THE EFFECT OF FENITROTHION AND AMINOCARB ON SECOND INSTAR SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA* (CLEM.) IN QUEBEC

by

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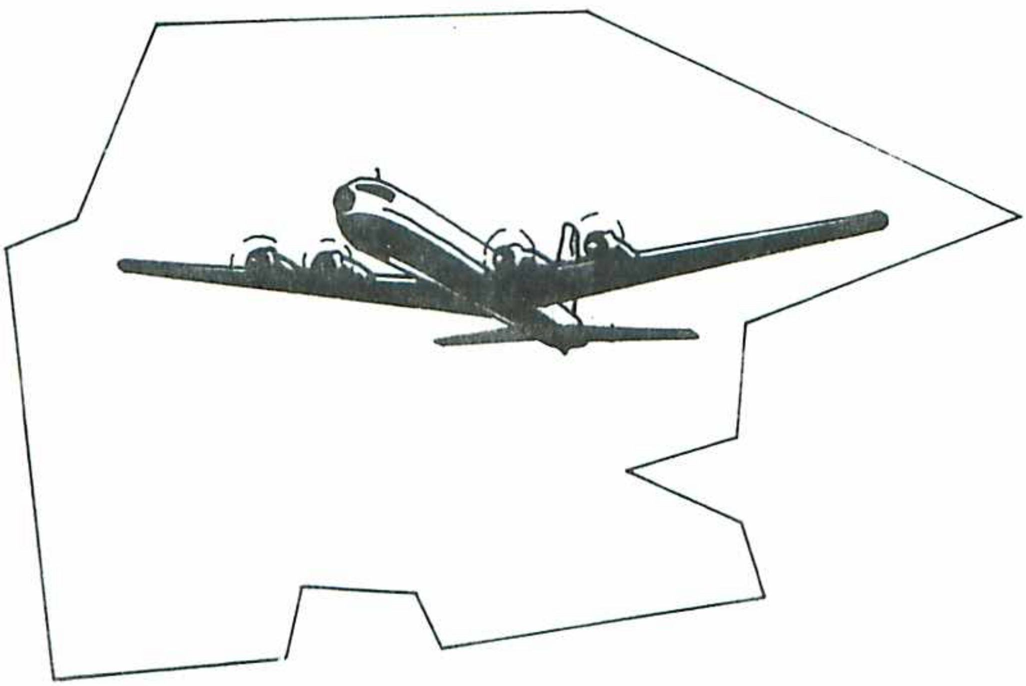

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ERRATA

1. Since the printing of this report, it has been learned that aminocarb was emitted at 0.07 kg per hectare A.I. (1.0 ounces per acre, A.I.) instead of the reported 0.088 kg/hectare A.I. (1.25 oz/acre A.I.). Therefore, aminocarb 0.088 kg/ha A.I. (1.25 oz/ac A.I.) should read 0.07 kg/ha A.I. (1.0 oz/ac A.I.) wherever it appears in this report.

2. Table I., page 6; Table II, page 7 -- Heading Deposit (Volume) should read only Deposit.

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ABSTRACT

Two treatments of fenitrothion at 0.28 A.I. Kg/ha (4 oz A.I./ac) were applied to an extremely high population of eastern spruce budworm, *Choristoneura fumiferana* (Clem.), to control 2nd instar larvae (L_2) and prevent severe defoliation of balsam fir (*Abies balsamea*) and spruce (*Picea* spp.) in the Gaspé region of Quebec. This was followed by a third application of 0.088 Kg A.I./hectare (1.25 oz/ac) of aminocarb when larval development had reached 25% 4th instar (L_4). Results of the treatments indicated good control of L_2 larvae with populations being reduced an average of 70% by the first two applications. The final application of aminocarb showed no subsequent reduction in the remaining larval population. This can be attributed to poor spray droplet coverage and the fact that the insecticide was applied before the shoots were fully flared. Foliage protection within the treated area was very good compared to the untreated area. Only 46% defoliation on fir and 40% on spruce occurred in the treated area compared to 99% on fir and 82% on spruce in the untreated check block.

RESUME

Nous avons répandu à deux reprises du fénitrothion, à raison de 0.28 kg d'ingrédient actif (IA) par hectare (4 oz à l'acre), sur des populations très denses de tordeuses des bourgeons de l'épinette, *Choristoneura fumiferana* (Clem.), pour les détruire à leur deuxième stade larvaire, et ainsi enrayer la défoliation du Sapin baumier (*Abies balsamea*) et de l'épinette (*Picea* spp.) de la région de Gaspé, au Québec. Nous avons ensuite répandu de l'aminocarbe, à raison de 0.088 kg d'IA/ha (1.25 oz/acre), lorsque 25% des tordeuses sont parvenues au quatrieme stade larvaire (L_4). Les résultats nous montrent qu'avec les deux premières applications, les populations de larves au deuxième stade ont été réduites de 70%. Pour finir, nous avons appliqué de l'aminocarbe, mais son effet sur les survivants a été nul. Cela s'explique par la mauvaise répartition des gouttelettes et par l'application antérieure au débourrement complèt des bourgeons. Comparativement à celui de la parcelle non traitée, le feuillage a été bien protégé; en effet dans la parcelle traitée, la défoliation des sapins et des épinettes a été de 46% et de 40%, tandis qu'elle a été respectivement de 99% et de 82% dans la parcelle non traitée.

INTRODUCTION

The 1977 population density of the spruce budworm (*Choristoneura fumiferana*) for the eastern half of the Gaspé region of Quebec was forecast to be extremely high since surveys showed egg mass counts in excess of 2,800 per 10 meters^2 of foliage (Desaulniers 1977). Population densities of such magnitude were considered to be too high to achieve adequate control using the normal registered dosage rates of insecticides. As the condition of the trees in some of these areas was poor due to previous heavy defoliation, it was felt that heavy tree mortality would result if dosages of registered insecticides were not applied.

It was recommended by F.P.M.I. to spray 2nd instar larvae (L_2), which are relatively more tolerant to fenitrothion than later stadia (Nigam, 1976, personal communication) with two early treatments of 0.28 kg A.I./ha (4 oz/ac) fenitrothion/acre each: the first at 20 percent emergence; the second to follow in five (5) days. This would then be followed by a third spray of 0.088 kg A.I./hectare (1.25 oz/ac) of aminocarb when remaining populations were at the 25% 4th instar level.

Following a meeting of concerned officials of the Federal Inderdepartmental Committee on Pesticides (FICP), it was further recommended that the effect of these sprays on the budworm population as well as effects on selected non-target organisms be monitored throughout the entire project.

This report deals solely with the effect of these sprays on the spruce budworm population and subsequent host tree defoliation.

MATERIALS & METHODS

Experimental Site

The block to be sprayed was an irregularly shaped area of 120,960 hectares (298,900 acres) in the interior of the eastern Gaspé region, designated as block 305 (Fig. 1). The terrain in the block, part of which was located in the Chic-Choc mountain range, was very hilly. The forest was comprised of a spruce-fir complex showing signs of at least two years heavy defoliation. Nearly all of the 29 fir trees selected as biological sampling stations showed 100 percent defoliation in 1976, with some heavy back feeding.

The block was to be sprayed with the flight lines running generally in an east-west direction. Because of this, it was planned to use a north-south transect to establish biological and chemical sampling stations across the sprayed area, but it soon became evident that this would be impossible due to the abundance of snow on the ground, making travel impossible on all but the main road through Gaspesia Provincial Park in the northern third of the block. All sampling stations, therefore, were situated along this road.

