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PROGRESS REPORT

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AEC Contract AT(11-1)2002

MASTER

ENERGETICS OF NATURAL POPULATIONS
OF FRESHWATER MACROCONSUMERS

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1.0. Technical Documents Resulting from AEC Contract No. AT(11-1)2002

<u>Document No.</u>	<u>Date</u>	<u>Type of Document</u>	<u>Title</u>
COO-2002-1	1969	Progress Report	Energetics of natural populations of the plankton predator <u>Leptodora kindtii</u> (Focke). K. W. Cummins. Progress Report, 136 pp.
COO-2002-2	1970	Publication	Energy budgets. K. W. Cummins. Pp. 31-37 in: The stream ecosystem. K. W. Cummins (ed.) An Amer. Assoc. Advancement Science Symposium (Boston, Dec. 29, 1969). Tech. Rept. Series, Institute for Freshwater Research, Michigan State University, No. 7, 42 pp.
COO-2002-3	1970	Manuscript	Energy budgets for the stream caddisfly <u>Glossoma nigrior</u> (Insecta: Tricoptera: Glossosomatidae). K. W. Cummins, R. C. Peterseh, J. C. Wuycheck, F. O. Howard and V. I. Holt. 50 pp.
COO-2002-4	1970	Progress Report	Energetics of natural populations of freshwater macroconsumers. K. W. Cummins. Progress Report, 20 pp.
COO-2002-5	1971	Multilithed compilation (distributed from Kellogg Biological Station)	A world wide directory of stream ecologists. K. W. Cummins and C. Struble. 26 pp.
COO-2002-6	1971	Multilithed paper (distributed from Kellogg Biological Station)	An energy budget model for woodland stream ecosystems. K. W. Cummins. 5 pp.
COO-2002-7	1971	Publication	Energy relations in cladoceran populations. K. W. Cummins. Trans. Amer. Micros. Soc., 90:101-102.
COO-2002-8	1971	Publication	Calorific equivalents for studies in ecological energetics. K. W. Cummins and J. C. Wuycheck. <u>Mitt. int. Ver. Limnol.</u> 18:1-158.
COO-2002-9	1972	Publication	What is a river: zoological description. K. W. Cummins. Proceedings of an invited symposium on rivers. (Univ. Mass., Amherst, June 20-23, 1971).

<u>Document No.</u>	<u>Date</u>	<u>Type of Document</u>	<u>Title</u>
C00-2002-10	1971	Progress Report	Energetics of natural populations of freshwater macro-consumers. K. W. Cummins. Progress Report, 36 pp.
C00-2002-11	1972	MS submitted to <u>Bioscience</u>	Organic enrichment with leaf leachate in experimental lotic ecosystems. K. W. Cummins, M. J. Klug, R. G. Wetzel, R. C. Petersen, K. F. Suberkropp, B. A. Manny, J. C. Wuycheck and F. O. Howard.
C00-2002-12	1972	Publication in Press	Trophic relations of aquatic insects. K. W. Cummins. <u>Ann. Rev. Ent.</u> , 18 (20 pp.).
C00-2002-13	1972	MS submitted to <u>Ecology</u>	The utilization of leaf litter by stream detritivores. K. W. Cummins, R. C. Petersen, F. O. Howard, J. C. Wuycheck and V. I. Holt.
C00-2002-14	1972	MS	Leaf processing in a woodland trout stream. R. C. Petersen, K. W. Cummins, F. O. Howard.
C00-2002-15	1972	MS	The influence of leaf litter conditioning time on ingestion and growth rates of the stream detritivore <u>Lepidostoma costalis</u> (Trichoptera). K. W. Cummins, D. J. King, J. C. Wuycheck and V. I. Holt.
C00-2002-16	1972	MS	The metabolism of microorganisms associated with leaf litter in streams as determined with hickory leaf discs. K. W. Cummins and R. C. Petersen.
C00-2002-17	1972	MS	Respiratory metabolism of the stream caddisfly <u>Glossosoma nigrum</u> Banks (Trichoptera:Glossosomatidae). K. W. Cummins, R. C. Petersen, V. I. Holt and J. C. Wuycheck.
C00-2002-18	1972	MS	Estimates of field density and production of the stream caddisfly <u>Glossosoma nigrum</u> Banks (Trichoptera:Glossosomatidae). K. W. Cummins, J. C. Wuycheck, R. C. Petersen, F. O. Howard and R. H. King.
C00-2002-19	1972	MS	Laboratory determined growth and feeding rates of the stream caddisfly <u>Glossosoma nigrum</u> Banks (Trichoptera:Glossosomatidae). K. W. Cummins, R. C. Petersen, D. K. King, V. I. Holt and L. M. Ewers.

<u>Document No.</u>	<u>Date</u>	<u>Type of Document</u>	<u>Title</u>
C00-2002-20	1972	Progress Report	Energetics of natural populations of freshwater macroconsumers. K. W. Cummins.

2.0. INTRODUCTION

Within the framework of a generalized model of stream ecosystem functioning (TD-COO-2002-10, Fig. 1 and 2; Cummins, 1972), work continued on delineating energy budgets for key component macroconsumer species. The emphasis has continued to be on natural field populations and the interrelation of data at the population level to the overall structure and function of woodland stream ecosystems. Of particular interest have been species associated with leaf litter processing. The larger species, termed "shredders" are involved in the initial fragmentation of microbially infested litter; the resultant fine detrital particles (including shredder feces) are fed upon by smaller species termed "collectors" (Fig. 1). The amount of organic matter processed and the numerical and biomass densities of macroconsumers involved are orders of magnitude greater than the primary producing (periphyton) and grazing macroconsumer components of woodland stream ecosystems (Fig. 1; see also TD-COO-2002-15 for additional discussion of general woodland stream ecosystem structure and function).

The general plan of the progress report is to present, primarily in outline form (see Contents), the methods and results of various components of the overall project. Detail has either been previously provided (methods) or is presented in the form of accompanying Technical Documents (see pp. 1 and 2 for a listing by number and title).

3.0. METHODS

For a general discussion of methods see particularly Technical Documents COO-2002-3 and -10.

3.1. Streams and Culture Systems

Three general systems have been employed as simulators of natural conditions in Augusta Creek (Kalamazoo and Barry Counties, Mich.). Culture

chambers used in feeding and growth studies (TD-COO-100213), consist of one liter plastic blow-mold bottles with one side removed. The bottles are filled with stream water, aerated and maintained in a constant temperature bath ($\pm 0.5^{\circ}\text{C}$) under normal light regime. Two seven meter long temperature controlled systems (Frigid Units) are employed as holding tanks for rearing studies and additional growth and feeding experiments. Finally, two large (eleven meter long, 1.5 meter wide and 0.6 meter deep) recirculating experimental channels housed in a greenhouse are used for large scale experiments under essentially natural stream conditions (Cummins, 1972).

Field densities are determined in, and experimental animals collected from, Augusta Creek, a local woodland brown trout stream. Some comparative collections have been taken from Spring Brook and Seven Mile Creek in the same region and Linesville Creek in Pennsylvania (Crawford Co.; Coffman et al., 1971).

3.2. Gravimetric and Calorimetric

After considerable difficulty, including attempts to use commercially available equipment, a semi-automated weighing and calorimetry system has been assembled and has been fully operational for almost a year. The savings in time, increased accuracy, and ease of measurement and accumulation of data are outstanding. The electronics package (built by Nationwide Electronic Systems, Inc., Itasca, Illinois) interfaces both a G-2 Cahn electrobalance and a Gentry Wiegert oxygen bomb microcalorimeter through a pre-amplifier, with a teletypewriter output device. The data are rendered in both printout and punch tape form (as well as shown on a visual display during operation) with appropriate code numbers and decimals. Weights are obtained $\pm 0.2 \mu\text{g}$ (1 - 5 mg scale) and temperatures $\pm 0.02^{\circ}\text{C}$ ($\pm 0.01 \text{ min.}$) for calorific determinations.

3.3. Field Densities

Considerable effort has continued to be expended in providing estimates of age-specific field densities (numerical and biomass) of the representative species under investigation (see 4.0 below). Special attention has been placed on the mathematical treatment of sample data as discussed by Elliott (1970). Three kinds of sampling methods have been used: 1) a grid frame technique for non-burrowing, exposed, surface periphyton grazers such as Glossosoma and Neophylax; 2) A sampling frame with a variable mesh net for species such as Pycnopsyche, Tipula, Pteronarcys, Stenonema, Lepidostoma, Stictochironomus and Nigronia, which are, at various times during their life cycles, found in or on the sediments or organic debris; and, 3) Leaf packs placed in the stream at various periods for colonization.

3.3.1. Grid Samples

One or more 0.25m^2 frames each divided into 16 - 0.016m^2 sections, are laid on the stream bottom and the animals collected, a square at a time, with a fine mesh net. The mesh size is adjusted so as to be fine enough to collect the smallest individuals in the population at any given time (TD-COO-2002-3). By combining and comparing collections from more than one 0.25m^2 frame, a variety of mathematical treatments are possible (see 4.3.1 below).

