Acta Agraria Kaposváriensis (2000) Vol 4 No 1, 35-40
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Comparison of stress response of two different carp (*Cyprinus carpio,* L.) genotypes

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ABSTRACT

Investigations on stress response intensity were carried out in two distant strains of common carp: scaled Danube wild and selected mirror strain. First stressing was a 3 hour transport in polyethylene bags followed by tagging and measurement. Stress response was measured by plasma cortisol and glucose concentrations. Mirror carp showed significantly (P=0.001) lower cortisol (166.8 ng/ml) and glucose (10.2 mmol/l) levels than the Danube wild carp (436.1 ng/ml and 13.1 mmol/l, respectively). Medium high correlation was found between the two blood parameters (r=0,427, P=0,001, n=61). High variance of cortisol level observed in both strains provides the basis for the selection of high and low responding individuals which can be artificially propagated by andro- or gynogenesis to develop highly inbred lines.
(Keywords: common carp, selection, stress tolerance)

ÖSSZEFOGLALÁS

Két különböző pontyvonal stresszre adott válaszreakciója

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Vizsgálatainkat két egymástól genetikailag távol álló fajtával, a dunai vadponttyal és egy intenzív tógazdasági tükrös fajtával végeztük. Az első stresszelést egy 3 órás, polyetilén zsákokban történő szállítást követő egyedi jelölés jelentette. A halaknak a stresszre adott reakcióját a vérplazma kortizol és glükóz szintjének mérésével indukáltuk. A stresszelési kísérletben a tükrös fajta szignifikánsan (P=0,001) alacsonyabb kortizol (166,8 ng/ml) és glükóz (10,2 mmol/l) szinteket mutatott, mint a dunai vadponty (436,1 ng/ml ill. 13,1 mmol/l) és a két paraméter összefüggését közepes erősségűnek találtuk (r=0,427, P=0,001, n=61). A fajtán belüli nagy egyedi különbségek lehetővé teszik, hogy a magas ill. alacsony szintekkel reagáló egyedeket kiválaszthassuk és belőlük andro- vagy gynogenetikus vonalakat hozzunk létre.
(Kulcsszavak: ponty, szelekció, stressz)

INTRODUCTION

Stress is an unavoidable component of the aquaculture environment in large-scale fish production. Fish under intensive culture conditions are exposed to repeated acute stressors (handling, transport, prophylactic treatment) and chronic stressors (overcrowding, deterioration of water quality). The inappropriate activation of the stress response may result in significant adverse effects on growth *(Pickering*, 1990), reproduction (*Carragher et al.*, 1989) and disease resistance (*Pickering et al.,* 1989). It is well known that the steroid hormone cortisol has a causal role in the deleterious consequences of chronic stress (*Barton et al.,* 1991).

Therefore, in a stressful environment, animals responding to environmental stressors with less pronounced elevation of plasma corticosteroids will have an advantage over those displaying larger increases (*Pottinger et al.,* 1994). This provided the reason to select strains of poultry more resistant to stress (*Brown et al.,* 1974) and was used in the enhancement of disease resistance in salmonid fishes (*Fevolden et al***.,** 1991,1992). Improvement of growth rate and reproductive performance in salmonid fish by selective breeding was studied extensively (*Gjedrem,* 1992), but less attention was paid to the possibilities of manipulating components of the endocrine system. In two populations of rainbow trout a proportion of fish displayed a stable responsiveness to stress, that is, a tendency to a high or low corticosteroid response to stress was identifiable (*Pottinger et al.,* 1992).

Although reared and selected for centuries, surprisingly little is known about the stress physiology of carp. Effects of sublethal ammonia concentrations (*Jeney et al.,* 1992) and heat stress (*Jeney et al.,* 1995) was studied in common carp where adrenaline and noradrenaline levels of different organs and glucose concentrations, hematocrit and leukocrit values were measured, respectively, as response parameters. *Pottinger* (1998) measured changes in blood cortisol of common carp where the applied stressor was confinement. Confinement is an easily standardizable and widely used stressor in experiments with salmonid fish (*Fevolden et al.,* 1993, *Pottinger et al.,* 1994).

