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Comparative Study on the Rates of Respiration of a Native Saudi Arabian Fish *Aphanius dispar* (Ruppell, 1828) and an Introduced Competitor, *Gambusia affinis* (Baird and Girard, 1853) Under Laboratory Conditions

Hmoud F. Alkahem, Zubair Ahmed and Mohammed A. Arrasheed
Department of Zoology, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia
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Abstract. Oxygen consumptions of *Aphanius dispar* and *Gambusia affinis* were measured under the laboratory conditions. The effect of body weight on the rate of oxygen consumption was estimated for both species. The native fish, *Aphanius dispar,* consumed less oxygen when compared with the exotic fish species, *Gambusia affinis*. When the results obtained were plotted on a double logarithmic grid, the oxygen consumption increased linearly with increased body weight meaning that the rate of oxygen consumption (*i.e.* the oxygen consumption per gm body weight) was higher in smaller fishes than larger specimens.

Introduction

The maintenance energy requirements of a fish species is reflected by its metabolic rate [1]. This can be determined by measuring oxygen consumption which can be regarded as a general measure of the intensity of metabolism [2;3,pp.1-64;4,pp.250-284]. Much work has been done on the oxygen consumptions of different fish species under various environmental conditions. Some valuable contributions in this area are those of Beamish [5], Andrews and Matsuda [6], Marais [1], Kumari and Nair [7], Ulrich [8], Degani and Gallangher [9], Du-Preez *et al.* [10], and Al-Kahem and Ahmed [11].

Aphanius dispar is ubiquitous in all natural and man-made freshwater bodies and coastal drainages with permanent or periodic connection with sea [12] through-

out the coastal regions of Middle East and Saudi Arabia bordering the Red Sea, Persian Gulf, Northern Arabian Sea and Eastern Mediterranean [13-16]. *Aphanius dispar* has been studied by previous investigators in terms of its physiology [17-19], ecology [12;20], feeding behaviour [21] and acid tolerance [22].

Gambusia affinis is an introduced species to the Middle East including Saudi Arabia, commonly occurring in freshwater and coastal drainages along with native species including *Aphanius dispar* [20]. Rauchenberger [23] reported that the *Gambusia affinis* had been introduced world wide primarily for mosquito control, but with limited success in that function. In fact, *Gambusia* apparently prefers larval fish to mosquito larvae a fact which can have devastating effects on the native fish fauna.

The present study measured the oxygen consumptions of *Aphanius dispar* and *Gambusia affinis*. The effects of this feature on competition between these fish species is discussed in the light of published information.

Materials and Methods

Specimens of *Aphanius dispar* and *Gambusia affinis* were collected by hand nets from the irrigation canal located at Al-Kharj area (near Riyadh). They were transported to Riyadh in plastic bags filled with oxygenated water. On reaching the laboratory, 100 fishes of each species were transferred to separate glass aquaria (480 l capacity) containing dechlorinated and aged water. The weight of fish ranged from 0.265-2.585 gm. They were kept for two weeks to acclimatize to the laboratory conditions (pH 7.6, Temperature 22°C, Dissolved oxygen 7.2 ppm). During this period of acclimatization, the fish were fed on a commercial food twice daily.

The 'sealed vessel' method previously used by Kumari and Nair [7], Mercy *et al.* [24], Alkahem and Ahmad [11] was employed to measure the oxygen consumption (Fig. 1). The supply of food to the fish was stopped 48 hours before recording to avoid the effects of ingestion, digestion and assimilation of food on respiratory metabolism. The size of the respirometer used in the present study and time of food deprivation had been established on the basis of previous studies [7;11;24]. For measurng the oxygen consumption, five active and healthy fish were released, after weighing, into separate respirometers and left for 12 hours to acclimatize to this condition. Water flowed continuously through the respirometers throughout this