3.3.2. Bottom Samples (Howard Sampler)

The Howard sampler (Fig. 2), a modification of the Hess sampler (Waters and Knapp, 1961) is a 0.125m^2 circular frame with a nytex mesh covering and side arm. The mesh size can be changed, depending upon the size structure of the population being sampled, and the side arm is fitted with a detachable

bag joined with a zipper. The sampler is turned into the bottom, the sediments disturbed violently and the dislodged material washed into the side arm and concentrated in the detachable bag. The bag is removed and the sample sorted or returned for later sorting (when the age structure is dominated by large individuals, sorting is accomplished in the field; see 4.1.2 below).

3.3.3. Leaf Packs

The leaf pack method for studying animal colonization and leaf processing rates has been extremely useful. The leaves, by single or mixed species, removed from the tree or shrub just prior to abscission, are weighed into 10 gram (oven dry, 51°C) amounts. These are dampened, fastened together with Buttoneere (Dennison Manufacturing Co., Framington, Mass.) and lashed loosely to bricks with monofilament nylon line (Fig. 3). If air dry weights are used, subsamples are taken to determine the difference between air and oven dry wt. Additional subsamples are taken to determine the weight loss associated with dampening the leaves, leaf pack preparation and transportation to the experimental site. The bricks are placed in the stream so that the leaf packs face into the current. This simulates the natural condition quite well, since leaves lodge in "packs" on the leading edge of obstructions such as rocks and logs. Investigations of naturally occurring packs indicate that 10 grams is an average sized accumulation and that microbial and animal colonization and utilization in the artificial packs occurs at normal rates. This is definitely not true if the leaves are enclosed in mesh bags or "cages."

3.4. Leaf Litter Utilization

Measurements of leaf litter processing rates have been made, both in the laboratory and the field, for a wide variety of terrestrial leaf species.

The emphasis has been on the identification of "decay constants" for the various components of leaf litter processing: leaching, mechanical fragmentation, microbial utilization and animal feeding. These data are summarized and compared to a variety of literature values in the accompanying Technical Document C00-2002-14.

3.4.1. Leaf Packs

As indicated in TD C00-2002-14, many of the experiments designed to determine processing rates of leaf litter have involved the use of artificially prepared leaf packs. Over 2000 such packs prepared from 15 tree and shrub species (TD C00-2002-14) have been used in Augusta Creek and the experimental channels. The packs (described above in 3.3.3) attached to bricks were placed in Augusta Creek or the greenhouse channels at several sites at different seasons and picked up on a variety of schedules. The procedure has proven to be extremely useful and its use has been extended to cooperative programs involving streams in Kansas, South Carolina, California and Montana.

3.4.2 Leaf Disc Respiration

In order to investigate the microbial communities associated with leaf litter during the decomposition process in the stream, the metabolism of such communities, associated with both the leaf surface and the leaf matrix, have been investigated using leaf discs. The discs (usually 2.5 cm diameter) are punched from leaves with a die so as to produce substrates of fairly uniform weight and surface area. The uniformity is enhanced by including approximately the same amount of major vein structure in each disc. Prior to punching, the leaves are dampened briefly to avoid breakage (controls are used if the determination of % leaching is facet of the experiment). The discs are either

punched from dried leaves that are then incubated in culture or the stream, or they are made from leaf packs that have been stream incubated. Stream incubated discs are held on insect pins (3 to a pin) fastened in a styrofoam block that is anchored on the stream bottom. The sets (3 to a pin) are picked up at random and the replicates compared to evaluate the position affect. Following incubation in the stream or a culture vessel, the discs are placed in a Gilson differential respirometer and temperature-specific O_2 consumption per unit weight of leaf (dry or ash free dry) is determined. If a tracer such as glucose- ^{14}C is added to the culture vessel, then the radioactivity per unit weight is determined by combustion to CO_2 (Packard tricarb sample oxidizer) followed by liquid scintillation counting (Beckman LS-150). A further discussion of methods together with some typical results are given in TD-C00-2002-16.

3.5. Ingestion

The methods used in investigations of ingestion, described previously (TD C00-2002-10 through 13), are only briefly summarized below. Data processing (see Section 5.0) involves the use of a Hewlett-Packard 2100A minicomputer (40% of which was purchased with funds from AEC Contract AT(11-1)2002; Appendix I).

3.5.1. Determination of Consumption Indices (CI).

Consumption index (CI, Waldbauer, 1968) has the units mg food ingested/mg animal wt/day (when multiplied by 100 this equals ingestion as a % of body wt/day) and is calculated as:

$$CI = \frac{\text{wt food ingested during time interval } t \text{ (days)}}{\text{median wt of ingesting animals during time interval } t \text{ (days)}}$$

The strategy has been to determine consumption indices for representative species (see Section 4.0) in relation to age, density, food quality

and quantity, temperature and species interactions. The appropriate CI values are then used to calculate the impact of measured field or constructed lab (greenhouse channels) densities on detrital input (also measured or constructed). Such calculations are compared to independent measurements of detrital processing (TD-COO-2002-14). Some preliminary calculations of this type appear in TD-COO-2002-13.

3.5.2. Tracer Studies

Tracer studies have been employed for additional independent estimates of CI values in the case of shredders and for collectors and grazers when it is difficult to make gravimetric assessments of the food supply. In addition to ingestion data it is also possible to obtain information on assimilation and, if the animals are moved to non-tagged food at some point during the experiment, respiration and egestion. The general procedures are summarized in Fig. 4 and the large plexiglass chambers, equipped with stirring devices, used in tracer studies in the natural stream or greenhouse channels are shown in Fig. 5. For a further discussion of methods and results from tracer studies see TD-COO-2002-11, -15, -16 and -19.

3.6. Growth

The general procedure has been to independently assess the growth rate of field and laboratory populations of selected species. As in ingestion studies, laboratory measurements have focused on age, density, food quality and quantity, temperature and species interactions.

3.6.1. Field Growth Rates

Estimates of growth rates (production at the population level) from field data have primarily followed the procedures discussed by Waters (1969) with

certain modifications (TD-COO-2002-3 and -18) where growth is assumed to be logarithmic and calculated as:

$$\text{Daily growth} = \ln \frac{\bar{x} \text{ maximum wt attained by an individual}}{\bar{x} \text{ minimum wt at which an individual starts growth}} \div \bar{x} \text{ number of days to grow from minimum to maximum weight.}$$

Such estimates can be made from field determinations of $\bar{x}$ minimum and maximum weights and the growth interval (the latter = generation time less egg period, adult period, and pupal and/or diapause period if applicable). Production estimates are then made from periodic assessments of field density (Section 3.3 above) and age structure of the selected populations.

3.6.2. Laboratory Measurements of Relative Growth Rate (GR) and Efficiency of Food Conversion (ECI)

The methods by which the parameters are measured to calculate relative growth rate and efficiency of conversion of food to growth (Waldbauer, 1968) have been summarized in Fig. 6 and TD-COO-2002-13 and -15. Experiments of from 1 to 4 weeks duration are conducted in plastic blow-mold bottles filled with stream water and aerated and held in constant temperature bath for the duration of the experiment. For experiments involving shredders, various species of leaf food conditioned for various periods in culture, the greenhouse channels or natural streams are used. For collectors and grazers, a variety of natural or cultured food materials have been used (TD-COO-2002-13, -19).

3.7. Respiration

Through the use of two Gilson differential respirometers and computer programs for data processing and calculations (summarized previously TD-COO-2002-10), many additional measurements of oxygen consumption by age, and temperature have been completed for selected species. Particular emphasis has been placed on the grazer Glossosoma nigrilor; these data are summarized

in TD-COO-2002-17 which is an extension of TD-COO-2002-3 (see Section 4.3.1).

3.8. Assimilation

As discussed above (Section 3.5.2) assimilation has been determined in tracer studies using ^{14}C tagged food. After an initial period of gut loading (at the time when ingestion of labeled food = egestion of labeled food), the additional incorporation of label represents assimilation (tissue loading) less respiration. If respiration (tissue unloading) and egestion (gut unloading) are determined by transferring animals to non-labeled food, an estimation of assimilation can be obtained (see TD-COO-2002-19 as an example). When respiration and growth are determined independently, assimilation is also calculated as the summation of the two.

3.9. Egestion

In addition to gut unloading determined in tracer studies when the animals are moved to non-labeled food, a rough approximation has been determined by the collection of fecal material from growth and feeding chambers (TD-COO-2002-13, -15).

4.0. RESULTS

As for the methods, results have been summarized primarily in the form of accompanying Technical Documents (TD-COO-2002-11 through -19). Results not already considered as part of the Methods section (3.0) have been organized according to feeding category (Fig. 1) and by selected species.

4.1. Shredders (Large Particle Detritivores)

4.1.1. Tipula (caloptera and abdominalis).

Data collected on Tipula feeding and growth are given in TD-COO-2002-13. Estimates of Tipula field density have been combined with other shredders

for calculations in TD-COO-2002-14.

4.1.2. Pycnopsyche (guttifer, scabripennis, lepida)

For data on Pycnopsyche see TD-COO-2002-13 and -14. Additional information on these large particle detritivore caddisflies will appear in the form of a Ph.D. thesis (Howard, 1972) to be completed in the fall of 1972.

4.1.3. Lepidostoma costalis (Banks) (Trichoptera:Lepidostomatidae)

The data on Lepidostoma have been summarized in preliminary manuscript form (COO-2002-15) which is included as part of the material of this Progress Report. Since the growth period of this species is late winter through early summer, it is of particular interest as a processor of both the resistant material remaining from the autumn input and new particulate substrates brought in with the spring run off.

