

Comparison of growth, tyrosinase activity, melanin content, and gene expression between common carps with different pigmentation

Jianjun Fu¹, Wenbin Zhu¹, Wentao Luo², Lanmei Wang¹, Mingkun Luo¹, Zaijie Dong^{1,2*}

1. Key Laboratory of Freshwater Fisheries and Germplasm Resource Utilization, Ministry of Agriculture and Rural Affairs, Freshwater Fisheries Research Center of Chinese Academy of Fishery Sciences, Wuxi 214081, China;
2. Wuxi Fisheries College, Nanjing Agricultural University, Wuxi 214128, China.

Background

Orange individuals were found in certain families of the FFRC No. 2 strain common carp (*Cyprinus carpio*) during reproduction (Fig. 1). In most cases, colored individuals exhibited lower weight increases and poorer survival than fish with wild coloration [1]. Aimed to unveil the pigmentation variation and its correlations with growth performance in *C. carpio*, one full-sibling family was constructed using artificial breeding, and the differentiations of growth traits were compared for different skin-color groups of *C. carpio*. The tyrosinase is known as key enzyme for melanogenesis, and melanin plays an important role in fish pigmentation [2]. Many genes related to pigmentation variation and growth performance, which had commonly revealed in fish species [3, 4]. In the present study, the tyrosinase activity, melanin content and gene expression were compared between gray and orange individuals of *C. carpio*.



Fig.1 The *Cyprinus carpio* individuals with different skin colors

Results

Base on three-month growth traits comparison, the body weight (BW), standard length (SL), body depth (BD), and body thickness (BT) of gray group were higher than orange group ($P < 0.01$), and the SL/BD ratio of gray group was higher than orange group ($P < 0.05$) (Table 1, Fig. 2).

Table 1 Descriptive statistics of three-month phenotypic traits in *C. carpio* with different skin-colors (n = 30, mean ± SE)

Skin color	Body weight	Standard length	Body depth	Body thickness	SL/BD	SL/BT
	BW /g	SL /cm	BD /cm	BT /cm		
Gray	43.67 ± 2.91 ^A	11.35 ± 0.28 ^A	3.63 ± 0.09 ^A	2.28 ± 0.06 ^A	3.14 ± 0.06 ^a	4.98 ± 0.05
Orange	21.33 ± 3.23 ^B	8.50 ± 0.39 ^B	2.84 ± 0.12 ^B	1.74 ± 0.08 ^B	2.98 ± 0.03 ^b	4.88 ± 0.03

Note: In the same column, value with different small and capital letter superscripts mean significant ($P < 0.05$) and extremely significant difference ($P < 0.01$), respectively.