Biological Sample Trees

The block was divided into thirteen theoretical areas or "zones" for sampling purposes. This was done so that each zone would be sprayed by different passes of the spray aircraft, i.e. no two zones would be directly under the same swath. These zones were designated alphabetically as shown in Fig. 1. An average of five sample trees were selected in each zone.

A total of sixty sample trees (29 balsam fir, 31 spruce) of 10-18 meters in height were selected off the road as the biological sampling trees to get indices of population density before and after spray applications. The trees were dominant, with no overhanging foliage from other trees to block spray deposit on the target tree.

Sample trees were marked so that each could be readily identified for re-sampling.

An area of approximately six by six meters was cleared out immediately adjacent to the tree for placement of sample cards to retrieve data on insecticide deposit.

A check block (untreated) of twenty trees consisting of eleven fir and nine spruce was established about five miles east southeast of the town of Murdockville. These trees would provide data on population reduction due to natural causes and each tree was sampled once a week. (Fig. 2).

Biological Sampling

The standard rearing method on 46 cm (18 inch) branch tips underestimates budworm population densities (Blais 1976) because the pre-emergent budworm are scattered over the entire branch as well as on the trunk of the tree itself. As they emerge, the tiny L_2 larvae move out towards the branch tips and into the buds (Morris 1963).

In October of 1976, 720 full branches were cut from spruce and fir trees near Matane, Quebec. A study of these branches indicated that a 91 cm - 102 cm (36 to 40 inch) branch contained about 90% of the green foliage and that this was about the maximum size of branch one could sample using standard pole pruning equipment. It was therefore decided to use 96 cm (38 inch) branch samples instead of the standard

46 cm branch tips to give the pre and post spray population fixes. This would, hopefully, greatly reduce the underestimation of second instar spruce budworm population densities.

From each of the sample trees, an upper and midcrown 96 cm branch were taken and placed in 102 x 50 x 8 cm cardboard rearing containers, designed for this purpose by A. P. Randall, Forest Pest Management Institute. Each rearing box was divided down the middle to hold both an upper and mid-crown branch. The total count from both halves of each rearing container were averaged to give the population density index for that particular tree. The samples were left in these containers for 12-15 days and the emerging 2nd instar larvae were counted twice every day. As the numbers of emerging larvae started to drop, the containers were opened and the remaining foliage and container were checked by hand for any remaining larvae. It was found that 90% of the total number of L_2 larvae recovered crawled into the plastic holding cup.

Upon reaching the fourth instar (L_4) in its life cycle, the spruce budworm on the 96 cm branches were counted by hand. However, this was done only for the last three counts when all larvae had emerged from the hybernaculae.

Chemical Sampling

Data on insecticide deposit was recovered on a 10 cm x 10 cm (4 in. x 4 in.) Kromekote^R card and two 50 x 75 mm glas slides. These were fastened to two 10 x 10 cm pieces of aluminum plate, hinged at the middle so it could be closed after retrieval. One such sample unit was placed in the cleared area adjacent to each of the biological sampling trees immediately before a spray application to yield data on the deposit received by each tree. The glass slides were washed off using 1.5 mℓ of toluene and were analysed colorimetrically for insecticide deposit (volume/hectare).

The deposit on the Kromekote cards was counted and sized using a NCR microcard reader. These gave data on drop density, droplet size and distribution throughout the sampling area. These data could be correlated to budworm mortality and host tree defoliation (Tables I, II, and III).

Spray Formulations

The spray formulations used for each of the three spray applications on block 305 were as follows:

1st Application	Fenitrothion	26.27%
	Arotex 3470	30.93%
	#2 Fuel Oil	13.40%
	#4 Fuel Oil	29.40%
	Total	100.00%
2nd Application	same as first.	
3rd Application	Aminocarb	49.60%
	#2 Fuel Oil	26.20%
	#4 Fuel Oil	24.20%
	Total	100.00%

All formulations were applied at an emission rate of 0.882 liters/hectare (11.52 fl. U.S. oz/ac).

RESULTS AND DISCUSSION

Check Block

The untreated check block indicated an average population density of 237 larvae/96 cm branch on fir and 262 larvae/branch on spruce on the first sample taken on May 12, 1977. These densities showed a high rate of

Table I

Effects of First Application of 0.28 kg/ha (4 oz/ac) Fenitrothion
2 Days After Treatment

Host:Fir

Treatment	Spray Date	Drops /cm^2	Deposit (Volume) Liquid l/ha	Active kg/ha	MMD µm	NMD µm	Pop. Red. %	No. Samp.
Fenitrothion		0-1	0.0	0.0			31	6
	19-5-77	1-10	0.268	0.086			56	5
4 oz/ac (AI)		10-20	0.494	0.164	112	57	72	11
	A.M.	20-30	0.496	0.165			61	4
0.28 kg/ha		30-40	0.493	0.163			52	1
		40-50	-	-			-	0
		50±	2.536	0.844			52	1

Host:Spruce

Treatment	Spray Date	Drops /cm^2	Deposit (Volume) Liquid l/ha	Active kg/ha	MMD µm	NMD µm	Pop. Red. %	No. Samp.
Fenitrothion		0-1	0.004	0.001			26	2
	19-5-77	1-10	0.196	0.065			45	15
4 oz/ac (AI)		10-20	0.892	0.297	112	57	60	3
	A.M.	20-30	0.636	0.211			76	8
0.28 kg/ha		30-40	1.553	0.517			84	1
		40-50	1.273	0.424			88	1
		50±	0.725	0.241			36	1

Table II

Effects of Two Applications of 0.28 kg/ha (4 oz/ac) Fenitrothion

Host:Fir

Treatment	Spray Date	Drops /cm^2	Deposit (Volume)				% Population Reduction		Number Samples		Days After 2nd Treatment		Defoliation Final	
			Liquid l/ha	Active kg/ha	MMD µm	NMD µm	1 Count	2 Count	1 Count	2 Count	1 Count	2 Count	Bl. 305	Check Block
Fenitrothion	19-5-77	0-1	0.0	0.0			26	0	5	5			99	
4 oz/ac (AI)	A.M.	1-10	0.083	0.028			65	55	2	2			81	
±		10-20	0.469	0.156	108	52	78	74	3	3	2	8	32	98
0.28 kg/ha	29-5-77	20-30	0.806	0.268			90	68	10	10			57	
Fenitrothion		30-40	1.097	0.365			95	83	4	4			55	
4 oz/ac (AI)	P.M.	40-50	0.367*	0.122			99	81	1	1			39	
0.28 kg/ha		50±	1.448	0.482			93	95	4	4			6	

Host:Spruce

Treatment	Spray Date	Drops /cm^2	Deposit (Volume)				% Population Reduction		Number Samples		Days After 2nd Treatment		Defoliation Final	
			Liquid l/ha	Active kg/ha	MMD µm	NMD µm	1 Count	2 Count	1 Count	2 Count	1 Count	2 Count	Bl. 305	Check Block
Fenitrothion	19-5-77	0-1	0.0	0.0			74	40	1	1			99	
4 oz/ac (AI)	A.M.	1-10	0.014	0.005			66	76	1	1			97	
±		10-20	0.400	0.133	108	52	90	75	12	12	2	8	59	82
0.28 kg/ha	29-5-77	20-30	0.723	0.241			91	82	8	8			29	
Fenitrothion		30-40	1.400	0.466			94	78	3	3			26	
4 oz/ac (AI)	P.M.	40-50	1.582	0.527			99	88	2	2			11	
0.28 kg/ha		50±	1.425	0.474			99	98	4	4			19	

* Single Sample - Insufficient Data.

