读书报告

汇报人：邓大鹏　时间：2019.7.21

Mechanisms for Temperature Modulation of Feeding in Goldfish and Implications on Seasonal Changes in Feeding Behavior and Food Intake

在金鱼中，温度对摄食的调控机制及季节变化对摄食行为和摄食量的影响

*Ting Chen†, Matthew K. H. Wong, Ben C. B. Chan and Anderson O. L. Wong**

School of Biological Sciences, The University of Hong Kong, Hong Kong, China

IF=3.519

OPEN ACCESS

Edited by:
María Jesús Delgado, Complutense University of Madrid, Spain

Reviewed by:
Hélène Volkoff, Memorial University of Newfoundland, Canada
Lingqing Zeng, Chongqing Normal University, China

****Correspondence:***
Anderson O. L. Wong
olwong@hku.hk

In fish models, seasonal change in feeding is under the influence of water temperature. However, the effects of temperature on appetite control can vary among fish species and the mechanisms involved have not been fully characterized. Using goldfish (*Carassius auratus*) as a model, seasonal changes in feeding behavior and food intake were examined in cyprinid species. In our study, foraging activity and food consumption in goldfish were found to be reduced with positive correlation to the gradual drop in water

01 研究背景

02 材料方法

03 结果

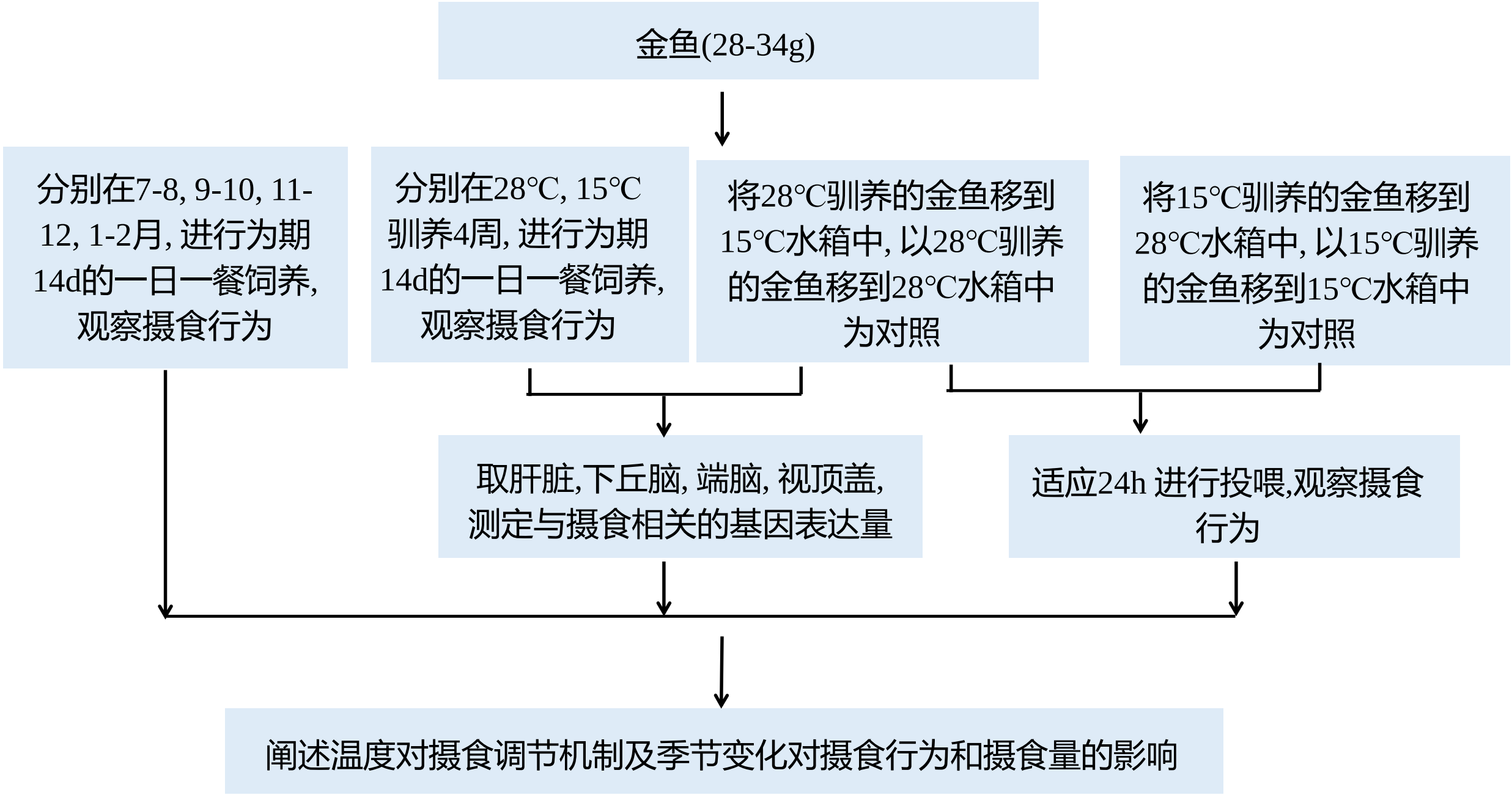
04 结论

1 研究背景

环境温度的变化是影响能量代谢和动物生长的关键因素, 对于不同种类的鱼类, 温度对摄食的影响存在着差异. 例如鳕鱼, 比目鱼会随水温升高而增加食物摄入量，而大西洋鲑鱼则相反. 有关温度对摄食的影响研究很多, 但温度对摄食调节的机制及季节性变化对摄食行为和摄食量的影响作用还有待进一步探究.

本文以金鱼为研究对象，旨在探究温度变化对摄食调控的潜在机制以及季节的变化对摄食行为和摄食量的影响.