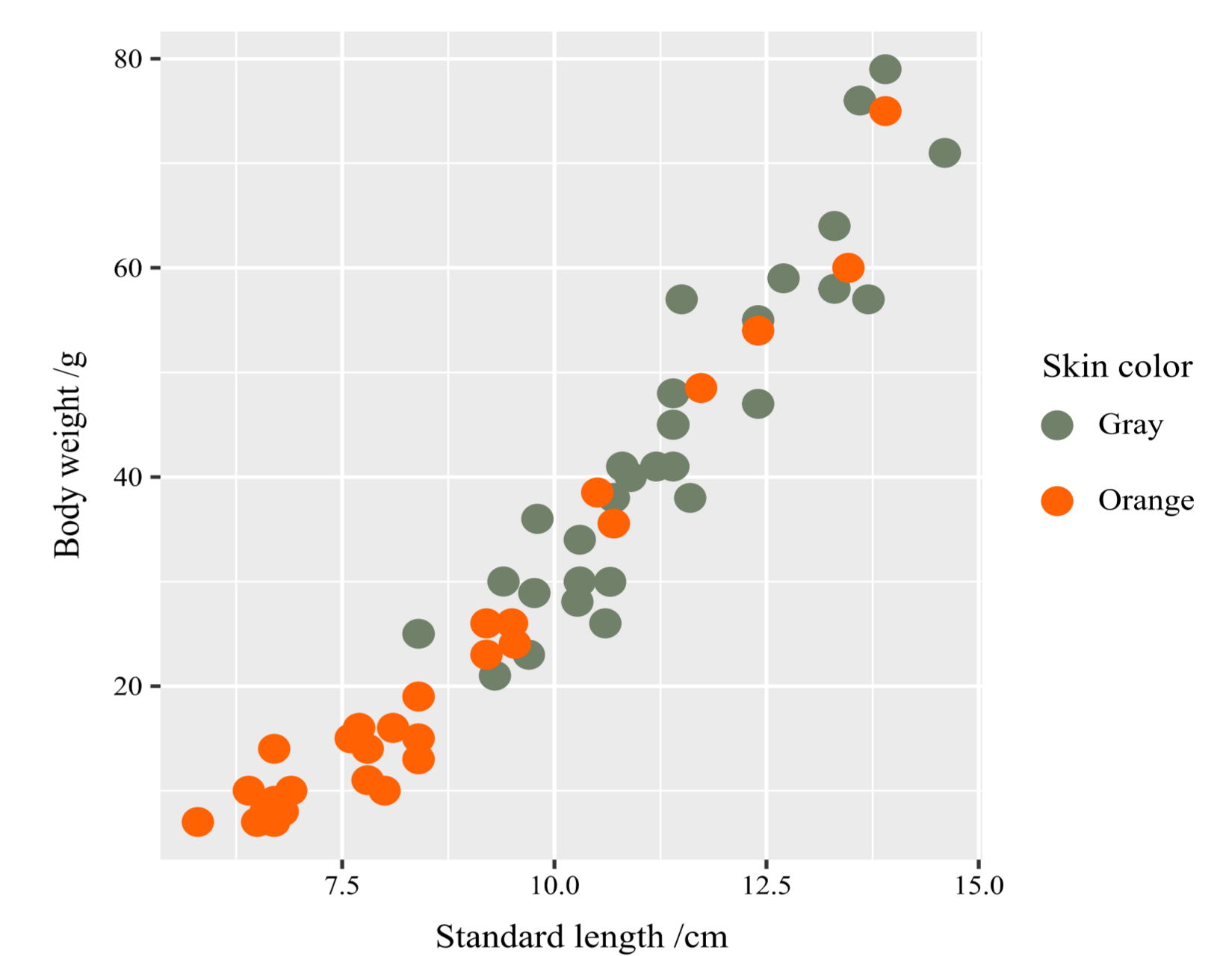


Fig. 2 Scatter plot for growth traits in *C. carpio* individuals with different skin colors

The higher tyrosinase activity and melanin content were detected in gray group, and significant different with orange group ($P < 0.05$, Fig. 3). Based on the qPCR results, twelve genes (*det*, *mc1r*, *tyrp1*, *tyr*, etc.) of the melanogenesis pathway (ko04916) were down-regulated in the skin of orange group compared to the gray group ($P < 0.05$, or $P < 0.01$); meanwhile, six genes (*gh*, *ghr*, *igf2*, etc.) of the growth hormone synthesis, secretion and action pathway (ko04935) were down-regulated in the muscle of orange group ($P < 0.05$, or $P < 0.01$), synchronously (Table 2). Furthermore, the co-expression patterns of genes were detected within pathways; and the shared genes of pathways showed with similar expression patterns in different tissues (Fig. 4).

Table 2 Relative expression levels of genes in *C. carpio* (n = 5, mean ± SE)

Tissue	Gene	Accession no.	Skin color group		
			Gray	Orange	
Skin	<i>asip</i>	KC178677	1.06 ± 0.11	2.04 ± 0.61	
	<i>dct</i>	XM_019069482	2.95 ± 0.39	1.10 ± 0.16**	
	<i>frizzed</i>	XM_019064880	2.62 ± 0.32	1.00 ± 0.30**	
	<i>kita</i>	XM_019125867	66.13 ± 8.44	23.82 ± 2.04**	
	<i>mc1r</i>	XM_019114733	12.58 ± 1.82	3.42 ± 0.36**	
	<i>mitfa</i>	KC565527	15.86 ± 2.32	53.03 ± 11.07**	
	<i>mitfb</i>	XM_0190840110	25.35 ± 7.88	9.10 ± 2.10*	
	<i>pka</i>	XM_019069650	106.80 ± 11.30	52.27 ± 10.69**	
	<i>pkc</i>	XM_019080659	5.27 ± 1.49	0.46 ± 0.08**	
	<i>raf</i>	XM_019113428	43.73 ± 5.65	26.77 ± 5.66*	
	<i>ras</i>	XM_019066893	23.88 ± 2.98	9.97 ± 2.20**	
	<i>tyr</i>	JQ670941	4.09 ± 0.74	0.63 ± 0.17**	
	<i>tyrp1</i>	KF709395	151.55 ± 15.78	48.96 ± 18.08**	
	<i>wnt3</i>	XM_019113280	26.16 ± 1.90	12.75 ± 0.89**	
	Muscle	<i>gh</i>	M27000	11.72 ± 1.32	3.95 ± 0.48**
		<i>ghr</i>	XM_019108925	831.90 ± 124.23	308.13 ± 141.83*
<i>igf1</i>		XM_019092966	27.95 ± 4.50	30.70 ± 6.78	
<i>igf2</i>		XM_019112130	261.73 ± 24.50	83.64 ± 36.40**	
<i>igf3</i>		KT895500	3.98 ± 0.72	3.18 ± 0.41	
<i>pka</i>		XM_019069650	175.64 ± 17.76	114.46 ± 29.12	
<i>pkc</i>		XM_019080659	2.15 ± 0.78	0.21 ± 0.05*	
<i>raf</i>		XM_019113428	111.92 ± 6.21	66.84 ± 12.81**	
<i>ras</i>		XM_019066893	33.09 ± 3.36	12.96 ± 3.19**	

Note: * and ** means significant ($P < 0.05$) and extremely significant difference ($P < 0.01$) between gray and orange groups, respectively.

