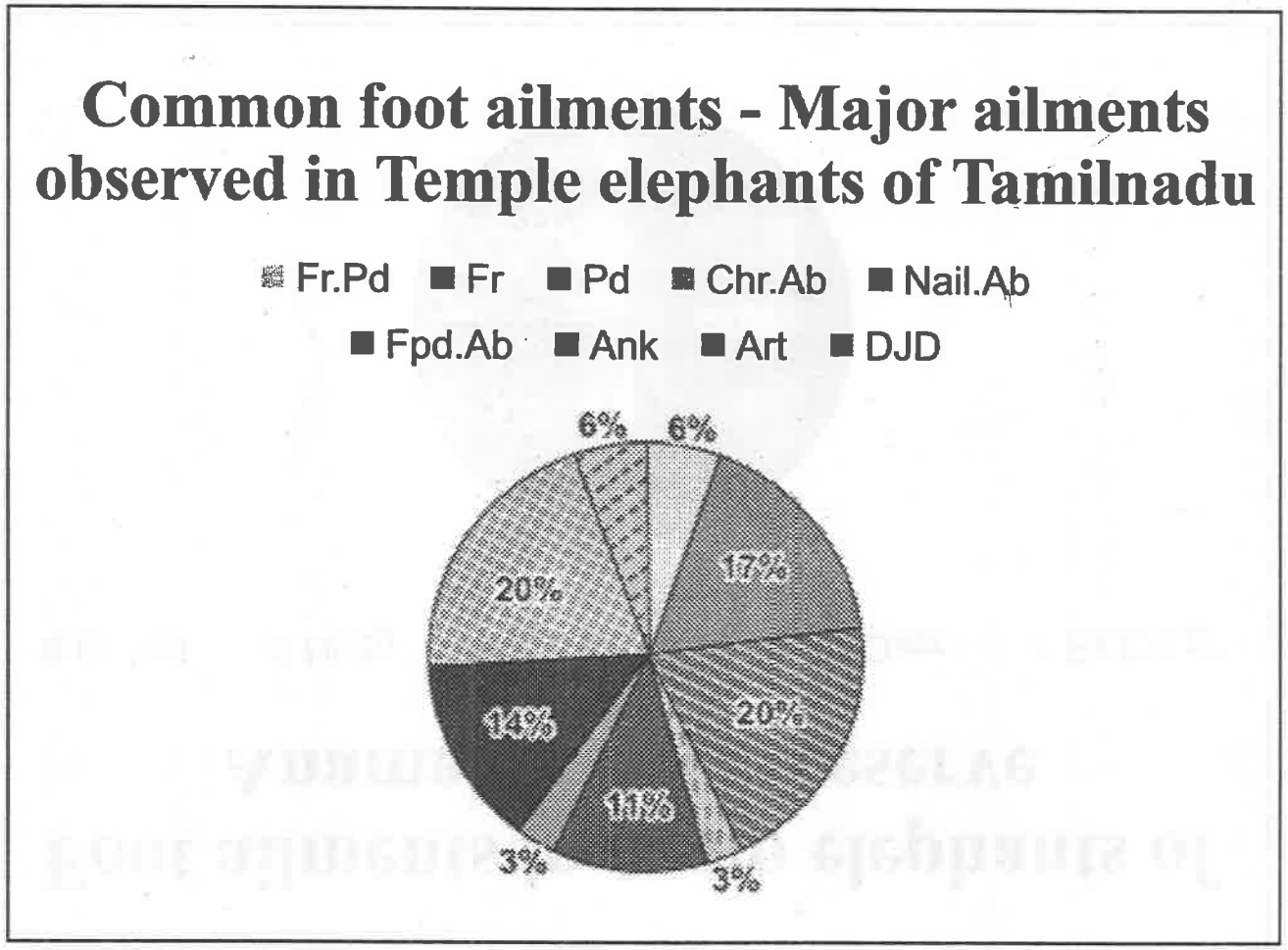

Foot ailments in captive elephants of Arignar Anna Zoological Park
Cuticular abscess
Cuticular overgrowth
Splitnail
25%
50%
25%



