



读书报告

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Interactions of long-term food ration variation and short-term fasting on insulin-like growth factor-1 (IGF-1) pathways in copper rockfish (*Sebastes caurinus*)



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ABSTRACT

Variation in food intake affects somatic growth by altering the expression of hormones in the somatotrophic endocrine axis including insulin-like growth factor-1 (IGF-1). Here, we examined IGF-1 pathway responses to long- and short-term variation in food availability in copper rockfish (*Sebastes caurinus*), a nearshore Pacific rockfish important for commercial and recreational fisheries. Juvenile copper rockfish were raised under differing ration amounts (3% or 9% mass feed g^{-1} fish wet mass day^{-1}) for 140 d to simulate 'long-term' feeding variation, after which some fish from both rations were fasted for 12 d to generate 'short-term' conditions of food deprivation. Rockfish on the 9% ration treatment grew more quickly than those on the 3% ration and were larger in mass, length, and body condition (k) after 152 d. Fish on the 9% ration had higher blood glucose than those on the 3% ration, with fasting decreasing blood glucose in both ration treatments, indicating that both long-term and short-term feed treatments altered energy status. Plasma IGF-1 was higher in rockfish from the 9% ration

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研究背景

食物的可利用性和营养成分可通过多种激素的分泌（生长激素和胰岛素样生长因子等）来影响鱼类体细胞生长。



在脊椎动物中，GH通过促进组织中的某些代谢过程（如增加脂肪组织中的脂肪分解、提高肝脏对甘油三酯的吸收等）直接调节生长，并通过刺激包括IGF-1，IGFBPs在内的生长相关激素的合成和释放间接调节生长（Bergan Roller, 2018年）。



在鱼类(如斑马鱼, 罗非鱼)和其他脊椎动物的实验中研究发现, 禁食或营养的变化会改变血浆IGF-1浓度。

尽管有大量的研究探讨食物供应如何影响鱼类的GH/IGF-1信号传导, 但在铜石鱼中, 先前的食物供应是否会改变禁食对IGF-1产生的影响或外周组织对IGF-1的敏感性依然是未知的。



本实验以9%或3%的食物配给量喂养铜石鱼140天，然后禁食12天，探究长期摄食量差异和短期禁食对IGF-1通路的影响。



材料与方法

铜石鱼(24.54g)

3%投饲量

9%投饲量

长期饲养

饲养140d, 在第28, 58, 87, 120, 140d称重。

短期禁食或继续饲养

每组鱼一部分禁食12d, 另一部分鱼继续饲养。在第152d, 取血液, 肝脏和肌肉组织。

生长指标

血液指标

生长相关基因表达量

长期摄食量变化和短期禁食对IGF-1通路的影响



结果分析

3.1 日粮引起的体型，肥满度和生长率变化

Ration-induced variation in body size, condition factor (k), and growth rate

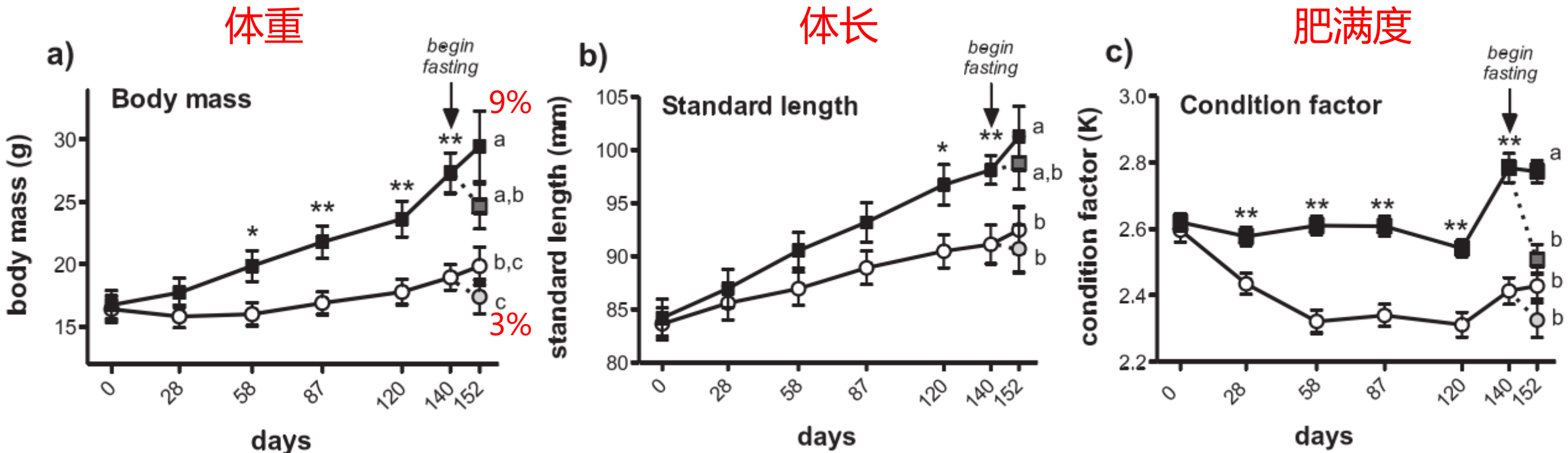


Fig. 1. Mean (\pm SEM) values of (a) body mass, (b) standard length, and (c) body condition factor (k) for juvenile copper rockfish reared under the 9% (dark squares) or 3% (light circles) ration (% wet wt.) treatments for 140 d, and then either fasted (dotted line) or continually fed for 12 d (days 140–152).

