Advances in Healthcare and Nutritional Management of Camel

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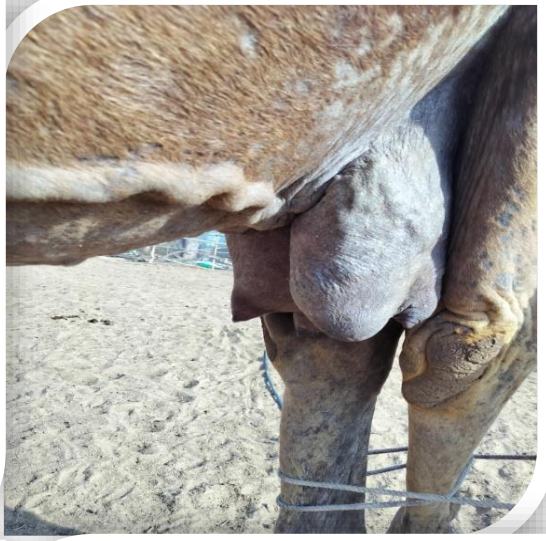

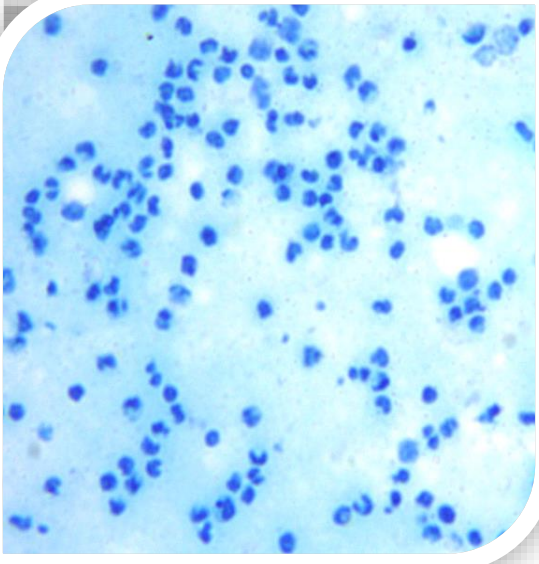

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This e-book is a compilation of resource text obtained from various subject experts of ICAR- National Research Centre on Camel, Bikaner, Rajasthan, India & MANAGE, Hyderabad, on "Advances in Healthcare and Nutritional Management of Camel". This e-book is designed to educate extension workers, students, research scholars, progressive farmers, and academicians about the Advances in Healthcare and Nutritional Management of Camel. Neither the publisher nor the contributors, authors, and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editors/authors. Publisher and editors do not give a warranty for any error or omissions regarding the materials in this book.

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FOREWORD

Single humped or dromedary camel (*Camelus dromedarius*) has served the humankind since ancient times. It has unique bio-physiological characteristics with formidable ways of living in harsh situations of arid and semi-arid regions. The proverbial "*Ship of Desert*" earned its epithet on account of its indispensability as a mode of transportation and draught ability in desert. The camel has also played a significant role in civil law and order, defense and battles from the ancient times till date. However, its efficient utilities are subject to continuous social and economic changes. At one side, the camel population on global level is increasing, particularly in those in African countries; the camel population in India has declined rapidly during recent past. This is largely due to decline in its utility as a draught animal, for which it was traditionally being used in remote villages in arid regions of the country. Our centre is now emphasizing and promoting its utility as a dairy animal. Camel milk has several human health benefits, the same have been validated by several scientific studies conducted at the Centre in collaboration with different medical institutions. Besides, utility of camel in tourist activities is also increasing, though the pace is slow and presently below the satisfactory level. There is a need for continued efforts to develop modalities for increasing remuneration from camel farming by development of new value added products from camel milk and from different by products like camel dung, leather, hair etc. All these need trained manpower and increased awareness among the common people.

The present training on 'Advances in Healthcare and Nutritional Management of Camel' was desinged to cater the need for updating the knowledge of camel farmers on various aspectss of camel health and nutrtion. These aspects are very important for profitable camel farming and generating livelihood through camel husbandry. The team of scientists from the Centre under the leadership of course director, Dr. Rakesh Ranjan served hard to make this program a bigh success. This was quite evident from the feeback that I received from the participants after completion of the training program. I hope this nice compilation of scientific knowledge in the form of different chapters will serve as a ready recknoer for camel farmers and other stakeholders. Participants may also dowload different pertinent literature that is freely avialble on the Centre's website https://nrccamel.icar.gov.in/.

I thankfully acknowledge the initiatives taken by the Dr. Rakesh Ranjan, Principal Scientist, IACR-NRC on camel, Dr. Shahaji Phand, Deputy Director, MANAGE, Hyderabad, and Dr. Sushrirekha Das (MANAGE Fellow) for their wholehearted support for compiling the ebook.

R.K. Sawal
(Director, ICAR- NRC on Camel)

PREFACE

Sharp decline in camel population in India during the past decade is an alarming situation that requires immediate attention by animal lovers, policy makers and administrators to safeguard the sustained survival of this important germplasm of our Country. There is an urgent need to attract and build-up the capacity of young people towards scientific camel farming to support livelihood generations by camel farming. There is a vast scope for increasing income from camel farming. However, generating public awareness about the neutraceutical and therapeutic potential of camel milk in different human ailments, engaging camel in tourist activities at different places and optimizing utilization of camel products and by-products are essential to speed up the process. Emerging health challenges like outbreak of infectious diseases like camel-pox, camel contagious ecthyma and trypanosomiasis that accounts for heavy morbidity and mortality in almost all camel rearing parts of our country also needs immediate attention. Shrinking pasture or grzing land is another big problem, hence desiginig balanced feed from alterative fodder resources is essential to minimize cost of camel rearing.

Realising above-mentioned challanges, a 4-days training on 'Advances in Healthcare and Nutritional Management of Camel' was designed to cover all important aspects of camel health and nutrtion in the present context. Different chapters submitted by well experienced resource persons of this traiining program have been compiled, edited and is being published as an e book to serve as a ready recknor for the camel owners, handlers and field veterinarians.

We extend our sincere thanks to the Director, Dr. A. Sahoo for his inspiration and support at different levels to deliver quality with excel. We would also like to thank officials from ICAR Headquarter, Hon. DDG (Animal Science) Dr. Raghuvendra Bhatta, ADG (ANP) Dr. Amrish Tyagi and Principal Scientists and officials for their support and generous help wheever required. We are thankful to all the learned and experienced resource persons of this training program who have shown their keen interest in delivering the topic and answering queries of the participants. Thanks are also extended to Shri Meetpal Singh, Shri Hemendra and Shri Manmohan Vyas (YPs) for their active support for running the training program smoothly. The kind support extended by all administrative staff, scientists, technical officers and other supporting staff of the Cenre is also thanfully acknowledged.

We hope this publication will inspire camel farmers and enterpreneurs, livestock assistants, field veterinarians, extension functionaries, policymakers, researchers and other stakeholders to promote scientific camel husbandry for livelihood security.

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CHAPTER 1

Profitable Camel Farming: Challenges and Opportunities

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Abstract

The concept of 'Dairy camel' because of it milk production abilities that provides nutrition to the camel rearers in the resource-scarce areas of the world and most importantly, camel milk usage as nutraceutical-adjuvant in various human health ailments and chronic debilitating diseases.Although, present-day technology advancement questions its sustenance due to extension of modern-day road-transport system minimizing its utility as 'Ship of the Desert', the alternate usage in camel dairy entrepreneurship has a large scope of expansion.Moreover, the importance of camel as a food security agent in climate change scenario and the pharma-value of camel milk has re-instate camel as a multi-utility animal species of arid ecology that needs sustenance to reach out people living beyond the boundaries of arid-ecology across the world.It has additional application in eco-tourism, which will further the scopeofprofitability from camelhusbandry and rekindled socio-economic linkage for providing opportunities in camel-based livelihood and its future sustenance.

Introduction

Camels serve as multipurpose animals providing milk by the females, used for transport or draught usually by the males, yield fiber/hair from both the sexes and finally, providing meat as the animals culled from any production purposes and skin and bones after its death. Historically, the Raika herded and sold camels to the Maharajas for warfare, and supplied to a thriving draught camel market until the late 1990s. Traditionally, camel has played a very significant role in livelihood and economy of the people of arid and semiarid regions, which is now under threat due to lesser use of camel in draft and agricultural operations and advent of rapid mechanization.Unfortunately, the statistics on camel population of India as of now is not at all encouraging, which showed a decline from around one million at the start of the Century to mere 0.25 million. We need to work for higher returns from this husbandry practice, jobs for the rural youth and exploring area of entrepreneurship to widen camels' applicability in human life.

Camel for dairy

Camels are the most adapted desert-dwelling domesticated ungulates with peculiar physiological (thermoregulation, water metabolism, glucose and energy metabolism, salt tolerance, forbearance against choking dust, etc.) and anatomical (fore limb and hind limb, long neck, single and double

hump, third eye-lid, forestomach, etc.) differences so as to adapt to different desert ecology (Sahoo, 2020). Amongst the two species, *Camelus dormedarius* of hot and arid ecology has shown promise to develop as dairy animals compared to *Camelus bactrianus* of high altitude or cold desert temperate regions.

Breeding and selection

In India, Kachchhi breed of camels in Gujarat have shown good potential as milk-type breeds yielding nearly 2000 kg of milk in its lactational cycle of 365 days (NRCC 2020). The other promising breeds in order of superiority are Jaisalmeri, Mewari and Bikaneri, but it needs further confirmation from a large pool of field data. The breeding and selection based on milkability data from each breed and multiplication of germplasm with improved milk traits will certainly help in harvesting maximum lactational average that adds to the total revenue from camel husbandry or in other words more per animal productivity. Significant breed differences for milkabilitywas reported in camel under hand milking system (Kumar et al., 2021).

Camel reproduction

Considering seasonality of reproduction, higher age of puberty (4-5 yrs) and long gestation period (13 mo), it is important to restrict lactation not to exceed 12 mo so that a greater number of offspring and more lactational cycle can be obtained in its productive lifespan.Further, if a calf dies when the breeding season is over, farmers have to wait for the next year that straightway reduces one lactation.It remains a challenge to propagate post-parturient breeding and non-seasonal breeding in camel at the field level for increasing reproductive efficiency. Nutritional interventions have successfully reduced the age of puberty in camels to 36 months (Vyas et al., 2023).

Nutrition and feeding

Pastoralists by nature, they usually move with their herds within stretches of about 250 km to 300 km so the animals can feed on a vast variety of vegetation. Their routes and stops vary with the seasons, and the availability of water and food for the animals. The Raikas, who are a sub-segment of the Rabaris, have immense knowledge of these animals, their behaviour and feeding habits. Thus, there is a good chance that nomadic pastoralists can show us the way to a better food future in which nutritionally-dense food is produced without fossil fuels, without destroying biodiversity, and in an animal-friendly way.In India, camels are not kept in stalls (like in the Middle East) and are not fed standard fodder, which is given to milk-producing cows and buffaloes. For any intervention in feeding, it is of paramount importance that the therapeutic value of camel milk is not compromised.

Camels are mostly reared by the farmers on zero input pasture lands, rangelands, forests and post-harvest agricultural lands. The feeds and fodders of camels arerelatively different from that of other domesticated livestocks, viz. desert-grown thorny shrubs, bushes, trees, resistant vegetation and grasses.These mainly depend on evergreen shrubs, tree leaves and dry leaves of the usually preferred shrubs from the ground during the dry season.This showed major preference for shrubs that erupted during the wet season. During grazing/browsing, the camels use to focus on leaves and twigs, and often spends 70-100% of their time showing preference in the early morning and late afternoon.It is also observed that camel fails to meet its daily nutrients requirement form the grazing/browsing resources, particularly during the scarcity periods of summer. Moreover, camel calf, pregnant and lactating camels requires additional supplementation, and the keepers usually offer them home-made feeds comprising of grain/seed by-products, auxiliary/sorted grains and other leftover from the agricultural produce.

Camel calf nutrition and care

Camel calf grows more or less in a similar pattern as that observed in other livestock. The average daily gain (ADG; g/d) of Bikaneri camels increased from 400 g during 0–1 year to 720 g during 7–8 years and then declined to 300 g at the later stages (10–11 years of age) (Tandon et al., 1988). Thepre and post-weaning growth rates have significant effects on pubertal/breeding age and body weight of camels (Sahoo and Sawal., 2021). The nursing ability of mothers based on milk yield and sustained lactation have major impact on early weight gain in suckling calves. Later, the post-weaning growth rate depends mainly on husbandry practices, availability of pasture/vegetation and browse in the area. Assessment of nutritional requirements for different physiological stages (ICAR, 2024) and feed formulations involving these preferred feed types will certainly boost rearing camel for dairy purposes with an economic and profitable input-output ratio.

Dairy Camel rearing, economics and profitability

The existing camel rearing modules can be categorized in to three systems, i) Nomadic/transhumance system, ii) Extensive system and iii) semi-intensive or semi-extensive system. Stall feeding of camel is not generally practiced. The economics of dairy camel rearing under extensive system is detailed in table 1. The table shows negative balance during the first year due to major investment and repay of loan, but farmer can have a ready source of income from second year onwards (1.90 to 5.92 lakhs per annum), which will very well support his family. This could be a source of income/job avenue for the rural youth with a promise to earn Rs 40000/month.

Farmers can opt for extensive and semi-intensive system of rearing starting with 10 females and 1 male and the additional supplemental feed cost adds to higher cost of feeding management. Also, the cost of stall feeding, construction of manger or purchase of feeding troughs adds to its total cost of management. On the other hand, an improvement in production may have a positive effect on input: output ratio in such feeding system (Table 2). Farmers can seek financial help from Banks/NABARD for the initial investment on animal, shelter and other infrastructures and repay it in five years. There is further scope of rearing camel for breeding stock, expanding it in eco-tourism and establishing cottage industry for maximizing return from various produce and products.

Health management

The change in rearing system for camel dairy management may put the animal to production stress thereby attracting various production diseases although camel is said to have a robust immune system that is highly efficient in making them less susceptible to several common health problems as compared to other domestic animals. Nevertheless, the emerging diseases may cause significant production loss besides consequential morbidity and mortality, particularly when raised in a large herd under semi-intensive or intensive management system. There is also a need to look at clean-milk production and public health aspects, especially concerning the diseases of zoonotic importance. Prevalence of mastitis in camel has been reported (Abera et al., 2010; Husein et al., 2013; Al-Dughaym and Fadlelmula, 2015) that deserves attention due to its potential impact on milk production.

Challenges

Major issues regarding intensifying the camel husbandry practices in India have been identified as detailed below.

- Preference of cow or buffalo milk and meat utility over camel food products;
- Lack of information about value addition of camel products;
- No value chain services regarding camel production;
- Lack of guidelines regarding formulation of ration and nutritional standards;
- Lack of consultancy regarding commercializing the camel husbandry;
- Calf mortality;
- Poor extension services for herder's empowerment and entrepreneurship;
- Main reliance on ethno-veterinary practices;
- Traditional way of camel husbandry.

Besides,majority of camel owners have a low socioeconomic status, medium level of family education status, and landholdings with joint ownership of land and camel herd among the family

members (Gahlot, 2021). The camel husbandry has also lost its shine due tomodern-day advancements that have occupied camel-dependent transportation and usage in agricultural and trading practices. It is becoming less attractive on account of i) drudgery involved; ii) less gainful employment days; iii) younger generation of camel breeders are showing much less interest to continue with this enterprise; iv) insufficient grazing/browsing resources; v) restriction on entry in forest area and unregulated access to forest for grazing; v) less opportunity to sell camel milk; vi) lack of mobile veterinary care facility to camel breeders. But there are opportunities if alternate utility as dairy camel and its role in human health is explored and understood.

Table 1. Economics of camel rearing under extensive system of rearing

Attributes	**Starting year**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Expenditure on livestock					
Adult male	1	1	1	1	1
Adult Female	10	10	10	12	15
Calf		3	3	4	5
Total	**11**	**14**	**14**	**17**	**21**
Loan for Purchase of animals @ 10000/h	110000				
Output					
Milk production (3kg/d) in 3 she camel each	-	3285	3285	4380	5475
Manure 15 kg/d	60225	76650	76650	93075	114975
Hair @ 0.5 kg/h	5.5	7	7	8.5	10.5
Expenditure on management					
Grazing charges @ Rs 300/d 2 labour/tola 10% incremental increase in wages	219000	240900	264990	291489	320638
Vermicompost preparation labour charges 1 h/d pit filling, watering, packaging	10950	11498	12072	12676	13310
Shearing of camels @ Rs 100/h	1100	1470	1540	1955	2520
Prophylaxis treatment	1100	1540	1694	2263	3075
Repayment of loan@20%/year	22000	22000	22000	22000	22000
Repayment of interest	2200	8800	6600	4400	2200
Total expenditure	**366350**	**286208**	**308896**	**334783**	**363742**
Expenditure/animal	**33305**	**20443**	**22064**	**19693**	**17321**
Income					
Sale of milk @Rs 50/kg (50% raw milk) increase 5%/ year	0	82125	86231	120450	157406
Sale of milk @Rs 100/kg pasteurized/milk products (50% milk) increase 5%/ year	0	164250	172463	240900	314813
Sale of vermicompost @ Rs 5/kg, 40% of output	120450	160965	168630	214073	275940
Sale of dry manure @Re1/kg, 60% of output 5% annual increase	36135	48290	50589	64222	82782
Sale of wool @ Rs 40/kg (50%) 5% annual price increase	110	147	154	170	210
Sale of wool products 200/kg (50%) 5% annual price increase (30% recovery)	165	221	231	293	378
Sale of calf @ 2000 at least one male calf/year	0	2000	4000	6000	8000
Income from domestic carting	18000	18900	19845	20837	21879
Income from marriage functions	18000	18900	19845	20837	21879
Total	**174860**	**476897**	**502143**	**666945**	**861408**
Income	**-191490**	**190690**	**193246**	**332162**	**497666**
Net income per animal	**-17408**	**13621**	**13803**	**19539**	**23698**

Table 2. Economics of camel rearing under semi-extensive system of rearing

Attributes	Starting year	Year 2	Year 3	Year 4	Year 5
Expenditure on livestock					
Adult male	1	1	1	1	1
Adult Female	10	10	10	12	15
Calf		3	3	4	5
Total	**11**	**14**	**14**	**17**	**21**
Loan for Purchase of animals @ 10000/h	110000				
Output					
Milk production (4 kg/d) in 3 she camel each	-	4380	4380	5840	7300
Manure 15 kg/d	60225	76650	76650	93075	114975
Hair @ 0.5 kg/h	5.5	7	7	8.5	10.5
Expenditure on management					
Grazing charges @ Rs 300/d 2 labour/tola 10% incremental increase in wages	219000	240900	264990	291489	320638
Feed/fodder supplements for lactating camels 5% annual price increase	0	32850	34493	48180	62963
Vermicompost preparation labour charges 1 h/d pit filling, watering, packaging	10950	11498	12072	12676	13310
Shearing of camels @ Rs 100/h	1100	1470	1540	1955	2520
Prophylaxis treatment	1100	1540	1694	2263	3075
Repayment of loan@20%/year	22000	22000	22000	22000	22000
Repayment of interest	2200	8800	6600	4400	2200
Total expenditure	**366350**	**319058**	**343389**	**382963**	**426705**
Expenditure/animal	**33305**	**22790**	**24528**	**22527**	**20319**
Income					
Sale of milk @Rs 50/kg (50% raw milk) increase 5% per year	0	109500	114975	160600	209875
Sale of milk @Rs 100/kg pasteurized/milk products (50% milk) increase 5%/ year	0	219000	229950	291999	419750
Sale of vermicompost @ Rs 5/kg, 40% of output	120450	160965	168630	214073	275940
Sale of dry manure @Re1/kg, 60% of output 5% annual increase	36135	48290	50589	64222	82782
Sale of wool @ Rs 40/kg (50%) 5% annual price increase	110	147	154	170	210
Sale of wool products 200/kg (50%) 5% annual price increase (30% recovery)	165	221	231	293	378
Sale of calf @ 2000 at least one male calf/year	0	2000	4000	6000	8000
Income from domestic carting	18000	18900	19845	20837	21879
Income from marriage functions	18000	18900	19845	20837	21879
Total	**174860**	**559022**	**588374**	**758194**	**1018814**
Income	**-191490**	**239965**	**244985**	**375231**	**592109**
Net income per animal	**-17408**	**17140**	**17499**	**22072**	**28196**

Opportunities

Opportunities are many, first we need to provide trainings to rural youth on all aspects of profitable camel rearing practices including knowledge on pharmaceutical properties of its milk and processing and technologies for consumers acceptability and market reach. Second, overcoming the socio-economic issues and emphasizing its environmental importance in the changing modern world that demands co-habitation and existence of all species of livestock through contribution towards the need and welfare of one another. Some of the areas of opportunities are briefed here with an eye on job opportunities from camel-based livelihood.

Milk collection, processing and marketing

There is no second thought that camel milk has unique therapeutic potential, but non-existing of proper pricing and market-chain deter its potential to reach the needy people. Separate collection of camel milk at the milk collection centre or establishing village collection centre for camel milk and then pooling them at central facility having storage and processing unit may be the first-step in this direction. Then, the processed milk and milk products can be transported to distance places for marketing and distribution to the needy consumers. The milk-cooperatives can play a significant role in establishing the processing unit nearby the pooled collection unit and infuse in to the marketing-chain with proper pricing and marketing.

Camel milk union/cooperatives

There is a need to establish village-level dairy cooperative societies and then form a linkage amongst these small-scale groups to large union, which will be responsible for coordinating collection, processing and packaging and then transportation and marketing to allow reach of camel milk to other parts of the country.

Entrepreneurial aspects for camel milk trade

The modern-day camel regains its importance through its ability to produce quality meat, milk, and fiber and recognizing ‘Camel Diary’ as a means of opportunity for the rural or semi-urban farmers and job creation through ‘Entrepreneurship’. Prospects relate both to production and its movement to metro cities through cold chain. Hygienic milk production needs to be ensured with camel health care to ensure better quality. Due to wide spread of camel keepers, their migratory nature, it is a biggest challenge for quality milk collection. To meet customer demand and monitor milk price and its quality, there is need to develop cold chain facilities which are good entrepreneurial prospects for its expansion.

Pharmaceutical value of camel milk

Efforts have been made to popularize milk through radio talks and TV programs have increased its demand in the country. However, lack of cold chain has prevented its widespread transport in the country. Efforts need to be done at for all aspects from rearing of camel, milking, milk quality assessment, packaging and transport through cold chain to reach every corner of the country for management of diseases as diabetes, autism, milk allergies etc. Camel is reared under arid ecology but requirement for milk is being felt from all parts of the country for its benefits in human health.

Job avenues in camel rearing

Present day camel has somehow lost its potential as 'Ship of the Desert', but considering its immense potential as multi-utility animal a variety of job opportunities can be ascribed from camel rearing. It starts from upkeep of unique germplasm to marketing of live animals, produce, products and opportunities in 'camel-ecotourism'. Some of the distinct areas of job opportunity is detailed in table 3.

SN	**Areas of opportunities**	**Job avenues**
1.	Camel rearing	1. Supply of camel germplasm: calf, breeding male, breeding female, lactating camel etc.
2.	Camel dairy: Milk production	2. Camel milk collection: making of cooperatives and collection from farmers' door 3. Processing & packaging: pasteurization and packaging 4. Camel milk powder processing unit: packaging, transportation & marketing 5. Camel milk transportation: Transportation to other cities 6. Camel milk supply and marketing: supply to needy consumers 7. Online marketing: online booking and managing delivery to far-reach states
3.	Milk product processing & marketing	8. Products making (flavoured milk, whey, probiotic, cheese, paneer, ice-cream, ghee, etc) 9. Packaging, storage and transportation 10. Marketing of products: high value, designer-type, brand name
4.	Draught Camel	11. Camel in agriculture: ploughing, harvesting, oil extraction

		12. Camel for transportation: moving from one place to another (camel cart, camel cabin, camel truck etc.) 13. Unmanned transport 14. Camel for transportation of goods and services: building materials, house-hold items, agricultural produce etc. 15. Camel for energy production: transferring mechanical to electrical energy
5.	Camel in armed forces	16. Patrolling in difficult and sandy terrainsbyborder security forces (BSF) 17. Transportation of goods and services 18. Arm Forces Military operations 19. Republic Day Parade
6.	Camel in Sports	20. Camel Polo 21. Camel Race 22. Camel Jumps and other related sports activities as in horse
7.	Camel in Eco-tourism	23. Camel safari 24. Camel riding in the desert/sea-beach 25. Double-hump camel riding/safari 26. Camel-Cart, Camel-Van, Camel-Bogie 27. Camel in culture & festival: decoration, Ceremony, Mela, Exhibition, 28. Camel dance 29. Camel in beauty competition 30. Camel museum: exhibits, short-film, decorates, mementos, souvenirs etc
8.	Camelfiber	31. Hair & Wool: shearing and collection 32. Camel fiber cleaning & processing, thread-making 33. Namda/Mat making: Yoga mat, Dari/Chatai, foot mat, car mat 34. Camel wool garments 35. Blended fiber making: with polyster, silk, jute/plant fiber 36. Camel fiber in Agro-textiles: adsorbent, sappling bag, soil-holding/binding 37. Camel hair: rope making, brush, foot mat,

		38. Camel fiber in manufacturing/construction: centralized insulation, car insulation
9.	Camel skin	39. Processing for leather 40. Camel leather product making, establishment of cottage industry
10.	Camel bones & teeth	41. Souvenir making, jewelry, traditional art & innovation 42. Camel bone-gelatin manufacturing unit
11.	Camel dung/Faeces	43. Camel dung: collection, transportation 44. Camel dung manure making: Organic manure production unit 45. Camel dung processing for paper and souvenir 46. Camel dung as fuel: Hukka, Sigar, cooking
12.	Camel urine:	47. Therapeutic usage:Camel urine in Ayurvedic medicine for the treatment ofskin diseases, antimicrobial agent, cancer, etc. 48. Camel urine as liquid manure, growth promoter spray, insecticide
13.	Camel in research and development	49. Camel in socio-cultural dissertation/education programme 50. Camel in biomedical research 51. Camel in climate-change adaptation research 52. Camel physiology: resilient phenomena
14.	Education/Training & Demonstration	53. Camel management, housing, physiology, anatomy etc. 54. Camel-based livelihood 55. Camel ridding, dance, show

Conclusion

Emphasis on ‘Camel Dairy’ and its popularization focussing on the therapeutic benefits of camel milk, viz. autism, diabetes, liver disease, jaundice, cancer, etc. may have widen the prospects of camel rearing and earn additional revenue to the farmers. Similarly, one less exploited area ‘Camels Eco-tourism’ seems to be a promising revenue making prospects due to application of male camel in culture/festivals, safari-ridding, sports/dance, etc. besides its age-old contribution to drafting. Moreover, revenue form camel fibre, dung, skin and bones are not generally accounted and thus, keeping an eye on doubling farmers income; there is need to establish camel as ‘Multi-utility Animal’ and increase its demand beyond its present boundaries.Nevertheless, camel’s unique ability of adapting to extreme desert ecosystem has a significant bearing on its survival and livelihood of the dependent population. The recognition and contribution of single-humped camel

as 'Dairy Animal' has many encouraging prospects as its milk and milk-products have functional, nutraceutical and therapeutic value besides contributing to human protein nutrition.

