SOME EPIDEMIOLOGICAL ASPECTS OF FOOT AND MOUTH DISEASE IN WILDLIFE IN SUB-SAHARAN AFRICA

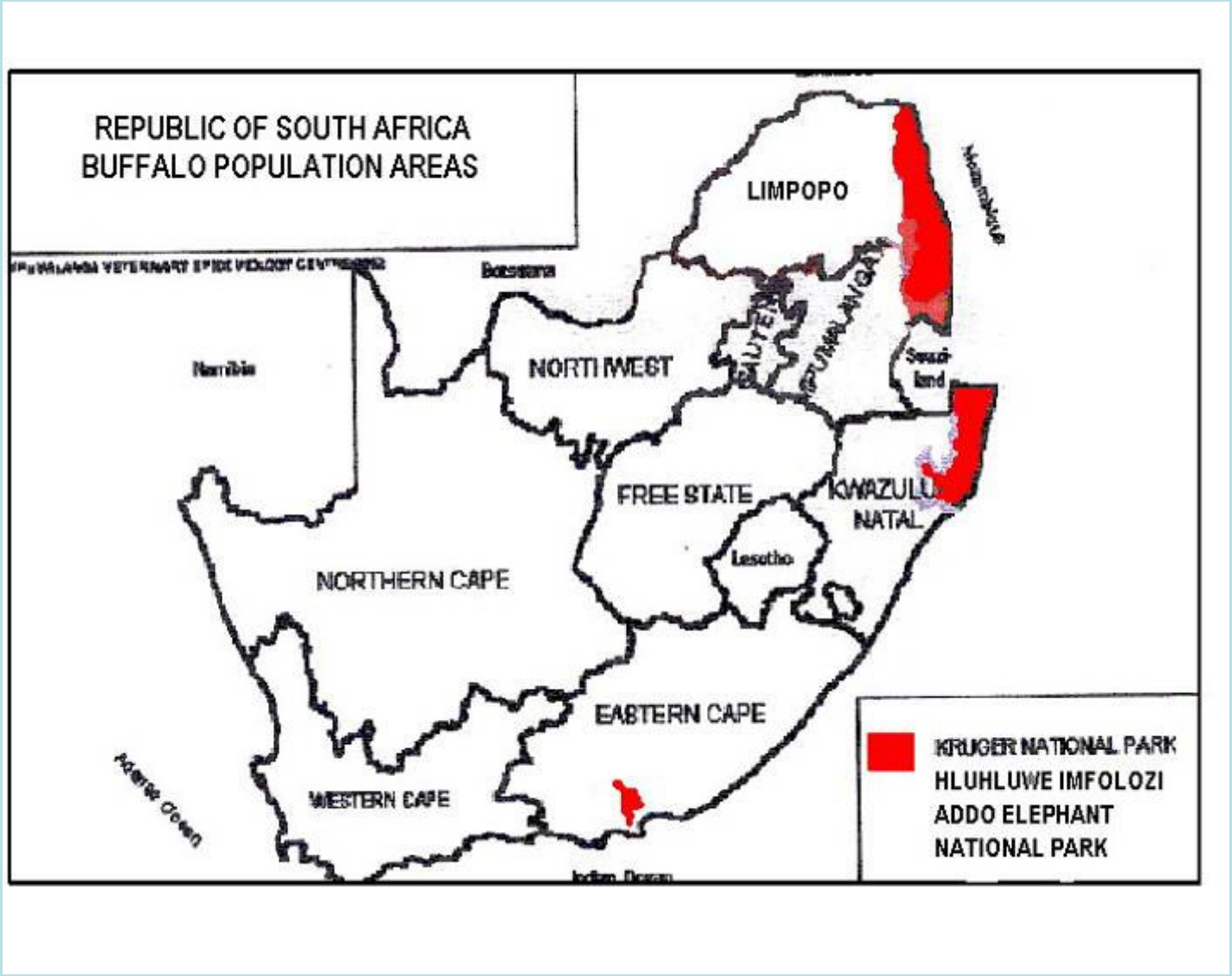
Roy Bengis

FOOT AND MOUTH DISEASE (FMD) – THE BUFFALO CONNECTION

- ***THE AFRICAN STRAINS OF FOOT AND MOUTH DISEASE (SAT1, SAT 2 & SAT 3) ARE CURRENTLY LIMITED TO THE AFRICAN CONTINENT.***
- ***AN IMPORTANT CONCEPT IS THAT THE SAT VIRUSES ARE BUFFALO ADAPTED VIRUSES.***
- ***AFRICAN BUFFALO ARE THE NATURAL DEFINITIVE HOST OF THESE VIRUS STRAINS AND THEIR TOPOTYPES.***
- ***GENERALLY, FMD INFECTION IN BUFFALO IS ASYMPTOMATIC.***
- ***FMD INFECTION IN BUFFALO IS PERSISTENT - LASTS FOR YEARS.***
- ***FREQUENTLY ALL THREE SAT STRAINS OF FMD WILL BE FOUND CIRCULATING IN A PARTICULAR BUFFALO HERD.***

