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The effect of gradual temperature increase on oxygen consumption rates by three species of carp fishes (Cyprinidae)

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Abstract

The effect of gradual temperature increase on oxygen consumption by *Cyprinus carpio*, *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix* have been investigated. Studied fishes showed defferent responses as in the following, *Cyprinus carpio* > *Ctenopharyngodon idella* > *Hypophthalmichthys molitrix* > control .

It is obviously clear that fishes in active way were consumed oxygen more than in resting and controls, statistical analysis showed significant correlation among the results

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Keywords: consumption; thermostat; acclimation; aquaria; activity scope;

Introduction:

Elevated temperatures have an influence aquatic organisms directly, as the organisms responded physiologically or behaviorally to the new conditions; or indirectly, as the changed in water temperature influences the water chemical environment. For example, increased temperature reduces the solubility of oxygen in water [(3)], while [(4)] pointed that temperature is of such profound importance in chemical and biological processes that the effects of temperature alterations on aquatic biological communities is potentially large. The effects of temperature on the respiratory physiology of fish are particularly important. Increased temperature reduces the amount of O_2 available and increases the animal's demand for it and may increase BOD by stimulating more rapid breakdown of organic matter by micro-organisms [(11)].

The main source of hot water which is discharged from industrial processes and power generation can cause temperature increase in the receiving water of 10°C or more [(6,8)]. The effects become more serious during summer months and high salinity values were found near discharge points [(1,9)].

The maximum temperature, which fish can withstand, varies from species to other, and with in a species according to the environmental history of the fish. Generally, fish can acclimate to gradually rising temperatures, so that the lethal temperature depends to some extent on the temperature to which the fish was initially acclimated. Relatively small, sudden changes of temperature, which do not allow the acclimation process to occur, can be more harmful than larger, more gradual changes. [(7)].

[(5)]reported that at very low temperatures, it has a little scope for muscular activity of any sort, since the efficiency of muscle tissue decreases with increasing temperature.

The aim of the present study to measure oxygen consumption by studying fishes in the laboratory during increase of water temperatures gradually. These measurements were in two fish groups (i.e. the fishes were either in rest or in active conditions in comparison with controls.

Materials and Methods:

Three fish species from Cyprinidea, common carp (*C. carpio*, the weight range was 5-6.5 gms.), grass carp (*C. idella*, the weight range was 6-8 gms.) and silver carp (*H. molitrix*, the weight range was 5-6.5 gms) have been brought from the ponds of "Marine Science Center-University of Basra". Fifty (50) fishes from each species were acclimated for one week before experiments in glass aquaria (30X30X60 cm.), electric aerated were used, the temperatures were ranged between 11-12.5 °C during November, 2007 to March, 2008, and pH values of water ranged 7.4-7.6. The fishes were fed everyday with mixed dry algae and fish muscles during acclimation period.

The mean of body length was 5.5 cm., water temperatures in the control aquaria were measured by normal thermometer (0-100) C°, while the water temperature in the test aquaria were gradually increased (reach about 33 °C) by using electric thermometer with thermostat type BN-788- China, following the procedure by [(6)]. Fishes in the rest experiments were exposed to gradual increase in temperatures (ranged between 17-33 °C), while the fishes in the active experiments were exposed to external effects (by glass pointer) in addition to increase in temperatures. The values of dissolved oxygen (as mg/l) were measured azide modification of Winkler's method (as recommended by [(12)]. Oxygen consumption ($mg.kg^{-1}.hr^{-1}$, i.e. to calculate the weight as kg and time as an hour) was calculate by a comparison between dissolved oxygen values in the water of rest and active experiments as recommended by [(2)].

Results:

The relationship between fish oxygen consumption in both rest and active conditions comparison with controls may be summarized in the following figs.:

Fig. (1) shows oxygen consumptions by *Cyprinus carpio* in the rest and active experimental fishes. These results have been obtained when the temperature increases gradually from 17.5 °C to 33 °C. The range of oxygen consumption of resting fishes were 25-220 mg/kg^{-1}/hr^{-1}, while the range in active fishes were 100-410 mg.kg^{-1}.hr^{-1}.

The maximum values of oxygen consumption were 45-216 mg. kg^{-1}.hr^{-1} of *C. idella* (fig. 2), while the minimum values were 20-125 mg. kg^{-1}.hr^{-1} during active and resting fishes respectively.