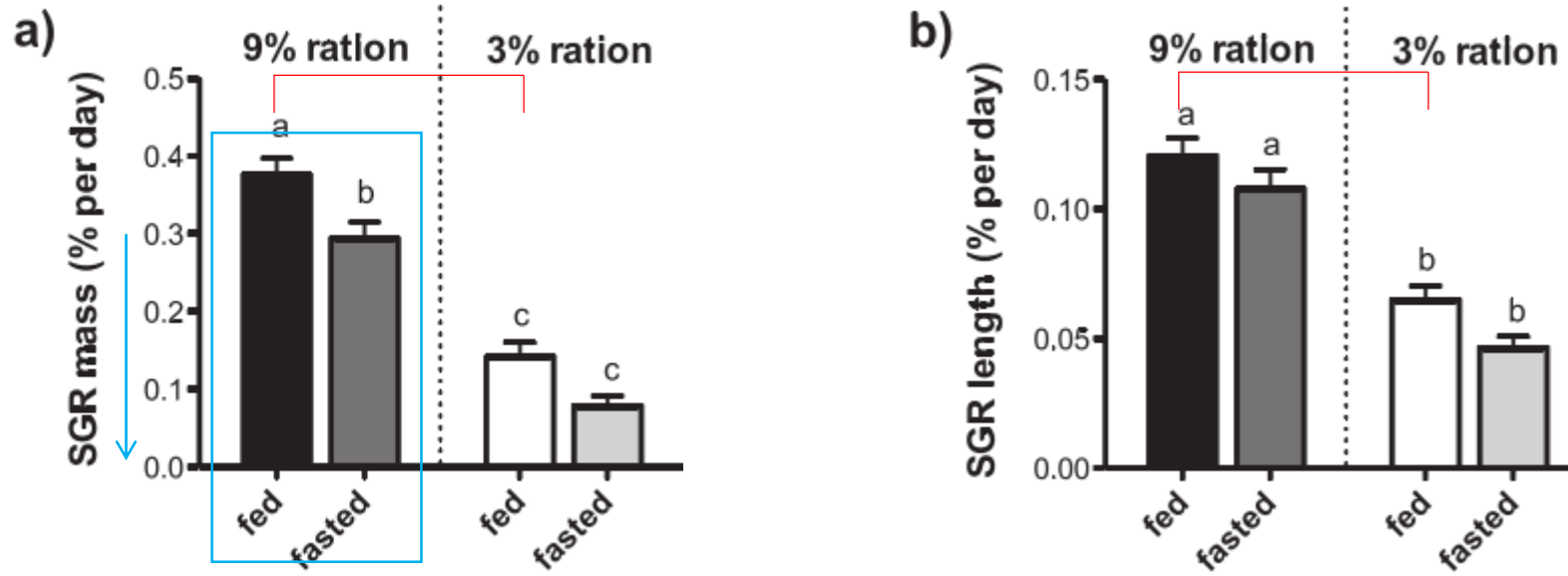
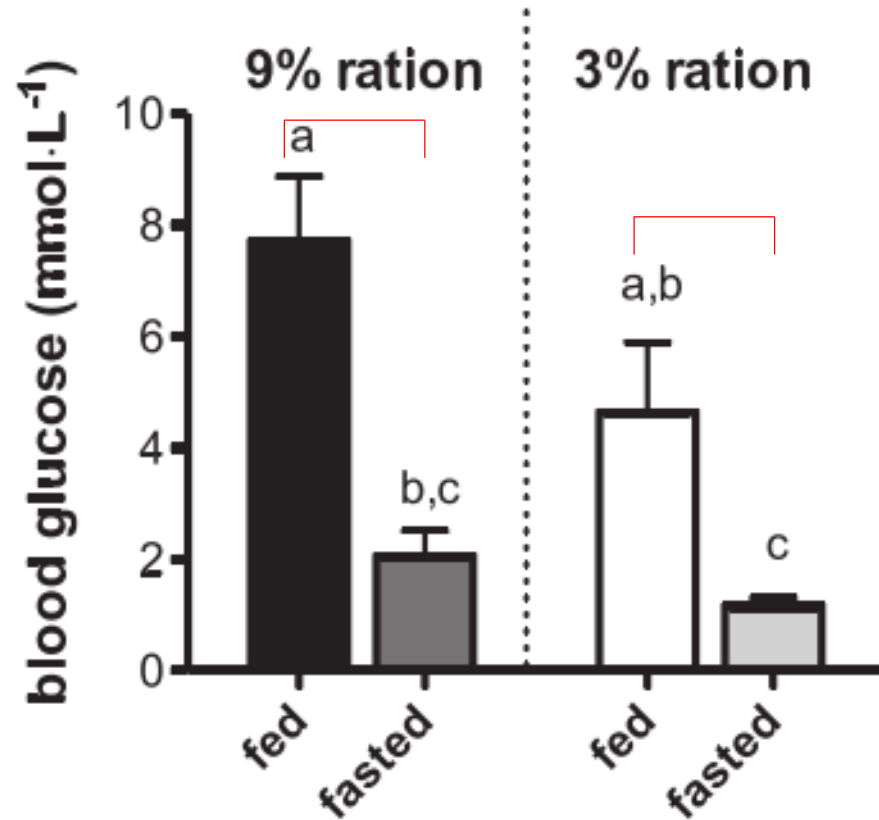


Fig. 2. Mean (\pm SEM) values of specific growth rate (SGR) on day 152 as calculated by (a) body mass or (b) length. Letters indicate pairwise differences among treatments (Tukey HSD tests).

