Analysis of slaughtering value of diploid and triploid population of tench (*Tinca tinca*, Linnaeus 1758)

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ABSTRACT: The goal of this study was to determine differences in weight (W_{abs}) C-of carcass$_{without\ head,\ fins\ and\ viscera}$ and waste body parts (H-head$_{without\ gills}$, F-fins $_{both\ paired\ and\ unpaired}$, AF- also abdominal fat in tench of T_{3+} age) and organs (G-gills, V-viscera$_{sum}$, of them: HP-hepatopancreas, also S-spleen in tench of T_{3+} age) and their ratios in fish weight (W_{rel}) between diploid (2*n*) and triploid (3*n*) tench of the same origin kept in a communal stock in relation to sex (female – F vs. male – M) and age (three-year old tench in spring – T_3 and in autumn – T_{3+}). Analyses of 137 siblings in total were made. Control group consisted of 72 diploid specimens (39 F and 33 M) and experimental group consisted of 65 triploid specimens (38 F and 27 M). The effect of ploidy level was reflected in significantly higher values of W_{abs} (C, H, G, F, V, HP) in triploid females at T_3 and T_{3+} age ($P < 0.001$) and value of W_{abs} (S, AF) in triploid females at T_{3+} age. Triploid females at T_3 age showed significantly higher CW_{rel} ($P < 0.01$) and lower VW_{rel} ($P < 0.001$), those at T_{3+} had significantly higher AFW_{rel} ($P < 0.001$). Triploid males at T_3 had significantly higher W_{abs} (C, H also at T_{3+} , G, F, V, HP) ($P < 0.001$) compared to diploids, due to the effect of ploidy level. The effect of sex was expressed by significantly higher values of CW_{rel} ($P < 0.01$) and FW_{rel} ($P < 0.001$) in diploids at T_3 and T_{3+} age as well as by lower $VW_{abs,\ rel}$ ($P < 0.001$) of males. Diploid males at T_3 age were also found with significantly lower W_{abs} (H, G) ($P < 0.001$) and those at T_{3+} were found with lower HPW_{abs}. In triploids at T_3 and T_{3+} age, the effect of sex resulted in significantly higher values of W_{abs} (C, H, G, V) ($P < 0.001$) as well as lower FW_{rel} ($P < 0.001$) of females. Triploid females at T_3 age were found with significantly higher HW_{rel} ($P < 0.05$) and those at T_{3+} also with significantly higher W_{abs} (HP, S, AF) ($P < 0.001$) and AFW_{rel}. The weights of carcass (CW_{abs}), body parts (HW_{abs}, FW_{abs}) and organs (GW_{abs}, HPW_{abs}) were found significantly enhanced in relation with age ($P < 0.001$) in all tench groups under study.

Keywords: diploid and triploid tench; genome polyploidy; absolute and relative weight; head; fins; gills; viscera; abdominal fat

Experimental studies focused on waste body parts (head, fins, abdominal fat) and organs of fish (gills, viscera) are rather scarce. Sporadic results of research on these parts of the fish organism are mentioned only marginally as a part of other topical studies.

In tench (*Tinca tinca* L.), Zięcik and Sławiński (1965) dealt among others with observations of some of these parameters (gonads, liver, soft waste, hard waste) in relation to sex, and a study of Jirásek and Laudát (1984) mentioned the parameters of head, fins, skin, gonads and hepatopancreas. While Zięcik and Sławiński (1965) examined the mean weight of the parts, Jirásek and Laudát (1984) also mentioned their ratio in the fish weight. However,

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the results in these papers were not tested statistically in a sufficient way.

The culture of diploid tench and of chromosomally manipulated triploid tench in the Czech Republic as well as scientific studies aimed at differences between both populations enabled us to assess some of these waste parts of the tench organism also in relation to the ploidy level. This research, seemingly not important for the fish culture practice from the production aspect, cannot be replaced by any other observations if we wish to understand anatomical and physiological differences between intact- and triploid tench. All studies focused in this direction are therefore indispensable and take a specific position in research on aquaculture products.

This study is a part of extensive research on diploid and triploid populations of tench (Flajšhans *et al*., 1993; Kvasnička and Flajšhans, 1993; Flajšhans, 1997a,b; Svobodová *et al*, 1998, 2001; Sedláček, 1999) conducted at the University of South Bohemia, Research Institute of Fish Culture and Hydrobiology at Vodňany (USB RIFCH). The USB RIFCH initiated a co-operation with the Faculty of Veterinary Hygiene and Ecology, Veterinary and Pharmaceutical University in Brno. Research on diploid and triploid tench at this workplace (Buchtová and Vorlová, 2002) was focused on their biometric and weight parameters and relevant indices (Buchtová *et al*., 2003). These authors also experimentally studied parameters associated with nutritional assessment of tench flesh, such as the basic chemical composition of their flesh and quantitative and qualitative assessment of amino-acid composition of muscle proteins. These results have not been published yet.

The goal of this study was to determine differences in the weight (W_{abs}) of waste body parts (head$_{without\ gills}$, fins$_{both\ paired\ and\ unpaired}$, abdominal fat also in tench of T_{3+} age) and organs (gills, viscera$_{sum}$, of them: hepatopancreas, also spleen in tench at T_{3+} age) and their ratio in fish weight (W_{rel}) between diploid (2*n*) and triploid (3*n*) tench of the same origin, in relation to sex (female – F vs. male – M) and age (three-year old tench in spring – T_3 and in autumn – T_{3+}).