54	B6	17-Jul-07	6yrs	M	Bububu	2.8	>3.1	3.0	
55	B7	17-Jul-07	18mnths	M	Bububu	2.9	2.9	2.4	
56	B8	17-Jul-07	6yrs	F	Bububu	2.1	2.3	2.5	
57	B9	17-Jul-07	12 yrs	F	Bububu	2.4	2.6	2.6	
58	B10	17-Jul-07	8yrs	F	Bububu	2.4	2.2	2.4	
59	B11	17-Jul-07	10yrs	F	Bububu	2.4	2.1	2.2	
60	B12	17-Jul-07	5yrs	M	Bububu	1.9	2.0	2.0	
61	B13	17-Jul-07	8mnths	M	Bububu	<1.3	<1.3	1.5	
62	B14	17-Jul-07	2.5yrs	F	Bububu	2.6	3.0	2.5	
63	B15	17-Jul-07	16mnths	M	Bububu	2.3	2.6	2.5	
64	B16	17-Jul-07	Sub-Adult	F	Bububu	2.7	2.2	<1.3	
65	B17	17-Jul-07	3yrs	F	Bububu	2.9	>3.1	1.5	
66	B18	17-Jul-07	10yrs	F	Bububu	>3.1	2.3	1.9	
67	C1	19-Jul-07	3mnths	M	Shingumeni	1.8	2.0	2.5	
68	C2	19-Jul-07	7yrs	F	Shingumeni	1.8	2.4	2.3	
69	C3	19-Jul-07	10yrs	F	Shingumeni	2.4	2.2	2.3	
70	C4	19-Jul-07	12yrs	F	Shingumeni	2.0	1.9	1.6	
71	C5	19-Jul-07	8yrs	F	Shingumeni	2.3	2.2	1.7	
72	C6	19-Jul-07	7-8yrs	M	Shingumeni	2.6	2.3	1.9	
73	C7	19-Jul-07	4.5yrs	M	Shingumeni	2.1	2.3	2.3	
74	C8	19-Jul-07	2yrs	M	Shingumeni	2.4	2.4	2.0	
75	C9	19-Jul-07	3.5yrs	F	Shingumeni	2.6	2.8	1.6	
76	C10	19-Jul-07	18mnths	M	Shingumeni	<1.3	<1.3	2.6	
77	C11	19-Jul-07	20mnths	M	Shingumeni	2.3	2.3	2.7	
78	C12	19-Jul-07	12yrs	F	Shingumeni	1.9	2.0	2.4	
79	C13	19-Jul-07	3yrs	F	Shingumeni	2.3	2.7	2.4	
80	C14	19-Jul-07	6yrs	F	Shingumeni	2.5	2.5	2.5	
81	C15	19-Jul-07	2mnths	F	Shingumeni	1.6	2.0	1.9	
82	C16	19-Jul-07	6mnths	M	Shingumeni	<1.3	2.1	<1.3	
83	C17	19-Jul-07	5yrs	F	Shingumeni	1.5	2.3	2.3	
84	C18	19-Jul-07	6yrs	M	Shingumeni	1.8	<1.3	2.0	
85	C19	19-Jul-07	4yrs	M	Shingumeni	2.3	2.2	2.5	
86	C20	19-Jul-07	5.5yrs	F	Shingumeni	2.1	2.4	1.7	
87	C21	19-Jul-07	1yr	F	Shingumeni	2.5	2.6	2.3	
88	C22	19-Jul-07	6yrs	F	Shingumeni	2.8	2.4	2.4	
89	C23	19-Jul-07	2yrs	M	Shingumeni	3.0	2.7	2.2	
90	C24	19-Jul-07	7yrs	F	Shingumeni	3.0	2.5	2.8	
91	C25	19-Jul-07	8yrs	M	Shingumeni	2.3	2.3	2.7	
92	C26	19-Jul-07	3yrs	M	Shingumeni	1.5	2.3	2.0	
93	C27	19-Jul-07	2.5yrs	M	Shingumeni				

MAJOR BUFFALO SUB-POPULATIONS IN SOUTH AFRICA



IN THE KNP, THE AVERAGE BUFFALO HERD SIZE IS IN THE REGION OF 300 INDIVIDUALS

IMPORTANCE OF VIRUS SURVEILLANCE

- MONITORING THE CURRENT CIRCULATING STRAINS OF SAT VIRUSES.
- DEVELOPMENT OF SAT VIRUS BANKS FOR GENOTYPING AND ASSESSING VACCINE CANDIDATE POTENTIAL.
- DETERMINING THE RELATEDNESS OF STRAINS FOR MOLECULAR EPIDEMIOLOGICAL ANALYSIS.
- ***THE SAT VIRUSES (ESPECIALLY SAT 2) ARE HIGHLY LABILE AND GENETIC SHIFT / DRIFT OR REASSORTMENT ?? APPEARS TO RESULT IN EMERGENCE OF NEW TOPOTYPES WITH DIFFERING ANTIGENICITY OR PATHOGENICITY.***