2 材料方法


金鱼(28-34g)
分别在7-8, 9-10, 11-12, 1-2月, 进行为期14d的一日一餐饲养, 观察摄食行为
分别在28℃, 15℃驯养4周, 进行为期14d的一日一餐饲养, 观察摄食行为
将28℃驯养的金鱼移到15℃水箱中, 以28℃驯养的金鱼移到28℃水箱中为对照
将15℃驯养的金鱼移到28℃水箱中, 以15℃驯养的金鱼移到15℃水箱中为对照
取肝脏,下丘脑, 端脑, 视顶盖, 测定与摄食相关的基因表达量
适应24h 进行投喂,观察摄食行为
阐述温度对摄食调节机制及季节变化对摄食行为和摄食量的影响

3 结果

冷却装置可用性验证

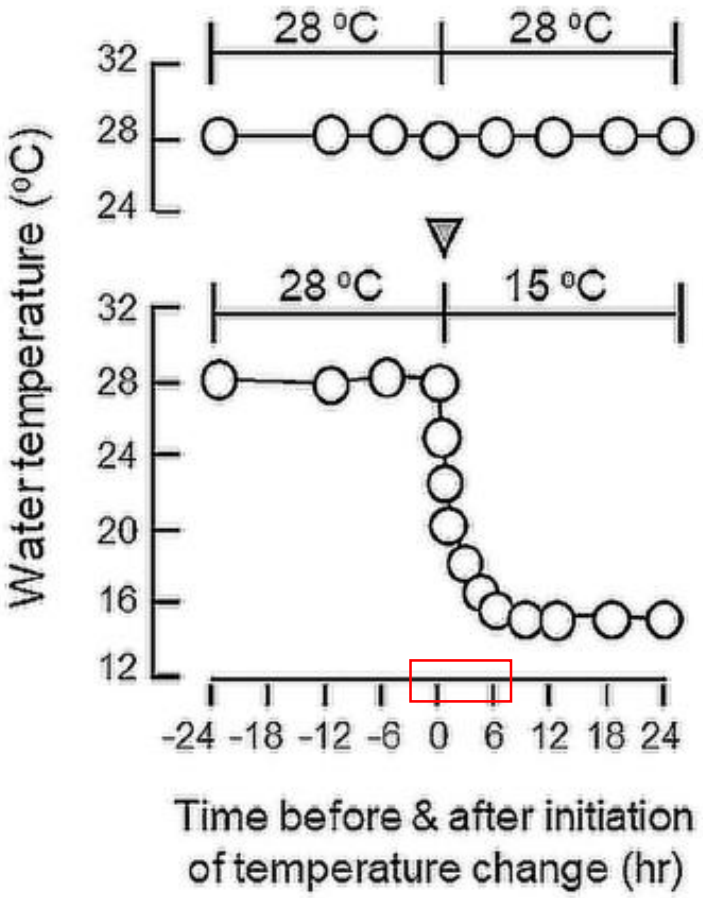


FIGURE 1 | Profile of temperature change during the short-term acclimation of goldfish from summer temperature (28°C) to winter temperature (15°C). Goldfish were maintained in 28°C water for 4 weeks during the summer (Jun–July, 2017) prior to the activation of the cooling system linked to the water tank to gradually reduce the water temperature to 15°C (as indicated by the inverted triangle). The cooling system could allow for a gradual drop in water temperature from 28 to 15°C within 6 h without the need of transferring the fish during the experiment. Without activating the cooling system (as shown in upper panel), water temperature was maintained at 28°C without noticeable change over a 24-h period.