MATERIAL AND METHODS

Tench (*Tinca tinca*, L.) populations were established at a hatchery of the Department of Fish Genetics and Breeding at Vodňany, Research Institute of Fish Culture and Hydrobiology of the University of South Bohemia in 1998 by mass propagation as described in Buchtová and Vorlová (2002). Triploidy (3*n*) was induced by means of cold shock following the protocol of Flajšhans and Linhart (2000).

Diploid and triploid larvae were nursed separately in pond monoculture. At the end of the 1st growing season, diploid fry was given a group-mark by means of freeze-branding while triploid fry was left unmarked. Both groups (300 specimens each) were stocked into a 0.2 ha experimental earthen pond for a communal test in monoculture until 2001. Feeding was based upon regularly checked production of natural food. Pollard was administered to tench fry as supplemental feeding, larger fish were given cereals.

Prior to checking (March 27, 2001 and October 10, 2001), fish were harvested and maintained in tanks with original pond water under stress-eliminating conditions (O_2 saturation above 80%, constant water temperature).

Altogether 137 siblings of tench were studied. Control group consisted of 72 diploid specimens (39 females – F, 33 males – M) and experimental group consisted of 65 triploid specimens (38 F, 27 M). The experiment was carried out in two periods. The first one involved 76 specimens of three-year-old tench before the onset of adult period (T_3, harvested in March 27, 2001) with control group of 37 diploid specimens (19 F, 18 M) and experimental group of 39 triploid specimens (19 F, 20 M). The second period involved 61 specimens of three-year-old tench after the first reproductive cycle (T_{3+}, harvested in October 10, 2001) with control group of 35 diploid specimens (20 F, 15 M) and experimental group of 26 triploid specimens (19 F, 7 M).

The age of fish was determined directly from hatching data in breeding records.

The sex of tench was determined upon expressive sexual dimorphism (120 specimens), according to pathological and anatomical examination of gonads (10 specimens) and according to histological preparations (7 specimens) according to Flajšhans *et al.* (1993) and Kvasnička and Flajšhans (1993). Diploid specimens were identified according to freeze-branded marks on skin.

Ploidy level was checked by means of flow cytometry as relative DNA content in peripheral blood cells sampled by the punction of caudal vessel (*vena caudalis*). Blood samples were processed for flow

cytometry according to Vindelov and Christensen (1990).

Weight (W_{abs}) was checked for the following waste parts and for their ratio in the fish weight (W_{rel}): H-head$_{without\ gills}$ (head hereinafter), F-fins$_{both\ paired\ and\ unpaired}$ (fins hereinafter), G-gills, V-viscera$_{sum}$, HP-hepatopancreas and also AF-abdominal fat and S-spleen in tench at T_{3+} age. The weight of abdominal fat of each specimen was determined gravimetrically after preparation from the surface of the viscera.

For a complete review, the study contains statistically processed results (ANOVA, Statgraphics 5.0) of other two parameters – weight of carcass (CW_{abs}, where C is body without head, fins and viscera) and its ratio in fish weight (CW_{rel}).

Tables 1 and 2 are complemented with the values of gonad weight (gonad W_{abs}), gonadosomatic index (GSI) and hepatosomatic index (HSI) with statistical evaluation (ANOVA, Statgraphics 5.0) of the effect of ploidy level and of sex on these parameters in groups of tench at T_3 and T_{3+} age according to Buchtová *et al.* (2003). The effect of age (ANOVA, Excel 97) on these parameters according to the same author is given in Figures 1 and 2. The results of checking the effects of ploidy level, sex and age on these parameters will not be discussed in this study.

Basic statistical values (mean, S.D.) of the observed parameters were processed in Excel 97. The evaluation of statistical significance of the results was performed on a static level (separately for T_3

Table 1. Summarized data on the carcass, waste body parts and organs of 3-years-old diploid (2*n*) tench and their artificially induced triploid (3*n*) siblings (March 2001)

Index	F 2*n* (*n* = 19) mean ± S.D.	M 2*n* (*n* = 18) mean ± S.D.	F 3*n* (*n* = 19) mean ± S.D.	M 3*n* (*n* = 20) mean ± S.D.	Statistical significance
CW_{abs} (g)	92.93 ± 46.97^{ab}	52.33 ± 15.26^{a}	182.91 ± 48.83^{c}	131.98 ± 43.72^{b}	$P < 0.001$
CW_{rel} (%)	65.89 ± 1.68^{a}	68.24 ± 1.90^{b}	67.94 ± 1.90^{b}	68.58 ± 2.26^{b}	$P < 0.01$
HW_{abs} (g)	19.41 ± 8.76^{b}	10.59 ± 2.69^{a}	37.64 ± 9.99^{c}	24.49 ± 7.67^{b}	$P < 0.001$
HW_{rel} (%)	14.06 ± 1.24^{b}	13.99 ± 1.19^{ab}	14.01 ± 1.03^{b}	12.87 ± 1.33^{a}	$P < 0.05$
GW_{abs} (g)	3.96 ± 1.77^{b}	1.93 ± 0.51^{a}	6.93 ± 1.73^{c}	5.00 ± 1.74^{b}	$P < 0.001$
GW_{rel} (%)	2.86 ± 0.45	2.55 ± 0.36	2.59 ± 0.53	2.64 ± 0.54	–*
FW_{abs} (g)	4.37 ± 2.33^{a}	3.23 ± 1.04^{a}	8.92 ± 2.39^{b}	8.01 ± 2.35^{b}	$P < 0.001$
FW_{rel} (%)	3.09 ± 0.32^{a}	4.19 ± 0.53^{b}	3.32 ± 0.3^{a}	4.23 ± 0.48^{b}	$P < 0.001$
VW_{abs} (g)	20.22 ± 11.46^{ad}	8.39 ± 2.31^{b}	32.22 ± 8.15^{c}	22.17 ± 6.62^{d}	$P < 0.001$
VW_{rel} (%)	14.10 ± 1.49^{a}	11.04 ± 1.38^{bcd}	12.11 ± 1.67^{cd}	11.68 ± 1.53^{d}	$P < 0.001$
Of that:[1,2]					
Gonad W_{abs} (g)	4.18 ± 2.62^{b}	0.23 ± 0.14^{a}	1.35 ± 1.08^{a}	0.38 ± 0.38^{a}	$P < 0.001$
GSI	2.85 ± 0.89^{b}	0.28 ± 0.16^{a}	0.57 ± 0.54^{a}	0.20 ± 0.15^{a}	$P < 0.001$
HPW_{abs} (g)	3.24 ± 2.36^{ab}	1.69 ± 0.61^{a}	6.14 ± 1.68^{c}	4.65 ± 0.33^{bc}	$P < 0.001$
HSI	2.18 ± 0.53	2.20 ± 0.38	2.30 ± 0.41	2.44 ± 0.33	–*

