Big houses, big cars, superguppies and the costs of producing sperm

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Life history theory assumes that the investment in reproduction is constrained by trade-offs with survival, because resources are limited and their allocation to different costly tasks cannot proceed independently [1-3]. Negative genetic correlations are therefore expected to arise, for example, between reproduction and survival, and, in polyandrous species, between pre- and postcopulatory traits [4, 5]. Because producing competitive ejaculates is costly, an increased postcopulatory success can only be attained at the expenses of traits involved in mate acquisition and/or survival. Interspecifically, increased levels of sperm competition are nearly universally associated with increased sperm production, yet the evolutionary consequences of sperm production at the intraspecific level are much less known. Using artificial selection, we investigated the trade-offs between sperm number and both reproductive (pre- and post-copulatory) and survival traits in the guppy (*Poecilia reticulata*), a species in which the number of sperm is the main predictor of postcopulatory success [6].

Methods

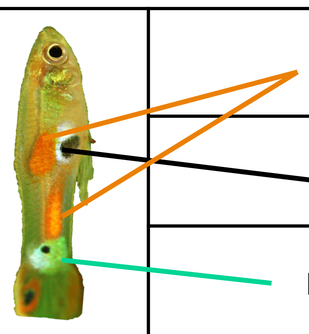
We performed a bi-directional artificial selection experiment for sperm production (no. of sperm stripped at rest) by selecting, at each generation, 20 males out of 100 with highest sperm (HSP) and lowest sperm production (LSP), + 1 unselected control group. Each selection line was replicated twice. Male traits were measured in the 1st and 2nd generation of selection (F1 and F2). See table 1 for details.

Results

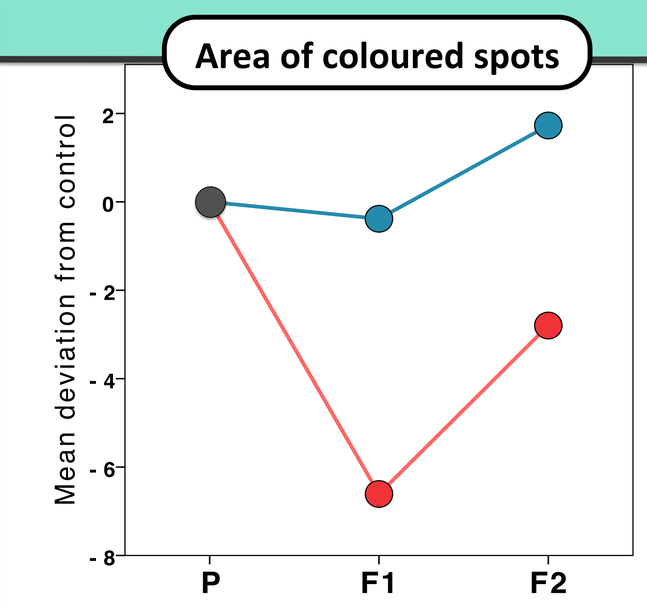
Sperm production in HSP and LSP lines differed significantly from the control group (F1: $F_{2,109} = 34.33$, $p < 0.001$; F2: $F_{2,370} = 38.19$, $p < 0.001$) and this effect was consistent across replicates.

Table 1 shows the effect of selection for sperm production on other fitness related male traits and the relative statistical test for HSP / LSP comparison. In all cases in which selection lines were significantly different, HSP males performed relatively better than LSP males.