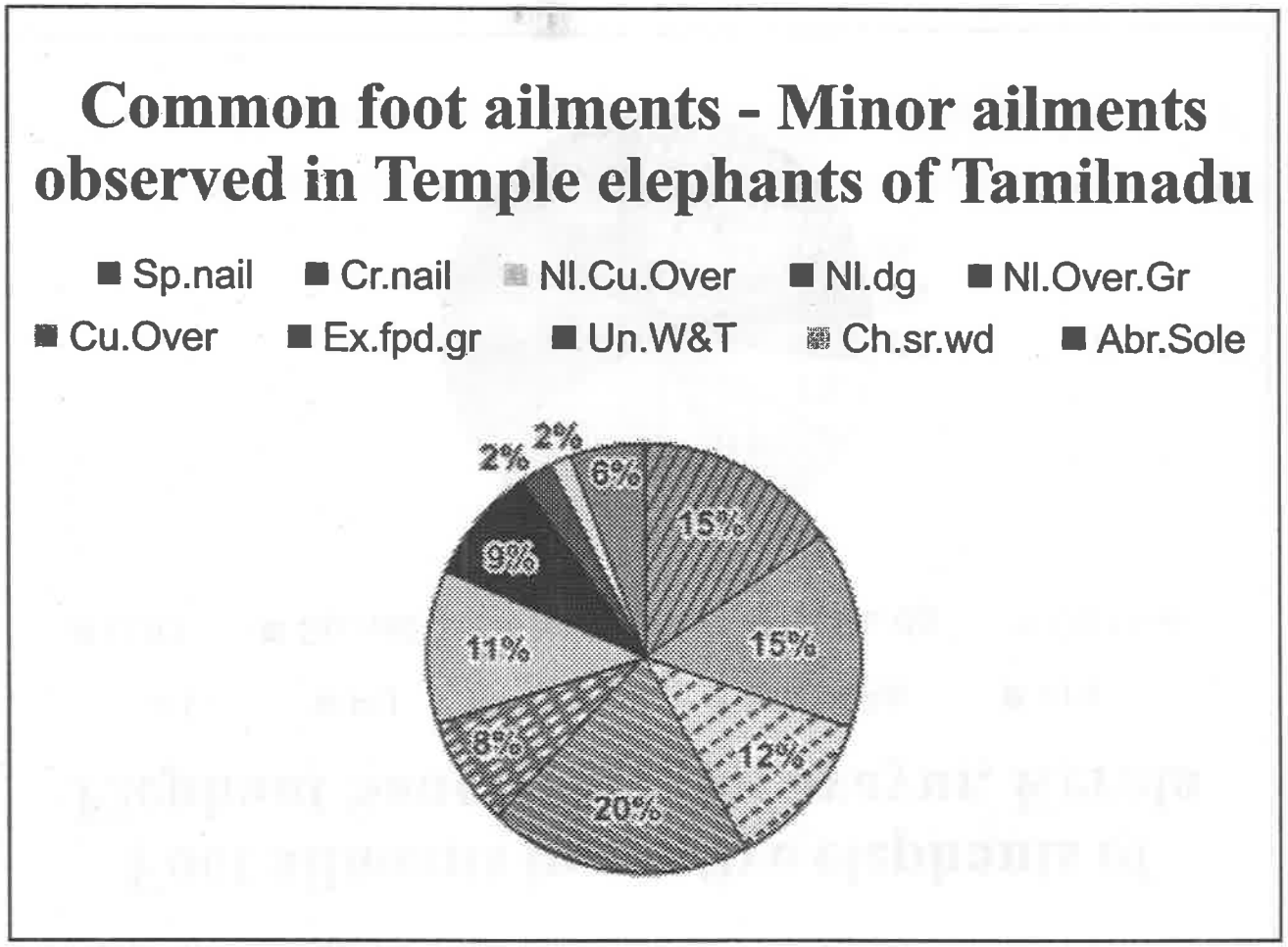
- Cut.Over – Cuticular overgrowth



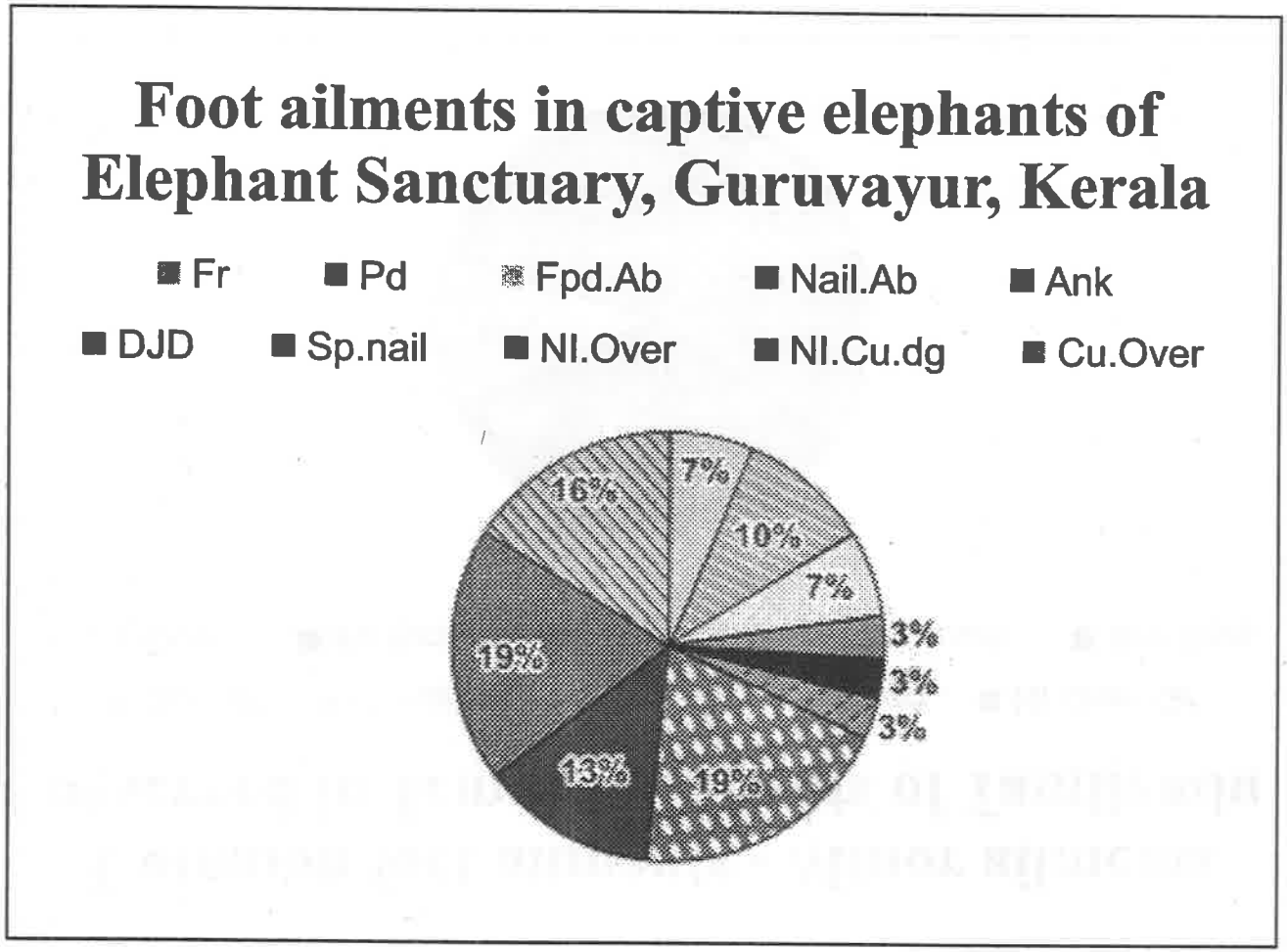
- Cr.nail – Cracknail
- Nl.dg – Nail Damage
- Cut.Ab – Cuticular Abscess
- Nl.Cu.Over- Nail and Cuticular Overgrowth
- Ex.fpd.gr – Excessive Foot Pad Growth