First we tried to identify individuals performing high and low post-stress plasma cortisol and glucose levels in two genetically and morphologically distant strains of common carp, scaled Danube wild carp and a selected mirror carp strain.

MATERIALS AND METHODS

The wild Danube and the selected mirror carp strains have participated in the 1998/99 national performance test that includes artificial propagation and controlled pre-rearing. After the autumn harvesting, 155 one-summer-old fish of the two races were transported from the TEHAG Fish Center to the Eel Farm of Balaton Fishing Co., Hévíz. The fish were packed in polyethylene bags with water and oxygen. The transport lasted about three hours in 12°C water.

The fish were weighed and measured and individually marked with Floy fingerling tags immediately after arrival. These circumstances were considered to be strong confinement and handling stressors.

Blood samples were taken from the caudal vein of the first 61 anaesthetised (Chinaldin solution) fish (31 mirror and 30 scaled carp) using a hypodermic needle and heparinized syringe.

Blood samples were kept and transported refrigerated at 0°C. Glucose was determined with the standard enzymatic, colorimetric GOD-POD-PAP method with a ROCHE Cobas Mira Plus analyser. Plasma cortisol was measured by ^{125}I-Cortisol RIA set.

Statistical analysis were carried out by SPSS for Windows 7.5 (1996). Means were compared by Student's t-test. Data transformation for normality was done when necessary.

RESULTS AND DISCUSSION

The mean body weight of the two strains were 87.3±63.9 g (SD) and 93.4±30.9 g (SD), respectively in the mirror and scaled carps. The difference was not significant and the coefficient of variance was extremely high (73.2%) in the mirror carp.

Cortisol and glucose levels at the sampling (mean±SD) are shown in *Table 1*. After the severe confinement and handling stress the mirror carp showed significantly (P=0.001) lower cortisol and glucose levels than the scaled, "wild" carp strain. (The distribution of plasma cortisol level was not normal in the case of the mirror carp, the cortisol data, therefore, were transformed by square root before comparing means.) Mean values of plasma cortisol concentrations are in accordance with the findings of *Davis et al.* (1986) who measured an increase of 286 ng/l of corticosteroids in common carp after a transport of 2 hours.

Table 1

Plasma cortisol and glucose levels of the two strains of common carp after prolonged confinement and handling stress

		Cortisol (ng/ml) (1)		Glucose (mmol/l) (2)	
Strain (3)	N (6)	Mean (7)	SD (8)	Mean	SD
Mirror (4)	31	166.81[a]	70.28	10.24[a]	2.48
Scaled (5)	30	436.10[b]	176.55	13.14[b]	3.62

Values with different letters within the same column are significantly different (P=0.001). (*Az oszlopokon belül eltérő betűvel jelölt értékek P=0,001 szinten szignifikánsan különböznek.)*

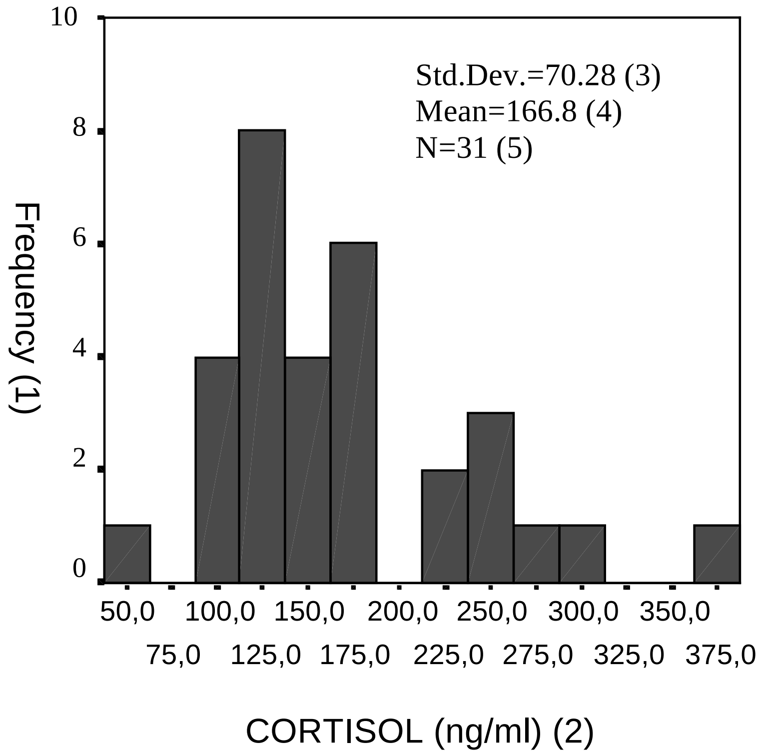
1. táblázat: A két pontyfajta plazma kortizol és glükóz szintjei hosszantartó összezsúfolás és kezelési stresszt követően

