

chironomids. Proc. 10th Int. Congr. Entomol. (1956), 2:219-24.

Remmert, H. 1955a. Tageszeitlich gebundenes Schlüpfen bei *Pseudosmittia arenaria* (Dipt., Chironomidae). Naturwissenschaften 42:261.

Remmert, H. 1955b. Untersuchungen über

das tageszeitlich gebundene Schlüpfen von *Pseudosmittia arenaria* (Dipt., Chironomidae). Z. Vergl. Physiol. 37:338-54.

Remmert, H. 1965. Über den Tagesrhythmus arktischer Tiere. Z. Morph. Ökol Tiere 55:142-60.

## BUNYAVIRUS INFECTION RATES IN CANADIAN ARCTIC MOSQUITOES, 1978<sup>1</sup>

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**ABSTRACT.** From 20,305 unengorged female mosquitoes of 4 species collected in the western Canadian Arctic between latitudes 60 and 69°N from 5 June through 24 July 1978, 9 strains of snowshoe hare (SSH) virus (California encephalitis complex) were isolated from

*Aedes communis* (minimum field infection rates 1:159 to 1:3003), 4 strains of SSH virus were isolated from *Culiseta inornata* (MFIR 1:73 to 1:112) and 3 strains of Northway virus were isolated from *Cs. inornata* (MFIR 1:267 to 1:1322).

### INTRODUCTION

Isolation of two antigenically distinct Bunyaviruses, snowshoe hare (SSH) virus (California encephalitis complex) and Northway (NOR) virus from mosquitoes collected near Northway, Alaska (62°N, 142°W) during July and August 1970 (Ritter and Feltz 1974), stimulated the search for similar mosquito-borne arboviruses throughout the geographically contiguous Yukon Territory from 1971 through 1974 (McLean et al. 1975) and the Mackenzie Valley of the Northwest Territories during summer 1976 (McLean et al. 1977b). The present report confirms the endemic prevalence of SSH virus in mosquitoes collected during 1978 along transportation corridors throughout the Yukon Territory and Mackenzie Delta, N.W.T., and identifies a third location some 300 miles southeast of Northway at which both NOR and SSH virus

have been detected in mosquitoes during the same summer.

### METHODS

Unengorged adult female mosquitoes were collected by hand aspirators at 11 locations throughout the boreal forest of the Yukon Territory from latitudes 60 to 66°N, and at 2 locations in the open woodland terrain of the Mackenzie Delta, N.W.T. at latitudes 68 to 69°N, between 5 June and 24 July, 1978.

Mosquitoes were sealed immediately in glass tubes and stored at -70°C in styrofoam containers with dry ice for shipment by air to Vancouver, where they were held frozen at -70°C until tested 1 to 3 months later. Pools comprising 30 to 90 mosquitoes of the same species were examined for virus content by intracerebral injection of newborn mice, and virus isolates were typed by mouse neutralization tests as described previously (McLean et al. 1972). Type-specific antisera were prepared by single intravenous injection of rabbits with Canadian

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Arctic prototype strains of SSH virus (Marsh Lake 23) and NOR virus (76-Y-330), whose serotypes have been confirmed by Dr. C. H. Calisher (personal communication November 1976).

## RESULTS

From 20,305 mosquitoes collected between 5 June and 24 July 1978 throughout the Yukon Territory and the Mackenzie Delta, N.W.T., 16 strains of Bunyavirus were isolated from 2 of 4 mosquito species (Table 1). Mosquitoes were processed in 345 pools. Virus isolates included 13 strains of SSH including 9 from *Aedes communis* De Geer and 4 from *Culiseta inornata* Williston, together with 3 strains of NOR virus, all of which were from *Cs. inornata*.