[1]gonad W_{abs}, GSI and HSI according to Buchtová *et al.* (2003)
[2]W_{abs} and W_{rel} S-spleen and AF-abdominal fat were not investigated in tench at T_3 age
–*not significantly different at $P < 0.05$

Table 2. Summarized data on the carcass, waste body parts and organs of 3+ years-old diploid (2*n*) tench and their artificially induced triploid (3*n*) siblings (October 2001)

Index	F 2*n* (*n* = 20) mean ± S.D.	M 2*n* (*n* = 15) mean ± S.D.	F 3*n* (*n* = 19) mean ± S.D.	M 3*n* (*n* = 7) mean ± S.D.	Statistical significance
CW_{abs} (g)	239.30 ± 34.84^{a}	201.05 ± 34.56^{a}	504.82 ± 111.52^{b}	293.52 ± 106.54^{a}	$P < 0.001$
CW_{rel} (%)	65.54 ± 1.88^{a}	67.94 ± 1.54^{b}	66.94 ± 1.61^{ab}	66.13 ± 1.73^{ab}	$P < 0.01$
HW_{abs} (g)	56.67 ± 9.25^{ab}	43.23 ± 7.00^{a}	108.84 ± 22.01^{c}	70.35 ± 27.65^{b}	$P < 0.001$
HW_{rel} (%)	15.54 ± 1.37	14.70 ± 1.38	14.51 ± 1.18	15.75 ± 1.35	–*
GW_{abs} (g)	6.87 ± 1.48^{a}	6.13 ± 1.51^{a}	15.55 ± 4.04^{b}	10.38 ± 5.01^{a}	$P < 0.001$
GW_{rel} (%)	1.88 ± 0.30	2.06 ± 0.27	2.08 ± 0.34	2.25 ± 0.38	–*
FW_{abs} (g)	9.34 ± 1.66^{a}	12.26 ± 2.58^{ab}	20.37 ± 5.61^{c}	15.94 ± 4.31^{bc}	$P < 0.001$
FW_{rel} (%)	2.55 ± 0.20^{a}	4.14 ± 0.41^{b}	2.68 ± 0.28^{a}	3.73 ± 0.61^{b}	$P < 0.001$
VW_{abs} (g)	53.05 ± 10.02^{a}	33.18 ± 6.86^{b}	108.25 ± 24.49^{c}	53.80 ± 18.96^{ab}	$P < 0.001$
VW_{rel} (%)	14.49 ± 1.54^{a}	11.62 ± 2.06^{bc}	14.39 ± 1.48^{ad}	12.15 ± 1.08^{cd}	$P < 0.001$
Of that:[1,2]					
Gonad W_{abs} (g)	10.13 ± 2.70^{b}	1.43 ± 0.67^{a}	11.17 ± 5.53^{b}	2.72 ± 2.59^{a}	$P < 0.001$
GSI	2.78 ± 0.69^{c}	0.47 ± 0.17^{a}	1.52 ± 0.78^{b}	0.56 ± 0.36^{a}	$P < 0.001$
HPW_{abs} (g)	13.80 ± 2.78^{b}	8.59 ± 2.23^{a}	23.98 ± 4.25^{c}	12.81 ± 3.87^{ab}	$P < 0.001$
HSI	3.78 ± 0.60^{b}	2.89 ± 0.48^{a}	3.24 ± 0.52^{a}	2.95 ± 0.30^{a}	$P < 0.001$
SW_{abs} (g)	1.08 ± 0.50^{a}	0.91 ± 0.35^{a}	2.80 ± 1.35^{b}	1.61 ± 0.49^{a}	$P < 0.001$
SW_{rel} (%)	0.29 ± 0.10	0.31 ± 0.10	0.37 ± 0.14	0.37 ± 0.08	–*
AFW_{abs} (g)	4.93 ± 2.34^{a}	3.23 ± 1.91^{a}	19.89 ± 8.19^{b}	7.85 ± 5.02^{a}	$P < 0.001$
AFW_{rel} (%)	1.32 ± 0.50^{a}	1.05 ± 0.47^{a}	2.58 ± 0.85^{b}	1.63 ± 0.66^{a}	$P < 0.001$

[1]gonad W_{abs}, GSI and HSI according to Buchtová *et al.* (2003)
[2]W_{abs} and W_{rel} S-spleen and AF-abdominal fat were not investigated in tench at T_3 age
–*not significantly different at $P < 0.05$

and T_{3+}) related to ploidy level and sex by means of multifactorial ANOVA in Statgraphics 5.0. The effect of increasing age on the studied parameter was evaluated on a dynamic level (T_3 - T_{3+}) separately for each group (F 2*n*, M 2*n*, F 3*n*, M 3*n*) at * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ by means of one-way ANOVA in Excel 97.

