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Source: Journal of Wildlife Diseases, 10(3) : 279-293

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-10.3.279

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ISOLATION OF VIRUSES FROM WILD MAMMALS IN WEST AFRICA, 1966-1970

GRAHAM E. KEMP*, OTTIS R. CAUSEY*, HENRY W. SETZER†, and DOROTHY L. MOORE*

Abstract: During the 5-year period 1966-1970, a total of 7497 wild mammals of at least 101 different species were collected from 36 locations in Nigeria, Dahomey, and Togo and sampled for virus. The collections were made in five ecologically distinct vegetative zones: high forest, Guinea, Sudan, and Sahel woodland, and the Jos Plateau. Sixteen different virus types, represented by 83 isolates, were recovered, as follows: Arumowot (6 isolates), Bhanja (2), bluetongue type 7 (1), Chandipura (1), Congo (2), Dakar bat (3), Dugbe (1), IbAn 17143 (1), IbAn 33709 (1), Lebombo (1), Mokola (4), poxvirus IbAn 34325 (1), Semliki Forest (1), SudAn 754/61 (53), Uganda S (3), and West Nile (2). Viruses were isolated from Nigeria, the principal area of mammal collecting, and Dahomey, but not from Togo. The possible relationship of these viruses to diseases of man and domestic animals is discussed.

Over the past 10 years, the Virus Research Laboratory (VRL) at the University of Ibadan has examined materials from a variety of sources for the presence of arboviruses. Isolations have been attempted from man, domestic and wild animals, reptiles, and arthropods, as well as from sentinel mammals and birds.[6,9] This report deals with a single aspect of the surveillance, namely, the virologic investigation of wild mammals collected in the environs of Ibadan and on numerous field trips in Nigeria, Dahomey, and Togo during the period 1966-1970. Many of these collections were made conjointly with personnel of the Smithsonian Institution, Division of Mammals, who were then engaged in a Pan-African mammal study.

MATERIALS AND METHODS

Collection and Identification of Animals

Cooperative studies between the VRL and the Smithsonian Institution were carried out in Nigeria in 1966 and 1967, and in Dahomey and Togo in 1968. Since the primary objective of the Smithsonian team was to collect mammals from a variety of habitats for correlation of taxonomic and ecologic data, most of the animals they captured were prepared as permanent museum specimens and later definitively identified in Washington, D.C. These animals were routinely made available for virologic assay, but not all were actually sampled. Conversely, not all the animals collected by the VRL were prepared as museum specimens; indeed, as VRL staff gained proficiency in identification, it was necessary only occasionally to send museum specimens to the Smithsonian for verification of species.

During 1967, responsibility for mammal trapping in the vicinity of Ibadan was gradually assumed by the VRL, and during the years 1968 through 1970 all collecting and processing of animals in Nigeria was done by VRL staff.

Collection Sites

Collecting was done at 36 sites (see map, Fig. 1). Continuing collections were

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made at Ibadan, but only three other sites were visited more than once, as noted below. A detailed listing of the locations is omitted in favor of general information about the vegetative zones in which the sites occur: high forest, Guinea woodland, Jos Plateau, Sudan woodland, and Sahel woodland. The following account is based on Keay's[17] description of Nigerian vegetation.

The entire region sampled is tropical and experiences high temperatures the year round. As one proceeds from south to north, however, the dry season becomes progressively longer, so that annual rainfall varies overall from 355 cm in portions of the high forest zone to as low as 25 cm in the Sahel woodland zone. The vegetation varies accordingly.

The high forest zone of Nigeria, a belt of dense rain forest with tall trees forming a canopy, has suffered vast patchy destruction owing to heavy human population pressure, and much of it now qualifies as "derived savannah." This is particularly true of the area surrounding Ibadan, which city is located near the northern limit of the forest zone and has an annual rainfall of about 122 cm.