与3%投饲量组相比，9%投饲量组体重和体长的SGR均显著升高，9%投饲量组，体重SGR在禁食后显著降低，而3%投饲量组无显著变化。说明长期摄食的差异会导致SGR的不同。

3.2 血糖水平

Blood glucose

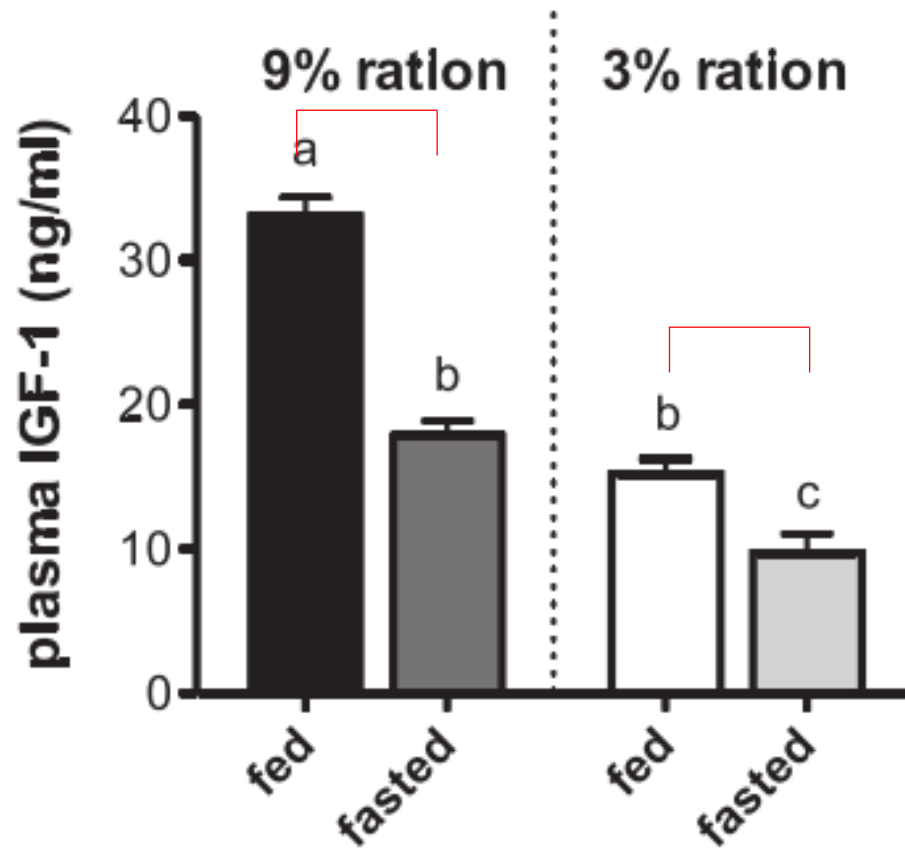


禁食会降低血
糖水平

Fig. 3. Blood glucose concentration (mmol.L⁻¹) of juvenile copper rockfish in the 9% or 3% ration treatments that were fasted or continued to be fed for 12 d prior to sampling. Values are plotted as mean \pm SEM values. Letters indicate pairwise differences among the treatments (Tukey HSD tests).

3.3 血浆IGF-1随营养状况和生长速度的变化

Plasma IGF-1 varied with nutritional status and growth rate



禁食会降低血浆中
IGF-1的水平

Fig. 4. Comparison of mean (\pm SEM) plasma IGF-1 concentrations in rockfish across ration and fast/fed treatments. Rockfish in the 9% ration had higher plasma IGF-1 than fish in the 3% ration, and fasted fish from both ration groups showed a reduction in plasma IGF-1, but the degree of that IGF-1 decline differed with prior nutritional experience (ration-fasting interaction; $F_{1,65} = 16.683$, $p = 0.0001$). Letters indicate pairwise differences among the treatments (Tukey HSD tests).

