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TEMPERATURES ON OR NEAR AN EXPOSED TAMARACK TREE

by

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The data presented in this report were collected in 1960 and 1961. They were gathered primarily to determine whether the increase in bark temperatures due to solar radiation was of sufficient magnitude to justify the purchase of expensive equipment for more detailed studies. The results showed that differences between bark and air temperatures were appreciable, and a multiple point recording potentiometer was purchased. The author had planned to use this instrument to continue the study of temperature as a mortality factor. However, due to a recent change in responsibilities these plans have been altered and the study will be continued by W. J. Turnock. The author's obligations in these studies will terminate with the presentation of the data in this report.

METHODS

Copper-constantin thermocouples were assembled from 6-foot lengths of glass-insulated 24-gauge thermocouple wire. The junctions were soldered, and the wire near the junctions wrapped in aluminum foil as suggested by Wellington (1950). Fifteen thermocouples were placed in groups of three on an exposed tamarack tree near the White-shell Field Station. In each group, the junction of one thermocouple was in contact with the bark surface, a second was 0.25 inches from the bark and a third was several inches from the bark. The latter was shielded from the sun's rays by a 9-inch aluminum foil plate mounted on a stiff wire support several inches above the thermocouple. The thermocouples were at least 7 feet off the ground and were located in the following positions:

1. north side of trunk;
2. south side of trunk;
3. upper side of a large branch (about 1.5 inches in diameter);
4. on the upper sides of small branches (about 0.25 inches in diameter); and
5. on the upper sides of small terminal twigs.

Foliage and branches that would cast shadows on the selected locations were removed as necessary. Temperatures were measured with a Rubicon portable potentiometer graduated to 0.5°C.

RESULTS

The temperatures recorded on days when measurements were taken are shown in Tables I and II for 1960 and 1961. It is evident from these tables that bark temperatures on the south side of the trunk and on the upper side of the large branch reached levels well above air temperature on August 5 and 12 in 1960 and on July 6, August 16 and 22 in 1961. The bark temperatures on the 0.25-inch branches increased slightly in relation to air temperature, but the terminal twigs showed no increase (Table III). Temperatures 0.25 inches above the bark did not increase as much as bark surface temperatures but the trends were similar (Table IV).

No experiments were conducted to determine larval heat tolerances, so it is impossible to determine which of the above temperatures would have lethal effects. However, field observations suggest that the higher temperatures would almost certainly be lethal to larvae crawling on the bark surface.

The weather information recorded in the tables under "Remarks" is very sketchy, and no wind speed records are available. However, there is clear empirical indication that wind speed affects the degree of radiant heating. Air temperature records indicate the days on which high radiant temperatures are likely, but are not an infallible indication of this. For example, in 1960 the air temperature on July 27 was over 30°C but there were scattered clouds and it was windy and no radiant heating effects were recorded. On the other hand, on August 12 the air temperature did not exceed 27°C, but the sky was clear and there was very little wind until late afternoon and the bark temperature on the south side of the trunk reached 39°C. In 1961, the maximum air temperatures on July 6, August 14, 17 and 22 were between 29 and 30°C, but the degree of radiant heating differed considerably, the maximum bark temperatures being about 46, 37, 38 and 48°C respectively.

In conclusion, it is recommended that further study should be directed toward experimental determination of tolerances of larvae to gradations of temperature and that wind speed records be kept when studying solar radiation as a mortality factor.

REFERENCE

Wellington, W. G. 1950. Effects of radiation on the temperatures of insectan habitats. Sci. Agr. 30: 209-234.

Table I

Temperature recorded on an exposed tamarack tree in 1960*

Date and time (CDT)	Remarks	Temperature (°C)								
		North side of trunk			South side of trunk			Top of large branch (1.5")		
		A			A			A		
		B			B			B		
		C			C			C		
July 27	Scattered clouds	31.8			32.2			33.0	-	-
1615	windy		32.0			31.5		33.8	-	-
				30.8			30.0			
Aug. 5	Clear	34.2			45.8			45.0	35.8	33.8
1530			33.8			38.0		41.0	35.5	33.8
				34.2			32.2	33.8	33.8	33.5
Aug. 15	Partly overcast	21.5			23.0			25.8	21.8	20.5
1030			20.2			21.0		23.2	20.8	21.8
				19.8			21.0	21.8	20.5	21.8
Aug. 15	Hazy clouds	24.5			35.8			36.2	24.0	26.8
1145			25.5			26.2		31.0	25.0	25.2
				23.2			26.0	23.0	24.0	25.2
Aug. 15	Clear	26.0			39.0			37.8	27.5	25.5
1315			24.5			37.5		29.0	29.2	27.2
				24.5			26.5	24.5	24.5	27.0
Aug. 15	Clear, moderate	26.2			37.8			32.5	26.8	26.8
1515	breeze		26.5			31.5		27.8	29.2	28.2
				25.5			26.5	26.0	26.0	27.0