4.1.4. Pteronarcys pictetii (Plecoptera:Pteronarcidae)

Although this species is the largest, most rapidly feeding (highest consumption index) of the shredders in Augusta Creek, it is present in low densities that make field population estimates difficult.

When fed conditioned hickory leaves at 9°C, P. pictetii in the range of 860-1027 mg dry wt had a mean relative growth rate (GR) of 0.005 mg/mg/day and a consumption index (CI; Walbauer, 1968) of 3.725 mg/mg/day. The latter value is an over-estimate approximation, as pointed out by McDiffett (1970), since particles of leaf are removed from the food source, but dropped rather than eaten. From McDiffett's (1970) data a CI of only 0.291 can be calculated.

4.2. Collectors (Fine Particle Detritivores)

4.2.1. Stenonema (tripunctatum and fuscum) and stenacron (interpunctatum and canadenses)

The heptageniid mayflies constitute a complex group of species in Augusta Creek, a situation undoubtedly representative of most woodland streams in the eastern deciduous biome. The general nature of feeding and growth of this species complex has been covered in TD-C00-2002-13. Given the temperature and biomass (age) it appears to be possible to assign average rates somewhat independent of species. Stenonema and Stenacron have been selected for detailed study because of their association with accumulations of leaf litter.

4.2.2. Stictochironomus sp.

In those woodland streams which have been investigated in sufficient detail (e.g. Coffman et al., 1971) it has become apparent that the midge fauna can be expected to number between 50 and 100 species on an annual basis. Despite this dominance, most studies continue to avoid this group because of their generally small size and the taxonomic problems associated with the group.

In Augusta Creek, a species of Stictochironomus is found in large numbers in detrital accumulations where it feeds on fine particulate organic matter. Some preliminary data from feeding and growth experiments are summarized in Table 1. These data indicate that Stictochironomus larvae (fall winter generation) have relatively slow growth rates (.0011 - .0059 mg/mg/day; compare to TD-C00-2002-13) but very high consumption indices (.607 - 3.666 mg/mg/day; compare to TD-C00-2002-13 and 15) and, consequently, low ECI values.

4.3. Grazers (Algal Herbivores)

4.3.1. Glossosoma nigrior Banks

Information on the stream grazer G. nigrior was originally summarized in TD-COO-2002-3 (and TD-COO-2002-10) which was to be submitted for publication after certain modifications and the inclusion of additional data. However, field and laboratory data on both summer and winter populations from several sites on three streams are so extensive that a single paper is clearly out of the question unless it were to represent the most cursory summary. Therefore, the data have been organized into three general categories as indicated by the titles of TD-COO-2002-17, -18 and -19. These manuscripts are presently being prepared for submission to appropriate journals; to avoid costly duplication, these have been presented essentially in outline form, including some new data, rather than as sections of the Progress Report per se.

4.3.2. Neophylax (oligius, fuscus, ayanus, concinus).

The only new information obtained on these species is some respirometric data. Work on this group of species was suspended pending the completion of a Ph.D. study of N. oligius and concinus by Sedell (1972).

4.4. Predators (Carnivores)-Nigronia serricornis

Data on the megalopteran predator Nigronia serricornis will constitute a Ph.D. thesis scheduled for completion in the fall (Petersen, 1972).

5.0. DATA REDUCTION AND INTEGRATION

As indicated above, a Hewlett-Packard 2100A minicomputer is being employed in data processing (e.g. see Appendices I and II). We are now in the process of converting the programs (see TD-COO-2002-10) presently

operational on the MTS (Michigan Terminal System - time sharing data phone communication to an IBM 360) for use on the 2100A. Because of the greatly increased convenience and considerable savings in expense of operation, the Hewlett-Packard 2100A will be used as the primary computational device.

The primary integrative activity has been continued cooperative efforts with the System Science - Ecology group on the main MSU campus. The integration of data on stream woodland ecosystems continues to center on the general model presented in TD-COO-2002-10 and repeated here as Fig. 7 (in simplified form in Fig. 1).

6.0. CONCLUSIONS

Given existing data on streams of the temperate zone, there is little doubt that the general pattern in undisturbed systems is a dependence upon the input of reduced carbon compounds of terrestrial origin and, therefore, the dominance of heterotrophic processing. These data are such that it is now possible to formulate a general statement covering the overall aspects of leaf litter processing (Fisher, 1971; Triska, 1971; Fisher and Likens, 1972; TD-COO-2002-13). It is also possible presently to make predictions concerning the relative roles of microbial populations, shredders and collectors in the processing of large particle detritus (e.g. TD-COO-2002-13, -14).

However, many aspects of detrital processing, particularly concerning the collectors and shredder-collectors interactions, still remain to be delineated in sufficient detail to permit the sort of predictions that can be translated into appropriate field experiments. Therefore, the ultimate goal of this project continues to be the dimensioning, on a

seasonal basis, of the animal components shown in Fig. 1 and 7. Specifically this means working with selected species (chosen on the basis of their dominance in processing functions) and determining food processing rate (CI or ingestion), growth rates (GR or relative growth rate) and respiratory metabolism of ingested food.

Only the literature cited in the Progress Report itself has been included. For additional references see the accompanying Technical Documents C00-2002-11 through C00-2002-19 (also C00-2002-3).

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Sedell, J. R. 1971. The trophic ecology and natural history of Neophylax concinnus and N. oligius (Trichoptera:Limnephilidae). Ph.D. Thesis, Univ. Pittsburgh, Pittsburgh, 154 p.

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Fig. 2. The Howard stream bottom sampler showing nytex covering, side arm and detachable bag (end of side arm joined to the base with a zipper).

Fig. 3. Leaf packs fastened to bricks. Packs held together with Butoneers (Dickinson Co.) and lashed loosely to bricks with monofilament nylon line. Bricks are laid on the stream bottom with the leaf pack facing into the current so as to simulate a natural leaf pack caught on the leading edge of an obstruction.

Fig. 4. Diagrammatic representation of methods used in ^{14}C tracer animal feeding studies. CO_2 traps are KOH unless the $^{14}\text{CO}_2$ is to be counted in which case hyamine and ethylamine are used and the water is acidified at the end of the experiment. Materials removed from experimental chambers or vessels are rinsed with .005 N HCl and distilled water. Killed controls are prepared by freezing and/or sterilization with ethylene oxide.

Fig. 5. Plexiglass circulating chambers for tracer studies. Current is simulated with an electric stirring motor. The lid has a port for an aeration line or the introduction of tracer and is held in place with rubber bands.

1. Size selection must be as accurate as possible; in some instances it is necessary to select initial groups after weighing (e.g. *Tipula*).
2. Head width and/or total length.
3. Perforated chambers can be used in the natural stream or greenhouse channels to achieve more natural conditions, all other procedures are kept the same.

Fig. 6. Four generalized methods for measuring laboratory growth rates of shredders (e.g. *Tipula*, *Pycnopsyche*, *Pteronarcys*), collectors (e.g. *Stenonema*) and grazers (e.g. *Glossosoma*).

VERAGE DAILY ENERGY BUDGET FOR A WOODLAND STREAM

Fig. 7. A generalized model of material processing in a woodland stream ecosystem.

Table 1. Feeding and growth of Stictochironomus sp. from Augusta Creek. Aerated chambers held at 10°C under normal light regime

Animal density in chamber	Size or wet wt. range	Probable instar	Survival (%)	Duration (days)	Other animals		Type of food and conditioning	CI ¹ (mg/mg/day)	GR ² (mg/mg/day)	ECI ³
					Species	Density in chamber				
20	9-10.9 mm	3-4	80	28	<u>Tipula</u>	10	Hickory leaves, lab conditioned 10 days	-	-0.0059	-
20	11.0-12.4 mm	4 ⁴	40	28	<u>Tipula</u>	10	Hickory leaves, lab conditioned 10 days	-	0.0011	-
20	7.5-8.9 mm	2-3	40	28	<u>Tipula</u>	10	Hickory leaves, lab conditioned 10 days	-	0.0033	-
20	9.0-10.9 mm	3-4	95	28	-	-	<u>Tipula</u> feces	1.021	0.0095	0.0093
20	11.0-12.4 mm	4 ⁴	95	28	-	-	Detritus, collected from Augusta Creek	3.666	-0.0005	-
20	9.0-10.9 mm	3-4	95	28	-	-	Hickory leaves, lab conditioned 10 days	-	0.0052	-
	9.0-12.4 ⁵ mm				-	-		0.607	0.0001	0.0002
20	4.9-6.0 mg	3-4	80	18	-	-	<u>Tipula</u> feces	1.936	0.0025	0.0013
20	7.9-9.0 mg	4	90	18	-	-	<u>Tipula</u> feces	-	0.0023	-
	7.9-10.0 ⁶ mg	4 ⁴			-	-	<u>Tipula</u> feces	3.192	0.0043	0.0014

1. CI = consumption index = mg food consumed/median mg animals/day

2. GR = relative growth rate = mg growth per individual/median mg wt per animal/day

3. ECI = efficiency of conversion of food to growth = GR/CI

4. Some late 4th instar larvae, indicated by swollen thoracies, that had probably stopped growing were included, but not those that had pupated.