季节改变对摄食行为及摄食量的影响

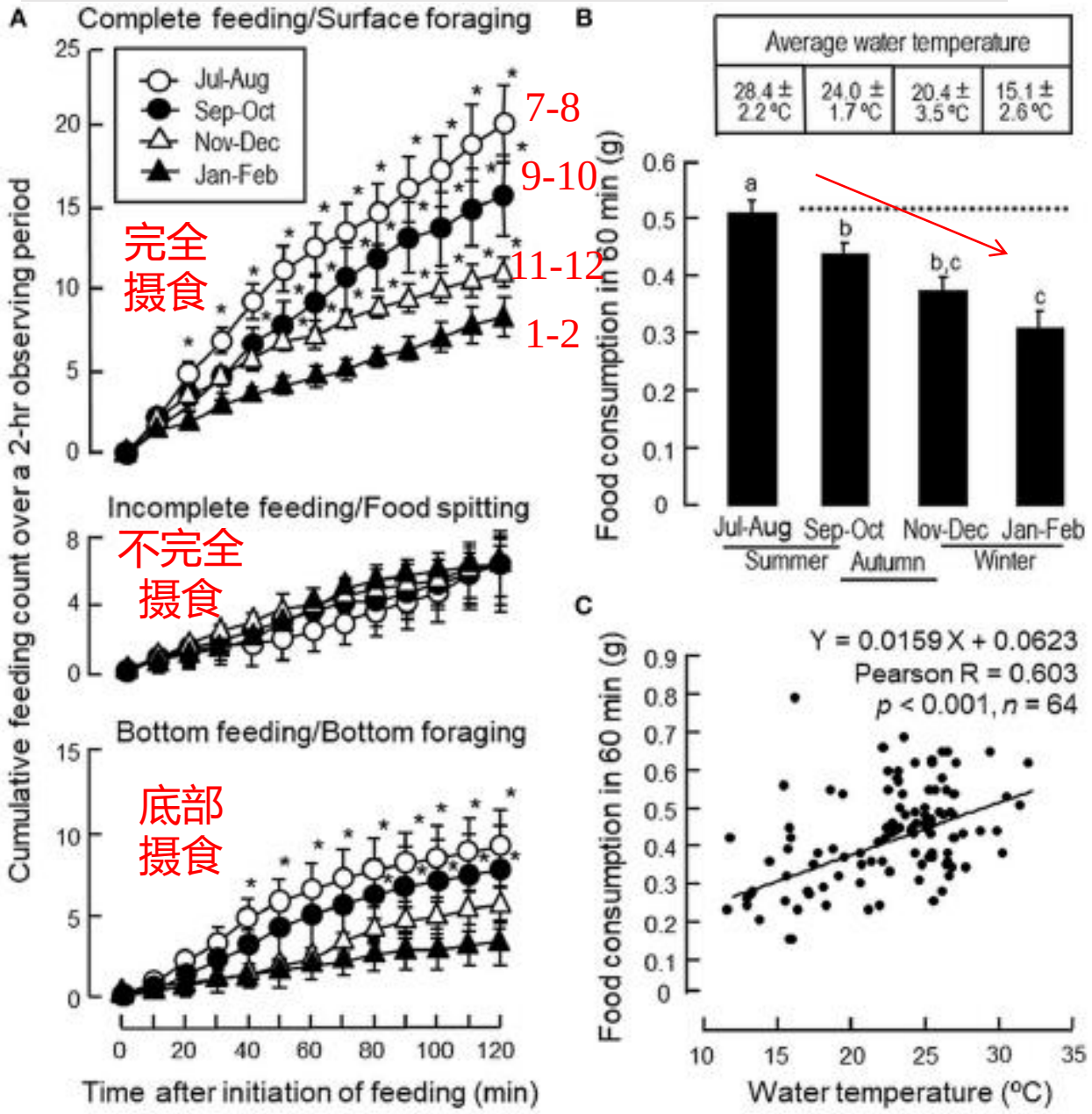
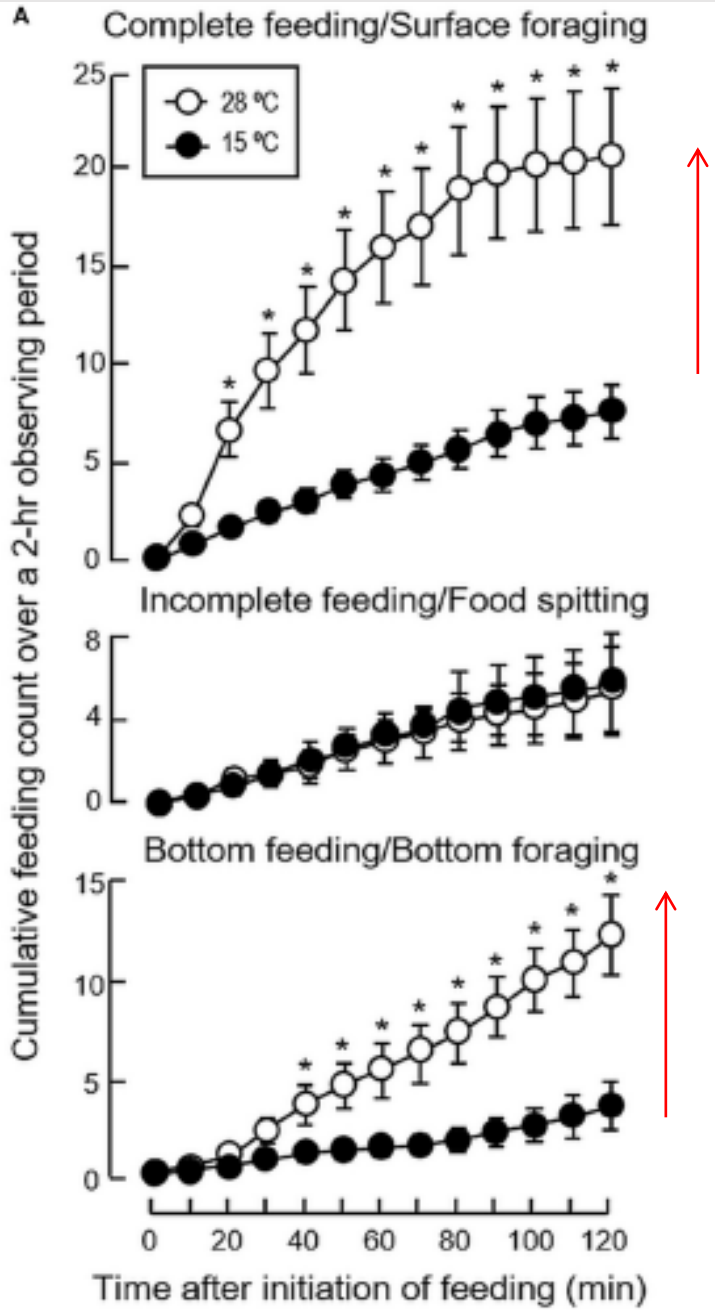


FIGURE 2 Seasonal changes of feeding behaviors and food intake in goldfish during the transition from summer to winter. (A) Seasonal changes of complete feeding/surface foraging, incomplete feeding/food spitting and bottom feeding/bottom foraging during the transition from the summer (Jul–Aug, 2016), autumn(Sep–Oct, 2016), early-mid phase of the winter (Nov–Dec, 2016) to the peak phase of the winter (Jan–Feb, 2017). (B) Seasonal change of food consumption related to the temperature drop in the environment during the same period. (C) Positive correlation of the gradual decline in food intake observed during the transition from summer to winter months as shown in (B) with the parallel drop in water temperature as revealed by Pearson product-moment regression analysis.

随月份推移, 摄食行为显著下降，温度与摄食量呈正相关.