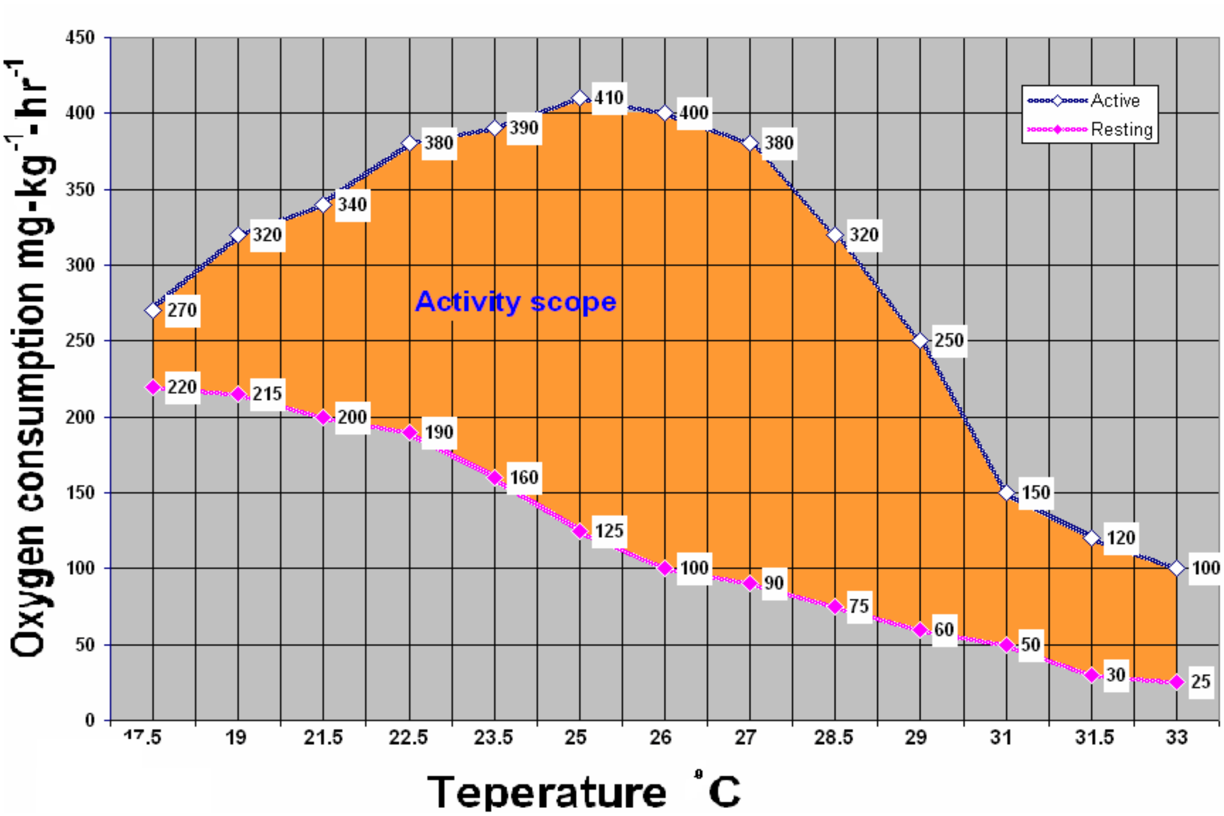

Fig. (1) Activity scope between active and resting fish Breathing of *C. carpio* during temperature rise

