Effect of age upon retention of mercury in chickens with a different growth rate

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ABSTRACT: Retention of total mercury was examined in groups of 95 slowly-growing laying type chickens and 52 fast-growing broiler hybrids in 47 subsequent balance periods from 1 to 100 days of age. Chickens were fed *ad libitum* on a diet containing 5.41 μg of Hg per kilogram. Until Day 4 the values of coefficients of apparent retention of Hg were negative or very low. They were influenced by excretion of endogenous nutrients originating primarily from the yolk sac. When evaluating the period of 4 to 100 days of age, the dependence of Hg retention coefficients upon age was highly significant ($P < 0.01$). The course of this dependence was expressed by parabolas for laying type chickens with the maximum value at Day 61 of age and for broilers with the minimum value at Day 53. In fast growing chickens, Hg content in body gain decreased until Day 14 and then increased while in slow growing chickens it was linearly increasing for the whole experimental period. The average coefficients of Hg retention from the feed mixture were 48.18 ± 0.719 (mean ± SEM) and 47.90 ± 1.057% and Hg retained per g of live body gain were 7.494 ± 0.4682 and 6.775 ± 0.6233 ng in laying and meat type cockerels, respectively. The difference between hybrids was insignificant ($P > 0.05$). The growth rate of total amount of Hg in the body was lower ($P < 0.01$) than that of body weight of chickens, allometric coefficients were 0.706 and 0.747 for slow and fast growing chickens, respectively.

Keywords: poultry; deposition of mercury; allometry of growth

Mercury contamination of food chain can represent a risk factor both for animal and human health. For farm animals, European Commission Directive 2005/8/EC permitted the maximum content of Hg 0.1 mg/kg of complete feedstuffs. Until now, there have been no claims that Hg is an essential constituent of the diet for any species (Underwood and Suttle, 1999).

Inorganic forms of Hg are poorly absorbed; the range was variously quoted 5–15% of intake (Clarkson, 1987) and 1–3% (Kostial et al., 1978), but in very young animals 30–40% of intake (Kostial et al., 1978). Methylmercury is a more available form of Hg (Underwood and Suttle, 1999). Houserova et al. (2005) found the highest mercury concentration (39.2 mg/kg dry matter) in liver of an adult population of cormorant (*Phalacrocorax carbo*) while the content of mercury in younger individuals it was approximately six-times lower (5.8 mg/kg DM). Srebocan et al. (2007) mentioned that with the increasing age the concentration of Hg in the organism of bluefin tuna (*Thunnus thynnus*) increased as well. Goutner et al. (2001) did not find significant correlation of mercury levels in feathers of squacco heron (*Ardeola ralloides*) with age. We did not find any literature data on Hg accumulation in chickens.

The objective of this research was to determine the differences in toxicodynamics of mercury in the body of chickens with different growth rate. Influence of age on the retention of total Hg was investigated in laying- and meat-type chickens. To evaluate the effect of age as exactly as possible, it is necessary to carry out a great number of estimations within very short time intervals during a longer period of life.

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MATERIAL AND METHODS

The effect of age on the apparent Hg retention was studied using 95 Isa Brown slow growing laying type cockerels (SG) and 52 fast growing Ross (FG) meat type male chickens. This was the same experiment in which the effect of age upon utilization of selenium was studied (Zelenka and Fajmonova, 2005).

Chickens of each group were kept in four balance cages. Data collection began at Day 2. Until Day 22 of age the retention was estimated in one-day balance periods and from Day 22 until the end of experiment at the age of 100 days in three-day subsequent periods. In each balance period, excreta of groups SG and FG were collected daily and pooled from all four balance cages. Chickens were fed on a practical type of starter diet during the whole experimental period. The diet contained 225 g of crude protein, 12.06 MJ nitrogen-corrected metabolizable energy, and 5.41 μg of Hg per kilogram.

The feed was supplied *ad libitum* and its consumption within each group was recorded. Body weight of chickens was measured at the end of each balance period. The coefficients of Hg retention were estimated using the chromic oxide indicator method. When using this method, individual balance periods can follow sequentially without periods of starvation. The content of chromic oxide in feed and freeze-dried excreta was estimated iodometrically (Mandel et al., 1960). The method used for the determination of total Hg was described by Houserova et al. (2006). Homogenized solid samples were directly weighed into pre-cleaned combustion boats, and inserted into the Advanced Mercury Analyser AMA 254 (Altec, Prague, Czech Republic). The samples were dried at 120°C for 90 s and thermally decomposed at 550°C for 180 s under oxygen flow. The selectively trapped Hg was released from the amalgamator by a brief heat-up and finally quantified as Hg^0 by cold-vapor atomic absorption spectroscopy technique at a wavelength of 253.65 nm.