FMD VIRUS STRAIN SURVEILLANCE IN BUFFALO

COLLECTION OF BLOOD SAMPLES

AGING OF BUFFALO - < 2 YEARS OLD

2.5 – 3 YEARS OLD

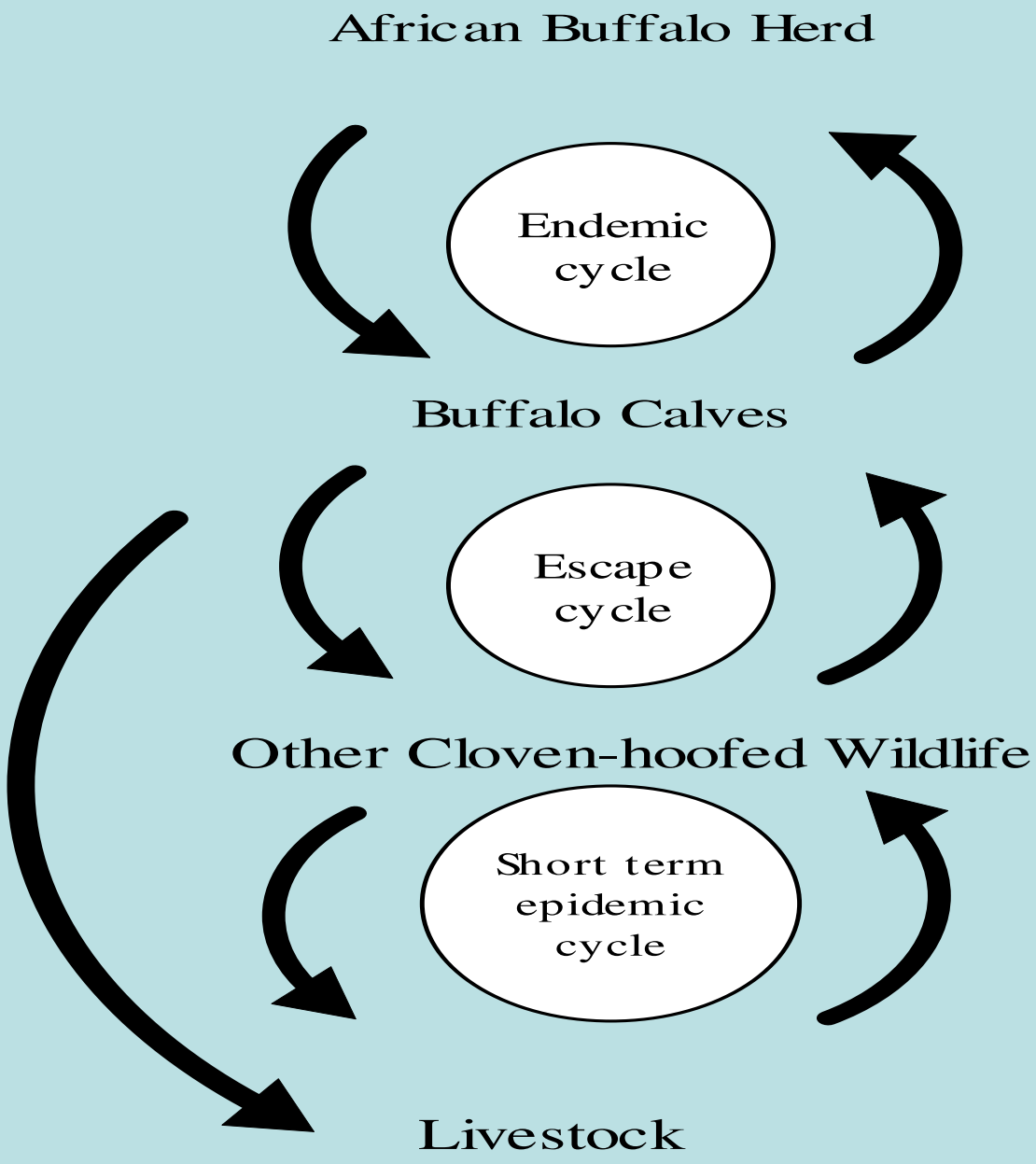
3.5 – 4 YEARS OLD

COLLECTING – OESOPHAGO-PHARYNGEAL PROBANG SAMPLES FOR VIRUS ISOLATION.

BUFFALO SOCIAL BIOLOGY IN RELATIONSHIP TO FMD VIRUS CIRCULATION

- BUFFALO ARE SOCIAL, CLOSE CONTACT ANIMALS AND GENERALLY LIVE IN LARGE HERDS.
- HEIFERS REACH PUBERTY AT 2 – 3 YEARS..
- BUFFALO COWS HAVE FIRST CALF AT FOOT AT AGE 3 – 4 YEARS. GESTATION IS 11 MONTHS
- BUFFALO COWS GENERALLY HAVE 2 CALVES WITHIN A THREE YEAR CYCLE. THEY MAY BREED UP UNTIL THE AGE OF 15 YEARS.
- BUFFALO ARE SEASONAL BREEDERS AND MOST CALVES ARE BORN IN SUMMER.
- COLOSTRAL ANTIBODIES PROTECT CALVES FROM FMD UNTIL APPROXIMATELY 6 MONTHS OF AGE.
- TRANSMISSION OF FMD VIRUS FROM ADULT CARRIER BUFFALO TO SUSCEPTIBLE ANIMALS APPEARS TO BE A RARE EVENT.
- EACH YEARS CALF COHORT WITHIN A HERD GENERALLY BECOMES INFECTED WITH FMD AFTER THEY ARE 6 MONTH OF AGE. THIS WOULD BE MID- TO LATE WINTER.
- VIRUS TRANSMISSION WITHIN THE ANNUAL CALF COHORT IS VERY EFFICIENT (CHICKEN POX IN A NURSERY SCHOOL ANALOGY).
- MOST CALVES HAVE BECOME INFECTED WITH ALL THREE SAT VIRUSES BY THE AGE OF 12 MONTHS.

Foot and Mouth Disease



IMPALA SOCIAL BIOLOGY

- IMPALA ARE THE MOST NUMEROUS RUMINANT IN THE GREATER KRUGER PARK ECO-SYSTEM
- THEY ARE GREGARIOUS ANTELOPE – HERDS NUMBERING FROM TENS TO HUNDREDS OF ANIMALS
- THEY BREED IN AUTUMN AND ALL THE LAMBS ARE BORN IN EARLY SUMMER
- THEY ARE SEDENTARY ANTELOPES WITH HOME RANGES OF BETWEEN 1 AND 4 sq. Km.
- THEY ARE RARELY FOUND FURTHER THAN 4 Km FROM SURFACE WATER, EXCEPT DURING THE RAINY SEASON.
- THEY MIX FREELY WITH OTHER UNGULATE SPECIES, ESPECIALLY IN THE VICINITY OF WATER
- THEY HAVE INTIMATE INTRA-SPECIFIC SOCIAL BEHAVIOUR SUCH AS GROOMING AND LICKING

IN THE KNP ECO-SYSTEM, IMPALA ARE AN IDEAL SENTINAL SPECIES FOR DETECTING THE SHORT TERM FMD EPIDEMIC CYCLES

- THEY ARE EXQUISITELY SENSITIVE TO FMD INFECTION.
- THEY GENERALLY DEVELOP CLINICAL SIGNS, AND LESIONS
- VIRUS STRAINS ISOLATED FROM IMPALA GIVE US A GOOD INDICATION OF CURRENT ACTIVELY CIRCULATING BUFFALO STRAINS.

