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· 综述 ·

鱼类促性腺激素抑制激素及其受体的研究进展

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摘要： 促性腺激素抑制激素是2000年由日本学者首次从鹌鹑脑中分离出的一种新型下丘脑神经肽，通过其受体介导参与机体的生长、生殖以及摄食等生理过程。迄今，只在金鱼、斑马鱼、星点东方鲀、罗非鱼以及斜带石斑鱼等几种鱼中鉴定出促性腺激素抑制激素。目前，鱼类促性腺激素抑制激素的生理学功能研究相对较少，且存在争议。鱼类促性腺激素抑制激素及其受体的表达调控以及其他生理学功能仍有待进一步研究。本研究简要总结鱼类促性腺激素抑制激素及其受体的研究进展，并对促性腺激素抑制激素的生理学功能进行概括讨论，旨在加深对鱼类促性腺激素抑制激素的认识和了解，为进一步研究做铺垫。

关键词: 鱼类；促性腺激素抑制激素；促性腺激素抑制激素受体；生长；生殖

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脊椎动物生殖主要受到生殖轴的调控，下丘脑分泌的促性腺激素释放激素(gonadotropin-releasing hormone，GnRH)促进垂体促性腺激素(gonadotropin，GTH)的分泌，GTH作用于性腺促进性类固醇激素的释放进而促进性腺发育，性类固醇激素也可以通过负反馈作用于脑和垂体影响GTH的合成和分泌[1-2]。下丘脑十肽GnRH是GTH神经内分泌调控的主要促进因子，然而却没有一种下丘脑神经肽能够抑制GTH分泌。直到2000年，日本学者从鹌鹑(*Coturnix japonica*)脑中分离出一种新型下丘脑神经肽，因其具有抑制垂体GTH分泌的功能故命名为促性腺激素抑制激素(gonadotropin-inhibitory hormone，GnIH)，这是首次在脊椎动物中鉴定出具有抑制生殖功能的下丘脑神经肽[3]。随后，在其他脊椎动物中也鉴定出了GnIH的同源基因，并对其结构与功能的多样性开展了大量的研究[4-6]。本研究简要总结鱼类促性腺激素抑制激素及其受体的研究进展，并对促性腺激素抑制激素的生理学功能进行概括讨论，旨在加深对鱼类促性腺激素抑制激素的认识和了解，为进一步研究做铺垫。

1 促性腺激素抑制激素的发现及分布

1977年，研究人员首次从软体动物*Macrocallista nimbosa*的神经节中分离出一种C末端为Arg-Phe-NH2的神经肽(RFa多肽)[7]。鉴于在非脊椎动物中RFa多肽作为神经递质、神经调节因子或者外周激素的重要功能[8]，人们尝试从脊椎动物的中枢神经系统中鉴定出RFa多肽。2000年，日本学者首次从鹌鹑的脑中分离出一种新型RFa多肽，因其具有抑制垂体GTH分泌的功能故命名为促性腺激素抑制激素[3]。鹌鹑GnIH为十二肽，其氨基酸序列为SIKPSAYLPLRF- NH_2，C末端为RFa基序，属于RFa多肽家族[9]。除了GnIH外，GnIH相关肽2 (GnIH-RP-2)也在鹌鹑脑中被鉴定出来[3]。随后，在八哥(*Sturnus vulgaris*)以及斑胸草雀

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(*Taeniopygia guttata*)脑中也分离得到了内源性的GnIH [10-11]。通过免疫组化在鹌鹑下丘脑室周核区细胞体以及正中隆起末端均检测到了GnIH的阳性信号；此外，在小叶间隔区也检测到少量阳性信号；间脑GnIH的含量比其他脑区均高[3,12]。因此同GnRH类似，GnIH由下丘脑释放，然后作用于垂体进而调控GTH的合成和分泌。