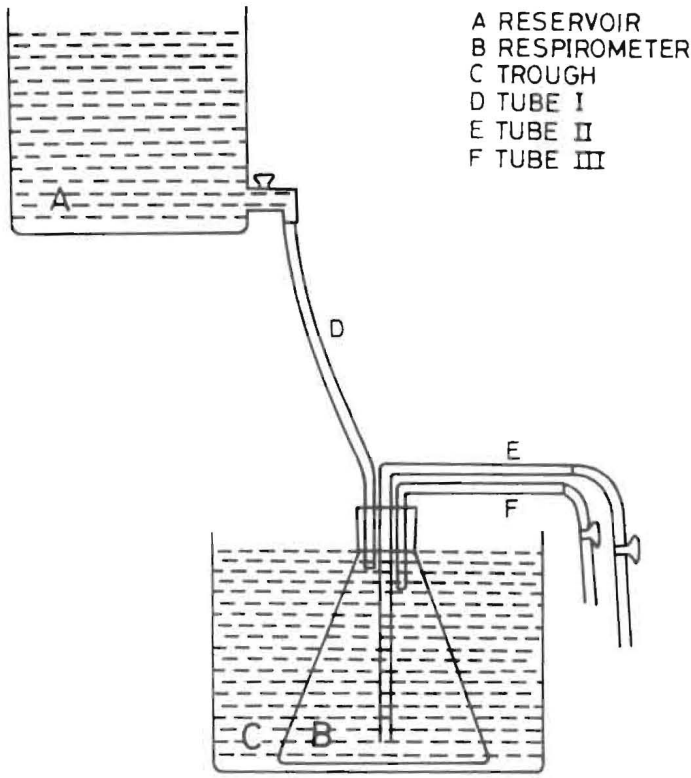

Fig. 1. Diagramatic representation of the arrangement used for conducting the experiment on oxygen consumption.

period. When the acclimation period was over, the flow of water was stopped and oxygen in the respirometers measured. The fish were then allowed to respire for one hour, and the oxygen content of water in respirometer was redetermined. The difference between two readings gives the oxygen consumed by the fish. Oxygen consumptions of each fish were measured separately. Only fish showing normal activity in respirometer was considered and those showing abnormal behaviour were discarded. Using the principle of least squares, a relationship between the oxygen consumption and body weight was established after transforming both values into their corresponding logarithms.

Results and Discussion

Oxygen consumption values of *Aphanius dispar* and *Gambusia affinis* are represented graphically by Fig. 2 and tabulated in Table 1 and 2, respectively. It is clear

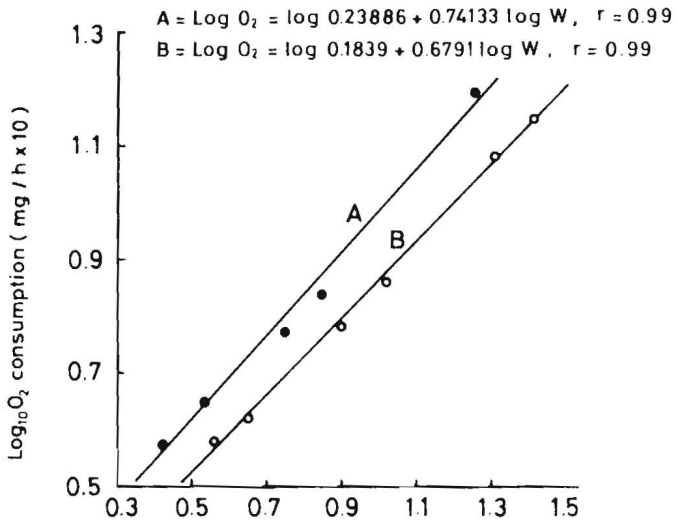

Fig. 2. Oxygen consumption of fish in relation to body weight. A = *Gambusia affinis*, B = *Aphanius dispar*

Table 1. Oxygen consumptions of *Aphanius dispar* in relation to body weight. Values are means and ± standard errors. The number of observations are in parentheses.