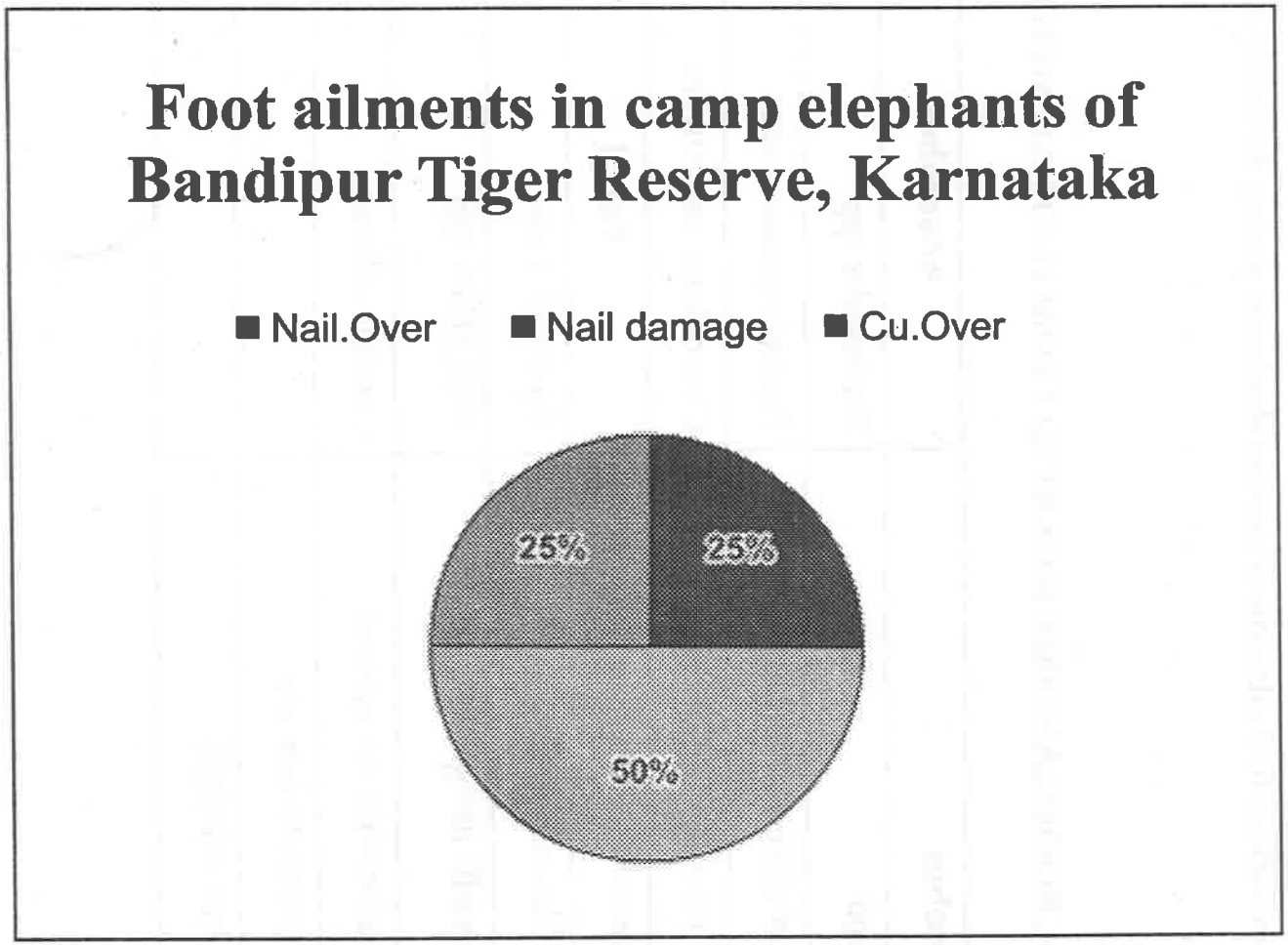
- Fr.Pd - Foot rot with Pododermatitis
- Fr - Foot rot
- Pd – Pododermatitis
- Chr.Ab - Chronic Abscess
- Nail.Ab – Nail Abscess
- Fpd.Ab – Foot Pad Abscess
- Ank – Ankylosis
- Art – Arthritis
- DJD – Degenerative Joint Disease



- Sp.nail – Split Nail
- Cr.nail – Crack Nail
- Nl.Cu.Over – Nail/ Cuticular Overgrowth
- Nl.dg – Nail Damage
- Nl.Ovr.gr. - Nail Overgrowth
- Cu.Over - Cuticular Overgrowth
- Ex.fpd.gr. - Excessive Foot Pad Growth
- Un.W&T - Uneven Wear & Tear
- Ch.sr.wd - Chain Scratch Wound
- Abr.Sole- Abrasion of Sole



- Fr– Foot rot
- Pd – Pododermatitis
- Fpd.Ab – Foot Pad Abscess
- Nail.Ab – Nail Abscess
- Ank – Ankylosis
- DJD – Degenerative Joint Disease
- Sp.nail – Split Nail
- Nl.Over – Nail Overgrowth
- Nl/Cu.dg – Nail/ Cuticular Damage
- Cu.Over – Cuticular Overgrowth



- Cu.over – Cuticular overgrowth
- Nail.over - Nail overgrowth

MICROBIOLOGICAL EXAMINATION

A total of 281 samples were collected from different foot ailments of captive elephants maintained at Arignar Anna Zoological Park, Anaimalai Tiger Reserve, Mudumalai Tiger Reserve, Temples of Tamilnadu, Guruvayur Devaswom and Bandipur Tiger Reserve, Karnataka for microbiological examination.

A wide spectrum of microbial organisms (both aerobes and anaerobes) were isolated from various foot ailments of captive elephants during the study as described below.

MICROORGANISMS ISOLATED FROM FOOT AILMENTS

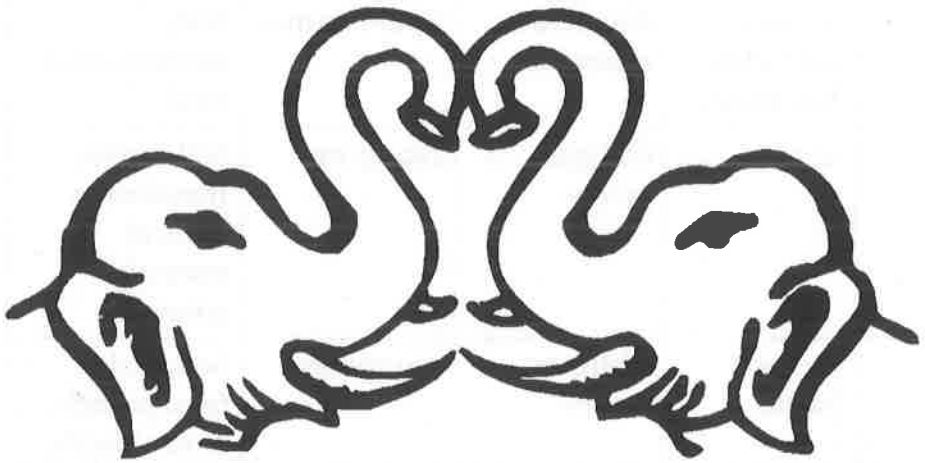
Aerobes	**Anaerobes**
E. coli	*Bacteroides spp*
Staphylococcus aureus	*Peptostreptococci spp*
Streptococcus agalactiae	*Clostridium perfringens*
Salmonella enteritidis	**Fungi**
Bacillus cereus	*Aspergillus spp*
Klebsiella aerogenes	*Penicillium spp*
Pseudomonas aeruginosa	*Candida albicans*
Corynebacterium spp	
Proteus mirabilis	