The contents of Hg in the live body gains (ng/g) were calculated using feed intake, content of Hg in the diet, coefficients of their utilisation, and body weight increments in each of balance period.

The regressions of determined values were computed according to Snedecor and Cochran (1967). For the regression and other statistical analyses the daily results from Day 4 to Day 22 were used. Thereafter, data for each three-day period were used. For the expression of the relationship between Hg retained in the body and body weight of chicken, a power function (Brody, 1945) was used

$$Y = aX^b$$

where:

Y = content of Hg in the body in μg

X = live body weight of chicken in g

a = extrapolation of Y for $X = 1$

b = allometric coefficient (i.e., the ratio of the percentage of change in Y to the corresponding percent change in X).

Significances were considered at $P \leq 0.05$ and $P \leq 0.01$.

RESULTS AND DISCUSSION

Dependences of body weight in g (Y) upon the age of chickens in days (X) were described by equations

$$Y_{SG} = 27.9 + 3.42X + 0.4013X^2 - 0.00197711X^3 \quad (r = 0.999;\ P < 0.01)$$

$$Y_{FG} = 90.5 - 3.79X + 1.7314X^2 - 0.01040439X^3 \quad (r = 0.999;\ P < 0.01)$$

and dependences of daily feed consumption in g upon age by equations

$$Y_{SG} = 1.0 + 1.53X - 0.0026X^2 \quad (r = 0.994;\ P < 0.01)$$

$$Y_{FG} = 7.5 + 2.77X + 0.0331X^2 - 0.00042826X^3 \quad (r = 0.982;\ P < 0.01)$$

for SG and FG, respectively. Growth curves of FG and SG chickens and their daily feed consumptions are presented in Figure 1. In FG cockerels, feed intake decreased during the last balance periods and their growth rate was also reduced. At 100 day of age, the body weight of FG and SG cockerels were 6 640 g and 2 411 g, respectively.

During the second day after hatching, chickens excreted more Hg than they consumed. Until Day 4, the values of coefficients of apparent retention of Hg were negative or very low in both hybrids and lower in SG than in FG chicks (Table 1). Observed changes could be explained on the basis of excretion of endogenous nutrients originating primarily from the yolk sac (Zelenka and Fajmonova, 2005) and of the difference between hybrids by different feed intake.

When evaluating the period of 4 to 100 days of age, the average coefficients of Hg retention from the feed mixture were 48.18 ± 0.719 (mean ± stand-