The Guinea woodland zone, next to the north, typically consists of rather open woodland, with smaller trees (about 12 m) and tall bunchy grass. The dry season here lasts an average of 5 months;

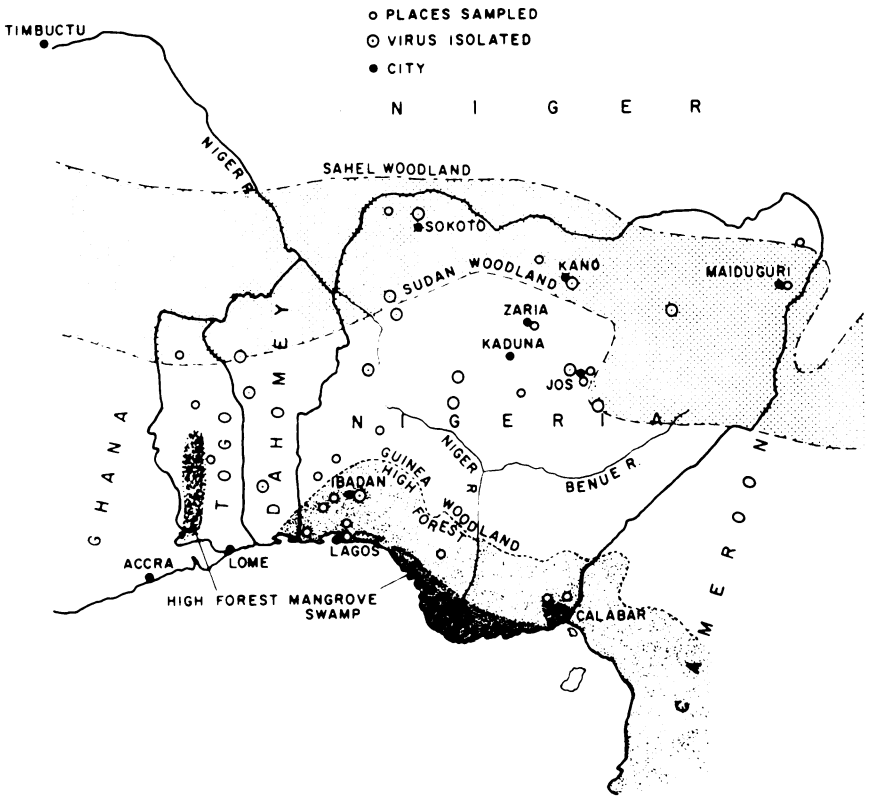


FIGURE 1. Map showing locations in West Africa where wild mammals were collected, 1966-1970. [Map adapted from D. R. Rosevear. 1965. The Bats of West Africa. British Museum (Nat. Hist.).]

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annual rainfall varies from 122 to 102 cm, south to north; and the lowest mean relative humidity is 28%.

The Jos Plateau, although located in the northern Guinea zone, is considered separately because of its very different altitude—about 1280 m above sea level. As a result of widespread degradation by man, the plateau today consists of wide grassy plains dotted with rocky hills that may or may not be wooded. In recent years, rainfall has varied from 122 cm to as high as 172 cm.[22] Two of the four collecting sites on the plateau were visited twice: Jos town, in 1969 and 1970; and the village of Panyam, in 1967 and 1969.

The Sudan woodland zone is clearly differentiated from the Guinea zone: the dry season average 7 months; annual rainfall varies from 84 to 71 cm, south to north; and the lowest mean relative humidity is 23%. In Nigeria, nearly all of the Sudan zone has been inhabited for centuries, with consequent modification of the vegetation by farming. More of the trees here have thorns than in the Guinea zone, and the grass is shorter and feathery. At Kware, a village 13 miles north of Sokoto, collecting was done in both May and November 1966 and again in 1970.

Methods of Collection

In the vicinity of Ibadan, ordinarily two collections were made each week. Terrestrial mammals were caught mainly by snap traps, although folding aluminum box traps were also used. Occasionally traps were placed on tree limbs to capture arboreal rodents. Insectivorous bats were caught in mist nets set up in strategic positions near the openings from which the animals emerged for evening flights; frugivorous bats were caught in mist nets placed adjacent to fruiting trees or shrubs. On occasion, mist nets were strung in locations that favored the capture of both insectivorous and frugivorous species.

During field trips, animals were captured or were purchased dead or alive from local residents. Official personnel captured small animals mainly by the use of snap traps, but again some folding aluminum traps were used. Ordinarily traps were set late in the afternoon and checked early the next morning; however, if ants were found to be attacking the trapped animals, checks were also made at intervals during the night. Bats were either caught in mist nets or else were shot, usually during the day as they rested in leafy trees but occasionally when they were on the wing in the early evening. Some night hunting was conducted to capture nocturnally active mammals of many different genera.