Table III

Effect of One Application of 0.07 kg/ha Aminocarb on Remaining Population

Host:Fir

Treatment	Spray Date	Drops /cm^2	Deposit				% Population Reduction		Number Samples		Days After 3rd Treatment	
			Liquid ℓ/ha	Active kg/ha	MMD µm	NMD µm	1 Count	2 Count	1 Count	2 Count	1 Count	2 Count
Aminocarb		0-1	0.006	0.0005			27	27	7	7		
0.07 kg/ha	16-6-77	1-10	0.239	0.0207			30	2	12	12		
	P.M.	10-20	0.511	0.0443	123	73	28	22	7	8	2	6
1.0 oz/ac		20-30	0.806	0.0699			69	0	1	1		
		30-40	1.395	0.1211			79	55	1	1		
		40-50	-	-			-	-	-	-		
		50+	-	-			-	-	-	-		

Host:Spruce

Treatment	Spray Date	Drops /cm^2	Deposit				% Population Reduction		Number Samples		Days After 3rd Treatment	
			Liquid ℓ/ha	Active kg/ha	MMD µm	NMD µm	1 Count	2 Count	1 Count	2 Count	1 Count	2 Count
Aminocarb		0-1	0.008	0.0007			2	0	4	4		
0.07 kg/ha	16-6-77	1-10	0.296	0.0257			31	0	14	14	2	6
	P.M.	10-20	0.717	0.0622	124	73	16	0	11	11		
1.0 oz/ac		20-30	0.839	0.0728			11	0	2	2		
		30-40	-	-			-	-	-	-		
		40-50	-	-			-	-	-	-		
		50+	-	-			-	-	-	-		

decline down to 60.7 larvae/branch on fir and 94 larvae/branch on spruce by the final count taken on June 22, 1977, indicating a natural population decline of 74% on fir and 64% on spruce. However, by this time the insects were at about peak L_4 in their life cycle, so considerably more natural reduction could be expected from that date on.

The highest percentage natural reduction occurred during the second instar phase when natural mortality and redistribution by wind are important factors (Morris 1963).

Sprayed Block

Initial budworm populations in the spray block were 400 larvae/96 cm branch on fir and 337 larvae/96 cm branch on spruce. These were reduced to 130.9 for fir and 132.8 for spruce based on 58 and 62 samples, respectively, after the first application of 0.28 kg/ha (4 oz/ac) fenitrothion. Using Abbotts' formula (1925) for percent population reduction, this gave a corrected mortality of 56% on fir and 57% on spruce (Fig. 3 and 4).

The second application of fenitrothion was scheduled five days after the first, but bad spraying weather delayed the spray for another four days. Post spray counts (48 hrs. after application) indicated population levels reduced to 56 larvae/96 cm branch on fir and 21 larvae/96 cm branch on spruce, giving a corrected mortality of 47% and 78% on fir and spruce, respectively, due to the second application.

Cumulative results of the two applications of fenitrothion indicated corrected mortality of 77% on fir and 91% on spruce (Fig. 3 and 4).

Data from a second post spray count, 6 days after the second application, indicated population levels had increased slightly from the first post spray count which reduced mortality to 58% on fir and 80% on spruce. This increase in population was possibly due to sampling errors inherent in sampling populations of 2nd instar spruce budworm. Also, further migration of L_2 larvae from the tree towards the branch tips could account for part of this increase.

The third application (0.088 ℓ/ha) aminocarb, was made on June 16, 1977 when larval development had reached an estimated 25% L_4 level. However, the new buds were just starting to flare in the eastern part of the block. A residual population density of 70.6 larvae/96 cm branch on fir and 43 larvae/96 cm branch on spruce, measured prior to spraying, was reduced to 33.2 larvae/96 cm branch on fir and 24.5 larvae/ 96 cm branch on spruce. This gave corrected mortalities of 25% on fir and 0% on spruce. The data indicates virtually no effect on the remaining larvae 6 days after spray treatment with the aminocarb.

As was the case with the second application, the first post spray reduction figures for the third application show higher mortality than the second post spray count, indicating that some larvae were finding their way back onto the foliage.

Budworm mortality, defoliation, and insecticide deposits are summarized in Tables I, II, and III.

<u>Spray Deposit:</u>

<u>1st Application</u> (.28 kg A.I./ha Fenitrothion 4 oz/ac)

Droplet density across the sampling area was irregular from tree to tree but still averaged 17.3 drops/cm^2 and a maximum deposit of 90.75 drops/cm^2 (Fig. 7). A mass median diameter (MMD) of 112 μm and a number median diameter (NMD) of 57 μm were recorded for this spray application (Fig. 5).

The difference in deposit densities from sample to sample was probably due to the variations in the terrain as well as the fact that samples were located on both sides of the road right-of-way. This would leave some samples in the open while those on the opposite side of the road would be partially sheltered by the sample tree itself.

<u>2nd Application</u> (0.28 kg A.I./ha Fenitrothion 4 oz/ac)

An average deposit density of 14.2 drops/cm^2 was recorded, with a minimum deposit of 1.13 drops/cm^2 and a maximum deposit of 51.5 drops/cm^2. The MMD and NMD recorded for this spray application were 108 µm and 52 µm, respectively. Accumulated deposit of the first and second applications of fenitrothion for each sampling location are shown graphically on Fig. 8. The letters A, B, C. etc. represent the thirteen geographical sampling zones that were established; the numbers 1, 2, 3, etc. represent the tree number within each zone. For example: K-1 represents the first tree in the "K" zone (refer also to map, Fig. 1).

Droplet spectra and distribution of the first two applications were similar (Fig. 5, 6). This was expected as the two formulations were identical and meteorological conditions were very similar.

<u>3rd Application</u> (0.088 kg A.I./ha Aminocarb 1.25 oz/ac)

The third application resulted in an average deposit of 10.2 drops/cm^2 over sampling area, with a minimum deposit of 0.14 drops/cm^2 and a maximum deposit of 33.5 drops/cm^2. The MMD and NMD figures were 124 µm and 73 µm respectively (Fig. 6). This spray was considerably coarser than either of the first two applications of fenitrothion; hence the less effective distribution of spray droplets throughout the sprayed area (Fig. 9). This poorer deposit, in addition to the fact that the buds were not fully flared, probably contributed to the lack of budworm mortality achieved.

Host Tree Defoliation

A defoliation study was done on the untreated check block as well as block 305 in early August using Fettes' method of measuring defoliation to determine damage to the host tree by the spruce budworm (Fettes 1950). Two forty-inch branch samples were collected from each sample tree in the field and new shoots were inspected for defoliation. Upper and mid-crown samples were averaged for each tree to give an average figure (percent) for defoliation.

Data from the check block indicated an average defoliation of 98% on fir and 82% on spruce. Data from the spray block indicated an average of 46% defoliation on fir and 40% on spruce. Figures ranged from 99% defoliation for trees with little or no deposit to 6% defoliation for trees with 50 or more drops/cm^2 on fir and 99% to a low of 11% on spruce with a deposit of 40 drops/cm^2 or more. Table II shows the decrease in defoliation with increase in deposit. Had no spraying been carried out, the entire northern half of block 305 would likely have been totally stripped of any new growth this year.