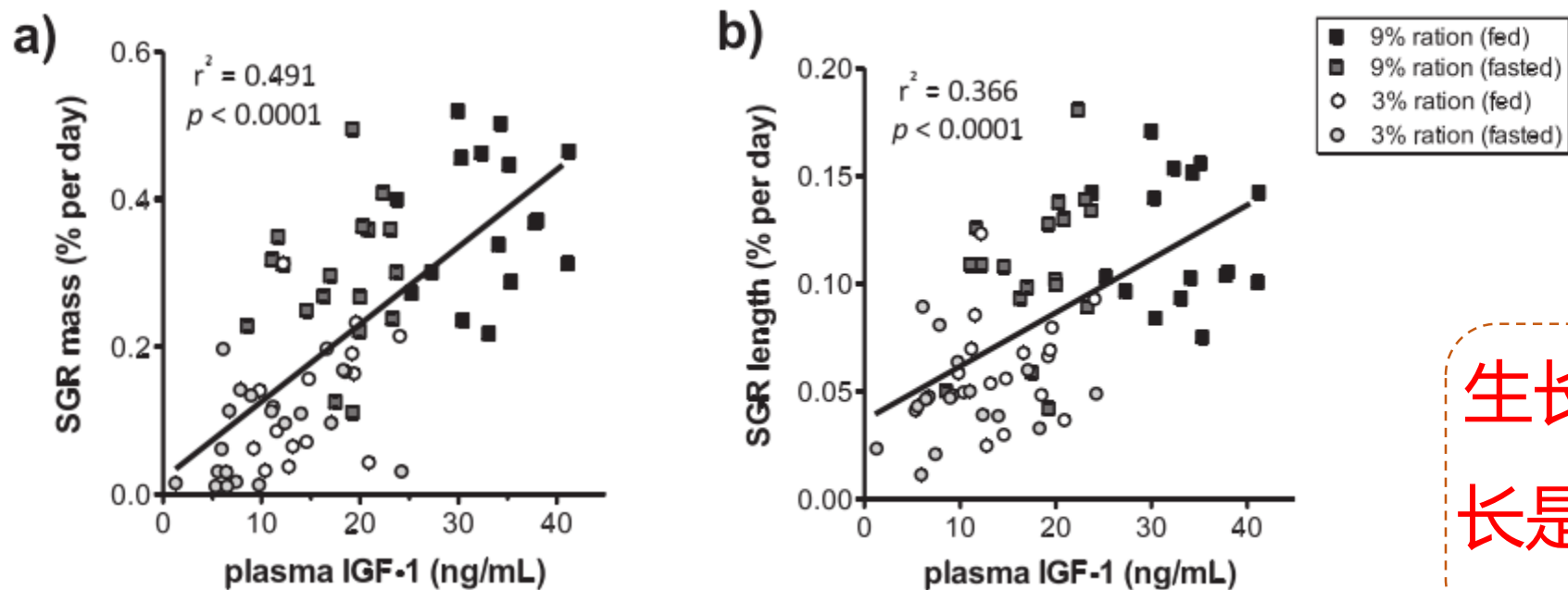


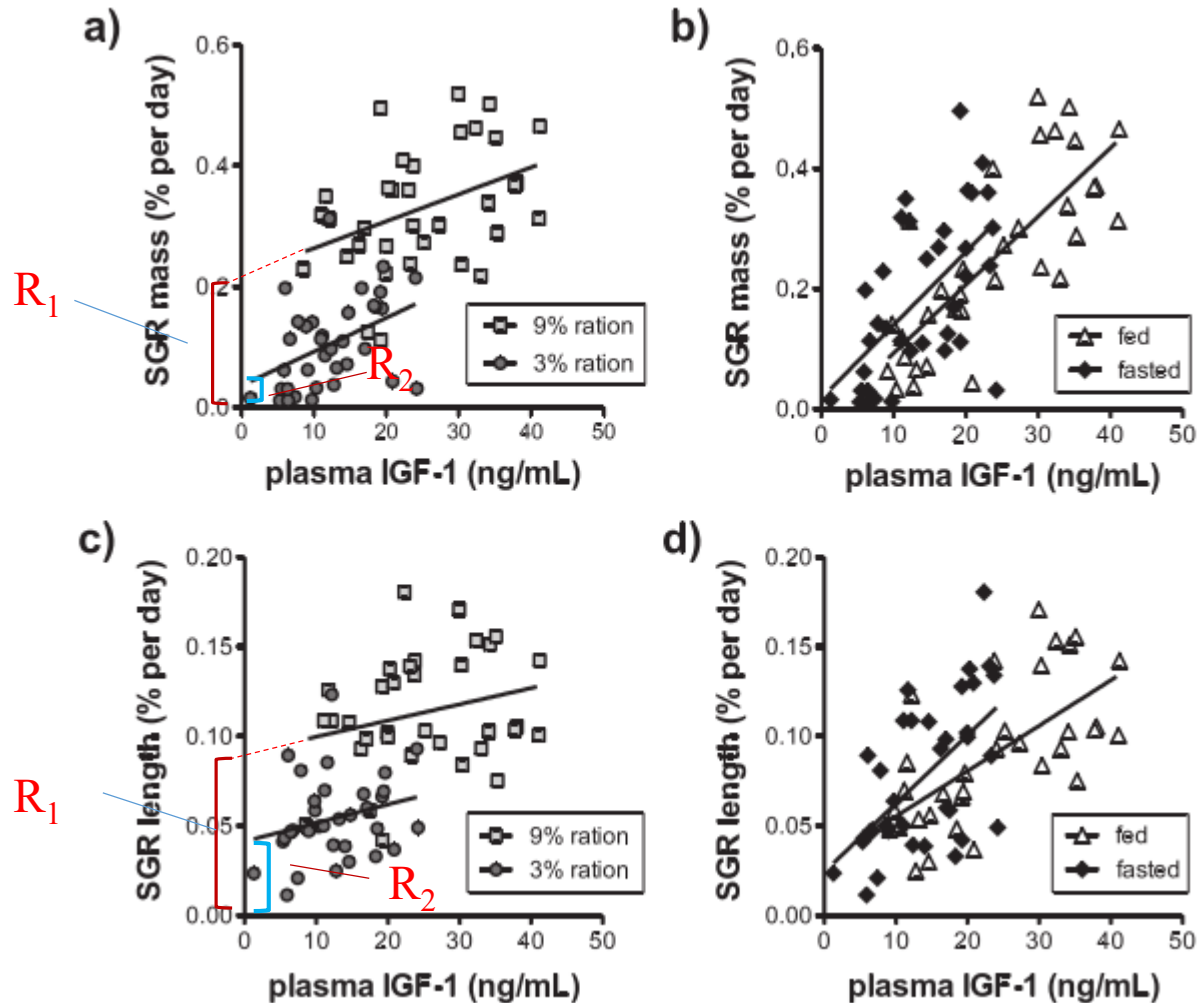
Fig. 5. Relationships between individual variation in plasma IGF-1 and specific growth rate (SGR) as calculated by change in (a) body mass or (b) body length (SL). Individual variation in both mass- and length-SGR, as calculated across the entire experimental period (152 d), associated positively with individual IGF-1 concentrations.

生长速率的增
长是否一致呢?

在不同营养条件下，个体血浆中IGF-1浓度与SGR呈正相关。

长期摄食差异

(图a,c)



摄食和禁食

(图b,d)

Fig. 6. Relationships between an individual's plasma IGF-1 concentration and specific growth rate (SGR) as calculated by grouping fish by long-term ration treatment (a and c) or fasting or continued feeding (b and d) for the final 12 d. Separate correlation analyses are shown for SGR calculated by change in body mass (a and b) or length (SL) (c and d). Relationships between SGR and IGF-1 in rockfish grouped by ration treatment had similar slopes but showed relationship discordance as differing intercepts, while relationships in fish grouped by recent feeding/fasting had similar slopes and intercepts.