Sampling of Tissues for Virologic Studies

Most animals were killed in the process of capture. All, whether dead or alive, were immediately treated with chloroform to immobilize parasites. Live animals were then killed by exsanguination under anesthesia or, if blood was not taken, by the use of chloroform. After identification, the animal was brushed by hand to loosen ticks, fleas, lice, and mites, which were collected in a white enamel pan. In the case of animals requiring more definitive identification, the host was then weighed, measured, and carefully prepared as a museum specimen, the cleaned skull being preserved separately for later taxonomic studies. All components of a single animal were labeled with the same number. Tissues were then taken from the carcass and the carcass discarded.

On field trips, approximately 0.1 g samples of liver and spleen were removed and placed together in a vial, which was then kept in a cryogenic vessel on liquid nitrogen until returned to the laboratory. For animals captured at Ibadan, the organ pool usually consisted of liver, spleen, kidney, heart, and lung. In the case of bats, salivary glands also were removed, with separate instruments, and placed in a vial by themselves. Brain tissue was seldom taken. Although live animals occasionally were bled for serologic testing, blood specimens usually were not examined for virus—the one notable exception being the specimens collected at Bassa in 1970 in connection with Lassa fever investigations.[3]

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At the laboratory, vials containing tissues were stored at —60C in a mechanical refrigerator until processed for virus isolation attempts. Blood samples were kept at ambient temperatures until the clot began to retract; after centrifugation, serum was poured into plastic tubes and stored at —60C.

Virologic Techniques

All attempts to isolate virus were carried out by intracerebral (ic) inoculation of 2- or 3-day-old mice. The methods used in processing of specimens, inoculation of mice, passaging of isolates, and characterization of agents have been described.[5,6] Reisolation was not always attempted. Once established by passage in mice, viruses were screened in complement-fixation tests against a battery of reference immune mouse ascitic fluids for agents previously isolated in Ibadan, and immune fluids and antisera from other laboratories. When necessary, identification was confirmed by neutralization test. Agents that remained unidentified were referred to the Yale Arbovirus Research Unit, New Haven, Connecticut, for further study.

RESULTS

During the 5-year period, 7497 wild mammals, collected from each of the major vegetative zones south of the Sahara except the mangrove swamps, were examined for virus (Table 1). These animals comprised at least 101 different species and were collected in all months of the year. The six most frequently taken species, which together made up more than half the total animals sampled, were: multimammate rat, *Mastomys natalensis,* 1292; brown grass rat, *Arvicanthis niloticus,* 839; shrew, *Crocidura* complex (perhaps as many as six species), 548; desert gerbil, *Tatera kempii,* 505; African hedgehog, *Atelerix albiventris,* 450; and big-toothed mouse, *Uranomys ruddi,* 441.

Sixteen different virus types (83 isolates) were recovered from 14 different species of animal (Table 2). Nine virus types were isolated from insectivores, either *Atelerix albiventris* (6) or *Crocidura* sp. (3). Multiple virus types also were isolated from the rodents *Tatera kempii* (4), *Arvicanthis niloticus* (4), the giant rat, *Cricetomys gambianus* (3), and *Mastomys natalensis* (2).

SudAn 754/61 virus, the agent most frequently encountered, was recovered 53 times from nine species—one insectivore, one primate, and seven rodent. Arumowot virus, second in frequency with six isolates, was recovered from one insectivore and three rodent species. Only one other virus, Bhanja, was recovered from both an insectivore and a non-insectivore species. Bluetongue type 7, Chandipura, Congo, IbAn 17143, Mokola, and Semliki Forest viruses were each exclusive to a single insectivore species. Uganda S virus was isolated from three species, all rodents, and Dugbe, IbAn 33709, Lebombo, poxvirus (IbAn 34325), and West Nile viruses were each exclusive to a single rodent species. Dakar bat virus was obtained only from *Tadarida condylura.*

Table 3 analyzes the distribution of virus isolates by month and in relation to monthly numbers of animals tested. If we assume that the dry season months for the areas sampled are November through March, then in the dry season 10 isolates (8 virus types) were recovered from 3039 animals tested for an isolation rate of 0.3%. If, by corollary, April through October are considered the rainy season months, then in the rainy season 73 isolates (11 types) were obtained from 4458 animals tested for an isolation rate of 1.6%. April and May were the months with the highest isolation percentages, 1.8 and 2.7 respectively.