RESULTS

The values (mean, S.D.) and statistical significance of the observed parameters in tench at T_3 age in relation to ploidy level (F 2*n* vs. F 3*n*, M 2*n* vs. M 3*n*) and sex (F 2*n* vs. M 2*n*, F 3*n* vs. M 3*n*) are given in Table 1.

The weight of carcass (CW_{abs}), body parts (HW_{abs}, FW_{abs}, VW_{abs}) and organs (GW_{abs}, HPW_{abs}) was significantly higher ($P < 0.001$) in both sexes of the triploid population of tench at T_3 age (the effect of ploidy level). The ratios of these parameters (W_{rel}) in the fish weight were not affected by the ploidy level in tench at T_3 age on the given levels of significance, except for highly significant differences in CW_{rel} ($P < 0.01$) and VW_{rel} ($P < 0.001$) in females of T_3 age.

The effect of sex on CW_{abs} in tench at T_3 age was expressed by a significantly higher ($P < 0.001$) value of CW_{abs} in triploid females; while considering CW_{rel}, a significantly higher value was registered for diploid males of T_3 age ($P < 0.01$). Further effects of sex in both ploidy levels of tench at T_3 age resulted in significantly ($P < 0.001$) higher HW_{abs}, GW_{abs} and VW_{abs} of females. In triploids of T_3 age, there was a higher ratio of HW_{rel} in females ($P < 0.05$) while the males of both ploidy levels showed significantly higher FW_{rel} ($P < 0.001$). Diploid females showed significantly higher values of VW_{rel} ($P < 0.01$). Other parameters were not affected by the sex on the given levels of significance.

The values (mean, S.D.) and statistical significance of the given parameters in tench at T_{3+} age in relation to the ploidy level (F 2*n* vs. F 3*n*, M 2*n* vs. M 3*n*) and sex (F 2*n* vs. M 2*n*, F 3*n* vs. M 3*n*) are given in Table 2.

Triploid females of tench at T_{3+} age were found to have significantly ($P < 0.001$) higher carcass weight (CW_{abs}), body parts (HW_{abs}, FW_{abs}, VW_{abs} and AFW_{abs}) and organs (GW_{abs}, HPW_{abs}, SW_{abs}) as the effect of ploidy level. The effect of ploidy level in males at T_{3+} age was proven as significantly higher ($P < 0.001$) HW_{abs} of triploid males. The ratios of W_{rel} of the observed parameters in the fish weight were not found to be affected by the ploidy level in tench at T_{3+} age, except for AFW_{rel} of females where significantly higher values ($P < 0.001$) were registered for triploids.

The effect of sex on the given parameters was found more expressed in triploids at T_{3+} age. There were significantly higher ($P < 0.001$) weights of CW_{abs}, HW_{abs}, organs (GW_{abs}, HPW_{abs}, SW_{abs}) and AFW_{abs} (and its ratio in the fish weight, AFW_{rel}) of triploid females at T_{3+} age. The values of VW_{abs} were found to be significantly higher ($P < 0.001$) in the females of both ploidy levels. In accordance with those at T_3 age, the males of both ploidy levels at T_{3+} age showed a significantly higher ($P < 0.001$) ratio of FW_{rel}. Compared to diploid males at T_{3+}