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CHAPTER 2

Feeding and Nutritional Management in Camel

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It is well known that food provides nutrition to the body, various popular methods to get this nutrition and can remain healthy. In this age of information technology; knowledge related to nutrition is spreading as it is more related to health and production of animals to support human needs.Camels which are usually raised on free range conditions choose of foragestype according to their physiological needs, environmental constraints, stage of production to meet their nutrition need. Camel is known for its unique physical structure, it can withstand harsh conditions of the desert region, it is capable of using most of the vegetation as feed resource growing in the arid zones.The camel herder uses it for work and when not needed it leaves the animal for grazing so that it can move freely and gather feed materials from the open fields to meet needs of its hunger. In this era of squeezing pastureland and mechanization; utility of camels has undoubtedly been affected. But the situation is not so dire because even today, due to its unique physical structure, it is considered most suitable as a border guard in the desert.

Besides, it is maintaining its deep penetration in rural areas from livelihood and transportation point of view. In the urban areas, it is also used for many works such as transportof bricks, gravel, stones, masonry materials, gas cylinders, house hold goods, animal fodderetc.which is of relevant for registering the presence of this animal in today's mechanical age.

Research on various aspects of camels is being done by ICAR-National Camel Research Centre, Bikaner and to conserve and prove usefulness of this species, this center carries out intensive scientific research as well and different kinds of practical demonstrations/ trainings.Research work has also been done on nutrition management during different physiological stages as a result, information about a requirement, concentrate diet and fodder management at different age groups in camel could be devised looking to available feed resources in the region.

Relationships exists between nutrition and development of animal body structure. On an average the body contains 54-60% water, 15-26% fat, 15-18% protein and 3.5-4.5% ash. Body growth depends on diet of the animal on which it is raised apart from its age and production. With age,

the ratio of water and protein in the body decreases and fat changes. Bone growth is rapid in the beginning but later it slows down. Muscles grow slowly at first, then at a faster pace. Protein-rich diet leads to help in growth of muscles in the body and fat-rich diet leads to accumulation of fat in the body.

Diet plays a very important role in keeping camels healthy; dry fodder/grains account for more than 80% of the cost on maintenance/rearing. Therefore, it is important to give proper quantity and quality food to the camel indicating it should have adequate amount of energy, protein, vitamins and minerals in its diet. The animal should get adequate feed/ forage/ roughage; diet of low quantity and low quality will make the camel weak and their late onset of puberty. Diet containing high quantity and quality of nutrients will lead to accumulation of excess fat in the body. Nutrients will not be used in the body, instead the animal will get tired quickly. With proper quantity and quality of feed materials, the animal's body will remain healthy and optimum productivity can be achieved.

When an animal is not in breeding condition and is not producing and its body weight and health, ratio of fat and protein are stable then it is in state of maintenance condition. Respiratory system, nervous system, blood circulatory system, digestive system, excretory system etc. are maintenance functions which are necessary for survival.At the second level, the animal uses the food for its body growth, reproduction, milk production and work which is indicative that different levels of feed would be required at different physiological functions.

Pregnant camel

During stage of pregnancy, attention should be given towards nutrition of the she-camel at three levels, one for its maintenance, second for the developing fetus and the third for storing nutrients in its body for milk production after calving. In this state nourishment is required both for mother and the calf; special care is required as the stress reduces feed intake of the mother thus there is need to provide nutrient rich feeds to the pregnant she camel. Therefore, there is a need to pay more attention towards its nutrition. The gestation period of cow, buffalo, sheep, goat and camel is different. Gestation period of a camel is 389 days i.e. thirteen months. Body development of the growing calf in the uterus is slow during first 8-9 months, however, during the last 3-4 months of pregnancy, 70% of the development of the fetus takes place during this period.

Therefore, special attention should be given towards nutrition of she camel during the pregnancy period. Balanced diet rich in energy digestible protein, minerals and vitamins should be provided. Poor nutrition of she camel during the pregnancy period may result in a weak calf and reduced milk production, deficiency of vitamin A, birth of weak or blind calves or abortion.

In the last month of pregnancy, she camels should be given light walking exercise; for the last 3-5 days, they should be stopped from grazing and kept in the enclosure. Animals should be given about 20%additional nutrients during the 9^{th} and 10^{th}months of gestation and 50% extra during the last quarter of pregnancy till calving.

Body weight gain of a she-camel during pregnancy depends on her nutritional status, it is betterin animals fed on quality fodders improved when concentrates were supplemented as pregnant camels supplemented with 2.0 kg of the concentrated mixture consumed 23–29% more dry matter, 24–36% more digestible protein, having 40–93% more protein than in the diet of non-pregnant camels.

Diet of growing calves

Diet given to the calves is very important as it ascertains growth and helps in improvement of production potential capacity of the camel. It depends upon the physiological stage at which care is taken, earlier is better to accelerate pace of growth which reduces age at puberty and helps in improving lifetime performance of the animal. Growing calf need to be provided well balanced diet containing dry roughages and concentrate so that it does not become week and else it achieves late adulthood which becomes harmful when the animals are reared in a group. It is also not good to give more than requirements as the excess is not utilized properly, there is accumulation of body fat.

Either the calf should suckle else colostrum from the mother (first milk of camel) should be provided within 1-2 hours of its birth. Colostrum contains antibodies or immunoglobulins i.e. disease-fighting elements along with plenty of nutrients. Usually absorption of antibodies from the intestines decreases as the age progresses. Colostrum contains 75-80% water, 20-25% total solids, 0.1- 0.4 percent fat, 16-20% protein, 4-5% lactose, 1.5-2.8% total minerals.

Antibodies or immunoglobulins protect calves from many diseases. Colostrum is also helpful in removing the first stool from the body. If the calf mother is unable to feed its own milk, then there

is need to provide milk of another female camel through a bottle. Camel milk should be provided for at least three months so that it helps in proper growth of the calf. Green fodder/ dry fodder and grains/ concentrated mixture. After 10-15 days of birth, allow the calves to graze along with their mothers as this helps in development of rumen. Slowly reduce the quantity of milk and increase the quantity of fodder/grains.

Under field conditions calves takes a long time 4-5 years to become adult but with scientific nutrition, they can achieve puberty in 2-3 years and have calved in 3 years age. Birth weight of calf ranges from 30-40 kg, it reaches about 100 kg at six months, 200 kg at one year and about 360-400 kg in 2.5-3 years age. Growth above 500g/d has been achieved in calves fed balanced diet containing legume-based crop residues with 15-20% concentrate with 9-10% CP and 55-60% TDN in the overall diet to achieve early puberty. Balanced feed has advantages over sole feed due to higher energy content of the diet. Calves consuming milk when supplemented with moth fodder have been found to gained up to 200 kg at one year of age. Male calves at 2-2.5 years of age could be used for draft purposes and could be sold for livelihood purposed. Female calves can also be mated to aid further as milk producing animal.Calvesgiven low quality feed materials attain puberty in 4-5 years due to slow growth Good feeding regimes save feed resources and time, fodder and money and help the owner to use the animal either for work/ sale and earn good profit.

Age	Body weight (kg)	Growth rate (g/d)	Feed intake (kg/d)
Birth	40		
3 Months	100	650	
One year	250	400	5
Two years	400	400	7-8
Three years	500-550		9-10

Female camel: as a dairy animal

Calving season in camels extends from December to March; under farm conditions, lactation length extends from 12-18 months. A healthy female camel can easily give 8 to 10 liters of milk if given proper diet. Milk production of a female camel depends on its breed, calving, stage of milk production and diet provided. To manage the nutrition of lactating camel following points need to be kept mind; body weight, milk production, stage of production and the diet provided. At the level

of maintenance; lactating female camel needs nearly 1.25-1.50 kg dry fodder/100 kg body weight, which is less than that of cow, buffalo, sheep and goat.Camel milk contains 88-90% water, 9-10% Total solids, 2-3% fat, 3.5-4.5% protein, 3.5-4.5% lactose and 0.8-0.9% minerals.

10-20% extra maintenance nutrition is required for increasing body weight during the first and second lactation. When lactating camels are sent out to graze in forests/ pastures, extra energy is spent for which 20%above maintenance requirement should be provided. It is necessary to provide extra nutrition to the lactating camels to overcome nutrient loss through milk. Dairy animals convert dietary protein in to milk protein very efficiently, this can be met by providing dietary protein 1.25 times of maintenance requirement. Dairy animals are capable of converting the sugar in the diet into milk fat but it is easier for them to convert dietary fat into milk fat. Therefore, at least 3% fat content in the diet should be provided from roughage sources and concentrates.

Lactating camels are stressed due to excessive milk production in the initial stage as the diet does not supply enough nutrients. Energy, protein, minerals, vitamins available in the body are secreted in milk, which leads to a decrease in their body weight. Diets of lactating camels need to be provided higher quantities of nutrients, the dry matter intake should be at least 2% of body weight so that the body weight does not fall. Research shows that camel milk has good digestive nutrients. Camel milk is not only nutritious but easily digestible and also has properties to prevent many diseases like tuberculosis, diabetes, cancer due to this, it is in great demand in the market.

Diet of Male Camel

Reproduction in male camel is very different from other animals like cow, buffalo, sheep, goat. Nutritional management in male camel is different from other animals. During winter (November to March) the male camel exhibits special kind of symptoms.

Such as making metallic sounds from the mouth, foaming from the mouth, making a balloon out of the upper palate of the mouth, flowing out of the smelly liquid between the ears on top of the head, the waist sinking inwards, standing with the hind legs spread, repeatedly urinating and hitting the tail with the reproductive organs, thin dung, etc. During this season the camel stops eating and drinking, which causes a decrease in its weight.

There is a significant reduction in body weight during the period as it stops eating and drinking thus it is difficult to maintain the level of fodder and grains in the diet of male camel as food intake

decreases by nearly 50% and there is a loss of 16% body weight.To maintain the nutrition, body weight and reproductive power of male camels, in such condition of male camels, give 500 grams of jaggery and 250 grams of groundnut oil daily along with fodder or 2-3 kg of feed mixtureso that its daily dry matter intake remains at least 1.25 kg/100 kg body weight.

Work production from camel

Camels have been used for providing rides, helping in agricultural work and carrying burdens for their owners, through which the farmers earn money to support their families since centuries. Poor camel farmers even today support their families by carrying fodder, building materials, bricks, cement and water tanks on camel carts to earn their livelihood.

Generally, a camel is put into use at age of 2 to 2.5 years; at about 5 years age it attains full working capacity. Camel nutrition research at the Center found that camels harnessed to 2- and 4-wheel carts consumed 14-18% extra DM, 52% extra protein and 62% extra energy compared to non-working camels. For a camel weighing 500 kg for 6 hours of daily work, use a balanced diet consisting of 7-8% digestible crude protein, 60% total digestible elements which will maintain its health and performance.

Balanced diet: option for better camel production and malnutrition

Legume crop residues which are usually offered to camels in arid regions are rich in protein compared to cereal straws however they do not contain all the elements of nutrition. To maintain good health camels, need to be provided a balanced diet so that nutrients are provided in a balanced proportion and quantity. This would aid in optimal utilization of fodder, maintain the level of rumen micro-organisms and optimize for microbial production and volatile fatty acid production in the rumen.Balanced diets can be prepared from locally available feed/ fodder resources for different physiological stages and for draft purposes.

Conclusion: Like any other animals, camel also requires proper maintenance and nutritional management. In the changing scenario, both the number and usefulness of this animal has been limited due to problems like decreasing pasture and other food etc.Under such situation, it is absolutely necessary to scientifically manage the nutrition of this animal. On the basis of intensive research in the field of nutritional management done at ICAR-National Camel Research Centre,

Bikaner; Camel farmers are advised for better care of their animals looking to the availability of resources available with them which helps them to improve productivity of their animals.

CHAPTER 3

Important Healthcare Problems in Camel: An appraisal

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Single humped or Dromedary camel (*Camelus dromedarius*) is a multi-utility animal well adapted to harsh environmental conditions of hot arid zone. They are largely thought to be resistant to the majority of livestock diseases, but recent research studies suggest that camels are vulnerable to a wide variety of pathogenic agents, including Brucella spp., Toxoplasma gondii (T. gondii), bluetongue virus, Mycobacterium avium subsp. paratuberculosis, Neospora caninum, Coxiella burnetii, and Staphylococci spp (Selim et al., 2023). For many infectious diseases, they may serve as potential reservoir and without showing any clinical symptoms of illness can transmit pathogens to other livestock species. Certain infectious diseases may also cause significant morbidity and mortality, particularly when raised in large herd under farm conditions. Besides, mortality, decrease in growth rate, milk production, abortion and poor draught capacity are some common problems responsible for economic losses to farmers. In this paper, a summary of important healthcare problems in Indian perspective is described.

1. Infectious diseases

1.1 Viral diseases

Two viral diseases, camel pox and camel contagious ecthyma are important for clinical point of view.

1.1.1 Camel pox

Camelpox is a contagious viral disease caused by the virus belonging to the genus Capripox of the sub-family Chordopoxvirinae of the Poxviridae family. It is transmitted by the aerosol route, close contact and mechanically by biting flies. Presently, it is reported to occur in almost all camel rearing countries and its outbreak occurs in almost every year in Indian dromedary camel. The disease is characterized by fever and a papularpustular eruption on the skin and mucous membranes that are largely distributed on facial skin, lips, nose and skin under thigh. Infected or

a recovered camel, carcasses and animal by-products, contaminated feed and water, animal accommodations, pens and pastures are common source of infection. The disease can occur in two forms, localized and generalized. Camels aged two to four years most often develop the localized form, wherein lesions are largely distributed on lips, face and nose. Weak, old or female camels in the final months of pregnancy may suffer from generalized form of the disease. After an incubation period of 3-14 days, there is a rise in rectal temperature to 39-41°C, general depression, complete or partial anorexia, dyspnoea, rapid pulse, hyperaemia of oral and nasal mucous membranes, conjunctivitis and corneal opacity. Papules develop on the skin and mucous membranes, measuring 3-5 mm in diameter, that later on becomes vesicles, then converted into pustules, and eventually they burst leaving flat, pale-pink scars. A pregnant camel may abort, and the aborted foetus may have a nodular-pustular eruption on the skin and mucous membranes. Diagnosis is based on clinical, epidemiological and pathological findings, and the results of laboratory tests. The symptoms are commonly confused with those observed in contagious ecthyma. Affected and suspected camels should be segregated and treated, while those still healthy should be moved to a different building or pasture, and vaccinated. Attenuated camel pox vaccine is reported to be effective and is recommended to be given first at the age of 6-9 months followed by a booster dosing after 4 weeks. Vaccinated and recovered animals develop lifelong immunity. In our country, camel pox outbreaks are reported to occur during winter season (December to February). Topical application of glycerine-betadine mixture or boroglycerine on lesions and symptomatic treatment with antibiotics (oxytetracycline), and NSAIDs (Meloxicam) are recommended (Kachhawaha et al., 2014). The disease is largely self limiting, but mortality may occur in weak or young animals. Some viral strains can cause gastrointestinal ulcers and hence mortality even in adults with good body condition (Narnaware et al., 2021). It also has zoonotic potential, though other animals are not susceptible for infection with camel pox virus (Bera et al., 2011).

1.1.2 Contagious ecthyma

The contagious ecthyma is caused by pseudocowpox virus (PCPV) in India which comes under the genus Parapoxvirus, subfamily Chordopoxvirinae and family Poxviridae (Nagarajan et al., 2011). The virus is transmitted through direct or indirect contact, through cuts and abrasions on skin induced during grazing on thorny plants. The important clinical symptoms include depression, swelling of the lips, cheeks, nasal skin and eyelids, with a slight rise in body

temperature (38.5-39°C). After 1-2 days, small nodules of a millet grain size develop on the inflamed areas of skin, rapidly changing to vesicles containing lymph which is clear at first, and then becomes turbid. When the vesicles rupture spontaneously, or as a result of being rubbed, the exudate released is spread over the skin, leading to the formation of fissured crusts, through which an inflammatory exudate emerges and soon dries upon exposure to air. The formation of a grayish firm crust conceals inflamed skin. Newborns may fail to suckle their dams leading to emaciation and anaemia (Khalafalla, 1998). Pustular and nodular lesions develop in and around the skin of lips, eyes, nose and sometimes around neck, trunk, perineum and legs (Bazargani et al, 2010). The lesions later becomes ulcerated, haemorrhagic and with frequent secondary bacterial infection (Ali et al, 1991). Morbidity may go up to 100% in young camels, but is rarely recorded in adult infected camel (Azwai et al, 1995). Currently, no vaccine is available for contagious ecthyma. Wound dressing with antiseptic solution and topical antibiotic application is recommended. Symptomatic treatment may be warranted in severe cases.

1.1.3 MERS

Middle East respiratory syndrome (MERS) is caused by a novel beta coronavirus that was first identified as the cause of severe respiratory disease in humans during 2012. Then, in year 2013, the dromedary camels (*Camelus dromedarius*) were implicated for the first time as a possible source for human infection on the basis of the presence of MERS-CoV neutralizing antibodies in dromedaries from Oman and the Canary Islands of Spain (Reusken et al., 2013) Thereafter, presence of MERS-CoV antibodies in dromedaries has been reported from several countries across the globe including Jordan, Egypt, the United Arab Emirates, Qatar and Saudi Arabia (Reusken et al., 2014). In human beings, typical symptoms include fever, cough and shortness of breath and occasionally pneumonia. Approximately 35% of reported patients with MERS die, though asymptomatic carriers are also reported. Dromedary camels harboring the virus remains largely asymptomatic, though mild respiratory symptoms may be observed in few cases particularly young animals (Hemida et al., 2017).

1.1.4 FMD

FMD is a highly contagious viral disease of cattle, sheep, goats, Bactrian camels and swine. Old World camels (Single humped or dromedary camel) and New World camels (Double humped camel or bactrian camel, llama, alpaca and guanaco, vicuna) possess noticeably different

susceptibilities to FMD. Bactrian camels can contract the disease. In contrast, dromedaries are not susceptible to FMD and do not transmit infection, even after living in close contact with susceptible or infected animals (Wernery and Kinne 2012a).

1.2 Bacterial diseases

1.2.1 Pasturellosis

Though, Pasturellosis in dromedary camel has been reported from our country, uncertainty prevails regarding susceptibility of dromedary camels towards sensitivity to *Pasturellamultocida* infection. It is largely believed that the organism causes diseases only when immune system of the camel is compromised, as several experimental trial failed to induce the disease in healthy dromedary camel. The pasturellosis in camel may occur in three clinical forms: acute, peracute and an abdominal form. The abdominal form is characterized by diarrhea and dysentery. In acute and peracute form, clinical sings include fever, nasal discharge, lacrimation, dyspnea, congestion of mucous membranes, swelling of throat and neck and pneumonia (Wernery and Kaaden 2002). The outbreaks occur during rainy season. Mainly adult camels suffer from the disease but infection can occur in all age groups.

1.2.2 Enterotoxaemia

It is a toxaemic condition caused by the toxins produced by the bacterium Clostridium perfringens, primarily types C and D. Camel is typically infected by ingesting feed or water contaminated with Clostridium perfringens spores. Factors such as sudden changes in diet, overeating, or stress can predispose animals to the development of enterotoxaemia. The clinical manifestations vary depending upon the severity of infection, age and health status of the host. In mild cases, watery or loose stool is recorded first and the animal become lethargic, depressed and show signs of abdominal pain. In severe cases diarrhea is severe with watery and voluminous faces leading to dehydration and electrolyte imbalances, abdominal pain is severe and animal may become recumbent. Usually onset of disease is rapid and animal may exhibit neurological signs like ataxia, convulsions and recubency. Colic-like abdominal pain, abdominal distension, and diarrhea may also be observed. The disease can progress rapidly, leading to death within hours of the onset of clinical signs.For the diagnosis faecal samples are examined for presence of C. perfringens and its toxins. Intestinal contents, intestinal mucosa and other affected tissues collected

during post-mortem for toxins or the bacterial analysis. Samples of feed or water that the camel may have consumed can be tested for contamination with C. perfringens.Administration of specific antitoxin against Clostridium perfringens toxins is required for saving life of the affected animal. Five to 25 ml of a multivalent antitoxin can be administered intravenously, depending upon the body weight of the animal to neutralize circulating toxins and mitigate clinical signs. Antibiotic therapy with Penicillin G sodium at the rate of 22000 to 44000 IU/ kg body weight every 6 to 12 hourly can be administered intravenously or intramuscularly. Supportive measures such as fluid therapy, electrolyte supplementation, and nutritional support are essential for managing affected animals.

1.2.3 Tuberculosis

Though susceptibility of dromedary camel for tuberculosis is thought to be low, the clinical disease has been documented since the 19th century. *M. bovis* is the most common form of tuberculosis in camels. The disease is characterized by granulomatous abscesses in various tissues with a predilection for lymphoid tissues and lungs (Wernery and Kaaden, 2002). The disease does not occur in nomadic camels but is common in those kept in herd or in close contact with cattle. Aerogenic transmission by inhalation of the organism in contaminated droplets from infected animals, either directly or on dust particles is common, though alimentary transmission by ingestion of food contaminated with infected feces urine or milk can also occur. Clinical symptoms include mild fever, occasional coughing and emaciation. Affected animals lose weight rapidly despite good appetite and die within a month.

Antemortem diagnosis of tuberculosis in Dromedary camel (*Camelus dromedarius*) is seldom achieved due to lack of overt clinical sings and non-availability of any reliable diagnostic test or protocol. The sensitivity and specificity of intradermal tuberculin testing are reported to be poor, hence the disease is largely diagnosed at postmortem. SIDT when performed in skin in neck region show poor sensitivity than that performed on skin in axillary area or undertail. A possible reason may be the thick and resilient skin in the neck region of camelids (Wernery and Kinne 2012b). Recently, a lateral flow assay based rapid diagnostic test kit based on immuno-chromatographic detection of antibodies of *Mycobacterium tuberculosis* and *Mycobacterium bovis*in serum, plasma or whole blood of the infected animals was reported to be effective in antemortem diagnosis of tuberculosis in camels (Ranjan et al., 2017). Early diagnosis, segregation

or slaughter of the infected animal is essential for disease control. Treatment is not recommended. Administration of isoniazid at a dose of 2.4 mg/ kg is reported to be toxic and fetal in Bactrian camels.

1.2.4 Brucellosis

Brucellosis in camel is caused by *Brucella abortus* and *Brucella melitensis*. The disease is characterized by abortion, and to a lesser extent by orchitis and infection of the accessory sex glands in males (Wernery and Kaaden 2002). In camel, abortion is the most obvious manifestation of the disease. However, in contrast to cattle, retained plancentas have not been described in camels. Camels may get infection from other infected camel or from sheep and goat herds reared nearby or during co-grazing. Presence of testicular lesions, hygromas, lameness are other lesions recorded sporadically. Abortion and reduced fertility in camel may also be associated with salmonellosis, trypanosomosis, or infections with Campylobacter or *Trichomonas fetus*, hence differential diagnosis is warranted. The RBPT is widely used for brucellosis screening. It is very sensitive and is suitable for screening herds for brucellosis, but it can give false positive results due to vaccination with *B. abortus* strain 19 vaccine or cross reactions with other bacteria. The RBPT has been reported to have high sensitivity; therefore false negative responses are reported to occur less frequently than false positive responses (Omer et al., 2010). In serum agglutination test an end titre of 1:20 (40IU) is regarded as suspicious. Camel milk can not be used to detect latcteal brucellosis antibodies using the conventional milk ring test (MRT) because camel milk lacks the agglutinating substance required to cluster fat globules (Straten et al,. 1997).

1.3 Parasitic Diseases

1.3.1 Trypanosomiasis

Camel trypanosomosis (surra), caused by *Trypanosoma evansi*, is the most important disease of camel causing high morbidity and mortality (Pathak and Chhabra 2010). The disease is endemic in all camel rearing countries in Africa, Asia and South America. The parasite is transmitted non-cyclically by haematophagus flies, including *Tabanus*spp and *Stomoxys* spp. Anaemia appears to be a major component of the pathology of surra. Persistent anemia results into anoxic conditions with end result of multiorgan dysfunction, fall in tissue pH and vascular damage. Large quantities of cytoplasmic and mitochondrial enzymes, especially aspartate alanine

transferase and alanine transferase are released in circulation aggravating cellular and tissue damage. The net effect associated with the above changes is immunosuppression which later develops and predisposes the animals to other infections and death if untreated. Clinical symptoms of the disease are largely vague and include chronic weakness, abortion, hair fall, infertility and reduced milk production. If left undiagnosed and untreated, the animal usually dies within a period of three years, hence the disease is also known as "Tibersa".

Diagnosis is largely based upon demonstration of the parasite in the blood of camel. In addition, low blood glucose level and low hemoglobin concentration can serve as a useful adjunct in screening animals. Subcutaneous administration of Quinapyramine chloride and quinapyramine sulfate (in 1:1.5 ratio) @ 5 mg/kg body weight is recommended in positive animals. In addition, Suramin @ 0.4 to 0.6 gram/ 45 kg intravenously can also be tried. Vector control is essential for effective control of the disease. The fly population usually increases just after the rainy season, hence farmers should remain alert. Prophylactic administration of Quinapyramineprosalt is advocated once in a year from July to August.

1.3.2 Sarcoptic mange

Mange in camels is a highly contagious disease caused by *Sarcoptesscabei* var cameli mites. Sarcoptes larvae burrow into the epidermis forming tunnels. Symptoms of the disease include intense pruritis leading to weight loss, hair loss, and exudative dermatitis. Subcutaneous oedema occurs in some cases. Chronic infections lead to dark and thickened skin, weight loss, increased susceptibility to other diseases like trypanosomiasis and tuberculosis. It is a debilitating disease resulting into severe compromise in health and production of the animal. If not treated, the animals may even die.

Traditional treatments topically applied such as coal tar based preparations, chlorinated hydrocarbons and organophosphates require repeated application and are often not completely effective (Kumar et al. 1992). Ivermectin @ 200 microgram per kg body weight subcutaneously can also be tried, but is not highly effective. Topical application of a mixture of fenvalerate and sulfur powder in mustard oil base is found highly effective in our farm.

1.4 Fungal diseases

1.4.1 Camel dermal mycosis

Dermal mycosis in camel is caused by fungi belonging to the genera Trichophyton, Microsporum, and Epidermophyton. They thrive in warm, humid environments and can infect camels through direct contact with contaminated objects, infected animals or environmental sources like soil or bedding. Clinical signs include alopecia that may be localized or diffuse. Erythema and Inflammation of the skin are other clinical signs that may result into scaling and crusting. Pruritus (Itching) can range from mild to severe and may lead to self-trauma. Hyperpigmentation or darkening of the skin may occur in chronic or severe cases of dermatomycoses. For the diagnosis skin scraping and hair plucks can be collected by scrapping the edge of the lesion. Microscopic examination ofskin scrapings for the presence of fungal elements such as hyphae, spores, or arthroconidia is often helpful. Fungal culture is considered the gold standard for diagnosing dermatomycoses. Treating dermatomycoses (fungal skin infections) in camels requires a combination of antifungal medications, environmental management, and supportive care. Topical applications include Miconazole (2%) cream to the affected areas twice daily for 2-4 weeks or Clotrimazole (1%) cream to the lesions twice daily for 2-4 weeks can be tried. Weekly topical application of a combination containing captan and hexaconazole dissolved in water (as 3% solution) is also reported to be effective (Ranjan et al.,2019).

