A METHOD FOR SUB-SAMPLING INSECT COLLECTIONS THAT VARY WIDELY IN SIZE[1]

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INTRODUCTION. Sub-sampling systems involving examination of a known proportion (e.g. Morgan *et al.*, 1955) or an aliquot (e.g. Tjønneland, 1960) of the whole catch are adequate for many types of study. But where successive collections are liable to vary widely in size a more versatile method may be needed. During recent studies of pest Trichoptera on the St. Lawrence River at Montreal, Quebec, nightly estimates were required of the numbers caught (in a light-trap) of each sex, of up to 100 species. The nightly catch ranged from zero to half a million insects (median 3×10^3) and exceeded 10^4 on more than 32 percent of occasions. A sub-sampling system was used such that the volume of insects examined was held below a chosen level, irrespective of the size of the whole catch. The system gave good service during two summer seasons, during which the trap caught more than 6 million Trichoptera. Details of successive steps in the procedure are available in mimeographed form and will be sent, by the author, to interested persons on request.

THE METHOD. Insects are collected in fluid. After removal of large, irregularly shaped insects (e.g. certain moths or beetles), the catch is stirred and strained. As soon as it stops dripping, the whole catch is measured out into units of 25 c.c. (called 'dishfuls') which are preserved in sequence. The volume of the whole catch is recorded to the nearest quarter of a dishful. Subsequent procedure depends on the volume of the catch: Procedure I is followed for three or more dishfuls, II for one or more but less than three, III for more than a quarter and less than one, and IV for a quarter or less.

Procedure I will be described first. Three dishfuls are selected at random, and each is placed in an annular dish (A, B or C) marked radially into sixteenths (Figure 1). For 'sector-sampling', each operator (A, B or C) covers the insects with fluid, levels the dish, distributes the insects evenly, and then removes from two opposite sectors (say 1 and 9) all that are of concern to the investigator. Insects removed are those within each sector and those lying across sector-boundaries ½ and 9/10 only. For this purpose, what constitutes an insect must be defined: the costal margin of the right fore-wing is a suitable criterion, because the area it covers is independent of the wings being open or closed. Insects thus removed from one eighth of each dishful are then identified and counted as required, unless further, aliquot sub-sampling (of the eighth) is deemed necessary for very small species that may still be excessively numerous.

Procedure II involves examination of one eighth of each *complete* dishful; III, examination of one eighth of the whole catch; IV, examination of the whole catch. In Procedures I–III (which involve sub-sampling) the fraction of the catch examined is known, and therefore the total can be estimated.

The main steps in Procedure I are shown in Figure 1.

SOURCES OF ERROR. These mainly concern variation between dishfuls (Table 1) which can result from the presence of large, irregularly shaped insects that reduce the homogeneity of the sub-sample; inconsistent pressure applied to the insects when the 25 c.c. container is being filled; differential wetness of the catch from top to bottom after straining.

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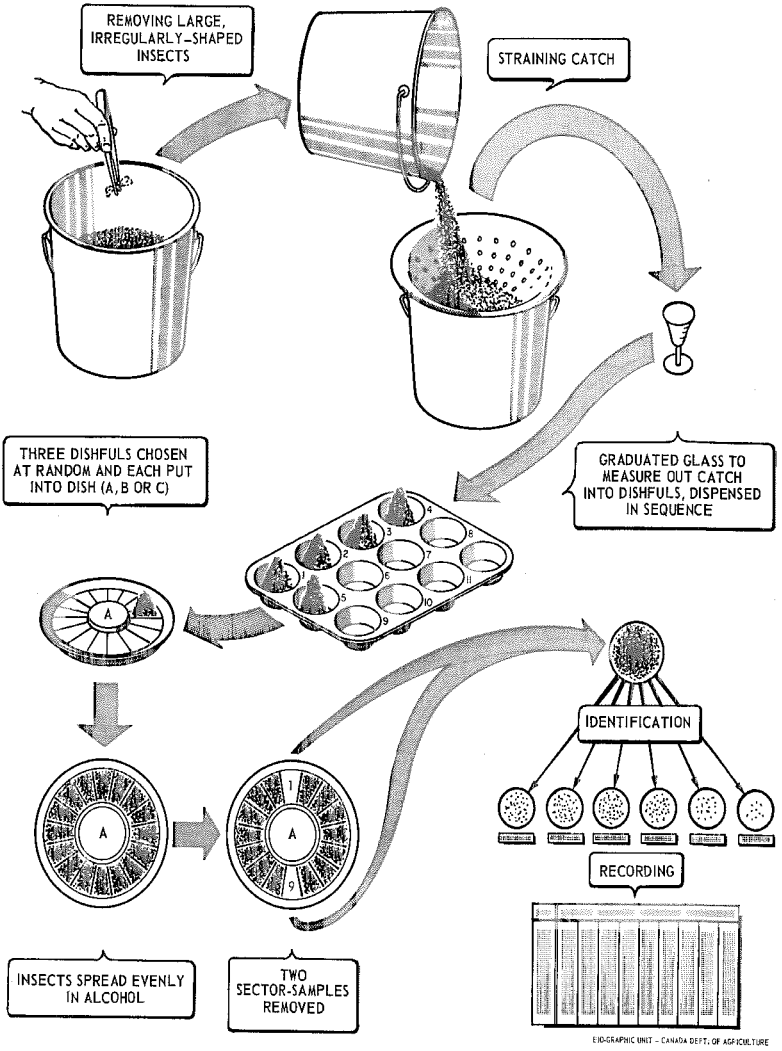