Kortizol(1), Glükóz(2), Fajta(3), Tükrös(4), Pikkelyes(5), Darabszám(6), Átlag(7), Szórás(8)

Distributions of cortisol levels of the two carp strains are shown in *Figure 1 and 2.* High variance of the cortisol level observed at the stressing trial in both strains indicates that individual selection based on post stress plasma cortisol concentration can be a feasible basis for the selection of high and low responding individuals.

Figure 1

Distribution of cortisol level in the mirror carp strain



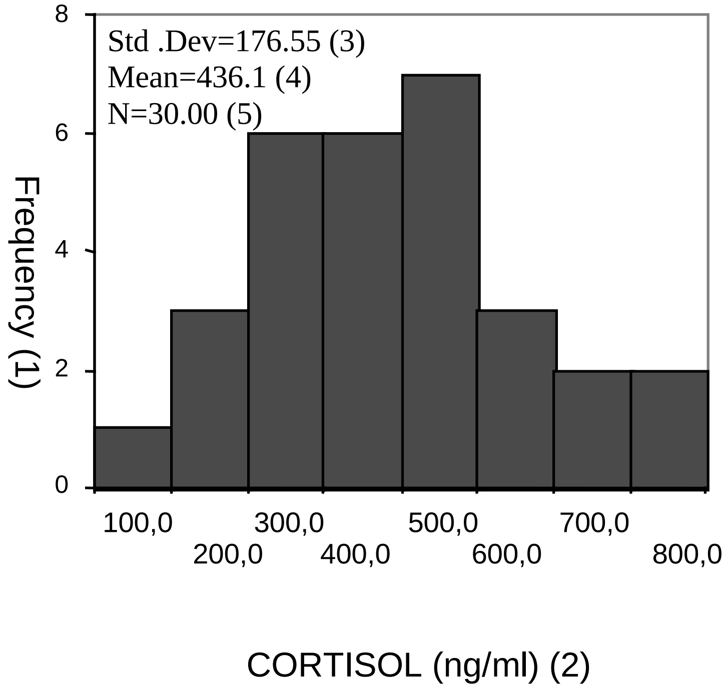
1. ábra: A kortizol szintek eloszlása a tükrös ponty vonalban

Gyakoriság(1), Kortizol(2), Szórás(3), Átlag(4), Darabszám(5)

Analysis of regression showed no significant effect of sampling sequence (time) on cortisol and glucose levels. It means that no important changes in the physiological state of fish can be expected within the 20 to 30 minutes of time range used for measurement, tagging and blood sampling of one group of fish, at least at 12°C water temperature.
Regression on body weight was also found to be non-significant. Linear regression of cortisol on glucose was significant (P=0.001), where R=0.427, a=21.466, b=23.818 (n=61). Moderate correlation between cortisol and glucose indicates a possibility of future investigations on the field of stress response detectability in common carp.
According to our results there is safe ground for the possibility of the future separation of high and low responding individuals and the creation of two distinct lines within both strains by andro- or gynogenetic propagation in the near future. Further investigations are needed to standardise experimental stressing conditions and to clarify correlations between stress resistance and productional traits in common carp.

Figure 2

Distribution of cortisol level in scaled Danube wild carp



2. ábra: A kortizol szintek eloszlása a pikkelyes dunai vadpontynál

Gyakoriság(1), Kortizol(2), Szórás(3), Átlag(4), Darabszám(5)

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