2 促性腺激素抑制激素的基因、结构、组织分布以及系统进化

2001年，编码GnIH前体多肽的cDNA首次在鹌鹑脑中被克隆出来[13]，随后在其他鸟类中也鉴定出了GnIH cDNAs，例如鸡(*Gallus domesticus*)、麻雀(*Zonotrichia leucophrys gambelii*)、八哥以及斑胸草雀[14-16]。GnIH前体编码GnIH以及2个GnIH相关肽(GnIH-RP-1和GnIH-RP-2)，它们C末端均为保守的Leu-Pro-X-Arg-Phe-NH_2 (LPXRF-a; X=L或者Q)基序，因此从结构的观点看，GnIH及其相关肽应该被称作LPXRFa多肽[14-16]。鸡和斑胸草雀GnIH基因均由3个外显子和2个内含子组成[11,17]，其中斑胸草雀GnIH基因全长3 701 bp，外显子1编码5’UTR和信号肽，外显子2编码GnIH和2个GnIH相关肽，外显子3编码短开放读框和3’UTR [11]。通过原位杂交证实GnIH mRNA主要在下丘脑室周核区细胞中表达[12]。在哺乳类中也鉴定出了GnIH同源基因(RFRP) [18-20]。在人(*Homo sapiens*)、恒河猴(*Macaca mulatta*)和牛(*Bos taurus*)中，RFRP前体cDNA编码3种RFRP多肽(RFRP-1, -2和 -3)，然而在啮齿类中，RFRP前体cDNA只编码RFRP-1和-3 [6,21-22]。除RFRP-2外，RFRP-1和-3的C端均为LPXRFa (X=L或者Q)基序，因此它们被认为是哺乳类GnIH。

鱼类GnIH同源基因首次在金鱼(*Carassius auratus*)脑中被鉴定出来[23]。金鱼GnIH cDNA全长742 bp，其中5’UTR 15 bp，3’UTR 136 bp，开放读框591 bp，编码197个氨基酸的前体蛋白，经加工可产生3种假定多肽(gfLPXRFa-1, -2和-3)，然而只有gfLPXRFa-3被鉴定为成熟肽[23]。随后，在斑马鱼(*Danio rerio*)、星点东方鲀(*Takifugu niphobles*)、罗非鱼(*Oreochromis niloticus*)以及斜带石斑鱼(*Epinephelus coioides*)中鉴定出了GnIH同源基因[24-27]。此外，在无颌鱼类海七鳃鳗(*Petromyzon marinus*)以及褐副盲鳗(*Paramyxine atami*)中也鉴定出了GnIH同源基因[28-29]。在大多数鱼类中，GnIH基因编码3种假定多肽(LPXRFa-1, -2和-3)，然而在某些鱼类中只存在2种假定多肽(LPXRFa-1和-2) [24]。RT-PCR以及Southern Blot证实金鱼GnIH mRNA只在间脑(包括下丘脑)中特异性表达，在端脑、中脑以及后脑中均不表达；通过原位杂交进一步证实金鱼GnIH mRNA只在下丘脑核后脑室外周表达[23]。

GnIH及其相关肽属于RFa多肽家族，该家族C末端为Arg-Phe-NH_2 (RFa)基序，该家族包括NPFF亚家族、PrRP亚家族、GnIH亚家族、kisspeptin亚家族以及QRFP/26RFa亚家族[16]。RFa多肽家族均参与了生殖调控，介导了环境因子(光周期、类固醇激素、代谢信号以及压力)调控的生殖活动[30]。

3 促性腺激素抑制激素受体的基因、结构及组织分布

鸟类GnIH受体(GnIH-R)首次在鹌鹑间脑中被克隆出来[31]。鹌鹑GnIH-R cDNA全长1479 bp，其中开放读框1197 bp，编码399个氨基酸，预测分子量为45.7 kμ；鹌鹑GnIH-R属于七次跨膜的G蛋白偶联受体，由3个胞外环、3个胞内环、胞外N端区以及胞内C端区组成[31]。RT-PCR以及Southern Blot证实鹌鹑GnIH-R主要在垂体、大脑、间脑、中脑以及脊髓中表达，然而在小脑中没有表达[31]。同样GnIH-R在鸡垂体及不同脑区中有类似表达[17]。此外，GnIH-R在八哥脑GnRH神经元以及鸡的精巢和卵巢中均有表达[10,32]。哺乳类GnIH-R在人、大鼠(*Rattus norvegicus*)、羊(*Ovis aries*)中得到鉴定[33-36]，同样哺乳类GnIH-R也主要在下丘脑和垂体中表达[4,6,30]。