2. Non-infectious Diseases

2.1 Impaction

Impactionrefers to a condition in which the normal movement of ingesta through the digestive tract is obstructed, leading to the accumulation of dry or hardened faecal material. Impaction may occur in different parts of the digestive system, including the stomach, intestines, or colon. Symptoms of impaction vary with the etiology and severity of the condition.

Inadequate water intake or consumption of low quality forage is the most important causative agents. It results into dry, compacted stomach and intestinal content and thereby limits gastrointestinal movements and normal defecation procedure. Limited physical activity or confinement to small enclosures can also result into reduced gastrointestinal motility and impaction may develop. Ingestion of foreign objects, such as stones, sand, or fibrous material, can obstruct the digestive tract and lead to impaction. Dental problems may interfere normal chewing activity and can predispose to impaction.

Affected camel passes small, dry fecal pellets infrequently or defection may be completly absent. Signs of abdominal pain or discomfort, such as restlessness, pawing at the ground, or lying down and getting up repeatedly are evident, particularly in later stages of the conditon. Appetite is reduced, animal appears dull and depressed and abdominal distention or bloat may be evident. Signs of colic, such as rolling, stretching, or kicking at the abdomen, may be present in severe cases of impaction.

Rehydration with intravenous or oral fluids and electrolytes is essential Providing access to fresh water and high-fiber forage can help promote normal bowel movements and prevent further impaction. Administration of laxative medications or enemas is often essentially required. Mustard oil - 1.5 to 2.0 liter - may be given once or may be repeated after 48 hours. Analgesic medications may be used to alleviate abdominal discomfort. In cases of severe or persistent impaction, surgical procedures such as rumenotomy may be required to remove obstructive material and restore normal gastrointestinal function. Rectal enema using soap water may be helpful, particularly in calves. Rule out chances of peritonitis in cases of impaction. Blood examination may be helpful in deciding the needfor antibiotics. Early recognition and intervention are crucial for successful management of impaction in camels.

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CHAPTER 4

Diagnosis and Prevention of Important Viral Diseases of Camel

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Camels are renowned for their capacity to endure and adapt to the most severe climates. In the past, it was believed that dromedary camels had a particular resistance to infectious diseases that affected most domestic animals. However, subsequent research has shown this assumption to be incorrect, as camels have been found to be susceptible to various viral infections and can play a role in transmitting them. Originally, camels were identified as the main species susceptible to camelpox, a condition exclusive to them and not transmissible to other animals or humans. However, the zoonotic capability of camel infections was noted in 2011 in India when three individuals contracted a disease transmitted from camels. Presently, camels are recognized as carriers of numerous infectious diseases, such as peste-des-petits ruminants (PPR), African horse sickness, Rift Valley fever (RVF), bluetongue (BT), and West Nile disease.

Camel Pox

Camelpox presents as a highly contagious skin ailment prevalent among camels, particularly in regions where camel husbandry is widespread. It is caused by the camelpox virus (CMLV), belonging to the *Orthopoxvirus* genus within the *Poxviridae* family. This virus shares close genetic similarities with the variola virus. Manifestations of camelpox include elevated body temperature, skin abnormalities, and swelling of lymph nodes. Various stages of pox lesions may develop, primarily appearing on the face, throat, and around the tail region.

Diagnosis of the illness often relies on observing clinical symptoms, although similar symptoms can be induced by camel contagious ecthyma and camel papillomatosis. Several diagnostic techniques are accessible for identifying camelpox. Transmission electron microscopy (TEM) stands out as the quickest method for detecting the distinct brick-shaped orthopoxvirus in tissue samples or skin lesions. Immunohistochemistry provides additional valuable insights. Virus isolation in embryonated chicken eggs (ECE) and cell culture in primary cell culture and continuous cell lines are valuable to confirm the presence of live virus. Polymerase chain reaction (PCR), Loop-Mediated Isothermal Amplification (LAMP) serves to confirm the existence of viral nucleic acid, while DNA restriction enzyme testing and DNA sequencing aids in pinpointing particular strains of the camelpox virus (CMLV).

Similar to the management of smallpox in humans, controlling camelpox involves isolating infected camels and immunizing the rest with either the standard vaccinia virus vaccine or the newly formulated camelpox virus (CMLV) vaccine. This CMLV vaccine is obtainable in both live attenuated and inactivated forms. A supplementary vaccine dose is advised for young camels vaccinated before reaching 6–9 months of age. The inactivated vaccine can be administered annually, while the live attenuated vaccine offers prolonged protection. Most vaccines are produced from the CMLV strains Ducapox 298/89, Jouf-78, VD47/25, and CMLV-T8. The typical nonspecific treatment for infected camels involves administering 10 mg/kg of oxytetracycline and 0.2 mg/kg of meloxicam for duration of 5 days. Additionally, a spray containing gamma benzene hexachloride, proflavine hemisulphate, cetrimide, eucalyptus oil, turpentine oil, and neem oil can be applied for wound therapy and to control fly infestations.

Camel Contagious Ecthyma (CCE)

Camel contagious ecthyma (CCE) also known as orf, contagious pustular dermatitis, sore mouth or scabby mouth is a highly contagious viral ailment characterized by a 38% fatality rate, primarily affecting young camels and resulting in calf debilitation. It is caused by a poxvirus belonging to the *Parapoxvirus* genus within the *Poxviridae* family. CCE is marked by the presence of pustular lesions around the mouth, lips, buccal cavity, and swelling of the head. The disease typically exhibits a swift onset and rapid lesion development.

Clinical signs and symptoms are of diagnostic importance, yet laboratory confirmation is essential. PCR targeting the RPO30 gene is commonly utilized for analyzing samples obtained from skin scrapings or pustules. Negative contrast electron microscopy, immuno-fluorescence, and immuno-peroxidase assays are also employed in diagnosis.

Traditional therapies encompass techniques such as cauterizing regional lymph nodes, applying sesame oil and hot milk, and occasionally using plant tar. Administering broad-spectrum antibiotics, either topically or systemically, for duration of 3–5 days helps prevent secondary bacterial infections. While vaccination utilizing CCE virus-containing material shows promise, attempts at immunization using vaccinia virus and a vaccine designed against infectious ecthyma in sheep and goats have proven ineffective in protecting camels from infection.

Rift Valley Fever

Rift Valley Fever (RVF) is indeed a significant concern in regions like the Arabian Peninsula and Sub-Saharan Africa, particularly due to its impact on both animal and human populations. The involvement of camelids, such as camels, in RVF epidemics is well-documented, particularly in East Africa and Egypt. Clinical manifestations of RVF in camels often include fever, weakness, reproductive issues like infertility, and unfortunately, a heightened mortality rate, particularly among younger animals. These symptoms, along with ocular discharge, tongue hemorrhages, and edema, serve as crucial indicators of RVF infection.

Diagnostic methods such as Reverse Transcription-Polymerase Chain Reaction (RT-PCR) are pivotal in detecting the presence of the virus in blood and tissues during an active infection. Additionally, enzyme-linked immunoassays (ELISA) play a crucial role in confirming RVFV infection by identifying specific antibodies produced by the immune system. IgM auto-antibodies,

which emerge rapidly during acute infections, and IgG antibodies, which persist for extended periods, are both key indicators of RVFV infection.

Among the various vaccine options, the modified live Smithburn vaccine has been a longstanding choice due to its single-dose requirement. However, concerns regarding its safety, particularly in pregnant camels, have been raised due to its association with birth abnormalities and miscarriages. In contrast, live-attenuated vaccines like MP-12 and Clone 13 offer promising prospects. Furthermore, research into alternative vaccination strategies based on recombinant molecular structures is underway, yielding encouraging results. For instance, the live CL13T RVF vaccine has demonstrated safety and effectiveness in camels, eliciting robust and durable immune responses with no significant adverse effects observed in vaccinated animals. These advancements signify a shift towards safer and more efficient vaccination approaches for combating RVF in animals like camels.

Peste-des-petits ruminants (PPR)

Peste-des-petits ruminants (PPR)/Kata is indeed a concerning infectious disease that primarily affects sheep and goats, but it has also been observed to impact other ruminants like camels. Typical symptoms of PPR in affected animals include anorexia, diarrhea, nasal and ocular discharge, high fever, necrotic stomatitis, and respiratory distress. The causative agent of PPR is the peste-des-petits ruminants virus (PPRV), which belongs to the genus *Morbillivirus* within the *Paramyxoviridae*family.

While camels were not initially recognized as susceptible hosts for PPR, studies have shown positive serum reactivity in Sudanese camels, indicating their potential involvement in the transmission and spread of the virus. The first documented PPR epidemic in camelids occurred in 1996, characterized by highly contagious respiratory illness with notable morbidity but relatively low mortality rates. Subsequent outbreaks in eastern Sudan, Somalia, and Kenya further highlighted the impact of PPR on camel populations.

Indeed, the diagnosis of PPR relies on various laboratory techniques to identify specific viral antigens or antibodies in medical samples. Pathological lesions observed during necropsy or postmortem examinations can provide valuable clues, but definitive diagnosis often requires laboratory confirmation.Serologic tests, such as Immunocapture Enzyme-Linked Immunosorbent

Assay (ELISA), play a crucial role in detecting viral antibodies in serum samples. Molecular assays, particularly Reverse Transcription Polymerase Chain Reaction (RT-PCR), are highly sensitive and specific methods for detecting viral nucleic acids in clinical samples. Currently, there are live-attenuated vaccines providing extended protection against PPRV.

Bovine Viral Diarrhea (BVD)

Bovine viral diarrhea (BVD) is increasingly being recognized as a significant concern in both new and old-world camel populations. Bovine viral diarrhea virus (BVDV) belongs to the *Pestivirus* genus, part of the *Flaviviridae* family and is responsible for causing bovine viral diarrhea (BVD) disease. In camels, the disease manifests with symptoms such as diarrhea, reproductive issues, and respiratory problems.

A single test cannot conclusively diagnose chronic BVDV infection in camelids. While the BVDV antigen ELISA test is employed for chronic BVDV infections in cattle, its applicability and interpretation in camelids remain uncertain. Thus, identifying chronic infections in camelids should involve virus detection through PCR or viral isolation from samples collected over a period of 3 to 4 consecutive weeks.

While various BVDV vaccines are accessible for cattle, none have been officially sanctioned for employment in camelids to date. Although vaccinations do not prevent infection entirely, they can mitigate the manifestation of clinical symptoms. It might be feasible to diminish the incidence of infections by maintaining a closed herd, implementing rigorous biosecurity measures for all incoming animals, and regularly screening open herds.

Bluetongue

Bluetongue (BT) is an infectious ailment triggered by the bluetongue virus (BTV), which belongs to the *Orbivirus* genus within the *Reoviridae* family. It spreads through biting midges primarily from the *Culicoides* spp. genus. While alpacas and llamas are susceptible to bluetongue virus (BTV) outbreaks, they typically do not show symptoms. However, they can serve as carriers because BTV infection can persist for several days in these species. Camels are generally regarded as low-risk animals for BTV, but some studies have documented instances of BTV infection in camels.

According to the OIE (World Organisation for Animal Health), competitive ELISA, real-time PCR, and agar gel immunodiffusion tests are considered dependable and effective diagnostic methods for bluetongue virus (BTV). These tests are recommended for international trade purposes. Confirmation of BTV in the laboratory typically involves virus isolation in embryonated chicken eggs or cell cultures derived from mammals or insects, or the identification of viral RNA using PCR assays. The identity of isolates can be confirmed through various methods, including group-specific antigen-capture ELISA, group-specific PCR assays, immunofluorescence, immunoperoxidase techniques, serotype-specific virus neutralization tests, serotype-specific PCR assays, or hybridization with complementary gene sequences specific to groups or serotypes.

There isn't a specific treatment for animals affected by bluetongue, aside from providing them with rest, soft food, and attentive husbandry. However, any complicating or secondary infections that arise should be addressed appropriately during the recovery phase. Controlling vectors through the application of insecticides or implementing measures to shield animals from vectors can reduce the frequency of *Culicoides* bites, thereby lowering the risk of exposure to bluetongue virus (BTV) infection. Although vaccines are available for use in small ruminants, yet the vaccine has not been developed for use in camel.

Rotavirus

Rotavirus (RV) has been found in New World and Old World camels. The disease shows typical symptoms of diarrhea and dehydration. Diagnostic procedures for rotavirus infection include ELISA, AGID, and virus isolation in cell cultures, sequence analysis and the visual identification of the characteristic wheel-like morphology of rotavirus particles through electron microscopy.

Isolating infected animals, implementing rigorous sanitation and hygienic measures on the farm, and enforcing strict bio-safety and bio-security protocols are crucial steps in controlling the spread of diseases and maintaining the health of livestock populations. These measures help prevent the transmission of pathogens and minimize the risk of disease outbreaks among animals.

Rabies

An acute progressive viral infection, rabies is caused by the rabies virus, a member of the *Lyssavirus* genus within the *Rhabdoviridae* family. It primarily affects the central nervous system, leading to symptoms such as neurological disturbances, paralysis, and eventual death.

Diagnosing rabies involves several techniques. The Fluorescent Antibody Test (FAT) is a common method, which detects viral antigens in tissue samples. Negri bodies, characteristic inclusions found in the hippocampus, can be identified using Seller's stain or modified Mann's stain. Cell culture isolation techniques, such as using BHK-21, HEK-293, or neuronal cell lines like Neuro-2a, can also confirm the presence of the virus. The Habel's mouse inoculation test involves injecting suspect material intracerebrally into mice to observe for rabies symptoms. The Rapid Rabies Enzyme Immuno Diagnostic (RREID) technique is another rapid test option. Other methods include ELISA, RFFIT (Rapid Fluorescent Focus Inhibition Test), and RT-PCR (Reverse Transcription Polymerase Chain Reaction), including real-time RT-PCR, which can detect viral RNA. These diverse diagnostic approaches help ensure accurate identification of rabies infections.

There is no treatment after the camel becomes rabid. Yet to prevent the spread of virus the wound is scraped and bled, followed by washing with soap and water and then strong dressing with antiseptics along with immunoglobulin therapy. To prevent the infection, the infected and suspected animals should be separated and observed. Vaccines that are applicable in cattle and sheep can also be utilized for camel.

Middle East Respiratory Syndrome (MERS-CoV)

Middle East respiratory syndrome (MERS) is an illness affecting both humans and dromedary camels, caused by a specific type of coronavirus known as Middle East respiratory syndrome coronavirus (MERS-CoV). In camels, MERS-CoV infections typically result in minimal to no apparent illness, though occasionally mild respiratory symptoms such as nasal discharge, watery eyes, and slight fever may occur, especially in younger camels.

For diagnosis of the disease, serum samples can undergo screening to detect MERS-CoV-specific antibodies through methods like the MERS-CoV enzyme-linked immunosorbent assay, MERS-CoV neutralization assay, or MERS-CoV pseudo-particle neutralization assay. Further, a positive RT-PCR outcome can confirm the existence of viral genetic material.

Currently, there's no vaccine or specific treatment available for MERS-CoV, though there are ongoing developments in creating vaccines and treatments tailored to it. Treatment primarily involves providing support based on the patient's clinical condition. As a general precautionary measure, individuals visiting places like farms, markets, or barns where dromedary camels and other animals are present should practice basic hygiene, such as regular handwashing before and after interacting with animals, and should avoid contact with sick animals. Consuming raw or undercooked animal products, including milk and meat, poses a significant risk of infection leading to illness in humans. However, properly processed animal products, through cooking or pasteurization, are safe for consumption. It's crucial to handle these products carefully to prevent cross-contamination with raw foods. Camel meat and camel milk, after undergoing pasteurization, cooking, or other heat treatments, remain nutritious and can be safely consumed.

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CHAPTER 5

Diagnosis and Management of Important Parasitic Diseases of Camels

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Accurate diagnosis and management of parasitic infections in camels are crucial for the well-being of these species and the ecosystems they inhabit.Parasitic infections in camels haveasignificant negative impact on their health as well as the ecosystems in which they reside.Parasitescause enteric diseases leading to weight loss and decreased reproductive success. Helminth infections, including flukes and roundworms, result in tissue damageand impaired foraging capabilities. Ectoparasites like lice, ticks and mites cause blood loss and skin irritations, compromising the overall health of camels. Accurate diagnosis is important in effectively managing and controlling parasitic diseases in camel populations. Diagnostic techniques such as faecal examination, serology, and molecular assays facilitate the identification of the parasite species, assess infection intensity and treatment efficacy. Targeted interventions can also effectively control camel parasites, providing essential data for understanding their epidemiology and ecology.

1. Introduction

Camels, often called the "ships of the desert," hold significant socio-economic value in many arid and semi-arid regions worldwide. They provide essential resources such as milk, meat, and wool and serve as vital means of transportation in these challenging environments. Despite their remarkable resilience and adaptability, camels are vulnerable to a variety of parasitic diseases that can adversely affect their health, productivity, and overall well-being.

Parasitic infections in camels are caused by diverse parasites, including protozoa, helminths (worms), and ectoparasites (external parasites like ticks and mites). These infections can lead to a range of clinical outcomes, from mild discomfort and reduced productivity to severe, life-threatening diseases. The economic impact of these parasitic diseases is considerable, affecting not only individual camel owners and communities but also the agricultural economies.

Diagnosing and managing parasitic diseases in camels is particularly challenging due to the extensive and often remote areas where camels are raised, limiting access to veterinary services and diagnostic facilities. The diverse range of parasitic species and their complex life cycles require a thorough and informed approach to identification and treatment. The integration of

traditional knowledge from camel herders with modern veterinary practices is crucial for effective disease management.

2. Diagnosis of Parasites in Camels

2.1 Faecal Examination

Examining excretory-secretory products, such as faecal, cloacal, nasal, and lachrymal discharges, is crucial in identifying the nature of parasitic infections. Such examinations are essential for clinical diagnosis.Most helminths and coccidia reside in the intestinal tract, and clinical diagnosis of gut-dwelling helminths and coccidia is mainly dependent on the identification of ova/oocyst in faecal samples.

2.1.1 Direct Smear Method

This is utilised to identify relatively heavy infections and detect parasite stages (Eggs or larvae of helminths, oocysts of coccidia) or protozoan trophozoites which are easily distorted by floatation solutions by examination of eggs in emulsified faeces. A small quantity of faeces is placed on a clean glass microscopic slide which is mixed with a drop of saline. A dropof lugols iodine will enhance the internal structures of protozoan cysts but will also kill the trophozoites present.This method though easy, is not sensitive and reliable and does not produce quantitative results.

2.1.2 Flotation Methods

Separating the eggs from faecal debris by floating them on a variety of solutions. When faeces are emulsified in liquids of high specific gravity and either centrifuged or allowed to stand in a fluid floatation medium since faeces are less dense than the fluid floatation medium,Therefore, it will remain buoyant on the surface of the waterto the top of the container, the worm eggs and many protozoan cysts float to the top while the heavy coarse debris settles at the bottom. The top film can then be collected and examined for microscopic evaluation. Nematode and cestode eggs float in a liquid with a specific gravity of between 1.10- 1.20. Trematode eggs which are much heavier require a specific gravity of 1.30-1.35. One disadvantage of this test is that as the osmolarity of the floatation solution increases, there is a higher chance of damaging the eggs. This is becausehigher specific gravity of the solution causes more debris to float, which increases the risk of harming the eggs.

2.1.3 Sedimentation Method

This procedure is used for the isolation of trematode/cestode/nematode eggs which are more likely to sink at the bottom of the floatation solution. Mostly, eggs that are dense and require high specific gravity solutions are collected through this method. In the basic sedimentation process, faeces are mixed with tap water, allowed to settle briefly, and then the liquid above the settled material is removed. This procedure facilitates the elimination of fine particles.21.1.4 Quantitative Methods

They are used to determine the extent of infection in terms of egg per gram (EPG) of faecal material and offer a sensible approximation of the number of adult worm present which is utilised for epidemiological surveys. The egg count before treatment will ascertain whether treatment is required and the counts after treatment evaluate its effectiveness.

2.2 Identification of parasites in the blood

Identifying blood parasites in camels is crucial to maintain their health. These parasites, including *Trypanosoma .evansi, Babesia*, and*Anaplasma* have a severe impact on camel populations. Monitoring and identifying blood parasites can help in diagnosis and to know the extent of infections.

Blood microscopic analysis is a common practice to determine the presence of haemoprotozoansin camel erythrocytes or white blood cells. The prevalence of haemoparasites is mainly studied by examining Giemsa-stained blood films, although Wright's stain can also be used. The most effective time to examine blood smears is during the acute phase of infection. Immunological studies are preferred when the infection becomes chronic.

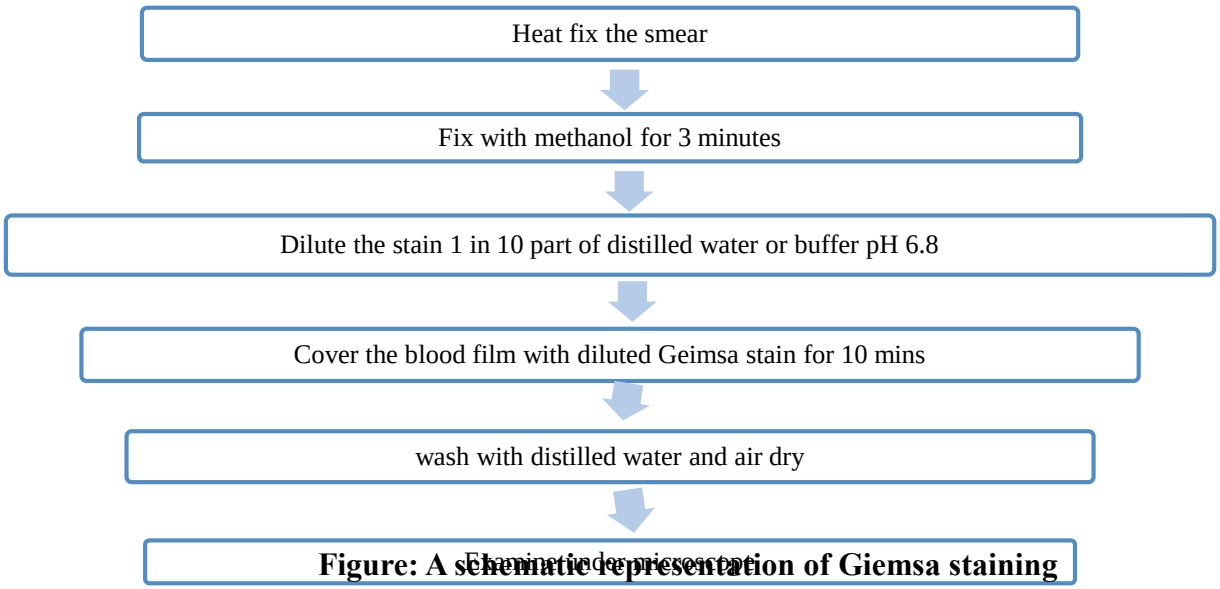

Figure: A schematic representation of Giemsa staining

2.3 Diagnosing skin infestation

Ectoparasites include ticks, mites, fleas, mosquitoes, blowflies, and stableflies that live on the skin or feathers. Microscopic examination is necessary for species identification. Procuring specimens requires locating the arthropods on the host and collecting them into alcohol for preservation and identification Typically these are spread by cameltocamelcontact. The head is examined first and followed by the neck, body sides, back, ventral part, abdomen, inguinal region and legs. Ectoparasites like lice, fleas, and ticks are collected from the camels which are visible in the hairs or skin horizontally against their anatomical direction of alignment. Mites are collected by scraping the skin with a scalpel blade. Representative ectoparasites found in the body of camels are collected in vials containing 70% alcohol, the wet film prepared from the skin scrap to which 10% potassium hydroxide was added to digest debris and examined under light or stereomicroscope, further species are identified using entomological keys.

2.4 Immunodiagnostic Tests

Traditional parasitological diagnostic methods, such as microscopy and serology, exhibit limitations in sensitivity and specificity. Immunodiagnostic techniques, including enzyme-linked immunosorbent assays (ELISAs), immunofluorescence assays (IFAs), and lateral flow assays, present several advantages. These methods primarily rely on the identification of specific antigens or antibodies associated with parasitic infections. Consequently, they provide enhanced sensitivity, specificity, and the capacity to distinguish between active and past infections. A notable advancement in immunodiagnostic involves the use of recombinant antigens, which offer improved specificity and diminish the risk of cross-reactivity with related parasites. Furthermore, multiplex assays permit the concurrent detection of multiple parasite species, enhancing diagnostic efficiency in cases of co-infections or within regions exhibiting multiple parasite endemicities.

2.5Molecular Diagnostic tests

Molecular diagnosis holds immense significance in diagnosing parasitic diseases latest technologies have revolutionized the field of parasitology and are providing valuable tools for a wide range of applications. Molecular diagnostic tests can be conducted using a diverse range of samples, including blood, urine, tissues, faeces, body exudates, and environmental samples which can be used to diagnose a wider range of parasites, including mixed infections and early infection. Parasitic molecular tests are becoming gradually available facilitating early diagnosis, and identification of parasites before the onset of symptoms, enabling well-timed

treatment, and preventing disease progression and transmission. They also play a vital role in monitoring the emergence of drug-resistant parasite strains, managing treatment decisions, and preventing further resistance development. In parasitic epidemiological studies, these tools contribute in tracking parasitic disease prevalence and distribution, introducing public health interventions and resource allocation. This knowledge with the help of molecular tools deepens our understanding of parasitic diseases and supports the development of new diagnostic methods and treatments.

3. Management Strategies for Controlling Parasitic Diseases in Camels

3.1 Pasture Management

- ✓ Adopting a nomadic system can be beneficial as it allows pastures to rest and reduces parasite burden.
- ✓ Avoid overcrowding pastures. Overgrazing increases the risk of parasite transmission.
- ✓ If possible, graze camels of different ages in separate pastures. Young camels are more susceptible to parasites compared to adults.

3.2 Housing Management

- ✓ Maintain clean housing for your camels. Regularly removing manure since dirty environments provide a breeding ground for parasites.
- ✓ Make sure to avoid the accumulation of stagnant water.
- ✓ Consistently use antiparasitic solutions like cypermethrin or deltamethrin in animal shelters to manage ticks. Additionally, seal any openings in animal sheds to stop ticks from hiding.

3.3 Mass Treatment

- ✓ Participate in mass treatment programs organized by veterinary departments or NGOs.
- ✓ Administer deworming medications regularly as advised by a qualified veterinarian.

3.4 Isolation

- ✓ Quarantine newly introduced camels for a period to eliminate potential parasite introduction in the flock.
- ✓ Separate sick camels from healthy ones

3.5 Nutrition

- ✓ A balanced and nutritious diet plays a vital role in boosting a camel's immune system, making it better equipped to fight off parasitic infections
- ✓ The foundation of a camel's diet should be high-quality forage like grasses, legumes, and shrubs.
- ✓ During periods of low-quality forage or high workloads, camels may benefit from concentrated feeds. These can provide additional energy, protein, and essential vitamins and minerals, grains like barley/gram/moth (in moderation), and oilseeds like groundnut or sunflower seeds (limited quantities)
- ✓ Ensure camels have access to mineral licks or supplements formulated specifically for camels. These provide essential minerals like copper, selenium, and zinc, which are crucial for immune function and overall health.
- ✓ Salt plays a crucial role in ensuring camels maintain the right balance of electrolytes and stay hydrated. Offer salt blocks or include salt in their feed blends to avoid pica in camels.

