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ESTIMATION OF STANDING CROPS AND RATES OF FEEDING FISH IN PONDS

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CONTENTS

Abstract

Rate of daily feeding is calculated either as a percentage of the total weight of the standing crop or on the basis of the daily increase in total weight of the standing crop. Both methods are subject to two sources of error. The first is the possible error in estimating the average weight of the population and the second is the error in estimating the number of individuals in a population at any one time, on the basis of seining samples.

Estimates of standing crops may be made from the total amount of daily feed, added to any one point, from the equation:

$$W = IR^N, \text{ where}$$

I = initial weight of fish,
R = the rate of change in weight during interval T, and
N = number of intervals "T" at which the daily feeding is readjusted.

For estimation of the rate of change in weight "R", it is necessary to know the pond conversion value "S" for the feed used at the rate it is being fed:

$$R_T = 1 + \frac{DP}{S}, \text{ where}$$

D = number of days feed is added during interval T,
T = intervals at which feeding rate is readjusted,
P = daily feeding rates from 0.02 to 0.05, (2 percent to 5 percent of body weight),
S = pond conversion value at P and T for a particular feed and for a particular species of fish.

ESTIMATION PONDERALE DU STOCK ET DE LA RATION ALIMENTAIRE DES POISSONS EN ETANG

Resume

La quantité d'aliments fournie journellement est calculée soit en pourcentage du poids total du stock présent, soit sur la base de l'accroissement journalier du poids total de ce stock. Les deux méthodes peuvent être entachée d erreurs au départ: erreur dans l'estimation numérique du stock à un moment donné.

Une estimation pondérale du stock peut être faite à partir du poids total de la ration alimentaire quotidienne sommée jusqu'au moment consideré à l aide de l'equation suivante:

$$W = IR^N \text{ ou}$$

I = poids initial du poisson

R = le taux d'accroissement en poids au cours de l'intervalle T, et

N = le nombre d'intervalles "T" où la ration quotidienne a été modifiée

Pour estimer le taux d'accroissement de poids "R", il faut connaître le taux de conversion "S" applicable a l'etang en fonction des aliments fournis et de la quantité distribuée:

$$R_T = 1 + \frac{DP}{S} \text{ ou}$$

D= le nombre de jours durant lesquels une ration alimentaire est fournie pendant l'intervalle T

T= les intervalles auxquels la ration alimentaire est modifiée

P = le taux d'alimentation quotidien allant de 0,02 a 0,05 (2 a 5 pour cent du poids corporel

S = le taux de conversion de l'etang en fonction de P et T, pour un aliment déterminé et une espèce donnée de poisson

ESTIMACIÓN DE LOS RECURSOS POTENCIALES EXISTENTES Y TASAS DE ALIMENTACIÓN DE LOS PECES EN LOS ESTANQUES

Extracto

La proporción de alimentación diaria se calcula, sea como porcentaje del peso total de los efectivos existentes de la poblacion, sea sobre la base del incremento diario del peso total de dichos efectivos. Ambos métodos estan sujetos a dos causas de error. El primero es el posible error en la estimacion del peso medio de la población, y el segundo es el que procede de la estimacion del numero de individuos en una población en un momento cualquiera sobre la base de muestras obtenidas mediante redes de cerco. La estimacion del efectivo en organismos puede realizarse partiendo de la cantidad total de alimento añadida en cualquier punto, de la ecuación:

$$W = IR^N \text{, en la que}$$

I = peso inicial del pez,

R = cambio en peso durante el intervalo T, y

N = numero de intervalos "T" a los cuales ha sido reajustada la alimentación diaria,

Para la estimación de la tasa de cambio en peso "R", es necesario conocer el valor "S" de conversión en el estanque para el alimento utilizado en la proporción en que se suministro:

$$R_T = 1 + \frac{DP}{S} \text{, en la que}$$

D = numero de dias en que se ha añadido alimentos durante el intervalo T,

T = intervalos a los que se ha reajustado la proporcion de alimentación,

P = tasas diarias de alimentacion de 0, 02 a 0,05 (2% a 5%) del peso corporal,

S = valor de conversión del estanque para P y T y para un alimento determinato y una especie determinada de pez.