鱼类GnIH-R最初是从斑马鱼脑中鉴定出来的，这也是首次在1种脊椎动物中鉴定出3种不同的GnIH-Rs[24]。斑马鱼GnIH-R1、GnIH-R2和GnIH-R3的开放读框分别为1197 bp、1452 bp、1338 bp，各自编码398、484、445个氨基酸；3种GnIH-Rs均为典型的G蛋白偶联受体，包括胞外N端区、七次跨膜区以及胞内C端区[24]。此外，在金鱼脑中也鉴定出3种不同的GnIH-Rs[37]。在斑马鱼中，GnIH-R1主要在脑、精巢、脾脏和眼中表达，在肌肉和肾脏中也有表达；GnIH-R2主要

在脑、眼以及精巢中表达，在肾脏中也有表达；GnIH-R3在多种组织中均有表达，然而表达水平不高，例如精巢、卵巢、脾脏、眼、垂体、脑、鳃丝以及肌肉；此外在斑马鱼不同发育时期，3种GnIH-Rs表达水平也有差异[24]。在金鱼中，通过原位杂交证实GnIH-Rs在下丘脑和垂体中均有表达，表明GnIH既可以在下丘脑水平也可以在垂体水平调控GTH分泌[37]。此外，在鲫精巢和卵巢中均有GnIH-Rs分布[38]。除斑马鱼和金鱼外，其他鱼类只鉴定出1种GnIH-R，例如星点东方鲀、罗非鱼以及斜带石斑鱼[25-27]。

4 促性腺激素抑制激素的功能

4.1 促性腺激素抑制激素对下丘脑GnRH神经元活性以及表达调控的影响

通过原位杂交以及免疫细胞化学证实GnIH-R在GnRH神经元中表达，暗示GnIH可能影响GnRH神经元的活性[10]。电生理学研究证实RFRP-3抑制了GnRH神经元的兴奋性，表明RFRP-3可以通过作用于GnRH神经元的活性来调控GTH分泌[39-40]。此外，无颌鱼类海七鳃鳗LPXRFa-2增加了脑GnRH-III的含量[29]，然而金鱼gfLPXRFa-2和-3均显著性降低了下丘脑sGnRH的表达水平[37]。最近在斜带石斑鱼中有报道称，3种LPXRFa多肽(gLPXRFa-1、gLPXRFa-2和gLPXRFa-3)均降低了下丘脑GnRH-1的表达，然而gLPXRFa-3却促进了下丘脑GnRH-3的表达[27]。综上所述，GnIH可以通过影响下丘脑GnRH神经元活性、GnRH的合成与分泌来间接调控垂体GTH的释放。

4.2 促性腺激素抑制激素对垂体激素合成与分泌的影响

在鸟类中，鹌鹑GnIH以浓度梯度依赖的方式抑制了鹌鹑原代垂体细胞LH分泌，同样也降低了FSH分泌，然而却不影响PRL分泌[3]。埋植GnIH以浓度梯度依赖的方式降低了鹌鹑垂体GTHα和LHβ的表达水平以及血浆中LH浓度[41]。同样，GnIH也降低了鸡垂体FSH和LH分泌以及GTHα和FSHβ的表达水平，然而对LHβ表达水平无影响[42]。此外，GnIH降低了麻雀GnRH诱导的LH分泌[43]。在哺乳类中，RFRP-3不影响垂体基础GTH的合成和分泌，然而却降低了GnRH诱导的GTH的合成和分泌[18,20,44-45]。也有报道称，RFRP-3抑制了基础以及GnRH诱导的LH分泌[19,46-48]。相反，RFRP-3促进了GH、ACTH以及催产素的分泌[46,49]。此外，RFRP-3不影响垂体GH、POMC以及PRL的表达[18]。RFRP-1抑制了LH分泌，促进了PRL、ACTH以及催产素的分泌[33,48-49]。总体来说，在鸟类和哺乳类中，GnIH/RFRP通过降低垂体GTH的合成和分泌来抑制生殖。