CHARACTERISTICS OF ORGANISMS ISOLATED FROM FOOT LESIONS

Organism	Gram Stain/ Shape	Oxygen Requirements	Spore status	Natural Habitat	Toxins
Streptococcus agalactiae	+/ cocci	Aerobe to facultative anaerobe	No spores	Commensal in upper airways and G.I. tract	None
Beta haemolytic *Streptococci*	+/ cocci	Aerobe to facultative anaerobe	No spores	Commensal in upper airways and G.I. tract	None
Staphylococcus aureus	+/ cocci	Aerobe to facultative anaerobe	No spores	Mucocutaneous borders, transient in G.I. tract.	Exotoxins
Peptostreptococci	+/ cocci	Obligate anaerobe	No spores	Normal flora	Exotoxin
Corynebacterium spp,	+/ cocci rod	Aerobe to facultative anaerobe	No spores	Normal inhabitant of oral cavity and G.I tract.	Exotoxin
Clostridium tetani,	+/ rod	Obligate anaerobe	Terminal spore former	Feces, soil, necrotic wounds	Exotoxin
Bacillus cereus	+/ rod, related to *B.anthracis*	Facultative anaerobe	Spore former	Soil, contaminated food.	
Pseudomonas aeruginosa,	-/ rod	Obligate aerobe	No spores	Soil, water, transient in feces of normal animals	Exotoxin
Klebsiella spp	-/cocco bacilli	Obligate aerobe	No spores	Soil, water, fecal particle, animal feeds.	Endotoxin
Proteus spp	-/cocco bacilli	Obligate aerobe	No spores	Soil, water, fecal particle.	Endotoxin
Salmonella	-/cocco bacilli	Obligate aerobe	No spores	Soil, water, fecal particle.	Endotoxin

E. coli	-/cocco bacilli	Obligate aerobe	No spores	Large intestine and lower small intestine	Endotoxin
Bacteroides spp	-/ rod	Obligate anaerobe	No spores	Normal flora of skin, infectious agent of ovine foot rot.	Exotoxin
Candida spp	Yeast	--	Chlamidospores, Blastospores	Commensal in mucocutaeneous areas of GI tract and genital tract	--
Aspergillus spp	Fungi	--	Conidiospores, Ascospores.	Soil, fecal material.	Aflotoxins

(Reference: Biology, Medicine and Surgery of Elephants by Murray E. Fowler & Susan K. Mikota)




Nail trimmer


Nail Trimming

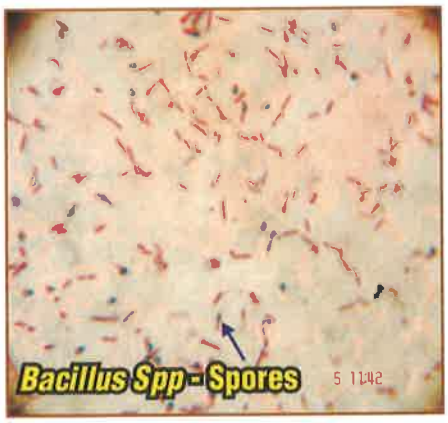

Nail Trimming


Healthy foot pad & sole

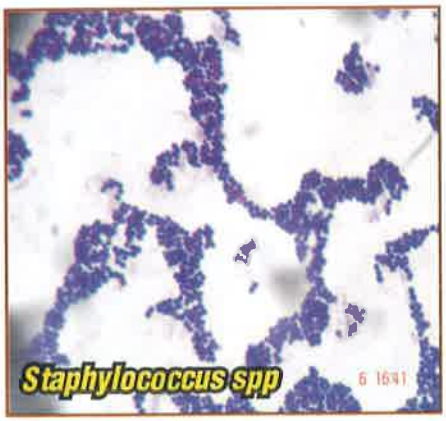

Application of Decameli oil


Healthy foot


Microbiological examination


Bacillus Spp - Spores


Streptococci spp


Staphylococcus spp


Pseudomonas spp


Clostridium spp

Photo : K.S. Subramanian

MICROBIAL ORGANISMS ISOLATED FROM THE FOOT LESIONS OF CAPTIVE ELEPHANTS (STUDY AREA WISE)

Place	No. of samples	Minor ailments		Major ailments	
		Aerobe	Anaerobe	Aerobe	Anaerobe
AAZP	14	*Bacillus cereus, Streptococcus agalactiae,* and *Salmonella enteritidis* (10)	--	*Proteus mirabilis, Bacillus cereus, Klebsiella aerogenes, Candida albicans, Pseudomonas aeruginosa* and *Streptococcus agalactiae* . (3)	*Peptostreptococci spp.* (1)
Anamalai Tiger Reserve	11	*Bacillus cereus , Streptococcus agalactiae* and *Salmonella enteritidis* (7)	--	*Streptococcus agalactiae , Klebsiella aerogenes, Bacillus cereus* and *Streptococcus agalactiae* (4)	--
Mudumalai Tiger Reserve	12	*Bacillus cereus* and *Streptococcus agalactiae* (9)	--	*Aspergillus spp* (2)	*Peptostreptococci spp.* (1)
Temple elephants of Tamilnadu	227	*Staphylococcus aureus, Streptococcus agalactiae, E.coli, Proteus mirabilis* and *Bacillus cereus* (153)	*Peptostreptococci spp* and *Clostridium perfringens* (57)	*Klebsiella aerogenes, Streptococcus agalactiae, E.coli, Staphylococcus aureus, Bacillus cereus Pseudomonas aeruginosa* and *Salmonella enteritidis.*(10)	*Clostridium perfringens, Bacteroides spp* and *Peptostreptococci spp.*(7)

Guruvayur Devaswom, Kerala	17	--	--	*Streptococcus agalactiae, Klebsiella aerogenes, Bacillus cereus, Staphylococcus aureus, Corynebacterium spp.* (17)	--
Bandipur Tiger Reserve, Karnataka	--	--	--	--	--

MICROBIOLOGY AND ANTIBIOGRAM OF FOOT AILMENTS IN CAPTIVE ELEPHANTS OF MUDUMALAI TIGER RESERVE

Type of ailments		Organism Isolated	Sensitivity
MINOR	Over grown nails	*Bacillus cereus* and *Streptococcus agalactiae*	Ciprofloxacin, Gentamicin, Chloramphenicol, Enrofloxacin.
MAJOR	Nail Abscess	*Aspergillus spp* and *Peptostreptococci spp.*	Ciprofloxacin, Enrofloxacin, Gentamicin, Co-trimoxazole