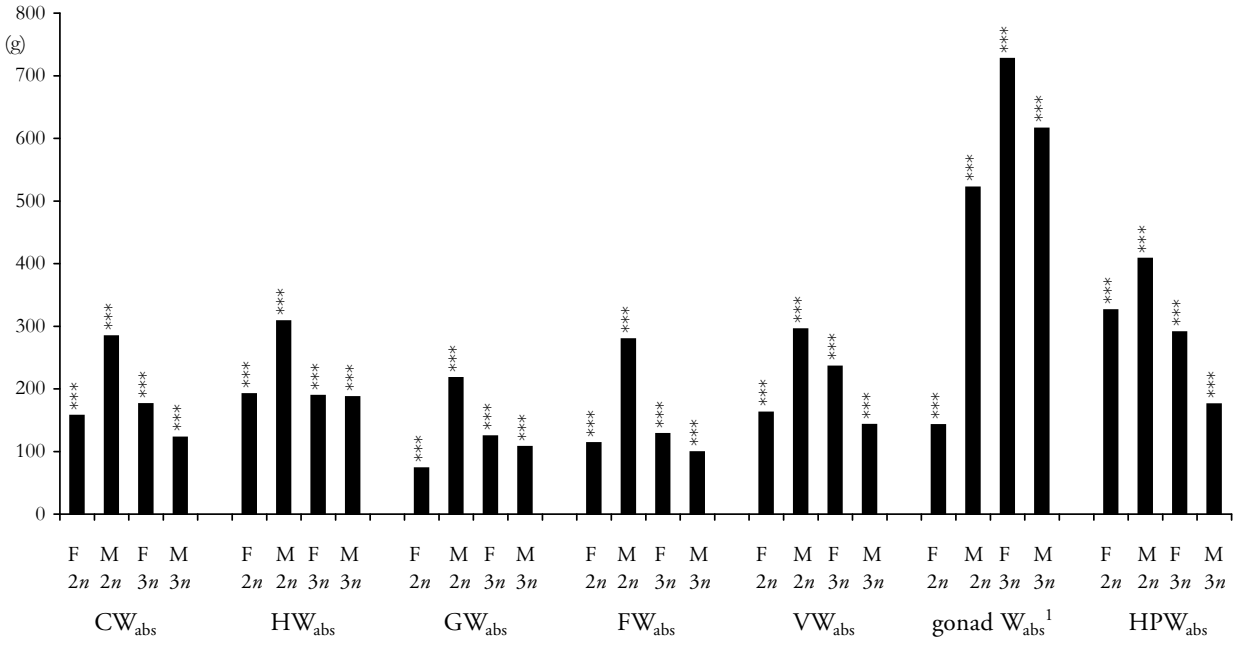

Figure 1. Comparison of the weight W_{abs} of carcass, head, gills, fins, viscera, gonads and hepatopancreas in tench at T_3 (= 100%) and T_{3+} age

[1]according to Buchtová *et al.* (2003)

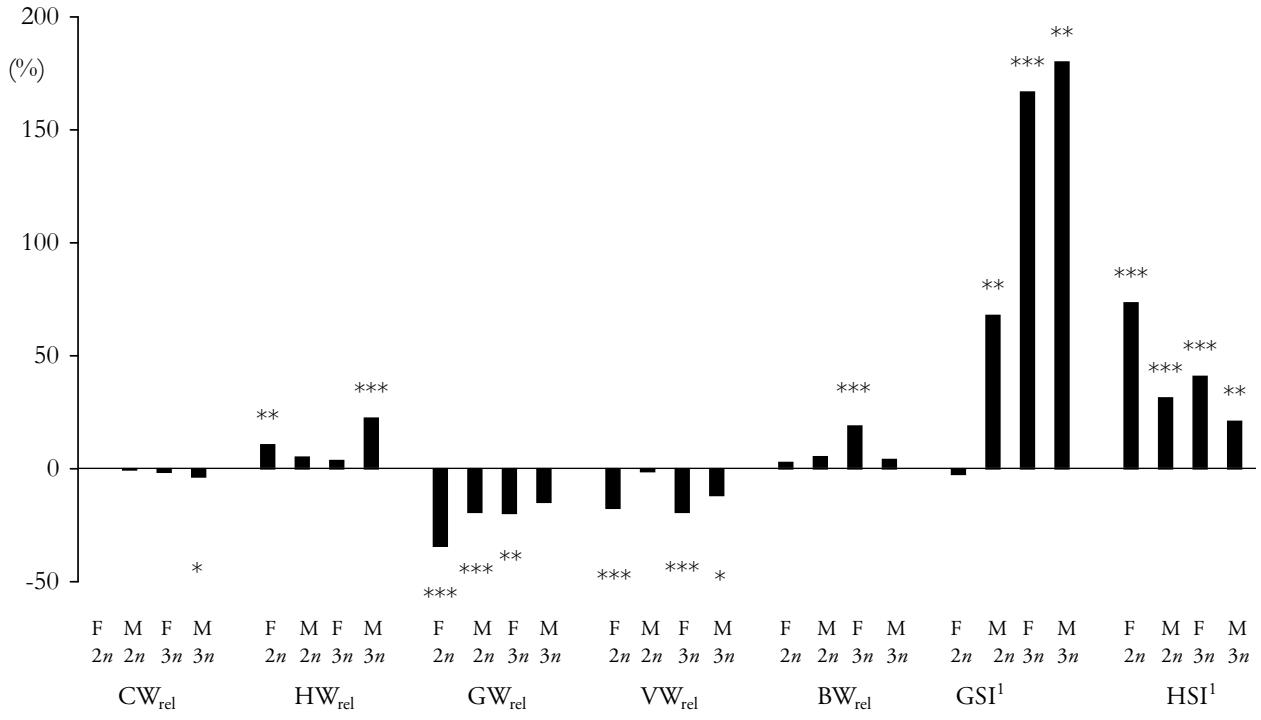

Figure 2. Comparison of the relative weight W_{rel} of carcass, head, gills, fins, viscera, gonads and hepatopancreas in the fish weight in tench at T_3 (= 100%) and T_{3+} age

[1]according to Buchtová *et al.* (2003)

age, diploid females showed a significantly higher ($P < 0.001$) ratio of VW_{rel} and weight of HPW_{abs} as well as a lower ratio of CW_{rel} ($P < 0.01$). The other parameters under study were not significantly affected by the sex at the given probability levels in tench at T_{3+} age.

Figures 1 and 2 show a comparison of the values of the given parameters in percentage of difference occurring due to increasing age of tench. Parameters of tench at T_3 age were taken as 100%. The effects of age on the weight and ratio of spleen and abdominal fat were not determined as they were not checked in tench at T_3 age.

The weight of carcass (CW_{abs}), body parts (HW_{abs}, FW_{abs}) and organs (GW_{abs}, HPW_{abs}) significantly increased with the age of tench ($P < 0.001$) in all groups of tench under study (Figure 1). The most marked differences in weight W_{abs} were registered for diploid males during the observed period $T_3 - T_{3+}$.

The ratios of CW_{rel} in the fish weight were nearly the same in all groups of tench, except for a significant decrease ($P < 0.05$) in triploid males (Figure 2).

Tench at T_{3+} age were found to have significantly lower ratios of FW_{rel} and GW_{rel} in the fish weight, except for triploid (GW_{rel}) and diploid (FW_{rel}) males. No significant effect of age was observed for these parameters (Figure 2). The ratios of HW_{rel} and VW_{rel} were found to be increased with age in all tench groups under study (Figure 2): significant effects were found for HW_{rel} in diploid females ($P < 0.01$) and triploid males ($P < 0.001$) and for VW_{rel} in triploid females ($P < 0.001$).