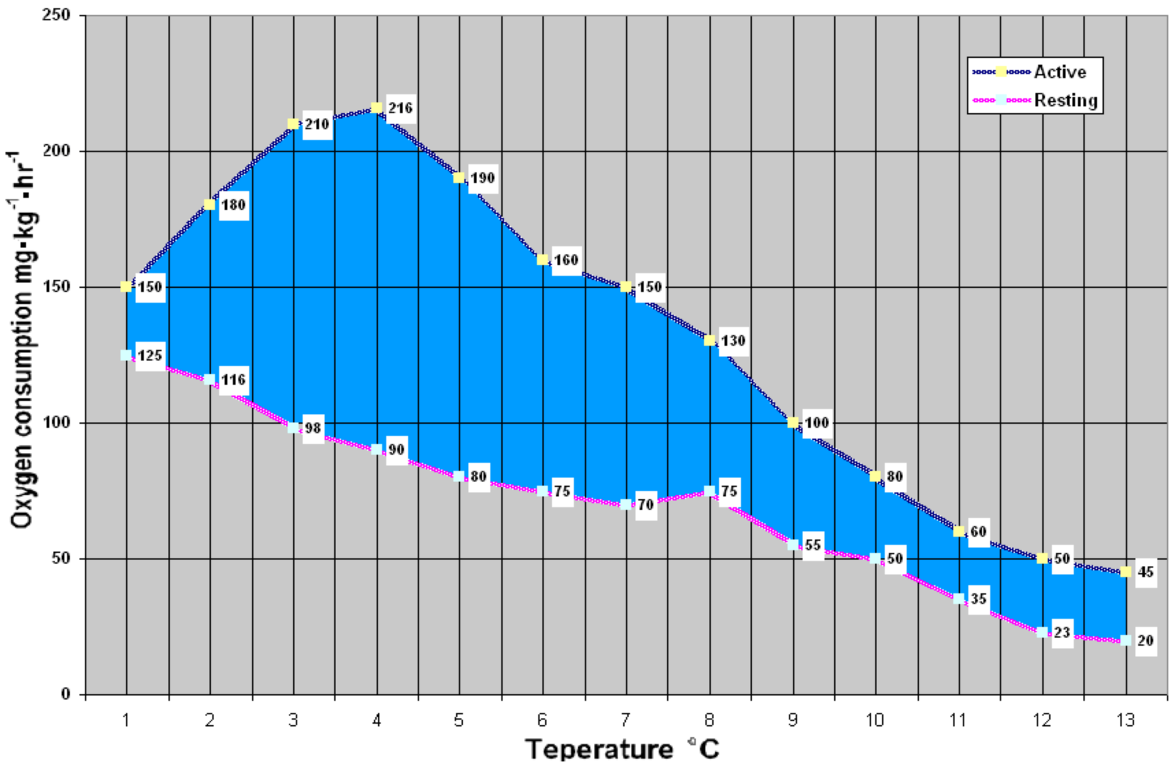

Fig. (2) Activity scope between active and resting fish breathing during of *Ctenopharyngodon idella* temperature rise

Fig.(3) shows oxygen consumption by active fishes, the maximum values were ranged between 55-165 mg. $kg^{-1}.hr^{-1}$ *H. molitrix*, the minimum values of oxygen consumption during resting fishes were 39-85 mg. $kg^{-1}.hr^{-1}$. Fig. (4) shows the values of oxygen consumption during resting time for all tested fishes, while fig. (5) shows the values of oxygen consumption by three studied fishes during active experiments.

Fig. (6) shows the values of oxygen consumption of *C. carpio* comparison with controls in both active and resting period, while fig. (7) shows oxygen consumption of *C. idella* during active and resting period in comparison with controls.

Fig. (8) shows oxygen consumption by *H. molitrix* during active and resting periods, fig. (9) shows the comparison between oxygen consumption by three fish species for resting and active values.