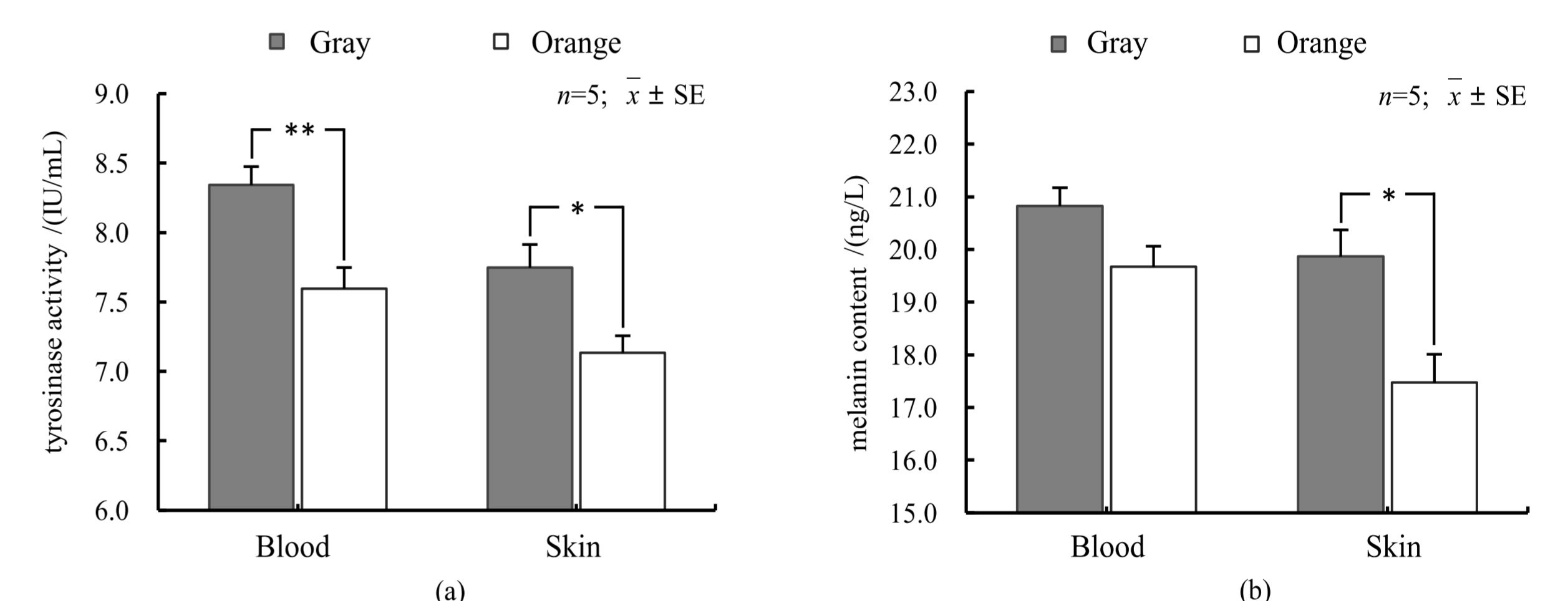


Fig. 3 Tyrosinase activity (a) and melanin content (b) in blood and skin of *C. carpio*

Note: *, ** means with significant ($P < 0.05$) and extremely significant ($P < 0.01$) different, respectively.