* A- on bark surface; B- 0.25" from bark; C- air

Temperatures recorded on an exposed tamarack tree in 1961*

Date and time (CDT)	Remarks	Temperature ($^{\circ}\text{C}$)								
		North side of trunk			South side of trunk			Top of large branch (1.5")		
		A	B	C	A	B	C	A	B	C
July 6 0930	Clear, smoke haze	22.0	22.5	23.5	23.8	24.5	24.5	32.0	28.2	23.2
July 6 1040	Clear, smoke haze	25.0	24.5	24.2	22.5	22.8	26.2	37.0	28.2	25.2
July 6 1110	Clear, smoke haze	25.2	26.2	30.0?	29.0	31.2	25.8	38.0	33.5	26.5
July 6 1150	Clear, smoke haze	27.2	26.0	25.8	30.0	29.0	26.5	40.8	28.8	27.0
July 6 1330	Scattered clouds	29.0	28.0	27.5	40.5	35.2	27.8	45.8	39.0	28.8
July 6 1440	Scattered clouds	28.0	25.5	26.5	36.0	30.2	27.5	36.5	29.0	26.5
July 6 1540	Scattered clouds	29.5	27.5	27.5	28.8	28.0	27.5	36.8	34.5	27.0
July 6 1640	Scattered clouds	28.8	26.5	26.8	30.5	29.5	27.0	32.8	28.5	27.0

Table II (cont.)

Date and time (CDT)	Remarks	Temperature (°C)														
		North side of			South side of			Top of large			Top of small			Top of small		
		trunk			trunk			branch (1.5")			branches(0.25")			twigs		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Aug. 14 0900	Clear, calm	18.0			19.0			24.2			25.5			21.0		
			20.2			19.5			23.8			20.0			21.5	
				19.0			20.5			19.2			24.5			21.8
Aug. 14 0930	Clear, light breeze	20.8			22.8			29.0			26.2			23.5		
			22.2			22.5			26.2			22.5			23.8	
				22.0			23.0			27.0			24.0			23.0
Aug. 14 1000	Clear, light breeze	23.2			25.0			32.5			26.8			24.5		
			23.8			25.0			29.2			24.5			24.8	
				23.8			25.8			24.2			25.5			24.0
Aug. 14 1030	Clear, moderate breeze	24.5			27.2			35.2			27.8			26.2		
			25.8			26.8			32.2			25.5			26.5	
				25.2			26.8			25.0			27.2			26.0
Aug. 14 1100	Clear, moderate breeze	25.8			28.2			36.0			31.0			27.2		
			26.5			28.0			32.2			27.2			28.2	
				26.5			27.5			27.5			28.2			27.2
Aug. 14 1130	Clear, strong breeze	27.2			34.0			34.5			30.8			28.0		
			27.2			31.5			30.0			28.8			28.5	
				27.5			27.5			27.5			28.5			28.5
Aug. 14 1200	Clear, moderate breeze	27.2			32.5			35.2			29.0			29.0		
			27.2			31.0			30.0			27.8			28.5	
				27.2			27.8			27.2			28.0			29.0
Aug. 14 1310	Clear, windy	28.5			36.5			36.5			30.2			29.5		
			27.8			34.2			32.5			28.8			30.0	
				29.2			29.2			29.2			29.2			30.5
Aug. 14 1400	Clear, windy	29.0			36.2			36.8			30.5			30.2		
			28.8			33.8			31.8			30.0			30.5	
				28.8			28.8			29.2			29.8			30.2
Aug. 14 1500	Clear, windy	29.5			35.5			37.0			30.0			31.0		
			29.0			34.8			34.0			30.5			30.0	
				29.8			30.0			29.5			30.0			30.2

Table II (cont.)