MICROBIOLOGY AND ANTIBIOGRAM OF FOOT AILMENTS IN CAPTIVE ELEPHANTS OF ANAMALAI TIGER RESERVE

Type of ailments		Organism Isolated	Sensitivity
MINOR	Crack nail/ Split nail	*Bacillus cereus, Streptococcus agalactiae* and *Salmonella enteritidis*	Chloramphenicol, Ciprofloxacin, Enrofloxacin, Neomycin.
MAJOR	Nail Abscess	*Streptococcus agalactiae* and *Klebsiella aerogenes.*	Chloramphenicol, Ciprofloxacin, Gentamicin, Enrofloxacin.
	Chain scratch wound	*Staphylococcus aureus, Klebsiella aerogenes, Bacillus cereus* and *Streptococcus agalactiae*	Gentamicin, Chloramphenicol, Enrofloxacin, Neomycin, Ciprofloxacin, Amoxycillin, Enrofloxacin.

MICROBIOLOGY AND ANTIBIOGRAM OF FOOT AILMENTS IN TEMPLE ELEPHANTS

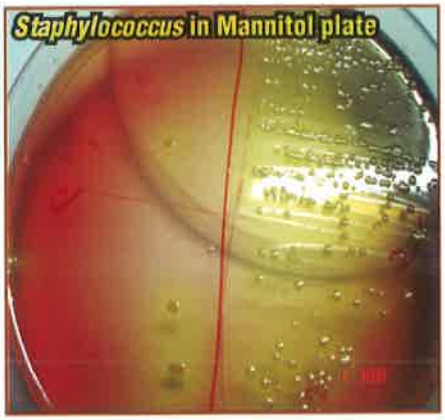
MINOR	Crack nail/ Split nail	*Staphylococcus aureus, Streptococcus agalactiae , E.coli, Proteus mirabilis* and *Peptostreptococci spp*	Gentamicin, Neomycin, Chloramphenicol, Enrofloxacin, Ciprofloxacin.
	Excessive cuticular, pad growth, nail growth,	*Staphylococcus aureus, Streptococcus agalactiae* and *E.coli*	Amoxycillin, Enrofloxacin, Chloramphenicol, Ciprofloxacin.
	Nail damage	*E.coli, Penicillium spp, Bacillus cereus, Candida albicans* and *Clostridium perfringens*	Penicillin, Amoxycillin, Chloramphenicol, Neomycin, Enrofloxacin, Gentamicin, Ciprofloxacin.
	Uneven wear and tear of foot pad	*Staphylococcus aureus* and *Bacillus cereus.*	Amoxycillin, Ampicillin, Gentamic in, Neomycin, Chloramphenicol.
MAJOR	Foot rot	*Klebsiella aerogenes, Streptococcus agalactiae, E.coli, Staphylococcus aureus, Bacillus cereus, Candida albicans, Peptostreptococci spp, Clostridium perfringens* and *Bacteroides spp*	Chloramphenicol, Gentamicin, Neomycin, Ciprofloxacin, Enrofloxacin, Penicillin, Co-trimoxazole.
	Podo – dermatitis	*Staphylococcus aureus*	Gentamicin, Chloramphenicol, Enrofloxacin.
	Nail, pad and sole abscess	*Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus cereus, Streptococcus agalactiae, Salmonella enteritidis, Klebsiella aerogenes, Candida albicans, Clostridium perfringens* and *Peptostreptococci spp.*	Gentamicin, Chloramphenicol, Enrofloxacin, Neomycin, Ciprofloxacin.
	Necrotic wound	*Staphylococcus aureus, Bacillus cereus, Streptococcus agalactiae, Klebsiella aerogenes, Peptostreptococci spp* and *Clostridium perfringens .*	Chloramphenicol, Enrofloxacin, Gentamicin, Amoxycillin, Erythromycin, Ciprofloxacin, Neomycin.
	Chronic abscess and fistulated wound	*Pseudomonas aeruginosa, Candida albicans, Streptococcus agalactiae , Bacillus cereus, Klebsiella aerogenes, Staphylococcus aureus* and *Clostridium perfringens.*	Chloramphenicol, Enrofloxacin, Amoxycillin, Ciprofloxacin, Gentamicin, Co-trimoxazole

MICROBIOLOGY AND ANTIBIOGRAM OF FOOT AILMENTS IN THE ELEPHANTS OF ARIGNAR ANNA ZOOLOGICAL PARK, CHENNAI

Type of ailments		Organism Isolated	Sensitivity
MINOR	Crack nail/ Split nail	*Bacillus spp, Streptococci spp* and *Salmonella spp*	Chloramphenicol, Ciprofloxacin, Enrofloxacin, Neomycin.
MAJOR	Necrotic wound in the foot	*Proteus spp, Bacillus spp* and *Klebsiella spp.*	Chloramphenicol, Neomycin, Ciprofloxacin, Gentamicin, Amoxycillin, Enrofloxacin.
	Foot Pad , Cuticle, sole and nail abscess	*Proteus spp, Bacillus spp, Candida spp, Pseudomonas spp, Streptococci spp* and *Peptostreptococci spp.*	Gentamicin, Chloramphenicol, Neomycin, Enrofloxacin, Ciprofloxacin, Amoxycillin, Enrofloxacin.

MICROBIOLOGY AND ANTIBIOGRAM OF FOOT AILMENTS IN CAPTIVE ELEPHANTS OF GURUVAYUR DEVASWOM

Type of ailment		Organism isolated	Sensitivity
Major	Foot rot	*Streptococci spp,Klebsiella spp, Staphylococcus spp,Corynebacterium spp.*	Ciprofloxacin, Chlorampenicol,Gentamicin, Amikacin.
	Footpad abscess	*Klebsiella spp Streptococci spp,, Staphylococcus spp.*	Ciprofloxacin, Gentamicin, Amikacin.