4. Conclusion

The diagnosis and management of parasitic diseases in camels are crucial components of maintaining the health and productivity of these vital animals. As camels play an essential role in the livelihoods of many communities in arid and semi-arid regions, focusing on these challenges by parasitic infections is of primary importance.Effective diagnostic techniques, ranging from traditional methods to advanced molecular toolshighlighting the need for accurate and timely identification of infections. The integration of modern veterinary practices with traditional knowledge from camel herders is essential for the successful management of these diseases. By implementing preventive measures, therapeutic interventions, and integrated parasite management programs, the impact of parasitic infections on camel health can be significantly reduced.

CHAPTER 6

Haematology and Serum Biochemistry Profile for Disease Diagnosis and Monitoring

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A. Clinical Hematology:

In veterinary science, the analysis of hematology and serum biochemistry profiles plays a crucial role indiagnosing and monitoring a wide range of diseases across various animal species. These diagnostic tools provide vital insights into the health status of animals by evaluating their blood components andbiochemical markers. Hematology focuses on the study of blood cells and their characteristics, including red blood cells, white blood cells, and platelets. Abnormalities in these cells can indicate conditions such as anemia, infections, or hematological malignancies. For instance, a low red blood cell count may suggest anemia, while an elevated white blood cell count could point to an ongoing infection or inflammatory process.

In veterinary medicine, precise blood collection and preparation are foundational for accurate hematological analysis. The quality of the blood sample can significantly impact the diagnostic results, influencing the assessment of an animal's health. This essay delves into the essential aspects of blood collection and preparation, highlighting the critical factors such as anticoagulant use, tube size, and the evaluation of various hematological parameters.

1. Blood Collection and Anticoagulant Use

For reliable hematological results, blood must be collected into tubes containing EDTA (ethylenediaminetetraacetic acid), a potent anticoagulant. EDTA works by binding calcium ions in the blood, which are crucial for the coagulation process. By preventing clotting, EDTA ensures that the blood sample remains in a liquid state, allowing for accurate analysis of blood cells. It is imperative to mix the blood thoroughly with the EDTA anticoagulant immediately after collection. Inadequate mixing can result in partial clotting, which can alter the concentration and morphology of blood cells, leading to erroneous results. Proper mixing ensures that the anticoagulant is evenly distributed throughout the sample, maintaining the integrity of the blood cells and preventing clot formation.

Note: Serum separated from coagulated blood is used for enzyme analysis and therefore in this case, anticoagulant must not be added to the collected blood. Rather blood should be allowed to coagulate in the collection tube itself.

1.1. Tube Size and Selection

The choice of blood collection tube size is another critical factor. Larger tubes, typically holding 2.5 mL of blood, are generally preferred over smaller 1 mL pediatric tubes. Larger tubes are less prone to clotting due to a greater volume of anticoagulant relative to the blood sample, which ensures more effective prevention of coagulation. Additionally, larger tubes provide a more representative sample, which can be crucial for accurate hematological analysis. Uniformity in tube size is also important. Consistent use of larger tubes helps maintain standardization in sample handling and analysis, reducing variability and potential errors in results. By minimizing the risk of clot formation and ensuring sufficient sample volume, larger tubes contribute to the reliability of hematological assessments.

1.2. Evaluation of Blood Cell Morphology

Size and Uniformity of Size of blood cells: The size of blood cells is a fundamental aspect of their morphology. Variations in size, such as microcytes (smaller-than-normal red blood cells) or macrocytes (larger-than-normal red blood cells), can indicate specific hematological conditions. For instance, microcytes are commonly associated with iron deficiency anemia, while macrocytes may suggest vitamin B12 or folate deficiencies.

Cell Shape: The shape of blood cells provides crucial diagnostic information. Abnormal shapes, such as schistocytes (fragmented red blood cells) or spherocytes (spherical red blood cells), can be indicative of underlying pathological conditions. Schistocytes are often associated with hemolyticanemia ordisseminated intravascular coagulation (DIC), whereas spherocytes may be seen in autoimmune hemolyticanemia.

Cell Color and Uniformity of Color: The color of red blood cells, as observed in a stained blood smear, reflects their hemoglobin content. Normal red blood cells have a central pallor and a pinkish color. Hypochromasia, characterized by a reduced color intensity, often indicates a decrease in hemoglobin content, commonly seen in iron deficiency anemia. Conversely, polychromasia, the presence of red blood cells with varying colors, usually suggests regenerative anemia.

Presence of Hypochromasia, Polychromasia, and Nucleated RBCs: Hypochromasia and polychromasia are significant indicators of anemia and regenerative responses, respectively. Additionally, the presence of nucleated red blood cells (nRBCs) in the blood, which are typically found in the bone marrow, can indicate a response to severe anemia or bone marrow disorders. These cells are not normally seen in peripheral blood and their presence can signal an underlying pathology.

2. Red Blood Cells:

Packed Cell Volume (PCV): Packed Cell Volume (PCV), also known as hematocrit, measures the proportion of the blood volume occupied by red blood cells (RBCs). This is a critical parameter for evaluating the degree of anemia or polycythemia in animals. The PCV is typically expressed as a percentage, representing the volume of RBCs relative to the total volume of blood.

Increased PCV: Elevated PCV indicates polycythemia, which can result from conditions such as Chronic hypoxia, polycythemia vera, or dehydration.

Decreased PCV: Low PCV signifies anemia, which may be due to blood loss, hemolysis, or impaired RBC production.

Hemoglobin (Hgb) Concentration: Hemoglobin (Hgb) concentration refers to the amount of hemoglobin present in a unit volume of whole blood. Hemoglobin is the oxygen-carrying protein within red blood cells and is crucial for assessing the blood's oxygen-carrying capacity.

Increased Hgb: Elevated hemoglobin levels can be associated with polycythemia or conditions that lead to increased RBC production.

Decreased Hgb: Reduced hemoglobin levels are indicative of anemia and can arise from various causes including nutritional deficiencies, chronic diseases, or acute blood loss.

Red Blood Cell (RBC) Count: The RBC count measures the number of red blood cells per unit volume of whole blood. This count provides information about the blood's ability to transport oxygen and is integral to diagnosing and managing anemia and other hematological conditions.

Increased RBC Count: A high RBC count can indicate polycythaemia or dehydration.

Decreased RBC Count: A low RBC count is often a sign of anemia or blood loss and may require further investigation to determine the underlying cause.

MCV (Mean Cell Volume): MCV measures the average volume of individual red blood cells. It is expressed in femtoliters (fL) and helps classify anemia based on the size of RBCs. MCV values vary widely between species. For instance, in mammals, MCV ranges from approximately 15 fL in goats to 90 fL in humans. Avian and reptilian species can have even larger MCV values, up to 300 fL.

Increased MCV: High MCV (macrocytic RBCs) may indicate conditions such as vitamin B12 or folate deficiency, or regenerative anemia.

Decreased MCV: Low MCV (microcytic RBCs) is often seen in iron deficiency anemia or certain chronic diseases.

MCHC (Mean Cell Hemoglobin Concentration): MCHC represents the average concentration of hemoglobin in a given volume of red blood cells. It is expressed in grams per deciliter (g/dL) and provides insight into the hemoglobin content relative to the cell volume.

Normal Range: MCHC values tend to be relatively consistent across species.

Increased MCHC: A high MCHC can be an artifact of hemolysis or lipemia, which falsely elevates hemoglobin readings.

Decreased MCHC: Low MCHC typically indicates hypochromic anemia, where there is a reduced hemoglobin concentration in the red blood cells.

Artifacts Affecting Hematological Parameters

1. Old Samples: As blood samples age, RBCs may swell, leading to falsely elevated PCV and MCV, and decreased MCHC. This swelling occurs due to the breakdown of cellular integrity over time.

2. Lipemia: The presence of lipids in the blood can interfere with accurate measurement of hemoglobin, leading to falsely high Hgb readings and subsequently a higher MCHC.

3. Hemolysis: When red blood cells break down in the sample, PCV may decrease while Hgb levels remain unchanged, resulting in a falsely high MCHC. Hemolysis can occur due to improper handling or storage of the blood sample.

4. Underfilling of Tubes: Inadequate blood volume in the collection tube can cause RBCs to shrink, leading to decreased PCV and MCV, while MCHC may appear elevated.

5. Autoagglutination: The clumping of red blood cells can result in a falsely low RBC count, which in turn can cause a falsely high MCV.

3. White Blood Cells

White blood cells (WBCs) play a crucial role in the immune response, and their varied functions are vital for maintaining the body's defense mechanisms. In veterinary medicine, evaluating the different types of white blood cells—neutrophils, eosinophils, basophils, monocytes, and lymphocytes—provides significant insights into an animal's health. This essay explores the functions of these cells, their variations, and their clinical implications in the context of various health conditions.

3.1. Neutrophils: Neutrophils are the most abundant type of white blood cells in many mammals and serve as primary phagocytes. Their main function is to ingest and destroy pathogens, particularly bacteria, through a process known as phagocytosis. Neutrophils are essential in the early stages of inflammation and help to contain and eliminate infections.

Neutrophilia: An increase in neutrophil count, or neutrophilia, can occur due to various conditions

Inflammation: bacterial infection, acute stress, steroid effects (corticosteroids can lead to neutrophilia by reducing the migration of neutrophils from the blood into tissues, thus increasing their concentration in the bloodstream) and neoplasia.

Neutropenia: Conversely, a decrease in neutrophil count, or neutropenia, can result from several factors-viral infections, toxin exposure, certain drugs like carbimazole and methimazole, autoimmune destruction, bone marrow neoplasia and aplasia.

3.2. Eosinophils: Eosinophils are involved in modulating allergic responses and combating parasitic infections. They help inactivate histamine and inhibit edema formation, thereby reducing inflammation and tissue damage.

Eosinophilia: An increased eosinophil count, or eosinophilia, is associated with allergic and hypersensitivity reactions, parasitic diseases, tissue injury, mast cell tumors, estrus and pregnancy.

Certain breeds, such as German Shepherds and Rottweilers, may naturally have higher eosinophil counts.

Eosinopenia: A reduction in eosinophil count, or eosinopenia, is often due to the action of glucocorticoids. Glucocorticoids can suppress eosinophil production or induce their migration out of the bloodstream.

3.3. Basophils: Basophils are involved in initiating the inflammatory response. They release histamine and other chemicals that contribute to inflammation and allergic reactions.

Basophilia: An increase in basophil count, or basophilia, can occur alongside eosinophilia in some hypersensitivity reactions, reflecting a combined allergic response.

Monocytes: Monocytes are large white blood cells that differentiate into macrophages once they enter tissues. Their primary role is phagocytosis, where they engulf and destroy pathogens, dead cells, and debris.

3.4. Monocytes: An elevated monocyte count, or monocytosis, is often seen in chronic Inflammation, neoplasia, steroid response.

3.5. Lymphocytes: Lymphocytes are crucial for the adaptive immune response, including antibody production (B cells) and cell-mediated immunity (T cells). They are essential for recognizing and responding to specific pathogens.

Lymphocytosis: An increased lymphocyte count, or lymphocytosis, may be physiologic or

pathologic. In some animals, particularly cats, lymphocytosis can be a normal response to stress or excitement. Significant increases are often indicative of leukemia or other hematologic malignancies.

Lymphopenia: A decreased lymphocyte count, or lymphopenia, can be associated with

corticosteroids, viral infections.

4. Platelets:

Platelets, or thrombocytes, are crucial components of the blood that play a fundamental role in the clotting process. Their primary function is to facilitate hemostasis, the process that prevents and stops bleeding by forming blood clots. This essay delves into the role of platelets in clotting, explores conditions associated with abnormal platelet counts—thrombocytosis and thrombocytopenia—and examines the clinical implications of these abnormalities.

Thrombocytosis: Thrombocytosis refers to an elevated platelet count in the blood. While a high platelet count can be a normal physiological response in some cases, it can also indicate an

underlying pathology such as after injury, after splenectomy, after vincristine treatment, megakaryocytic leukemia

Thrombocytopenia: Thrombocytopenia is characterized by a low platelet count and can lead to increased bleeding tendencies. Various conditions can cause thrombocytopenia, and understanding these causes is crucial for proper diagnosis and treatment. Autoimmune Reactions such as immune-mediated thrombocytopenia (IMT), occur when the immune system mistakenly targets and destroys platelets. This destruction typically occurs in the spleen or bone marrow.

Thrombotic Thrombocytopenic Purpura (TTP) is a rare but severe condition characterized by the formation of small blood clots throughout the small blood vessels, leading to a low platelet count. The condition involves a deficiency of a von Willebrand factor-cleaving protease, resulting in excessive platelet aggregation and consumption. Conditions that suppress or inhibit bone marrow function, such as aplastic anemia or exposure to certain toxins or drugs, can lead to reduced production of platelets. This reduction results in thrombocytopenia and increased risk of bleeding. Malignancies affecting the bone marrow, such as leukemia or lymphoma, can interfere with platelet production and lead to thrombocytopenia. Equine Infectious Anemia (EIA) can cause thrombocytopenia as part of its clinical manifestation in horses. EIA leads to decreased platelet production and increased destruction due to the virus's impact on the bone marrow and spleen.

Clinical Manifestations:
Petechiation: Small, pinpoint red or purple spots on the skin or mucous membranes due to bleeding under the skin. This condition is a common clinical sign of thrombocytopenia.
Ecchymosis: Larger areas of bleeding or bruising that occur due to the leakage of blood from damaged blood vessels. Ecchymosis indicates a more severe level of bleeding or platelet dysfunction.

B. Clinical Biochemistry

Clinical biochemistry, examines the chemical components of blood serum and other body fluids (eg, urine, ascitic fluids, CSF). This analysis measures various substances such as electrolytes, proteins, enzymes, and metabolites. Abnormal levels of these components can reflect underlying systemic issues, including liver disease, kidney dysfunction, endocrine disorders,

and metabolic imbalances. For example, elevated liver enzymes might indicate hepatocellular damage, while abnormal glucose levels could signal diabetes mellitus.

Together, hematology and serum biochemistry profiles offer a comprehensive view of an animal's health, enabling veterinarians to diagnose diseases more accurately and monitor the effectiveness of treatments. By integrating these diagnostic results with clinical observations and other diagnostic modalities, veterinarians can formulate more precise treatment plans and improve patient outcomes.

1. Liver function test

Albumin:

A protein synthesized by the liver and is crucial for maintaining oncotic pressure and transporting various substances in the blood. Decreased levels of albumin can indicate liver disease, as the liver is responsible for producing this protein. Low albumin can also result from conditions such as nephrotic syndrome, malnutrition, or chronic inflammation. However, it is a non-specific marker but can be valuable in assessing overall liver function and protein synthesis capability.

Albumin- globulin (A/G) ratio: This ratio generally falls within a certain range depending on the species. A typical normal A/G ratio is approximately 1.0-1.5 in dogs and cats, but this can vary in different large animals such as horses and cattle.

Decreased A/G Ratio:

Hypoalbuminemia: Reduced albumin levels due to liver dysfunction, protein-losing nephropathy or enteropathy, or malnutrition.

Hyperglobulinemia: Increased globulin levels due to chronic inflammation,

immune system activation, or certain infections (e.g., chronic bacterial infections or viral diseases). Conditions include chronic liver disease, protein-losing enteropathy (e.g., due to gastrointestinal disease), or neoplastic conditions (e.g., multiple myeloma).

Increased A/G Ratio:

Hyperalbuminemia: Increased albumin levels, which are rare but can be seen with dehydration or excessive albumin production.

Hypoglobulinemia: Decreased globulin levels due to immunodeficiency, genetic disorders, or severe liver damage affecting globulin synthesis. Conditions include some types of liver

disease where globulin synthesis is impaired or certain types of inherited disorders affecting globulin production.

Alanine Aminotransferase (ALT): ALT is more specific to the liver in dogs and cats, making it a useful marker for liver injury. However, elevated levels can also be seen in other conditions such as muscle damage.

Alkaline phosphatase (ALP): Increases due to increased bone deposition, liver damage, hyperthyroidism, biliary tract disease, intestinal damage, hyperadrenocorticism, corticosteroid administration, barbiturate administration, and generalized tissue damage (including neoplasia).

Glutamate Dehydrogenase (GDH): GDH is considered a reliable marker of hepatocellular injury in large animals like horses and cattle.

Sorbitol Dehydrogenase (SDH): SDH is highly specific to liver tissue in large animals and is often used to monitor liver health and diagnose liver conditions.

Gamma-Glutamyl Transferase (GGT): Increases in longer-term liver damage (Horses and ruminants). Increased GGT levels are indicative of biliary tract disease or cholestasis. GGT is more specific to liver and biliary tract disorders compared to ALP.

Aspartate transaminase (AST): Increased AST levels can indicate liver damage, but since AST is also present in other tissues, elevated levels may also reflect muscle or heart injury. AST is less liver-specific compared to ALT, so it is often used in conjunction with other tests for a more comprehensive evaluation.

Bilirubin level increases due tofasting (benign effect in horses and squirrel monkeys, may be caused byhepatic lipidosis in cats), hemolytic disease (usually mild increase),liver dysfunction and biliary obstruction(intra- or extrahepatic) Theoretically, hemolysis is characterized by an increase in unconjugated (indirect)bilirubin, whereas hepatic and post-hepatic disorders are characterized by an increase in conjugated (direct)bilirubin; however, in practice this differentiation is unsatisfactory.

2. Urinalysis

A thorough urinalysis typically includes several key components:

Physical Examination: This involves assessing the urine’s appearance, color, clarity, and specific gravity.

Color: Normal urine color ranges from pale yellow to amber. Abnormal colors can indicate various conditions:

Red or Brown: May suggest hematuria (blood in urine), hemoglobinuria (hemoglobin in urine), or myoglobinuria (myoglobin from muscle damage).
Cloudy or Turbid: Often due to the presence of cells, crystals, or bacteria.
Clarity: Normal urine is clear. Cloudy or turbid urine can indicate infection, inflammation, or the presence of abnormal substances.
Specific Gravity (SG): Measures urine concentration compared to water. Normal SG varies by species and hydration status:
High SG: Can indicate dehydration or a condition where the kidneys are concentrating urine more than normal.
Low SG: Can suggest conditions like diabetes insipidus, kidney disease, or overhydration.
Chemical Analysis: This tests for various substances and their concentrations in the urine, including glucose, protein, bilirubin, ketones, blood, and pH.
Microscopic Examination: This involves examining urine sediment under a microscope to identify cells, crystals, bacteria, and other components.

3. Pancreatic tests:

α-Amylase level increases in acute pancreatitis but in dogs is also increased in chronic renal dysfunction. It is therefore of limited use in the diagnosis of pancreatitis. Not a useful indicator of pancreatitis in cats. Lipase level increases in acute pancreatitis in dogs (longer half-life than amylase) and also occasionally in chronic renal dysfunction. Lipase (routine assay) is not a useful indicator of pancreatitis in cats. Pancreatic lipase immunoreactivity is now the test of choice for diagnosis of pancreatitis in dogsand cats.Immunoreactive trypsin (trypsin-like immunoreactivity) level decreases in exocrine pancreatic insufficiency in dogs. It will also increase in pancreatitis.

4. Additional tests:

Polydipsia panel: calcium, glucose, and cholesterol.
Calcium allows recognition of hyperparathyroidism and other causes of hypercalcemia (whichcauses polydipsia and renal insufficiency)Glucose may indicate diabetes mellitus
Cholesterol also adds to the appreciation of the “Cushing pattern.”Collapsing animal: calcium and glucose may be added to screen for hypocalcemia or hypoglycemia. C-reactive protein (CRP): marker for inflammation
Cardiac troponin: marker for cardiac muscle damage.

Bile acid: Its level increase when hepatic anion transport is impaired, usually during liver dysfunction (bile acids are more sensitive than bilirubin to hepatic impairment) and in the presence of a portosystemic shunt (congenital or acquired). The latter condition is characterized by a marked increase in bile acid concentration after feeding, from a fasting concentration that may be normal. It also increases in bile duct obstruction; very little increase is seen in feline infectious peritonitis or mild cases of hepatic lipidosis. Very high levels can sometimes be seen without structural histologic changes. The reason for this is not known.

5. Sample Handling:

Most biochemistry tests can be performed on either serum or heparinized plasma.Glucose measurement requires fluoride/oxalate plasma.Samples for biochemical analysis should be separated as soon as possible after collection tominimize artifacts caused by hemolysis and leakage of intracellular fluid components(eg,potassium) out of the cells.Samples in anticoagulant may be centrifuged immediately, but clotted samples need at least 30 minto allow the clot to form

CHAPTER 7

Recent Biotechnological Tools Available for Disease Diagnosis

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Introduction

Biotechnological applications have been making critical commitments in the advancement of novel powerful diagnostic assays for the efficient diagnosis and control of animal infectious diseases. Various techniques such as neutralization, Enzyme-Linked Immunosorbent Assay (ELISA), Agar Gel Immunodiffusion, Complement Fixation Test (CFT), etc. have been used since time for disease diagnosis (Netto et. al., 2003). In the past few years, the diagnosticians have begun to incorporate new molecular techniques such as the Polymerase Chain Reaction (PCR) (Singh et. al., 2014) and Western blot (Kim, 2017) and improved older techniques through the use of recombinant antigens, monoclonal antibodies and synthetic peptides, which has made disease diagnosis fast, more precise and accurate. The purpose of this chapter is to provide general information and updates on the most critical biotechnology-based methods currently used in our diagnostic laboratories.

1. Nucleic acids baseddetection techniques

The use of nucleic acid-based diagnostics in the field of medicine has expanded greatly in recent years. These methods are amongst the best in detecting pathogens with high sensitivity and specificity in the clinical samples (Gingeras, 1990). There are numerous methods of nucleic acid extraction, like manual extraction, centrifugal spin column-based elution, magnetic bead extraction, etc. Nucleic acid isolation and purification consists of three main steps: disruption of cells, removal of proteins and contaminants, and recovery of nucleic acid suitable for analysis (Ali et. al., 2017). Nucleic acid-based detections are used mainly through the hybridization methods and amplification methods, which could be in-situ, in-vitro, and in-vivo (Barken et. al., 2007). One critical issue, however, is that the quality of the initial specimen, i.e. the extracted DNA/RNA is vital for successful use of any of these technologies (Ali et. al., 2017). Several automated extraction systems for robotic workstations have recently been developed which can minimize the risk of contamination, enable processing of large numbers

of samples and establishment of high-throughput, robust diagnostic assays, shortening the processing time required per sample (Verheyen et. al., 2012).

Hybridization based methods

The most common and widely used hybridization-based method is in-situ hybridization, that uses a probe, i.e. a labeled complementary nucleic acid strand (DNA/RNA) to localize a specific DNA/RNA sequence in cells using fluorescent (FISH) or chromogenic (CISH) molecules for visualization. For example, many CISH-based assays have been used conventionally for the rapid characterization of Mycobacterium species, whereas recently FISH-based assay for differential diagnosis of *Mycobacterium tuberculosis* have also been developed (Frickmann et. al., 2017).

Polymerase-Chain Reaction (PCR)

The molecular technique with the most extensive variety and application in diagnostics is Polymerase-Chain Reaction (PCR). PCR platforms are fast and highly sensitive and specific in detecting a wide range of pathogens (Van Brunt, 1990). Diagnostic PCR is performed on nucleic acids extracted from clinical samples. PCR achieves in-vitro amplification by exploiting natural DNA replication mechanisms, using a succession of cyclic incubation steps at different temperatures(Sellon, 2003). The key to the amplification of target DNA sequences by the PCR is the selection of paired primers that, when extended, will create additional reciprocal primer-annealing sites for primer extension in subsequent cycles. Modifications in the PCR technique have led to emergence of other variants like -

1. Real-time PCR - where quantification of DNA sequence is possible without any further step of running the amplified product on agarose gel;
2. Multiplex PCR - where multiple sequences can be detected in a single reaction mixture;
3. Reverse transcriptase PCR (RT-PCR) - where RNA is transcribed to cDNA and this cDNA is used in the amplification as a template (Rahman et. al., 2013).

The real-time PCR can utilize different fluorescence chemistries such as SYBR green, TaqMan or molecular beacon probes. RT-PCR technique is used for detection of RNA viruses/RNA. The real-time RT-PCR technique is deployed in detection and quantification of Japanese encephalitis virus in swine (Pantawane et. al., 2019).

The amplified products can be detected through -

i. Methods that define their characteristic size, such as gel electrophoresis (Teanpaisan and Dahlen, 2006).;
ii. DNA probes (Vary et. al., 1990);
iii. High resolution melting (Yue et. al., 2014);
iv. Fluorescence-based detection systems (real-time technology) (Pantawane et. al., 2019);
v. Nucleotide sequencing technologies (Ota et. al., 2007).

Isothermal amplification methods

In isothermal amplification, a number of target nucleic acid copies increase at a constant temperature in just one cycle without the need of a thermal cycler. Various techniques have been developed using isothermal amplification methods, such as-

1. Nucleic acid sequence-based amplification (NASBA), a two-step process to produce multiple copies of single stranded RNA by first annealing specially designed primers to the ssRNA and then utilizing an enzyme cocktail to amplify it
2. Transcription-mediated amplification (TMA), an isothermal amplification technique of rRNA by reverse transcription and subsequent generation of numerous transcripts by RNA polymerase
3. Signal-mediated amplification of RNA technology (SMART), used for detecting both DNA and RNA targets by a three-way junction mechanism
4. Loop mediated isothermal amplification (LAMP), most widely used isothermal amplification method which uses 4-6 primers recognizing 6-8 distinct regions of target DNA for a highly specific amplification reaction
5. Strand displacement amplification (SDA)
6. Rolling circle amplification (RCA)
7. Isothermal multiple displacement amplification (IMDA)
8. Helicase-dependent amplification (HDA), etc. (Gill & Ghaemi, 2008; Glokler et. al., 2021)

A multiplex real-time nucleic acid sequence-based amplification (qNASBA) system for detection of rotavirus A and astrovirus have recently been developed (Mo et. al., 2015).

2. Immunoassays

All immunoassays exploit the innate ability of antibodies to bind to an antigen or epitope(s) within the antigen with high specificity and affinity. Immunoassays are designed to detect pathogen-specific antigen or antibody in test samples, as indicators of active or prior infection. Various serological diagnostics have been developed such as-

1. Enzyme-linked immuno-sorbent assay (ELISA), works on the basic principle of specific binding of antigen to antibody, using enzymes as probes, with each type of ELISA exploiting this principle in different way;
2. Radio-immunoassay (RIA), an in-vitro assay that works on the principle of competitive binding and measures the presence of an antigen with very high sensitivity;
3. Haemagglutination assays;
4. Haemagglutination inhibition assays;
5. Complement fixation test (CFT);
6. Immunofluorescence test (IFT);
7. Latex agglutination (LA);
8. Immunochromatography test (ICT), combines the principle of capillary flow and antigen-antibody complex formation;
9. Immunoblotting, which combines the high resolution of gel electrophoresis with the specificity of immuno-detection, offering a means of identifying immunodominant proteins recognised by antibodies from infected animals or antibodies directed against the target agent;
10. Chemiluminescent immunoassay (CLIA);
11. Counter-immunoelectrophoresis, etc. (Malik et. al., 2020)

Types of ELISA

1. **Indirect ELISA (I-ELISA)** is used for the detection of antibodies in a serum sample to an antigen. This test is highly sensitive for antibody detection. The target antigen is bound to the solid surface of the wells of an ELISA plate (solid phase) and anti-species antibodies conjugated with an enzyme (e.g. peroxidase) are used to detect binding of test antibodies onto the solid phase. This technique is applied most appropriately in determining the antibody titre (Yun et. al., 2015).
2. **Antigen-capture ELISA (Ag-ELISA)** is used to detect the presence of pathogen-specific antigens in a sample and are useful for diagnosis prior to or during clinical

disease. The Ag-ELISA commonly follows a 'sandwich assay' format. This technique is used to detect various food allergens, viruses like rinderpest virus, PPRV and bovine viral diarrhoea virus, as well as certain bacterial infections, like Listeria, Salmonella and E. coli (Libeau et. al., 1994; Mignon et. al., 1991).