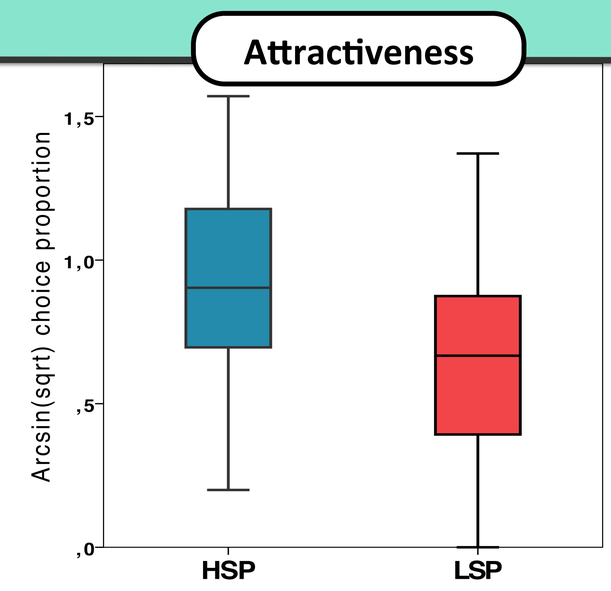
Table 1

Pre-copulatory traits	
Sexual behaviour (Courtship + Sneaky attempts)	F1: $t_{58} = 2.20$, $p = 0.032$
Attractiveness to females (dichotomous choice test)	F1: $F_{1,27} = 5.43$, $p = 0.03$
Standard length	F1: $t_{193} = 2.39$, $p = 0.018$ F2: $t_{341} = 2.69$, $p = 0.007$
Area of coloured spots  Orange	F1: $t_{193} = 3.61$, $p < 0.001$ F2: $t_{322} = 6.75$, $p < 0.001$
Black	F1: $t_{193} = 7.30$, $p < 0.001$ F2: $t_{341} = 2.32$, $p = 0.021$
Iridescent	F1: $t_{193} = 4.06$, $p < 0.001$ F2: $t_{333} = 2.98$, $p = 0.003$
Post-copulatory traits (F2 only)	
Sperm velocity (computer assisted sperm analysis)	$t_{202} = 0.3$, $p = 0.735$
Sperm viability *in vitro*	$t_{172} = 3.34$, $p = 0.019$
Sperm size (total length)	$t_{159} = -0.20$, $p = 0.843$
Insemination efficiency (no. of sperm transferred during cooperative mating with unselected female)	$F_{1,44} = 5.86$, $p = 0.021$
Traits subject to natural selection (F1 only)	
Condition (evasion test from simulated predator)	$t_{58} = -1.12$, $p = 0.267$
Sexual Maturity (time from birth until sexual maturity occurred)	$t_{69} = 2.64$, $p = 0.010$
Growth rate (mm/day from birth to sexual maturity)	$t_{69} = 2.97$, $p = 0.004$