Date and time (CDT)	Remarks	Temperature (°C)								
		North side of trunk			South side of trunk			Top of large branch (1.5")		
		Top of small branches (0.25")			Top of small twigs					
Aug. 14 1600	Clear, windy	28.8			37.2			37.0		
		28.0			35.5			32.0		
		28.5			29.0			29.0		
Aug. 16 0900	Clear, light breeze	18.5			20.8			24.5		
		20.5			21.0			23.5		
		20.0			21.5			20.8		
Aug. 16 1030	Clear, moderate breeze	24.0			27.8			28.5		
		25.0			27.5			28.8		
		25.0			26.5			26.0		
Aug. 16 1200	Clear, moderate breeze	28.0			34.5			39.5		
		28.8			29.2			39.5		
		29.2			29.0			29.2		
Aug. 16 1300	Clear, moderate breeze	30.0			44.5			44.0		
		29.2			34.2			41.2		
		29.0			31.5			31.2		
Aug. 16 1430	Clear, moderate breeze	32.5			44.0			48.0		
		31.8			38.5			36.2		
		32.0			32.2			33.0		
Aug. 16 1545	Clear, moderate breeze	34.0			36.0			47.2		
		33.8			36.8			37.2		
		33.0			32.5			33.0		
Aug. 16 1645	Clear, moderate breeze	34.0			36.5			37.8		
		33.8			35.8			36.5		
		33.2			33.0			33.2		
Aug. 17 0850	Hazy, strong breeze	25.0			24.2			28.0		
		25.0			24.0			27.5		
		24.2			24.8			24.5		

Table II (cont.)

Date and time (CDT)	Remarks	Temperature (°C)											
		North side of			South side of			Top of large			Top of small		
		trunk			trunk			branch (1.5")			branches (0.25")		
		A	B	C	A	B	C	A	B	C	A	B	C
Aug. 17 0910	Hazy, strong breeze	25.8	26.5	25.2	27.5	26.0	27.5	29.2	30.0	25.2	28.0	25.2	27.8
Aug. 17 0935	Intermittant cloud, strong breeze	27.5	27.0	26.2	28.0	27.0	28.0	34.8	32.5	27.0	27.0	26.8	27.8
Aug. 17 0955	Hazy, strong breeze	27.8	27.5	27.2	29.5	27.5	28.8	33.8	31.5	27.0	28.8	27.5	29.2
Aug. 17 1040	Hazy, strong breeze	29.2	28.5	28.0	31.2	29.2	28.0	35.5	31.5	28.2	29.5	27.5	30.0
Aug. 17 1115	Hazy, strong breeze	30.2	29.0	28.2	31.5	31.0	29.0	37.5	36.0	27.8	29.5	28.2	30.0
Aug. 17 1155	Hazy, strong breeze	31.0	30.0	29.5	34.0	33.8	29.2	36.2	34.2	28.8	30.5	29.0	30.0
Aug. 17 1315	Cloudy, windy	31.0	29.8	28.5	30.2	28.8	29.2	37.0	32.5	28.8	29.8	28.5	29.5
Aug. 17 1420	Light rain, windy	29.2	25.5	27.0	28.0	27.8	27.5	27.0	28.2	27.5	27.5	27.2	27.8
Aug. 22 0900	Clear, light breeze	17.2	17.2	17.2	19.5	19.2	19.8	22.2	18.8	17.8	22.0	17.8	21.0

Table II (concl.)

Date and time (CDT)	Remarks	Temperature (°C)														
		North side of trunk			South side of trunk			Top of large branch (1.5")			Top of small branches (0.25")			Top of small twigs		
		A			A			A			A			A		
		B			B			B			B			B		
		C			C			C			C			C		
Aug. 22 1000	Clear, light breeze	20.0			23.0			22.5			22.8			20.5		
		20.0			25.8			22.5			20.0			20.8		
			21.0			21.8			19.8			23.8			21.5	
Aug. 22 1100	Clear, moderate breeze	23.8			31.0			34.5			26.8			24.2		
		23.2			27.5			26.5			23.8			24.0		
			24.5			24.5			24.5			25.5			24.5	
Aug. 22 1200	Clear, light breeze	25.5			33.5			35.0			27.2			26.2		
		24.2			28.8			32.2			25.5			28.2		
			24.8			25.0			25.0			27.0			26.5	
Aug. 22 1315	Intermittant cloud, light breeze	28.8			35.5?			42.8			30.2			27.0		
		29.2			30.8?			30.2			28.5			28.0		
			27.5			27.5			28.5			29.0			28.5	
Aug. 22 1500	Intermittant cloud, light breeze	29.0			39.8			44.5			33.8			29.2		
		28.0			35.5			35.5			31.2			28.8		
			27.5			28.8			29.2			29.5			29.2	
Aug. 22 1600	Intermittant cloud, light breeze	29.5			39.5			42.8			30.0			28.8		
		29.5			37.0			32.5			28.8			28.2		
			27.8			29.0			27.8			29.8			29.0	
Aug. 22 1700	Intermittant cloud, light breeze	28.2			30.5			34.0			30.2			27.0		
		28.0			27.2			30.0			28.5			26.5		
			26.8			26.8			27.0			30.2			28.0	