Mean weight of fish (gm)	Total oxygen consumed (mg/h)	Oxygen consumed/g body weight (mg/g/h)
0.366 ± 0.013	0.382 ± 0.019	1.0446 ± 0.032
(5)	(5)	(5)
0.450 ± 0.012	0.420 ± 0.018	0.9326 ± 0.024
(5)	(5)	(5)
0.788 ± 0.015	0.605 ± 0.022	0.7675 ± 0.014
(4)	(4)	(4)
1.043 ± 0.022	0.730 ± 0.013	0.7010 ± 0.024
(4)	(4)	(4)
2.040 ± 0.017	1.204 ± 0.039	0.5898 ± 0.015
(5)	(5)	(5)
2.585 ± 0.017	1.405 ± 0.045	0.5433 ± 0.014
(4)	(4)	(4)
Regression equation	$\log O_2 = \log 0.1839 + 0.6791 \log W$	$\text{Log } O_2 = \log 1.1842 - 0.3212 \log W$
Regression Co-efficient	r = 0.99	r = 0.99

Table 2. Oxygen consumptions of *Gambusia affinis* in relation to body weight. Values are means and ± standard errors. The number of observations are in parentheses.

Mean weight of fish (gm)	Total oxygen consumed (mg/h)	Oxygen consumed/g body weight (mg/g/h)
0.265 ± 0.021	0.374 ± 0.010	1.4394 ± 0.089
(5)	(5)	(5)
0.343 ± 0.016	0.445 ± 0.017	1.3021 ± 0.044
(4)	(4)	(5)
0.558 ± 0.016	0.588 ± 0.010	1.0548 ± 0.018
(5)	(5)	(5)
0.706 ± 0.019	0.680 ± 0.008	0.9655 ± 0.036
(4)	(4)	(4)
1.783 ± 0.032	1.556 ± 0.021	0.8737 ± 0.020
(5)	(5)	(5)
Regression equation	$\log O_2 = \log 0.23886 + 0.74133 \log W$	$\text{Log } O_2 = \log 1.2466 - 0.26575 \log W$
Regression Co-efficient	r = 0.99	r = 0.94

that oxygen consumption of fish increases with increased body weight. *Aphanius dispar* weighing 0.366 gm consumed 0.382 mg oxygen in one hour whereas fish weighing 2.585 gm consumed 1.405 mg oxygen per hour. In the same way the *Gambusia* weighing 0.265 gm and 1.78 gm consumed 0.374 and 1.556 mg oxygen per hour, respectively.

This linear relationship between respiratory metabolism and body weight of fish obtained in the present investigation shows the same correlation observed in other fish species by Marais [1], Mercy *et al.* [24], and Alkahem and Ahmed [11]. Naturally, the energy requirements of the fish to perform their vital life activities will be higher for larger fishes than the smaller fishes. To obtain the required amount of energy, larger fish will consume more oxygen than the smaller fish because the energy is produced by the oxidation of fuel molecules in the presence of oxygen.

The exponential values (b) in the equation: oxygen consumption = a $(\text{weight})^b$, for *Aphanius dispar* and *Gambusia affinis* obtained in the present study were 0.67 and 0.74, respectively. The values are lower than the value (0.8) generally found for other fish species [1;2;11]. Due to the great variation in the values of 'b' (0.05-1.0) for

the different fish species [10;24-27], the acceptance of a general value for 'b' is questionable.

The data embodied in Table 1 and 2 indicate that the rate of oxygen consumption (Oxygen consumption per gm body weight) for the two species was higher in small fishes as compared to the larger specimens (Fig. 3). Generally, the rate of activities of the animal slows down with the increase in size and age, and this may be the cause of lower rate of oxygen consumption of larger fishes compared to smaller specimens. Decreases in the rate of oxygen consumption with increased body weight have also been reported in *Gadus callaries* [28], *Platichthys stellatus* [29], *Puntius sophore* [30], *Tilapia mossambica* [31], *Noemacheilus Krishnai* [24], *Pomadasys commersoni* [10] and *Orechromis niloticus* and *Cyprinus carpio* [11].