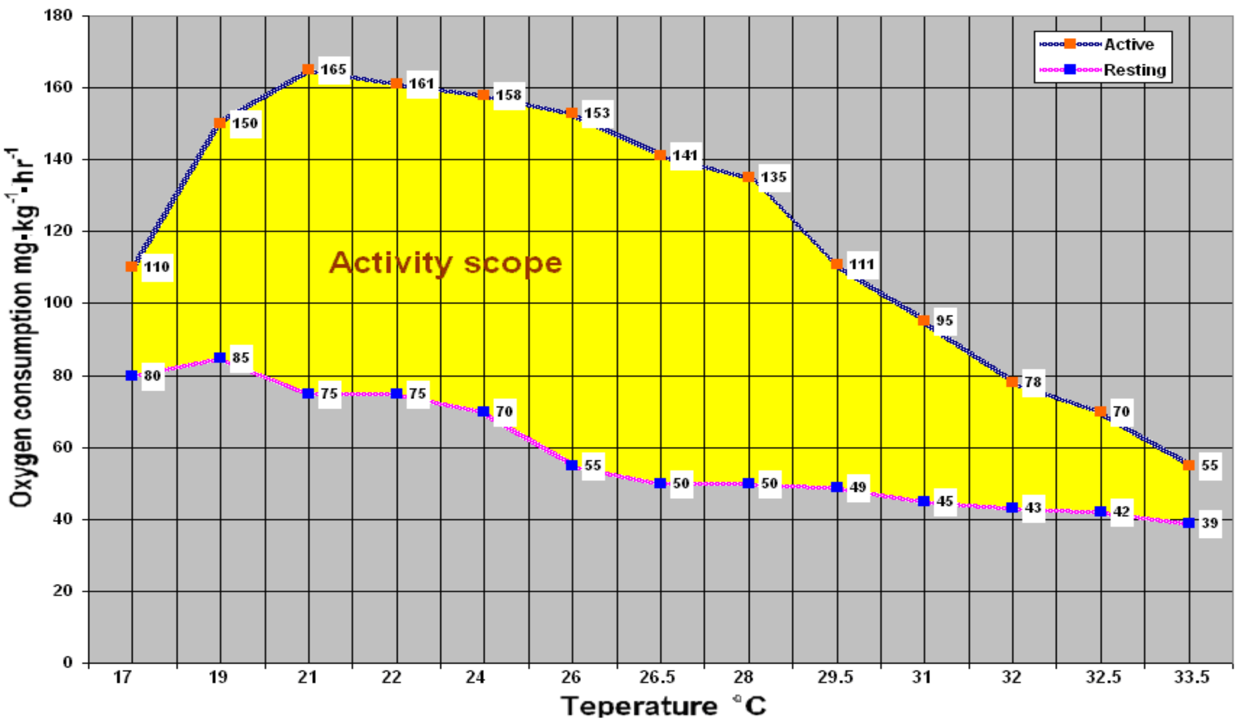

Fig. (3) Activity scope between active and resting fish breathing for *H. molitrix* during temperature rise

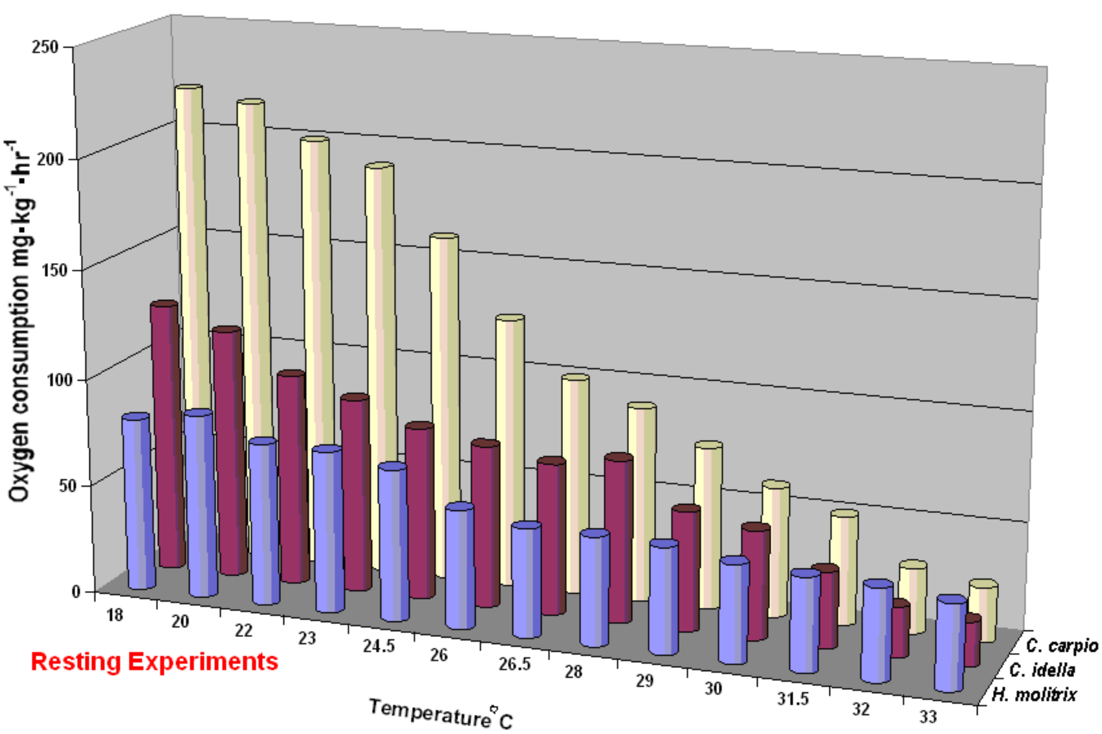

Fig. (4) Shows the values of oxygen consumption by experimental fishes during rest and temperature rise