鱼类GnIH对垂体激素分泌及其基因表达的调控作用仍存在争议。金鱼gfLPXRFa-1、-2和-3均显著性促进了红大麻哈鱼(*Oncorhynchus nerka*)原代垂体细胞FSH、LH和GH的分泌，对PRL和SL分泌没有影响[50]；罗非鱼LPXRFa-2也促进了垂体FSH以及LH的分泌，对GH分泌没有影响[26]；金鱼gfLPXRFa-1促进了星点东方鲀垂体FSHβ和LHβ的表达，对GTHα表达没有影响[25]；此外，海七鳃鳗LPXRFa-2以及褐副盲鳗LPXRFa也均显著性促进了垂体GTHβ的表达水平[28-29]。综上所述，鱼类GnIH对垂体激素分泌及其基因表达具有正向调节作用。相反，腹腔注射斑马鱼LPXRFa-3显著性降低了金鱼血清LH水平[24]；腹腔注射金鱼gfLPXRFa-2和-3显著性降低了金鱼垂体FSHβ的表达水平，gfLPXRFa-2也降低了LHβ的表达水平，然而gfLPXRFa-2和-3不影响金鱼原代垂体细胞GTH的合成，但是gfLPXRFa-3却抑制了GnRH诱导的GTH的合成[37]。有意思的是，有报道称金鱼gfLPXRFa-3以季节性生殖依赖的方式促进或者抑制垂体激素分泌及其基因的表达[51-53]。最近在斜带石斑鱼中研究发现，3种LPXRFa多肽(gLPXRFa-1、gLPXRFa-2和gLPXRFa-3)均不影响垂体FSHβ的表达水平，只有gLPXRFa-2抑制了垂体LHβ的表达[27](表1)，本研究对不同鱼类GnIH氨基酸序列与功能的差异进行分析比较(表1)。

4.3 促性腺激素抑制激素促进了摄食

GnIH不仅参与了下丘脑和垂体激素分泌及其表达调控，而且也参与了摄食调控。在鸟类中，侧脑室注射GnIH均促进了鸡和北京鸭(*Anas platyrhynchos domestica*)的摄食[54-56]。进一步研究发现，GnIH增加了鸡的摄食是由中枢阿片样物质受体介导的[57]。此外，侧脑室注射GnIH也增加了下丘脑NPY(促摄食因子)的表达水平，降低了POMC(抑摄食因子)的表达水平[56]。在哺乳类中，通过免疫组化证实在羊下丘脑中参与摄食

