A C T A İ C H T H Y O L O G I C A E T P I S C A T O R I A
Vol. II, 1 1972

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Physiology

METHOD FOR APPLICATION OF PHYSICAL EFFORT TO FISH

METODA OBCIĄŻANIA RYB OGÓLNYM WYSIŁKIEM FIZYCZNYM

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A method was elaborated for application of physical effort to fish and for calculation of fish performance ability in physical units (kGm).

The changes appearing in fish organism under dynamic effort represent particularly interesting problem in aspect of its adaptability to variations of environment (temperature, salinity, contamination etc.).

The existing methods permitted an observation or registration of motions frequency and locomotive velocity of hydrofauna (J o n e s, 1955; K a s i m o v, 1961; K l e e r k o p e r, et al. 1961; S p e n c e r, 1939; S p e e r, 1941; S a b u r e n k o v et al. 1967).

To obtain more exact quantitative measurements, a method was elaborated for application of physical effort to fish with possibility of calculating the obtained results in work units kGm.

Owing to reflexogenous reaction, a fish will move into deeper waters in case of any danger or when its liberty of motion may be hindered. Exploiting such reaction known in majority of fish, a device was applied to coerce the fishes to dynamic effort under aquarium conditions.

By this method, a ball float of determined force of buoyancy is fitted to base of dorsal fin approximately at centre of fish gravity. Basing on locomotive velocity, the effort of fish required to equalize buoyancy force of float (F_w) in determined time, was calculated in physical units (kGm).

Specific weight of fish, owing to reflexive regulation of gas pressure within the air-bladder, corresponds approximately to specific weight of environment for determined depth at which the fish remains. A float fitted to dorsal fin represents additional force acting vertically upwards. A fish resisting the force which is pulling it upwards to surface, is coerced to intensive work which is proportional to buoyancy force of float. It ascertained experimentally that, the fishes such as Rutilus rutilus (L.), Abramis brama (L.), Perca fluviatilis L., Tinca tinca (L.), Anguilla anguilla (L.), equibalanced buoyancy force of float by continous swimming in horizontal plane, in diagonal position, or down-headed under angle of $20^{\circ} \pm 3^{\circ}$ to water surface and their swimming speed amounted approximately to 0.125 ± 0.015 m/sec. In tests performed on 5 mentioned species ascertained that, about 90% of swim-

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ming time with attached float prevailed on locomotive motion in vertical plane. Fish motions in other planes were rather sporadic (particularly at beginning of test) and therefore are considered as admissible errors in calculations.

Friction force of floats at speed of 0.125 ± 0.015 m/sec., calculated according to Stokes formula, did not exceed on average 2% of floats buoyancy force; this permits to consider friction force as non essential in further calculations. To calculate buoyancy force of float, following formula was applied:

1) $$F_w = g\, V(d_c - d_p)$$

where: F_w - buoyancy force of float (N)
g - accelleration of gravity (m/sec.^{2})
V - volume of float (m^3)
d_c - density of water (kg/m^3)
d_p - density of float (kg/m^3).

1a) $$\text{m/sec.}^2\ \text{m}^3\ \text{kg/m}^3 / = \text{m/kg/sec}^2 / = (\text{N})$$

1b) $$F_w\,(\text{kG}) = \frac{1}{g} F_w\,(\text{N})$$

Graphic distribution of forces (simplified) acting on fish swimming in plane **parallel to surface with fitted float of buoyancy force F_w is presented in fig. 1.**