3. **Competitive ELISA (C-ELISA)** is a variant of ELISA used to detect or quantify antibodies or antigen by means of a competition between antibodies that may be present in the test serum and the detecting antibody (which in this case binds directly to the antigen). This strategy is used when the antigen is small and has only one epitope or antibody binding site (Reddington et. al., 1991).
4. **Dot-ELISA**, an easy, rapid, and visually read form of ELISA which is suitable for field diagnosis of diseases. The technique has found its use in rapid detection of staphylococcal enterotoxin-A in food with high sensitivity and specificity as well as in diagnosis of many important poultry diseases (Singh et. al., 2017).

3. Novel methods of disease diagnosis

Microarrays

A microarray is a multiplex lab-on-a-chip test. It is a two-dimensional arrangement of specific biological probes for high throughput screenings (e.g. DNA, proteins, peptides, glycans) immobilized on solid substrates like glass slide, polymer-coated glass, plastics, nitrocellulose, etc (Barbulovic-Nad et. al., 2006). This technology has the potential to identify the presence of agents of interest at the serotype or subspecies level, or to differentiate agents that cause similar clinical signs, for example, vesicular lesions. Microarrays also prove to be useful in detecting causes of outbreaks, simultaneous detections of coinfections during the outbreaks and other more phenomenal changes, which are crucial factors for epidemiological studies (e.g. SARS). Microarrays also help in identification of single-nucleotide polymorphisms (SNPs) and mutations, classification of tumors, drug discovery, and identification of target genes of tumor suppressors, cancer biomarkers, genes associated with chemoresistance, etc (Butcher, 2004; Ojha &Kostrzynska, 2008).

Proteomics

Proteomics is the study of proteins, including their expression level, post translational modification and interaction with other proteins. The proteome is the total complement of proteins expressed within a cell, a tissue, or an organism. In addition to the use of proteomics

to identify and characterize the protein produced by pathogenic agents, proteomic technologies have great potential in disease diagnostic applications because they target the patterns of protein expression of the target analyte. The principle behind proteomic study is staining of the proteins and their separation on gel based on their molecular weight. The protein 'pattern' or fingerprint is then analyzed by performing image analysis. Proteome maps can be compared to find proteins that may be up- or down-regulated due to disease. Additionally, a protein of interest can be cut from the gel and fully characterized using methods such as mass spectrometry. Within the veterinary field, proteomic studies have been developed for a variety of applications for animal and zoonotic diseases. Proteomics has played a major role in identifying the sera proteins during times of SARS-CoV-2 outbreak (Haas et. al., 2021).

Biosensors

A new approach to the detection of either the agent or antibodies is the development of biosensors. They are portable, easy to handle, ultrasensitive, quick, and are quite specific too. Biosensor assays involve the use of a receptor (usually an antibody) for the target pathogen or a disease specific antibody and a transducer which converts a biological interaction into a measurable signal. They work on various principles viz intercepting the changes in the pH or ion concentrations, detect mass, enzymatic reaction, loss of functionality, change in the electrical potential, change in color, and temperature. The transducer works on technologies like electrochemistry, reflectometry, interferometry, resonance, fluorimetry, etc (Tarasov et. al., 2016). Many biosensors have been devised for the detection of infectious agents such as BHV-1 virus(Tarasov et. al., 2016), H5N1 virus(quartz crystal microbalance (QCM) based immunosensors) (Li et al., 2011), bovine viral diarrhea virus (a nanowire-based immuosensor) (Montrose et. al., 2015), FMD virus (Bhatta et. al., 2012), etc.

Next-generation sequencing (NGS)

The unlimited methods for detection of microbial antigens and the emergence of newer technologies for rapid and real-time diagnosis have made the detection of microbial disease easier. The basic principle of Next-generation sequencing (NGS), also sometimes known as High-throughput Sequencing (HTS) or Massive Parallel Sequencing (MPS) is that genomes are fragmented, and universal adapters and primers are used to generate sequences. Applications of NGS are considered as more resourceful. It is enabling study of whole genome sequencing, pathogen discovery (de novo sequencing), metagenomics, microbiome detection and transcriptome detection. Next-generation sequencing (NGS) is now being increasingly

applied in understanding the molecular epidemiology, transmission, and characterization of animal pathogens. Instead of gene-by-gene analysis, large deposits of genes available in the clinical sample can be detected in a single test (Belak et. al., 2009; Goodwin et. al., 2016). Thus, it is widely accepted as a diagnostic tool and speedily is being replaced with most other molecular diagnostic technologies and has brought revolution in the diagnosis of pathogens. NGS has made it possible to sequence the complete viral genomes of many viruses cost-effectively such as avian influenza virus, classical swine fever virus, Bluetongue viruses, etc.

Conclusion

Biotechnological novelties have led to the advent of new generation diagnostic techniques for fast as well as precise diagnosis of various diseases of humans and animals. Traditional diagnostic methods are laborious, time consuming, inaccurate, and unable to meet the needs of the emerging pathogen diagnostics. These new biotechnologies include the production of more specific antigens by the use of recombination, expression vectors and synthetic peptides. Coupled with the use of monoclonal antibodies, the sensitivity and specificity of several traditional types of diagnostic assays have been significantly improved. Various forms of PCR have become routine diagnostic tools in veterinary laboratories not only to make specific typing determinations, but also to rapidly screen large numbers of samples during disease outbreaks. Although the development of new technologies can often mean faster results and improved capability, consideration should always be paid to the actual value and the role of the confirmatory test in diagnosis and of the modes of reaction of appropriate Competent Authorities. In this context, the expertise present in laboratories remains as important as ever in explaining the significance and limitations of diagnostic results.

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CHAPTER 8

Drug Formulations and Their Administration to Camel

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The administration of drug formulations to camels (*Camelusdromedarius* and *Camelusbactrianus*) requires specialized knowledge due to their unique anatomical, physiological, and behavioral traits. This chapter explores various drug formulations tailored specifically for camels, including oral, injectable, topical, and intramammary options, focusing on appropriate dosage forms and routes of administration. It also addresses the challenges unique to camel-specific drug therapy and offers strategies for optimizing treatment outcomes.Given their vital role in arid regions, camels' distinct physiological adaptations necessitate specialized veterinary care. Their large body size, complex digestive system, and specific behavioral traits make selecting the correct formulation and administration route crucial. This chapter serves as a comprehensive guide for those involved in camel health management, focusing on the unique challenges and effective treatment strategies for camels.

Drug formulation & Dosage forms

Drug formulation involves combining various chemicals, primarily focused on the active ingredient, to create a finished pharmaceutical product. Dosage forms refer to the different presentations of these products, such as solids, semi-solids, or liquids. Camels, like other animals, receive medications in various formulations tailored to their specific needs, conditions, and preferred routes of administration. Understanding the appropriate methods for administering these drugs is essential for effective treatment and disease prevention in camels.

Oral dosages formulations

In veterinary practice, certain medications are designed for oral administration (through the mouth), requiring the animal to swallow them. The term 'oral medication,' often denoted as 'per os' or 'p.o.,' refers to this route of administration. These medications can be formulated in various forms:Liquid forms: solutions, suspensions, emulsions, elixirs, and syrups; Semi-solid forms: pastes; Solid forms: boluses, tablets, capsules, powders, granules, pellets, and medicated blocks.

Liquid Dosage Formulations

Liquid dosage formulations play a crucial role in the veterinary care of camels, providing effective and convenient methods for administering medications. These formulations are particularly beneficial due to the unique anatomical and physiological characteristics of camels, as well as their handling during treatment.

- **Solutions** are liquid formulations in which one or more active ingredients are completely dissolved in a solvent, creating a homogeneous mixture. In camels, solutions allow for rapid absorption and quick therapeutic action, making them ideal for acute conditions where immediate intervention is necessary. For instance, electrolytic solutions can be administered to address dehydration effectively.
- **Suspensions** contain larger, insoluble drug particles dispersed within a liquid medium, typically water. These formulations require thorough shaking before administration to ensure even distribution of the active ingredient, as the particles can settle over time. Suspensions are useful for medications that are poorly soluble, such as certain antibiotics or anti-bloat agents, allowing for effective treatment while accommodating the camel's unique digestive physiology.
- **Emulsions** consist of two immiscible liquid phases, one of which is dispersed as tiny droplets within the other. This formulation is beneficial for delivering oil-soluble drugs that are essential for treating conditions like mastitis or other inflammatory processes in camels. Emulsifying agents are often included to stabilize the mixture, ensuring a uniform distribution of active ingredients.
- **Syrups** are sweetened liquid formulations that combine a high concentration of sugar or sugar substitutes with a water-soluble medicine. These formulations are particularly useful for enhancing palatability, making it easier to administer medications to camels that may be reluctant to consume bitter-tasting drugs. Syrups can be used for various conditions, including respiratory issues or gastrointestinal disorders.
- **Drenches** are liquid formulations specifically designed for oral administration to large animals, such as camels. These preparations are typically delivered using a drenching gun, which allows for accurate dosing and easy administration.

Understanding the various liquid dosage formulations and their appropriate use is essential for veterinarians treating camels. The choice of formulation depends on factors such as the specific medical condition, the pharmacokinetic properties of the drug, and the ease of administration, all of which contribute to the overall effectiveness of the treatment regimen.

Semisolid Dosage Formulations

Semisolid oral dosage formulations play a vital role in the veterinary treatment of camels, providing an alternative to liquid and solid forms that can be more challenging to administer. These formulations are designed for ease of use and effectiveness, particularly in delivering medications to camels that may be uncooperative or have specific dietary requirements.

- **Pastes** are thick, viscous semi-solid formulations are typically administered orally, either directly into the mouth or mixed with food. A paste is composed of two main components: a semisolid base, which may be water or fat, in which the drug is dispersed in powdered form. Pastes should have a pleasant flavor or be neutral in taste, and they need to remain stable across a wide temperature range. These formulations are particularly popular for treating cats and horses, as they can be easily and safely given by pet owners.
- **Gels** are another type of semisolid formulation that can be used for oral administration. They are characterized by their jelly-like consistency, which allows for easy application and swallowing. Gels can be formulated with various active ingredients, including vitamins and minerals, making them suitable for nutritional supplementation or as carriers for medications that require a slower release into the gastrointestinal tract. The palatable nature of gels can enhance compliance in camels, especially when flavoring agents are included.

Semisolid formulations provide advantages like improved palatability, stability of active ingredients, and ease of administration, making them essential for effective treatment in camels.

Solid Dosage Formulations

Solid oral dosage formulations are commonly used in veterinary medicine for administering medications to camels, offering several benefits such as precise dosing, stability, and ease of storage. The main types of solid oral dosage formulations include:

- **Tablets:** Compressed solid forms that contain a specific dosage of active ingredients, often combined with excipients to enhance stability and absorption. Tablets can be coated for easier swallowing and to mask unpleasant tastes.
- **Boluses:** Large, elongated tablets designed for easier administration to larger animals like camels. They are particularly useful for delivering high doses of medication, such as anti-parasitic or anti-inflammatory agents, in a single administration.
- **Capsules:**Gelatin or polymer shells that encase powdered or liquid medications. Capsules provide a convenient means of delivering drugs and can be designed to release their contents rapidly or slowly, depending on the formulation.

- **Powders:** Finely milled solid particles that can be mixed with feed or water for administration. Powders are often used for antibiotics or nutritional supplements, allowing for flexible dosing and ease of administration.
- **Medicated Blocks/Bricks:** A medicated block is a compressed feed material that contains an active ingredient, such as a drug, anthelmintic, surfactant (for bloat prevention), or nutritional supplement. These blocks are usually packaged in cardboard boxes and fed to production animals. In the case of camels, salted bricks are commonly used to provide nutritional supplements and to implement prophylactic measures against diseases.

Solid oral dosage formulations for camels offer advantages such as ease of handling, accurate dosing, and extended shelf life. The choice of formulation depends on the specific medication, the camel's health condition, and the preferred method of administration.

Oral dosages administration

Administering medication to a camel can be achieved through several methods, including:

Forcing the animal to drink ('drenching')

"Administration of medication can be done using various tools, such as a long-necked bottle (preferably plastic to prevent breakage if the camel bites it), a drenching gun, a cup, or a jar. If opting for a glass bottle, it is advisable to attach a piece of plastic or rubber tubing to the neck, ensuring that only the tube enters the camel's mouth during administration."

Fig. Administering syrup in the mouth (easy method for young camels)

To administer medication effectively, first, restrain the camel by securely tying its forelegs together and having it sit down. With one hand, grasp the upper lip and with the other, hold the lower lip to tilt the animal's head back, ensuring its mouth is directed upwards. Insert the neck

of the bottle into the side of the camel's mouth, avoiding the area with teeth, and pour a small amount of medicine onto the back of the tongue. Allow the camel time to swallow the medication before administering more. If the camel does not swallow, the handler can gently shake its head from side to side or massage its throat to encourage swallowing."

Force-feeding

This method is suitable for administering tablets, pastes, capsules, or boluses. It is similar to the drenching technique. Dipping the medication in oil or water can facilitate swallowing. Place the medicine as far back on the tongue as possible for optimal effectiveness. A tube can also be used to deliver tablets or capsules directly.

Mixed with Feed

Medications for camels are generally not mixed with their feed, as camels tend to select their own food. However, an exception is made for anthelmintics, which are often combined with mineral mixtures. To encourage the camel to consume the medication, it can be placed inside a ball of dates or mixed with molasses, date juice, or honey.

Fig. Mixing the medicine in flour and making small tablets of it and giving it

Through a stomach tube

This method is used to deliver liquids or medications directly into the stomach when a camel is unable to swallow on its own, such as in cases of bloat or hemorrhagic enteritis. For adult camels, a heavy-walled, flexible plastic or rubber tube approximately 3 meters long is recommended. It is essential to smooth the ends of both tubes with sandpaper or a file to prevent injury to the camel's throat. A funnel can be used to pour liquids into the free end of the tube for administration.

Precautions for Oral Administration

When administering oral medications, it is essential to follow these precautions:

- Ensure that the camel's neck is parallel to the ground or its body while feeding the medicine, as raising the neck increases the risk of aspiration into the lungs.
- Avoid holding the tongue while administering the medicine, as this can also raise the risk of aspiration.
- Grind tablets into a fine powder and mix it with jaggery, flour, or another food item before feeding it to the camel.
- If the camel refuses to eat the mixture with jaggery or flour, quickly open its mouth and place the pill directly in the throat, then gently close its mouth until it swallows—without holding the tongue.
- Instead of placing the powder or mineral salt mixture directly into the mouth, consider mixing it with jaggery, flour, or another food item, or dissolve it in water and offer it for drinking.

Topical dosages formulation

Topical administration involves the localized treatment of the skin and the management of external and internal parasites through the application of therapeutic agents. Drugs used for localized effects include antiseptics, antifungals, anti-inflammatories, and skin emollients. The release rate of drugs from ointments, creams, and pastes is largely determined by the semisolid base used. Various topical formulations, such as pour-ons, dips, and jetting fluids, are employed to control external parasites in food animals, particularly camels. Notably, many pour-on formulations have endectocidal activity, primarily due to the camel's licking behavior, which enhances systemic absorption.

- **Dusting Powder:** Dusting powders consist of finely divided insoluble particles, such as talc or zinc oxide, and are effective for application on skin folds. They should be avoided on wet surfaces to prevent caking.
- **Cream:** Creams are semisolid emulsions for skin or mucous membrane application. They can be either oil-in-water or water-in-oil, with the former being easily absorbed and the latter providing a more emollient effect.
- **Ointment:** Ointments are greasy semisolids containing dissolved or dispersed drugs, using bases like hydrocarbons or vegetable oils. Their occlusive properties help hydrate the skin, making them suitable for chronic dry lesions.

- **Paste:** Pastes are stiff formulations with a high content of powdered solids. They are less greasy than ointments and are often recommended for ulcerated lesions.
- **Gel:** Gels are non-greasy, semisolid aqueous solutions stabilized by polymers. They release medications effectively and are easily washable due to their water solubility.
- **Solution:** Topical solutions are single-phase mixtures, including eye drops, ear drops, and lotions. Eye drops contain various drugs for ocular treatment, while ear drops deliver antimicrobials and anti-inflammatories to the external auditory canal. Lotions cool inflamed skin and are ideal for hairy areas and mild exudative lesions.
- **Suspension:** Suspension concentrates are high-concentration mixtures of insoluble solids suspended in water or oil. They are often used in pour-on formulations and dip concentrates.
- **Suspoemulsion:** Suspoemulsions combine properties of emulsions and suspensions, enabling the formulation of active ingredients with varying solubilities into one product.
- **Tinctures:** Tinctures utilize a solvent containing 15%–80% ethanol and may include stabilizers and solubilizers. An example is iodine tincture, an anti-infective that stains the skin to indicate treated areas.
- **Pour-Ons:** Certain fly repellents and tick treatments are available in the form of 'pour-ons.' These medications are simply poured onto the back of the animal for effective application.
- **Poultice:** A 'poultice' is a soft, often heated preparation applied to a sore or abscess. If needed, secure the poultice in place by tying a cloth over it to ensure it remains on the affected area.
- **Topical Sprays:** When using topical sprays, it is essential for everyone nearby to wear protective clothing and masks to ensure safety. Secure the animal by tying it to a tree or post to keep it steady during the application. Be thorough in spraying all parts of the animal, taking care to avoid the eyes. If a spray pump is unavailable, you can apply the pesticide using a brush or by dipping a cloth or sponge attached to a stick into the solution.

Fig. Spraying Medicine for Tick, Fly,Mosquito, and Lice Control

Fig. Applying ointment on wounds

Precautions for Applying Ointment, Gel, or Lotion

When applying ointment, gel, or lotion to a camel, it is essential to take certain precautions to ensure effective treatment and avoid complications. Always begin by wearing plastic or rubber gloves to maintain hygiene and prevent contamination. Thoroughly clean the wounds with lukewarm water using a clean cotton cloth before applying the medication. To prevent the camel from licking off the treatment, tie its mouth for one to two hours after application, allowing the medication to absorb properly. It's important to avoid bandaging wounds that are oozing watery discharge, as this can exacerbate the condition. Additionally, ensure that medicine and bandages are applied to wounds that are frequently pecked at by crows to protect them from further irritation and infection. For wounds infested with insects, consult a veterinarian to clean the area before applying any medication, reducing the risk of complications.

Precautions for Spraying Medications That Kill Ticks, Flies, Mosquitoes, and Lice

When spraying medications designed to kill ticks, flies, mosquitoes, and lice on a camel, certain precautions must be taken due to the toxic nature of these substances. First, ensure the animal's mouth is tied shut before spraying to prevent it from licking the medication. To protect yourself from exposure, cover your nose and mouth with a towel and wear gloves before applying the spray. It is advisable to administer the spray after the animal has been fed and given water, as this reduces the likelihood of it attempting to lick the product. Avoid spraying directly onto large wounds, as this can lead to further irritation. After the spray has been applied, allow the camel to bask in the sun for a short period before bathing it with clean water. If the camel does

lick the medication and begins to drool or foam at the mouth, contact a veterinarian immediately for assistance.

Injectable/parenteral dosage formulations

Parenteral dosage formulations are crucial for delivering medications directly into the body, bypassing the gastrointestinal tract. This method is particularly important in cases where rapid therapeutic effects are required or when oral administration is not feasible. Injectable medications allow for rapid absorption and can provide immediate therapeutic effects, making them a preferred choice in various clinical situations. This method is particularly useful for delivering antibiotics and vaccines, as well as other types of medications, such as Ivermectin for managing mange.

Syringes and Needles for Camel Administration

When administering medications to camels, the choice of syringes and needles is crucial for effective delivery. For most purposes, a 20 ml syringe is commonly used, while smaller volumes of medication can be administered using 5 ml or 10 ml syringes. As for needles, sizes 16G and 18G are generally adequate for most procedures. For intramuscular injections, a needle length of 2.5 cm is recommended, ensuring proper penetration into the muscle tissue. Conversely, when performing intravenous injections, a longer needle measuring 3.7 cm is ideal to facilitate access to the vein. Selecting the appropriate syringes and needles is essential for safe and effective treatment in camels.

Preparing the Injection Site

Ensuring a clean injection site is vital for preventing infections and ensuring the efficacy of the treatment. Before administering an injection, it is important to clip the hair at the injection site to provide clear access to the skin. Following this, use a piece of cotton wool dipped in alcohol or another antiseptic solution to thoroughly clean the area. This preparation minimizes the risk of contamination and promotes a safer injection process.

Injecting into the Muscle/Intramuscular (IM)

Intramuscular injection is the most common and straightforward method for administering medications into the muscle tissue, providing a slower, more sustained release of the drug compared to IV administration. When performing this type of injection, it is important not to exceed a volume of 15 to 20 ml at a single site. If the required dosage is greater than this, it should be divided and injected into two separate locations to minimize discomfort and ensure proper absorption. The usual sites for intramuscular injections are the muscles of the neck and the upper portion of the back legs, where the muscle mass is sufficient to accommodate the medication.

Injecting Under the Skin/ Subcutaneous (SC)

Subcutaneous injections involve delivering medication into the tissue layer between the skin and muscle. SC is an effective method for administering medications in camels, particularly when a slower absorption rate is desired. This route is typically used for vaccines and certain medications (Inj. Ivermectin for mange in camel) that require slower absorption. The best sites for this type of injection are just in front of the shoulder or behind the shoulder, where the skin is looser and allows for easier penetration. It is crucial not to inject more than 50 to 100 ml at a single site; if a larger volume is required, it should be divided and administered in two separate locations to avoid causing discomfort or complications for the animal.

Injecting into the Vein/ Intravenous (IV)

Intravenous injections deliver medications directly into the bloodstream. IV is the preferred method when a rapid therapeutic response is required, such as in emergency situations. This route is often used for fluid therapy, emergency treatments, and administering medications that require rapid absorption. The jugular vein, located in the neck, is the primary site for this type of injection due to its size and accessibility. However, caution is necessary, as some intravenous medications can be highly irritating and may cause tissue damage if injected outside the vein. Therefore, it is crucial to ensure that the majority of the needle, not just the tip, is properly positioned within the vein to facilitate accurate administration and minimize the risk of complications.

Giving a Drip

A 'drip' refers to the administration of a large volume of liquid injected slowly into the vein, making it an effective method for treating severely dehydrated camels, particularly those suffering from diarrhea. The jugular vein, located in the neck, is the preferred site for this procedure due to its size and ease of access. Administering a drip allows for the gradual replenishment of fluids and electrolytes, which is essential for restoring the camel’s hydration status and overall health.

Intradermal Injections: Although less common, intradermal injections can be used for certain vaccines or tests. This method delivers medication into the dermis, just beneath the skin surface.

Precautions in Injecting

Injecting into muscles or veins should only be performed by a qualified veterinarian or a trained compounder to ensure safety and efficacy. It is essential to use a new needle for each injection and to clean the skin with antiseptic solution, such as spirit, before administering the medication. If swelling occurs at the injection site, it is advisable to consult a veterinarian; they

may recommend adding salt to hot water to create a compress or applying ice to reduce inflammation. Always remember that medications should only be given based on a veterinarian's advice, as incorrect, excessive, or unnecessary treatments can jeopardize the animal's health and may even lead to serious complications or death.

Enema Administration in Camels

An enema involves the introduction of liquid medicine into a camel's rectum and is primarily used to alleviate constipation. Enemas typically come in a tube with a plunger, similar to a syringe. To administer an enema, first, ensure the animal is sitting down and properly restrained. It is helpful to have someone hold the camel's tail for stability. Carefully insert the nozzle of the enema package into the rectum, and gently press the plunger to release the medication into the anus. Alternatively, a syringe without a needle can be used to squirt the liquid directly into the rectum. This method provides a direct approach to relieve constipation and promote bowel movements in the animal.

Administering Medicine to the Camel Udder

Medicines are often applied directly into the camel udder to treat mastitis, a common condition affecting dairy camels. The medication typically comes in a tube equipped with a nozzle and a plunger, similar to a syringe without a needle. However, applying this treatment can be challenging due to the camel’s teat having two small openings, making it more difficult and potentially painful to insert the nozzle. Therefore, it is important to select a tube with a fine nozzle and to treat both openings in the teat.

To administer the medicine, first, milk the udder if possible to remove any excess fluid. Next, sedate and restrain the animal to ensure safety during the procedure. Clean and disinfect both the teat and the nozzle of the tube using an antiseptic solution, such as Savlon. Carefully insert the nozzle into the openings of the teat, and gently push the plunger to deliver the ointment into the udder. After administering the medicine, close the teat with your hand and massage the udder to help distribute the medication. If this method proves too difficult, an alternative approach is to inject antibiotics directly into the udder.

Administering Medicine to the Camel Uterus

Medications can be administered directly into the camel uterus to treat various reproductive issues, such as endometritis or other uterine infections. This procedure requires careful handling and the right equipment, typically using a sterile catheter or syringe designed for uterine infusion. First, ensure the animal is properly restrained and sedated to minimize stress and movement during the procedure.

Before insertion, clean and disinfect the external genitalia and the tip of the catheter or syringe with an appropriate antiseptic solution. Carefully insert the catheter into the cervix and gently advance it into the uterus. Once in place, slowly administer the medication, ensuring that it is distributed evenly throughout the uterine cavity. After administration, monitor the camel for any signs of discomfort or adverse reactions. It is crucial to follow up with a veterinarian to assess the effectiveness of the treatment and to ensure proper recovery.

Careful Considerations for Parenteral Administration

Aseptic Technique: It is essential to use sterile equipment and maintain aseptic conditions during the preparation and administration of injections to prevent infections.

Proper Restraint: Ensuring that the camel is adequately restrained during injection is crucial for the safety of both the animal and the handler.

Dosage Calculation: Accurate dosage calculations based on the camel's weight and specific medical needs are vital for effective treatment and to avoid overdose or underdose.

Monitoring: After administration, the animal should be monitored for any adverse reactions or side effects, particularly with new medications or treatments.

When Using Medication: It is essential to exercise special care when administering medication under certain circumstances. This includes situations where the animal is too weak or of a young age, has not consumed water or food for several days, or is pregnant, particularly during the last two to three months of gestation. Additionally, caution should be exercised with any medication labeled as poisonous.

Medications to Avoid: Never administer medicines that are past their expiration date, as well as those without clear labeling of the expiration date or manufacturer’s address. Medications that have been removed from their original packaging and left exposed to the environment for an extended period should also be avoided, as their efficacy and safety cannot be guaranteed.

