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Chapter 18

BUNYAMWERAL FEVERS: BUNYAMWERA, ILESHA, GERMISTON,  
BWAMBA, AND TATAGUINE

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55 I. INTRODUCTION

56  
57 Bwamba, Bunyamwera, Germiston, Ilesha, and Tataguine viruses, all members of the family  
58 Bunyaviridae,<sup>1-4</sup> are endemic in Africa and have never been recognized elsewhere. All these  
59 viruses can cause mild febrile illness, with or without rash; none is responsible for important  
60 epidemic disease or has a great social or economic impact. Interest in the study of these  
61 viruses centers on both their epidemiology and their structure. Among the five viruses,  
62 Bunyamwera, Bwamba (including Bwamba-related virus such as Pongola), and Tataguine  
63 have been isolated most frequently.

64  
65 II. HISTORICAL BACKGROUND

66  
67 A. Discovery of Agents

68 In 1941, Smithburn et al.<sup>5</sup> first described the isolation of Bwamba virus. In 1946, they<sup>6</sup>  
69 reported the first isolation of Bunyamwera virus, which is considered the prototype of the  
70 Bunyamwera group; it was recovered in Uganda from a pool of *Aedes* mosquitoes.

71 In 1957, Ilesha virus was isolated in a Nigerian village of the same name from blood of  
72 a 9-year-old girl.<sup>7</sup> Germiston virus was recognized by Kokernot et al.<sup>8</sup> in 1960 in South  
73 Africa. The first isolation of Tataguine was made by Brès et al.<sup>9</sup> from a mixed pool of *Culex*  
74 and *Anopheles* mosquitoes collected in Senegal in 1961.

75  
76 B. History of Human Cases and Geographical Spread

77 Bwamba virus was first recognized in the setting of a small outbreak in western Uganda;

109 Germiston viral polypeptides have been studied by Ozden and Hannou<sup>23</sup> consist of three  
110 major structural polypeptides (mol wt  $125 \times 10^6$ ,  $27 \times 10^6$ ,  $18 \times 10^6$ ) and one minor  
111 larger protein (mol wt  $185 \times 10^3$ ).

#### 112 113 A. Antigenic Relationships

114 Bunyamwera virus is closely related to other members of Bunyamwera group, but a prior  
115 infection by any member of this serogroup does not prevent human infection with another  
116 virus of the same group. Ukauwa virus is now considered to be a strain of Bunyamwera  
117 virus.

118 Bwamba virus cross reacts by neutralization test (N) with Pongola virus<sup>24</sup> nevertheless,  
119 it clearly differs in a quantitative reciprocal manner. Johnson et al.<sup>14</sup> demonstrated that a  
120 Bwamba virus variant isolated in Kenya could present antigenic characteristics of Pongola  
121 virus.

122 Originally, Germiston virus was described as having significant reciprocal neutralization  
123 (adult mouse N test) with Bunyamwera; nevertheless, these two viruses are readily distin-  
124 guished by hemagglutination inhibition (HI) and CF, as mentioned by Kokernot et al.<sup>8</sup>

125 Ilesha virus cross reacts to some degree with Bunyamwera by the N test;<sup>25</sup> by HI, the  
126 closest relationship is with Cache Valley.<sup>26</sup> By CF test, Ilesha virus is related more closely  
127 to Bunyamwera and Cache Valley than to other members of the Bunyamwera serogroup.<sup>27</sup>

#### 128 129 B. Host Range

130 Table 1 summarizes the available data concerning natural host range, as evidenced by  
131 virus isolation and antibody tests. All five viruses have been isolated from humans, whereas  
132 data on other vertebrate species are scanty. Susceptibility of laboratory hosts is variable.  
133 All viruses are pathogenic for newborn mice by the intracerebral (i.c.) route; Bunyamwera  
134 and Germiston viruses are the most pathogenic, causing death in weaned mice by the  
135 peripheral route. Tataguine virus is the least pathogenic and does not produce illness in  
136 suckling mice inoculated i.c. or weaned mice by any route. Susceptibility of hamsters,  
137 rabbits, and other experimental hosts is described in the *International Catalogue of Arthro-*  
138 *pod-Borne Viruses*.<sup>27</sup>

#### 139 140 C. Methods for Assay

141 All of the viruses may be assayed by i.c. inoculation of newborn mice. Cell culture  
142 systems can be used, but the cytopathic effect is not always easy to see and is sometimes  
143 absent. Susceptibilities of some cell culture systems are given in Table 2.