Isolates of SSH virus were achieved as early as the 25th week from 1 of 112 *Cs. inornata* plus 1 of 780 *Ae. communis* mosquitoes collected along the Dempster Highway, Y.T. at mile 62 (65°N, 138°W) on 18 June, where the minimum field infection rates (MFIR) were 1:112 and 1:780 respectively (Table 2). Subsequently SSH virus was isolated from 2 of 336 *Ae. communis* (MFIR 1:168) collected at Marsh Lake, Y.T. (61°N, 134°W) and from 3 of 476 *Ae. communis* (MFIR 1:159) collected at Annie Lake, Y.T. (60½°N, 135°W) on 5 July. Other SSH isolates were achieved from 3 of 220 *Cs. inornata* (MFIR 1:73) plus 2 of 1318 *Ae. communis* (MFIR 1:659) collected along the Dempster Highway, Y.T. at mile 123 (66°N, 138°W) on 23 July. At Inuvik, N.W.T. 1 of 3003 *Ae. communis* collected on 12 July yielded SSH virus (MFIR 1:3003).

Isolates of NOR virus were achieved from 1 of 1322 *Cs. inornata* (MFIR 1:1322) collected at Marsh Lake on 14 June and from 2 of 534 *Cs. inornata* (MFIR 1:267) collected at Carcross, Y.T. (60°N, 135°W) on the same date.

## DISCUSSION

Isolation of NOR virus, in addition to

SSH virus, at the previously described focus of SSH infection at Marsh Lake (McLean et al. 1975), indicates the co-circulation of these 2 arctic Bunyaviruses at a 3rd location in addition to Northway, Alaska (Ritter and Feltz 1974) and Inuvik, N.W.T. (McLean et al. 1977b). Although Marsh Lake is about 300 miles southeast of Northway, vegetation at both foci is boreal forest, in contrast to the open woodland vegetation at Inuvik, some 600 miles north of Marsh Lake. Furthermore, the 1978 NOR isolates were achieved from mosquitoes 5 to 6 weeks earlier than those obtained at Northway from 1970 to 1972, or at Inuvik during 1976. However the NOR isolate from the blood clot of an indicator rabbit at Northway in 1970 was achieved during the same week of June (Ritter and Feltz 1974) as the 1978 mosquito isolates. Replication of NOR virus has been demonstrated after incubation at 13°C of *Cs. inornata* for 20 and 99 days and in *Ae. communis* for 27 days after feeding on blood meals containing NOR virus (McLean et al. unpublished data) thus substantiating the role of these mosquitoes as natural summertime vectors.

Isolation of SSH virus along the Dempster Highway during mid-June and late July 1978 both from *Ae. communis* as in previous years (McLean et al. 1975) and from *Cs. inornata* for the first time, reveals the high endemic prevalence of this Bunyavirus at the northern extremity of the boreal forest in the Yukon Territory. The high MFIR of 1:73 for *Cs. inornata* in 1978 was fourfold to fortyfold greater than rates for *Ae. communis* at the same location during 1972 through 1974. Throughout the Yukon Territory during 1978 the range of MFIR for *Ae. communis* of 1:159 to 1:780 was consistent with that observed during 1971 through 1974 (McLean et al. 1975), except at 3 locations during 1972 and 1973 when they approached the substantially lower MFIR of 1:3003 for *Ae. communis* at Inuvik during 1978 or 1:3662 for *Ae. hexodontus* during 1976 (McLean et al. 1977b). Multiplication of SSH virus in *Cs. inornata* after incubation at 13°C for 42 days and in *Ae.*

Table 1. Mosquito species assayed for virus in the western Canadian Arctic, summer 1978.

Locality	Week No.	Date	Mosquito Species <sup>1</sup>				Total
			Cs. in.	Ae. com.	Ae. hex.	Ae. nig.	
Marsh Lake 61°N 134°W	24	14 June	1/1322N <sup>2</sup>	0/500 <sup>4</sup>		1/1822	
	27	5 July	0/51	2/336S <sup>3</sup>		2/387	
	29	20 July		0/808	0/344	0/1152	
	23	5 June	0/738	0/21		0/759	
	27	5 July	0/53	3/476S		3/529	
Carcross							
60°N 135°W	24	14 June	2/534N	0/144		2/678	
Lake Lebarge							
61½°N 135°W	27	4 July	0/41	0/290		0/331	
Carmacks							
62°N 136°W	24	14 June	0/335	0/1069		0/1404	
Kusawa Lake							
61°N 136°W	24	12 June	0/238	0/181		0/419	
Beaver Creek							
63°N 141°W	29	20 July	0/82	0/453	0/110	0/645	
Dempster Highway							
mile 62 (65°N 138°W)	25	18 June	1/112S	1/780S		2/892	
mile 110 (66°N 138°W)	30	23 July		0/905	0/167	0/1072	
mile 123 (66°N 138°W)	30	23 July	3/220S	2/1318S		5/1538	
mile 140 (66°N 137°W)	30	24 July		0/1052	0/208	0/1260	
Arctic Red River							
68°N 135°W	28	12 July		0/1975	0/301	0/565	
Inuvik							
69°N 135°W	28	12 July	7/3726	1/3003S	0/831	1/4576	
Total				9/13,311	0/1961	16/20,305	