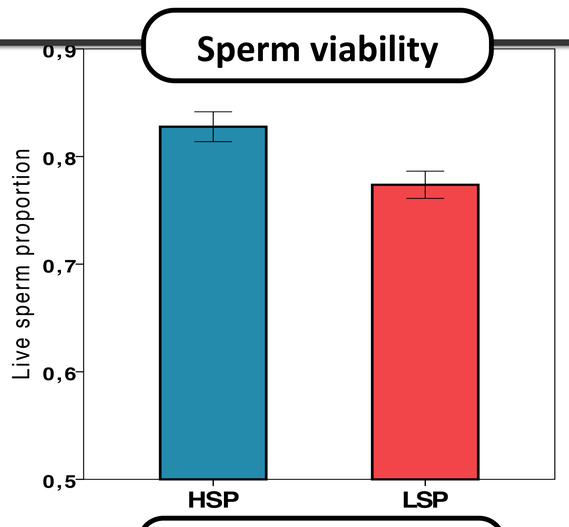
Area of coloured spots



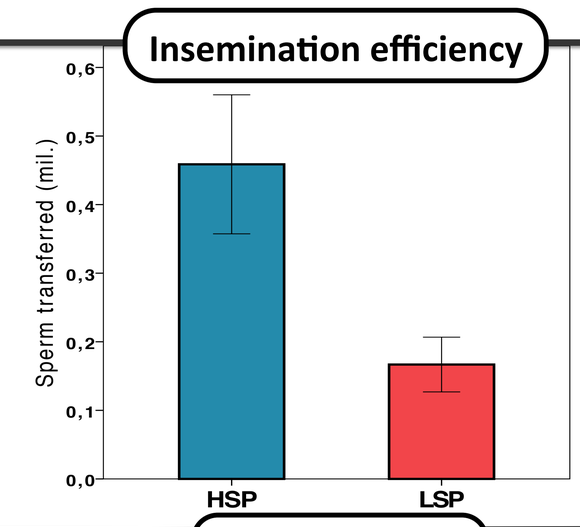
Attractiveness



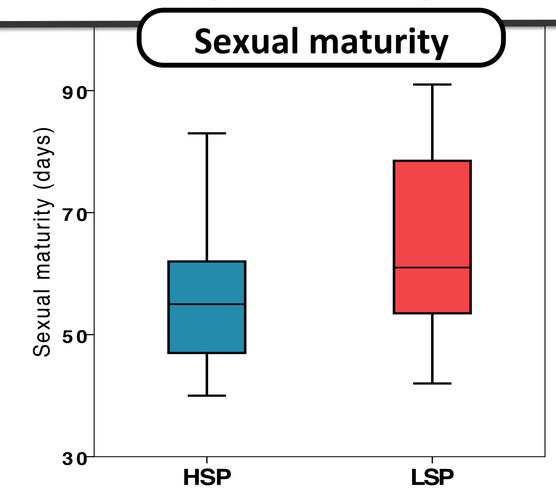
Sperm viability



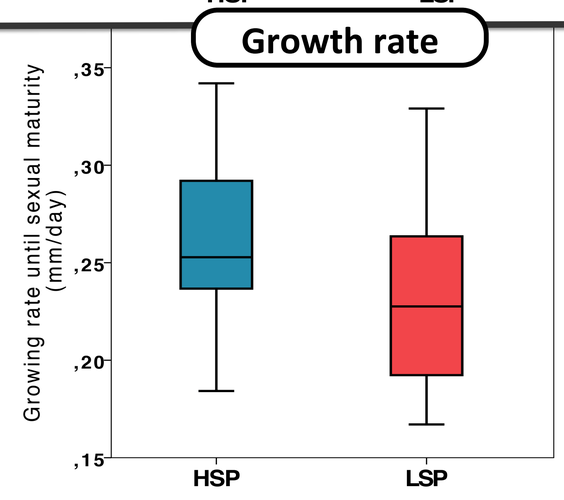
Insemination efficiency



Sexual maturity



Growth rate



Conclusions

Contrary to prediction, we did not find evidence of negative genetic correlation between sperm number and the other fitness related traits examined. In contrast, we found several positive correlations between sperm number and other important traits subject to sexual and natural selection.

These results may have several explanations:

1) **live fast-die young**: higher fitness of HSP males early in life (most of our measures were taken when males were ≤5 months) may be compensated by a shorter mean lifespan
2) **genetic x environment interactions**: LSP males may have higher performance in less favourable environments (food scarcity, predators)
3) **big cars, big houses hypothesis**: genetic variance for resource acquisition (condition) is greater than variance for resource allocation, leading males investing more resources in sperm production to perform better in many different tasks [7]. This may occur because the population is not at the equilibrium, or because condition is determined by the load of deleterious mutations (genic capture hypothesis).

Ongoing experiments are testing which of the three hypotheses is the most likely explanation for the observed pattern.

References

1. Roff. D. A. 1992 *The evolution of life histories*. Chapman & Hall.
2. Roff. D. A. 2002 *Life history evolution*. Sinauer Associates.
3. Stearns. S. C. 1992 *The evolution of life histories*. Oxford University Press.
4. Parker. G. A.. Lessells. C. M. & Simmons. L. W. *Evolution* **67**. 95–109.
5. Parker. G. A.. Immler. S.. Pitnick. S. & Birkhead. T. R. 2010 *Journal of Theoretical Biology* **264**. 1003–1023.
6. Boschetto. C.. Gasparini. C. & Pilastro. A. 2011. *Behav Ecol Sociobiol* **65**. 813–821
7. Reznick, D., Nunney, L. & Tessier, A. 2000. *Trends Ecol Evol* **15**, 421–425.