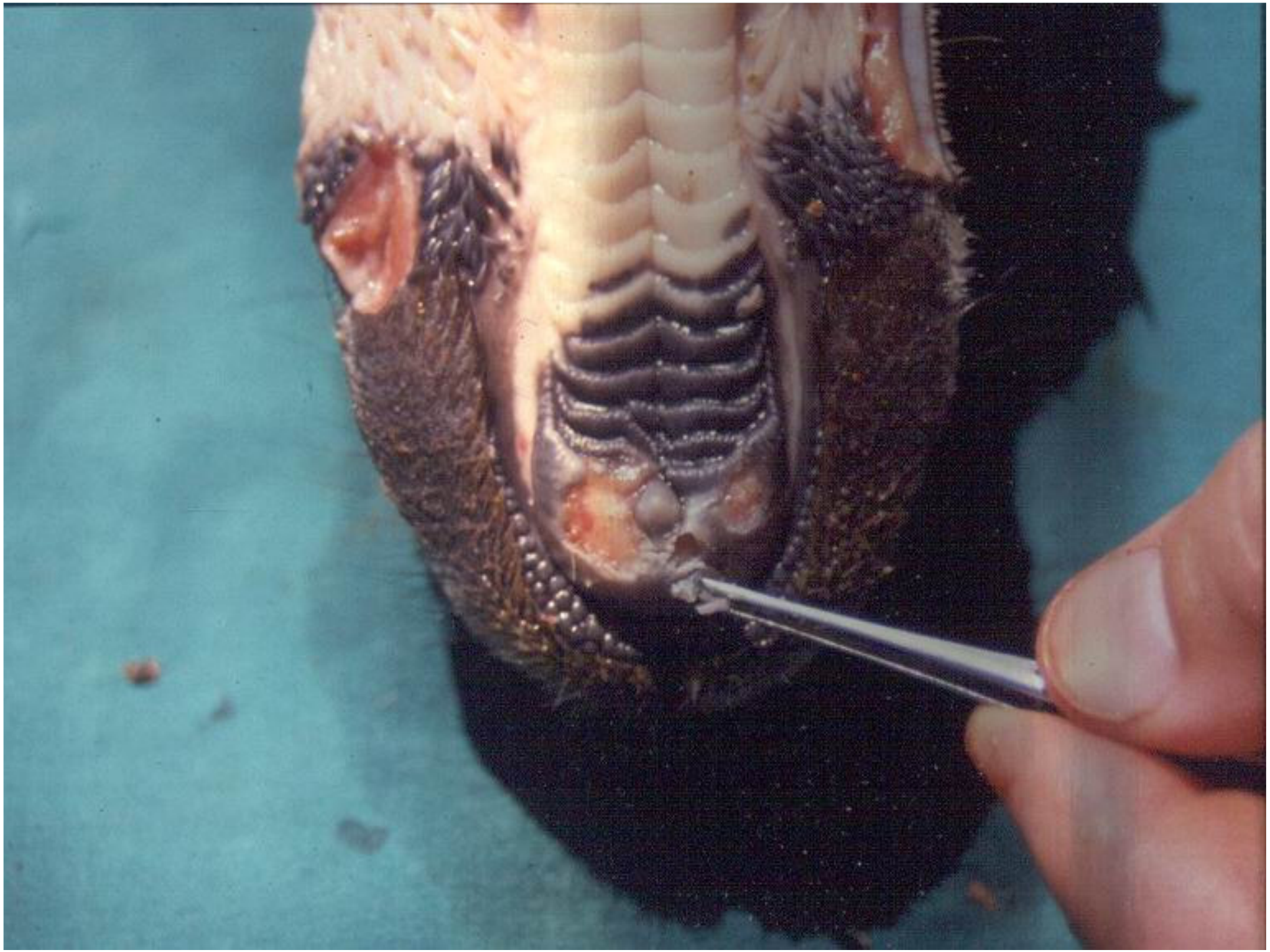
CLINICAL SIGNS INCLUDE :

- PILO-ERECTION (FEBRILE)
- “WALKING ON EGGS”
- VARYING DEGREES OF OVERT LAMENESS.
- SHAKING OF HOOVES
- EXCHANGING WEIGHT ON PAINFUL LIMBS
- LAGGING BEHIND HERD.
- LYING DOWN.

SALIVATION IS RARELY EVER SEEN.