* A - on bark surface; B - 0.25" from bark; C - air

Table III

Differences between bark and air temperatures on an exposed tamarack tree

Date and time (CDT)	Temperature differences (bark-air) in °C				
	North side of trunk	South side of trunk	Top of large branch (1.5")	Top of small branches (0.25")	Top of small twigs
1960					
July 27-1615	1.0	2.2	1.5	-	-
Aug. 5-1530	0.0	13.6	11.2	2.8	0.3
Aug. 12-1030	1.7	2.0	4.0	1.3	-1.3
Aug. 12-1145	1.3	9.8	13.2	0.0	1.6
Aug. 12-1315	1.5	12.5	13.3	3.0	-1.5
Aug. 12-1515	0.7	11.3	6.5	0.8	-0.2
1961					
July 6-0930	-1.5	-0.7	8.8	2.0	-0.3
July 6-1040	0.8	-2.7	11.8	1.8	-0.5
July 6-1110	-4.8?	3.2	11.5	3.5	-1.0
July 6-1150	1.4	3.5	13.8	1.8	-1.2
July 6-1330	1.5	12.7	17.0	3.0	0.0
July 6-1440	1.5	8.5	10.0	1.2	-0.7
July 6-1540	2.0	1.3	9.8	1.5	-0.5
July 6-1640	2.0	3.5	5.8	2.7	0.0
Aug. 14-0900	-1.0	-1.5	5.0	1.0	-0.8
Aug. 14-0930	-1.2	-0.2	2.0	2.2	0.5
Aug. 14-1000	-0.6	-0.8	8.3	1.3	0.5
Aug. 14-1030	-0.7	0.4	10.2	0.6	0.2
Aug. 14-1100	-0.7	0.7	8.5	2.8	0.0
Aug. 14-1130	-0.3	6.5	7.0	2.3	-0.5
Aug. 14-1200	0.0	4.7	8.0	1.0	0.0
Aug. 14-1310	-0.7	7.3	7.3	1.0	-1.0
Aug. 14-1400	0.2	7.4	7.6	0.7	0.0
Aug. 14-1500	-0.3	5.5	7.5	0.0	0.8
Aug. 14-1600	0.3	8.2	8.0	1.7	0.2
Aug. 16-0900	-1.5	-0.7	3.7	1.5	0.5
Aug. 16-1030	-1.0	1.3	2.5	-2.5	-0.2
Aug. 16-1200	-1.2	5.5	10.3	0.0	0.4
Aug. 16-1300	1.0	13.0	12.8	0.4	-0.8
Aug. 16-1430	0.5	11.8	15.0	1.0	0.5
Aug. 16-1545	1.0	3.5	14.2	2.7	0.5
Aug. 16-1645	0.8	3.5	4.6	1.0	-0.5

Table III (concl.)

Date and time (CDT)	Temperature differences (bark-air) in °C				
	North side of trunk	South side of trunk	Top of large branch (1.5")	Top of small branches (0.25")	Top of small twigs
1961					
Aug. 17-0850	0.8	-0.6	3.5	0.0	0.4
Aug. 17-0910	0.6	0.0	4.0	0.2	-1.3
Aug. 17-0935	1.3	0.0	7.8	-0.8	-0.2
Aug. 17-0955	0.6	0.7	6.8	-0.4	-0.5
Aug. 17-1040	1.2	3.2	7.3	-0.5	-0.5
Aug. 17-1115	2.0	2.5	9.7	-0.5	0.5
Aug. 17-1155	1.5	4.8	7.4	1.0	-1.5
Aug. 17-1315	2.5	1.0	8.2	0.8	0.4
Aug. 17-1420	2.2	0.5	-0.5	0.3	1.5
Aug. 22-0900	0.0	-0.3	4.4	1.0	-0.6
Aug. 22-1000	-1.0	1.2	2.7	-1.0	-1.0
Aug. 22-1100	-0.7	6.5	10.0	1.3	-0.3
Aug. 22-1200	0.7	8.5	10.0	0.2	-0.3
Aug. 22-1315	1.3	8.0?	14.3	1.2	-1.5
Aug. 22-1500	1.5	11.0	15.3	4.3	0.0
Aug. 22-1600	1.7	10.5	15.0	0.2	-0.2
Aug. 22-1700	1.4	3.7	7.0	0.0	-1.0