5. This group includes the 9.0-10.9 group above and a 9.0-12.4 group; both were in the same chamber.

6. This group includes the 7.9-9.0 group above and a 8.9-10.0 group; both were in the same chamber.

10.1. Appendix I. Instructions and BASIC Program for
Determining CI, GR, ECI and DF (Consumption Index,
Relative Growth Rate, Efficiency of Consumption and
Density Factor)

There are 4 separate punched paper tapes involved in this analysis of growth experiment data. Generally, the programs will accept up to and including 6 replicate chambers per treatment. There should be less than or equal to 40 leaf discs or animals in each chamber, not counting those discs or animals removed initially as subsamples. The number of leaf discs in a subsample must be constant among all experimental chambers and also among all control chambers. The number in the experimental subsample does not necessarily have to be the same as the number in the control subsamples. Likewise, the number of animals taken as a subsample must be constant for all chambers within a given treatment. All weights should be expressed in the same units, e.g. milligrams.

For explanation of BASIC computer language and "error messages" that you might encounter, refer to the manual, "A Guide to HP Educational BASIC." Pages 1-11 to 1-13, 2-27, 2-31, 2-32, 2-37 to 2-39, 2-42, E-2, E-4 to E-7, and G-1 to G-7 in this text contain essential information.

TO START THE COMPUTER:

1. Turn teletype switch to LINE and tape punch to OFF.
2. Turn computer key to POWER ON.
3. Press SYSTEM ON/OFF.
4. Press Display button P.
5. Press the buttons in the top row of the computer Display Panel so that only button 6 is lighted.
6. Press INTERNAL PRESET.

7. Press EXTERNAL PRESET.
8. Press RUN. Teletype should print READY.
9. Turn key to LOCK ON.

TO STOP THE COMPUTER:

1. Turn teletype switch to OFF.
2. Turn key to OFF.
3. Press SYSTEM ON/OFF.

TO ENTER A TAPED PROGRAM:

1. Put tape reader lever to FREE..
2. Place tape (◀ end) under plastic holder.
3. Type SCRATCH and return.
4. Type TAPE and return.
5. Put tape reader lever to START. Tape should pass thru tape reader.
6. Rewind tape (begin with ▶ end).
7. Type RUN and return.

TO ENTER DATA:

Each of the 4 programs will ask if you have entered the necessary data.

Input the appropriate value to answer. Data must be entered in a specific way on consecutively numbered "data statements." The useable statement numbers will be given below. The data elements must be entered in the order given below, with commas separating each number.

Do not put a comma at the end of a line of data. Before running the program, check the data you have entered. The format for data statements is shown in these examples;

```
1400 DATA 15,15,3.57,.39
1401 DATA 3.456789,-.99999
1402 DATA 1
1403 DATA 0,0,0
```

TAPE 1: FOOD LEAF DISCS

Data should be entered in the following order, on consecutive lines, starting with 1400 and not exceeding 1999:

A = the number of leaf discs taken as a subsample from an experimental chamber.

B = the number of experimental chambers.

C = the number of control chambers.

D1,D2,...DB = the number of leaf discs removed from each of the B experimental chambers at the end of the experiment.

E1,E2,...EA = the wet weight of each of the A subsample leaf discs for chamber 1.

.
.
.

F1,F2,...FA = " thru chamber B.

G1,G2,...GA = the dry weights ".

.
.
.

H1,H2,...HD1 = the dry weights of the D1 leaf discs from chamber 1 at the end of the experiment.

I1,I2,...ID2 = " D2 " chamber 2.

.
.
.

J1,J2,...JDB = " DB " chamber B.

The output gives, for each chamber:

TOTAL = the sum of weights of the subsample or experimental leaf discs.

MEAN = TOTAL/N.

SD, SE, CV (as a percent), N.

% WATER = [(wet weight - dry weight)/wet weight] X 100.

% DRY = 100 - % WATER

% DRY MEAN, SD, SE, CV taken for all chambers combined.

TAPE 2: CONTROL LEAF DISCS

Data lines are 1400 - 1999. Enter data in this order:

A = the number of leaf discs in a control chamber subsample.

B = the number of control chambers.

C1,C2,...CB = the number of leaf discs taken from each control chamber at the end of the experiment.

E ... J as for Tape 1, except with respect to the control chambers rather than the experimental or "feeding" chambers.

Output is similar to that of Tape 1. CONTROL WEIGHT LOSS = the "C" on the final (Xerox) data sheet.

TAPE 3: ANIMALS

Data lines are 1400 - 1999. Enter data in this order:

A = the number of animals in a subsample.

B = the number of experimental chambers.

C1,D1,C2,D2,...CB,DB where C = the number of animals starting the feeding experiment in each of the B chambers. (Does not include subsample animals.) D = the number of animals in each chamber for which final weights are obtained.

E1,E2,...EA = the wet weights of the subsample individuals of chamber 1.

F1,F2,...FA = " chamber 2.

.
.
.

thru chamber B.

G1,G2,...GA = the dry weights "

.

H1,H2,...HD1 = the final wet weights of the experimental animals from chamber 1.

.

I1,I2,...IDB = " chamber B.

J1,J2,...JD1 = the final dry "

Output is similar to that of Tapes 1 and 2.

MEAN IAW = TIAW/C; similarly for MEAN FAW.

TAPE 4: CALCULATIONS

Data lines 1200 - 1999. Enter data in this order:

A = the number of experimental chambers.

IFW1,FFW1,IFW2,FFW2,...IFWA,FFWA (from Tape 1 Output.)

C = CONTROL WEIGHT LOSS (from Tape 1 or Tape 2 Output.)

TIAW1,MEAN IAW1,TFAW1,MEAN FAW1

.

(from Tape 3 Output.)

TIAWA,MEAN IAWA,TFWA,MEAN FAWA

D = days.

E1,E2,...EA = the number of survivors from each of the A chambers.

F1,F2,...FA = the dry weight of the food scraps and fragments of each of
the A experimental chambers.

Output is 2 matrices containing the information necessary to fill in the
final (Xerox) data sheet.

TAPE

```

70 COM D[6],F[6],W[1]
71 PRINT "FEEDING EXPERIMENT ANALYSIS - TAPE 1: FOOD LEAF DISCS"
72 PRINT
73 PRINT "HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)"
74 INPUT Q
75 IF Q=1 THEN 80
76 IF Q#0 THEN 73
77 PRINT "ENTER DATA!"
78 GOTO 2000
79 PRINT
80 DIM G[6],A[6],X[40],C[6],Y[6]
83 FOR S9=1 TO 6
84 LET G[S9]=0
85 NEXT S9
90 READ A1,C1,C2
91 LET Q1=Q2=Q3=Q4=0
93 FOR X1=1 TO C1
94 READ A[X1]
95 NEXT X1
100 PRINT " ", " ", "LEAF DISCS"
110 PRINT " ", "SUBSAMPLE - INITIAL WET WEIGHTS"
120 PRINT "CHAMBER TOTAL      MEAN      SD      SE";
121 PRINT "      CV      N"
130 LET Q1=Q2=Q3=0
140 LET X9=A1
150 GOSUB 800
161 FOR S9=1 TO 6
162 LET C[S9]=G[S9]
163 NEXT S9
170 PRINT " ", "      - INITIAL DRY WEIGHTS"
180 GOSUB 800
191 FOR S9=1 TO 6
192 LET D[S9]=G[S9]
193 NEXT S9
220 LET X9=C1
226 FOR X1=1 TO X9
227 LET Y[X1]=(C[X1]-D[X1])*100/C[X1]
228 LET X[X1]=100-Y[X1]
229 NEXT X1
240 GOSUB 1110
243 FOR X1=1 TO C1
244 LET D[X1]=(D[X1]/A1)*A[X1]
246 NEXT X1
250 PRINT " ", "FOOD LEAF DISCS - FINAL DRY WEIGHTS"
255 LET Q1=1
260 GOSUB 800
271 FOR S9=1 TO 6
272 LET F[S9]=G[S9]
273 NEXT S9
280 PRINT
290 PRINT "ENTER FOLLOWING DATA LATER FOR TAPE 4:"
300 PRINT "CHAMBER","IFW","FFW (-SCRAPS)"
310 FOR X1=1 TO C1
320 PRINT X1,D[X1],F[X1]
330 NEXT X1
340 IF C2>0 THEN 390
350 PRINT "CONTROL WEIGHT LOSS = 0"
360 PRINT
370 PRINT "NO CONTROLS; DON'T USE TAPE 2 FOR THIS DATA. GO TO TAPE 3!"
380 GOTO 2000
390 PRINT
400 PRINT "GO TO TAPE 2!"