144 Techniques for virus isolation and assay using mosquito cell cultures or mosquitoes  
145 inoculated by the intrathoracic route are described below. The sensitivity and specificity of  
146 various infectivity assays are different for each virus. The N test performed with Tataguine  
147 virus in VERO cells has a high specificity and is more sensitive than the MPN test.<sup>28</sup>

### 148 149 IV. DISEASE ASSOCIATIONS

#### 150 151 A. Humans

152 The most frequent symptoms are fever, headache, arthralgia. The hallmark of nearly all  
153 cases is their brief duration (4 or 5 days) and benign nature: no fatalities are recorded.

154 Physical examination is generally normal except, at times, for the presence of conjunctivitis  
155 or stiffness of the neck.<sup>11-12</sup> Convalescence is characterized by marked asthenia lasting 8 to  
156 10 days.

157 Bwamba virus is responsible for a relatively severe form of generalized infection. Ex-  
158 anthem is nearly always present, and it is frequently associated with meningeal involvement.<sup>74</sup>  
159 A case of myocarditis has been reported.<sup>11</sup> Intestinal tract involvement, especially diarrhea,  
160 is also seen.<sup>74</sup>

161 Bunyamwera virus is generally responsible for pediatric infection. Children present with  
162 fever, headache, joint pains, and rash. Recovery occurs in less than 7 days. In some cases,  
163 visual disturbances and vertigo have been observed.<sup>14</sup> When infection occurs accidentally  
164 or in immunologically compromised patients, severe encephalitis can be observed.<sup>29</sup>

165 Ilesha virus infections are characteristically mild, with the primary symptom being a  
166 feeling of malaise. Fever, when present, is generally less than 39°C. A transient discrete  
167 exanthem is seen in about half of the cases.<sup>30</sup> Recovery occurs without sequelae, but asthenia  
168 persists for 8 to 10 days.

169 Tataguine virus is associated with mild disease in children and more severe symptoms in  
170 adults. Rash is present; however, fever is usually less than 39°C. Some patients complain  
171 of marked headache, gastrointestinal symptoms, and a florid, nonpruritic rash.<sup>10</sup>

172 Only two laboratory-acquired Germiston virus infections have been reported from South  
173 Africa; both were characterized by mild disease without specific symptoms and with recovery  
174 occurring in 37 hr to 3 days.<sup>8</sup>

175

#### 176 B. Wild and Domestic Animals

177 No natural disease has been reported.

178

#### 179 C. Diagnostic Procedures

##### 180 1. Virus Isolation

181 Viremia is usually of short duration (24 to 48 hr); Ilesha virus, however, has been isolated  
182 4 days after onset of disease.<sup>12</sup> The greatest number of successful virus isolations has been  
183 made using both i.c. and subcutaneous (s.c.) or intraperitoneal (i.p.) inoculation of suckling  
184 mice (usually 1 to 2 days of age). Material for inoculation consists of blood, serum, or  
185 plasma from humans and mammals or of arthropod pools diluted in Hanks' balanced salt  
186 solution or similar solution containing a source of protein (bovine albumin or serum). The  
187 virus can be identified at the time of harvest of a mouse brain tissue using the Chrom Elisa  
188 Technic of Lhuillier and Sarthou,<sup>31</sup> or it may be established by passage and identified by  
189 use of an appropriate serological test (CF or N test).

190

3  
4 Less experience has been accumulated with the use of cell culture systems for the isolations  
5 of these viruses. Continuous cell lines, such as VERO or BHK-21 or *Aedes albopictus*  
6 (C6/36), may be useful. Inoculated C6/36 cells can be tested between days 2 and 10 for  
7 virus by indirect immunofluorescence (IFA) with specific ascitic fluids or held for as long  
8 as 2 weeks with infectious virus detectable by an appropriate technique such as mouse  
9 inoculation.

10 The viruses under consideration can also be isolated by intrathoracic inoculation of *Tox-*  
11 *orhynchites* mosquitoes.<sup>32</sup> Antigen is demonstrated by testing mosquito head squashes by  
12 IFA or pooled mosquitoes by CF.

13 ¶ Detection of virus in serum by enzyme immunoassay, as described for yellow fever,<sup>33</sup> could  
14 represent a new approach to diagnosis, but is limited by the probable short duration and  
15 low titer of viremia in cases of most bunyaviral infections.