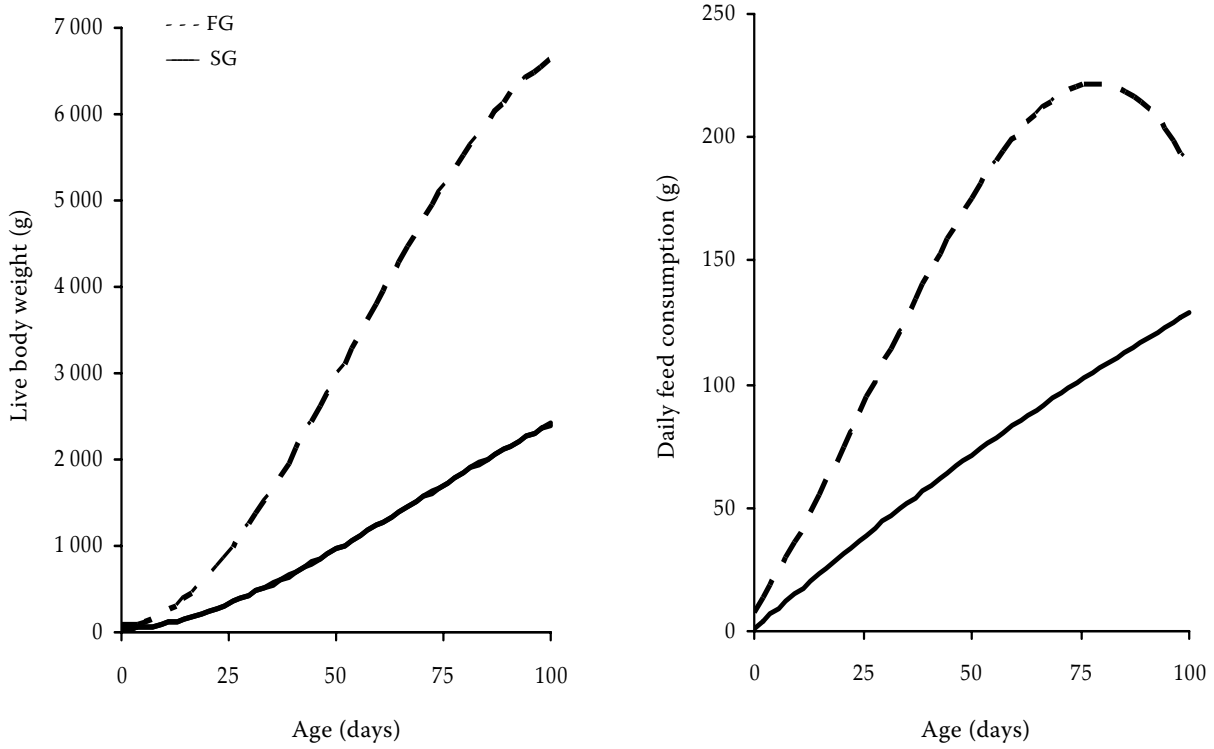

Figure 1. Live body weight of chickens and daily feed consumption (SG, slow growing chickens; FG, fast growing chickens)

ard error of the mean) and 47.90 ± 1.057 % for SG and FG, respectively. Values recorded in our experiments were higher than those mentioned by Clarkson (1987) and Kostial et al. (1978). SG and FG retained 2.61 ± 0.039 and 2.59 ± 0.057 ng of Hg, respectively, per gram of consumed feed mixture. The difference between hybrids was not significant ($P > 0.05$).

The dependence of Hg retention in % (Y) upon the age of chickens in days (X) for SG was described by the second degree parabola (r = correlation coefficient) $Y_{SG} = 42.22 + 0.2923X - 0.00239484X^2$ ($r = 0.504$; $P < 0.05$) with the maximum of 51.14% at 61 days of age and for FG by equation $Y_{FG} = 56.00 - 0.4787X + 0.00453951X^2$ ($r = 0.476$; $P < 0.01$) with the minimum of 43.38% at 53 days of age (Figure 2).

In the period of 4 to 100 days of age, the calculated amounts of Hg retained per g of live body gain in laying and meat type cockerels were 7.494 ± 0.4682 and 6.775 ± 0.6233 ng, respectively. The difference between hybrids was insignificant ($P > 0.05$). Such content of Hg cannot endanger consumers. On the base of Opinion of the Scientific Panel on Contaminants in the Food Chain of the European Food Safety Authority (EFSA) on a request from the European Commission related to Hg and methylmercury in food, Commission Regulation (EC)

Table 1. Daily intake and excretion of Hg in the first days of life

Age of chicks (days)	Hg intake (μg)		Hg excretion (μg)		Coefficient of Se retention	
	SG	FG	SG	FG	SG	FG
2	0.00874	0.03055	0.01635	0.03261	–87.03	–6.76
3	0.02184	0.05302	0.02070	0.02787	5.25	47.44
4	0.03665	0.08185	0.02546	0.04179	30.53	48.95