生长速率增长的差异可能与食物消耗率，饲料利用率和营养基础代谢相关。

3.4 摄食和禁食对肝脏基因表达的影响

Food ration and fasting experience alter liver gene transcript abundance

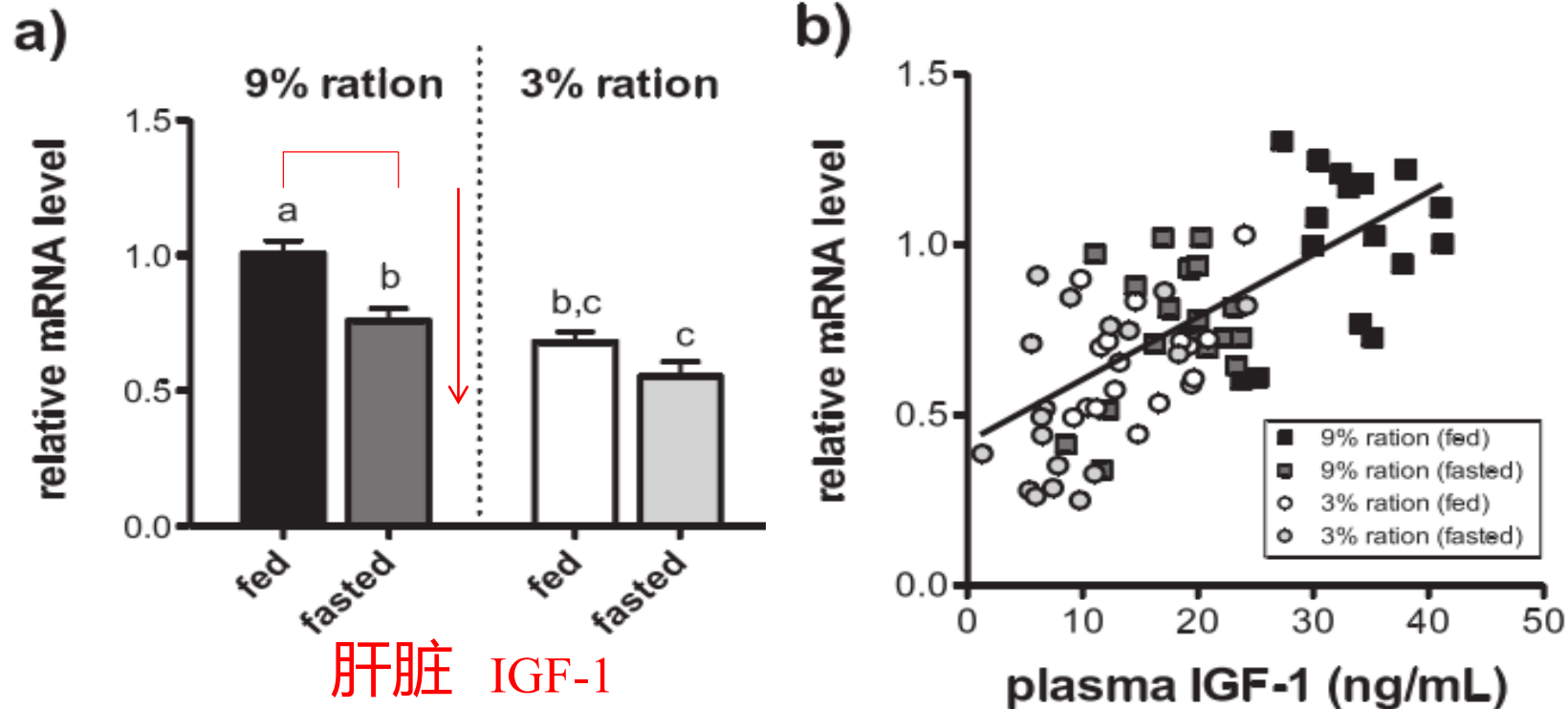


Fig. 7. Liver mRNA levels for *igf1* varied with nutritional experience. (a) Liver *igf1* mRNA levels were lower in rockfish reared on the 3% ration treatment than the 9% ration, and were also reduced by fasting. Data are plotted as mean \pm SEM, and letters indicate pairwise differences among treatments (Tukey HSD tests). (b) Individual variation in liver *igf1* mRNA level correlated positively with plasma IGF-1 concentration ($r = 0.707$, $p < 0.0001$).