In Table 4, virus isolations are analyzed by vegetative zone and year. The Sudan woodland zone provided the majority of isolates (53) and had the highest isolation rate (2.3%). Both figures reflect the numerous recoveries of SudAn 754/61 virus, of which 33 were made in 1970 at Kware, during an epizootic caused by this virus in small mammals.

Only SudAn 754/61 and Arumowot viruses were encountered in three zones—Guinea woodland, Jos Plateau, and Sudan woodland. Viruses common to two

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TABLE 1. Species and numbers of wild mammals sampled for virus in West Africa, 1966-1970, by year and vegetative zone (F, high forest; G, Guinea woodland; J, Jos Plateau; S, Sudan woodland; SA, Sahel woodland).

Species	1966	1967	1968	1969	1970	Total
INSECTIVORA						
Atelerix albiventris	68 S	112 J/S	9 G/S	12 J	249 J/S	450
Crocidura sp. A	12 F/S	8 G/J/S	0	0	0	20
sp. B	1 F	19 F/G/J/S	13 G/S	0	33 F/J	66
sp. C	7 F/S	4 J/S	13 G/S	0	0	24
sp. E	0	2 S	2 S	0	0	4
sp. F	12 F/S	0	0	0	0	12
sp. G	2 G/S	0	1 S	0	0	3
Crocidura sp.	0	71 F	260 F/G	86 F/J	2 S	419
Sylvisorex morio	0	3 G	0	0	0	3
CHIROPTERA						
Rousettus angolensis	0	0	1 G	0	0	1
Epomophorus gambianus	12 F/S	43 F/G/J/S	7 G/S	5 J	16 F/J	83
Epomops franqueti	11 F	15 F	0	11 F/J	27 F/S	64
Hypsignathus monstrosus	0	1 F	0	0	0	1
Micropteropus pusillus	0	47 F/G	3 G/S	0	0	50
Eidolon helvum	7 S	0	0	0	1 F	8
Megaloglossus woermanni	2 F	0	0	0	0	2
Taphozous nudiventris	0	0	8 G	0	0	8
perforatus	14 S	0	0	0	0	14
Nycteris aethiopica	0	0	0	0	1 S	1
arge	0	17 G	5 G	0	0	22
grandis	0	0	4 G	0	0	4
hispida	7 G/Sa	11 G/S	24 G	0	0	42
macrotis	4 G	0	0	0	0	4
thebaica	0	10 G/S	15 G/S	0	0	25
Lavia frons	0	0	47 S	0	0	47
Rhinolophus fumigatus	1 S	1 S	14 G	0	0	16
landeri	16 G	0	0	0	0	16

TABLE 1, continued

Species	1966	1967	1968	1969	1970	Total
CHIROPTERA continued						
Hipposideros caffer	1 F	35 G/S	6 G	0	2 S	44
Pipistrellus nanus	3 F/G	0	9 G	0	1 S	13
Eptesicus rendalli	0	0	1 G	0	0	1
tenuipinnis	1 F	0	0	0	0	1
Nycticeius schlieffeni	0	0	1 G	0	0	1
Scotophilus nigrita	49 F/G/S	16 F/G/J	3 G	4 F	1 F	73
Tadarida condylura	115 F/G	0	2 G/S	0	0	117
leonis	1 S	6 G/J	0	0	0	7
major	0	0	37 G	0	0	37
nanula	0	0	5 G	0	0	5
pumila	18 G	9 G/J	8 G	1 J	1 S	37
Tadarida sp.	0	1 F	1 G	4 F	0	6
PRIMATES						
Arctocebus calabarensis	2 F	0	0	0	0	2
Perodicticus potto	2 F	0	0	0	0	2
Galago alleni	2 F	0	0	0	0	2
demidovii	2 F	1 F	2 F/S	0	0	5
senegalensis	1 S	43 G/S	11 F/G/S	0	0	55
Cercocebus torquatus	0	0	0	5 G	0	5
Papio anubis	0	0	0	2 J	0	2
Cercopithecus aethiops	3 S	0	1 F	2 F	0	6
diana	2 F	0	0	0	0	2
mona	0	0	1 G	9 F/G	0	10
Erythrocebus patas	2 S	0	0	4 J	7 J	13
PHOLIDOTA						
Manis tricuspis	1 F	0	1 G	0	0	2
LAGOMORPHA						
Lepus capensis	5 G/S	2 G/S	3 G/S	0	2 J	12