CONCLUSIONS

1. Good population reduction and foliage protection is possible in an extremely high spruce budworm population by spraying early 2nd

instar larvae with two applications of an insecticide such as fenitrothion (Table II).

2. In the majority of sample trees, defoliation on the lower crown samples was higher than on the upper crown samples. This indicates insufficient deposit to evenly cover the entire tree crown, leaving a higher insect density on the bottom of the tree than the top.
3. The final (3rd) spray of aminocarb at 0.088 kg A.I./ha had very little effect on the remaining budworm popultion. This was surprising as aminocarb is generally considered quite effective in reducing L_4 budworm populations even at lower dosages (Randall 1971, unpublished data). These poor results can only be attributed to poor deposit and poor timing of the spray application, i.e., application of spray while larvae are protected by closed buds.

RECOMMENDATIONS

1. Further experimentation should be carried out to determine minimum dosage requirements to effectively reduce L_2 budworm populations.
2. The third application of a pesticide to further reduce population levels should be carried out when all spruce as well as fir buds have completely flared, leaving larvae more exposed to the pesticide, e.g. at peak L_4.
3. To ensure adequate coverage of deposit in very hilly terrain, e.g., Gaspé region of Quebec, it is recommended that a higher volume of spray be emitted. Although 0.87 ℓ/ha (12 oz/ac) appears adequate over fairly level terrain, 1.17 ℓ/ha (16 oz/ac) or even 1.46 ℓ/ha (20 oz/ac)

should be applied over very hilly areas to ensure sufficient deposit coverage over the entire tree to give adequate control of spruce budworm larvae and prevent heavy host tree defoliation. Data from Table II indicates that in order to achieve excellent protection, i.e. 95% or over population reduction and 10% defoliation, deposits should be in excess of 40-50 drops/cm^2 and volume in excess of 1.44 ℓ/ha (19.5 fl. oz/ac).

ACKNOWLEDGEMENTS

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Mr. W. W. Haliburton provided the spread factor analysis and Mr. W. W. Hopewell the colorimetric analysis of deposit.

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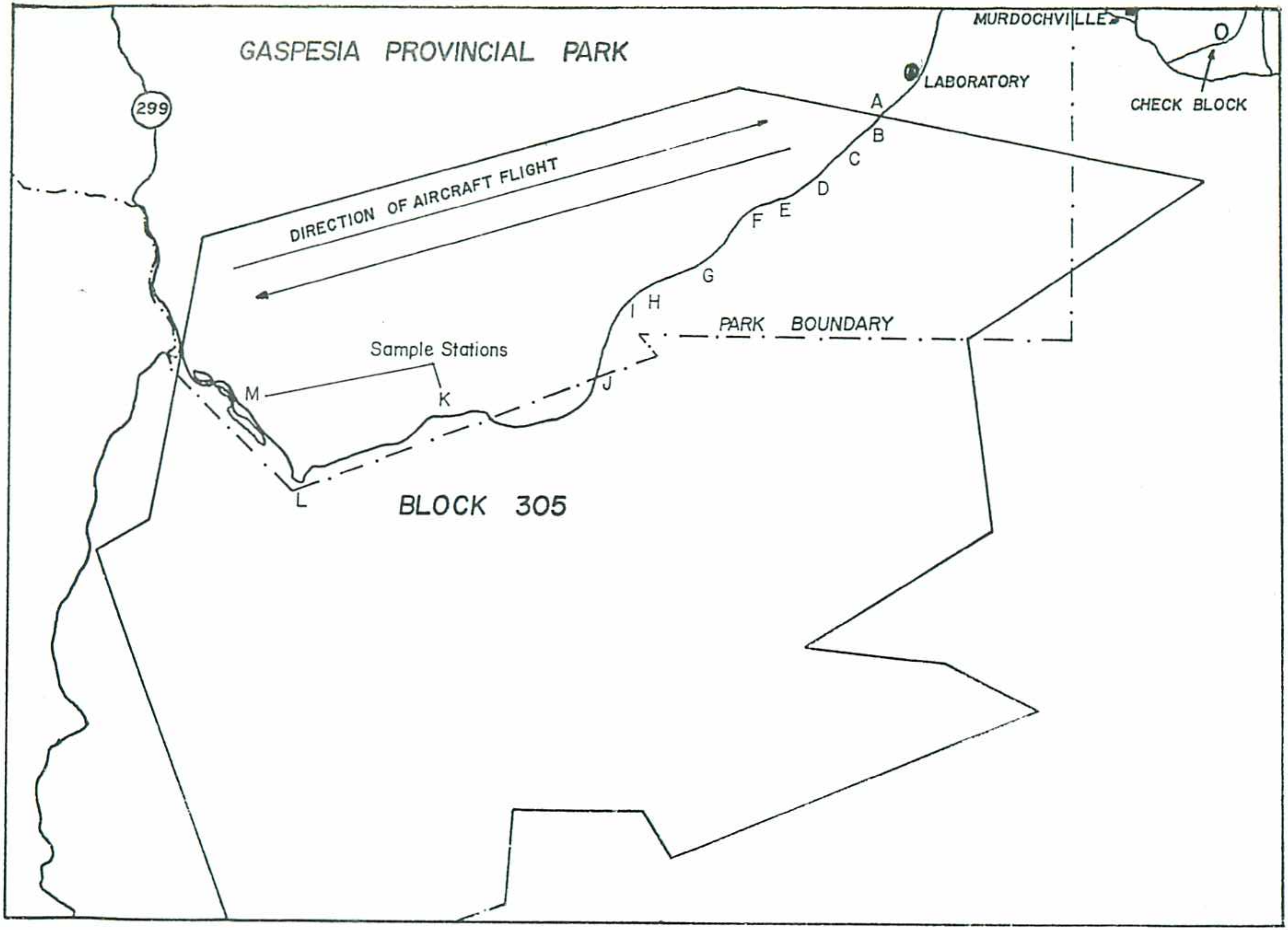