摄食和禁食营
养状态下，肝脏
IGF-1 mRNA水平变
化与血浆IGF-1浓度
呈正相关。

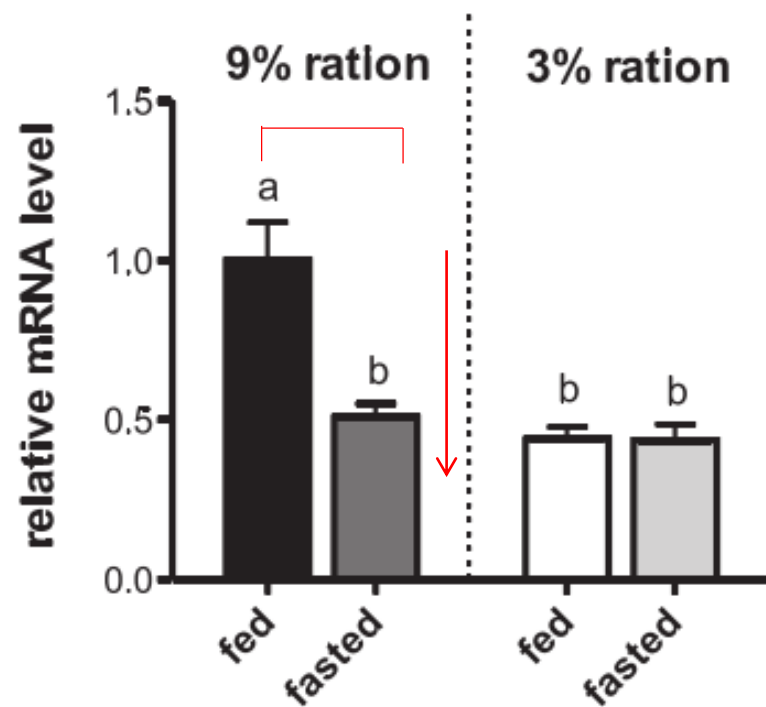


Fig. 8. Gene transcript abundance for *igf2* in the liver of copper rockfish reared on a 9% or 3% ration amount for 140 d, and then fed or fasted for an additional 12 d. Fasting resulted in lower liver *igf2* mRNA abundance in fish reared on the 9% ration, but not the 3% ration. Data are plotted as mean \pm SEM. Letters indicate pairwise differences among treatments (Tukey HSD tests).

9%投饲量组，禁食下调肝脏IGF-2 mRNA表达。

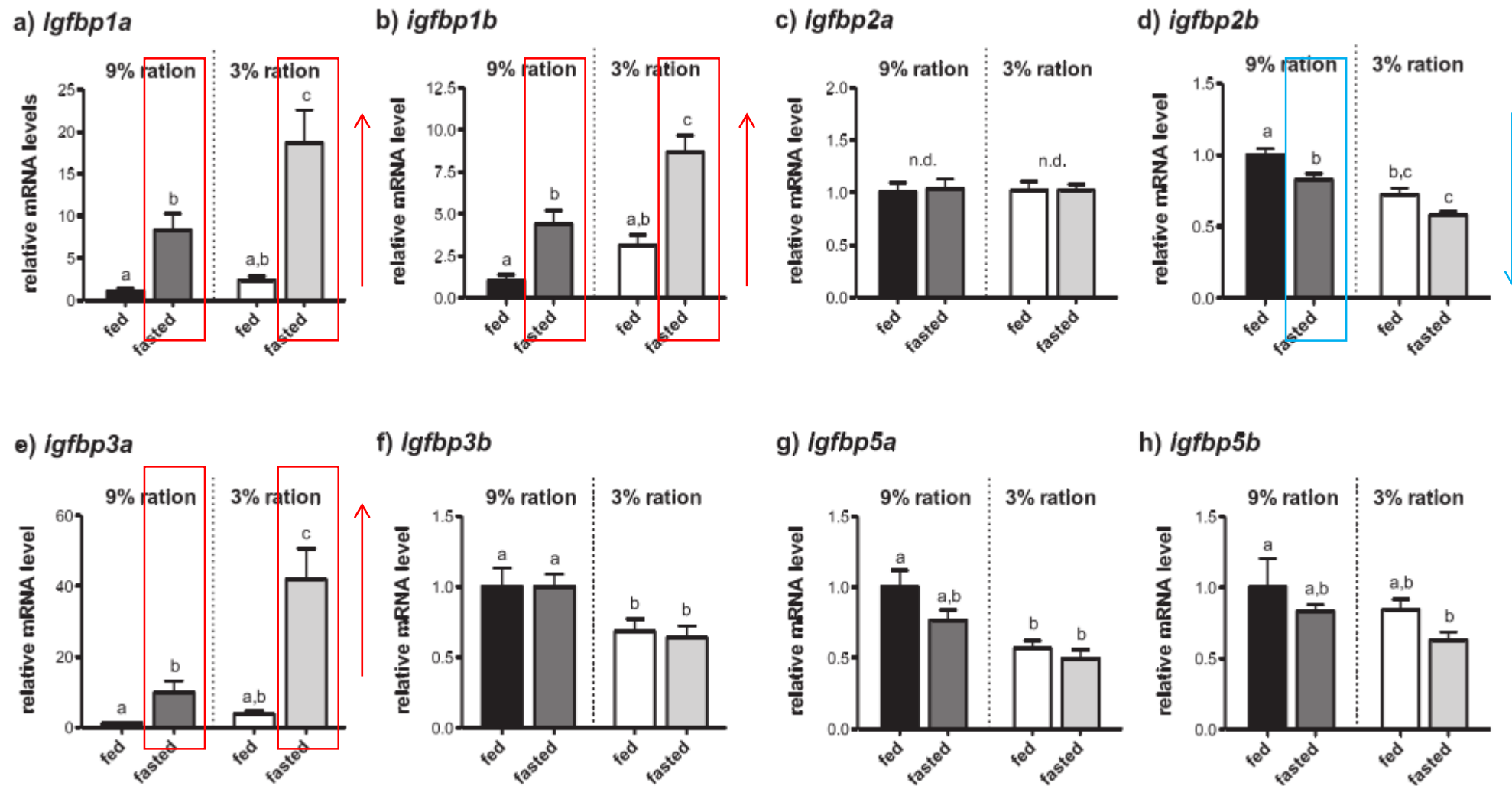


Fig. 9. Relative mRNA levels for IGF binding proteins (Igfbp) type 1, 2, 3 and 5 in the liver. Data are plotted as mean \pm SEM.