长期驯养对摄食行为及摄食量的影响



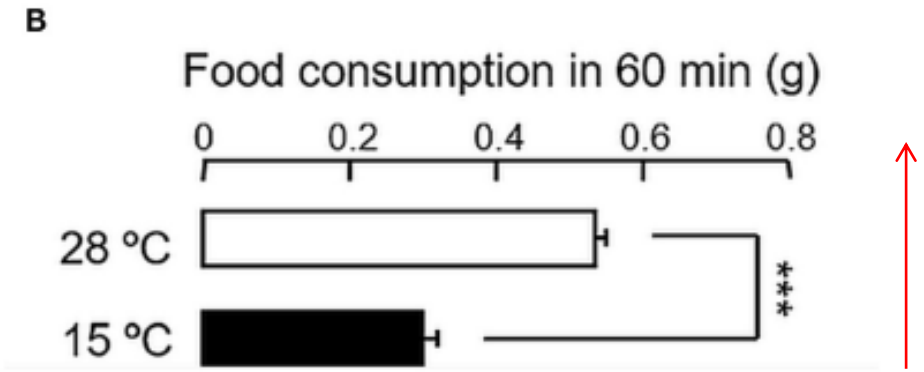
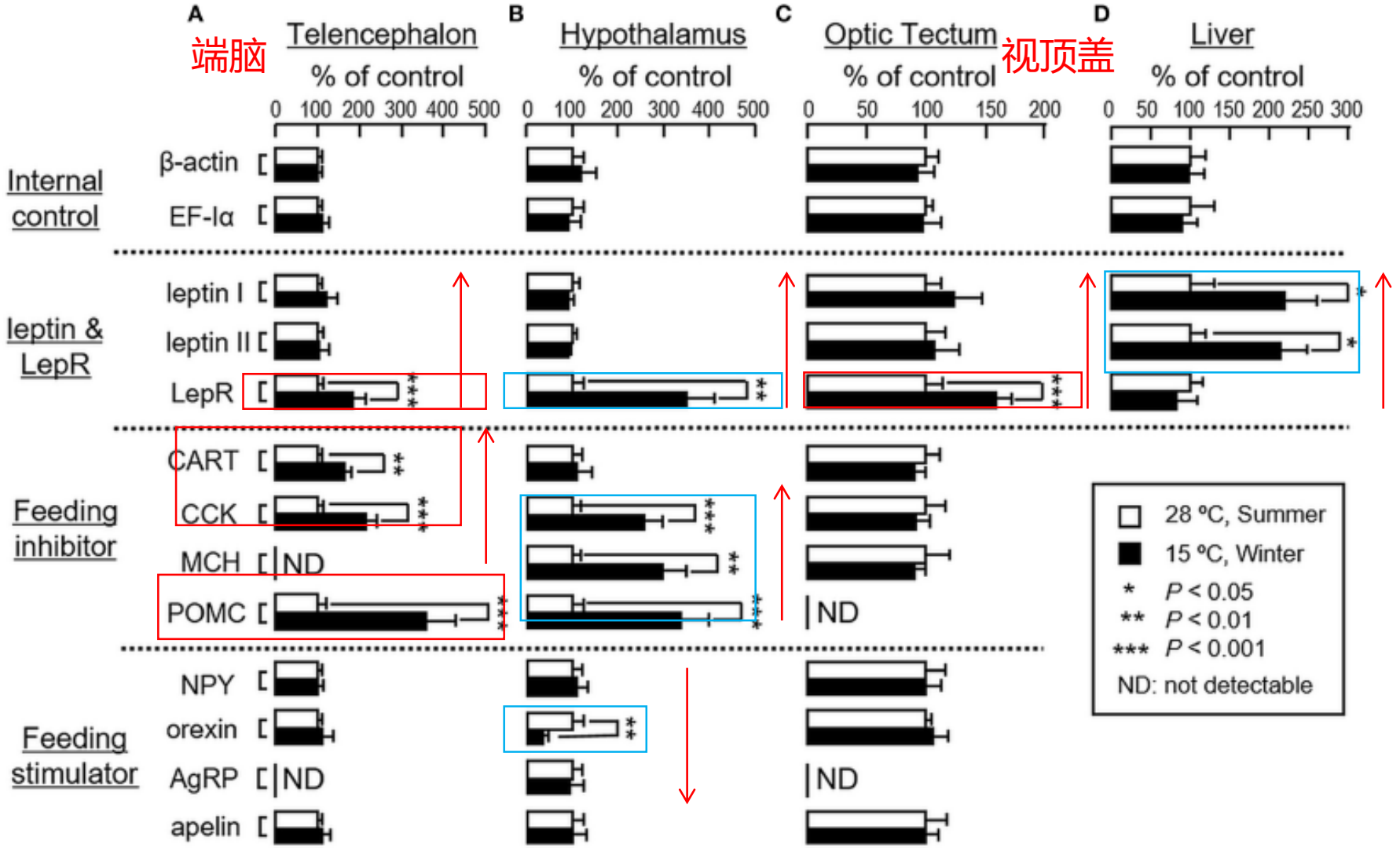


FIGURE 3 | Long-term acclimation to the summer temperature (28°C) and winter temperature (15°C) on feeding behaviors and food consumption in goldfish. Goldfish acclimated to 20°C during the autumn months (Sep–Oct, 2017) were maintained for 4 weeks in 28 and 15°C water tanks respectively prior to the measurement of **(A)** feeding behaviors and **(B)** food consumption. In this experiment, the feeding counts for the three types of feeding behaviors, namely complete feeding, incomplete feeding and bottom feeding, as well as **FIGURE 3 |** the food intake occurred during the same period were compared between the two groups using Student's *t*-test. Data presented are expressed as mean ± SEM ($n = 12$) and the difference between the two groups was considered as significant at $p < 0.05$ ($^{*}p < 0.05$ and $^{***}p < 0.001$).