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TABLE 1, continued

Species	1966	1967	1968	1969	1970	Total
RODENTIA						
Protoxerus stangeri	1 F	0	3 G	0	0	4
Funisciurus pyrrhopus	5 F	20 G	0	0	0	25
Heliosciurus gambianus	3 F	20 G/S	14 G/S	0	0	37
rufobrachium	4 F	0	0	0	0	4
Xerus erythropus	14 S	4 G/S	8 G/S	0	14 J/S	40
Anomalurus beecrofti	2 F	0	1 F	0	0	3
Gerbillus gerbillus	21 S	99 S	0	0	0	120
Tatera kempii	13 F/G/S	140 F/G/S	350 F/G/S	2 F	0	505
welmanni	16 S/Sa	3 S	0	0	5 S	24
Taterillus gracilis	21 S	82 G/S	0	0	19 S	122
nigeriae	0	275 F/G/J/S	140 F/G/S	0	2 F	417
Desmodilliscus braueri	4 S	12 S	0	0	0	16
Thamnomys macmillani	0	7 J	0	0	0	7
rutilans	0	0	1 F	3 F	0	4
Dasymys foxi	2 S	84 G/S	0	0	0	86
incomtus	1 S	11 F	22 F/G/S	2 F	16 F/J/S	52
Dasymys sp.	7 F	0	0	0	0	7
Arvicanthis niloticus	95 S	234 F/G/S	88 F/G/S	29 F/J	393 F/J/S	839
Lemniscomys barbarus	1 G	75 G/J/S	7 G/S	7 J	0	90
striatus	22 F/G	22 F/G/J	30 F/G	10 J	5 J	89
Hybomys trivirgatus	12 F	0	0	0	0	12
Aethomys stannarius	0	0	0	0	15 J	15
Rattus rattus	1 F	93 F/G	26 F/G	9 F/J	27 F/J	156
Hylomyscus alleni	43 F	53 F/G/S	6 F/G	0	0	102
Hylomyscus sp.	1 F	0	0	0	0	1
Mastomys natalensis	100 F/G/S	546 F/G/J/S	229 F/G/S	298 F/J	119 F/J/S	1292
Praomys jacksoni	6 F	4 G	0	0	0	10
tullbergi	20 F	0	0	0	0	20
Myomys daltoni	9 G/S	123 G/J/S	4 G/S	0	24 J/S	160
fumatus	0	21 G/S	3 G/S	0	0	24

TABLE 1, continued

Species	1966	1967	1968	1969	1970	Total
RODENTIA, concluded						
Malacomys longipes	3 F	0	0	0	0	3
Mus hausa	10 S	34 J/S	0	0	3 S	47
minutoides	0	0	58 G/S	0	11 J/S	69
musculoides	30 F/G/S	19 G/S	0	0	0	49
musculus	2 F	0	0	0	21 F/J	23
Mus sp.	2 F	86 F	62 F	117 F/J	0	267
Lophuromys sikapusi	14 F	78 F	43 F	30 F	17 F	182
Uranomys acomyoides	0	1 G	0	0	0	1
ruddi	0	172 F	177 F/G	67 F	25 F	441
Cricetomys gambianus	34 F/G/S	32 F/G/S	9 G/S	1 J	110 J/S	186
Dendromus exoneratus	0	1 J	0	0	0	1
Steatomys caurinus	0	35 G	0	0	0	35
cuppedius	0	1 S	0	0	0	1
Graphiurus hueti	0	0	1 G	0	0	1
murinus	1 S	15 F/G/J	7 G/S	1 F	0	24
Atherurus africanus	1 F	0	0	0	0	1
Thryonomys swinderianus	0	2 F	1 G	0	0	3
CARNIVORA						
Poecilictis libyca	0	2 S	0	0	0	2
Genetta tigrina	1 F	0	0	0	0	1
Nandinia binotata	0	0	2 G	0	0	2
Atilax paludinosus	1 F	0	0	0	0	1
Mungos gambianus	0	1 G	0	0	0	1
Crossarchus obscurus	1 F	0	0	0	1 J	2
HYRACOIDEA						
Procavia ruficeps	0	0	2 G	0	0	2
Totals	910	2884	1812	721	1170	7497