禁食后，铜石鱼通过上调*igfbp1a*，*igfbp1b*和*igfbp3a*表达来调控生长。

3.5 骨骼肌mRNAs的摄食调节

Food intake regulation of skeletal muscle mRNAs

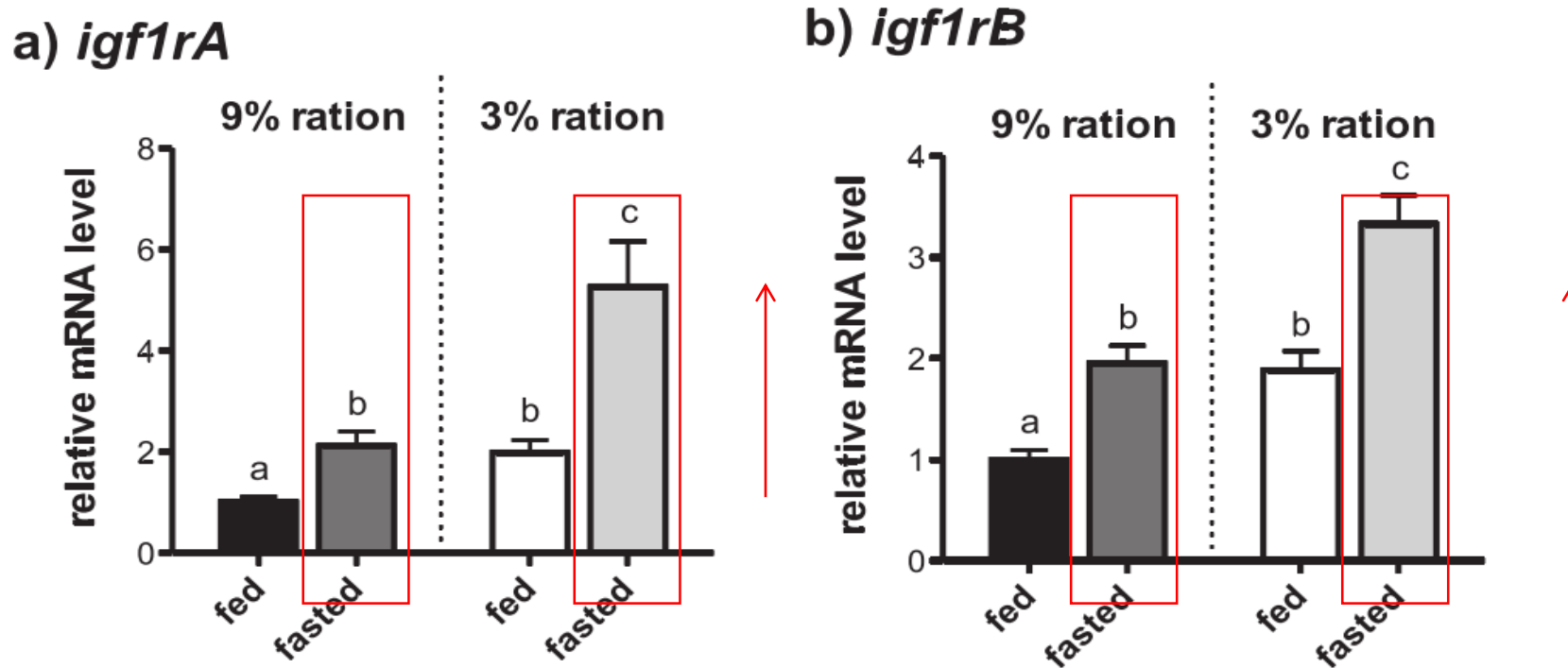
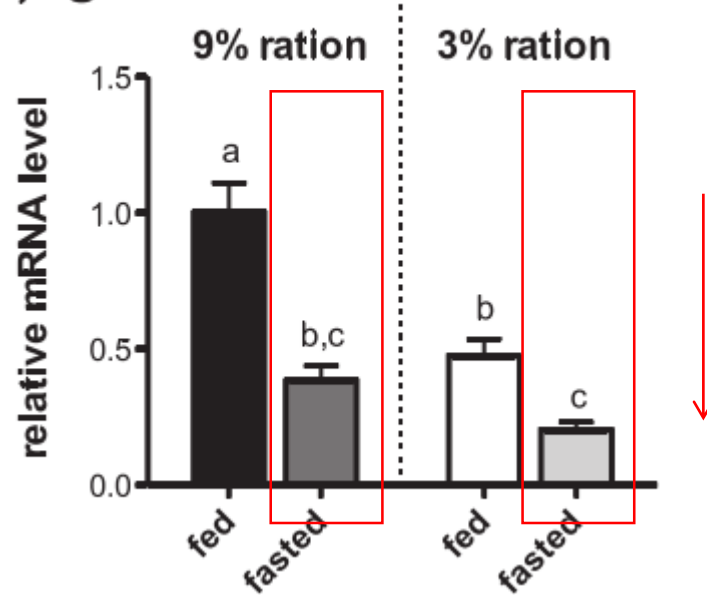


Fig. 10. Relative mRNA levels for IGF-1 receptors (a) *igf1rA* and (b) *igf1rB* in the skeletal muscle. Transcripts encoding both IGF-1 receptors were elevated in fish experiencing the reduced, 3% ration amount, and were also elevated in fish under fasting stress prior to sampling. Data are plotted as mean \pm SEM. Letters indicate pairwise differences among treatments (Tukey HSD tests).