```

```

410 GOTO 2000
800 REM---INPUT SUBROUTINE
810 FOR X2=1 TO C1
820 IF Q1=0 THEN 870
830 IF Q1=1 THEN 860
840 LET X9=B[X2]
850 GOTO 870
860 LET X9=A[X2]
870 FOR X1=1 TO X9
880 READ X[X1]
890 NEXT X1
900 GOSUB 1200
910 LET G[X2]=W1
920 NEXT X2
930 RETURN
1110 REM---% WATER SUBROUTINE
1115 LET Q3=1
1120 GOSUB 1200
1130 PRINT " ", " - WET: DRY WEIGHT RELATIONSHIPS"
1140 PRINT "CHAMBER", "% WATER", "% DRY"
1145 IF Q4=0 THEN 1148
1146 LET X9=C2
1147 GOTO 1150
1148 LET X9=C1
1150 FOR X1=1 TO C2
1160 PRINT X1, Y[X1], X[X1]
1170 NEXT X1
1180 PRINT "% DRY: MEAN="; W3; "SD="; W5; "SE="; W6; "CV="; W7
1185 LET Q3=0
1190 RETURN
1200 REM--- STATISTICS SUBROUTINE
1210 LET W1=W2=0
1220 FOR X1=1 TO X9
1230 LET W1=W1+X[X1]
1240 LET W2=W2+X[X1]^2
1250 NEXT X1
1260 LET W3=W1/X9
1270 LET W4=(W2-W1^2/X9)/(X9-1)
1280 LET W5=SQR(W4)
1290 LET W6=W5/SQR(X9)
1300 LET W7=W5*100/W3
1305 IF Q3=1 THEN 1320
1310 PRINT X2; W1; W3; W5; W6; W7; X9
1320 RETURN
1399 REM--- 1400 DATA
2000 END

```

LIST 1400
 1400 DATA 5.3,0,34,30,35
 1401 DATA 45.48,32.96,40.52,34.54,29.22
 1402 DATA 40.52,37.32,33.92,39.52,27.28
 1403 DATA 44.06,40.5,49.96,36.74,35.46
 1404 DATA 9.98,7.62,9.64,8.38,7.52
 1405 DATA 10.26,8.68,8.28,9.14,6.44
 1406 DATA 11.12,10.14,10.06,9.32,10
 1407 DATA 5.72,6.72,7.5,6.88,11.83,8.75,8.17,7.38,10.24,7.19
 1408 DATA 4.27,9.74,7.55,3.18,7.34,7.86,4.6,6.46,5.28,8.5,7.5,7.7
 1409 DATA 6.38,7.89,6.01,8.59,6.98,4.39,7.69,4.91,7.29,6.48,2.52
 1410 DATA 2.34
 1411 DATA 10.54,8.21,8.3,8.18,7.38,5.62,6.25,8.11,6.4,8.7,5.37,5.47
 1412 DATA 7.57,9.33,11.92,5.98,13.72,8.54,3.42,8.89,7.16,7.4,5.68
 1413 DATA 8.88,9.1,5.98,2.58,1.26,1.42,1.46
 1414 DATA 11.18,10.8,6.07,4.98,8.3,6.22,6.62,8.63,4.49,10.02,7.77
 1415 DATA 8.83,5.83,6.88,3.98,7.2,6.97,6.54,8.92,6.12,7.98,6.69
 1416 DATA 7.88,7.91,9.3,5.03,11.54,7.08,8.46,13.8,8.49,6.76,8.28
 1417 DATA 8.42,5.54
 2000 END

READY

RUN

FEEDING EXPERIMENT ANALYSIS - TAPE 1: FOOD LEAF DISCS

HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)
 ?1

LEAF DISCS						
CHAMBER TOTAL		SUBSAMPLE - INITIAL WET WEIGHTS				
		MEAN	SD	SE	CV	N
1	182.72	36.544	6.44521	2.88239	17.6369	5
2	178.56	35.712	5.35053	2.39283	14.9824	5
3	206.72	41.344	5.87675	2.62816	14.2143	5
- INITIAL DRY WEIGHTS						
1	43.14	8.628	1.13548	.507803	13.1604	5
2	42.8	8.56	1.39762	.625037	16.3274	5
3	50.64	10.128	.643809	.28792	6.35672	5
- WET: DRY WEIGHT RELATIONSHIPS						
CHAMBER	% WATER	% DRY				
% DRY:	MEAN= 24.0254	SD= .446339	SE= .257694	CV= 1.85778		
FOOD LEAF DISCS - FINAL DRY WEIGHTS						
1	231.83	6.81853	2.06333	.353858	30.2606	34
2	208.82	6.96067	2.93179	.535269	42.1194	30
3	269.51	7.70029	2.08818	.352966	27.1182	35

ENTER FOLLOWING DATA LATER FOR TAPE 4:

CHAMBER	IFW	FFW (-SCRAPS)
1	293.352	231.83
2	256.8	208.82
3	354.48	269.51

CONTROL WEIGHT LOSS = 0

NO CONTROLS: DON'T USE TAPE 2 FOR THIS DATA. GO TO TAPE 3!

READY


```

70 COM DI[6],FI[6],W[1]
71 PRINT "FEEDING EXPERIMENT ANALYSIS - TAPE 2: CONTROL LEAF DISCS"
72 PRINT
73 PRINT "HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)"
74 INPUT Q
75 IF Q=1 THEN 80
76 IF Q#0 THEN 73
77 PRINT "ENTER DATA!"
78 GOTO 2000
79 PRINT
80 DIM L[6],X[40],G[6],M[6],N[6],O[6],Y[6]
90 FOR S9=1 TO 6
91 LET G[S9]=0
92 NEXT S9
100 READ C3,C2
110 LET Q1=Q2=Q3=0
130 PRINT " ", " ", "CONTROL LEAF DISCS"
140 LET Q4=1
150 PRINT " ", "SUBSAMPLE - INITIAL WET WEIGHTS"
160 PRINT "CHAMBER TOTAL      MEAN      SD      SE";
161 PRINT "      CV      N"
170 FOR X1=1 TO C2
180 READ L[X1]
190 NEXT X1
200 LET Q1=0
210 LET X9=C3
220 GOSUB 1000
230 FOR S9=1 TO 6
231 LET M[S9]=G[S9]
232 NEXT S9
240 PRINT " ", "      - INITIAL DRY WEIGHTS"
250 GOSUB 1000
260 FOR S9=1 TO 6
261 LET N[S9]=G[S9]
262 NEXT S9
270 FOR X1=1 TO C2
280 LET Y[X1]=(M[X1]-N[X1])*100/M[X1]
290 LET X[X1]=100-Y[X1]
300 NEXT X1
310 LET X9=C2
320 GOSUB 1100
330 PRINT " ", "EXPERIMENTAL - FINAL DRY WEIGHTS"
340 LET Q1=1
350 GOSUB 1000
360 FOR S9=1 TO 6
361 LET O[S9]=G[S9]
362 NEXT S9
370 FOR X1=1 TO C2
380 LET X[X1]=(N[X1]/C3)*L[X1]-O[X1]
390 NEXT X1
400 IF C2>1 THEN 440
410 LET W=X[X1]
420 PRINT "CONTROL WEIGHT LOSS = ";W
430 GOTO 500
440 LET Q3=1
450 LET X9=C2
460 GOSUB 1200
470 PRINT "CONTROL WEIGHT LOSS"
480 PRINT "      MEAN=";W3;"SD=";W5;"SE=";W6;"CV=";W7
490 LET W=W3
500 PRINT

```

```

510 PRINT "ENTER THE FOLLOWING DATA LATER FOR TAPE 4."
520 PRINT "CONTROL WEIGHT LOSS ="; W
530 PRINT
540 PRINT "GO TO TAPE 31"
550 GOTO 2000

1000 REM---CONTROL CHAMBER INPUT SUBROUTINE
1010 FOR X2=1 TO C2
1020 IF Q1=0 THEN 1040
1030 LET X9=L[X2]
1040 FOR X1=1 TO X9
1050 READ X[X1]
1060 NEXT X1
1070 GOSUB 1200
1080 LET G[X2]=W1
1090 NEXT X2
1100 RETURN

1110 REM---% WATER SUBROUTINE
1115 LET Q3=1
1120 GOSUB 1200
1130 PRINT " ", " - WET: DRY WEIGHT RELATIONSHIPS"
1140 PRINT "CHAMBER", "% WATER", "% DRY"
1145 IF Q4=0 THEN 1148
1146 LET X9=C2
1147 GOTO 1150
1148 LET X9=C1
1150 FOR X1=1 TO C2
1160 PRINT X1, Y[X1], X[X1]
1170 NEXT X1
1180 PRINT "% DRY: MEAN="; W3; "SD="; W5; "SE="; W6; "CV="; W7
1185 LET Q3=0
1190 RETURN

1200 REM--- STATISTICS SUBROUTINE
1210 LET W1=W2=0
1220 FOR X1=1 TO X9
1230 LET W1=W1+X[X1]
1240 LET W2=W2+X[X1]^2
1250 NEXT X1
1260 LET W3=W1/X9
1270 LET W4=(W2-W1^2/X9)/(X9-1)
1280 LET W5=SQR(W4)
1290 LET W6=W5/SQR(X9)
1300 LET W7=W5*100/W3
1305 IF Q3=1 THEN 1320
1310 PRINT X2; W1; W3; W5; W6; W7; X9
1320 RETURN

1399 REM--- 1400 DATA
2000 END