### 16 2. Serological Diagnosis

17 One must consider the serological cross reactivity within the Bunyaviridae family.<sup>27</sup> The  
18 "original antigenic sin" phenomenon applies to humans infected with multiple Bunyamwera  
19 group viruses. Usually, a battery of viruses and tests is required to clarify the diagnosis.<sup>34</sup>

20 ¶ Serological response to infection can be low and/or without seroconversion in the case of  
21 Tataguine virus;<sup>12</sup> infection can be serologically diagnosed by the N test but not the CF  
22 test.<sup>11</sup> Methods such as IgM antibody detection, described for other arboviruses, could  
23 represent a new approach to serodiagnosis.

## 24 V. EPIDEMIOLOGY

### 25 A. Geographic Distribution and Seroepidemiology

26 The distribution of these viruses determined by virus isolation has been described (in  
27 Section II.B) and is shown in Table 3. The table also shows the results of seroprevalence  
28 surveys in various countries of Africa.

29 ¶ No serological or virological evidence for activity of any of these agents has been found in  
30 North Africa, with the exception of Egypt, where a low prevalence (0.9%) of N test antibodies  
31 to Bunyamwera but no antibodies to Bwamba virus was reported.<sup>35</sup>

32 In tropical parts of West Africa, the prevalence of BUN antibodies has been high in many  
33 countries.<sup>36</sup> In Equatorial Guinea, the prevalence of antibodies to Bunyamwera and Bwamba  
34 viruses appeared to be higher than to most other arboviruses.<sup>37</sup> In contrast, a low prevalence  
35 of Bunyamwera antibodies was reported in Togo, Benin, Mali, Niger, and Chad.<sup>38,39</sup>

36 ¶ In Central Africa, 100% of the populations inhabiting the rainforest area of the Congo had  
37  
38  
39

52. 4) Tataguine virus has a wide geographic distribution encompassing West and Central Africa. 44  
53. In Nigeria, the highest prevalence of antibodies was found in the derived savannah zone  
54. (61%) followed by lowland rain forest (42%).<sup>45</sup>  
55.

#### 56. B. Incidence

57. Evidence for human infections has been accumulated by many studies and is summarized  
58. in Table 3.<sup>13,15,36,40,43,44,46,50</sup> After chikungunya, Semliki Forest, Sindbis, yellow fever, Uganda  
59. S, West Nile, Wesselsbron, and Zika, Bunyamwera and Bwamba appear as the ninth and  
60. tenth most frequent arboviruses infecting humans in the African continent.<sup>36</sup> In the Central  
61. African Republic, Bwamba was the virus most often isolated from human cases of arboviral  
62. infection.<sup>12</sup> Tataguine virus also appears to be a very common human infection in some  
63. areas, e.g., Nigeria,<sup>45</sup> where multiple virus isolations have been made from febrile patients.<sup>46</sup>  
64.

#### 65. C. Seasonal Distribution

66. Bunyamwera virus has been isolated in either the middle or, more frequently, at the end  
67. of the rainy season. In the Central African Republic, Ilesha and Bwamba viruses were most  
68. often isolated during the dry season. All Tataguine virus isolations were made during the  
69. dry season. Germiston strains from Kenya were isolated at the beginning of the rainy season.<sup>47</sup>  
70.

#### 71. D. Risk Factors

72. Bunyamwera antibodies seem to appear earlier in age in females than in males, and the  
73. seroprevalence in females remains higher lifelong.<sup>49,50</sup>  
74.

## 75. VI. TRANSMISSION CYCLES

### 77. A. Evidence from Field Studies

#### 78. 1. Vectors

79. Bunyamwera virus has been isolated from mosquitoes belonging to three genera (*Aedes*,  
80. *Mansonia*, and *Culex*), but *Aedes* spp. appear to play the predominant role in transmission.  
81. Multiple strains of the virus were recovered from *Ae. circumluteolus* collected at the same  
82. time and place as a naturally infected human in South Africa.<sup>55</sup> The wide array of mosquito  
83. species which have yielded virus suggests that high viremia levels may occur in a variety  
84. of different vertebrate hosts.

85. Little field evidence has been accumulated for Ilesha virus; the virus has been isolated  
86. from *Anopheles gambiae* in the Central African Republic and Senegal and from *Cx. thalassius*  
87. in Senegal.<sup>57</sup> Germiston virus has been recovered repeatedly from *Cx. rubinotus* in South  
88. Africa,<sup>8,58</sup> Zimbabwe,<sup>58</sup> Mozambique,<sup>58</sup> Kenya,<sup>57</sup> and Uganda.<sup>59</sup> High minimum infection  
89. rates in this species suggest that transovarial transmission of the virus may occur.