Species Identification - Rapid test kit

Photo : K.S. Subramanian

ANTIBIOTIC SUSCEPTIBILITY OF AEROBIC ORGANISMS ISOLATED FROM THE FOOT AILMENTS OF CAPTIVE ELEPHANTS

S.No	Name of the Organism	Sensitive	Intermediate	Resistant
1	*Staphylococcus spp*	Gentamicin, Neomycin, Enrofloxacin, Chloramphenicol	Co-trimoxazole, Amoxycillin	Ampicillin Amphotericin – B, Penicillin
2	*Streptococcus spp*	Gentamicin, Enrofloxacin, Chloramphenicol, Co-trimoxazole	Amoxycillin, Neomycin	Ampicillin Amphotericin – B, Penicillin
3	*Bacillus spp*	Gentamicin, Enrofloxacin, Chloramphenicol, Ciprofloxacin	Neomycin, Co-trimoxazole	Ampicillin Amphotericin – B, Penicillin
4	*Pseudomonas spp*	Enrofloxacin, Gentamicin, Neomycin,	Chloramphenicol	Co-trimoxazole, Amoxycillin, Ampicillin Amphotericin – B, Penicillin
5	*Klebsiella spp*	Enrofloxacin, Chloramphenicol Gentamicin,	Neomycin, Co-trimoxazole.	Amoxycillin, Ampicillin Amphotericin – B, Penicillin
6	*Proteus spp*	Enrofloxacin, Ciprofloxacin Chloramphenicol,	Neomycin, Erythromycin, Gentamicin	Ampicillin Amphotericin – B, Penicillin
7	*Salmonella spp*	Chloramphenicol, Amoxycillin, Neomycin, Co-trimoxazole	Gentamicin	Ampicillin Amphotericin – B, Penicillin
8	*E. coli*	Enrofloxacin, Ciprofloxacin, Chloramphenicol, Gentamicin.	Neomycin, Erythromycin.	Ampicillin Amphotericin – B, Co-trimoxazole, Amoxycillin, Penicillin
9	*Corynebacterium spp*	Chloramphenicol, Ciprofloxacin,	Neomycin, Erythromycin	Ampicillin Amphotericin – B,

ANTIBIOTIC SUSCEPTIBILITY OF ANAEROBIC ORGANISMS ISOLATED FROM THE FOOT AILMENTS OF CAPTIVE ELEPHANTS

S.No	Name of the Organism	Sensitive	Meditatively sensitive	Resistant
1	*Clostridium spp*	Chloramphenicol, Amoxycillin, Gentamicin, Enrofloxacin, Ciprofloxacin	Erythromycin, Ampicillin Neomycin, Co-trimoxazole	Penicillin, Ampicillin Metronidazole.
2	*Peptostreptococci spp*	Ciprofloxacin, Enrofloxacin, Gentamicin, Co-trimoxazole, Neomycin.	Penicillin, Amoxycillin, Ampicillin Erythromycin, Chloramphenicol.	Ampicillin Metronidazole.
3	*Bacteriodes spp*	Ciprofloxacin, Chloramphenicol, Enrofloxacin, Gentamicin.	Co- trimoxazole, Neomycin, Erythromycin, Amoxycillin.	Penicillin, Ampicillin Ampicillin Metronidazole

FOOT CARE AND MANAGEMENT PRACTICES SUGGESTED

- Cleaning and dressing the foot lesions with Potassium permanganate and hydrogen peroxide solution, removal of necrotic tissues should be carried out regularly as a routine before any medication.
- Potassium permanganate (1 : 1000 solution) foot bath followed by Formalin (1 – 2 %) or Gentian violet foot bath (1 % solution) should be provided daily in case of foot rot and podo-dermatitis before medication.
- In order to facilitate formalin based foot bath (in case of elephants resisting to stand or to keep their foot into the tub / vessel filled with formalin) use 1 kg of nicely powdered husk or sawdust placed in a gunny bag and soak it in hot / luke warm water according to the weather and pour about 50ml of formaldehyde and now this can be applied under foot pad by tying around the leg, in order to facilitate the hardening of foot pad structures.

ANTIMICROBIALS APPLIED / USED FOR FOOT LESIONS

Generic name	Indications	Mixing Directions	Comments
Magnesium sulphate	A concentrated solution of Epsom salt is hypertonic and draws fluid from tissue; used for local inflammation, cellulitis, arthritis, and contusions.	For an elephant foot, 225 gms of Epsom salt in 2 litres of hot water; allow water to cool to luke warm state before use.	--
Chlorhexidine diacetate	General disinfectant	250 ml of the stock solution to 1.litre of clean water .	Not effective against *Pseudomonas spp* or gram positive cocci
Povidine- iodine solution.	General disinfectant	Dilute stock solution 1 : 10 (400 ml to 4 litres of water)	May dilute up to 1 : 100

Copper sulphate	An astringent in dilute solution	As an astringent, a 1.0% solution (10 gms in one litre of water).	Caustic in concentrated solution.
Formalin, 10 % formaldehyde	Powerful disinfectant	1 - 2 % solution (100 ml of 10 % formalin to 900 ml water)	Quite caustic
Hydrogen peroxide (H_2O_2); colorless, odorless liquid	Powerful antiseptic when in contact with tissue fluids, causing foaming and clensing	Use as supplied	Do not inject into punctured wounds or into closed cavities.
Zinc oxide	Antiseptic, soothing, will protect skin from exudates	Made into a 20% ointment	Ointments may attract dirt and debries.
Potassium permanganate ($KMnO_4$)	Antiseptic.	1:1000 concentration (1g $KMnO_4$ in 1 litre of water)	Used to clean the wound / lesiol before dressing and medication.
Polyhexosamine polymer from deacetylation of chitin/ chitosan	Stimulates wound healing	1% chitosan and 1% glacial acetic acid in water	--

(Reference: Biology, Medicine and Surgery of Elephants by Murray E. Fowler and Susan K. Mikota)

- For external wounds and abscesses, application of pure, raw honey over the lesion twice a day was observed to be very effective in removing the pus,necrotic tissue debries in the early stage of the lesion. This also promotes formation of granulation tissue earlier and facilitates healing.
- For conditions like foot rot and podo-dermatitis with mixed bacterial and fungal infection, initial cleaning of the complete footpad with 1% copper sulphate /

gentian violet solution and application of Castlani's paint is observed to provide an early and effective cure according to the elephant practitioners in Kerala.