Shaking and licking of hooves


Shifting of Weight



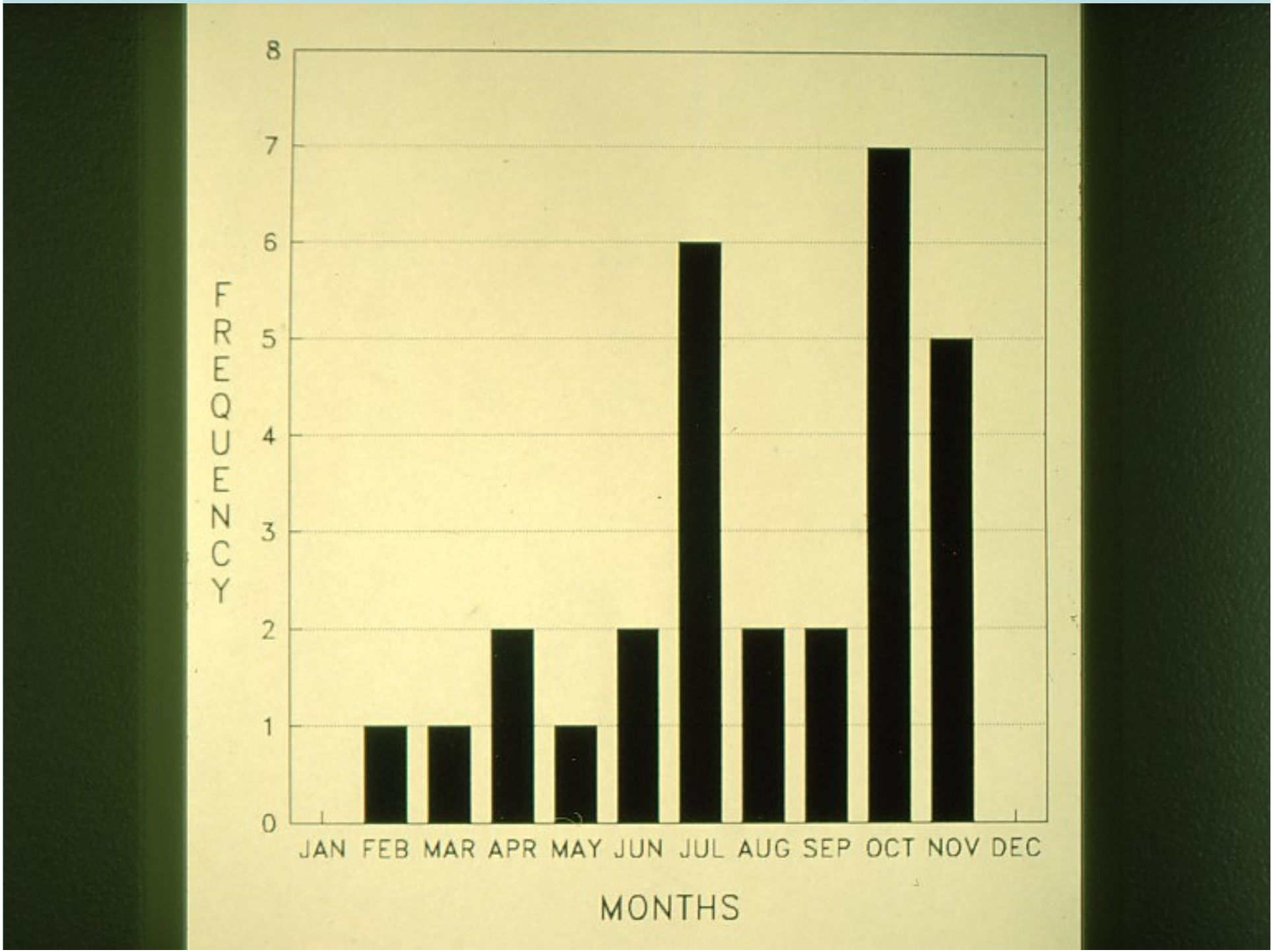
IMPALA FMD OUTBREAK FREQUENCY

- BETWEEN 1967 AND 2011, 28 OUTBREAKS OF FMD WERE DETECTED IN IMPALA IN THE GREATER KNP COMPLEX
- OF THESE, 16 OUTBREAKS WERE CAUSED BY SAT 2 VIRUSES, 8 OUTBREAKS BY SAT 1 VIRUSES AND A SINGLE OUTBREAK CAUSED BY SAT 3 VIRUS. .
- IN THREE OUTBREAKS, THE VIRUS COULD NOT BE TYPED.

- PATHOGENICITY AND TRANSMISSABILITY OF DIFFERENT STRAINS AND TOPOTYPES APPEAR TO DETERMINE :
  - THE CLINICAL PREVALENCE AND SERO-PREVALENCE RATES
  - THE SPATIAL SPREAD OF THE OUTBREAK, - LOCALISED OR WIDESPREAD.

TEMPORAL DISTRIBUTION OF IMPALA FMD OUTBREAKS

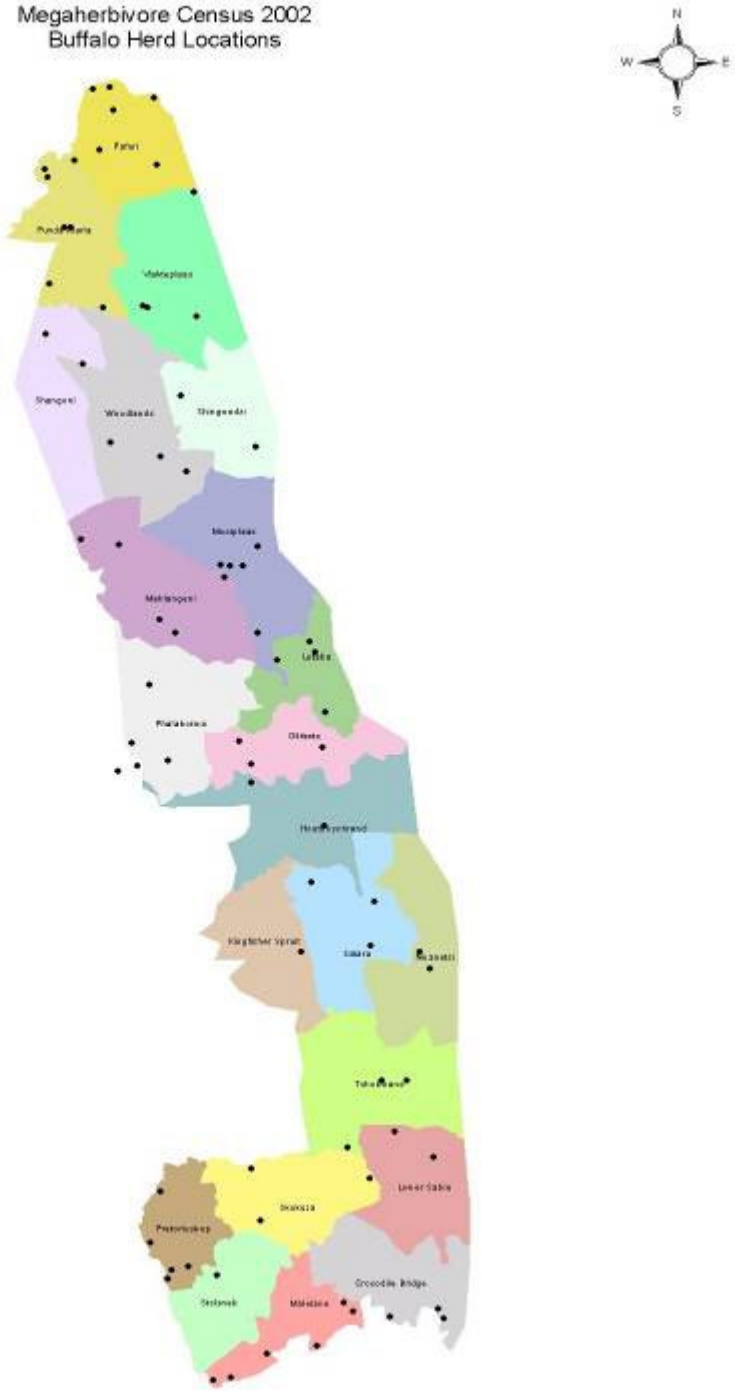
- FMD OUTBREAKS IN IMPALA ARE GENERALLY A DRY SEASON AND FREQUENTLY A WINTER PHENOMENUM.
- WHEN OUTBREAKS HAVE OCCURRED IN SUMMER, IT HAS BEEN DURING VERY DRY SUMMERS.
- DRY SEASONS AND DRY CYCLES ARE THE CLIMATIC CONDITIONS WHEN A VARIETY OF SPECIES CONGREGATE AND MIX AT WATERING POINTS.