90. Bwamba virus has been isolated from *An. funestus* in Uganda,<sup>27</sup> Senegal, Nigeria,<sup>27</sup> Central  
91. African Republic,<sup>57</sup> and the Ivory Coast<sup>57</sup> and from *An. gambiae* and *Ae. furcifer* in Senegal.<sup>57</sup>  
92. Twelve strains of Bwamba virus were isolated during field studies in riverine forest in  
93. Nigeria in 1971,<sup>60</sup> the majority from *Ae. (Neomelanoconion) spp.* and *Ae. (N.) circumlu-*  
94. *teolus*, but also from *An. coustani* and *Ma. uniformis*. The *Aedes* were captured on human  
95. bait, suggesting that these mosquitoes, as well as anophelines, may be responsible for human  
96. infections.

97. Tataguine virus has been isolated principally from anopheline mosquitoes. Multiple strains  
98. have been recovered from *An. gambiae* in Cameroon;<sup>15</sup> Central African Republic, Senegal,  
99. and Ethiopia; from *An. funestus* in Nigeria, Central African Republic,<sup>27,57</sup> and Ethiopia; and  
100. from *An. nili* in Senegal.<sup>27,57</sup> An isolate has also been made from *Coquillettidia aurites* in  
101. Cameroon.<sup>27,57</sup> The association between virus isolations from humans and anopheline mos-  
102. quitoes suggests that transmission occurs in the domestic habitat with humans serving as a  
103. viremic host.<sup>15</sup>  
104.

#### 105. 2. Vertebrate Hosts

Table

106 No isolations of Bunyamwera, Ilesha, Bwamba, or Tataguine viruses have been made  
107 from naturally infected vertebrates. Germiston virus has been isolated on multiple occasions  
108 from rodents (Table 4): from *Dasymys incomtus* in Kenya<sup>48</sup> and from *Rattus rattus*, *Arvi-*  
109 *canthus niloticus*, *Lophuromys sikapusi*, and *L. flavopunctatus* in Uganda.<sup>59,61</sup> An isolate  
110 was made from a mongoose (*Herpestes ichneumon*) in Kenya.<sup>48</sup> Multiple isolations of  
111 Germiston virus were also made from sentinel hamsters in South Africa and Mozambique.<sup>62</sup>

112 The interpretation of serological evidence for involvement of vertebrate hosts with Bun-  
113 yamwera group viruses is limited somewhat by the problem of antigenic cross reactivity  
114 among members of the serogroup. Neutralizing antibodies to Bunyamwera, Bwamba, and  
115 Germiston viruses have been found in domestic livestock (Table 4). A high seroprevalence  
116 to Germiston virus has also been found in rodents, in accord with virus isolation data  
117 implicating them as hosts. A high prevalence of antibodies to Tataguine virus in humans  
118 and absence of antibodies in wild and domestic animals<sup>45</sup> further support the conclusion that  
119 humans serve as hosts in the transmission cycle. Antibodies to Bwamba virus have been  
120 found in birds in South and East Africa.<sup>27,48</sup> A high prevalence of antibodies in monkeys  
121 was reported in Uganda.<sup>63</sup> In South Africa, the seroprevalence in humans to Bwamba and  
122 Bunyamwera viruses was significantly higher than in monkeys, birds, or domestic livestock.<sup>41</sup>

## 123

### 124 B. Evidence from Experimental Studies

#### 125 1. Vectors

126 After intrathoracic inoculation, Bunyamwera virus has been shown to replicate in *Ae.*  
127 *vexans*,<sup>64</sup> *Ae. canadensis*,<sup>64,65</sup> *Ae. aegypti*,<sup>64-66</sup> *Ae. triseriatus*,<sup>65,66</sup> *Psorophora ferox*,<sup>66</sup> *Cx.*  
128 *pipiens*,<sup>27</sup> and *An. quadrimaculatus*.<sup>27</sup> Oral infection of and transmission by *Ae. aegypti* has  
129 been demonstrated for both Bunyamwera<sup>64,65,67</sup> and Ilesha viruses.<sup>67</sup>