- Preparation of Castlani's paint:- Dissolve 8 gm of Resorcinol in 4 gms of liquid phenol. To this add 8 ml of methylated spirit and 4 ml of Acetone and leave it for one hour. Then add 0.8 gm of Boric acid, 0.4 gm of Basic fuchsin and make up the volume to 100 ml with distilled water. This should be applied as a topical paint over the foot lesions such as foot rot and podo-dermatitis.
- Application of antibiotic medication based on the microbiological examination and antibiotic susceptibility tests of the foot ailments should be carried out at regular intervals till the infection cures completely.
- For elephants suffering from severe chronic foot ailments a sandal type protective cover with proper aeration and drainage may be applied for a short period after medication to prevent external contamination of the wound / medication and to improve the healing process with less stress to the elephant.
- The treatment approach for the foot ailments should be carried out with systematic microbiological examination and antibiogram at regular intervals for early effective healing with least stress to the elephant.
- In elephants with proper cleaning and dressing of wounds, the granulation tissue forms faster but the external closure of epidermis and skin takes longer time generally. In such chronic cases, use of ethno-veterinary combination of medicines / herbal pastes like freshly prepared neem, tulsi, turmeric and *Aloe vera* in equal quantities along with Zinc oxide and sulphanilamide powder was found to be effective.
- Regular rasping of the nails using the nail rasper and brushing of overgrown foot sole (> 2.5 cm thick) should be trimmed as and when required. At the same time over-zealous trimming of sole should be avoided as it will expose the foot for traumatic and penetrating injuries.
- Tethering site should not have water logging environment, without dampness and should be kept dry with provision for adequate drainage.
- The captive elephants must be tethered on earthen / natural substrate with adequate shade to avoid foot & nail problems.

- Leg chains should be covered with cushioned rubber / leather hose to prevent chain scratch marks and other related inflammation.
- Scrub bath with brushing throughout the body including the feet should be carried out daily.
- Decameli oil (a plant resin substance belonging to *Gardenia sp.* mixed and boiled with neem oil – working as a good antiseptic and emollient) should be applied over the foot, cuticular area and in-between the nails daily after bath to prevent foot ailments and to improve the foot health.
- Mixture of Dicameli oil:- (Ref:- Dr.S.Gopalan, Z P Jr; Vol-11(4);17)

  Dicameli - 28 gms, Camphour – 28 gms, Garlic- 28 gms, Neem oil – 680 ml.

  All this solid items have to be crushed, boiled in neem oil (Except camphour) and after all items got dissolped in the boiling neem oil, cool the mixture. Now add the powdered camphour over the mixture and mix it well in luke warm state, cool it and use.
- This should be applied over the nails and foot daily after bath for better foot health.
- The elephant must be given adequate exercise daily.
- Mineral mixture (enriched with Vit - B) should be included in the diet @ 100 gms / day to improve the general health and foot care.
- Tetanus toxoide (@ 3 – 6 ml) may be administered whenever the ***Clostridium sp.*** of microorganisms are encountered in the foot lesions.
- The captive elephants especially in temples should not be made to stand on a solid stoned / cemented substrate continuously for a long time since this is the main predisposing cause for most of the minor foot ailments at the initial stage and if neglected leading to major foot ailments in the course of time.
- In case of necessity, a cushioned rubber matt may be used on the floor on which the elephant may be allowed to stand for a short period in order to reduce the pressure from the solid substrate.
- General hygiene and sanitation of the tethering site and enclosure is a must for proper foot care of captive elephants.

- Trimming of the excess cuticular growth over and in-between the nails should be practiced regularly to avoid infection.
- Regular trimming of the foot pad, cuticle and rasping of the nail should be practiced in order to control and prevent split / crack nail condition.

PREVENTION OF FOOT PROBLEMS

In natural habitat, elephants spend their day walking, eating and digging in soil etc., Natural vegetation particularly browse contains necessary trace minerals and vitamins that promote foot health. Elephants use their feet to help them forage like placing the feet on a clump of grass, pulling the grass blades between their toes which helps to groom the inter-digital skin and cuticles. Hence it is essential to understand and appreciate the benefits of natural habitat to foot health, to improve the foot care of elephants in captivity by providing appropriate environment similar to the natural wild state.

The best substrate for the elephant is river washed sand and as an alternative to concrete floors in captivity / shed heavy rubber mats, straw or waste dry fodder may be used. Excessive weight is a detriment to foot health. Biotin (vit- B) has been shown to be beneficial to equine hoof health which can be supplemented for elephants.

1) Prevention is the key to elephant foot health problems.
2) Training of mahouts and elephants for foot care is essential.
3) Daily foot inspection is a must.
4) Early detection of foot ailments and complete treatment with laboratory investigation will provide an early effective cure with least stress to the elephants.

DESIGNING OF INNOVATIVE TECHNIQUES / GADGETS FOR FOOT AILMENTS

- A modified sandal type protective foot covers with adequate drainage and ventilation was designed individually for three captive elephants maintained in different temples of Tamilnadu suffering from severe chronic foot lesions such as foot rot, nail and pad abscess with pododermatitis. The protective foot covers were successfully applied with acceptance by the elephants and remarkable improvement in the healing process was reported. The sandal type protective foot

cover designed is proved to be a real therapeutic tool for early and successful healing of severe chronic foot lesions in captive elephants.

- Nail rasping technique was demonstrated to the mahouts with hands on training using flat file – 10 " and the technique is being practiced by the mahouts effectively.

AWARENESS

- Awareness regarding the importance of regular foot care and management was emphasized to the mahouts, elephant keepers and officials in order to inculcate the habit of examination of foot and foot care of the elephants as a routine practice.

SUCCESS REPORTS

- Complete healing of a chronic foot pad abscess of a temple elephant in Rameswaram, Tamil Nadu was reported following the systematic treatment based on the culture examination and application of protective foot cover.

- Complete healing of a nail abscess of a temple elephant in Swamimalai, Tamil Nadu was reported following the systematic treatment based on the culture examination.

- Remarkable improvement in the healing process was observed in a temple elephant in Salem, Tamil Nadu suffering from severe chronic foot lesions on three of its foot following the systematic treatment based on the culture examination and application of sandal type protective foot cover.

- Complete healing of a chronic necrotic wound in between the nails of a temple elephant in Bhavani, Tamil Nadu was successfully treated with combination of allopathic and Ethno-veterinary therapy.

- Complete healing of the cuticular abscess of a male elephant belonging to the Aringar Anna Zoological Park, Chennai was revealed after systematic treatment based on microbiological examination.

Success stories

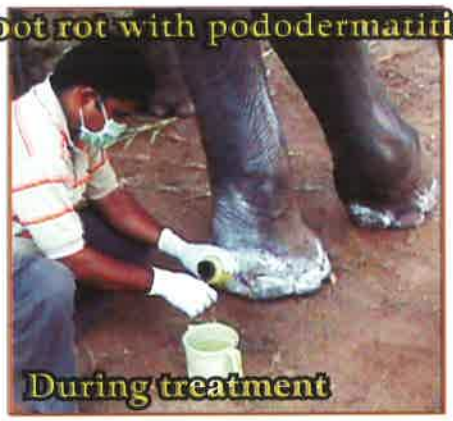


Photo : K.S. Subramanian

PUBLICATION / PRESENTATION OF PAPERS

- A booklet on " Captive elephant management " in Tamil was prepared for the (incorporating salient photographs of foot care and management) use of Mahouts, elephant keepers, field Veterinarians and Veterinary students in order to create awareness on the husbandry and management of captive elephants.