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zones were Congo, both Jos Plateau and Sudan woodland, and Dakar bat virus, both high forest and Guinea woodland. Of the remaining agents, bluetongue, Lebombo, and Mokola were exclusive to high forest; IbAn 33709, to Guinea woodland; Bhanja and Dugbe, to the Jos Plateau; and Chandipura, IbAn 17143, poxvirus (IbAn 34325), Semliki Forest, Uganda S, and West Nile, to Sudan woodland.

DISCUSSION

It is apparent that small mammals in the regions of West Africa covered by this study are infected with a wide range of viruses. Several of the agents encountered have been implicated in diseases of man or domestic animals, either in Nigeria or elsewhere. The present finding suggest possible wildlife reservoirs for these viruses, and study of the relationship of the animal hosts to the en-

TABLE 2. Viruses isolated from wild mammals in West Africa, 1966-1970.

Virus (Nigerian prototype*)	Total isolates	Source (no. of isolates)
Arumowot (IbAn 14130)	6	*Crocidura* sp. (1), *Tatera kempii* (1), *Thamnomys macmillani* (1), *Arvicanthis niloticus* (3)
Bhanja (IbAn 2709)	2	*Atelerix albiventris, Xerus erythropus*
Bluetongue type 7 (IbAn 22703)	1	*Crocidura* sp.
Chandipura (IbAn 9978)	1	*Atelerix albiventris*
Congo (IbAn 7620)	2	*Atelerix albiventris*
Dakar bat (IbAn 8646)	3	*Tadarida condylura*
Dugbe (IbAr 1792)	1	*Cricetomys gambianus*
IbAn 17143	1	*Atelerix albiventris*
IbAn 33709	1	*Tatera kempii*
Lebombo (IbAn 22853)	1	*Thryonomys swinderianus*
Mokola (IbAn 27377)	4	*Crocidura* sp.
Poxvirus (IbAn 34325)	1	*Tatera kempii*
Semliki Forest (IbAn 49809)	1	*Atelerix albiventris*
SudAn 754/61 (IbAn 10065)	53	*Atelerix albiventris* (2), *Galago senegalensis* (2), *Tatera kempii* (6), *Taterillus gracilis* (5), *Taterillus nigeriae* (5), *Arvicanthis niloticus* (26), *Lemniscomys barbarus* (1), *Mastomys natalensis* (2), *Cricetomys gambianus* (4)
Uganda S (IbAn 10069)	3	*Arvicanthis niloticus, Mastomys natalensis, Cricetomys gambianus*
West Nile (IbAn 4029)	2	*Arvicanthis niloticus*

* All Nigerian prototype strains listed were isolated during this study with the exceptions of those for Bhanja, Congo, Dugbe, and West Nile viruses.

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TABLE 3. Analysis of virus isolates by month.

Virus	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Arumowot	1			4								1	6
Bhanja												2	2
Bluetongue type 7											1		1
Chandipura					1								1
Congo						1						1	2
Dakar bat	1				1	1							3
Dugbe												1	1
IbAn 17143	1												1
IbAn 33709				1									1
Lebombo											1		1
Mokola					2	1	1						4
Poxvirus (IbAn 34325)				1									1
Semliki Forest					1								1
SudAn 754/61				14	35	4							53
Uganda S					3								3
West Nile					2								2
Virus total	3	—	—	20	45	7	1	—	—	—	2	5	83
No. animals tested	881	105	432	1096	1661	813	208	108	270	302	502	1119	7497
Isolation rate (%)	0.3	—	—	1.8	2.7	0.9	0.5	—	—	—	0.4	0.4	1.0

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vironment may shed light on the epizootiology and potential importance of the agents to man and animals in West Africa.

Dugbe, Congo, and Bhanja viruses are tick-borne agents frequently isolated from ixodid ticks and domestic livestock in Nigeria.[7,10,18] Dugbe is the virus most commonly recovered by the VRL in Nigeria and has also been responsible for febrile illnesses in man.[26] The present isolation from the giant rat *Cricetomys gambianus* represents the first of Dugbe from wildlife. *Cricetomys* occurs in greater numbers in Nigeria than this study would imply, since local residents prefer to eat these rats instead of contributing them for research.