130 *Cx. rubinotus* has been shown to become infected after feeding on virus and to transmit  
131 virus to hamsters.<sup>27</sup> Bwamba virus has been shown to infect *Ae. aegypti*, *An. quadrima-*  
132 *culatus*, and *Cx. pipiens* after intrathoracic inoculation,<sup>27</sup> but susceptibility to oral feeding  
133 has not been investigated. *Cx. pipiens* fed on virus-soaked pledgets become infected with  
134 but are incapable of transmitting Tataguine virus.<sup>68</sup>

#### 135

#### 136 2. Vertebrate Hosts

137 Wild African rodents (*Arvicanthus abyssinicus* and *Cricetomys gambianus*) experimentally  
138 infected with Bunyamwera virus develop viremias sufficient to infect mosquitoes, suggesting  
139 that rodents could play a role in natural transmission cycles.<sup>69</sup> Similar results have been  
140 reported for *Tadarida* bats.<sup>70</sup> Monkeys develop viremia, fever, and inapparent or mild  
141 illness.<sup>71</sup> Germiston virus behaves similarly in experimental animals, including rodents  
142 (*Arvicanthus niloticus*<sup>59</sup> and *Tatera brantsi*<sup>72</sup>) and monkeys.<sup>71</sup> Little or no useful information  
143 is available regarding experimental infections with Bwamba or Ilesha viruses.

#### 144

#### 145 C. Summary

146 Except for Germiston virus, for which convincing evidence of a rodent-*Cx. rubinotus*  
147 cycle is available, the natural history of the viruses under consideration remains obscure.  
148 All viruses are mosquito-borne; for Ilesha, Bwamba, and Tataguine viruses, anophelines  
149 appear to be the principal vectors, especially endo- and anthropophilic species (*An. gambiae*  
150 and *funestus*). A human-*Anopheles* cycle is suggested for Tataguine and possible Bwamba  
151 viruses, but a role for wild vertebrate hosts cannot be excluded.

152

160 Ilesha antibody prevalence in the endemic area of Nigeria appears to be highest in the  
161 savannah than in the plateau and rain forest, and the virus seems to be more active in rural  
162 than in urban communities.<sup>73</sup> Germiston virus isolations have been associated with irrigated  
163 areas, where cattle have a high antibody prevalence. Tataguine antibodies have been found  
164 in highest prevalence in the derived savannah vegetational zone.<sup>45</sup>

165

166

#### VIII. PREVENTION AND CONTROL

167

168 Vaccines are not available. Because of their relatively low pathogenicity and lack of  
169 economic impact, specific efforts have not been developed to reduce the incidence of these  
170 diseases.