SG = slow growing chicks; FG = fast growing chicks

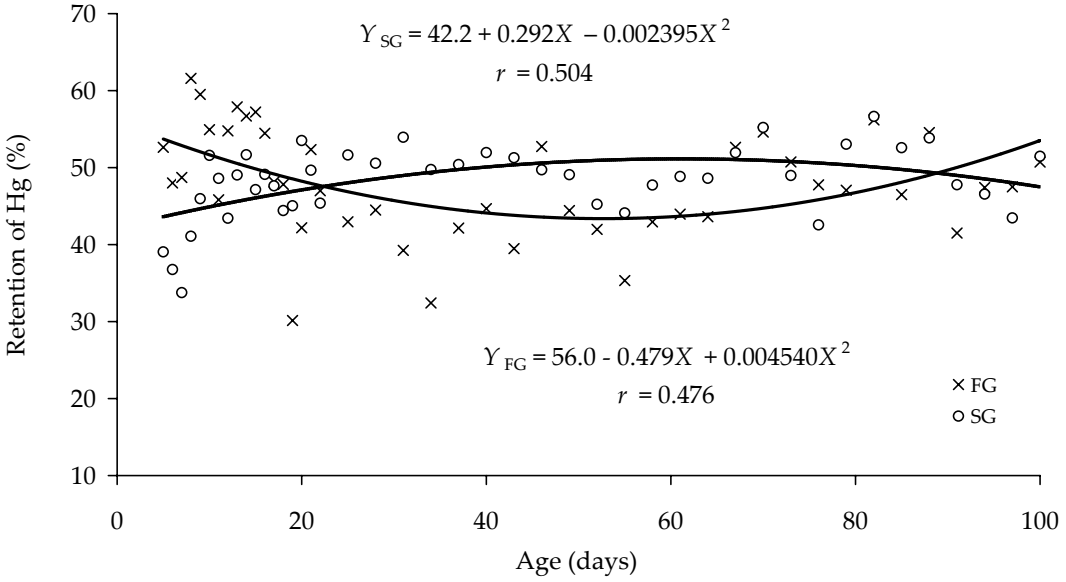

Figure 2. Retention of mercury

No 1881/2006 endorsed the provisional tolerable weekly intake of 1.6 μg/kg of body weight.

Dependence of Hg retention in ng/g of BW gain upon age of SG chickens was expressed by linear regression equation $Y_{SG} = 3.344 + 0.0977X$ ($r = 0.950$; $P < 0.01$) with no significant deviation from linearity. In FG, the relationship between Hg content in body gain and age was markedly non-linear ($P < 0.01$) and was expressed by the equation $Y_{FG} = 4.226 - 0.0439X + 0.00163916X^2$ ($r = 0.899$; $P < 0.01$) with the minimum at Day 14 of age (Figure 3).

We did not find any literary data on Hg accumulation allometry in chickens. In our experiment, relationships between the total amount of Hg in the body (μg) and body weight of chicken (g) were expressed by the equations for Day 4 to 100 $Y_{SG} = 0.0269\ X^{0.7056}$ ($r = 0.986$) and $Y_{FG} = 0.0194\ X^{0.7469}$ ($r = 0.979$). Correlation coefficients were highly significant ($P < 0.01$).

In conclusion, the growth rate of the total amount of Hg in the organisms of SG and FG were by 29 and 25%, respectively, lower than that of body weight.

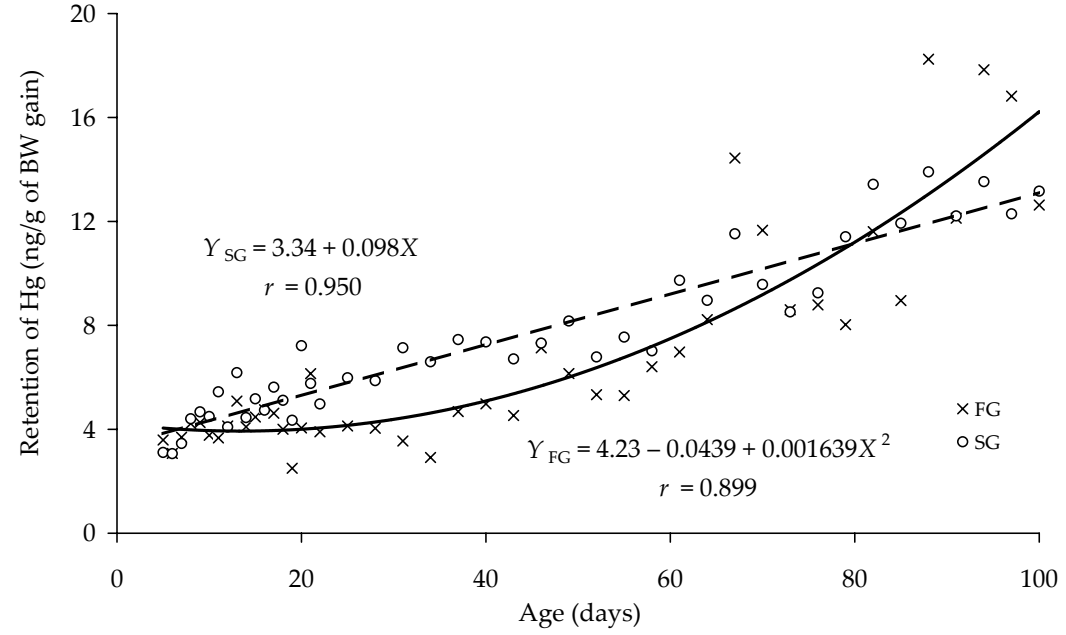

Figure 3. Mercury retained in body weight gain

This means that the Hg concentration in the body decreases with the age. The level of mercury in chickens fed by common type of feed mixture cannot endanger consumers.

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