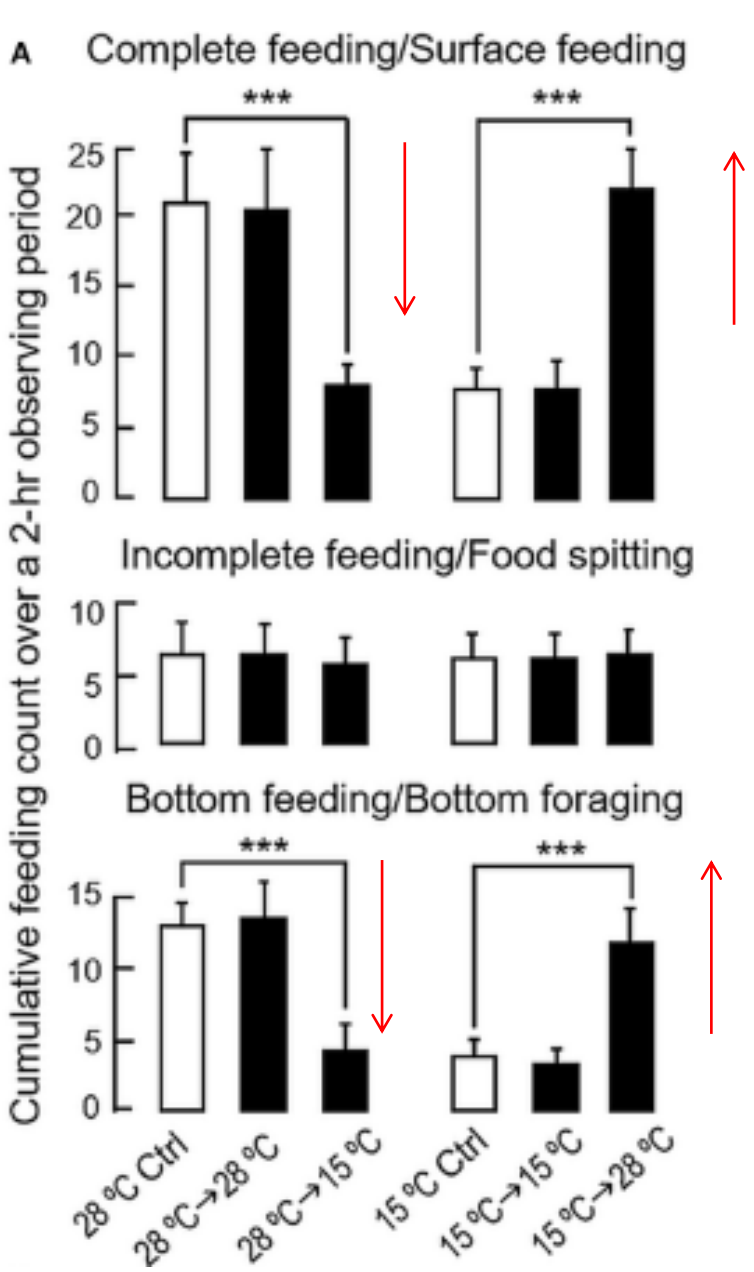
与15℃相比, 28℃驯养的金鱼，其摄食行为和摄食量均显著升高, 表明夏季和冬季摄食量的差异确实是由温度引起的.

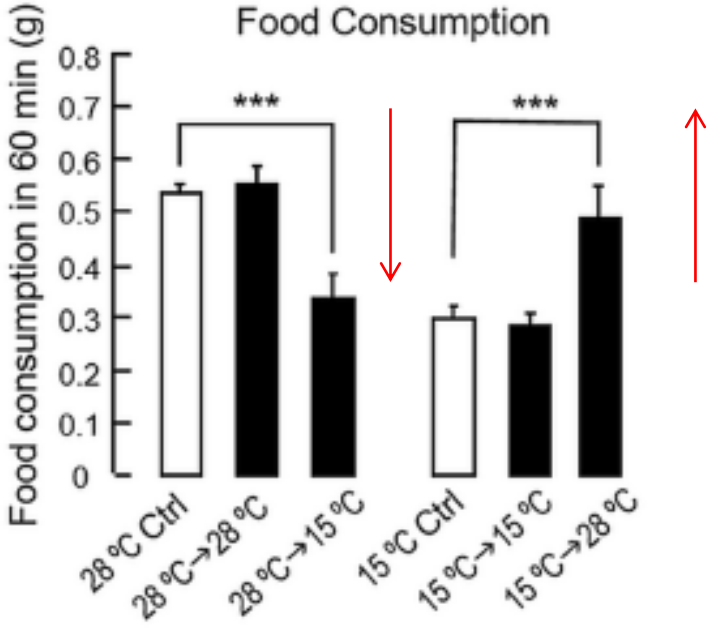


温度的不同，对摄食相关基因的表达会有怎样的影响呢?

FIGURE 4 | Transcript expression of orexigenic and anorexigenic factors in the liver and brain areas involved in feeding control in goldfish during the summer and winter months. To avoid the variability of daily fluctuation in water temperature, goldfish were maintained for 4 weeks at 28°C during the summer (July–Aug, 2016) and at 15°C during the winter (Jan–Feb, 2017). After that, the liver and brain areas, including the telencephalon, hypothalamus and optic tectum, were harvested and used for RNA isolation. RT samples were then prepared and used for real-time PCR for the respective gene targets. In this experiment, parallel measurement of β actin and EF-Iα mRNA expression were also conducted to serve as the internal control. Data presented (mean ± SEM, $n = 12$) were compared with Student's t-test and the difference between the two groups was considered as significant at $p < 0.05$ ($^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$).