Conclusion

Administering drugs to camels requires careful consideration of their unique physiological and behavioral traits. The choice of drug formulation and route of administration is critical to ensuring treatment efficacy and minimizing stress on the animal. Continued research into camel-specific formulations and drug delivery systems is essential for advancing veterinary care in this species.

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CHAPTER 9

Rational Use of Antibiotics and NSAIDs in Camel

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The word‘Rational’ comprises correct, proper and appropriate use of drugs for adequate period of time to get optimum effect and envisage minimum cost of treatment.Some questions should be asked before selecting any antibiotic/antimicrobialon the basis of clinical findings to get optimal effects?Have appropriate clinical specimens been obtained?What are the likely etiological agents for the patient’s illness?What measures should be taken to protect exposed individuals to prevent secondary cases?Is there any clinical evidence that antimicrobial therapy will confer clinical benefit for the patient? Before selecting any antibiotic for clinical use in camel,one needs to consider:1. Infectious agent/s to be isolated and accordingly antimicrobial agent to be used based on their sensitivity and 2. The host factor. However, there are many factors, which determine the choice of an antibiotic to be used in different disease conditions:

1. Host factor: It includes the immune status of the patient and concomitant disease status,prior adverse drug effects, impaired elimination of the drugs, age of the patient, pregnancy status etc.

2. Pharmacological factor: It includes pharmacodynamics of the drug (concentration dependent *vs* time dependent killing), pharmacokinetic behavior of the drug, site of infection (BBB etc), toxicity of the agent, interactions with other drugs, bactericidal or bacteriostatic, resistance patterns etc.

Unique features of camel: Camels are pseudo ruminants possessing several unique characteristics that distinguish them from other domesticated animals. Further, these peculiarities influence various aspects of their biology, behaviour, and interaction patterns with other drugs too. The family Camelides belong to order Artiodactyla (even-toed ungulates), suborder Tylopoda and is divided into two genera: The genus Camelus (Old world camelids), includes two species: *Camelus dromedarius*, the dromedary, one-humped or Arabian camel and the *Camelusbactrianus*, the bactrian or Mongolian camel or two-humped camel(Burger 2016).The Bactrian or two-humped camel are native to the Gobi Desert in China and the steppes of Mongolia i.e. in the cold deserts and dry steppes of Asia. Approximately 90% of the old world's camelids are dromedary camels, and nearly all of these are domesticated. Dromedary camels are basically well adapted anatomically as well as physiologically to cope up with the harsh climatic conditions of the hot desert. The genus Lama (*L. glama, L. guanicoe, L. pacos*) and genus Vicugna (*V. vicugna*) depict New-world camelids (Cebra and Cebra, 2013).

Physiological adaptations:

- Possess an extraordinary ability to endure thirst and dehydration.
- Tolerate water-loss at about 30% of its body weight when exposed to severe heat. Most mammals die if they lose even 15%.
- The red cells are oval and swell as much as 240 percent of their normal size for water storage.
- Undue water loss from sweating is not possible because of its flexible body temperature that varies from 34 degree to 40 degree during summer.
- The colon has a great ability to absorb water, so the faeces voided out is dry.
- Have double layered eyelids, long eyelashes to prevent ill effects of sand storms on eyes.
- Slit like nostrils that can close to prevent sand from entering lungs during sandstorms.
- Long legs keep body away/ farther from the hot ground.
- Camel fur/hair also helps in regulating their body temperature throughout the season.
- There are three distinct compartments in the stomach. Fore stomach have numerous glands.
- Digestive process is highly efficient. They can live exclusively on fibrous, low-quality diet due to retention of feed particles in the fore stomach for longer period of time.
- Store nutrients in the form of fat in their hump, which fulfil the hydration needs by generating the metabolic water during fat oxidation.

Indications to use Antibiotics and NSAIDs (Non Steroidal Anti-Inflammatory Drugs): Camel is very important source for transportation and food in several countries around the globe (Tefera and Gebreah 2001).It is susceptible to a wide range of pathogenic bacterial diseases like mastitis, pneumonia, Salmonellosis and Brucellosis. Camel calf diarrhoea,neonatal sepsis, upper respiratory tract infection, retained placenta, uterine infections, umbilical infections, tooth root infections, skin infections/ wounds, infected root pad, Listeriosis, intestinal coccidiosisare also common in camels and mostly require different groups of antibioticsfor treatment and prevention (Abbas and Omer 2005).NSAIDs are preferred in management of pain,inflammation, endotoxemia, pain of bone/cartilagenous origin, ulceration etc.

Facts about pharmacokinetics of different drugs in camels:

- Pharmacokinetics of different drugs in camels has not been widely investigated so far.Therefore, recommending standard dose rate for a given drug in camel is a difficult task. Often the doses are recommended based on the extrapolated data of another livestock, particularly cattle and buffalo.
- Volume of distribution for a given drug in camels varieswith the hydration status of the animal. Dose and frequency of drug administration, particularly for those drugs which are eliminated largely through urine like penicillins and aminoglycosides should be adjusted

according to the hydration status of the patient.Whenever toxicity is suspected due to larger doses in camel, concomitant fluid therapyshould be given.

- Drugs of 'High margin of safety' should be selected. Surprisingly, higher doses are often chosen by the clinician to hasten recovery and avoid sub-therapeutic drug concentrations.
- In general, antibiotics show longer elimination half lives in camels in comparison to other domestic ruminants, perhaps due to lower rate of urine production. Thus, therapeutic effect of a drug is longer in camel than that in other domestic ruminants.
- Calculation of total dose to be given under field conditions is often empirical as facility for determination of accurate body weight is seldom available.

Antimicrobials: It is a general term used for all the substances i.e. natural, semi-synthetic or synthetic, used for inhibiting the growth(bacteriostatic) or killing microbes (bactericidal).Antimicrobial drugs include antibiotics as well as synthetic and semi-synthetic compounds. They perform a variety of actions including inhibition of cell wall synthesis (penicillins and cephalosporins), inhibition of protein synthesis (tetracyclines, macrolides, phenicols, aminoglycosides) and inhibition of DNA function/metabolite alteration (sulfonamides and fluoroquinolones). Several researchers found beneficial effect of antimicrobials in different disease conditions in camels.

El-Ghareeb*et al*. (2019)reviewed the most commonly employed antimicrobials in camel and found that the list includeoxytetracycline, tylosin, sulphonamide, streptomycin, penicillin,ciprofloxacin,erythromycinand enrofloxacin.Fluoroquinolones are antimicrobial drugs which generally have very good activities against a broad spectrum of aerobic bacteria, including *Pasteurella* sppand *Mycoplasma*spp(Giles *et al*., 1991).Marbofloxacin and Danofloxacin are studied in camels following a single high dose administration in two-period crossover studies. Marbofloxacin was administered by intramuscular and intravenous routes @ 8mg/kg body weight and danofloxacin was administered by sub-cutaneous and intravenous routes @ 6mg/kg body weight in camels (Lachguer*et al*., 2013).Procaine Penicillin-G (3,00,000 IU/mL) is commonly used to treat tooth root infections, skin infections/wounds, infected foot pads, umbilical infections and follow-up treatment for Listeriosis in camel.

Oxytetracycline is a broad-spectrum antibiotic that is a bit more active in mucopurulent and anaerobic environment than other antimicrobials. Its irritating nature causes an inflammatory response, stimulates the defensive reaction of the uterus. For the treatment of endometritis in camels2 g of oxytetracycline-hydrochloride and 500 mg cephapirinis an efficient intra-uterine antibiotic combination. Comparison between cephapirin and oxytetracycline for the treatment of clinical endometritis revealed that the former drug (cephapirin) produces better post-treatment conception rates than oxytetracycline(Swelumand Alowaimer 2013).Tobramycin is an aminoglycoside drug

having antibacterial activity similar to gentamicin. It may have greater activity against *Pseudomonas aeruginosa*@ 1 to 2.5 mg/kg body wtIMorIV, but considered as ototoxic and nephrotoxic (Hadi*et al*., 1994).Benzylpenicillin ordihydrostreptomycin (parenteral)are recommended for treatment of *S. agalactiae*associated mastitis in camels(Younan 2002).Ten million IU penicillin is injected intramuscularly 24 hourlyfor three consecutive days for treatment of mastitis in camels,while erythromycin is given @ 10 mg/kg body wtintramuscularly once daily for three consecutive days (Younan 2002).

Ceftiofur, a third-generation broadspectrum cephalosporin antibiotic was used in she-camels with uterine infections that helped in achieving animproved conception rate. Subcutaneous injection of 1ml/50 kg body weight for 5 days can be used as an efficient treatment for uterine infection in female dromedary camels caused by *E. coli* and *Streptococcus species* for improving their fertility indexes(Zaher*et al*., 2023).Lugol's iodine solution infusion (30 ml IV per day for 7 days) and streptopenicillin (1500000 units of procaine penicillin G, 500000 units penicillin-Gsodium and 2.5 g streptomycin sulphate) intramuscularly dailyis the choice of treatment of actinomycosis in camels(Kilic andKirkan 2004).Penicillin or tetracyclines may be used for treatment of infection with subacute strains of *B. anthracis* in camel, whereas potentiated sulphonamides intravenously and later on orally is more suitablefor salmonellosis treatment (McGraneandHiggins 1985).However, penicillin-streptomycin combination or oxytetracycline is likely to be effective in pasteurollosis in the camels.Edelstenand Pegram (1974) treated animals with multiple lesions with intramammary penicillin-streptomycin suspension, injected into the sinuses followed by parenteral administration of long-acting penicillin.Amoxycillin and cloxacillin were administered intramuscularly @ 5 mg per kg body weight daily for three days in mastitis in camels(Tuteja*et al*.,2013).Ceftiofurwas administered subcutaneously for five days in for treatment ofclinical cases of leptospirosis in camels(Gyimesi*et al*.,2015).

The dose rate of different antibiotics/antimicrobials and NSAIDs in camels are depicted below in Table 1 and Table 2, respectively:

Table1. Dose rate of commonly used antibiotics in camel

Antimicrobials	**Dose rate**	**Remarks**
Penicillin-G Na	22000-44000 IU/ kg (6 to 12 h) IV/ IM/ SC	
Procaine Penicillin-G	10 mg/ kg (12h), 20 mg/ kg (24h)	
Streptomycin	10 to 25 mg/ kg IM (24h)	Effective against actinobacillosis and actinomycosis
Ampicillin	10 to 20 mg/ kg IV/IM/SC (8 to 12 h)	
Ceftiofur	2.2 to 4.4 mg/ kg IV/IM/SC (12 to 24h)	In neonates upto 8 mg/ kg
Amikacin	20 mg/ kg IV/IM/SC (24h)	
Gentamicin	4.4 to 6.6 mg/kg IV/IM/SC (24h)	
Tobramycin	1.3 to 2.5 mg/kg IM (12h)	
Kanamycin	6 to 8.5 mg/ kg IM (12h)	
Enrofloxacin	2.5 to 5 mg/ Kg IV/IM/SC (12 to 24 h), 7.5 mg SC (72h) (long acting preparation), 10 mg/kg PO (24h)	Useful in mastitis
Norfloxacin	10 mg/ kg IM	Rapid passage in milk, can be used in mastitis
Marbofloxacin	8 mg/ kg bw OD	Broad spectrumEffective against *Pasturellaspp*and *Mycoplasmaspp*
Oxytetracycline	5 to 10 mg/ kg IV (12 to 24h)	High dose (upto 20 mg/kg): 24h Low dose: 12h[Very useful antibiotic]
Oxytetracycline long acting (LA)	10 to 20 mg/ kg IM/SC (24 to 72h)	
Tylosin	4 to 10 mg/ kg IV/ IM	
Cefquinome	1 mg/ kg IM/IV/SC	
Florfenicol	10 mg/ kg IM (48h), 20 mg/kg SC every fourth day	
Gentamicin sulphate		Not safe, nephrotoxic

Tobramycin	2.5 mg/ Kg IM q12h	
Lincomycin	22 mg/kg IM	Effective in purulent abscess
Marbofloxacin	2 mg/kg IM/SC (24h)	
Neomycin	15 mg/ kg PO once daily	
Toltrazuril	20 mg/ kg once	Effective in coccidiosis
Trimethoprim-sulfadoxine	30 mg/ kg OD for 3 days	Used in coccidiosis
Amprolium hydrochloride	10-15 mg/ kg PO OD	
Metronidazole	20 mg/ kg IV (24h)	Used in clostridial enteritis

Table2. Dose rate of commonly used NSAIDs in camel

NSAIDs	**Dose rate**	**Remarks**
Meloxicam	0.5 mg/ kg PO (72h), 0.5 mg/ kg SC/ IV (24h)	Effective in lameness and musculo-skeletal pain
Flunixin meglumine	1.1 mg/ kg IV (6h), 1.2/2.2 mg/ kg IM (24h)	
Phenylbutazone	4.4 mg/ kg IV/IM OD	
Ketoprofen	2.2 mg/ kg IM/ IV (24h)	
Butorphenol	0.5 mg/ kg SC (24h), 0.1 mg/ kg IV	
Tolfenamic acid	4 mg/kg IV (24h)	

Emergence of resistance *vis-à-vis* misuse of antimicrobials:

The rational use of antibiotics/antimicrobials and NSAIDs in camels, as with any other animals too, is crucial to ensure their health and well-being as well asto minimize the development of antibiotic resistance and other adverse effects. Treating FUO (Fever of Unknown Origin), lack of adequate bacteriological information, improper dosing as well as inappropriate reliance on chemotherapy are some of the reasons behind the development of AMR (Antimicrobial Resistance). International and national campaigns for the rational use of the available antibiotics/antimicrobials have drawn attention of clinicians and common people worldwide.Drug-resistant pathogens having high prevalence rates are as follows:

1. Methicillin Resistant *Staphylococcus aureus* (MRSA): MRSA (methicillin-resistant Staphylococcus aureus) is a type of bacteria that's developed defense mechanisms (resistance) to antibiotics.

2. Vancomycin Resistant Enterococci (VRE), a threatening spread of development of resistance in Gram-negative rod-shaped bacteria

3. *Clostridium difficile:* Mechanism of development of resistance includes prevention of penetration of drug, enzymatic destruction of drug, rapid ejection of the drug, alteration of antibiotic or target site, mutation etc.Basically, it is categorized as genetic mechanism or biochemical pathway for the development of resistance to antimicrobials.

A.Genetic determinants of resistance

1. Chromosomal determinant: Spontaneous mutation rate in bacteria for any particular gene is thoughtto be very low (1:10,00,000). In most bacterial organisms, resistance from chromosomal mutation is of lesser significance because, mutants usually decreases the pathogenicity, except in case ofMRSA and Mycobacteriuminfections.

2. Extrachromosomal determinant: Plasmids are extra-chromosomal genetic elements(closed loops of DNA that consist of single gene or many genes), that exist free in the cytoplasm and can replicate on their own. Plasmids that carry genes for resistance for antibiotics/antimicrobials (rgenes) are called R plasmids. Drug resistance in clinical medicine is often plasmid mediated.

Transfer of R genes between bacteria:

1. **Transposons:** Stretches of DNA that can be transferred (transposed) from one plasmid to another or plasmid to chromosome.
2. **Conjugation:** Conjugate plasmids which cause bacteria to make a connecting tube among themselves through which the plasmid can pass.
3. **Transduction:** Transmission of R gene-carrying plasmid by bacteriophage

B.Biochemical mechanisms of resistance:

1. **Production of enzymes that inactivate the drug:**
    - β-lactamase:Penicillins, Cephalosporins
    - Acetyl transferase: Chloramphenicol
2. **Alteration of drug sensitive site or binding site:**
    - Plasmid-mediated alteration on 50-S binding site: Erythromycin
    - Alteration of 30-S subunit: Aminoglycoside
3. **Decreased drug accumulation in the bacteria:**
    - Active efflux of the drug: Resistance to β lactams, Aminoglycosides, Quinolones
    - Plasmid-mediated resistance to Tetracyclines (TCs) through efflux of the TCs
4. **Alteration of enzyme pathways:**
    - Plasmid-mediated synthesis of DHFR (Di-hydrofolate reductase) with low affinity for Trimethoprim

Isolation of Antimicrobial resistant and extended-spectrum ß-lactamase (ESBL) producing *E. Coli* bacteria in Camel:

Below are few documented evidences which highlights the issue of AMR in camels in different parts of the world.

1. Magdalena Nüesch-Inderbinen, Patrick Kindle, MelindaBaschera, Anne Liljander, Jörg Jores, Victor Max Corman and Roger Stephan (2020). **Antimicrobial resistant and extended-spectrum ß-lactamase (ESBL) producing *Escherichia coli* isolated from fecal samples of African dromedary camels**; Scientific African 7, doi.org/10.1016/j.sciaf.2020.e00274.

2. Isabel Carvalho, María Teresa Tejedor-Junco, Margarita González-Martín, Juan Alberto Corbera, Vanessa Silva, Gilberto Igrejas, Carmen Torres and Patrícia Poeta (2020). ***Escherichia coli* Producing Extended-Spectrum β-lactamases (ESBL) from Domestic Camels in the Canary Islands: A One Health Approach**; Animals 10, doi:10.3390/ani10081295.

3. Irene KaregiAkunda, Daniel W. Kariuki, Graham Matulis, Patrick Mwaura, Brian Maina, Halima Mohammed, Ayieko Paul, Frank G. Onyambu, Allan ole Kwallah, Dino J. Martins, Michael E. von Fricken and Joseph M. Kamau (2023). **Antimicrobial resistance patterns**

and characterization of emerging beta-lactamase-producing *Escherichia coli* in camels sampled from Northern Kenya; Veterinary Medicine and Science 9:1407–1416.

Summary and Conclusion: The resultsof optimal clinical treatment are achieved when the toxicity is lesser and thedevelopment of resistance is minimized.The essential target of therapy with antibiotics is **successful treatment of individual patient** with microbial especially bacterial infections. In this connection, **antibiotic stewardship program** aims to maintain their effectiveness by a rational use of the available antibiotics. Few steps must be taken to curb this menace of AMR e.g.

1. **Make a diagnosis:** As precisely as possible, state organism responsible and site of infection
2. **Decide** if chemotherapy is necessary: If **NO:** Symptomatic treatment
   If **YES:** Select the best drug
3. **Administer** drug: Suitable route, optimum dose , frequency & duration
4. **Continue therapy** until cured/improvement is visible
5. **Test** for cure/improvement (clinical & laboratory)
6. **To prevent resistance:**Antibiotics should be the last line of defence

Overall, the rational use of antibiotics and NSAIDs in camels involves proper diagnosis, veterinary supervision, appropriate dosing, and careful monitoring for both therapeutic effects and adverse reactions. Additionally, promoting good animal husbandry practices and preventive healthcare measures can help in reducing the need for antibiotic and NSAID use in camels.

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CHAPTER 10

Basic and Applied Aspect of Vaccination

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Introduction:

Active immunity, which results from the long-term memory responses of the immune system to an antigen, as opposed to passive immunity, which is temporary and acquired through the introduction of immune components. Active immunity can be acquired naturally through exposure to pathogens or induced through vaccination. Vaccines stimulate the immune system by introducing antigenic molecules, prompting the generation of memory cells and adaptive immune responses that provide long-lasting protection against disease.

Active immunity is crucial for animals for several reasons:

Long-Term Protection: Active immunity provides animals with long-lasting protection against specific pathogens. Once the immune system has been activated and memory cells are produced, animals can mount a rapid and robust response upon subsequent exposure to the same pathogen, preventing or minimizing the severity of the disease.

Natural Defence Mechanism: Active immunity is the body's natural defence mechanism against infectious agents. It enables animals to develop resistance to diseases through exposure to pathogens, either naturally or through vaccination.

Herd Health: Maintaining active immunity in a population contributes to overall herd or population health. When a significant portion of the population is immune to a disease, it creates a barrier to the spread of the pathogen, thereby reducing the likelihood of outbreaks and protecting vulnerable individuals.

Reduced Disease Burden: Active immunity helps in reducing the burden of infectious diseases in animal populations. By preventing infections or reducing their severity, active immunity contributes to improved animal welfare, productivity, and economic outcomes for livestock producers.

Sustainability of Agriculture: In agricultural settings, active immunity is essential for sustainable animal production. By reducing reliance on antibiotics and other therapeutic interventions, active immunity supports environmentally friendly and economically viable farming practices.

Public Health: Active immunity in animals can also have implications for human health. By preventing the spread of zoonotic diseases (those that can be transmitted from animals to humans), active immunity contributes to public health and helps in preventing disease outbreaks that could affect both animal and human populations.

In summary, active immunity is necessary in animals to provide long-term protection against diseases, maintain herd health, reduce disease burden, ensure sustainability in agriculture, and safeguard public health.

Factors influencing vaccine usage include identifying the primary cause of the disease and understanding how vaccines can induce protective responses. However, in certain viral diseases, such as equine infectious anaemia and feline infectious peritonitis, antibodies may exacerbate the disease process, making vaccination potentially harmful.An ideal vaccine should confer rapid and prolonged immunity, induce the most protective response, and produce distinguishable responses from natural infection. However, vaccination carries risks, and adverse effects can occur. Therefore, informed consent and careful consideration of the risks versus benefits of vaccination are essential.

An ideal vaccine has several characteristics:

1. Vaccination should rapidly confer prolonged, strong immunity in vaccinated animals.
2. Depending on the nature of the pathogen, vaccination should induce the most protective response (e.g. dominated by cytotoxic T cells vs antibodies, categorized as type 1 and type 2 responses, respectively).
3. Vaccination should stimulate responses distinguishable from those due to natural infection so that vaccination and eradication may proceed simultaneously.
4. Vaccination is not always an innocuous procedure; adverse effects can and do occur. Therefore, all vaccinations must be governed by the principle of informed consent. The risks of vaccination must not exceed those caused by the disease itself.

Vaccination is not always an innocuous procedure; adverse effects can and do occur. Therefore, allvaccinations must be governed by the principle of informed consent. The risks of vaccination must notexceed those caused by the disease itself.

Types of vaccines:

Vaccines can contain living or killed organisms, or purified antigens. Live vaccines tend to elicit strong immune responses, while killed vaccines may be less immunogenic but safer. Killed vaccines often stimulate antibody responses, while living vaccines generate cytotoxic T cell responses. Subunit vaccines focus on purifying critical protective antigens, while DNA plasmid vaccines involve injecting DNA encoding viral antigens. RNA vaccines, a newer technology, induce immune responses by encoding protein antigens. Attenuated vaccines, though effective, require careful balancing of virulence. Gene-deleted vaccines modify organism genes to reduce virulence. Virus-vectored vaccines use harmless viruses to deliver antigens, effectively stimulating immune responses.

Adjuvant usage in vaccine formulation:

To maximize the effectiveness of vaccines, especially those containing poorly antigenic components orhighly purified antigens, it is standard procedure to add immunologic adjuvants to the vaccine.

Adjuvants trigger innate immune responses that enhance the adaptive response to vaccines or that balanceor shift the nature of these immune response in the direction of either type 1 or type 2 responses. They candecrease the dose of antigen to be injected or the number of doses administered, and they may prolongimmunologic memory.

Adjuvants work through the following four major mechanisms:

1. Depot adjuvants protect antigens from degradation and prolong immune responses as a result of the sustained release of antigen over a period of time. Examples of depot-forming adjuvants include oil in water emulsions.
2. Another form of adjuvants consists of particles that effectively deliver antigen to antigen-presenting dendritic cells and thus enhance antigen presentation. The immune system traps and processes particles such as bacteria or other microorganisms much more efficiently than soluble antigens. As a result, particulate antigens are much more effective than soluble ones. Examples of such adjuvants include emulsions, nanoparticles, immune-stimulating complexes, and liposomes.
3. Some antigens trigger innate immune responses by simply causing tissue damage and inflammation. Aluminium-based adjuvants cause release of inflammatory molecules and cytokines, triggering innate immunity. Saponin-based adjuvants and water in oil emulsions also act by causing inflammation. Saponins (triterpene glycosides) are detergent-like molecules derived from the bark of the soapbark tree (*Quillajasaponaria*). Saponin-based adjuvants may selectively stimulate TH1 activity.
4. Another form of adjuvant contains microbial products that often represent pathogen-associated molecular patterns that trigger innate immunity. As a result, they activate dendritic cells and macrophages through toll-like receptors and stimulate the secretion of critical cytokines such as IL-1and IL-12. Depending on the specific microbial product used, they may enhance either TH1 or TH2responses.Commonly used microbial immunostimulants include lipopolysaccharides (or their detoxified derivatives), killed anaerobic corynebacteria (especially *Propionibacterium acnes*), and killed *Mycobacteria*.

Many commercially available and proprietary adjuvants are combinations. For example, very effectiveadjuvants can be constructed by combining particulate or depot adjuvants with an immune-stimulatoryagent.

Vaccine delivery:

Routes of administration and their suitability based on the target disease and the size of the animal population. While subcutaneous (SC) or intramuscular (IM) injection is common for systemic immunity in small groups, intranasal vaccines are preferred for diseases requiring local immunity. Intranasal vaccines are used for diseases like infectious bovine rhinotracheitis and infectious bronchitis in poultry. Spraying vaccines can be advantageous for large herds or flocks, ensuring all animals receive the vaccine. Additionally, vaccines can be administered via feed or drinking water, especially in large-scale operations like poultry and swine farming.

Combination Vaccines:

The use of combination vaccines to address complex disease syndromes and reduce the need for multiple injections in animals is generally advised. These vaccines contain mixtures of organisms targeting different pathogens. For example, in bovine respiratory disease complex, vaccines combine antigens for several pathogens like bovine respiratory syncytial virus, infectious bovine rhinotracheitis virus, bovine viral diarrhoea virus, parainfluenza 3 virus, and *Mannheimiahaemolytica*. Manufacturers adjust combination vaccines to prevent antigen competition.It emphasizes caution against indiscriminate mixing of vaccines, as one component may dominate and interfere with others. However, simultaneous administration of multiple vaccines is generally well-tolerated by the immune system of healthy animals, which has evolved to respond to complex challenges.

Vaccination schedule:

Schedule of vaccination can affect immune status of herd. Newborn animals initially rely on maternal antibodies for protection, but vaccination becomes necessary once maternal immunity wanes. Vaccination during late pregnancy of the mother can provide passive immunity to neonates via colostrum. However, maternal antibodies can interfere with vaccine effectiveness. Modified live virus vaccines are more effective in the presence of maternal antibodies compared to inactivated vaccines. Vaccination schedules for young animals often involve multiple doses due to variability in the timing of loss of maternal immunity. The duration of immunity varies depending on factors like vaccine type and route of administration, and revaccination frequency should be determined based on individual risk assessment. Vaccines are categorized as essential (core) or optional (noncore), with essential vaccines recommended for all animals, while optional vaccines are administered based on specific risks and benefits. [Table 1]

Differentiation of Infected from Vaccinated Animals (DIVA):

The DIVA vaccination strategy offers several advantages in animal health management

Disease Control: DIVA vaccines allow for the differentiation between animals that have been infected with a pathogen and those that have been vaccinated. This differentiation enables more precise disease control measures, as it helps in identifying and managing infected animals while protecting vaccinated ones.

Surveillance: DIVA strategies facilitate surveillance efforts by enabling the monitoring of disease spread and prevalence accurately. By distinguishing between infected and vaccinated animals, surveillance programs can more effectively track the spread of pathogens within populations.

Trade Facilitation: In international trade, DIVA vaccines help in meeting import/export requirements by providing assurance that vaccinated animals do not carry the infection. This reduces trade barriers and facilitates the movement of animals and animal products across borders.