DISCUSSION

Highly significant differences ($P < 0.001$) in the weight of body parts (CW_{abs}, HW_{abs} and FW_{abs}) determined in tench at T_3 and T_{3+} age in relation to ploidy level (Tables 1 and 2) are associated with growth potential characteristics of triploid individuals (accelerated somatic growth and higher final weight). It was recently described for the same groups of tench at T_3 and T_{3+} age by Buchtová *et al.* (2003). This effect was found by Flajšhans *et al.* (1993) for the same species ten years ago. No statis-

tically significant differences were found for CW_{abs} and FW_{abs} between males at T_{3+}, probably due to different growth of diploid and triploid males in these body parts during the observed period T_3 – T_{3+} (Figure 1).

Marked sex dimorphism described e.g. by Baruš and Oliva (1995) which, apart from other signs, was expressed by the larger size and weight of females was a reason for significant differences ($P < 0.001$) in the values of CW_{abs} (between triploids at T_3 and T_{3+}) and HW_{abs} (except for diploids at T_{3+} age) in the groups of tench under study. However, its effect on FW_{abs} of tench at T_3 and T_{3+} age was not proven at the given level of significance (Tables 1 and 2).

Statistical evaluation of objective parameters CW_{rel}, HW_{rel} and FW_{rel} related to the ploidy level did not prove any significant differences in the ratios of these body parts in the fish weight of tench at T_3 and T_{3+} age. Only the triploid females of tench at T_3 age showed significantly higher values ($P < 0.01$) of CW_{rel}, which was in accordance with our observations on dressing percentage (DP) in the same groups of tench, published elsewhere (Buchtová *et al.*, 2003). Differences in CW_{rel} ($P < 0.01$) of diploid tench at T_3 and T_{3+} age related to sex also referred to these results (Tables 1 and 2).

Sex dimorphism was also demonstrated by significant differences ($P < 0.05$) in HW_{rel} of triploid tench at T_3 age. Its most marked expression was found in FW_{rel}, with significantly higher ratio of fins in the fish weight ($P < 0.001$) in both diploid and triploid males at both age categories. In this fish species, sex dimorphism is also reflected by morphological characteristics of ventral fins (Kvasnička and Flajšhans, 1993) according to which the sex of diploid fish can be safely distinguished already since 15 months of age (Baruš and Oliva, 1995).

Highly significant differences in GW_{abs} ($P < 0.001$) in tench at T_3 and T_{3+} age (Tables 1 and 2) related to the ploidy level (except for males at T_{3+} age) and sex (except for diploid tench at T_{3+} age) can also be associated, apart from the fish size, with different requirements of the organism for oxygen supply to tissues. Triploids and females that are assumed to have different metabolism intensity due to higher food uptake have higher oxygen consumption under identical environmental conditions (Hochachka and Mommsen, 1995). If the water saturation with oxygen is sufficient (above 80%), the process of gill respiration is regulated by the intensity of respiratory motions and increased by the size (weight) of this respiratory organ. No statistically significant differences were registered in the values of GW_{rel} in relation to the ploidy level and sex in tench at T_3 and T_{3+} age.

The weight of internal organs of fish (VW_{abs}) can be affected by various internal factors (age, sex, muscular activity, health) and external factors (water temperature, oxygen content in water, nutrition) (Kouřil *et al.*, 1978). In relation to the ploidy level, triploids of both age categories T_3 and T_{3+} showed significantly higher values of VW_{abs} ($P < 0.001$) in accordance with their growth potential (except for T_{3+} males at the given level of significance). In relation to the sex, higher values were reached by females of both ploidy levels. Diploid females at T_3 and T_{3+} age also had a significantly higher ($P < 0.001$) ratio of VW_{rel} compared to diploid males. These differences in the values of VW_{abs} and VW_{rel} were due to more pronounced differences in the weight of gonads and hepatopancreas in the groups of tench at T_3 and T_{3+} age as well as to those in the weight of abdominal fat in tench at T_{3+} age (Tables 1 and 2).

According to Svobodová (1977) the weight of hepatopancreas highly correlates with the absolute quantity of glycogen deposited in it, and with its ability to retain or release water. The annual proportion of hepatopancreas fluctuates in relation to the seasonal cycle (Kouřil *et al.*, 1978).

In our experiment and in relation to the ploidy level, significantly higher HPW_{abs} ($P < 0.001$) were found for triploids of both age categories (except for males at T_{3+} age), which could probably be associated with higher intensity of food uptake and higher somatic growth of these fish. Neither the content of glycogen in hepatopancreas nor that of water was studied. The effect of sex showed higher values of HPW_{abs} in bigger and heavier diploid and triploid females although a high significance ($P < 0.001$) was found for T_{3+} age only.

Moreover, some other parameters were studied and statistically tested in tench of T_{3+} age. These were $SW_{abs, rel}$ and $AFW_{abs, rel}$. The highest value of SW_{abs} in triploid females at T_{3+} age (Table 2) was the reason for significant differences ($P < 0.001$) in SW_{abs} related to the ploidy level (in females) and sex (in triploids). The values of SW_{rel} were found nearly the same for all tench of T_{3+} age.