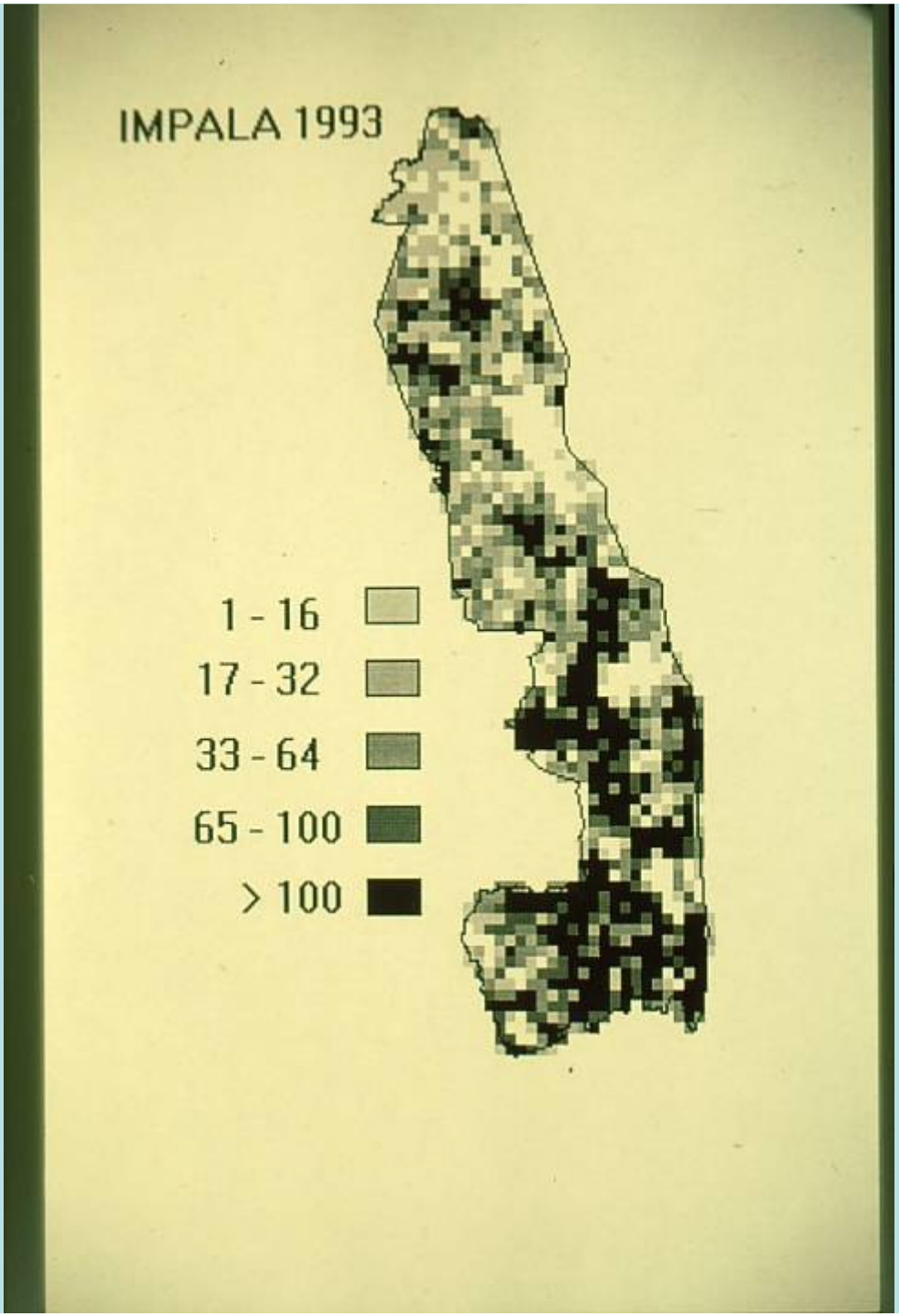

8
7
6
5
4
3
2
1
0
FREQUENCY
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTHS

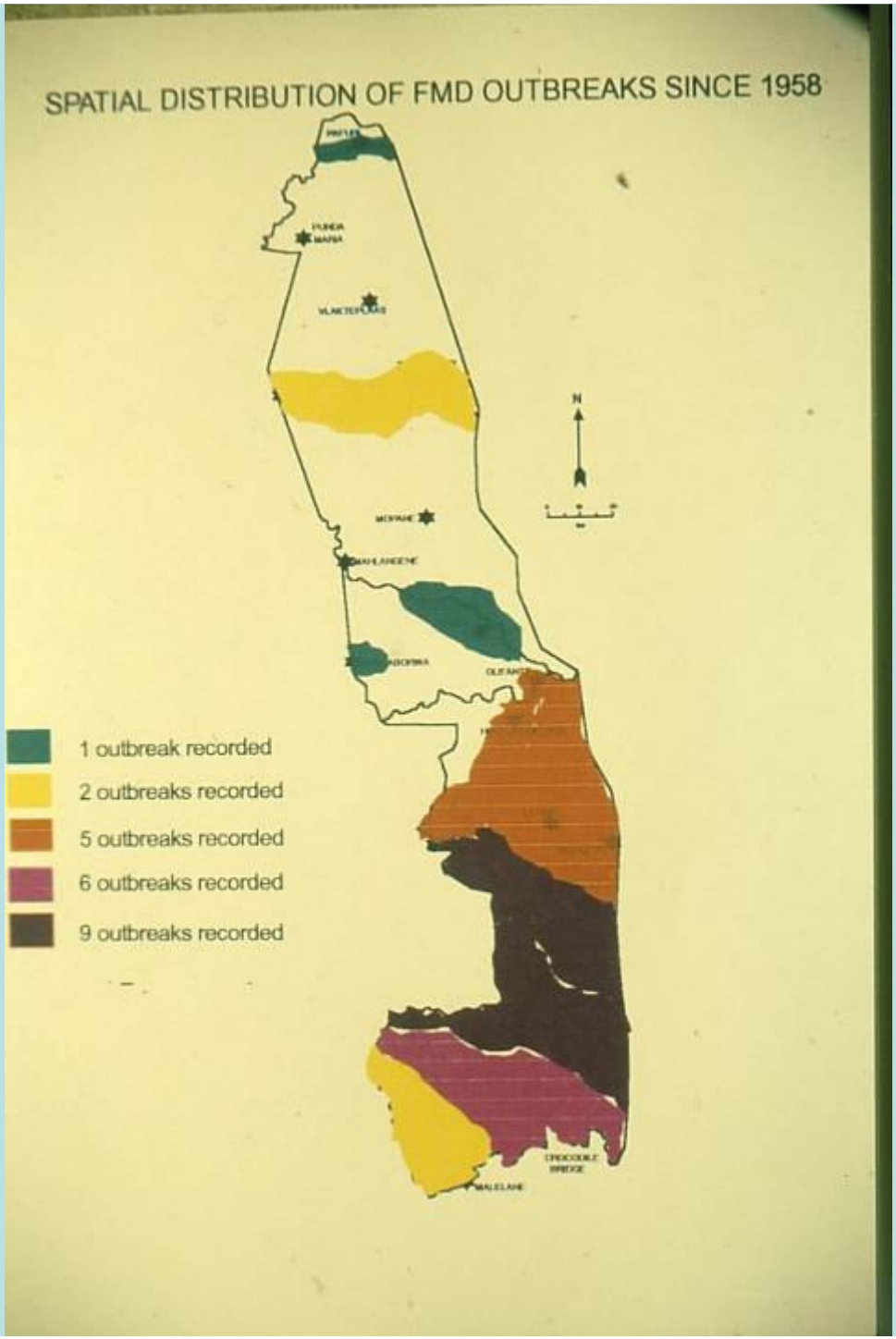
SPATIAL DISTRIBUTION OF IMPALA FMD OUTBREAKS

- GENERALLY RELATED TO IMPALA DENSITIES AND DISTRIBUTION.
- BUFFALO, WHICH ARE THE ULTIMATE SOURCE OF INFECTION, ARE WELL DISTRIBUTED THROUGHOUT THE KNP

Megaherbivore Census 2002
Buffalo Herd Locations




IMPALA 1993
1 - 16
17 - 32
33 - 64
65 - 100
> 100


SPATIAL DISTRIBUTION OF FMD OUTBREAKS SINCE 1958
1 outbreak recorded
2 outbreaks recorded
5 outbreaks recorded
6 outbreaks recorded
9 outbreaks recorded
N

OTHER CLOVEN-HOOFED WILDLIFE FOUND TO BE NATURALLY INFECTED WITH FMD IN THE KNP

- **OCCASSIONALLY, CLINICAL FMD OR SEROLOGICAL EVIDENCE OF EXPOSURE / INFECTION HAS BEEN DETECTED IN OTHER SYMPATRIC UNGULATES.**
- **THESE INCLUDE :**


1 12:00 AM

NEITHER IMPALA NOR ANY OF THESE OTHER SPECIES HAVE BEEN SHOWN TO BECOME PERSISTENTLY INFECTED

FMD SURVEILLANCE AND MONITORING IN THE KNP

THIS INCLUDES :

- **ACTIVE SURVEILLANCE – SYSTEMATIC VISUAL INSPECTION OF IMPALA HERDS IN THE DIFFERENT REGIONS OF THE KNP. CLINICALLY SUSPECT ANIMALS ARE DARTED OR SHOT, EXAMINED AND SAMPLED.**
- **BETWEEN 1997 AND 2007, 20 – 40 IMPALA FROM 3 GEOGRAPHICALLY DESTINCT POPULATIONS WERE DARTED FOR SERO-SURVEILLANCE AND EXAMINATION, ON A 3 MONTHLY ROTATIONAL BASIS.**
- **PASSIVE SURVEILLANCE AT IMPALA CULLS, AND CAPTURE OPERATIONS INVOLVING CLOVEN HOOFED WILDLIFE.**