FIG. I MAP OF EXPERIMENTAL SITE

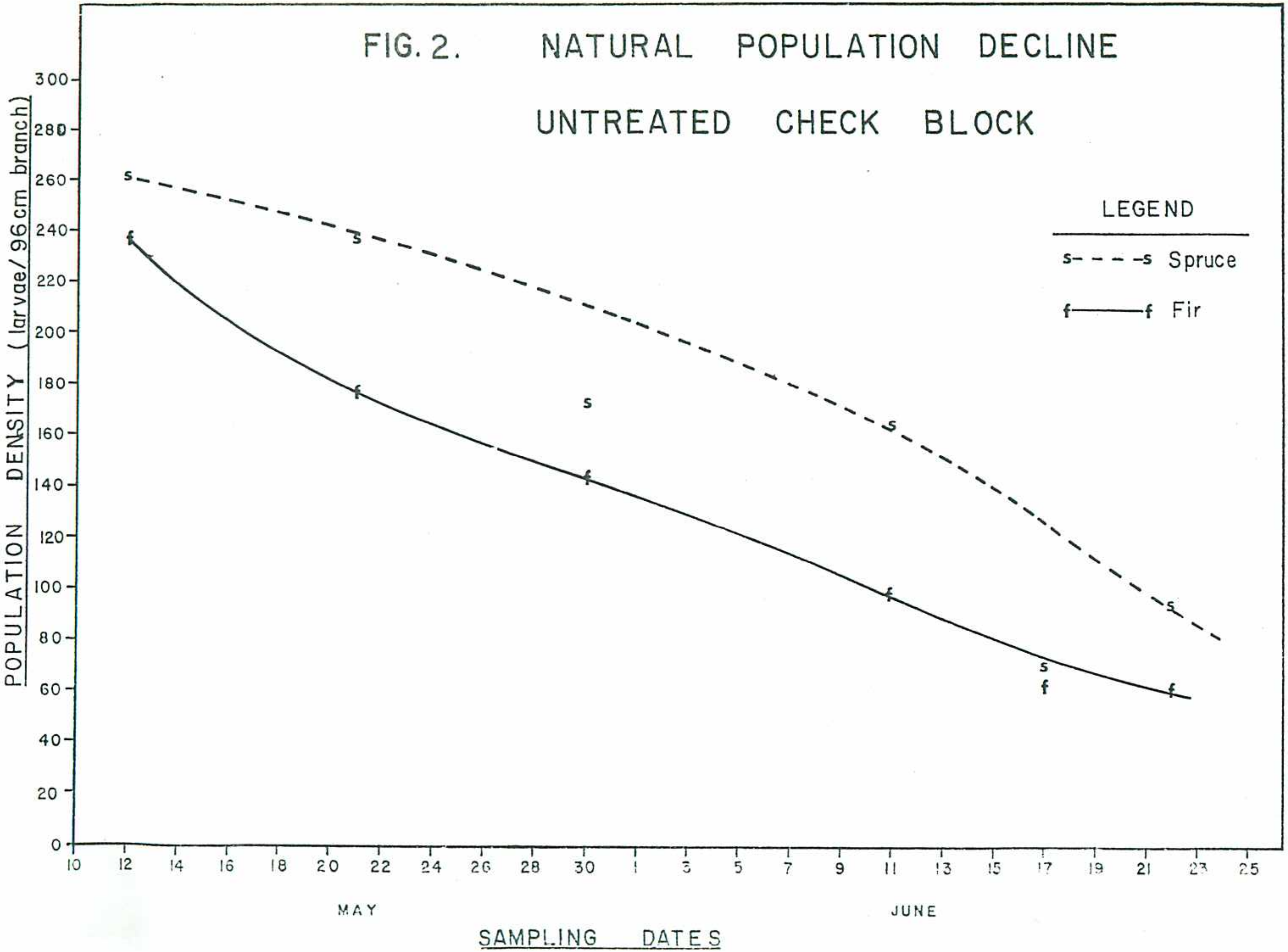
FIG. 2. NATURAL POPULATION DECLINE
UNTREATED CHECK BLOCK
LEGEND
s- - - -s Spruce
f——f Fir
POPULATION DENSITY (larvae/96cm branch)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
10
12
14
16
18
20
22
24
26
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MAY
JUNE
SAMPLING DATES

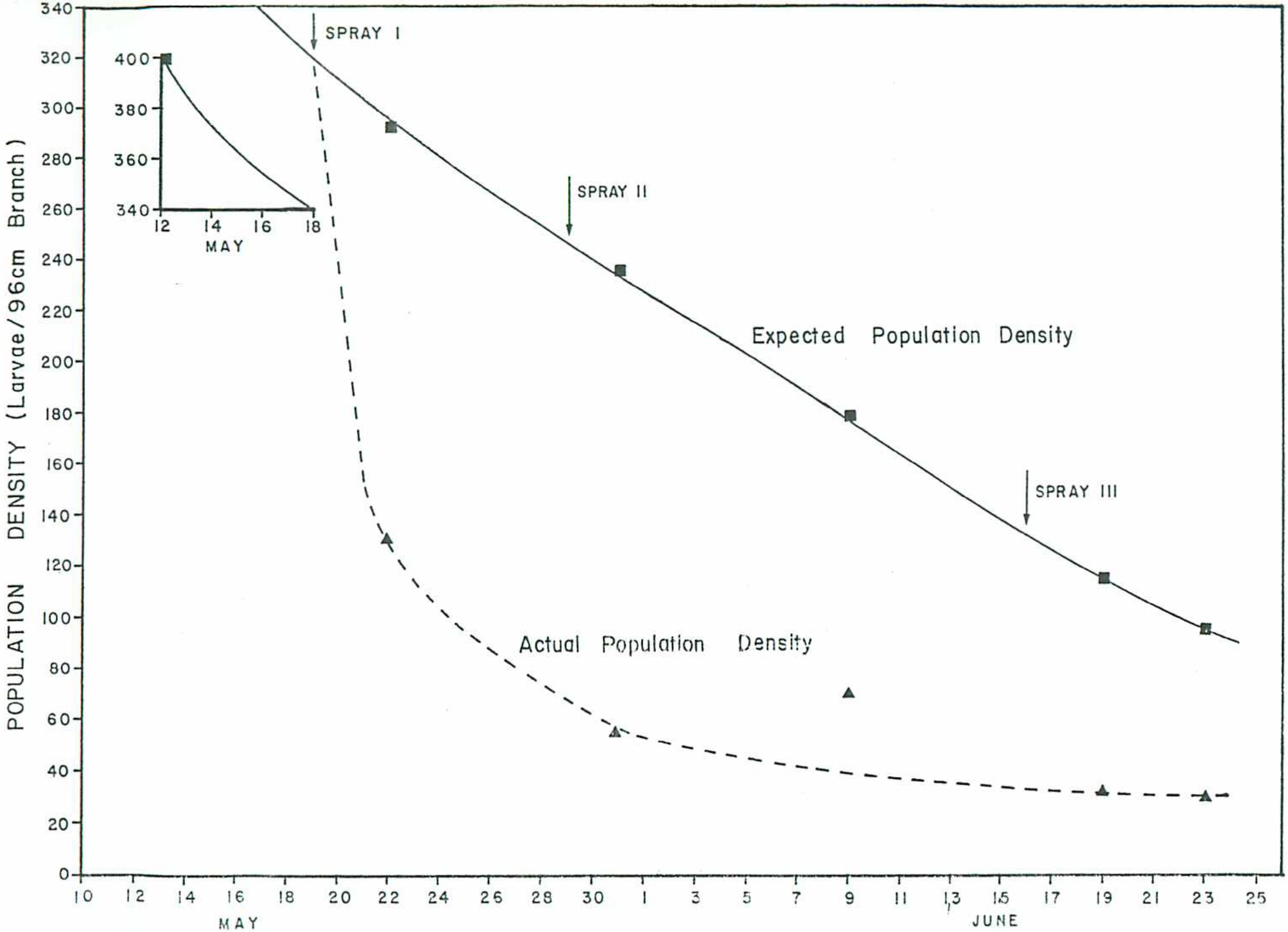


FIG. 3. EXPECTED vs ACTUAL DENSITIES (Fir)