短期驯养对摄食行为及摄食量的影响



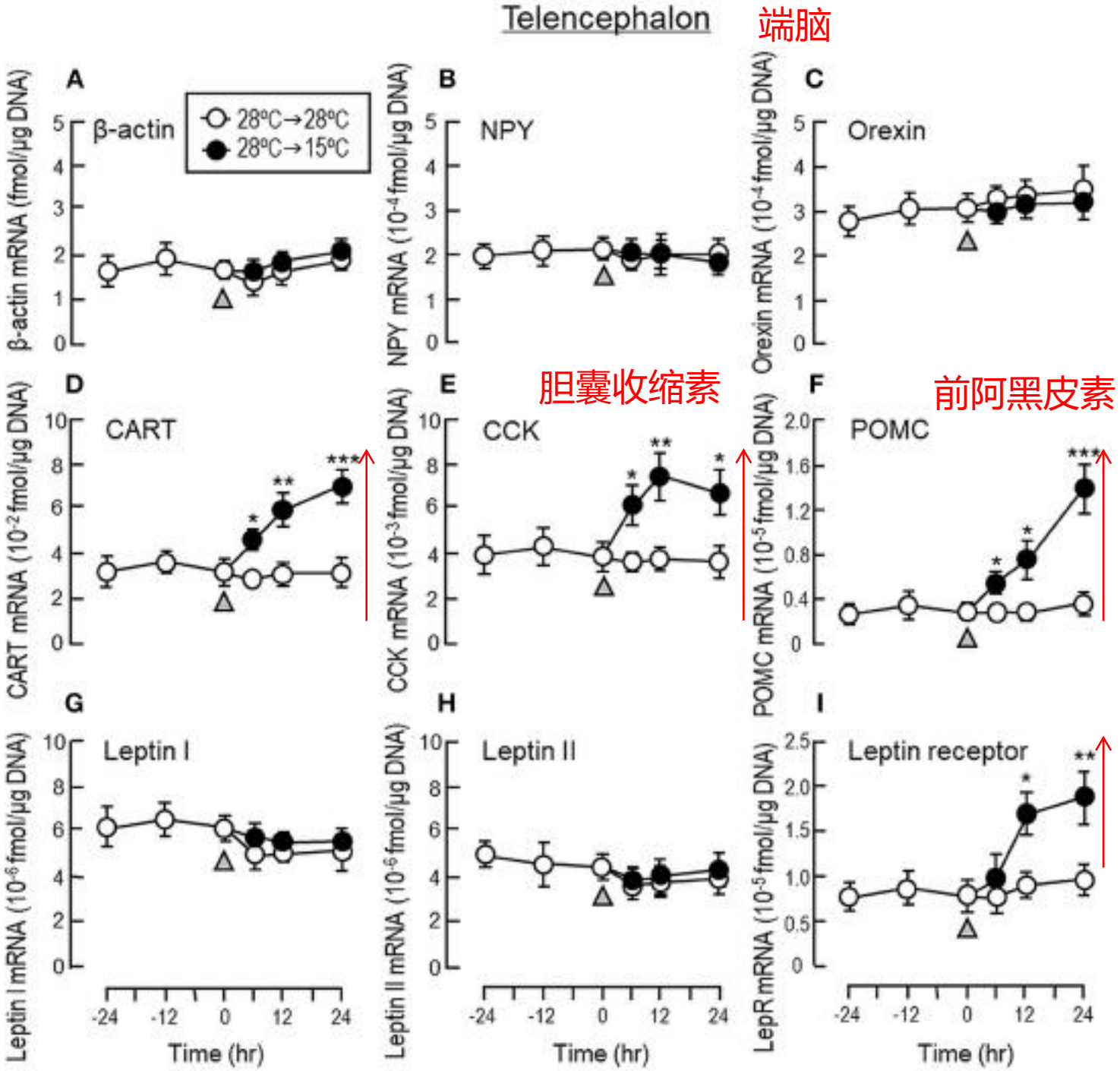


从28°C到15°C, 15°C到28°C, 金鱼摄食行为和摄食量会发生快速变化且高度可逆, 进一步证明夏季和冬季摄食量的差异确实是由温度引起的.

FIGURE 5 | Short-term acclimation to the summer temperature (28°C) and winter temperature (15°C) on feeding behaviors and food consumption in goldfish. Goldfish acclimated to 20°C during the autumn months (Sep–Oct, 2017) were maintained for 4 weeks in 28 and 15°C water tanks, respectively. After that, the fish acclimated to 28°C were transferred to water tanks at 15°C for 24 h. In reciprocal experiment, the fish acclimated to 15°C were transferred to water tanks at 28°C during the same period. As control treatment, parallel experiments without transferring the fish or with parallel transfer into water tanks with the same acclimation temperature (i.e., from 28 to 28°C/from 15 to