- A management guide entitled " Veterinary management of captive Asian elephants " in English was prepared and distributed to the Veterinarians associated with the health care of captive elephants in south India.

- Two papers were presented in the International conference of Indian society of Veterinary Medicine on Advanced veterinary medical care – Challenges and Strategies held at Madras Veterinary College, Chennai during 19th – 21st February – 2009.

    1) Antibiogram of various wounds in captive Asian elephants of Tamilnadu An overview
    2) Designing a protective cover for foot lesions of captive Asian elephants - A success report.

- News on Awareness to mahouts about Nail rasping technique and Boot for Elephant foot designed in this project as a therapeutic tool for the treatment of chronic foot lesions were published in TANUVAS News letter – September and December ' 09 ; an official publication circulated throughout our country.

- **Research article :** Protective cover for foot lesions in captive Asian elephants of South India. Zoos Print Journal : Vol. 25 (2) - Feb 2010 : Pg 28.

- Two papers were presented in the International conference on Ethno-Veterinary Practices held at Thanjavur, Tamilnadu during 4th – 6th January-2010.

    1) Successful combination of herbal and allopathic therapy for chronic foot abscess in a captive Asian elephant.

2) Study on Ethno-veterinary therapy for hip wounds in captive Asian elephants of Tamilnadu.

- Three papers were presented in the International conference on Wildlife conservation, health and disease management – A post-millennium approach held at Madras Veterinary College, Chennai during 3rd – 5th February – 2010.

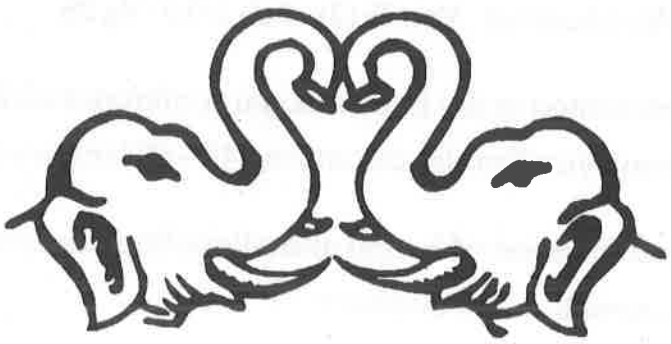
1) Microbiology and antibiogram of foot lesions in captive Asian elephants maintained in the temples of Tamilnadu.

2) Pilot study on common foot ailments in captive Asian elephant maintained in the temples of Tamilnadu.

3) Pilot study on ethno-veterinary medicine for foot ailments and other wounds in captive Asian elephants of Tamilnadu.

FUTURE AREAS OF RESEARCH

- This study can be carried out throughout our country involving larger numbers of captive elephants in different regions in order to understand the regional incidences of foot ailments and their microbial etiology.
- Use of Ethno-veterinary medicines and their successful combination for various foot lesions have to be explored.
- Hands on training for the mahouts and elephant keepers at the regional level has to be organized for creating better awareness on the foot care and management.



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7. Hindu Religious & Charitable Endowment, Tamil Nadu.
8. Temples Maintaining Elephants in Tamil Nadu.
9. Tamil Nadu Animal Husbandry Department.
10. Guruvayur Devaswom, Guruvayur, Kerala.
11. Elephant Sanctuary, Punnathurkotta, Guruvayur.
12. Karnataka Forest Department.
13. Bandipur Tiger Reserve, Karnataka.
14. Department of Forests and Wildlife, Govt. of Puducherry.
15. Mudumalai Tiger Reserve, Tamil Nadu.
16. Anaimalai Tiger Reserve, Tamil Nadu.
17. Arignar Anna Zoological Park, Chennai.
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19. Dr. Nambiyar, Dr. Vivek, Staffs & Mahouts of Guruvayur Elephant Sanctuary, Punnathur Kotta, Guruvayur
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21. Dr. K.C. Panicker, Kerala.

22. Dr. K.K. Sharma, Assam.
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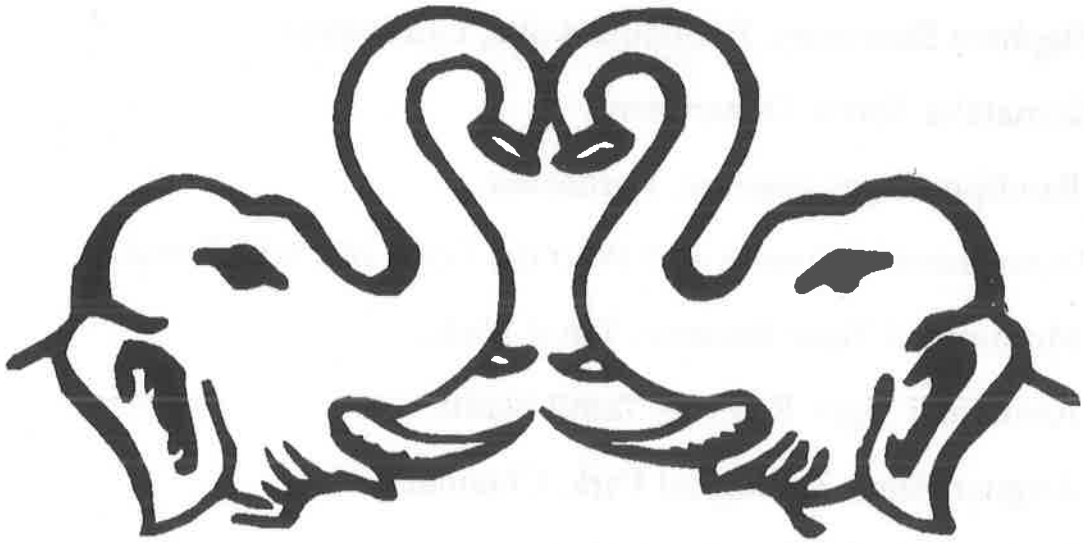
24. Elephant Study Centre, Kerala Agricultural University.
25. Elephant Study Centre, Assam Agricultural University.
26. All the Veterinarians associated with health care of Asian elephants in south India.
27. All mahouts & elephant keepers.




VETERINARY UNIVERSITY


MADRAS VETERINARY COLLEGE
CENTENARY PILLAR 2007