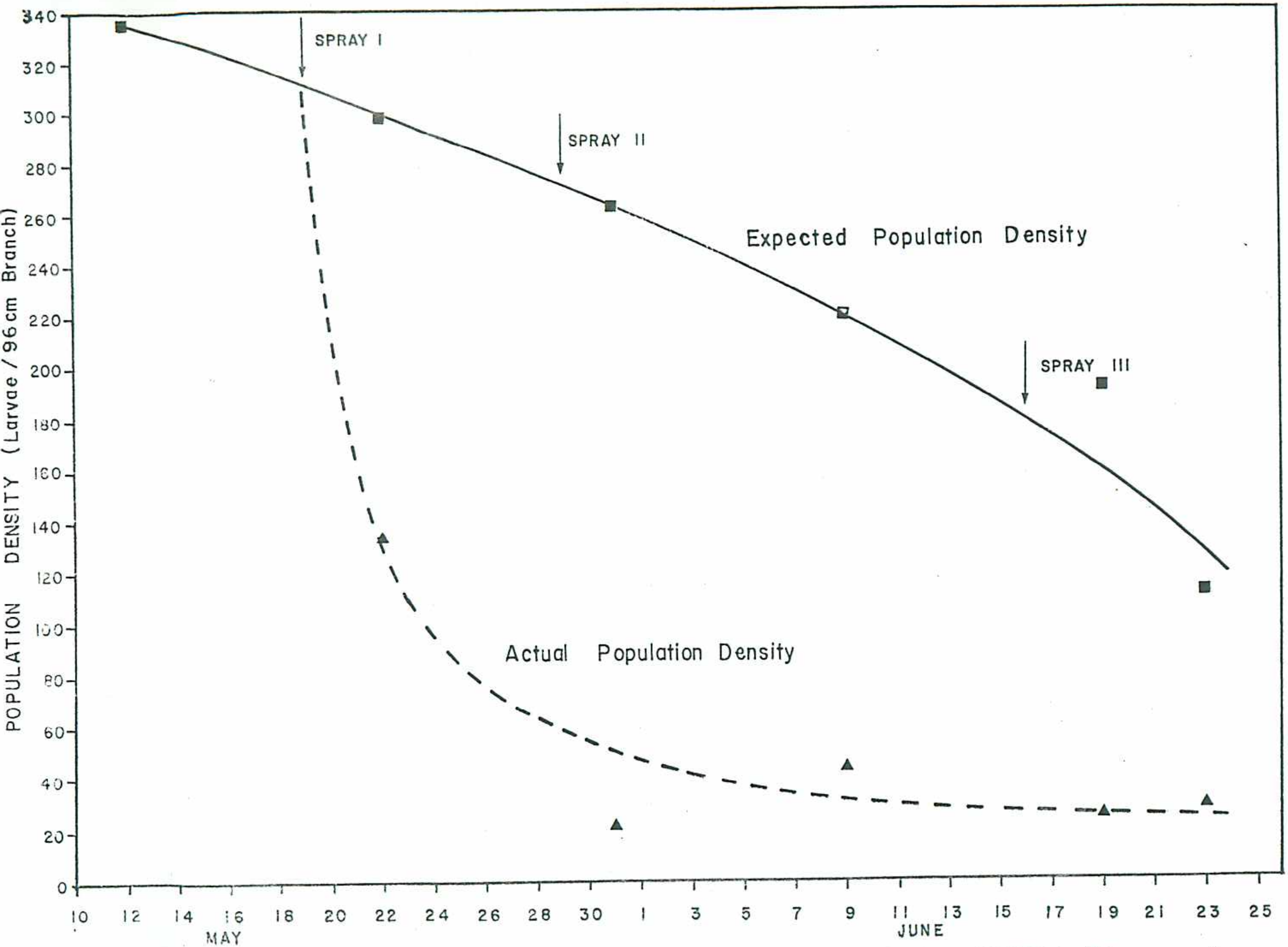


FIG. 4 EXPECTED vs ACTUAL DENSITIES (Spruce)

FIG. 5. MASS & NUMBER MEDIAN DIAMETER

1st & 2nd Applications of Fenitrothion

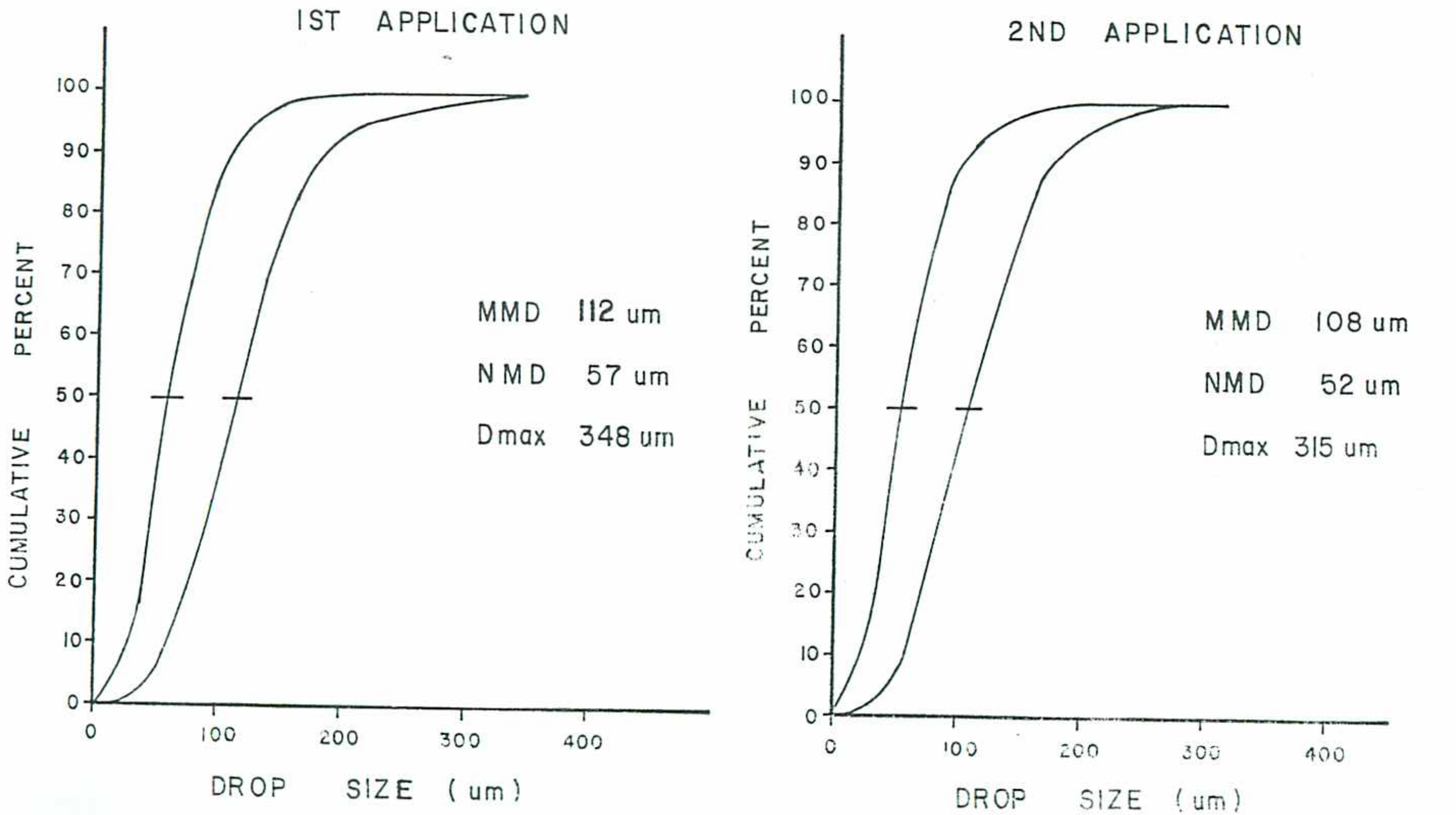
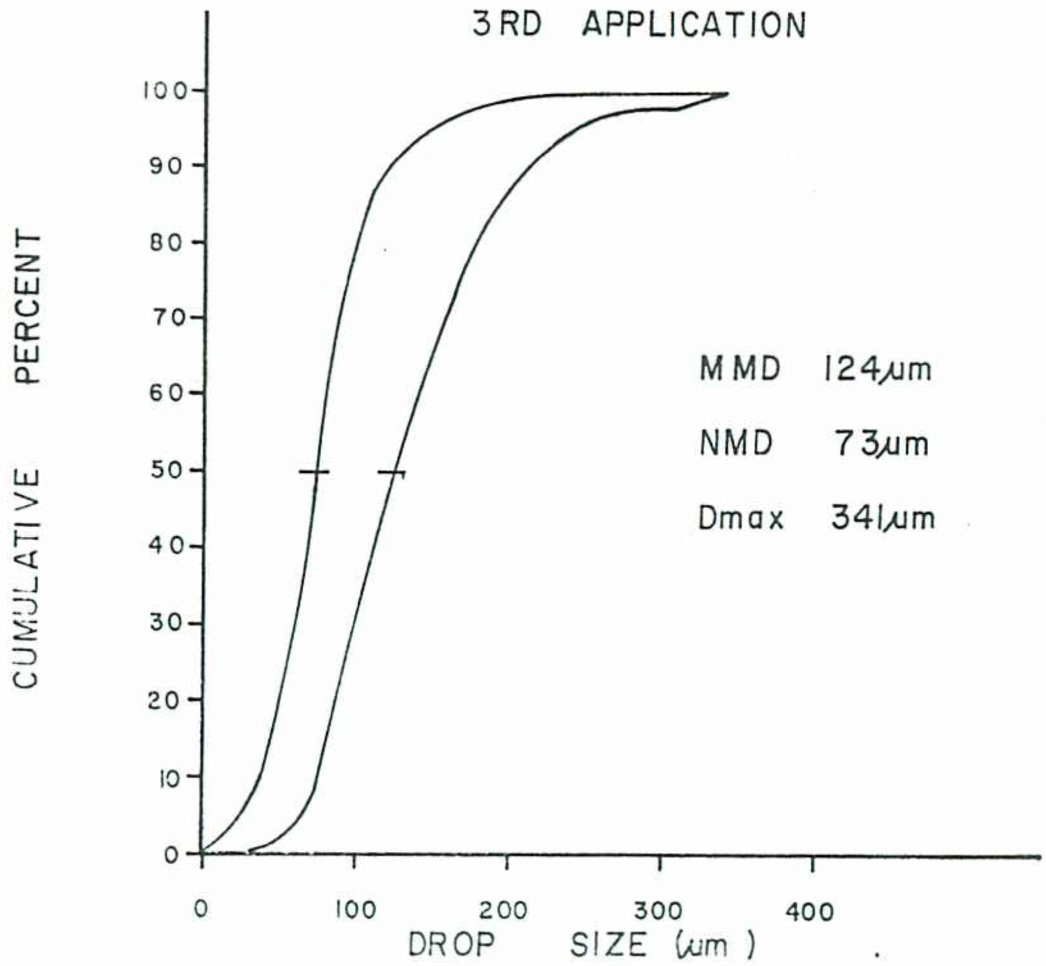