III/E-10

1 SOURCES OF ERRORS IN COMPUTATION OF STANDING CROPS AND RATES OF FEEDING

The successful fish culturist must supply feed to his fish at daily rates that allow efficient food utilization. In American and European fish cultures, amounts to be fed daily are calculated upon the basis of a certain percentage of the body weight of all fish in the pond (the standing crop). The percentage rate used varies with temperature and size of the fish being fed; the amount fed is readjusted weekly, bi-weekly, or monthly as the crop increases in total weight and average size.

In Israel, Tal (1956) recommended bi-weekly seining to determine the average daily growth of the common carp (*Cyprinus carpio*). The average daily increase during the past two-week period expressed as gain in kilos per hectare per day is then multiplied by a factor to give the amount of feed to be given the fish daily during the next two-week period. The factors recommended increase with increasing average size of the carp.

Both methods rely upon estimates of average size of fish made from seining samples and the results are multiplied by the number of fish estimated to be present per hectare, in one case to estimate the weight of the standing crop and in the other to estimate gain per hectare per day.

The estimates are thus open to two main sources of error. First, the average weight of fish taken in the seine may not represent the true average weight within the population at that time. In experiments at Auburn, it was found necessary with the channel catfish (*Ictalurus punctatus*) to weigh a sample of not less than 100 fish from ponds ranging from 0.5 to 10 ha to obtain a relatively accurate average. Despite such care, average weights of fish taken by seining have occasionally varied as much as eight to 19 percent from the average found by draining and weighing all fish a few days later. With *Tilapia mossambica* or *T. aurea*, samples of 300 or more fish were necessary for accurate estimates. Seining samples taken at times of day when fish were not being fed often appeared to underestimate the average size. It seemed probable that smaller fish remain in the shallow water and were thus more vulnerable to seining. Seining shortly after feeding often gives abnormally high weights for larger fish due to their habit of cramming their stomachs with more than their share of feed. Corrections can be made for this by using average weights of fish of the same lengths in the calculations.

The second source of error in estimating feed required is that the fish culturist seldom knows accurately the number of fish per hectare. He usually knows the number stocked and may know the average mortality at draining. He thus may use the number stocked or the average survival in his calculations. Use of either often leads to serious errors in calculations of the feed to be given daily. With the scaled variety of common carp, at this Station survivals normally varied from 97 to 100 percent per year and here use of the number stocked caused no serious error provided the pond was protected to prevent loss of carp during heavy outflows of water. The mirror variety of common carp has given survivals from 80 to 90 percent per year, whereas tilapias had survivals from 65 to 90 percent. In these cases estimates of the fish present may be quite inaccurate.

2 USE OF AMOUNT OF FEED SUPPLIED FOR ESTIMATES OF STANDING CROPS

2.1 Calculation of pond conversion value "S"

The need for additional and better methods of estimating the standing crop of fish is quite evident. Where a standard feed is used and where conversion rates for this feed are known for a particular species and for various rates of feeding, it appeared that this information could be used to give an estimate of standing crop by adding the expected gain from the feed to the weight of fish stocked. Since the feed and wastes directly or indirectly from feeding will produce additional fish-food organisms, it is better to use the pond conversion value (S) which is calculated:

$$S = \frac{\text{kg feed added}}{\text{net kg fish produced}}$$

2.2 Sizes of tilapia and efficient rates of feeding

For Java tilapia, *Tilapia mossambica*, Nile tilapia, *T. aurea*, and Congo tilapia, *T. melanopleura*, with Auburn No. 2 pelleted feed1/ during periods when the water temperatures remained above 22°C (70°F), "S" conversions varied from 0.7 to 1.2 with an average of 1.0 when fed at the rate given below for various sizes of fish:

Average total length		Rate daily
cm	in	Percent of body weight
2.4 - 12.0	1 - 5	5
12.0 - 24.0	5 -10	3