The values of AFW_{abs} deposited in the abdominal cavity and of its ratio AFW_{rel} in the fish weight were also found to be the highest in triploid females at T_{3+} age. If compared with the content of

intramuscular fat in the flesh of the same groups of tench of T_{3+} age where no effects of ploidy level or sex were proved (the results of analyses of the basic chemical composition of flesh in identical groups of tench performed by the same authors have not been published yet), we found highly significant differences ($P < 0.001$) in AFW_{abs} and AFW_{rel} between the females at T_{3+} age (the effect of ploidy level) and between the triploids at T_{3+} age (the effect of sex).

Due to the specific composition of fatty acids of fish oils that contain large proportions of PUFA n-3 even in freshwater fish (Steffens *et al.*, 1998; Quiros and Alvariňo, 1998; Vácha and Tvrzická, 1998), it is possible to anticipate the presence of these essential fatty acids also in abdominal fat of fish. However, the published data on fat composition concern the intramuscular fat exclusively. No due attention has been paid to qualitative and quantitative analyses of waste abdominal fat of freshwater fish yet although the waste fish fats could become a potential domestic source of PUFA n-3, namely for inland countries.

The effect of increasing age on W_{abs} values of the studied body parts and organs (C, H, F, G, V) was found to be significant for all tench groups ($P < 0.001$) and it was mostly expressed in diploid males (Figure 1). This was in accordance with the assessment of biometric and weight parameters in the same groups of tench (Buchtová *et al.*, 2003).

A significant increase in HW_{rel} by about 22% ($P < 0.001$) was found responsible for a 4% decrease in CW_{rel} ($P < 0.05$) in triploid males as a function of age as it was registered by this team of authors (Figure 2). In diploid females, the increase in HW_{rel} by about 11% ($P < 0.01$) had no effect on the CW_{rel} value.

A decreasing trend of the ratio of gills (GW_{rel}) and fins (FW_{rel}) in the fish weight was found due to changes in the weight parameters (GW_{abs}, FW_{abs} : fish weight) of the studied groups of tench in relation to age. The lower ratio of gills in tench at T_{3+} age could be associated with lower requirements of this category for oxygen consumption compared to T_3 fish. Svobodová *et al.* (1987) dealt with requirements for oxygen consumption in various age categories of common carp (*Cyprinus carpio*, L.). They reported decreasing oxygen requirements by the following indices: $C_1 = 1$; $C_2 = 0.5–0.7$; $C_3 = 0.3–0.4$.

From the anatomical aspects, there was an interesting decrease in the ratio of gills (GW_{rel}) with simultaneous increase in the ratio of head (HW_{rel}) in the fish weight related to age. The increasing ratio of head (HW_{rel}) in higher age categories of tench could probably be associated with increasing values of HW_{abs} due to the higher proportion of flesh and probably also of subcutaneous fat on the head.

This hypothesis was based on the results of the effect of age on the deposition of intramuscular fat in the same groups of diploid and triploid tench at T_3 and T_{3+} age, despite of the fact that the content of fat significantly increased ($P < 0.05$) in the flesh of triploid females only (the results of analyses of the basic chemical composition of flesh in identical groups of tench performed by the same authors have not been published yet).

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REFERENCES

Baruš V., Oliva O. (1995): Lampreys – *Petromyzontes* and fishes – *Osteichthyes* (2). Academia, Praha. 80–89.

Buchtová H., Vorlová L. (2002): Culture, selective breeding and genome manipulations of tench in the Czech Republic. A Review. Folia Vet., *46*, 109–112.

Buchtová H., Svobodová Z., Flajšhans M., Vorlová L. (2003): Analysis of growth, weight and relevant indices of diploid and triploid population of tench (*Tinca tinca*, Linnaeus 1758). Aquacult. Res., *33*, 1–8.

Flajšhans M. (1997a): Reproduction sterility caused by spontaneous triploidy in tench (*Tinca tinca*). Pol. Arch. Hydrobiol., *44*, 39–45.

Flajšhans M. (1997b): A model approach to distinguish diploid and triploid fish by means of computer-assisted image analysis. Acta Vet., *66*, 101–110.

Flajšhans M., Linhart O. (2000): The Production of Triploid Tench (in Czech). VÚRH Vodňany, Edice Metodik, *62*, 2–14.

Flajšhans M., Linhart O., Kvasnička P. (1993): Genetic studies of tench (*Tinca tinca* L.): induced triploidy and

tetraploidy and first performance data. Aquaculture, *113*, 301–312.

Hochachka P.W., Mommsen T.P. (1995): Metabolic Biochemistry (Biochemistry and molecular biology of fishes). 1st ed. Elsevier, Amsterdam. 515 pp.

Jirásek J., Laudát M. (1984): Consumption value of tench from various conditions of pond culture (in Czech). Sborník referátů ze semináře v Českých Budějovicích. In: Československá vědeckotechnická společnost, rybářská sekce, 68–76.

Kouřil J., Hamáčková J., Svobodová Z. (1978): Fluctuation of relative hepatopancreas weight in the course of the year in brood tench (*Tinca tinca* L.) kept in ponds (in Czech). Bulletin VÚRH Vodňany, *4*, 7–11.

Kvasnička P., Flajšhans M. (1993): A method of morphological identification of triploids in young broodstock of tench (in Czech). VÚRH Vodňany, Edice Metodik, *42*, 5–8.

Quirós M., Alvariño J.M.R. (1998): Major fatty acid composition and lipid content in tench (*Tinca tinca*). A comparison between two different culture systems. Pol. Arch. Hydrobiol., *45*, 347–351.

Sedláček P. (1999): Study on selected morphological, physiological and utility parameters of triploid tench (in Czech). [Graduate theses.] Mendel University of Agriculture and Forestry in Brno, 81 pp.