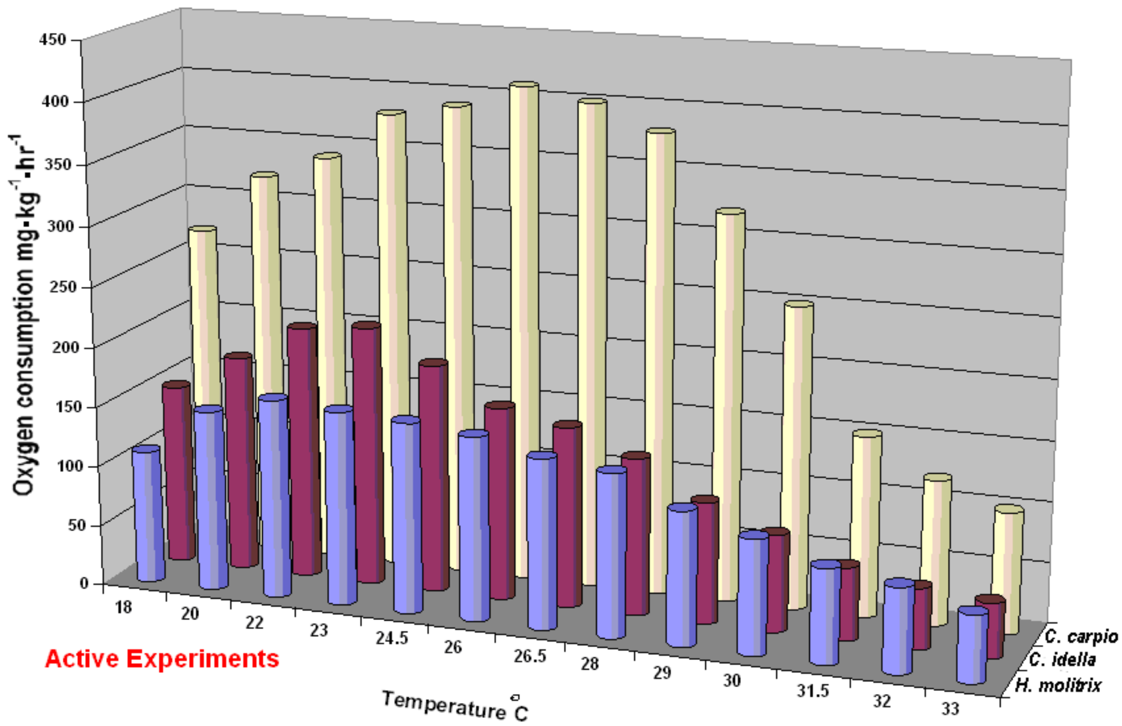

Fig. (5) Shows the values of oxygen consumption by experimental fishes during active and temperature rise

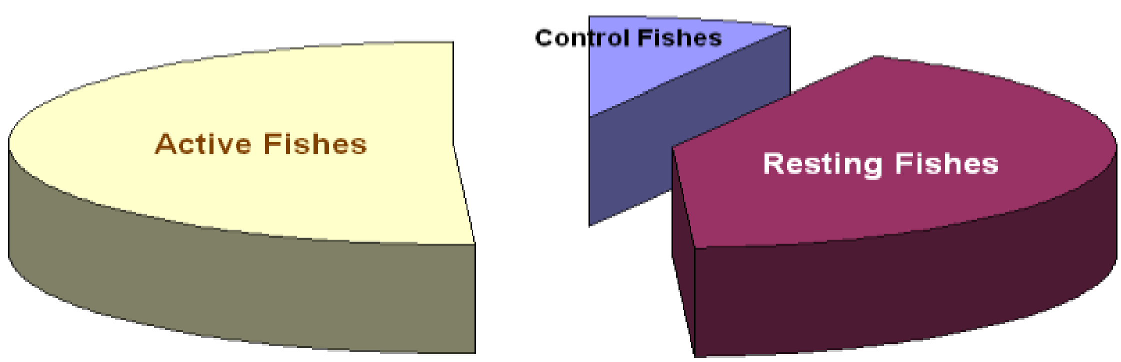

Fig. (6) Shows oxygen consumption by *C. carpio* comparison With the controls during temperature rise