<sup>1</sup> Cs. in. = *Culiseta inornata*.Ae. com. = *Aedes communis*.Ae. hex. = *Aedes hexodontus*.Ae. nig. = *Aedes nigripes*.<sup>2</sup> N: Northway virus.<sup>3</sup> S: Snowshoe hare virus (California encephalitis complex).<sup>4</sup> Ratio: number of virus isolates/number of mosquitoes processed.

Table 2. Bunyavirus isolations from Canadian Arctic mosquitoes, 1978.

Location	Week No.	Mosquito Species	Virus Serotype	Ratio <sup>1</sup>	MFIR <sup>2</sup>
Annie Lake, Y.T. 60½°N 135°W	27	<i>Ae. communis</i>	SSH	3/476	1:159
Carcross, Y.T. 60°N 135°W	24	<i>Cs. inornata</i>	NOR	2/534	1:267
Marsh Lake, Y.T. 61°N 134°W	24	<i>Cs. inornata</i>	NOR	1/1322	1:1322
	27	<i>Ae. communis</i>	SSH	2/336	1:168
Dempster Hwy, Y.T. 65°N 138°W mile 62	25	<i>Cs. inornata</i>	SSH	1/112	1:112
		<i>Ae. communis</i>	SSH	1/780	1:780
66°N 138°W mile 123	30	<i>Cs. inornata</i>	SSH	3/220	1:73
		<i>Ae. communis</i>	SSH	2/1318	1:659
Inuvik, N.W.T. 69°N 135°W	28	<i>Ae. communis</i>	SSH	1/3003	1:3003

A total of 20,305 unengorged female mosquitoes were tested in 345 pools, of which 13 yielded SSH virus (California complex) and 3 yielded NOR virus.

<sup>1</sup> Ratio: number of virus isolates/number of mosquitoes processed.

<sup>2</sup> MFIR: Minimum field infection rate.

Locations are indicated on a map (McLean et al. 1975).

*hexodontus* for 27 days following feeding on infective blood meals (McLean et al. unpublished data) and transmission of this agent by *Ae. communis* after 20 days incubation at 13°C following ingestion of 1 mouse LD<sub>50</sub> virus (McLean et al. 1977a), together with isolation of SSH virus from 7 species of *Aedes* mosquitoes in east-central Alaska, including *Ae. communis* and *Ae. hexodontus* (Ritter and Feltz 1974), strongly supports the role of these mosquitoes as natural vectors.

#### Literature Cited

McLean, D. M., E. J. Goddard, E. A. Graham, G. J. Hardy and K. W. Purvin-Good. 1972. California encephalitis virus isolations from Yukon mosquitoes, 1971. *Am. J. Epidemiol.* 95:347-355.

McLean, D. M., S. K. A. Bergman, A. P. Gould, P. N. Grass, M. A. Miller and E. E. Spratt. 1975. California encephalitis virus prevalence throughout the Yukon Territory 1971-1974. *Am. J. Trop. Med. Hyg.* 24:676-684.

McLean, D. M., P. N. Grass and B. D. Judd. 1977a. California encephalitis virus transmission by arctic and domestic mosquitoes. *Arch. Virol.* 55:39-45.

McLean, D. M., P. N. Grass, B. D. Judd, L. V. Ligate and K. K. Peter. 1977b. Bunyavirus isolations from mosquitoes in the western Canadian Arctic. *J. Hyg. (Camb.)* 79:61-71.

Ritter, D. G. and Feltz, E. T. 1974. On the natural occurrence of California encephalitis virus and other arboviruses in Alaska. *Canad. J. Microbiol.* 20:1359-1366.