Congo virus, associated with human morbidity in Zaire (the former Belgian Congo) and with both morbidity and mortality in East Africa,[36] has recently been shown to be indistinguishable antigenically from the causative agent of Crimean hemorrhagic fever of man in the USSR.[4] The fact that the first two wildlife isolates of Congo virus in Nigeria came from the African hedgehog,

TABLE 4. Analysis of virus isolates by vegetative zone and year*.

Zone (isolation rate)	Years sampled	No. isolates/ No. animals tested	Viruses isolated
High forest	1966	1/289	Dakar bat
(0.3%)	1967	2/783	Bluetongue type 7, Lebombo
	1968	3/660	Mokola
	1969	1/257	Mokola
	1970	0/175	—
Guinea woodland	1966	2/196	Dakar bat
(0.8%)	1967	1/724	Arumowot
	1968	11/845	IbAn 33709, SudAn 754/61 (10)
	1969	0/13	—
Jos Plateau	1967	5/324	Arumowot (4), SudAn 754/61
(0.7%)	1969	0/451	—
	1970	4/434	Bhanja (2), Congo, Dugbe
Sudan woodland (2.3%)	1966	4/420	Arumwot, Chandipura, SudAn 754/61, Uganda S
	1967	8/1053	Congo, IbAn 17143, SudAn 754/61 (6)
	1968	3/307	Poxvirus (IbAn 34325), SudAn 754/61 (2)
	1970	38/561	Semliki Forest, SudAn 754/61 (33), Uganda S (2), West Nile (2)
Sahel woodland (0%)	1966	0/5	—

* Animals were not sampled from the Guinea woodland zone in 1970; from the Jos Plateau in 1966 or 1968; from the Sudan woodland zone in 1969; or from the Sahel woodland zone in 1967-1970.

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Atelerix albiventris, and were widely spaced in time and location (one obtained in 1967 at Dada in the northwest,[9] the other in 1970 at Bassa on the Jos Plateau[24]) points to the hedgehog as a possible West African wildlife reservoir. Such a reservoir might well constitute a source of virus for migratory birds on their way to Europe or Asia, or for their ectoparasites. If so, gathering places for migratory birds may be important as dissemination and virus amplification sites; for example, Malamfatori on Lake Chad, where several avian species assemble in vast numbers from a wide area of West Africa before crossing the Sahara on their spring migration.

Bhanja virus, originally isolated in India from ticks, *Haemaphysalis intermedia,* removed from a paralyzed goat,[33] has not been implicated in human disease. In Nigeria, this virus has been isolated repeatedly from both livestock[18] and ticks.[10] The present two isolates, from the African hedgehog and the ground squirrel, *Xerus erythropus,* are believed to be the first from wildlife.

Chandipura, of the vesicular stomatitis (VS) group of arboviruses, was first isolated from man in India during an epidemic in which both it and the presumptive causative agent, chikungunya virus, were recovered from seemingly indistinguishable illnesses.[2] The present isolation of Chandipura from a hedgehog represents the first of a VS group virus in Africa and has been reported elsewhere.[34] This finding of the virus in northern Nigeria, in an important livestock-rearing area, would seem to have possible disease implications in West Africa for both man and his domestic animals.

Lebombo is a serologically ungrouped arbovirus that was originally isolated from mosquitoes, *Aedes circumluteolus,* in South Africa (South African Institute for Medical Research, unpublished data). In addition to its recovery in this study from a cutting grass rat, *Thryonomys swinderianus,* it has been isolated in Nigeria from lice (*Scipio aulacodi*) obtained from the same rat, from *Mansonia africana* (V.H. Lee, personal communication), and from a febrile child.[26]

Mokola virus of the rabies serogroup[35] has been isolated only in Nigeria: from non-nervous tissues of shrews,[20] from cerebrospinal fluid of a child who survived the infection,[12] and from the brain of a child who died of a paralytic illness.[13] Epidemiologic data pertaining to these infections[20] and results of experimental transmission studies in shrews[21] are reported elsewhere. This virus may well be a cause of significant morbidity or mortality in West Africa, where shrews are common in urban and rural habitats.