```

LIST1400

```

1400 DATA 5,2,37,36
1401 DATA 37.04,23.22,36.82,23.2,29.32,30.32,40.76,41.14,39.88,65.14
1402 DATA 9.26,7.89,9.73,5.85,7.36,8.81,9.27,9.66,17.66,6.83
1403 DATA 6.87,8.68,6.64,9.9,7.92,9.43,9.72,9.85,7.63,7.9,6.94
1404 DATA 5.12,10.37,8.95,7.29,12.46,7.2,8.43,10.46,11.37
1405 DATA 8.36,9.53,8.6,8.18,17.17,6.9,12.12,10.57,8.48,9.81,14.32
1406 DATA 10.56,11.6,9.14,9.06,6.31,10.1
1407 DATA 9.87,9.09,13.73,6.98,8.46,10.38,9.82,10.75,10.71,8.88,9.24
1408 DATA 8.22,9.09,9.2,8.97,7.64,6.68,9.62,11.42,10.14,6.94,8.94
1409 DATA 10.85,9.7,10.21,9.6,6.28,5.73,6.04,8.17,3.1,10.26,9.42
1410 DATA 6.21,9.2,9.5
2000 END

```

READY

RUN

FEEDING EXPERIMENT ANALYSIS - TAPE 2: CONTROL LEAF DISCS

HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)

? 1

```

                                CONTROL LEAF DISCS
SUBSAMPLE - INITIAL WET WEIGHTS
CHAMBER TOTAL      MEAN      SD      SE      CV      N
1      149.6      29.92      6.86864      3.07175      22.9567      5
2      217.24      43.448      12.9245      5.78001      29.747      5
- INITIAL DRY WEIGHTS
1      40.09      8.018      1.55105      .693651      19.3446      5
2      52.23      10.446      4.17716      1.86808      39.9881      5
- WET: DRY WEIGHT RELATIONSHIPS
CHAMBER      % WATER      % DRY
1      73.2019      26.7981
2      75.9575      24.0425
% DRY: MEAN= 25.4203      SD= 1.94849      SE= 1.37779      CV= 7.6651
EXPERIMENTAL - FINAL DRY WEIGHTS
1      343.94      9.29567      2.31315      .38028      24.8842      37
2      319.04      8.86222      1.94983      .324972      22.0016      36
CONTROL WEIGHT LOSS
MEAN= 4.87106      SD= 73.7441      SE= 52.1449      CV= 1513.92

```

ENTER THE FOLLOWING DATA LATER FOR TAPE 4.

CONTROL WEIGHT LOSS = 4.87106

GO TO TAPE 31

READY

```

70 COM D[6],F[6],W[1],I[6],K[6]
71 PRINT "FEEDING EXPERIMENT ANALYSIS - TAPE 3: ANIMALS"
72 PRINT
73 PRINT "HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)"
74 INPUT Q
75 IF Q=1 THEN 80
76 IF Q#0 THEN 73
77 PRINT "ENTER DATA!"
78 GOTO 2000
79 PRINT
80 DIM B[6],G[6],H[6],J[6],X[40],Y[6],P[6],Q[6]
81 DIM S[6]
82 DIM T[6]
90 FOR S9=1 TO 6
91 LET G[S9]=0
92 NEXT S9
100 LET Q1=Q2=Q3=Q4=0
120 READ C1
130 PRINT " ", " ", "ANIMALS"
140 PRINT " ", "SUBSAMPLE - INITIAL WET WEIGHTS"
150 PRINT "CHAMBER TOTAL      MEAN      SD      SE";
151 PRINT "          CV      N"
160 FOR X1=1 TO C1
170 READ T[X1],S[X1],B[X1]
180 NEXT X1
190 LET Q1=0
210 GOSUB 800
220 FOR S9=1 TO 6
221 LET H[S9]=G[S9]
222 NEXT S9
230 PRINT " ", "          - INITIAL DRY WEIGHTS"
240 GOSUB 820
250 FOR S9=1 TO 6
251 LET I[S9]=G[S9]
252 NEXT S9
259 LET X9=C1
260 FOR X1=1 TO X9
261 LET Y[X1]=(H[X1]-I[X1])*100/H[X1]
262 LET X[X1]=100-Y[X1]
263 NEXT X1
270 GOSUB 1110
280 FOR X1=1 TO C1
281 LET P[X1]=I[X1]/T[X1]
282 LET I[X1]=P[X1]*S[X1]
283 NEXT X1
300 PRINT " ", "FEEDING ANIMALS - FINAL WET WEIGHTS"
310 PRINT "CHAMBER TOTAL      MEAN      SD      SE";
311 PRINT "          CV      N"
320 LET Q1=2
330 GOSUB 800
340 FOR S9=1 TO 6
341 LET J[S9]=G[S9]
342 NEXT S9
350 PRINT " ", "          - FINAL DRY WEIGHTS"

```

```

360 GOSUB 800
370 FOR S9=1 TO 6
371 LET K[S9]=G[S9]
372 NEXT S9
375 LET X9=C1
380 FOR X1=1 TO X9
385 LET Q[X1]=K[X1]/B[X1]
390 LET Y[X1]=(J[X1]-K[X1])*100/J[X1]
400 LET X[X1]=100-Y[X1]
410 NEXT X1
420 GOSUB 1110
500 PRINT
510 PRINT "ENTER THE FOLLOWING DATA LATER FOR TAPE 4."
520 PRINT "CHAMBER","TIAW","MEAN IAW","TFAW","MEAN FAW"
530 FOR X1=1 TO C1
540 PRINT X1,I[X1],P[X1],K[X1],Q[X1]
550 NEXT X1
560 PRINT
570 PRINT "GO TO TAPE 4!"
580 GOTO 2000
800 REM---INPUT SUBROUTINE
810 FOR X2=1 TO C1
820 IF Q1=0 THEN 865
830 IF Q1=1 THEN 860
840 LET X9=B[X2]
850 GOTO 870
860 LET X9=A[X2]
862 GOTO 870
865 LET X9=T[X2]
870 FOR X1=1 TO X9
880 READ X[X1]
890 NEXT X1
900 GOSUB 1200
910 LET G[X2]=W1
920 NEXT X2
930 RETURN
1110 REM---% WATER SUBROUTINE
1115 LET Q3=1
1120 GOSUB 1200
1130 PRINT " ", " " - WET: DRY WEIGHT RELATIONSHIPS"
1140 PRINT "CHAMBER","% WATER","% DRY"
1145 IF Q4=0 THEN 1148
1146 LET X9=C2
1147 GOTO 1150
1148 LET X9=C1
1150 FOR X1=1 TO X9
1160 PRINT X1,Y[X1],X[X1]
1170 NEXT X1
1180 PRINT "% DRY: MEAN=";W3;"SD=";W5;"SE=";W6;"CV=";W7
1185 LET Q3=0
1190 RETURN
1200 REM--- STATISTICS SUBROUTINE
1210 LET W1=W2=0
1220 FOR X1=1 TO X9
1230 LET W1=W1+X[X1]
1240 LET W2=W2+X[X1]^2
1250 NEXT X1
1260 LET W3=W1/X9
1270 LET W4=(W2-W1^2/X9)/(X9-1)
1280 LET W5=SQR(W4)

```

```
1290 LET W6=W5/SQR(X9)
1300 LET W7=W5*100/W3
1305 IF Q3=1 THEN 1320
1310 PRINT X2;W1;W3;W5;W6;W7;X9
1320 RETURN
1399 REM--- 1400 DATA
2000 END
```

```

50 DIM Z[14,6],F[6]
60 PRINT "FEEDING EXPERIMENT ANALYSIS - TAPE 4: CALCULATIONS"
70 PRINT
80 PRINT "HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)"
90 INPUT Q
100 IF Q=1 THEN 150
110 IF Q#0 THEN 80
120 PRINT "ENTER DATA!"
130 GOTO 2000
140 PRINT
150 GOTO 160
160 PRINT "      THE FOLLOWING CATEGORIES ARE USED:"
170 PRINT "1  SURVIVORS = Z(1,X)"
180 PRINT "2  IFW = Z(2,X)"
190 PRINT "3  FFW = Z(3,X)"
200 PRINT "4  TFWL-C = Z(4,X)"
210 PRINT "5  TIAW = Z(5,X)"
220 PRINT "6  TFAW = Z(6,X)"
230 PRINT "7  MTAW = Z(7,X)"
240 PRINT "8  MEAN IAW = Z(8,X)"
250 PRINT "9  MEAN FAW = Z(9,X)"
260 PRINT "10 MEDIAL MEAN AW = Z(10,X)"
270 PRINT "11 GR = Z(11,X)"
280 PRINT "12 CI = Z(12,X)"
290 PRINT "13 ECI = Z(13,X)"
300 PRINT "14 DF = Z(14,X)"
310 PRINT
320 READ C1
330 FOR X1=1 TO C1
340 READ Z[2,X1],Z[3,X1]
350 NEXT X1
360 READ W
370 FOR X1=1 TO C1
380 READ Z[5,X1],Z[8,X1],Z[6,X1],Z[9,X1]
390 NEXT X1
400 READ D
410 FOR X1=1 TO C1
420 READ Z[1,X1]
430 NEXT X1
440 FOR X1=1 TO C1
450 READ F[X1]
460 NEXT X1
500 REM---CALCULATIONS
510 FOR X=1 TO C1
520 LET Z[3,X]=Z[3,X]+F[X]
530 LET Z[4,X]=Z[2,X]-Z[3,X]-W
540 LET Z[7,X]=(Z[5,X]+Z[6,X])/2
550 LET Z[10,X]=(Z[8,X]+Z[9,X])/2
560 LET Z[12,X]=Z[4,X]/(Z[7,X]*D)
570 LET Z[11,X]=(Z[9,X]-Z[8,X])/(Z[10,X]*D)
580 LET Z[13,X]=Z[11,X]/Z[12,X]
590 LET Z[14,X]=Z[7,X]/((Z[2,X]+Z[3,X])/2)*100
600 NEXT X
610 PRINT "CHAMBER",
620 IF C1>3 THEN 660
630 LET X9=C1
650 GOTO 680