Table IV

Differences between temperatures 0.25" from bark and air temperatures
on an exposed tamarack tree

Date and time (CDT)	Temperature differences (1/4" from bark-air) in °C				
	North side of trunk	South side of trunk	Top of large branch (1.5")	Top of small branches (0.25")	Top of small twigs
1960					
July 27-1615	1.2	1.5	2.3	-	-
Aug. 5-1530	-0.4	5.8	7.2	2.5	0.3
Aug. 12-1030	0.4	0.0	1.4	0.3	0.0
Aug. 12-1145	2.3	0.2	8.0	1.0	0.0
Aug. 12-1315	0.0	11.0	4.5	4.7	0.2
Aug. 12-1515	1.0	5.0	1.8	3.2	1.2
1961					
July 6-0930	-1.0	0.0	5.0	0.5	-0.7
July 6-1040	-0.3	-3.4	3.0	-0.2	0.0
July 6-1110	-3.8?	5.4	7.0	-0.7	2.5
July 6-1150	0.2	2.5	1.8	0.0	-0.8
July 6-1330	0.5	7.4	10.2	-1.0	1.8
July 6-1440	-1.0	2.7	2.5	0.7	-1.2
July 6-1540	0.0	0.5	7.5	-0.3	-0.3
July 6-1640	-0.3	2.5	1.5	1.2	-0.5
Aug. 14-0900	1.2	-1.0	4.6	-4.5	-0.3
Aug. 14-0930	0.2	-0.5	-0.8	-1.5	0.8
Aug. 14-1000	0.0	-0.8	5.0	-1.0	0.8
Aug. 14-1030	0.6	0.0	7.2	-1.7	0.5
Aug. 14-1100	0.0	0.5	4.7	-1.0	1.0
Aug. 14-1130	-0.3	4.0	2.5	0.3	0.0
Aug. 14-1200	0.0	3.2	2.8	-0.2	-0.5
Aug. 14-1310	-1.4	5.0	3.3	-0.4	-0.5
Aug. 14-1400	0.0	5.0	2.6	0.2	0.3
Aug. 14-1500	-0.8	4.8	4.5	0.5	-0.2
Aug. 14-1600	-0.5	6.5	3.0	0.7	0.2
Aug. 16-0900	0.5	-0.5	2.7	-3.7	0.5
Aug. 16-1030	0.0	1.0	2.8	-3.3	0.8
Aug. 16-1200	-0.4	0.2	10.3	-1.0	2.7
Aug. 16-1300	0.2	2.7	10.0	-1.8	3.0
Aug. 16-1430	-0.2	6.3	3.2	-1.5	0.2
Aug. 16-1545	0.8	4.3	4.2	1.0	1.5
Aug. 16-1645	0.6	2.8	3.3	0.0	1.3

Table IV (concl.)

Date and time (CDT)	Temperature differences (1/4" from bark-air) in °C				
	North side of trunk	South side of trunk	Top of large branch (1.5")	Top of small branches (0.25")	Top of small twigs
1961					
Aug. 17-0850	0.8	-0.8	3.0	-1.6	-0.3
Aug. 17-0910	1.3	-1.5	4.8	-2.6	-0.8
Aug. 17-0935	0.8	-1.0	5.5	-1.0	0.3
Aug. 17-0955	0.3	-1.3	4.5	-1.7	-0.2
Aug. 17-1040	0.5	1.2	3.3	-2.5	1.0
Aug. 17-1115	0.8	2.0	8.2	-1.8	0.2
Aug. 17-1155	0.5	4.6	5.4	-0.5	-1.0
Aug. 17-1315	1.3	-0.4	3.7	-0.5	-0.3
Aug. 17-1420	-1.5	0.3	0.7	0.6	0.5
Aug. 22-0900	0.0	-0.6	1.0	-2.2	0.2
Aug. 22-1000	-1.0	4.0	2.7	-3.8	-0.7
Aug. 22-1100	-1.3	3.0	2.0	-1.7	-0.5
Aug. 22-1200	-0.6	3.8	7.2	-1.5	1.7
Aug. 22-1315	1.7	3.3?	1.7	-0.5	-0.5
Aug. 22-1500	0.5	6.7	6.3	1.7	-0.4
Aug. 22-1600	1.7	8.0	4.7	-1.0	-0.8
Aug. 22-1700	1.2	0.4	3.0	-1.7	-1.5