Disease Eradication: DIVA strategies play a crucial role in disease eradication programs by allowing for targeted control measures. By accurately identifying infected animals, control efforts can be focused on eliminating the pathogen from populations more efficiently.

Public Confidence: The ability to differentiate between infected and vaccinated animals enhances public confidence in vaccination programs. It provides transparency and assurance that vaccinated animals do not pose a risk of spreading the disease, thus promoting trust in veterinary health interventions.

Overall, DIVA vaccination strategies offer a valuable tool for effective disease management, surveillance, trade, eradication efforts, and maintaining public confidence in animal health programs.

Types of vaccination strategies:

Vaccination programme means a plan to apply vaccination to an epidemiologically appropriate proportion of thesusceptible animal population for the purposes of disease prevention or control.Different vaccination strategies may be applied alone or in combination, taking into account the epidemiological andgeographical characteristics of occurrence of the disease.

The following strategies may be applied:

1) Barrier vaccination means vaccination in an area along the border of an infected country or zone to prevent thespread of infection into or from a neighbouring country or zone.

2) Blanket vaccination means vaccination of all susceptible animals in an area or an entire country or zone.

3) Ring vaccination means vaccination of all susceptible animals in a delineated area surrounding the location wherean outbreak has occurred.

4) Targeted vaccination means vaccination of a subpopulation of susceptible animals.

5) Emergency vaccination: A vaccination programme applied in immediate response to an outbreak or increasedrisk of introduction or emergence of a disease.

6) Herd immunity:The proportion of the target population effectively immunised at a specific time.Systematic vaccination: is an ongoing routine vaccination programme.

7) Vaccination coverage: is the proportion of the target population to which vaccine was administered during aspecified timeframe.

Salient features of vaccination program:

Certain criteria need to be followed to undertake vaccination strategies for disease prevention and control in animals. Vaccines are primarily meant to prevent diseases, reduce transmission of pathogens, improve animal and human health, welfare, and agricultural sustainability while reducing antimicrobial use. It emphasizes the importance of tailored vaccination programs based on epidemiological, technical, and resource considerations.

Aims and Objectives of the program:

Vaccination aims to prevent and control diseases and reduce pathogen transmission.Objectives include improving animal and human health, welfare, and agricultural sustainability.

Definitions:

- Emergency vaccination: immediate response to outbreaks or increased risk.
- Population immunity: proportion of immunized population.
- Systematic vaccination: ongoing routine program.
- Vaccination coverage: proportion vaccinated in a timeframe.

Vaccination Programs: Objectives and strategies of any control strategy depend on disease epidemiology, impact, and zoonotic potential.Regional coordination recommended for harmonized programs. A proactive liaison with public health authorities for always ensure zoonoses aspect of strategy.

Launch and implementation:

Considerations include disease epidemiology, containment feasibility, zoonotic potential, population immunity, vaccine availability, resources, and cost-benefit analysis.

Vaccination Strategies:

Barrier, blanket, ring, and targeted vaccination strategies based on disease epidemiology.

Choice of Vaccine:

Factors include availability, cost, vaccine characteristics, and side effects.Considerations vary depending on disease and vaccine type.

Critical Elements of Vaccination Program:

Legal basis, target population definition, vaccination coverage determination, stakeholder involvement, resources allocation, actions, timeline, timing of campaigns, auditing.

Logistics of Vaccination:

Detailed planning for vaccine procurement, equipment, implementation, human resources, public awareness, animal identification, record-keeping, and additional health-related activities.

Evaluation and Monitoring:

Periodic assessment of vaccination coverage, population immunity, side effects, and disease impact.

Exit Strategy:

Criteria for ceasing vaccination include disease eradication, risk reduction, alternative control measures, program effectiveness, adverse reactions, and cost-benefit analysis.

Impact assessment:

Vaccination can affect disease surveillance and trade; management strategies needed.

Overall, a comprehensive approach is needed in designing, implementing, and evaluating vaccination programs for disease prevention and control in animals, emphasizing tailored approaches based on epidemiological factors and available resources.

Key points for vaccination program

1. Newborn animals cannot be successfully vaccinated because of the presence of antibodiesderived from their mother. Effective vaccination must wait until maternal immunity haswaned.
2. Testing animals for preexisting antibodies prior to revaccination can help preventunnecessary vaccination.
3. The simultaneous administration of multiple vaccines to an animal does not present difficulties to the immune system of normal, healthy animals.
4. Vaccines can be categorized into several types, including inactivated, live attenuated, subunit, recombinant, and virus-vectored vaccines.
5. Some vaccines are adjuvanted, containing an additive to increase inflammation and the immune response.
6. Vaccines never confer 100% protection on an animal.
7. Always follow the manufacturer's instructions and do not vaccinate manifestly sick animals.

Table 1: Vaccination schedule for dairy animals

Sr. No	Disease/ pathogen	Age at first dose	Booster dose	Remark
1	Foot and MouthDisease (FMD)	4 months and above	1 month after first dose	Six monthly
2	HaemorrhagicSepticaemia (HS)	6 months and above	-	Annually in endemic areas.
3	Black Quarter (BQ)	6 months and above	-	Annually in endemic areas.
4	Brucellosis	4-8 months of age	-	Once in a lifetime
5	Theileriosis	3 months of age and above	-	Once in a lifetime. Only for crossbred and exotic cattle.
6	Anthrax	4 months and above	-	Annually in endemic areas.
7	IBR	3 months and above	1 month after first dose	Six monthly (vaccine presently not produced in India)
8	Rabies (as post-bite therapy only)	Immediately after suspected bite.	4th day	7,14,28 and 90 (optional) days after first dose.

CHAPTER 11

Management of Climatic Stress for Improved Health and Production

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Introduction

The discernible and projected ramifications of climate change, alongside shifts in global environmental variables, present formidable challenges to terrestrial ecosystems, comprising both flora and fauna, including human and livestock populations. This trend is also evident in adapted agro-ecological zones like arid regions, marked by a persistent decline in camel populations, rendering such areas increasingly susceptible to extreme climatic events. Environmental stressors such as drought, temperature extremes, ozone exposure, elevated carbon dioxide levels, soil water saturation, and salinity, compounded by biotic stressors, significantly curtail livestock productivity across all stages of production, thereby incurring substantial economic losses. Since stress within the microenvironment of an animal arises due to the interplay among these crucial interacting biotic and abiotic factors, their level, and the extent and duration of variations, it necessitates the optimal energy or resource accessibility to manage stressors. Abiotic stressors, in particular, compromises livestock welfare, causing reduction in growth, productivity, reproductive efficiency, immune responses, and health status. Additionally, optimal animal productivity hinges on factors such as genetics and other environmental conditions like feeding, housing, air circulation, and stocking rates, which also collectively influence the adaptable thermo-neutral range. Furthermore, camelids contend with an array of biotic stressors, including exposure to plant toxins, necessitating adaptive responses at various levels encompassing behaviour, endocrinology, metabolism, biochemistry, and molecular biology. Consequently, there exists a pressing need for optimal energy and resource availability to effectively mitigate these stressors.

Within the context of climate change, camels represent a promising avenue to bolster the socioeconomic resilience of underserved camel keepers by offering an alternative income source. Additionally, the pressing issue of global food security, exacerbated by population growth, calls for innovative solutions, including integrating camels into the food ecosystem. Despite their advantages over conventional livestock like cattle, sheep, and goats, camels have

been relatively overlooked. These animals provide essential resources such as meat and milk, playing a vital role in sustaining pastoral communities, particularly in harsh ecological environments where other domestic animals struggle. With increasing recognition of the health benefits associated with camel products, their traditional roles as transport and working animals have evolved into that of "food security animals," offering valuable commodities. The surge in non-bovine milk consumption over the past half-century highlights the nutritional richness and potential health benefits of camel milk, positioning it as a compelling alternative to traditional bovine milk. A shift is necessary in future strategies for camelids to ensure peak performance and justify the cost of domestication. This is especially pertinent this species, which often lack extensive feeding and housing management. Consequently, implementing adaptations and strategic interventions presents opportunities for sustainable production and are crucial to mitigate climate change-induced challenges (Fig. 1). Transforming camel farming from traditional nomadic practices to technologically advanced management systems is essential. Comprehensive strategies in this regard may encompass shelter management, nutritional interventions, genetic enhancement, and healthcare. Scientific management practices include altering herd composition, managing rangelands, providing training in camel husbandry, implementing intensive shelter management, and adjusting feeding practices. Promotion of mixed farming systems, low-cost stall feeding, and indigenous healthcare practices are also crucial. Studies indicate that camels in shaded areas exhibit natural behaviours for extended periods, suggesting that provision of shade enhances welfare conditions. Insufficient shaded areas and overcrowding can lead to negative welfare outcomes. Therefore, optimal housing conditions, including shade provision, are essential for maximizing productivity while ensuring animal welfare criteria such as thermal comfort and ease of movement.

Fig 1. 10-point strategy to strengthen the sustainable camel production in challenged agro-ecosystem.

Environmental stress and associated stressors

Climate change triggers ecological pressures such as limited food and water resources, temperature fluctuations, and more frequent extreme weather events. The interaction between the changing environmental dynamics and animal's adaptability profoundly influences species diversity within ecosystems and shapes the process of natural selection. Changes in environmental variables and the timing of specific weather patterns disturb the balance of ecosystems, resulting in shifts in biodiversity and species relationships. Moreover, these disruptions expose animals to new pathogens, potentially causing the emergence or resurgence of infectious diseases and affecting disease transmission by altering the distribution and abundance of disease vectors. Therefore it can be perceived that climate change significantly impacts disease dynamics, both directly and indirectly, exacerbating disease pressures within animal populations.

In field conditions, animals often experience multiple stresses simultaneously, including heat stress, nutritional challenges, water deprivation, and housing challenges, leading to a cascade of health issues. While heat stress and drought affect livestock productivity and health, camels possess unique physiological adaptations enabling efficient milk production even under water scarcity for extended periods. Numerous clearly defined housing elements, such as ventilation, cooling, flooring, animal density, and animal regrouping, can determine the onset and intensity of stress, and any inadequacy in these elements typically exacerbate seasonal stress. These complex multiple stressors lead to reduced growth, production, and reproductive potential due to nutrient redistribution for vital functions. Scientific findings underscore the impact of environmental stress, particularly heat stress, on camel's physiological parameters throughout seasons, affecting energy balance. Camels employ adaptive mechanisms like adaptive heterothermy and selective brain cooling to regulate body temperature, yet they can still experience heat stress, especially when dehydrated. Limited water availability, leading to reduced water intake, detrimentally affects feed digestion throughout the gastrointestinal tract, resulting in compromised production performance. Traditional practices and cultural preferences in arid regions influence camel husbandry methods which along with limited infrastructure and veterinary services, hinder the optimal management and productivity. Despite global efforts to enhance camel milk production, camels lag behind cattle and buffalo, underlining the need for comprehensive strategies and intensive care in these regions.

Effect on physiological, blood biochemical response, productive performance and reproductive potential

Animals possess intrinsic mechanisms to adapt to environmental challenges, involving physiological, molecular, endocrine, biochemical, and behavioural adjustments. Homeostasis, the primary adaptive mechanism, regulates vital physiological variables such as respiration rate, pulse rate, rectal temperature, sweating rate, and skin temperature to maintain thermal equilibrium. When ambient temperature deviates from the thermoneutral zone, a range of physiological and behavioural adaptive responses is triggered to restore homeothermy, promoting welfare, survival, and facilitating growth. Abiotic stressors impact water, protein, energy, and mineral metabolism, altering enzymatic reactions, biochemical profiles, and blood metabolite levels. Elevated ambient temperature affects the hypothalamic appetite centre, intestinal function, and metabolic pathways, leading to reduced growth performance. Cold stress, though rare, increases energy expenditure for thermoregulation, potentially impairing digestion and metabolic balance. Wind exacerbates cold stress, requiring more energy to maintain body temperature. Stress hormones influence reproductive function by suppressing gonadotropin secretion and impairing reproductive organ function. Heat stress negatively affects the anterior pituitary, pre-ovulatory follicle, corpus luteum, embryo development, estrus incidences and estrus intensity, leading to low fertility and fetal loss.

Different managemental strategies to counter abiotic stress for improved health and production

Climatechange induced abiotic stressors negatively affects the livestock health and production. These effects have huge economic consequences that lowers the livestock production profitability both directly and indirectly. Consequently, amelioration of either these abiotic stressors or their deleterious effects on livestock production is very important to achieve greater monetary benefits and maintain welfare of livestock. Few of the important ameliorative strategies (Fig. 2) to counter abiotic stressors are briefly discussed below:

Shelter management

Proper shelter management plays a crucial role in minimizing the effects of abiotic stressors on livestock. In animal shed, characteristics of floor, ventilation, ceiling height, properties of different roofs and space consideration are significant in the reducing stress especially associated to abiotic stress. To manage the inclement effect of climate effectively and if animals are required to keep in intensive system, the following measures should be

considered like adequate ventilation, shade provision, roof insulation, proper flooring, rest areas,optimal manger and water trough, sanitary measures and biosecurity protocols.

- Ensure proper airflow within the shelter to remove heat and humidity.
- Supplement natural ventilation with mechanical ventilation systems if necessary.
- Provide ample shade within the shelter and outdoor areas to protect animals from direct sunlight.
- Install roof insulation to reduce heat flow into the barn and maintain cooler temperatures.
- Plant trees or construct shade structures to create shaded zones that can be natural (trees) or artificial (cloth/plastic roof on metal or wood frame, gable type roof).
- For camel thatched roofed open type kuchcha shelter and loose housing are better.
- Construction of the shelter by utilising locally available eco-friendly agriculture materials like roof by Kheep plant, enclosure from bamboo/bali and shading around by Kikar plant.
- Offer resting areas with comfortable bedding along walking routes to allow animals to rest and recover during long journeys.
- Provide sufficient and continuous access to clean water to prevent water stress.Ensure water availability and quality to prevent dehydration and impaired physiological functions.
- Implement strict biosecurity measures to prevent disease introduction and spread.
- Control visitor access, quarantine new animals, and maintain hygiene practices.
- Regularly clean and disinfect shelters, equipment, and feeding areas to minimize disease transmission.
- Follow recommended disinfection protocols for different pathogens to ensure effective disease control.

Nutritional intervention

Livestock thrive best when maintained within a thermoneutral zone and provided with optimal nutrition. However, in real-world conditions, these animals encounter various stressors, including environmental factors like erratic rainfall and extreme temperatures. These stressors often lead to reduced forage yield and quality, resulting in nutritional stress, particularly in protein, micronutrients, and essential fatty acids. Moreover, climate-related

influences can elevate the levels of certain plant compounds known to hinder nutrient absorption and utilization. These compounds, such as tannins, saponins, alkaloids, and polypeptides, can bind with nutrients and enzymes crucial for digestion, making them inaccessible to livestock. This reduced nutrient availability contributes to nutritional stress, negatively impacting the health, physiology, and productivity of animals. Addressing nutritional stress caused by multiple stressors requires exploring effective strategies. Nutritional interventions offer a practical approach to mitigating climatic stresses and minimizing associated damages without imposing significant costs. These interventions may involve adjusting energy and nutrient density in feed, balancing electrolytes, and incorporating feed additives and antioxidants to support animal health and performance

- Ensure proper nutrition tailored to each livestock species and production stage to avoid nutritional stress. Formulate diets that meet specific nutritional requirements.
- Use high-quality feed ingredients and proper storage to prevent spoilage and nutrient degradation.
- Monitor feed availability and intake to prevent competition, nutritional deficiencies, and negative energy balance.
- Feeds high in fiber and proteins produce more heat during digestion and metabolism, leading to decreased feed intake in animals during hot summer conditions and reduced energy intake.
- Regulate energy density of the diet by increasing metabolizable energy (e.g., through bypass fat supplementation) that can compensate for reduced intake and provide necessary energy for thermoregulation.
- Incorporate easily digestible carbohydrates and balanced amino acids in the diet for maintaining energy balance in lactating animals.
- Adjust dietary electrolyte balance according to the season and nutrient composition of the diet.
- Supplementation of antioxidants is crucial to counter oxidative stress caused by heat stress.
- Include antioxidants such as vitamin E, vitamin C, or selenium (Se) and feed additives in the diet to balance the level of free radicals, support the animal's antioxidant defense system, and enhance production attributes.

Health management

Providing suitable shelter and housing facilities is essential to shield animals from harsh weather conditions. Alongside this, proper nutritional and water management is crucial to ensure animals receive a balanced diet and have continuous access to clean water, meeting their physiological needs and aiding in stress management. Additionally, implementing environmental enrichment strategies can contribute to reducing stress levels and enhancing animal welfare, allowing them to better cope with various stressors and promoting overall well-being. Monitoring reproductive health, including estrus cycles, pregnancy, and parturition, is essential for successful breeding and reproduction in camel herds. There must be a composite plan for emergencies, such as injury or illness, ensuring prompt medical attention and appropriate care for camels in distress and during transport. Keeping animals up-to-date on vaccinations and implementing effective disease prevention measures are vital steps in minimizing the risk of disease outbreaks and associated stress. Regular monitoring for signs of stress or health issues enables timely intervention and treatment when necessary. Lastly, scheduling regular veterinary check-ups and promptly providing medical attention when needed can significantly improve an animal's ability to endure and recover from stressors.

Genetic approaches

Through the process of natural selection, species gradually adapt and evolve to better survive and reproduce in their specific ecological environments. However, this evolutionary process typically takes a significant amount of time. As a result, modern genetic approaches have gained prominence in addressing this constraint. Techniques such as selective breeding, marker-assisted selection (MAS), genomic selection, genetic engineering, and transgenic technologies are increasingly utilized to target adaptive traits for mitigating abiotic stresses. Selective breeding plays a crucial role in this regard, involving the identification and breeding of animals with desirable genetic traits that confer improved tolerance to specific abiotic stressors, tailored to particular agro-climatic conditions. Traits such as heat tolerance, cold tolerance, water-use efficiency, and resilience to specific stressors are considered in this process. Selecting for thermotolerance alongside production traits in livestock can be based on differences in physiological, blood-biochemical, and genetic markers. Genomic selection, on the other hand, entails analyzing an animal's entire genome to predict its breeding value for various traits, including abiotic stress tolerance. By identifying specific genomic regions associated with stress tolerance, genomic selection enables breeders to make more informed decisions regarding animal selection for breeding purposes. This approach holds the potential

to accelerate genetic progress in enhancing both production performance and stress tolerance in camels.

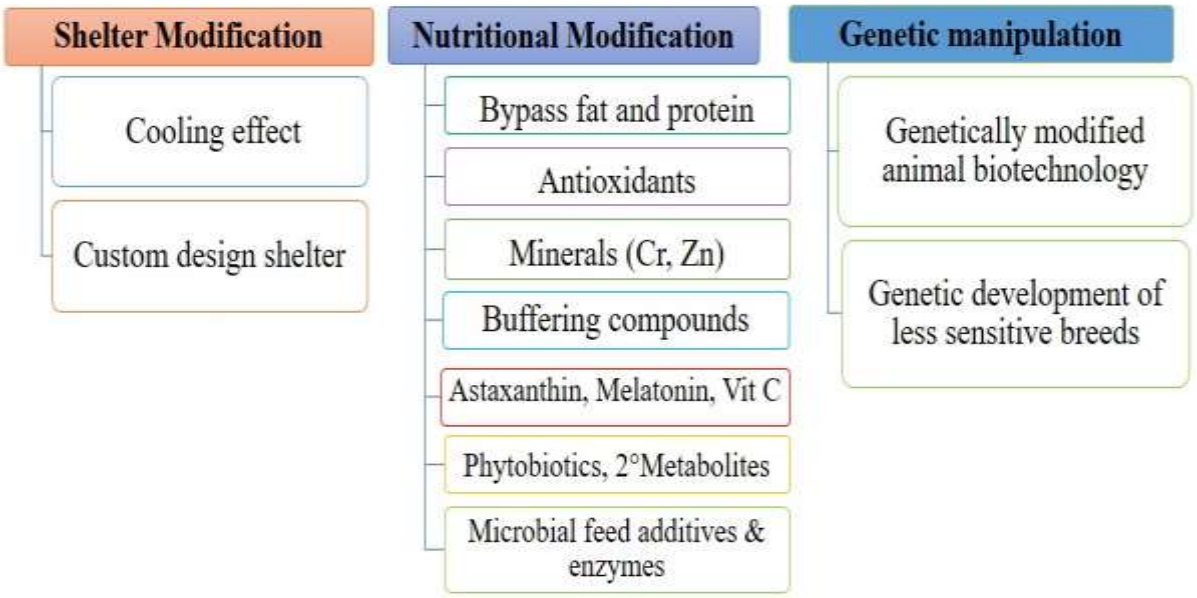

Fig 2. Basic ameliorative measures against complex climatic stressors.

Conclusion and way forward

The confluence of increasing climate challenges, rapid disease spread, limited access to quality feed, and the adoption of intensive production practices poses significant pressure on both domestic livestock and camels. This dynamic climate, especially in extreme agro-ecosystems, exposes animals to various abiotic stressors, prompting them to prioritize nutrients for vital functions over production pathways. This results in decreased growth, milk and meat production, immune function, and overall health. However, employing sustainable practices, technological advancements, and proactive management can mitigate the impact of these stressors, ensuring the long-term viability and resilience of livestock farming systems. Integrating genetic strategies with management practices such as shelter and health management, improved nutrition, environmental modification, and stress reduction techniques can effectively mitigate the impacts of abiotic stressors on animal health and productivity. Revising breeding policies and identifying quantifiable biomarkers using advanced "OMICS" technologies for marker-assisted selection programs offer opportunities to develop more climate-resilient breeds. Additionally, precision livestock farming holds promise for accurately predicting welfare and production performance. Hence, policymakers should prioritize the development of climate-smart animal agriculture with a farmer-centric approach to support

economically disadvantaged populations and sustain camel production amidst changing climate conditions.

CHAPTER 12

The Importance of Camels in One Health Program

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Introduction

Human, animal, and environmental health interconnectedness has been recognized by medical practitioners since ancient times. However, a collaborative effort to address these essential components together was lacking until recent past. The work on One Health Program (OHP) gained momentum after recognizing that human, animal, and environmental health are interconnected and a holistic, interdisciplinary strategy is essential to achieve a sustainable solution for severalglobal health challenges, particularly for emerging and re-emerging diseases.

This concept of OHP traces its roots back to the 19thcentury when physicians like Rudolf Virchow emphasized the link between human and animal health, coined the term "zoonosis" to describe diseases that can be transmitted from animals to humans. In the early 21stcentury, the contemporary One health movement began to gain momentum, driven by emerging infectious diseases such as Severe Acute Respiratory Syndrome (SARS), H5N1 Bird Flu, and later H1N1 influenza (Swine Flu). These outbreaks highlighted the need for a more integrated approach to address the human, animal and environmental health.Finally, the global outbreak of the COVID-19 pandemic drawn internationalattention to the critical need for the OHP, considering the zoonotic origins of the virus and the global impacts of the pandemic.The One Health framework promotes integrated efforts in disease prevention, surveillance, and response, advocating for policies that consider the health of people, animals, and ecosystems as interdependent and inseparable.

'One Health' is an integrated, unifying approach that aims to achieve optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment. It is particularly important to prevent, predict, detect, and respond to global health threats such as the COVID-19 pandemic.'One Health' is a collaborative, multi-sectoral, and trans-disciplinary approach. It promotes working at local, regional, national, and global levels.

A. Importance of One Health Programme in India

The One Health Programme is crucial for India due to its unique demographic and ecological characteristics. Itis vital for addressing the following challenges:

High Burden of Zoonotic Diseases

With a large and dense human population, alongside a substantial livestock population, the country faces heightened risks of zoonotic diseases. India's history is dotted with outbreaks of zoonotic diseases, such as Anthrax and Rabies, which persisted in various regions. More recently, the country faced challenges from the Nipah Virus, which led to localized outbreaks in Kerala, and the H5N1 Avian Influenza, that affected poultry farms across multiple states, leading to the culling of birds and significant economic losses. The emergence of COVID-19, which is suspected to have a zoonotic origin, further highlights the critical need for a coordinated OHP to prevent and control such diseases.

Antimicrobial Resistance (AMR)

The misuse and overuse of antibiotics in both human healthcare and livestock farming have led to a growing problem of antimicrobial resistance (AMR) in India. For instance, in the poultry industry, antibiotics are often used as growth promoters, leading to the development of drug-resistant bacteria that can easily spread to humans. The OHP emphasizes the need for integrated crosssectororial programs to monitor and regulate antibiotic use, thereby preventing the spread of drug resistantbacterial pathogens.

High Dependency on Agriculture and Livestock Sector

India's agricultural sector is closely tied to livestock industry, with many smallholder farmers depending on animals for their livelihood. This interdependence creates pathways for diseases to spread between animals and humans. For example, the recent outbreak of Lumpy Skin Disease in cattle caused significant economic losses to farmers and highlighted the vulnerability of the livestock sector to emerging diseases. Similarly, the ongoing threat of Avian Influenza requires vigilant monitoring and rapid response measures to protect both animal and human health.

Wildlife Conservation and Biodiversity

India is the home to rich biodiversity and extensive forested areas, making it a hotspot for wildlife-related zoonotic diseases. For instance, the spread of the Kyasanur Forest Disease (Locally known as Monkey Fever or or *manganakayile*) in parts of Karnataka is linked to interactions between humans and infected ticks in forested regions. Deforestation and

significant alterations in land use have brought the virus and its carriers into closer proximity to humans. The OHP plays a crucial role in conserving biodiversity by promoting practices that reduce human-wildlife conflicts and monitoring wildlife health to prevent the spillover of diseases into human populations.

Integrated Public Health Response

The COVID-19 pandemic exposed the gaps in India's public health system, particularly in terms of preparedness, coordination, and response. A one health approach promotes an integrated public health response that brings together experts from human health, animal health, and environmental sciences. This integration is crucial for development of early warning systems, rapid response mechanisms, and development of vaccines and therapeutics to address zoonotic diseases.

Changing Food Patterns

India's food patterns are changing rapidly, with increasing consumption of animal products. This shift raises concerns about food safety, as well as the environmental impacts of livestock farming, such as greenhouse gas emissions and water usage. The demand for animal-based products can lead to changes in farming practices, such as intensified livestock production. This can increase the risk of zoonotic diseases if not managed properly.Theone health approach emphasizes sustainable agricultural practices and the need for a food system that is resilient, safe, and capable of supporting the health of both people and the planet.

The strength of the OHP lies in its ability to bring together diverse sectors (e.g. public health, veterinary services, agriculture, and wildlife conservation) to create a unified response to health threats. It is essential for India, offering a comprehensive framework to address the complex interactions between human, animal, and environmental health. By fostering collaboration across sectors, it enhances the country's preparedness and response to emerging health challenges, ultimately protecting the well-being of its people, animals, and ecosystems.

Interdependency between Human and Animal Health

Human and animal health are deeply interconnected, with the well-being of one directly impacting the other. This interdependence is particularly evident in the context of zoonotic diseases, antibiotic resistance, food safety, environmental health, and the broader economic and social landscape.