2.3 Sizes of catfish and efficient rates of feeding

In experiments with both white catfish (*Ictalurus catus*) and channel catfish, "S" conversion values for the Auburn No. 2 pelleted feed, when water temperatures were above 16°C, varied from 1.5 to 2.0 with an average of 1.7 when the daily feeding rate for various sizes of fish were:

Average total length		Daily rate of feeding
cm	in	Percent of body weight
2.4 - 12	1 - 5	5
12.0 - 15.6	5 - 6.5	4
15.6 - 24.0	6.5 - 10	3
24.0 - 28.5	10 - 12	2.5
31.2 plus	13 plus	1.5

2.3.1 Variations in "S" values

Results indicated that use of a standard pond conversion value of 1.7 for both channel catfish and white catfish estimated final production satisfactorily, but underestimated the standing crops during spring and summer. This evidently was because natural fish-food organisms furnished a material part of the feed until a weight of approximately 1,000 kilos fish per hectare was reached. Examination of the data indicated that natural feeds were causing growth during summer period of approximately 2 kg/ha of fish per day. In effect, the "S" pond conversion then becomes a constantly increasing value during this period of growth. The average calculated "S" values for gradually increasing total cumulative feed, using average seining values for standing crops were as follows:

Cumulative feed added, kg	Conversion S
100	0.5
200	0.7
400	0.8
800	1.1
1000	1.2
1200	1.3
1500	1.5
1700	1.7

1/ Pelleted dry feed containing 46 percent protein, 25 percent carbohydrates and 5 percent fat (Prather, 1958).

2.3.2. Estimation of the standing crop from feeding records, seining and from draining

Following are comparisons of standing crop estimates in kg/ha made from seining records, by dividing total cumulative feed by the appropriate S conversion, and that found upon draining.

By seining	From feed	Upon draining
235	253	
433	578	
692	690	
-	1170	1303
183	249	
366	378	
501	708	
-	1204	1185
231	370	
363	560	
783	892	
1495	1251	1255
251	320	
531	480	
847	892	
1288	1252	1193
876	835	
764	1020	
1995	1761	
-	3165	3544

While disagreements in estimates of standing crop occurred, that calculated from feed supplied appeared as accurate as that from seining records.

In other experiments in these ponds without feeding or fertilization, the standing crop has averaged 97 kg/ha at the end of 210 days. If this correction is applied, the final S conversion would be changed by approximately 0.1 - from 1.7 to 1.8. The same correction cannot be applied to the S conversion for standing crops from 200 to 700 kg and would not help in estimating these standing crops.

2.4 Equation for estimation of standing crop from feed supplied

From these data it would appear that relatively reliable estimates of the standing crop or yield may be made from the equation:

(1) Standing crop = I plus $\frac{F}{"S"}$

where I = initial weight of fish stocked

F = weight of feed added

S = pond conversion value for cumulative amount of feed added and for the species of fish stocked.

For example channel catfish, where I = 50 kg; F = 2210 kg Auburn No. 2 pelleted feed; and S = 1.7, with the range 1.5 - 2.0.

Standing crop = 50 plus $\frac{2210}{1.7}$ = 1350 kg

but varying from 50 plus $\frac{2210}{1.5}$ = 1523 kg

to 50 plus $\frac{2210}{2.0}$ = 1155 kg

Calculations of standing crops from the feed should be useful in checking the accuracy of estimates from seining. It is evident that both are subject to certain inaccuracies, but from different sources.

2.5 Equations relating to expected weight of fish

From the foregoing results, it also appeared possible to devise equations relating feed supplied to the standing crop of fish to be expected after a certain period of feeding, as follows:

(2) $R_T = 1 + \frac{DP}{S}$ = Rate of change in weight during interval T

when D = number of days on which feed is added during interval T;

T = equal intervals at which feeding rate is readjusted (e.g. 1-week, 2-week, and 4-week intervals.);

P = daily feeding rates from 0.02 to 0.05 (2 percent to 5 percent rates); and

S = pond conversion values at P and T for a particular feed and for a particular species of fish.