TOYOTA

FMD RESEARCH IN THE KNP

FMD RESEARCH IN THE KNP OVER THE PAST 30 YEARS HAS BEEN FOCUSED ON :

- **ROLE OF BUFFALO AS MAINTENANCE HOSTS.**
- **VACCINATION OF BUFFALO**
- **SENSITIVITY OF IMPALA AS SENTINEL HOSTS**
- **DYNAMICS OF FMD INFECTION IN IMPALA**
- **ROLE OF OTHER CLOVEN-HOOFED SPECIES**
- **THE ROLE (IF ANY) OF PACHYDERMS IN FMD EPIDEMIOLOGY.**
- **FMD VIRUS SURVIVAL IN MEAT.**
- **STRAIN TYPING OF CIRCULATING FMD STRAINS, AND EVALUATING THEM AS VACCINE CANDIDATES**

DYNAMICS OF FMD INFECTION IN IMPALA FOLLOWING CONTROLLED EXPERIMENTAL INFECTION

- IMPALA ARE EXQUISITELY SUSCEPTIBLE TO INFECTION WITH FMD VIRUS (< 10 TCID'S)
- INCUBATION PERIOD WAS 2 – 5 DAYS
- VIRAEMIA WAS DETECTABLE FOR 1 – 4 DAYS, AND WAS ACCOMPANIED BY A FEBRILE RESPONSE (38,5 – 40,7°C) AND PILO-ERECTION.
- CLINICAL SIGNS OF LAMENESS TOGETHER WITH VISIBLE LESIONS OF HOOVES AND MOUTH BECAME APPARENT ON DAYS 4 – 6 POST INFECTION.
- VIRUS WAS PRESENT IN RESPIRATORY AEROSOLS,, SALIVA, AND OCULAR AND NASAL SECRETIONS OF IMPALA FOR UP TO 10 DAYS, BUT AT SIGNIFICANTLY LOWER LEVELS THAN THOSE FOUND IN CATTLE OR BUFFALO.
- DETECTABLE ANTIBODIES ARE PRESENT IN THE SERUM OF IMPALA FOR 7 – 12 MONTHS POST INFECTION.
- NO LONG TERM CARRIER STATE DEVELOPED IN IMPALA.

DURING PRIMARY INFECTION, BUFFALO EXCRETE AS MUCH VIRUS AS INFECTED CATTLE – BUT FOR A LONGER PERIOD. Thereafter they intermittently shed small amounts of virus.

WARTHOGS ARE CLINICALLY AND EXPERIMENTALLY SUSCEPTIBLE TO FMD INFECTION, BUT UNLIKE DOMESTIC PIGS, THEY ARE NOT MAJOR VIRUS AMPLIFIERS

EXPERIMENTALLY, WILDEBEEST APPEARED RESISTANT TO IN-CONTACT TRANSMISSION FROM INFECTED CATTLE.

INFECTED CATTLE WERE ABLE TO INFECT IMPALA, AND INFECTED IMPALA WERE ABLE TO INFECT CATTLE DURING THE ACUTE PHASE OF DISEASE

INFECTED CATTLE WERE UNABLE TO INFECT IN – CONTACT ELEPHANTS. THE ELEPHANTS DID NOT EVEN SERO-CONVERT.

FMD IN PACHYDERMS

- **NO SEROLOGICAL EVIDENCE OF FMD INFECTION WAS FOUND IN OVER 2000 ELEPHANT BLOOD SAMPLES, > 400 HIPPO BLOOD SAMPLES AND > 300 WHITE RHINO BLOOD SAMPLES COLLECTED IN THE ENDEMICALLY INFECTED KRUGER NATIONAL PARK.**

GIRAFFE ARE SUSCEPTIBLE TO NATURAL AND EXPERIMENTAL INFECTION

CONTROL OF FOOT AND MOUTH DISEASE

1. **ZONATION OF CONTROL AREA :**
   - **Infected (buffalo) area**
   - **Vaccinated part of protection zone**
   - **Unvaccinated part of protection zone**
   - **Free zone**

2. **BARRIER CONTAINMENT OF INFECTED BUFFALO ZONE**
3. **WEEKLY INSPECTION AND BI-ANNUAL VACCINATION OF CATTLE IN THE VACCINATED PORTION OF THE PROTECTION ZONE**
4. **Bi-weekly inspection of cattle in the rest of the protection zone**
5. **MOVEMENT CONTROL (PERMITS) OF ALL DISEASE RISK ANIMALS AND THEIR PRODUCTS**

THE CONTROL MEASURES FOR FMD AT THE INTERFACE RELY MAINLY ON PHYSICAL AND IMMUNE BARRIERS

- FENCES
- VACCINATION

SUMMARY

- BUFFALO ARE THE NATURAL MAINTENANCE HOST FOR THE SAT TYPES OF FMD VIRUS.
- VIRUS PERSISTENCE IN BUFFALO MAY LAST FOR YEARS.
- VIRUS SPILL OVER INTO SYMPATRIC CLOVEN HOOFED WILDLIFE OCCURS PERIODICALLY, BUT NO LONG TERM CARRIER STATE HAS BEEN DOCUMENTED IN THESE OTHER SPECIES.
- THE BUFFALO / LIVESTOCK INTERFACES ARE THE CRITICAL AREA FOR DISEASE PREVENTION / CONTROL.
- GOOD FENCE MAINTENANCE AND EFFECTIVE VACCINES ARE ESSENTIAL.

THE END