171



- Vertebrates, 3rd ed., American Society of Tropical Medicine and Hygiene, Washington, D.C., 1985.
- 34 28. Fagbami, A. H., Growth, plaque assay and immunofluorescent studies on Tataguine virus in cell culture, *Cytophos* 26, 37, 1979.
- 35 29. Southam, C. M. and Moore, A. E., West Nile, Ilheus, and Bunyamwera virus infections in man. *Am. J. Trop. Med. Hyg.*, 31, 724, 1951.
- 36 30. Brottes, H. and Salaun, J. J., Isolement au Cameroun d'une souche d'arbovirus a partir d'une fièvre exanthématique. *Arch. Inst. Pasteur Tunis*, 1, 77, 1965.
- 37 31. Lhuillier, M. and Sarthou, T. L., Chrom Elisa: a new technique for rapid identification of arboviruses, *Ann. Virol. (Inst. Pasteur)*, 134E, 349, 1983.
- 38 32. Gonzalez, J. P., Saluzzo, J. F., and Herve, J. P., Interet de la technique d'inoculation intrathoracique a *Aedes aegypti* dans l'isolement et le reisolement des arbovirus. *Ann. Virol. (Inst. Pasteur)*, 132E, 519, 1981.
- 39 33. Monath, T. P. and Nystrom, R. R., Detection of yellow fever virus in serum by enzyme immunoassay, *Am. J. Trop. Med. Hyg.*, 33, 151, 1984.
- 40 34. Peters, C. J. and LeDuc, J. W., Bunyaviruses, Phleboviruses, and related viruses, in *Textbook of Human Virology*, Belshe, R. B., Ed., PSF Publishing, Littleton, Mass., 1984.
- 41 35. Smithburn, K. C., Taylor, R. M., Rizk, F., and Kader, A., *Am. J. Trop. Med. Hyg.*, 3, 9, 1954.
- 42 36. Brès, P., Recent data from serological survey on the prevalence of arbovirus infections in Africa, with special reference to yellow fever. *Bull. WHO*, 43, 223, 1970.
- 43 37. Pinto, M. R., Survey for antibodies to arboviruses in the sera of children in Portuguese Guinea, *Bull. WHO*, 37, 101, 1967.
- 44 38. Brès, P., Carrie, J., Desbois, A., Lartigue, J. J., and Mace, G., Les arbovirus en Haute Volta. *Ann. Inst. Pasteur*, 108, 341, 1965.
- 45 39. Robin, Y., Brès, P., Lartigue, J. J., Gidel, R., Lefevre, M., Athawet, B., and Hery, G., Arboviroses en Afrique de l'Ouest. *Bull. Soc. Pathol. Exot.*, 61, 833, 1968.
- 46 40. Chambon, L., Brès, P., Chippaux, C. L., et al., Role des arbovirus dans l'étiologie des fièvres exanthématiques en Afrique Centrale. *Mé. Afr. Noire*, 185, 1969.
- 47 41. Kokernot, R. H., Smithburn, K. C., and Weinbren, M. P., Neutralizing antibodies to arthropod-borne virus in human being and animals in the union of South Africa. *J. Immunol.*, 77, 313, 1956.
- 48 42. Kokernot, R. H., Smithburn, K. C., Gandara, A. F., McIntosh, B. M., and Heymann, C. S., Provas de neutralização com soros de individuos residentes em Mozambique contra determinados virus isoladas em Africa transmittidos por arthropodes. *An. Inst. Med. Trop.*, 17, 201, 1960.
- 49 43. Sureau, P., Arbovirus a Madagascar. *Arch. Inst. Pasteur Madagascar*, 38, 27, 1965.
- 50 44. Kokernot, R. H., Szlamp, E. L., Levitt, J., and DeMeillon, B., Survey for antibodies against arthropod-borne viruses in the sera of indigenous residents of Caprivi strip and Bechuanaland Protectorate, *Trans. R. Soc. Trop. Med. Hyg.*, 59, 553, 1965.
- 51 45. Fagbami, A. H., Monath, T. P., Tomori, O., Lee, V. H., and Fabiyi, A., Studies on Tataguine infection in Nigeria. *Trop. Geogr. Med.*, 24, 298, 1972.
- 52 46. Fagbami, A. H. and Tomori, O., Tataguine virus isolations from humans in Nigeria, 1971—1975, *Trans. R. Soc. Trop. Med. Hyg.*, 75, 788, 1981.
- 53 47. Johnson, B. K., Shockley, P., Chanas, A. C., et al., Arbovirus isolations from mosquitoes: Kano Plain, Kenya. *Trans. R. Soc. Trop. Med. Hyg.*, 71, 518, 1977.
- 54 48. Johnson, B. K., Chanas, A. C., Shockley, P., et al., Arbovirus isolations from, and serological studies on, wild and domestic vertebrates from Kano Plain, Kenya. *Trans. R. Soc. Trop. Med. Hyg.*, 71, 512, 1977.
- 55 49. Gonzalez, J. P., Saluzzo, J. F., Herve, J. P., and Geoffroy, B., Enquetes serologiques sur l'incidence des arbovirus chez l'homme en milieu forestier et periforestier de la region de la Basse Lohaye (Empire