```

```

660 LET X9=3
680 FOR X1=1 TO X9
690 PRINT X1,
700 NEXT X1
705 PRINT " "
710 PRINT "CATEGORY"
720 FOR Y=1 TO 14
730 PRINT Y,
740 FOR X=1 TO X9
745 PRINT Z[Y,X],
750 NEXT X
755 PRINT " "
760 NEXT Y
770 IF C1>3 THEN 790
780 GOTO 900
790 LET X9=C1
800 PRINT
810 PRINT "CHAMBER",
820 FOR X1=4 TO X9
830 PRINT X1,
840 NEXT X1
845 PRINT " "
850 PRINT "CATEGORY"
860 FOR Y=1 TO 14
865 PRINT Y,
870 FOR X=4 TO X9
880 PRINT Z[Y,X],
885 NEXT X
886 PRINT " "
890 NEXT Y
900 REM--- STATISTICS ON Z-VALUES
905 PRINT
910 PRINT "CATEGORY TOTAL      MEAN      SD      SE";
911 PRINT "      CV"
920 FOR Y=1 TO 14
930 LET W1=W2=0
940 FOR X=1 TO C1
950 LET W1=W1+Z[Y,X]
960 LET W2=W2+Z[Y,X]^2
970 NEXT X
980 LET W3=W1/C1
990 LET W4=(W2-W1^2/C1)/(C1-1)
1000 LET W5=SQR(W4)
1010 LET W6=W5/SQR(C1)
1020 LET W7=W5*100/W3
1030 PRINT Y;W1;W3;W5;W6;W7
1040 NEXT Y
1199 REM--- 1200 DATA
2000 END

```


ENTER DATA!

READY

LIST 1200

1200 DATA 3

1201 DATA 379.328, 295.69, 374.458, 295.3, 384.23, 300.1, 0

1202 DATA 29.79, 1.986, 24.559, 1.63727

1203 DATA 31.041, 2.0694, 27.569, 1.83793

1204 DATA 30.579, 2.0386, 20.764, 1.59723

1205 DATA 12

1206 DATA 15, 15, 13

1207 DATA 3.64, 2, 15, 1.9

2000 END

READY

RUN

FEEDING EXPERIMENT ANALYSIS - TAPE 4: CALCULATIONS

HAS DATA BEEN ENTERED? (RETURN 1 FOR YES, 0 FOR NO)

?1

THE FOLLOWING CATEGORIES ARE USED:

- 1 SURVIVORS = Z(1,X)
- 2 IFW = Z(2,X)
- 3 FFW = Z(3,X)
- 4 TFWL-C = Z(4,X)
- 5 TIAW = Z(5,X)
- 6 TFAW = Z(6,X)
- 7 MTAW = Z(7,X)
- 8 MEAN IAW = Z(8,X)
- 9 MEAN FAW = Z(9,X)
- 10 MEDIAL MEAN AW = Z(10,X)
- 11 GR = Z(11,X)
- 12 CI = Z(12,X)
- 13 ECI = Z(13,X)
- 14 DF = Z(14,X)

CHAMBER	1	2	3
CATEGORY			
1	15	15	13
2	379.328	374.458	384.23
3	299.33	297.45	302
4	79.998	77.008	82.23
5	29.79	31.041	30.579
6	24.559	27.569	20.764
7	27.1745	29.305	25.6715
8	1.986	2.0694	2.0386
9	1.63727	1.83793	1.59723
10	1.81164	1.95367	1.81791
11	-1.60412E-02	-9.87332E-03	-2.02324E-02
12	.245322	.218984	.26693
13	-6.53885E-02	-4.50869E-02	-7.57967E-02
14	8.0083	8.72292	7.48189

CATEGORY	TOTAL	MEAN	SD	SE	CV
1	43	14.3333	1.15469	.666662	8.05599
2	1138.02	379.339	4.88301	2.8192	1.28724
3	898.78	299.593	2.29129	1.32288	.764799
4	239.236	79.7453	2.62016	1.51275	3.28566
5	91.41	30.47	.632571	.365215	2.07605
6	72.892	24.2973	3.41006	1.9688	14.0347
7	82.151	27.3837	1.82579	1.05412	6.66743
8	6.094	2.03133	4.21735E-02	2.43489E-02	2.07615
9	5.07243	1.69081	.128969	7.44604E-02	7.62765
10	5.58322	1.86107	8.02387E-02	4.63259E-02	4.31143
11	-4.61470E-02	-1.53823E-02	5.21089E-03	3.00851E-03	
-33.8758					
12	.731236	.243745	2.40113E-02	1.38629E-02	9.85096
13	-.186272	-6.20907E-02	1.56183E-02	9.01721E-03	-25.1539
14	24.2131	8.07104	.622885	.359623	7.71753

READY

```

9001 REM ***** PROGRAM CURFIT *****
9002 REM
9003 REM ***** DESCRIPTION *****
9004 REM
9005 REM     THIS PROGRAM PERFORMS A LEAST-SQUARES CURVE FIT TO
9006 REM     THE FOLLOWING FUNCTIONS:
9007 REM         1.  $Y=A+B(X)$ 
9008 REM         2.  $Y=A \exp(B \cdot X)$ 
9009 REM         3.  $Y=A \cdot (X \cdot B)$ 
9011 REM         4.  $Y=A+B/X$ 
9014 REM         5.  $Y=1/(A+B \cdot X)$ 
9017 REM         6.  $Y=X/(A+B \cdot X)$ 
9018 REM
9019 REM ***** INSTRUCTIONS *****
9020 REM
9021 REM     BEFORE RUNNING THE PROGRAM, ENTER THE FOLLOWING
9022 REM     DATA BEGINNING IN LINE 9900:
9023 REM
9024 REM         9900 DATA N
9025 REM         9901 DATA X1,Y1,X2,Y2,.....
9026 REM         .
9027 REM         .
9028 REM         99-- DATA ...XN,YN
9029 REM
9030 REM     WHERE: N=NUMBER OF DATA PAIRS
9031 REM           XN,YN = THE N-TH DATA PAIR; XN IS THE INDEPENDENT
9032 REM     VARIABLE AND YN IS THE DEPENDENT VARIABLE.
9033 REM
9034 REM     THE PROGRAM PRINTS SUMMARY DATA FOR THE CURVE FITS
9035 REM     FOR THE SIX FUNCTIONS AND REQUESTS THE USER TO INDICATE
9036 REM     WHICH FUNCTION HE WISHES DETAILED INFORMATION ABOUT
9037 REM     (INPUT 0,1,2,3,4,5 OR 6). A ZERO TERMINATES THE PROGRAM.
9038 REM
9039 REM     SUMMARY DATA INCLUDES SIMPLE CORRELATION COEFFICIENT,
9040 REM     INTERCEPT, REGRESSION COEFFICIENT AND STANDARD ERROR
9041 REM     OF THE REGRESSION COEFFICIENT.
9042 REM
9043 REM ***** RESTRICTIONS *****
9044 REM
9045 REM     IF THERE ARE MORE THAN 14 DATA PAIRS, CHANGE THE
9046 REM     DIMENSION STATEMENT OF VARIABLES X,Y,U,V, IN STATEMENT
9047 REM     9003 TO THIS NUMBER; THE HP BASIC SYSTEM MUST HAVE MORE
9048 REM     THAN 8K OF CORE MEMORY TO ACCOMMODATE MORE THAN 14 DATA
9049 REM     PAIRS IN THIS PROGRAM.
9050 REM
9051 REM ***** STATISTICAL REFERENCE *****
9052 REM
9053 REM     SOKAL, R. R. AND J. F. ROHLF 1969. BIOMETRY. W. H.
9054 REM     FREEMAN, SAN FRANCISCO. PP.775
9055 REM
9056 REM     NOTE: THIS COMMENT WILL NOT BE STORED DUE TO LACK OF ROOM
9057 REM     BUT WILL BE DESTROYED ON READ IN.
9058 REM
9059 REM