Zoonotic and Zooanthroponoses Diseases

Zoonotic diseases, which are transmitted from animals to humans, and zooanthroponoses, which are transmitted from humans to animals, are clear examples of this interdependence. In India, diseases like Rabies, often spread by stray dogs, are a major public health concern. Similarly, Nipah virus, first identified in India in 2001, spread from fruit bats to humans, causing severe outbreaks. On the other hand, tuberculosis (TB), a human disease, can be transmitted to cattle, affecting both livestock health and productivity.

Pets and Companion Animals

Pets and companion animals also play a role in human and livestock health. In urban India, the growing trend of keeping pets has resulted into an increased focus on their health and well-being. However, pets can also transmit diseases like Leptospirosis and Toxoplasmosis to their owners. Proper veterinary care, vaccination, and hygiene practices are essential to ensure the health of both pets and their owners.

Antibiotic Resistance

The misuse of antibiotics in both human medicine and animal husbandry has led to the rise of antibiotic-resistant bacteria, posing a significant threat to global health. In India, antibiotics are frequently used in livestock to promote growth and prevent disease, often without proper oversight. This has led to the emergence of drug-resistant bacteria like Methicillin-resistant *Staphylococcus aureus* (MRSA) in both animals and humans. The spread of such resistant strains makes infections harder to treat in humans, demonstrating the critical need for a one health approach to managing antibiotic use.

Food Safety

Food safety is another area where human and animal health intersects. The consumption of contaminated animal products can lead to foodborne illnesses in humans. For example, outbreaks of Salmonella and *E. coli* in India have been linked to the consumption of contaminated meat and dairy products. Ensuring the health of livestock through proper veterinary care, sanitation, and disease control is essential for preventing these outbreaks and safeguarding public health.

Environmental Health

Environmental health is closely tied to both human and animal health. Pollution, deforestation, and climate change can create conditions that favors the spread of diseases among animals, which can then be transmitted to humans. In India, deforestation and encroachment into wildlife habitats have been linked to the spread of diseases like Kyasanur Forest Disease (Monkey Fever). Protecting the environment, therefore, plays a crucial role in maintaining the health of both humans and animals.

Economic and Social Impact

The economic and social impact of the interdependence between human and animal health is significant. Outbreaks of zoonotic diseases can devastate communities, leading to loss of income, reduced food security, and increased healthcare costs. For instance, the 2020 outbreak of Lumpy Skin Disease in cattle caused significant economic losses for Indian dairy farmers, who rely heavily on livestock for their livelihoods.

The health of humans and animals is inextricably linked, with each influencing the other in numerous ways. Addressing health issues in one domain without considering the other can lead to incomplete solutions and ongoing risks. A holistic, one health approach that recognizes and responds to these interdependencies for improving public health, safeguarding food supplies, protecting the environment, and ensuring economic stability in India and beyond.

B. Effect of Environment on Human and Animal Health

The environment plays a crucial role in shaping the health and well-being of both humans and animals. Various environmental factors such as air and water quality, soil conditions, climate change, and urbanization have direct and indirect impacts on health.

Respiratoryproblemsand Stress due to Air Pollution:

Air pollution is a significant environmental health issue in India, particularly in urban areas like Delhi, Gurugram, Mumbai, and Kolkata. High levels of particulate matter (PM2.5 and PM10), nitrogen oxides, and sulfur dioxide from vehicles, industries, and burning of crop residues contribute to respiratory diseases in humans, such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD). For animals, especially livestock and pets, prolonged exposure to polluted air can lead to respiratory distress and reduced productivity. For example, dairy cattle in regions with poor air quality often show decreased milk production due to stress and respiratory problems.

Waterborne Diseases and Chemical Contaminants due to Water Pollution:

Water pollution in India, caused by the discharge of industrial effluents, agricultural runoff, and untreated sewage, leads to a range of waterborne diseases. Contaminated water sources are breeding grounds for diseases like cholera, viral hepatitis-A, and typhoid, affecting millions of people annually. Chemical contaminants like heavy metals (arsenic, lead) in water sources also pose serious health risks. Forexample, in the state of West Bengalarsenic contamination in groundwater has led to chronic arsenic poisoning among humans, as well as in animals that rely on the same water sources, leading to skin lesions, organ damage, and increased mortality rates. Likewise, excess fluoride either occurring naturally in groundwater or due to industrial contamination affects health and well being of both animals and livestock.

Chemicals and Heavy Metals Contamination due to Soil Quality Degradation:

The use of pesticides, fertilizers, and other agricultural chemicals significantly affects soil quality, with direct consequences for both human and animal health. In India, excessive use of chemical fertilizers has led to the accumulation of heavy metals like cadmium and lead in the soil, which can be absorbed by crops and enter the food chain. Animals grazing on contaminated soil may ingest these toxic substances, leading to health issues such as reduced fertility and growth rates. Humans consuming contaminated crops and livestock products are at risk of chronic diseases, including cancer and neurological disorders.

Heatwaves and Natural Disasters due to Climate Change:

Climate change is increasingly affecting India, with rising temperatures and more frequent natural disasters such as floods, droughts, and cyclones. Heatwaves, particularly in northern and central India, have become more common, leading to heat-related illnesses such as heatstroke and dehydration in humans and animals alike. For example, the 2019 heatwave in India resulted in hundreds of human deaths and significant livestock mortality due to extreme temperatures and water scarcity. Additionally, natural disasters like the 2020 Cyclone Amphanin West Bengal displaced millions, leading to health crises due to poor sanitation, waterborne diseases, and malnutrition.

Human-Wildlife Interaction:

Increased human encroachment into wildlife habitats has led to more frequent and closer interactions between humans and wild animals, raising the risk of zoonotic disease transmission. In India, deforestation and expansion of agricultural land into forested areas have brought humans into closer contact with species such as bats, monkeys, and rodents, which can

carry diseases like Nipah virus and Kyasanur Forest Disease (Monkey Fever). These interactions not only threaten human health but also disrupt ecosystems, leading to imbalances that can harm both wildlife and human communities.

Urbanization and Heat-Related Illnesses

Rapid urbanization in India has led to the creation of "urban heat islands," where temperatures are significantly higher than in surrounding rural areas due to concrete structures, asphalt, and reduced vegetation. Cities like Delhi and Chennai experience extreme temperatures during summer, exacerbating heat-related illnesses in humans such as heat exhaustion and heatstroke. Urban animals, including stray dogs and birds, also suffer from dehydration and heat stress during these periods, leading to increased mortality.

Shifts of Habitat and Range track

Climate change is causing shifts in the geographical range of many species, including insects, birds, and plants. In India, changes in temperature and precipitation patterns have led to the northward migration of mosquito species, increasing the range of vector-borne diseases like malaria and dengue fever into previously unaffected areas. These shifts also disrupt local ecosystems and can lead to conflicts between migrating wildlife and human populations, as seen in the increasing incidents of human-elephant conflicts in states like Odisha and Jharkhand.

Noise Pollution and Light Pollution

Noise and light pollution, particularly in urban areas, have significant impacts on both human and animal health. Chronic exposure to noise pollution, such as traffic and industrial noise, can lead to stress, sleep disturbances, and cardiovascular problems in humans. For animals, especially birds and nocturnal species, noise pollution can disrupt communication, mating calls, and feeding patterns, leading to reduced reproductive success. Light pollution in cities disrupts the natural behaviours of nocturnal animals, such as bats and owls, and can affect human circadian rhythms, leading to sleep disorders and other health issues.

C. Core Principles of the One Health Program

The One Health program is built on several core principles that guide its approach to improving health outcomes at the human-animal-environment interface. These principles are particularly relevant in a country like India, where diverse ecosystems, a large human and livestock population, and complex health challenges intersect.

Interconnected Health

The One Health program recognizes that the health of humans, animals, and ecosystems are inextricably linked.

Multisector & Multidisciplinary Collaboration

One Health emphasizes the need for collaboration across multiple sectors and disciplines, including human medicine, veterinary science, wildlife conservation, agriculture, and environmental science.

Prevention and Control: Early Detection & Proactive Measures

Early detection and proactive measures are essential components of the one health approach.

Sustainable Practices: Long-Term Solutions

Sustainability is at the core of the one health approach, which seeks long-term solutions that are not only effective but also environmentally and economically viable.

Integrated Public Health Response

An integrated public health response is vital for addressing health challenges that cross the boundaries between human, animal, and environmental health.

Cultural and Socioeconomic Considerations

Another important principle of one health is the recognition of cultural and socioeconomic factors in health outcomes.

Key Objectives of the One Health Program

The OHP aims to address the complex health challenges arising from the interconnectedness of human, animal, and environmental health.

Zoonotic Disease Control

One of the primary objectives of the OHP is to control and prevent zoonotic diseases. Vaccination programs for animals, such as rabies vaccination campaigns for dogs, are crucial in reducing the risk of transmission to humans.

Combat Antimicrobial Resistance (AMR)

The OHP also aims to combat antimicrobial resistance (AMR), a growing global health threat exacerbated by the misuse of antibiotics in humans, animals, and agriculture. The One Health approach encourages the adoption of best practices in animal husbandry, such as improved biosecurity measures and alternatives to antibiotics, to reduce the emergence of AMR.

Pollution Control

Pollution control is another key objective of the OHP, as environmental pollution directly impacts human and animal health. The OHP advocates for the implementation of policies that reduce pollution at the source, promote sustainable agricultural practices, and ensure safe disposal of waste.

Habitat Protection

Protecting natural habitats is essential for preventing the spreadof diseases from wildlife to humans and livestock.

Food Safety

Ensuring food safety is a critical objective of the OHP, as the safety of food products is closely linked to the health of animals and the environment. The one health approach promotes the adoption of good agricultural and manufacturing practices, as well as the implementation of robust food safety regulations. The Food Safety and Standards Authority of India (FSSAI) plays a key role in setting and enforcing standards to ensure that food products are safe for consumption.

Vector Control

Controlling vectors, such as mosquitoes, ticks, and flies, is essential for preventing the spread of vector-borne diseases like malaria, dengue, and Japanese encephalitis in India. The OHP advocates for integrated vector management, which includes environmental management, biological control, and the judicious use of insecticides. For instance, in areas where vector-borne diseases are prevalent, strategies such as improving water management, promoting the use of mosquito nets, and deploying biological controls like fish that feed on mosquito larvae are part of a comprehensive approach to vector control.

Develop Public Awareness

Raising public awareness is crucial for the success of the OHP, as informed communities are better equipped to participate in disease prevention and health promotion programs. In India,

public awareness campaigns about zoonotic diseases, the dangers of antimicrobial resistance, and the importance of hygiene and sanitation have been essential in reducing health risks. For example, the government's Swachh Bharat Abhiyan (Clean India Mission) has significantly improved public awareness about the importance of sanitation in preventing disease. The OHPencourages similar initiatives that educate the public about the interconnectedness of human, animal, and environmental health and the role individuals can play in protecting it.

Strengthening Health Infrastructure

Another important objective of the OHP is to strengthen health infrastructure to better respond to emerging health threats. In India, this includes improving the capacity of laboratories to diagnose zoonotic diseases, enhancing surveillance systems, and ensuring that health services are accessible, especially in rural and remote areas. The COVID-19 pandemic underscored the need for robust health infrastructure that can rapidly adapt to new challenges. Investments in health infrastructure, such as the establishment of the National Centre for Disease Control (NCDC) and the expansion of the Integrated Disease Surveillance Programme (IDSP), are aligned with the One Health objectives of early detection and response to health threats.

D. Implementation Strategies for the One Health Program

Implementing the OHP in India requires a comprehensive approach that integrates policy development, research, community engagement, data sharing, and other critical strategies. These strategies are designed to address the complex health challenges that arise at the intersection of human, animal, and environmental health.

Policy Development

Policy development is a crucial strategy for the successful implementation of the OHP in India. This involves creating and enforcing policies that promote the collaboration of various sectors, including health, agriculture, environment, and wildlife. The Indian government has made steps in this area by launching the National Action Plan for AMR (2017-2021), which outlines a coordinated approach to tackle antimicrobial resistance through multisectoral collaboration. The Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) in its 21stmeetingon 7thJuly 2022, approved to set up a National One Health Mission with a cross-ministerial effort to coordinate, support, and integrate all the existing one health activities in the country and fill gaps wherever it is appropriate.Additionally, policies that support the conservation of wildlife and natural habitats, such as the Wildlife Protection Act, 1972, are

integral to preventing zoonotic diseases. Developing policies that incentivize sustainable agricultural practices, regulate the use of antibiotics in livestock, and protect biodiversity are essential for advancing the one health agenda in India.

Research and Innovation

Research and innovation are at the heart of the OHP, driving the development of new tools, technologies, and strategies to address health challenges. In India, research organizationslike the Indian Council of Medical Research (ICMR) and the Indian Council of Agricultural Research (ICAR) play a pivotal role in advancing one health research. For example, research on the Nipah virus outbreak in Kerala led to a better understanding of the virus's transmission from bats to humans, informing public health responses. Innovations in vaccine development, diagnostics, and disease surveillance technologies is also crucial. The development of vaccines for livestock diseases, such as the Foot-and-Mouth Disease (FMD), not only protects animal health but also safeguards human livelihoods and food security.

Community Engagement

Community engagement is vital for the effective implementation of the OHP, as it ensures that local populations are informed, involved, and empowered to take action. In India, engaging communities in rural and tribal areas, where human-animal-environment interactions are most pronounced, is particularly important. For example, awareness campaigns about zoonotic diseases like rabies and the importance of vaccinating domestic animals can significantly reduce the incidence of human infections. Involving local communities in wildlife conservation efforts, such as those in and around protected areas like the Sundarbans (West Bengal), helps in the preservation of biodiversity and reduces the risk of human-wildlife conflict. Community-based initiatives that promote hygiene, sanitation, and sustainable agricultural practices can also play a crucial role in preventing the spread of zoonotic diseases.

Data Sharing and Communication

Effective data sharing and communication are critical for the OHP success, as they enable timely responses to health threats and facilitate informed decision-making. In India, improving the integration and sharing of health data across sectors is essential for early detection and management of zoonotic diseases. The Integrated Disease Surveillance Programme (IDSP) is an example of an initiative that collects and shares data on human health, which can be

expanded to include animal health data for a more comprehensive approach. Collaboration between different ministries, research institutions, and international organizations can enhance data sharing and improve the country's ability to respond to health crises. Transparent communication with the public about health risks and preventive measures is also crucial, as seen during the COVID-19 pandemic when accurate information was key to controlling spread of the virus.

Capacity Building and Training

Building capacity and providing training to professionals across sectors are essential for the successful implementation of OHP. This includes training of healthcare workers, veterinarians, environmental scientists, and agricultural workers on the principles of one health and how to apply them in their work. In India, initiatives like the establishment of the Centre for One Health (CoH) can provide specialized training and resources to professionals involved in managing health at the human-animal-environment interface. Additionally, strengthening the capacity of local health systems, particularly in rural areas, ensures that they are better equipped to detect and respond to zoonotic diseases and other health threats.

E. Status of One Health Initiatives at the Global and National Levels

The one health approach has gained significant drive both globally and in India as an essential framework for addressing the interconnected health challenges of humans, animals, and the environment. The status of one health initiatives reflects ongoing efforts to institutionalize this approach through policy, collaboration, research, and capacity building.

E.1 Key Global Initiatives:

Globally, one health initiatives have been recognized crucial for addressing issues like zoonotic diseases, antimicrobial resistance (AMR), and environmental health. Several international organizations, including the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organisation for Animal Health (WOAH, formerly OIE), have been at the forefront of promoting one health.

a) International Collaboration:

In March 2022, four international agencies, the FAO, WOAH, the UN Environment Programme (UNEP) and the WHO, signed an agreement to strengthen cooperation to sustainably balance and optimize the health of humans, animals, plants and the environment to form a quadripartite collaboration for one health.

b) One Health Global Leaders Group on AMR:

Thisgroup was launched in 2020. It comprises global leaders who advocate for urgent and sustained global action to combat AMR. They emphasize the need for a one health approach to ensure that human, animal, and environmental sectors work together to reduce the threat of AMR.

c) Pandemic Preparedness and Response:

The COVID-19 pandemic has underscored the importance of the one health approach in pandemic preparedness and response. Global initiatives, such as the Coalition for Epidemic Preparedness Innovations (CEPI), focus on developing vaccines and other measures to prevent zoonotic diseases from becoming global pandemics.

d) Examples of Global One Health Successes:

Rinderpest Eradication:

The global eradication of Rinderpest, a devastating cattle disease, is a prime example of a successful one health initiative. The collaboration between veterinary, health, and agricultural sectors, supported by international organizations, led to eradication of the disease, benefiting both animal and human populations by securing food supplies and livelihoods.

e) One Health Initiative in Vietnam:

In Vietnam, a One Health approach has been implemented to control avian influenza. Collaboration between the Ministry of Health, Ministry of Agriculture, and international partners has led to better disease surveillance and response strategies, thereby significantly reducing the avian influenza outbreaks.

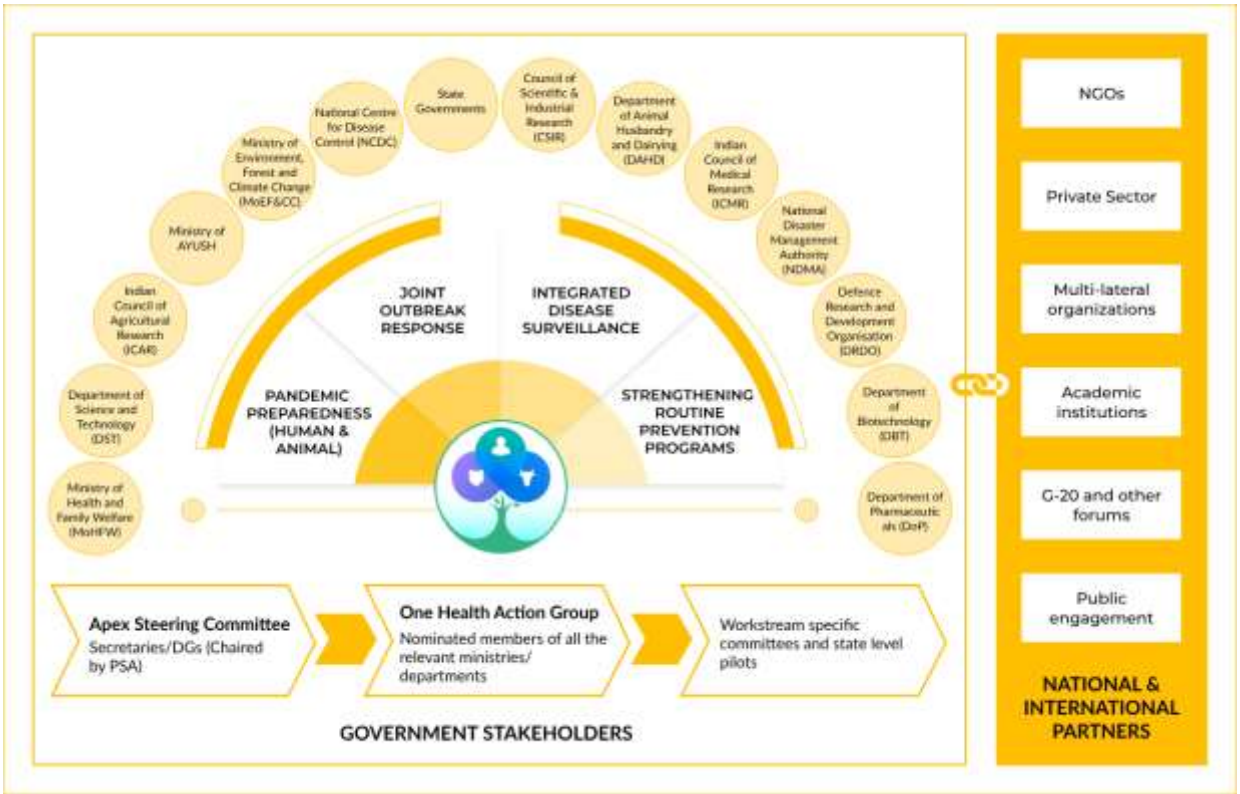
E.2 Key National Initiatives in India

In India, the one health approach has been gradually integrated into various health and environmental initiatives. Recognizing the country's vulnerability to zoonotic diseases, AMR, and environmental degradation, the Indian government and other stakeholders have made efforts to adopt One Health principles.

a. National One Health Mission

National One Health Mission with a cross-ministerial effort which will serve to coordinate, support, and integrate all the existing one health activities in the country and fill gaps where it is appropriate.

The National One Health Mission is a cross-ministerial effort which was formed to coordinate, support, and integrate all the existing One Health activities in the country.



Source:https://www.psa.gov.in/innerPage/psa-initiatives-covid/national-one-health-mission/4053/4053

The Mission aims to improve pandemic preparedness and disease control across human, animal, and plant sectors. It focus on early warning systems using integrated surveillance and response plans for both ongoing and new epidemic or pandemic threats.The Mission has to work on key areas of preparedness. This includes targeted research and development to create vaccines, diagnostics, and treatments. It will ensure readiness in clinical care, improve data sharing across sectors, and encourage close community involvement to maintain our ability to respond effectively.

b. National Action Plan on AMR (2017-2021):

India's National Action Plan on AMR is a comprehensive strategy that aligns with the global action plan. It focuses on surveillance, research, infection prevention, and antimicrobial stewardship across human, animal, and environmental sectors. The plan emphasizes the need for a one health approach to tackle AMR effectively.

c. National Mission on Biodiversity and Human Well-being:

Launched in 2018, this mission under the Indian government's National Action Plan on Climate Change aims to link biodiversity with human well-being through the one health framework. It focuses on protecting ecosystems, promoting sustainable agriculture, and enhancing the resilience of communities to health risks associated with environmental changes.

d. Zoonotic Disease Surveillance and Control:

India has strengthened its surveillance and control mechanisms for zoonotic diseases through programs like the Integrated Disease Surveillance Programme (IDSP) and the National Centre for Disease Control (NCDC). These initiatives monitor disease outbreaks in humans and animals, allowing for timely interventions.

F. Importance of Camel in Human & Environment Health

Camels, often called the "ships of the desert," are pivotal to the one health approach, which integrates human, animal, and environmental health. In India's arid regions, camels contribute significantly to this framework through their roles in nutrition, sustainable land management, disease research, and economic sustenance.

1. Camel Milk: Nutraceuticals

Camel milk is gaining recognition for its health benefits, particularly in managing diabetes, autism, TB and and gastrointestinal disorders. Camel milk is emerging as a superfood, richin insulin-like proteins, immunoglobulins, vitamins, and minerals. In Rajasthan and Gujarat, camel milk is traditionally consumed by local communities, and its demand is growing in urban areas due to its health benefits.

2. Sustainable Grazing

Camels play a crucial role in sustainable grazing, essential for maintaining ecological balance in arid regions.Camel grazing has a positive pruning effect on the local trees.Itsupportsthe germination of the hard-shelled seeds.

Less Methane Production: Camel is a environment friendly herbivore that produces less methane per kg body weight per day in comparison to other domestic ruminants like cattle and buffalo**.**

a. Zoonotic Disease Studies

Camels are central to studying zoonotic diseases like MERS, Brucellosis, and Camelpox, which can spread from animals to humans. In India, monitoring these diseases in camel populations is vital for preventing potential outbreaks.

b. Biomedical Research: Camel Antibodies

Camels possess unique antibodies, known as nanobodies, which are smaller and more stable than conventional antibodies. These nanobodies are being explored for their potential in treating diseases like cancer and developing snake antivenom.

c. Seed Dispersal: Biodiversity Support

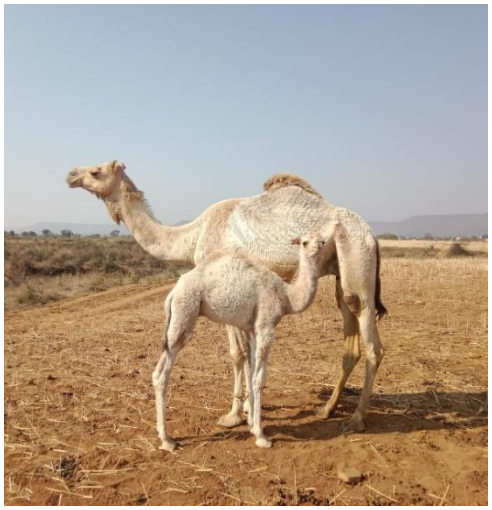
Camels contribute to environmental health by aiding in seed dispersal. As they graze, they ingest and later excrete seeds, promoting the growth of diverse plant species. This natural process helps regenerate vegetation in arid regions like Rajasthan and Gujarat, supporting local ecosystems and enhancing biodiversity.

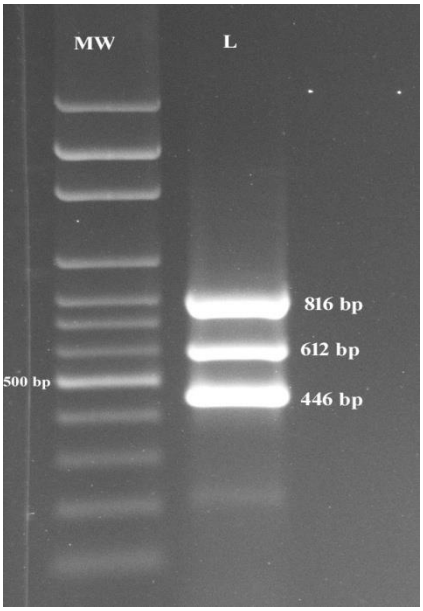
d. Livelihood and Economic Benefits

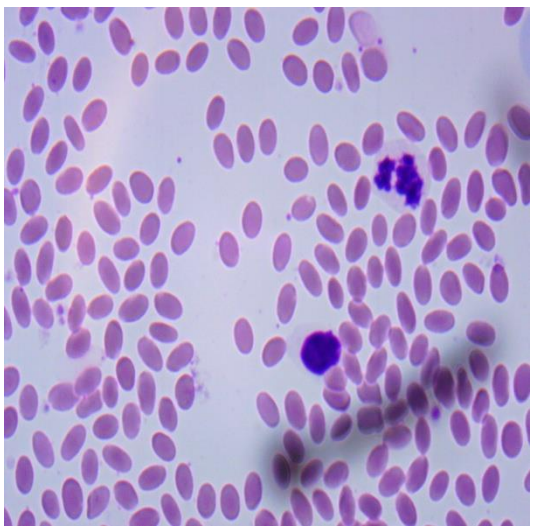
Camels are a vital source of livelihood for many communities in Rajasthan and Gujarat. They provide transportation, agricultural support, and milk, leather, bone and wool products.

e. Efforts of NRCC in this line

ICAR-National Research Centre on Camel, Bikaner is involved in research on Camel Zoonotic disease and collecting samples from the field to monitor camel diseases. The NRCC is conducting collaborative research with medical institutes like, Sardar Patel Medical College (Bikaner) and Dr. D.Y. Patil Medical College, Hospital and Research Centre (Pune). The research and development are going on to develop a safer and more effective anti-snake venom in collaboration Indian Institute of Science, Bengaluru. In another collaborative research project with IISc, the molecular structure of drug tansportersQacA and NorC ,present on bacterial cell wall (MRSA) and responsible for resistance against antibiotics was explored using camelid antibodies. The camelid nanobodies can also help curing diseases caused by muti-drug resistant bacteria in human beings. Collaborative research is going on to explore the use of camel milk/milk products as an adjunct therapy and prevention of respiratory problems, gastrointestinal problems, and diabetes management in human patients. NRCC also conducted lots of awareness camp, health Camp and many such events to engage common people.







Collaborative partners