Steffens W., Wirth M., Füllner G. (1998): Fatty acid composition of tench (*Tinca tinca* L.) under different nutritional conditions. Pol. Arch. Hydrobiol., *45*, 353–359.

Svobodová Z. (1977): Hepatopankreas kapra: vztah hmotnosti k obsahu glykogenu. Bulletin VÚRH Vodňany, *2*, 22–24.

Svobodová Z., Gelnarová J., Justýn J., Krupauer V., Máchová J., Simanov L., Valentová V., Vykusová B., Wohlgemuth E. (1987): Toxikologie vodních živočichů. SZN, Praha, Středisko interních publikací, 97–100.

Svobodová Z., Kolářová J., Flajšhans M. (1998): The first findings on the differences in complete blood count between diploid and triploid tench, *Tinca tinca* L. Acta Vet., *67*, 243–248.

Svobodová Z., Flajšhans M., Kolářová J., Modrá H., Svoboda M., Vajcová V. (2001): Leukocyte profiles of diploid and triploid tench, *Tinca tinca L.* Aquaculture, *198*, 159–168.

Vácha F., Tvrzická E. (1998): Polyunsaturated fatty acid proportion in fat of tench (*Tinca tinca*) under different rearing conditions. Pol. Arch. Hydrobiol., *45*, 337–346.

Vindelov L.L., Christensen I.J. (1990): Review of techniques and results obtained in one laboratory by an integrated system of methods designed for routine clinical flowcytometric DNA analysis. Cytometry, *11*, 753–770.

Zięcik M., Sławiński I. (1965): Skład chemiczny i wagowy ryb. IV. Skład chemiczny i wagowy części jadalnych i odpadów lina (*Tinca tinca* L.) pochodzącego z jeziora Legińskiego, w biologicznym cyklu rocznym. Zesz. Nauk. WSR w Olsztynie, *20*, 17–35.

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ABSTRAKT

Analýza jateční výtěžnosti diploidní a triploidní populace lína obecného (*Tinca tinca*, Linnaeus 1758)

Cílem práce bylo stanovení rozdílů v hmotnosti (W_{abs}) C-očištěného $trupu_{bez\ hlavy,\ ploutví\ a\ vnitřních\ orgánů}$ a odpadních částí těl (H-$hlava_{bez\ žaber}$, F-$ploutve_{párové\ i\ nepárové}$, u línů T_{3+} i AF-vnitřní tuk) a orgánů (G-žábra, V-$vnitřní\ orgány_{suma}$, z toho: HP-hepatopankreas, u línů T_{3+} i S-slezina) a jejich podílu na celkové hmotnosti (W_{rel}) mezi diploidními (2*n*) a triploidními (3*n*) líny identické genetické specifikace a chovných podmínek v závislosti na pohlaví (F-female vs. M-male) a věku ryb (T_3 vs. T_{3+}). Celkem bylo analyzováno 137 sourozenců lína obecného. Kontrolní skupinu tvořilo 72 línů 2*n* (39 F a 33 M) a experimentální skupinu 65 línů 3*n* (38 F a 27 M). Vliv ploidie se projevil u jikernaček T_3 a T_{3+} vysoce signifikantně ($P < 0{,}001$) vyššími hodnotami W_{abs} (C, H, G, F, V, HP) a u jikernaček T_{3+} i hodnotami W_{abs} (S, AF) ve prospěch 3*n* samic. Triploidní jikernačky T_3 vykazovaly vysoce signifikantně vyšší hodnoty CW_{rel} ($P < 0{,}01$) a nižší hodnoty VW_{rel} ($P < 0{,}001$), ve věkové kategorii T_{3+} pak vysoce signifikantně vyšší hodnoty AFW_{rel} ($P < 0{,}001$). U triploidních mlíčáků T_3 byly zjištěny v důsledku vlivu ploidie vysoce signifikantně ($P < 0{,}001$) vyšší hodnoty W_{abs} (C, H i u T_{3+}, G, F, V, HP) ve srovnání s M 2*n* líny. Vliv pohlaví se u 2*n* línů T_3

a T_{3+} projevil vysoce signifikantně vyššími hodnotami CW_{rel} ($P < 0,01$) a FW_{rel} ($P < 0,001$) a nižšími hodnotami $VW_{abs, rel}$ ($P < 0,001$) u mlíčáků. U $2n$ mlíčáků T_3 byly zjištěny i vysoce signifikantně ($P < 0,001$) nižší hodnoty W_{abs} (H, G) a ve věkové kategorii T_{3+} i nižší hodnoty HPW_{abs}. U $3n$ línů T_3 a T_{3+} se vliv pohlaví projevil vysoce signifikantně ($P < 0,001$) vyššími hodnotami W_{abs} (C, H, G, V) a nižšími hodnotami FW_{rel} ($P < 0,001$) u triploidních samic. U $3n$ jikernaček T_3 byly zjištěny průkazně ($P < 0,05$) vyšší hodnoty HW_{rel} a u věkové kategorie T_{3+} i vysoce průkazně ($P < 0,001$) vyšší hodnoty W_{abs} (HP, S, AF) a dále hodnoty AFW_{rel}. V závislosti na zvyšujícím se věku línů vzrostla vysoce signifikantně ($P < 0,001$) hmotnost trupu (CW_{abs}), částí těla (HW_{abs}, FW_{abs}) a orgánů (GW_{abs}, HPW_{abs}) u všech sledovaných skupin ryb.

Klíčová slova: diploidní a triploidní lín; genomová polyploidie; hmotnost a podíl; hlava; ploutve; žábra; vnitřní orgány; vnitřnostní tuk

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