FIG. 6. MASS & NUMBER MEDIAN DIAMETERS
AMINOCARB APPLICATION (1.25 oz./ac.)



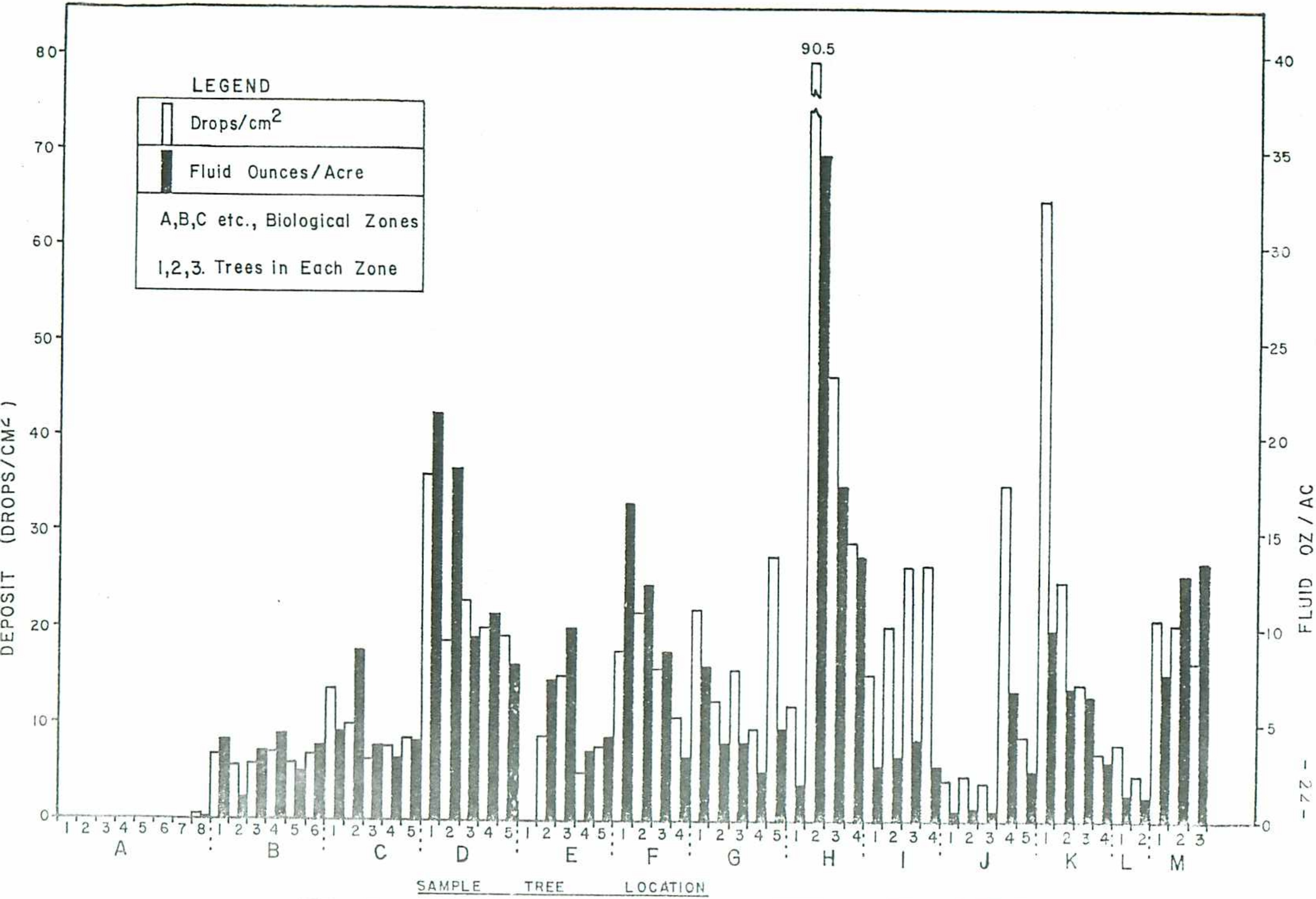


FIG. 7 COLLECTED DEPOSIT - FIRST APPLICATION -