FIG. 1.—The main steps in Procedure I.

TABLE 1.—The variation between dishfuls in the same catch.

Date (night beginning)		No. dishfuls examined	Total insects* per dishful		
			$\bar{x}$	S.D.	Range
1964	6 June	10	636.60	64.18	555–755
	30 June	4	1401.25	84.97	1296–1492
1965	8 June	3	750.59	38.9	722–795
	9 June	3	840.92	81.4	748–899
	12 June	3	777.92	16.8	759–791
	16 June	3	1849.15	53.14	1791–1895
	18 June	3	1310.20	56.71	1277–1376
	23 June	3	2234.78	84.43	2138–2292

* In 1964 only Trichoptera were counted; in 1965 both Ephemeroptera and Trichoptera.

Errors derive also from the performance of individual operators, particularly when distributing the dishful evenly before sector-sampling and deciding which insects are eligible for removal. The last two sources of error can be checked retrospectively whenever the whole dishful (from which a sector-sample has been removed) has been preserved. The true ratio (dishful/sector-sample) can then be calculated.

In the Trichoptera study referred to in the Introduction, operators A, B and C differed in the size of sector-samples they removed from randomly selected dishfuls (Figure 2). For the 53 catches that were

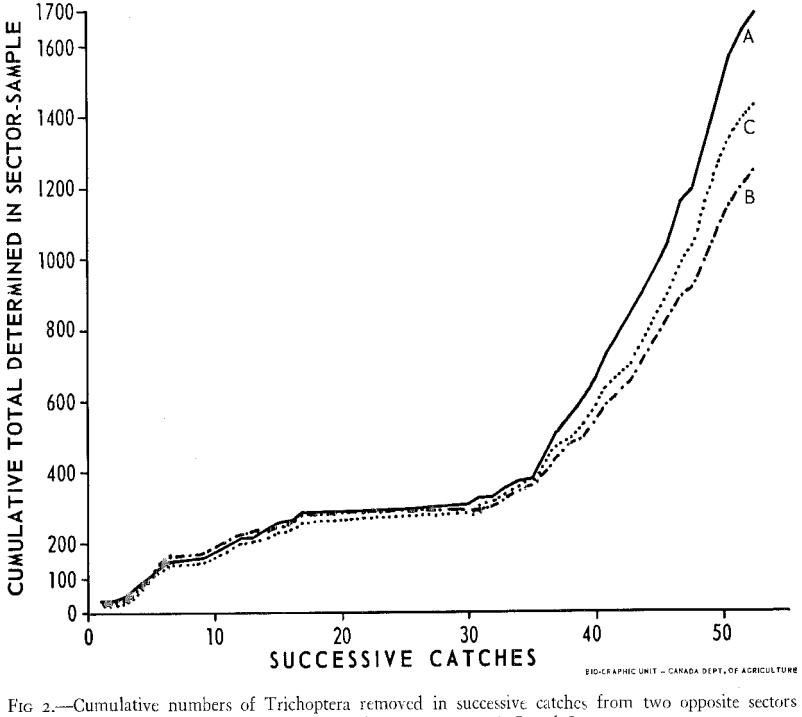

FIG 2.—Cumulative numbers of Trichoptera removed in successive catches from two opposite sectors of a dish by each of three operators, A, B and C.