ROSSES

- 66 60. Lee, V. H., Monath, T. P., Tomori, O., Fagbami, A., and Wilson, D. C., Arbovirus studies in Nupeko Forest, a possible natural focus of yellow fever in Nigeria. II. Entomological investigations and viruses isolated, *Trans. R. Soc. Trop. Med. Hyg.*, 68, 39, 1974.
- 67 61. Henderson, B. E., McCrae, A. W. R., Kirya, G. B., Ssenkubuge, Y., and Sempala, S. D. K., Arbovirus epizootics involving man, mosquitoes, and vertebrates at Lunyo, Uganda, 1968, *Ann. Trop. Med. Parasitol.*, 66, 343, 1972.
- 68 62. Annual Report, South African Institute of Medical Research, Johannesburg, 1972.
- 69 63. Dick, G. W. A., Epidemiologic notes on some viruses isolated in Uganda, *Trans. R. Soc. Trop. Med. Hyg.*, 47, 13, 1953.
- 70 64. Peers, R. R., Bunyamwera virus replication in mosquitoes, *Can. J. Microbiol.*, 18, 741, 1972.
- 71 65. Ogunbi, O., Ukauwa virus proliferation in mosquitoes, *Can. J. Microbiol.*, 14, 125, 1968.
- 72 66. Hayes, C. G., A comparison of suckling mouse and mosquito susceptibility to infection by the Bunyamwera group arboviruses, *Mosq. News*, 32, 172, 1972.
- 73 67. Boorman, J. P. T., Studies on the growth and transmission of two viruses of the Bunyamwera group in *Aedes aegypti* Linn., *Trans. R. Soc. Trop. Med. Hyg.*, 60, 332, 1966.
- 74 68. Fagbami, A. H., Studies on transmission of Tataguine virus by *Culex (pipiens) fatigans* mosquitoes, *Afr. J. Med. Sci.*, 8, 31, 1979.
- 75 69. Simpson, D. I. H., Experimental Bunyamwera virus infection in two species of African rats, *Trans. R. Soc. Trop. Med. Hyg.*, 59, 198, 1965.
- 76 70. Annual Report, East African Virus Research Institute, 1964, 5 and 46.
- 77 71. Schwartz, A. and Allen, W. P., Experimental infection of monkeys with Bunyamwera and Germiston viruses, *Infect. Immun.*, 2, 762, 1970.
- 78 72. McIntosh, B. M., Susceptibility of some African wild rodents to infection with various arthropod-borne viruses, *Trans. R. Soc. Trop. Med. Hyg.*, 55, 63, 1961.
- 79 73. Fagbami, A. H. and Fabiyi, A., A survey for Ilesha (Bunyamwera group) virus antibodies in sera from domestic animals and humans in three ecological zones of Nigeria, *Virologia*, 26, 27, 1975.
- 80 74. Gonzalez, J. P. and Georges, A. J., unpublished data.
- 81
- 82

Table I  
 ORIGIN OF VIRUS ISOLATIONS (ISOL) AND ANTIBODIES (AB) AGAINST  
 FIVE ARBOVIRUSES (BUNYAMWERA, BWAMBA, GERMISTON, ILESHA,  
 AND TATAGUINE)

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Origin	BUN		BWA		GER		ILE		TAT	
	Isol	AB	Isol	AB	Isol	AB	Isol	AB	Isol	AB
Man	+	+	+	+	+	+	+	+	+	+
Chimpanzee	ND <sup>b</sup>	+	ND	ND	ND	ND	ND	ND	ND	ND
Monkeys	ND	+	ND	ND	ND	ND	ND	ND	ND	ND
Domestic animals	ND	+	ND	ND	ND	ND	ND	ND	ND	ND
Rodents	ND	+	ND	ND	+	+	ND	ND	ND	ND
Birds	ND	+	ND	+	ND	ND	ND	ND	ND	ND
Donkeys	ND	ND	ND	+	ND	ND	ND	ND	ND	ND
Cattle	ND	ND	ND	ND	ND	+	ND	ND	ND	ND
Hamster (sentinel)	ND	ND	ND	ND	+	ND	ND	ND	ND	ND
Arthropods	+	+	+	+	+	+	+	+	+	+

<sup>a</sup> Positive isolation or presence of antibodies.

<sup>b</sup> ND, no data.

Table 1  
ORIGIN OF VIRUS ISOLATIONS (ISOL) AND ANTIBODIES (AB) AGAINST FIVE ARBOVIRUSES (BUNYAMWERA, BWAMBA, GERMISTON, ILESHA, AND TATAGUINE)

Origin	BUN		BWA		GER		ILE		TAT	
	Isol	AB	Isol	AB	Isol	AB	Isol	AB	Isol	AB
Man	+	+	+	+	+	+	+	+	+	+
Chimpanzee	ND <sup>a</sup>	+	ND	ND	ND	ND	ND	ND	ND	ND
Monkeys	ND	+	ND	ND	ND	ND	ND	ND	ND	ND
Domestic animals	ND	+	ND	ND	ND	ND	ND	ND	ND	ND
Rodents	ND	+	ND	ND	+	+	ND	ND	ND	ND
Birds	ND	+	ND	+	ND	ND	ND	ND	ND	ND
Donkeys	ND	ND	ND	+	ND	ND	ND	ND	ND	ND
Cattle	ND	ND	ND	ND	ND	+	ND	ND	ND	ND
Hamster (sentinel)	ND	ND	ND	ND	+	ND	ND	ND	ND	ND
Arthropods	+	+	+	+	+	+	+	+	+	+

<sup>a</sup> Positive isolation or presence of antibodies.  
<sup>b</sup> ND, no data.