The present recovery of Semliki Forest virus, a group A arbovirus, from a hedgehog represents the first isolation of this agent both in Nigeria and, to our knowledge, from a naturally infected mammal.

Uganda S virus, of arbovirus group B, has been isolated from mosquitoes and from a febrile child in South Africa.[38] The present three isolates, each from a different rodent genus, may indicate that small mammals play a role in the maintenance of the virus in nature. This possibility is supported by recovery of Uganda S virus from sentinel baby mice in the vicinity of Ibadan during 1966 (VRL, unpublished data).

West Nile virus, also of group B, is widely distributed, having been isolated in Africa, Asia, and southern Europe.[37,30,11] In man, infection with the virus may range from inapparent infection to febrile illness to a dengue-like illness, with or without rash, to encephalitis.[30,14,25,1] The virus also has been isolated from wild birds,[28] a bat,[29] and two naturally infected horses with encephalitis, one in Egypt[31] and the other in France.[16] In Nigeria, isolations have been made from sentinel mice (1965, 1967, 1969), wild birds (1965, 1968), and camels (1969).[19] The recoveries from *Arvicanthis niloticus* reported here are thought to represent the first from rodents.

Bluetongue is an important disease of sheep and cattle in some parts of the world. A number of bluetongue virus strains have been recovered from *Culicoides* spp. in Nigeria;[28] these seem to cause little or no observable disease in indigenous sheep,[27] but exotic animals, if introduced into the country, would probably be at risk. The significance of the isolation of bluetongue virus type 7 from

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a shrew is not yet known; however, bluetongue strains have been isolated from rodents in South Africa.[15]

So far there is no evidence to indicate that the remaining six virus types isolated in this study play a role in infections of man or domestic animals. Arumowot and SudAn 754/61 viruses, both members of the Phlebotomus fever group, were first isolated in the Sudan, the former from *Culex antennatus* in 1963[82] and the latter from a mixed tissue pool from animals (J. Schmidt, personal communication). Our findings extend their known range from the Sudan in northeast Africa to the savannah areas of West Africa, and one might thus expect these agents to be present in many of the arid regions of Africa. Neither virus seems to have a pronounced host preference, SudAn 754/61, in particular, having been isolated from nine different species of wild mammal in this study.

Dakar bat virus is a member of the group B bat salivary gland viruses, which appear to be host specific and perhaps are able to propagate in their mammalian hosts without the need for an arthropod vector.

Details of the characterization of poxvirus, IbAn 34325, will be reported separately. IbAn 17143 and IbAn 33709 are probably new viruses and are still under study; nothing is yet known concerning their pathogenicity for animals other than mice.

It should be noted that most of the isolations reported here were made from tissue specimens. With the collections at Bassa, however, only serum specimens were tested, and these yielded two isolates of Bhanja virus, and one each of Congo and Dugbe viruses. As already mentioned, the Bhanja and Dugbe isolates represent the first of the two agents from wildlife. Whether more general use of serum, rather than tissues, would have resulted in a greater number of Bhanja and Dugbe isolates is not known.

Acknowledgements

During the period in which these studies were carried out, the Virus Research Laboratory received support from The Rockefeller Foundation.

The authors are particularly indebted to the field representatives of the Smithsonian Institution, U.S. National Museum, who made their headquarters at Ibadan. These personnel did a good deal of training of VRL staff in the trapping and identification of animals and the preparation of museum specimens from them for definitive identification in Washington, D.C. In order of their arrival in Ibadan, they were Mr. and Mrs. Harry John Herbert and Mr. and Mrs. Julius Geest. The Smithsonian team in Togo and Dahomey consisted of Mr. Brian Robbins and Mr. James Leduc. All of these field team members deserve special praise in that they performed repetitive, exacting tasks under difficult living conditions understood only by those who have lived continuously in a tent in the humid and arid tropics.

Mr. Stanley Akpan assisted in the collection and identification of animals in the Ibadan area and also on trips independent of the Smithsonian teams with VRL staff. Mr. James Phillips collected the majority of the primate samples during 1969. Mr. Maxwell Alphonsus assisted in virology, and Mr. Edward O'Connor with identification of viral isolates.

Thanks are also due to governmental officials too numerous to mention in Nigeria, Dahomey, and Togo, who greatly facilitated the attempts to collect animals.

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Received for publication 27 December 1973

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