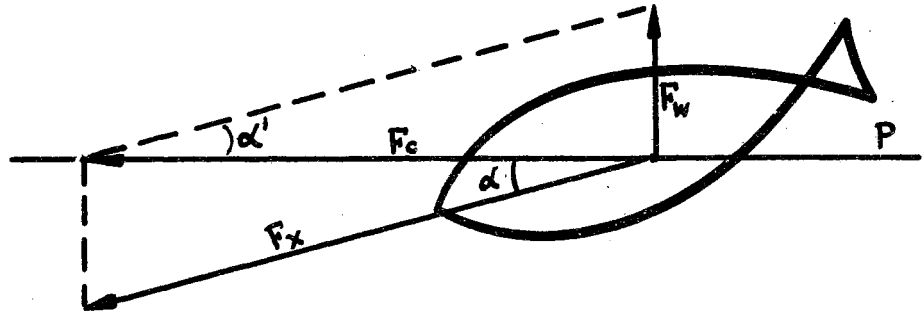

Fig. 1. Graphic distribution of forces (simplified) acting on fish swimming in plane parallel to surface with fitted float of buoyancy force F_w

It is apparent from fig. 1 that, the force F_c may be expressed by formula:

2) $$F_c = F_w \operatorname{ctg} \alpha$$

fish travel is defined by formula:

3) $$S = v\, t$$

where: s - fish travel (m)
v - fish speed (m/sec.)
t - swimming time (sec.).

The work performed by fish may be expressed as:

4) $$L = F_c s, \text{ what}$$

after substitution of value F_c from formula 2) gives final formula for fish work which swims with float of determined force of buoyancy, giving:

5) $$L = F_w s \operatorname{ctg}\alpha (kGm)$$

where: L - work of fish (kGm)
F_w - buoyancy force of float (kG)
s - travel of fish (m)
$\operatorname{ctg}\alpha$ - angle between longitudinal axis of fish and plane of water surface.

Thus, dynamic work performed by fish was calculated from product of float buoyancy force, of travel and of angle comprised by water surface and longitudinal axis of fish. Elaborated method permits for control of fish dynamic effort under determined conditions of environment. Qualification of physical effort in units of work may be applicable as basic method for study of metabolic changes in aspect of fish adaptability. Initial studies on biological tests framed within the investigations of environments contaminated with toxic substances, also prove the usability of this method.

ACKNOWLEDGEMENT

Authors are expressing deepest appreciations and thanks to dr Jan Budziński, the Adiunct of Physics Team from Institute of Agriculture Mechanisation of Agriculture Academy Szczecin, for His kind consultations in elaborating the formulas applied in this work.

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METODA OBCIĄŻANIA RYB OGÓLNYM WYSIŁKIEM FIZYCZNYM

S t r e s z c z e n i e

Opracowano metodę obciążania ryb ogólnym wysiłkiem fizycznym w warunkach akwaryjnych.

Metoda polega na umocowaniu do płetwy grzbietowej pływaka o określonej sile wyporu. Pracę fizyczną wykonaną przez ryby obliczano z iloczynu siły wyporu pływaka, przebytej drogi oraz ctg kąta zawartego pomiędzy powierzchnią wody a osią podłużną ciała ryby.

Opracowana metoda pozwala na sterowanie dynamicznym wysiłkiem ryb jak również może być zastosowana przy badaniu zmian metabolicznych w aspekcie zdolności adaptacyjnych.

ВИДОВЫЕ СПОСОБНОСТИ РЫБ К ДИНАМИЧЕСКОМУ ФИЗИЧЕСКОМУ УСИЛИЮ ABRAMIS BRAMA (L.), RUTILUS RUTILUS (L.), PERCA FLUVIATILIS L. ANGUILLA ANGUILLA (L.)

Р е з ю м е

Проведены сравнительные определения способности к динамическому физическому усилию четырёх видов рыб (Perca fluviatilis (L.) Abramis brama (L.) Rutilus rutilus (L.), Anguilla anguilla (L.) в аквариумных условиях при использовании авторсокого метода нагрузки общим физическим усилием.

В исследованиях определены предельные величины выталкивания поплавка, при которых исследуемые рыбы выполняли непрерывные ритмические поступательные дивжения в течение двух часов, не проявляя признаков усталости. Затем увеличили рабочую нагрузку до появления признаков острого утомления.

В результате исследований установлены значительные видовые различия в способности к динамическому усилию в определённых условиях среды.

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Received 15. VII. 1972