DUPLICATE

Table 2  
SUSCEPTIBILITY OF CELL CULTURE SYSTEMS FOR FIVE BUNYAVIRUSES

Cell system	BUN		BWA		GER		ILE		TAT	
	Eff <sup>a</sup>	Day <sup>b</sup>	Eff	Day	Eff	Day	Eff	Day	Eff	Day
Chick embryo	CPE	2-5	CPE	2	PLQ	3	PLQ	4-5	ND <sup>c</sup>	ND
VERO	PLQ	5	PLQ	5	PLQ	3	PLQ	6	PLQ	6
BHK-21	CPE	4	CPE	2	PLQ	2	ND	ND	ND	ND
LLC-MK <sub>2</sub>	PLQ	4	PLQ	3	PLQ	4	PLQ	4	NP <sup>d</sup>	NP

Note: Results given can vary with the virus passage history.

<sup>a</sup> Eff, effect in cell culture (CPE, cytopathic effects; PLQ, plaques).  
<sup>b</sup> Day, mean of days after isolation.  
<sup>c</sup> ND, no data.  
<sup>d</sup> NP, no plaque.

*20th June*

Table 3  
 DETECTION OF IMMUNITY TO BWAMBA (BWA), BUNYAMWERA (BUN),  
 ILESHA (ILE), GERMISTON (GER), AND TATAGUINE (TAT) VIRUSES IN  
 HUMANS: ANTIBODY PREVALENCE AND VIRUS ISOLATIONS

	BWA	BUN	ILE	GER	TAT
North Africa					
Algeria	ND*	0.0	0.0	ND	ND
Egypt	0.0*	0.9*	ND	ND	ND
Libya	ND	0.0	ND	ND	ND
Morocco	ND	0.0	0.0	ND	ND
Tunisia	ND	0.0	0.0	ND	ND
West Tropical Africa					
Benin	ND	3.0	ND	ND	ND
Burkina faso	ND	17.0	ND	ND	*
Bameroon	**	8.0*	*	ND	*
CAR	*	24.0*	*	ND	*
Chad	ND	0.0	ND	ND	ND
Gambia	+	+	ND	ND	ND
Ghana	ND	+	6.5*	ND	ND
Guinea	ND	*	ND	ND	ND
Guinea-Bissau	43.0	11.0	3.0	ND	ND
Ivory Coast	ND	14.0	ND	ND	ND
Liberia	ND	19.0	ND	ND	ND
Mali	ND	2.0	ND	ND	ND
Niger	ND	3.0	ND	ND	ND
Nigeria	33.0—40.0*	0.0—23.0*	27.0—45.0*	10.0	26.0—61.0*
Senegal	ND	19.0*	*	ND	*
Sierra Leone	ND	*	ND	ND	ND
Togo	ND	0.5	ND	ND	ND
East Tropical Africa					
Ethiopia	ND	ND	*	ND	ND

Characters should not touch

39	West Equatorial Africa				
40	Congo	ND	7.0—25.0	ND	ND

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- 57    ▪ ND, no data.
  - 58    ▪ Sera tested, but no evidence for antibody.
  - 59    ▪ Prevalence (%) of viral antibodies.
  - 60    ▪ Virus isolation.
  - 61    ▪ Presence of viral antibodies; prevalence not defined.
  - 62
  - 63

Table 4  
 EVIDENCE OF VIRUS CIRCULATION IN WILD AND DOMESTIC  
 VERTEBRATE HOSTS

		Serological evidence		
Virus isolation		Wild animals	Domestic animals	
10	BWA No	<i>Arvicanthys niloticus</i> <i>Boedon fuliginosus</i> <i>Varanus niloticus</i> <i>Turtur ater</i> Monkeys	Goats, sheep, cattle	
14	BUN No	Chimpanzee, cattle, sheep, rodents, nonhuman primates, goats	Goats, sheep	
15	ILE No	No	No	
16	GER <i>Herpestes ichneumon</i> <i>Dasymys incommis</i> <i>Rattus rattus</i> <i>Lophuromys</i> spp. <i>Arvicanthus niloticus</i>	<i>Arvicanthus niloticus</i> Horses	Goats, sheep, cattle	
20	TAT No	No	No	

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Rebreak

Not Bold

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