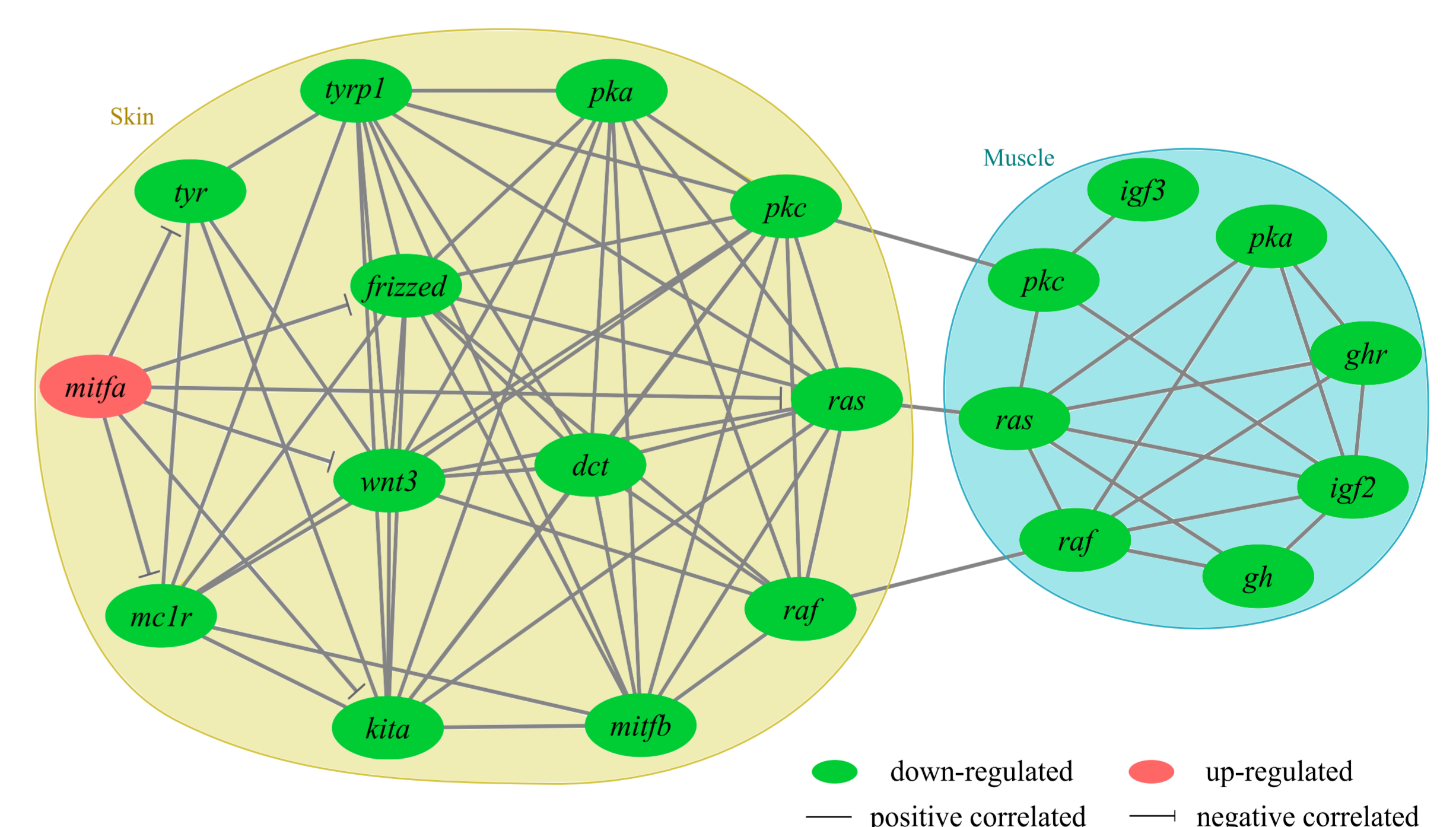


Fig. 4 Co-expression network of genes in skin and muscle of *C. carpio* (orang vs. gray)

Conclusion

The results indicated that, the pigmentation variation of *C. carpio* was highly associated with melanogenesis pathway, and different growths were presented in *C. carpio* with different pigmentations, this correlation might due to the same genes were shared between pathways related with color and growth.

Notes: results had published, cite as following if necessary:

Fu J, Zhu W, Luo W, et al. Comparison of growth, tyrosinase activity, melanin content, and gene expression between common carps with different pigmentations. Journal of Fishery Sciences of China, 2021.

DOI:10.12264/JFSC2020-0610 <https://kns.cnki.net/kcms/detail/11.3446.S.20210126.1655.004.html>

Corresponding author: Zaijie Dong, E-mail: dongzaijie@ffrc.cn

Funding Projects: CARS-45-05, 2020TD37, and 2019JBFM03.

Reference

- [1] Białowa H. Inheritance of orange pigmentation and scale pattern in common carp (*Cyprinus carpio* L.). Archives of Polish Fisheries, 2004, 12(2): 145-150.
- [2] Cal L, Suarez-Bregua P, Cerdá-Reverter J M, et al. Fish pigmentation and the melanocortin system. Comparative Biochemistry and Physiology, Part A, 2017, 211: 26-33.
- [3] Zhang Y, Liu J, Peng L, et al. Comparative transcriptome analysis of molecular mechanism underlying gray-to-red body color formation in red crucian carp (*Carassius auratus*, red var.). Fish Physiology and Biochemistry, 2017, 43: 1387-1398.
- [4] Wang L, Zhu W, Fu J, et al. De novo transcriptome analysis and comparison of the FFRC No. 2 strain common carp *Cyprinus carpio* associated with its muscle growth. Journal of Fisheries of China, 2021, 45(1): 79-87.