a) *igf1*



b) *igf2*

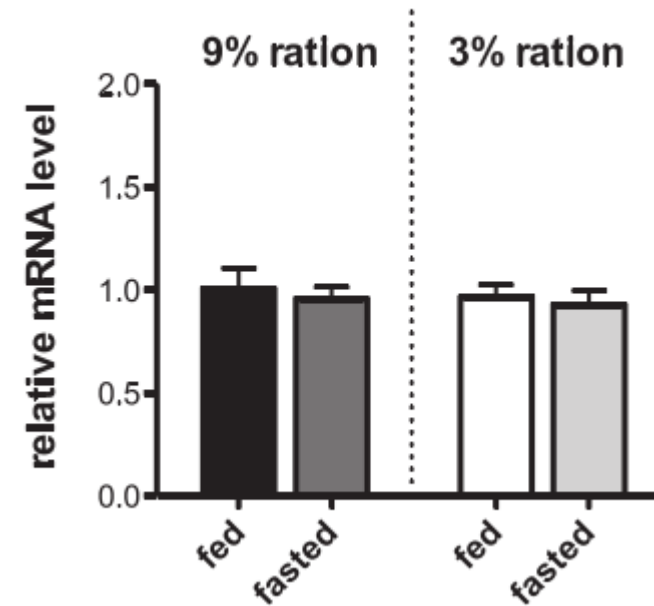


Fig. 11. Gene transcript abundance for (a) *igf1* and (b) *igf2* in the skeletal muscle. Muscle levels of *igf1* mRNA varied with nutritional experience and were observed to be at lower abundance in fish reared on the 3% ration compared to the 9% ration, and in fasted fish of both ration treatments. The abundance of *igf2* mRNAs, however, did not vary in muscle with nutritional experience. Data are shown as mean \pm SEM values, and letters indicate pairwise differences among treatments (Tukey HSD tests).

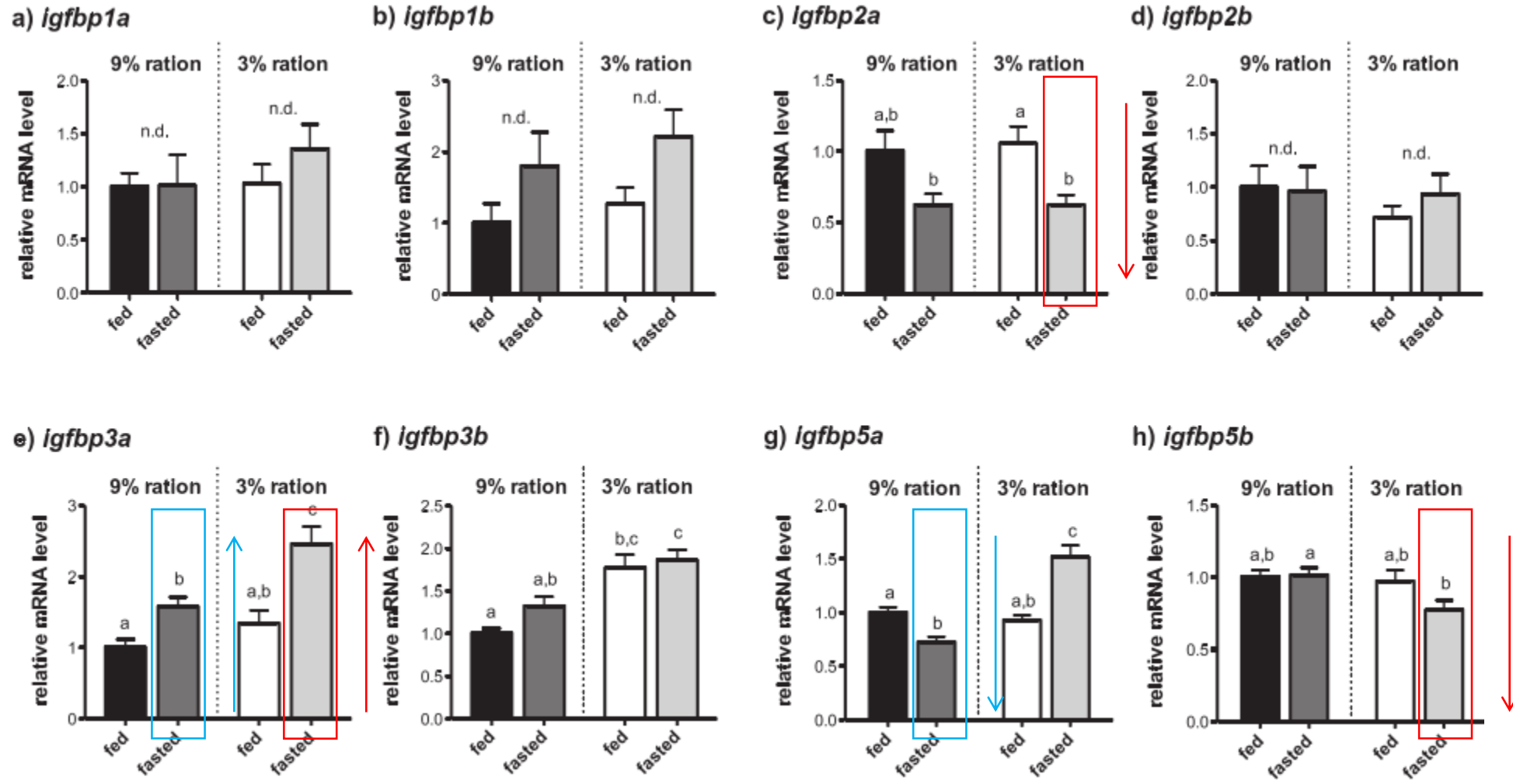
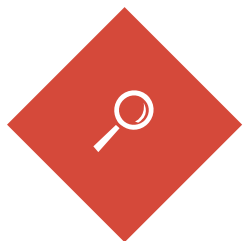


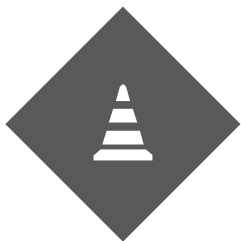
Fig. 12. Relative mRNA levels for IGF binding proteins (Igfbp) type 1, 2, 3 and 5 in the skeletal muscle. Data are plotted as mean \pm SEM.



结论



与3%投饲量组相比，9%投饲量组的个体生长较快，表明长期摄食量的差异会改变铜石鱼生长对IGF-1的敏感性。



不同营养状态下，循环的IGF-1和生长率呈正相关关系，但长期摄食量差异或短期禁食会降低循环的IGF-1浓度。



THANKS