comparable, the average numbers [2] of male *Hydropsyche recurvata* Banks removed per catch by the three operators respectively were 14.01, 11.01 and 12.48, and their individual dishful/sector-sample ratios differed accordingly (6.64, 7.38 and 7.32). In our study the differences could have been due to decisions concerning eligibility and perhaps also to small irregularities in the shape of the dish assigned permanently to each operator. That the ratios lay below 8 may have been due to a procedure we followed for including insects near the centre of the dish, since at that time an annular receptacle was not in use.

ADEQUACY FOR A GIVEN PROBLEM. Although the dishful/sector-sample ratio can be determined, the great daily variation in the proportion of dishfuls examined, and in the species-composition, make it impossible to obtain a meaningful estimate of its precision. Its adequacy for a given problem can, however, be determined empirically.

One of the main objectives of our Trichoptera study was to characterize fluctuations in numbers of active insects throughout the flying season. For this purpose, whether or not sub-sampling had been used, it was necessary to impose a 7-day moving Williams' mean on nightly values and to plot the means on a logarithmic scale. This prevented violent short-term fluctuations (caused by weather) from obscuring general trends.

To determine whether the sub-sampling errors could affect general conclusions drawn from such data, separate estimates of nightly totals (of male *Hydropsyche recurvata*) were made, these being based on sector-samples from threee sources: (1) dishes A, B and C, as in the normal procedure; (2) dish A (the largest sector-sample, see Figure 2); and (3) dish B (the smallest). The same dishful/sector-sample ratio, was used throughout. The resulting estimates, smoothed in the usual way, are shown in Figure 3. Estimate (1) has been plotted only for the 14 days on which it did not lie within antilog. 0.099 of either (2) or (3). The differences between estimates were unimportant for purposes of our investigation. The reason for the departure between catches 69 and 78 is that *H. recurvata* males were rare at a time when other species were very common. Factors were large (e.g. 437.3 for catch 70) and differences between the three sector-samples (which might, for example, have contained 0, 1 and 3 specimens) were greatly inflated, in this case

[2] Williams' means (see Haddow 1960).

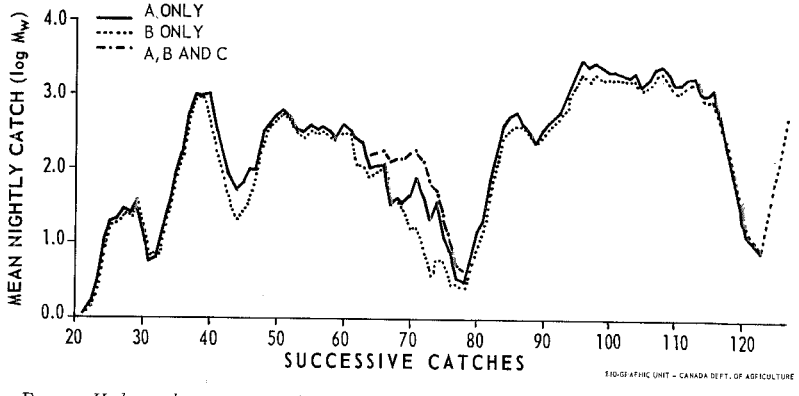

FIG. 3.—*Hydropsyche recurvata,* males. Estimated daily totals, expressed as moving Williams' means of 7, calculated from either: dish A only, dish B only, or all three dishes. Values for the third of these estimates are plotted only where they differ from either of the other two by more than 0.099 on the ordinate scale.

sufficiently to boost the moving average. In our study the error could easily be tolerated. In others where it cannot, it can be reduced by scanning more sectors or examining more dishfuls, for rare species only, and modifying their factors accordingly.

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SUMMARY. A simple, inexpensive subsampling method is described for examining insect collections that vary widely in size. Irrespective of the size of the collection the volume examined never exceeds a chosen amount. The main sources of error are mentioned, and an example given of a way of determining its adequacy for a given problem.

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