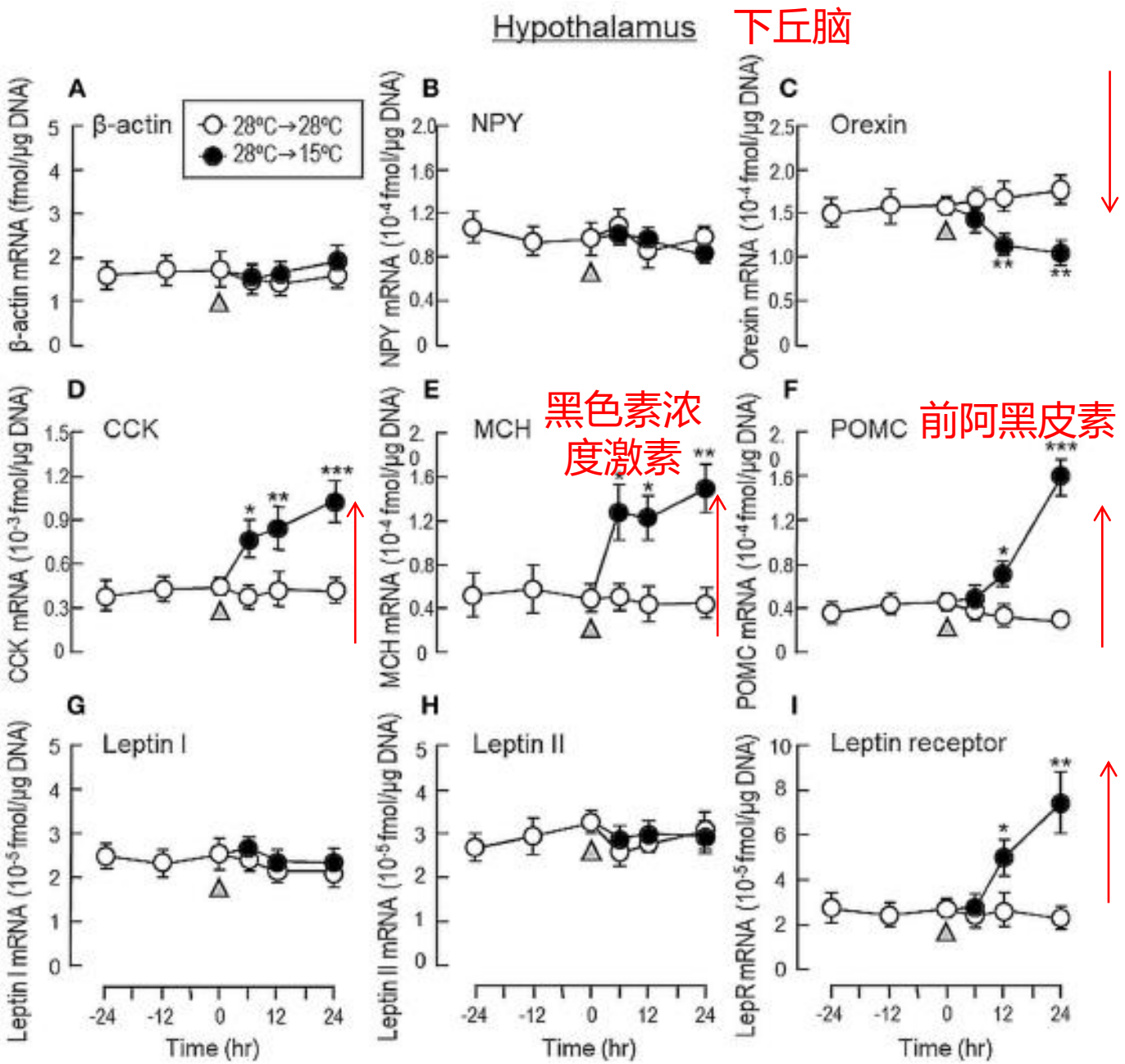
FIGURE 5 | 15°C) were also conducted. Following the short-term exposure to temperature change, measurement of different types of feeding behaviors **(A)** and food intake **(B)** were performed according to the standard protocols. The data obtained (mean ± SEM, $n = 10–12$) were analyzed with one-way ANOVA followed by Tukey *post-hoc* test. Difference between groups was considered as significant at $p < 0.05$ (***$p < 0.001$).

温度是通过怎样的机制来调控摄食行为和摄食量呢?