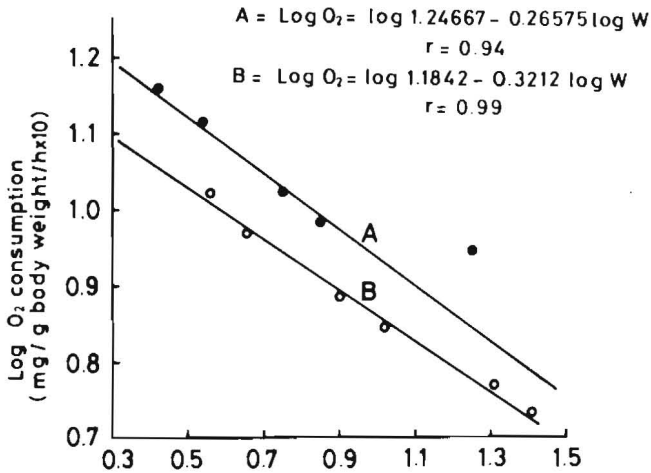

Fig. 3. Oxygen consumption per gram body weight in relation to the total weight of fish. A = *Gambusia affinis*, B = *Aphanius dispar*.

The results of the present investigation reveal that *Gambusia affinis* consumed more oxygen than *Aphanius dispar*. The difference in the amount of oxygen consumption suggests that the former fish is more active than the latter. Although, the present study did not assess any direct effect of *Gambusia's* introduction on *Aphanius dispar*, it is known that *Gambusia's* introduction has resulted in hybridization, predation and competition among native and non native species. It can be concluded from the present study that *Gambusia* would have competitive advantages over *Aphanius* as it is more active. This domination may account for reductions in the

populations of *Aphanius* or its elimination from the environment. It has been reported by earlier workers [23;32;33], that *Gambusia's* introduction has reduced populations of game fish, gold fish and *Aphanius dispar*.

Acknowledgements. Authors are grateful to Mr. Mohammed Essa for preparing the figures.

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دراسة مقارنة على معدّل استهلاك الأوكسجين بين الأسماك المحلية Aphanius dispar (Ruppell, 1828) والأسماك المستوردة Gambusia (Baird and Girard, 1853) في المملكة العربية السعودية

حمود بن فارس القحم، زبير أحمد ومحمد الرشيد
قسم علم الحيوان، كلية العلوم، جامعة الملك سعود، ص.ب ٢٤٥٥،
الرياض ١١٤٥١، المملكة العربية السعودية
(سُلِّمَ في ١٤١٥/١/٢هـ؛ وقُبل للنشر في ١٤١٥/٦/١٠هـ).

ملخص البحث. في هذه الدراسة، قيس استهلاك نوعين من الأسماك للأوكسجين، نوع محلي وهو Aphanius dispar (Ruppell, 1828) ونوع غير محلي وهو Gambusia affinis (Baird & Girard, 1853) وكذلك درست العلاقة بين وزن هذه الأسماك ومعدّل استهلاكها للأوكسجين. وتبين من هذه التجربة النتائج التالية:

- استهلكت Gambusia affinis أوكسجيناً أكثر من Aphanius dispar مما يدّل على منافسة النوع المستورد للنوع المحلي.
- كانت العلاقة طرديّة بين وزن الجسم ومعدّل استهلاك الأوكسجين.
- تستهلك الأسماك الصغيرة أو كسجيناً أكثر من الأسماك الكبيرة (لكل جرام من وزن الجسم).
- بلغت قيمة (b) حسب معادلة الانحدار الخطّي للعيّنات المفحوصة من أسماك **Aphanius dispar** ٠,٦٧٩١ و- ٠,٣٢١٢ للوزن الكلي ووحدة الوزن (لكل جرام) على التوالي.
- بلغت قيمة "b" حسب المعادلة السابقة للعينات المفحوصة من أسماك Gambusia affinis ٠,٧٤١٣ و -٠,٢٦٥٧ للوزن الكلي ووحدة الوزن على التوالي.