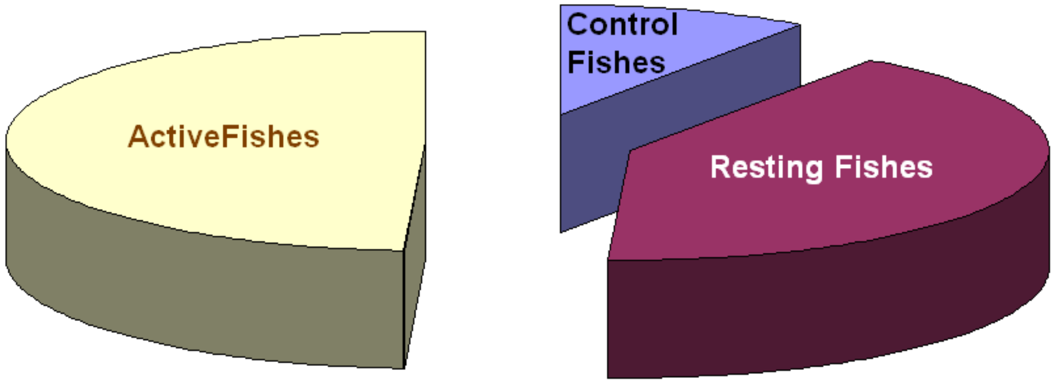

Fig. (7) Shows oxygen consumption by *C. idella* comparison with the controls during temperature rise.

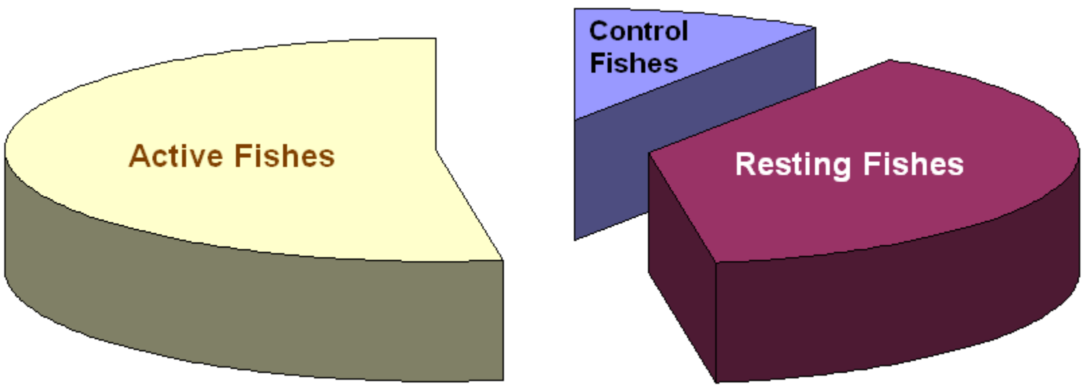

Fig. (8) Shows oxygen consumption by *H. molitrix* comparison with the controls during temperature rise