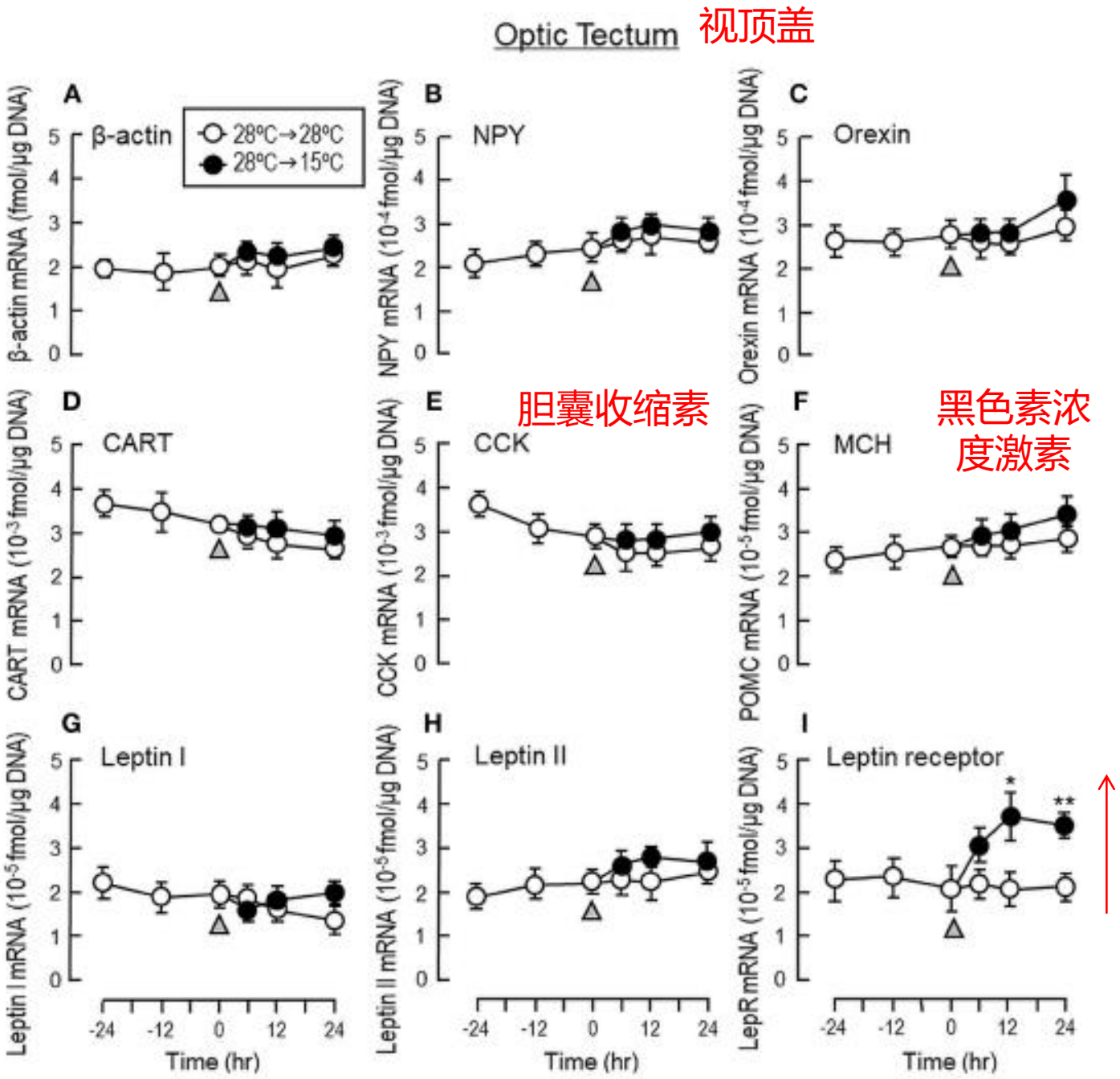
28℃→ 15℃

FIGURE 6 Transcript expression of orexigenic and anorexigenic factors within the telencephalon of goldfish with short-term exposure to winter temperature (15℃).Water temperature for goldfish acclimated at 28℃ was gradually reduced to 15℃ over a 24-h period using a cooling system linked with the water tank. The telencephalon was harvested from individual fish at different time points before and after the activation of the cooling system (as indicated by gray triangle).



28℃→ 15℃

FIGURE 7 Transcript expression of orexigenic and anorexigenic factors within the hypothalamus of goldfish with short-term exposure to winter temperature (15℃).Water temperature for goldfish acclimated at 28℃ was gradually reduced to 15℃ over a 24-h period using a cooling system linked with the water tank. The hypothalamus was harvested from individual fish at different time points before and after the activation of the cooling system (as indicated by gray triangle)



28℃→ 15℃

FIGURE8 Transcript expression of orexigenic and anorexigenic factors within the optic tectum of goldfish with short-term exposure to winter temperature (15℃).Water temperature for goldfish acclimated at 28℃ was gradually reduced to 15℃ over a 24-h period using a cooling system linked with the water tank. The optic tectum was harvested from individual fish at different time points before and after the activation of the cooling system (as indicated by gray triangle)

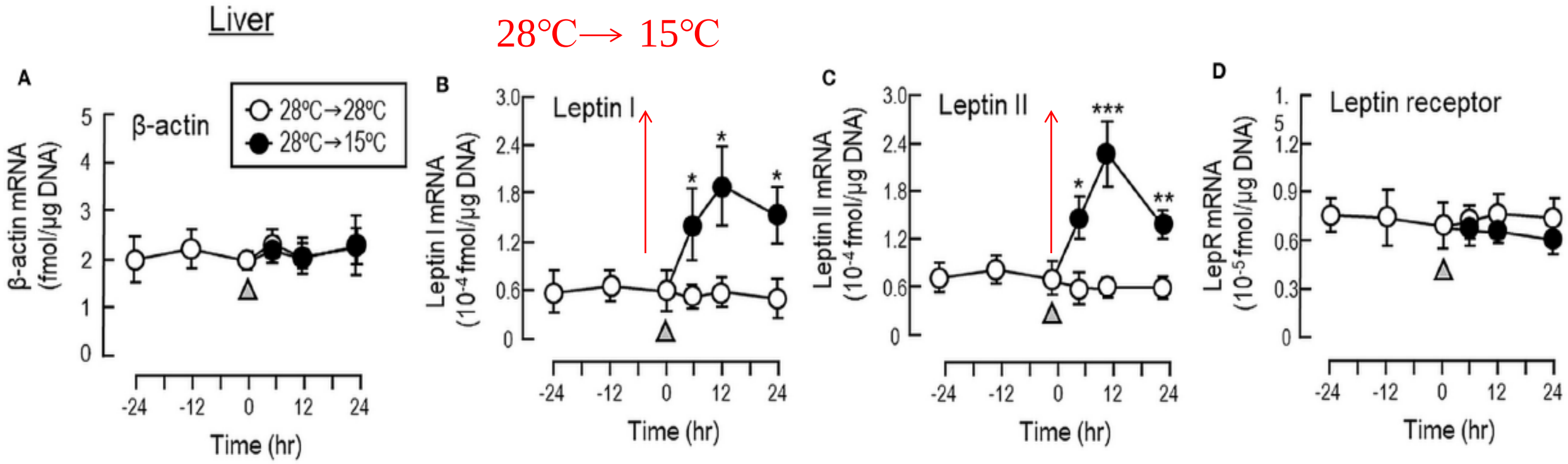


FIGURE9 Transcript expression of orexigenic and anorexigenic factors within the liver of goldfish with short-term exposure to winter temperature (15℃).Water temperature for goldfish acclimated at 28℃ was gradually reduced to 15℃ over a 24-h period using a cooling system linked with the water tank. The liver was harvested from individual fish at different time points before and after the activation of the cooling system (as indicated by gray triangle)

4 结论

1.夏季向冬季过渡, 环境温度的降低会减少金鱼的摄食行为及摄食量, 这些摄食响应可快速发生且是高度可逆的.

2.温度可通过调节肝脏leptin, 脑区域leptin受体及厌食/促食基因的表达来调控摄食.

请各位老师批评指正