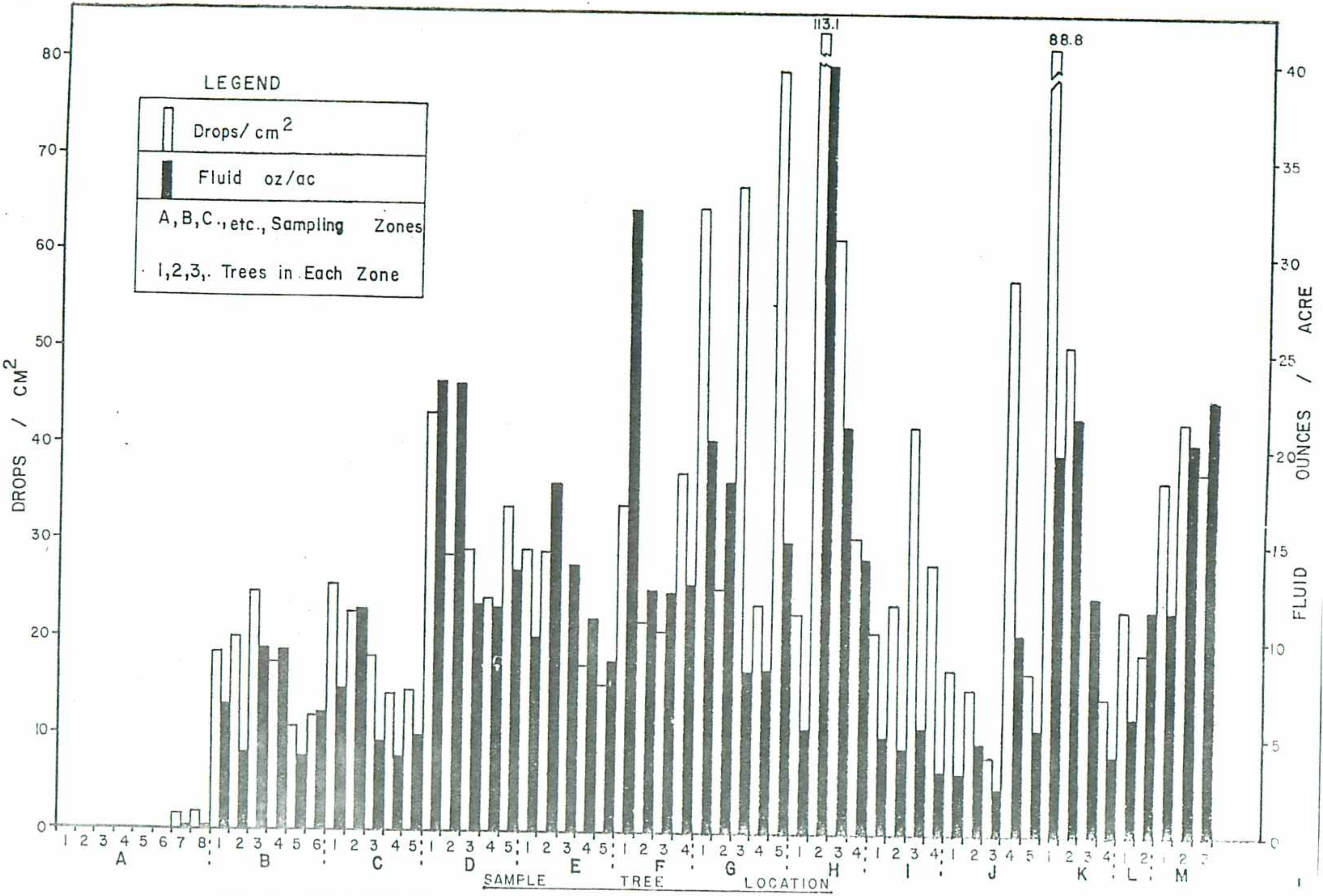


FIG. 8. COLLECTED DEPOSIT - TOTAL 1st & 2nd APPLICATIONS

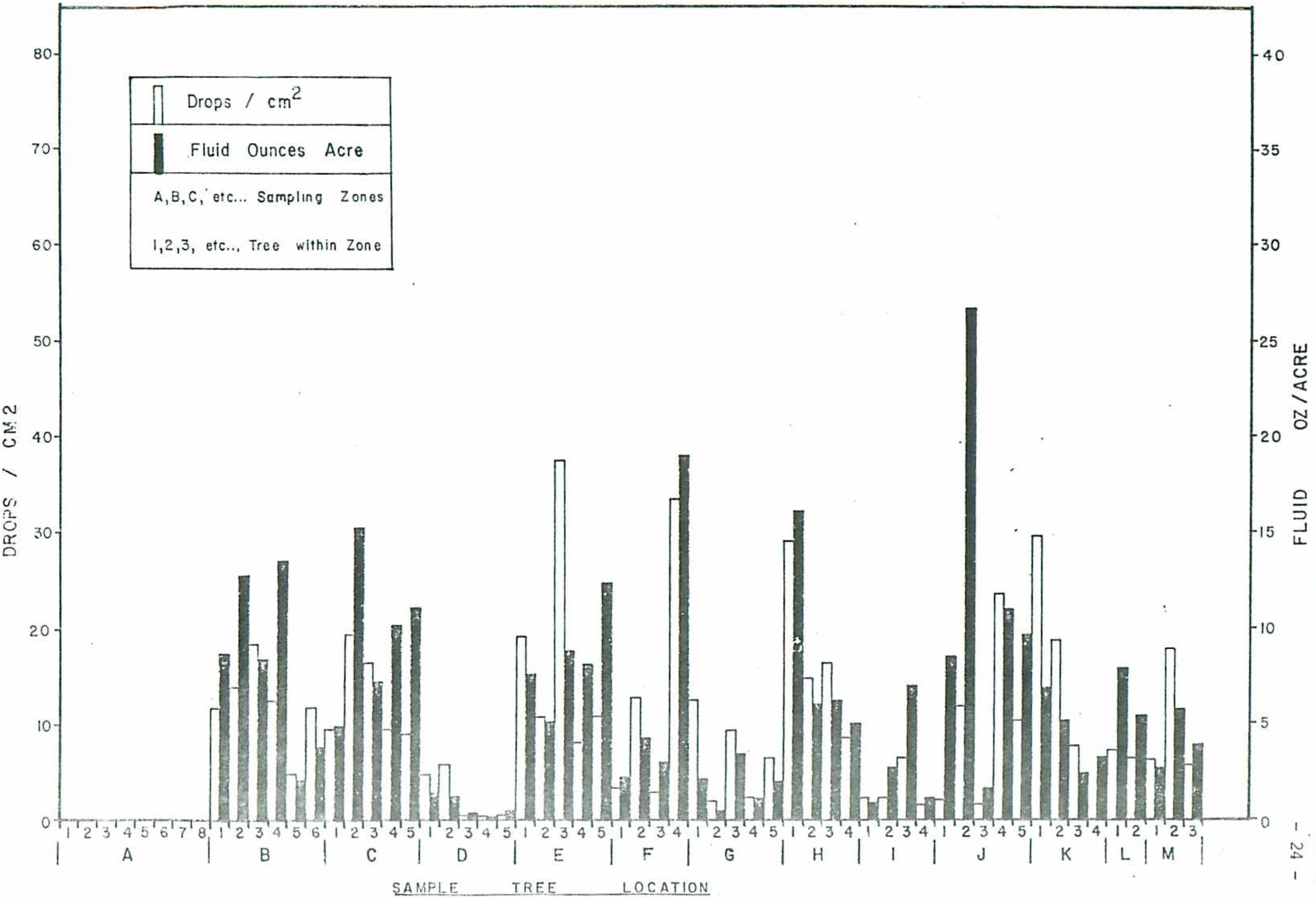


FIG. 9. COLLECTED DEPOSIT — THIRD APPLICATION — AMINOCARB