Example: Where T = 4 weeks, D = 24 when feeding is 6 days weekly, then, for the channel catfish where P = 0.03 and S = 1.6, $R = 1.0 + \frac{(24)(0.03)}{1.6} = 1.45$

The general forms of the equations are:

(3) $W = I\left(1.0 \text{ plus } \frac{DP}{S}\right)^N = IR^N$; or $\log W = \log I \text{ plus } N \log R$

where W = total weight of the standing crop at end of N intervals of feeding;

N = number of T intervals during which fish have been fed at rate "P";

I = initial weight of fish, then

Number of "T" intervals of feeding required to reach a certain weight are:

(4) $N = \frac{\log W - \log I}{\log R}$, and

Initial weight required to reach a specified total weight is:

(5) $\log I = \log W - N \log R$.

The above equations are useful in planning methods of management and in understanding the factors affecting production.

2.5.1 Limits of feeding within which the equations apply.

Range of use is limited by the maximum safe rates of feeding/hectare/day, which, when using Auburn No. 2 pelleted feed with the following species are:

Channel catfish - - - - 39 kg; 34 kg in mid-summer

White catfish - - - - - 39 kg; 34 kg in mid-summer

Java and Nile tilapia - 55 kg

Congo tilapia - - - - - 38 kg.

In addition, feeding must be at water temperatures above 16°C.

Since the above are limitations in the usefulness of equations (3), (4), and (5) it is evident that for channel catfish fed at the three percent rate, we can calculate as follows the maximum W for which the equation holds.

$3\% = 39$ kg

$100\% = \frac{100}{3} \times 39 = 1{,}300$ kg/ha

2.5.2 Examples of calculations

Where 40 kg of channel catfish are stocked and fed Auburn No. 2 pellets six days weekly, with feeding readjustments to three percent of weight of standing crop weekly for a period of 30 weeks, then

$I = 40$, $D = 6$, $T = 1$ week, $N = 30$ T., $P = 0.03$, and $S = 1.7$;

and, $R = 1.0 + \frac{(6)\ (0.03)}{1.7} = 1.106$, Equation (2);

then, $\log W = \log 40 + 30 \log 1.106$, Equation (3);

$\log W = 2.91486$

$W = 821$ kg

If W exceeds 1,300 kg/ha, it is necessary first to calculate the weeks of feeding required to reach 1,300 kg using equation (4),

$N = \frac{\log W - \log I}{\log R} = \frac{\log 1{,}300 - \log 40}{\log 1.106} = 35$ "T" intervals - 35 weeks

If we are attempting to produce 2,000 kg of catfish, the remainder of the time we cannot feed more than 39 kg of feed per day. If we feed six days per week, the increase in weight of catfish per week is:

$\frac{39 \times 6}{1.7} = 137$ kg

Then the added weeks needed to increase from 1,300 kg to 2,000 kg $= \frac{700}{137} = 5.1$ weeks.

The total time required is then 35 + 5.1 = 40.1 weeks. If we wish to reduce this time, we must start with a higher weight of fish: that is, either more fish of the same average size, or the same numbers of fish of larger size.

2.5.3 Calculation of feed required for maintenance

If we use a much larger initial weight of fish, another factor must be considered. The feeding rate with Auburn No. 2 pellets required to maintain weight of fish without growth is approximately 0.5 percent of their weight per day six days per week. If we start with 50 kg of fish in one case and 200 kg in another and continue feeding (six days weekly) for a 30-week period, the feed required for maintenance of this original weight for the former is:

$$50 \times 0.005 \times 30 \times 6 = 45 \text{ kg},$$

and for the latter:

$$200 \times 0.005 \times 30 \times 6 = 180 \text{ kg}.$$

The daily difference in maintenance requirements is first met and only the remainder of the feed is available for growth.

Where small fish (less than 15 cm) are grown to large size, usually no correction is needed in the equations given. However, a correction is necessary when high weights or large fish are fed for a short period of time. Equation (1) then becomes:

$$\text{Standing crop} = I \text{ plus } \frac{F-M}{S}, \text{ when}$$

I = initial weight of fish stocked,

F = total weight of feed supplied, and

M = I x 0.5% x number of days fish were fed.

In equation (2) the correction can be made by subtracting 0.5 percent from the percentage of daily feeding, P.

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