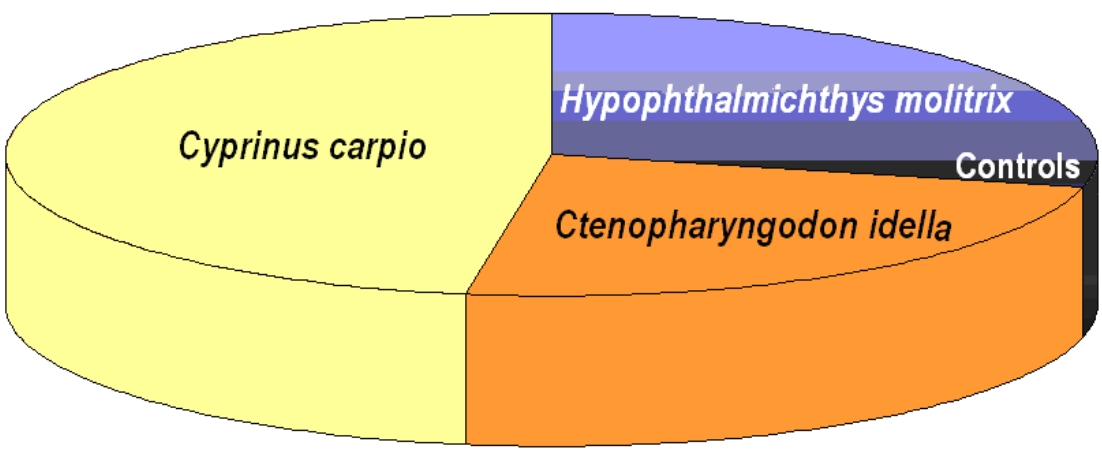

Fig. (9) Comparison between oxygen consumption during active and rest periods for each species with the controls

Statistical analysis was carry out using "SPSS" programs, the analysis of oxygen consumption values for *C. carpio* during rest and active fishes comparison with controls showed high significance ($p< 0.05$) and correlation was $r=0.922$. oxygen consumption by *C. idella* was high also; especially in the case of active fishes compared with resting and the control fishes. The analysis was significant ($p<0.05$) and correlation was $r=0.810$.

Oxygen consumption amount by *H. molitrix* was less in both active and resting fishes in comparison with other two studied species. The relation was insignificant ($p>0.05$) and the correlation coefficient was $r=-0.890$.

Discussion:

The maximum temperature, which fish can withstand, varies from species to species, and within a species according to the environmental history of the fish. Generally, fish can acclimate to gradually rising temperatures for some degree, so that the lethal temperature depends to some extent on the temperature to which the fish was initially acclimated. Relatively small, sudden changes of temperature, which do not allow the acclimation process to occur, can be more harmful than larger, more gradual changes [(13)].

[(14)]mentioned that in practice, the temperature regime, which is favorable for the indefinite survival of the fish, includes a much narrower range of temperatures than that which would allow the survival of the fish under laboratory conditions. This conclusion agrees with the present results concerned with the effects of temperature on oxygen consumption inside laboratory conditions. These effects differ between species and anothers. These results showed wide differences between the amounts of oxygen consumption, common carp (*C. carpio*) was more resistance than two studied species (fig.1), this is very clear in activity scope compared with those in figs.(2 and 3).

Grass carp (*C. idella*) showed more resistance as shown in fig. (2) than silver carp (*H. molitrix*) fig. (3) in the activity scope with increasing temperature. [(3)]described elegantly and in detail the respiratory predicament of fishes. A fish at rest in well-oxygenated, and water ventilation in the gills was slowly, same results were recorded by [(10,7,13,14)]. Respiratory exchange is efficient, and removes most of the oxygen from the water passing over its gills. If, however, the fish ventilates more quickly, as it must for example if it becomes physically active, the water passing over the gills has less time to equilibrate with the blood, and the efficiency of respiratory exchange drops. Thus, in order to double the rate of oxygen uptake, the fish must double the amount of water pumped over the gills.

Conclusions:

The oxygen consumption values and activity scope area which belong to the studied fish species were in the order: Common carp (*C. carpio*) > Grass carp (*C. idella*) > Silver carp (*H. molitrix*). The amounts of oxygen consumption by the same species were in the order: Active > resting > control fishes.

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تأثير زيادة درجة الحرارة التدريجي على معدلات استهلاك الأوكسجين لثلاثة أنواع من اسماك الكارب (عائلة الشبوطيات)

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المستخلص

تم اختبار تأثير زيادة درجة الحرارة التدريجي على استهلاك الأوكسجين من قبل اسماك الكارب الاعتيادي (*C. carpio*) والكارب العشبي (*C. idella*) والكارب الفضي (*H. molitrix*) ، أوضحت الأسماك المدروسة اختلافا في الاستجابة وكما موضح بالآتي، Controls < *H. molitrix* > *C. idella* > *C. carpio*.

من الواضح أن الأسماك في الحالة النشطة استهلكت الأوكسجين أكثر من تلك الأسماك في وقت الراحة وكذلك لأسماك السيطرة، ونتائج التحليل الإحصائي أظهرت علاقة معنوية في النتائج.