```

JUNE, 1972

RCP

```

9003 DIM X[14],Y[14],U[14],V[14],A[6],B[6],C[6],E[6],F[6],S[6]
9004 MAT F=CON
9005 READ N
9006 PRINT
9007 FOR I=1 TO N
9008 READ X[I],Y[I]
9009 NEXT I
9011 PRINT
9014 PRINT "CURVE TYPE","CORR. COEFF.", " A"," B","STD.ERR."
9017 FOR I=1 TO 6
9018 MAT S=ZER
9019 GOSUB 9120
9020 IF (I-5)*(I-6)=0 THEN 9035
9021 IF (I-2)*(I-3)=0 THEN 9028
9022 FOR J=1 TO N
9023 LET V[J]=Y[J]
9024 GOSUB 9098
9025 NEXT J
9026 IF I=1 THEN 9045
9027 GOTO 9056
9028 FOR J=1 TO N
9029 IF Y[J] <= 0 THEN 9042
9030 LET V[J]=LOG(Y[J])
9031 GOSUB 9098
9032 NEXT J
9033 IF I=3 THEN 9050
9034 GOTO 9045
9035 FOR J=1 TO N
9036 IF Y[J]=0 THEN 9042
9037 LET V[J]=1/Y[J]
9038 GOSUB 9098
9039 NEXT J
9040 IF I=6 THEN 9056
9041 GOTO 9045
9042 PRINT "CAN'T FIT"
9043 LET F[I]=0
9044 GOTO 9063
9045 FOR J=1 TO N
9046 LET U[J]=X[J]
9047 GOSUB 9101
9048 NEXT J
9049 GOTO 9061
9050 FOR J=1 TO N
9051 IF X[J]=0 THEN 9042
9052 LET U[J]=LOG(U[J])
9053 GOSUB 9101
9054 NEXT J
9055 GOTO 9061
9056 FOR J=1 TO N
9057 IF X[J]=0 THEN 9042
9058 LET U[J]=1/X[J]
9059 GOSUB 9101
9060 NEXT J

```

```

9061 GOSUB 9161
9062 PRINT C[I],A[I],B[I],E[I]
9063 NEXT I
9064 GOSUB 9105
9065 PRINT
9066 PRINT "DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)"
9069 INPUT I
9070 IF I=0 THEN 9999
9071 LET K=I
9072 IF F[I]=1 THEN 9076
9073 GOSUB 9120
9074 PRINT "COULD NOT BE FIT"
9075 GOTO 9065
9076 GOSUB 9138
9077 IF (I-1)*(I-5)*(I-6)#0 THEN 9087
9078 FOR J=1 TO N
9079 LET Y=A[I]+B[I]*X[J]
9080 IF I=1 THEN 9084
9081 LET Y=1/Y
9082 IF I=5 THEN 9084
9083 LET Y=X[J]*Y
9084 GOSUB 9177
9085 NEXT J
9086 GOTO 9065
9087 FOR J=1 TO N
9088 IF I=2 THEN 9094
9089 IF I=3 THEN 9092
9090 LET Y=A[4]+B[4]/X[J]
9091 GOTO 9095
9092 LET Y=A[3]*(X[J]+B[3])
9093 GOTO 9095
9094 LET Y=A[2]*EXP(B[2]*X[J])
9095 GOSUB 9177
9096 NEXT J
9097 GOTO 9065
9098 LET S[5]=S[5]+V[J]+2
9099 LET S[3]=S[3]+V[J]
9100 RETURN
9101 LET S[1]=S[1]+U[J]
9102 LET S[2]=S[2]+U[J]+2
9103 LET S[4]=S[4]+U[J]*V[J]
9104 RETURN
9105 FOR I=1 TO N-1
9106 LET M=I
9107 FOR J=I+1 TO N
9108 IF X[M] <= X[J] THEN 9110
9109 LET M=J
9110 NEXT J
9111 IF N=I THEN 9118
9112 LET P=X[M]
9113 LET Q=Y[M]
9114 LET X[M]=X[I]
9115 LET Y[M]=Y[I]
9116 LET X[I]=P
9117 LET Y[I]=Q
9118 NEXT I
9119 RETURN
9120 LET K=I

```

```

9121 IF K=1 THEN 9136
9122 IF K=2 THEN 9134
9123 IF K=3 THEN 9132
9124 IF K=4 THEN 9130
9125 IF K=5 THEN 9128
9126 PRINT "6. Y=X/(A+B*X) ";
9127 RETURN
9128 PRINT "5. Y=1/(A+B*X) ";
9129 RETURN
9130 PRINT "4. Y=A+(B/X)";
9131 RETURN
9132 PRINT "3. Y=A*(X+B)";
9133 RETURN
9134 PRINT "2. Y=A*EXP(B*X)";
9135 RETURN
9136 PRINT "1. Y=A+(B*X)";
9137 RETURN
9138 PRINT " ";
9139 GOSUB 9121
9140 PRINT " IS A";
9141 IF K=1 THEN 9146
9142 IF K=2 THEN 9148
9143 IF K=3 THEN 9150
9144 PRINT "HYPERBOLIC";
9145 GOTO 9151
9146 PRINT " LINEAR";
9147 GOTO 9151
9148 PRINT "N EXPONENTIAL";
9149 GOTO 9151
9150 PRINT " POWER";
9151 PRINT " FUNCTION. THE RESULTS"
9152 IF K=1 THEN 9154
9153 PRINT " OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM"
9154 PRINT " (SORTED IN ORDER OF ASCENDING VALUES OF X)"
9155 PRINT " ARE AS FOLLOWS"
9156 PRINT
9157 PRINT "X-ACTUAL", "Y-ACTUAL", "Y-CALC", "PCT DIFFER"
9158 PRINT
9159 RETURN
9160 PRINT
9161 LET B=(N*S[4]-S[1]*S[3])/(N*S[2]-(S[1]^2))
9162 LET A=(S[3]-B*S[1])/N
9163 LET C[1]=(B+2)*(S[2]-(S[1]^2)/N)/(S[5]-(S[3]^2)/N)
9164 IF (I-1)*(I-4)*(I-5)=0 THEN 9173
9165 IF (I-2)*(I-3)=0 THEN 9171
9166 GOSUB 9190
9167 LET E[6]=E[1]
9168 LET A[6]=B
9169 LET B[6]=A
9170 RETURN
9171 LET A[1]=EXP(A)
9172 GOTO 9174
9173 LET A[1]=A
9174 LET B[1]=B
9175 GOSUB 9190
9176 RETURN
9177 LET D=Y[J]-Y

```

```

9178 LET D=.1*SGN(D)*INT(1000*ABS(D/Y))
9184 PRINT X[J],Y[J],Y,D
9185 RETURN
9190 LET E1=S[5]-(S[3]*2)/N
9191 LET E2=(S[4]-S[1]*S[3]/N)+2
9192 LET E3=S[2]-(S[1]*2)/N
9193 LET E[1]=SQR((E1-E2/E3)/((N-2)*E3))
9194 RETURN
9900 DATA 5
9901 DATA 1,2,3,4,5,6,7,8,9,10
9999 END

```

READY

SAMPLE OUTPUT FROM ABOVE DATA

CURVE TYPE	CORR. COEFF.	A	B	STD. ERR.
1. $Y=A+(B*X)$	1	1	1	0
2. $Y=A*EXP(B*X)$	.947322	1.9594	.195601	2.66301E-02
3. $Y=A*(X+B)$	.993986	1.91961	.728722	3.27268E-02
4. $Y=A+(B/X)$	.710861	8.58203	-7.22327	2.65971
5. $Y=1/(A+B*X)$	.81316	.459583	-4.62500E-02	1.27996E-02
6. $Y=X/(A+B*X)$	.98394	.435862	7.25298E-02	3.21493E-02

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

?1

1. $Y=A+(B*X)$ IS A LINEAR FUNCTION. THE RESULTS
(SORTED IN ORDER OF ASCENDING VALUES OF X)
ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	2	0
3	4	4	0
5	6	6	0
7	8	8	0
9	10	10	0

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

?2

2. $Y=A*EXP(B*X)$ IS AN EXPONENTIAL FUNCTION. THE RESULTS OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM (SORTED IN ORDER OF ASCENDING VALUES OF X) ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	2.38272	-16
3	4	3.52346	13.5
5	6	5.21034	15.1
7	8	7.70483	3.8
9	10	11.3936	-12.2

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

?3

3. $Y=A*(X+B)$ IS A POWER FUNCTION. THE RESULTS OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM (SORTED IN ORDER OF ASCENDING VALUES OF X) ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	1.91961	4.1
3	4	4.27467	-6.4
5	6	6.20253	-3.2
7	8	7.92602	.9
9	10	9.51901	5

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

?4

4. $Y=A+(B/X)$ IS A HYPERBOLIC FUNCTION. THE RESULTS OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM (SORTED IN ORDER OF ASCENDING VALUES OF X) ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	1.35876	47.1
3	4	6.17428	-35.2
5	6	7.13738	-15.9
7	8	7.55014	5.9
9	10	7.77945	28.5

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

?5

5. $Y=1/(A+B*X)$ IS A HYPERBOLIC FUNCTION. THE RESULTS OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM (SORTED IN ORDER OF ASCENDING VALUES OF X) ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	2.41935	-17.3
3	4	3.11688	28.3
5	6	4.37956	37
7	8	7.36196	8.6
9	10	23.0769	-56.6

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

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6. $Y=X/(A+B*X)$ IS A HYPERBOLIC FUNCTION. THE RESULTS
OF A LEAST-SQUARES FIT OF ITS LINEAR TRANSFORM
(SORTED IN ORDER OF ASCENDING VALUES OF X)
ARE AS FOLLOWS

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	2	1.96698	1.6
3	4	4.591	-12.8
5	6	6.26165	-4.1
7	8	7.41862	7.8
9	10	8.26727	20.9

DETAILS FOR CURVE (1 TO 6, 0 TO END PROGRAM.)

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