表 1　鱼类GnIH氨基酸序列及其功能

Tab.1　Amino acid sequences and functions of GnIH in fish

物种 species	GnIH名称 GnIH names	序列 sequences	功能 functions	参考文献 references
褐副盲鳗 *Paramyxine atani*	LPXRFa	ALPQRFa	促进了褐副盲鳗垂体GTHβ的表达	[28]
海七鳃鳗 *Petromyzon marinus*	LPXRFa-1a	SGVGQGRSSKTLFQPQRFa		[29]
	LPXRFa-1b	AALRSGVGQGRSSKTLFQPQRFa		
	LPXRFa-2	SEPFWHRTRPQRFa	增加了海七鳃鳗脑GnRH-III的含量以及垂体GTHβ的表达	
金鱼 *Carassius auratus*	gfLPXRFa-1	SLEIEDFTLNVAPTSGRVSSPTIL RLHPKITKPTHLHANLPLRFa	促进了红大麻哈鱼原代垂体细胞FSH、LH和GH的分泌，对PRL和SL分泌没有影响；促进了星点东方鲀垂体FSHβ和LHβ的表达，对GTHα表达没有影响	[25,50]
	gfLPXRFa-2	AKSNINLPQRFa	促进了红大麻哈鱼原代垂体细胞FSH、LH和GH的分泌，对PRL和SL分泌没有影响；腹腔注射降低了金鱼垂体FSHβ和LHβ的表达水平；不影响金鱼原代垂体细胞GTH的合成	[37,50]
	gfLPXRFa-3	SGTGLSATLPQRFa	促进了红大麻哈鱼原代垂体细胞FSH、LH和GH的分泌，对PRL和SL分泌没有影响；腹腔注射降低了金鱼垂体FSHβ的表达水平；不影响金鱼原代垂体细胞GTH的合成，却抑制了GnRH诱导的GTH的合成；以季节性生殖依赖的方式促进或者抑制垂体激素的合成与分泌	[37,50-53]
斑马鱼 *Danio rerio*	zfLPXRFa-1	SLEIQDFTLNVAPTSGGASSPTIL RLHPIIPKPAHLHANLPLRFa		[24]
	zfLPXRFa-2	APKSTINLPQRFa		
	zfLPXRFa-3	SGTGPSATLPQRFa	降低了金鱼血清LH水平	
罗非鱼 *Oreochromis niloticus*	tiLPXRFa-1	TLLSSNDGTYSVRKQPHQETK NEIHRSLDLESFNIRVAPTTSKFSLP PTIIRFYPPTVKPLHLHANMPLRFa		[26]
	tiLPXRFa-2	QSDERTPNSSPNLPQRFa	促进了罗非鱼垂体FSH以及LH的分泌，对GH分泌没有影响	
	tiLPXRFa-3	APNQLLSQRFE		
星点东方鲀 *Takifugu niphobles*	gpLPXRFa-1	SLDMERINIQVSPTSGKVSLPTIV RLYPPTLQPHHQHVNMPMRFa		[25]
	gpLPXRFa-2	DGVQGGDHVPNLNPNMPQRFa		
斜带石斑鱼 *Epinephelus coioides*	gLPXRFa-1	LFPPTAKPFQLHANMPMRFa	降低了下丘脑GnRH-1的表达；不影响下丘脑GnRH-3、Kiss1及Kiss2的表达；不影响垂体LHβ及FSHβ的表达	[27]
	gLPXRFa-2	ESVPGDDSAPNSTPNMPQRFa	降低了下丘脑GnRH-1的表达；不影响下丘脑GnRH-3、Kiss1及Kiss2的表达；不影响垂体FSHβ的表达，却抑制了LHβ的表达	
	gLPXRFa-3	EAQNPILPQRLa	降低了下丘脑GnRH-1的表达，却促进了GnRH-3的表达；不影响下丘脑Kiss1及Kiss2的表达；不影响垂体LHβ及FSHβ的表达	

调控的神经元(NPY、POMC、orexin以及MCH)外周均有RFRP-3纤维分布[58]。侧脑室注射RFRP-3也显著性增加了大鼠、小鼠(*Mus musculus*)、羊以及食蟹猕猴(*Macaca fascicularis*)的摄食[19,46,59]。目前，GnIH是否参与了鱼类摄食调控仍不得而知。

4.4　促性腺激素抑制激素对性腺发育及类固醇激素合成与分泌的影响

除了作用于下丘脑和垂体来调控生殖外，GnIH也可以直接作用于性腺来调控生殖。埋植GnIH以浓度梯度依赖的方式减少了成年雄性鹌

鹑血浆中睾酮的含量，诱导了精巢凋亡，降低了精子生成的活性，然而却不影响精巢的质量；此外，GnIH减少了未成年雄性鹌鹑精巢质量、血浆中睾酮含量、精曲小管直径以及精细胞的数量，这些结果表明GnIH通过降低GTH的合成和分泌来抑制性腺发育及维持[41]。同样在麻雀中，GnIH降低了GTH诱导的睾酮分泌[60]。此外，GnIH可能影响了鸡卵巢类固醇生成、卵泡的生长和成熟[32]。在哺乳类中，侧脑室注射RFRP-3提高了仓鼠(*Mesocricetus auratus*)血浆中睾酮含量[61]。相反，RFRP-3降低了人粒层细胞GTH诱导的黄体酮分泌[62]。此外，GnIH通过降低LHR、StAR以及3βHSD的蛋白水平进而抑制小鼠卵巢卵泡发育和类固醇生成[63]。

埋植金鱼gfLPXRFa-2和-3对雌鱼血浆雌二醇浓度无影响，却显著性促进了雄鱼血浆睾酮的含量；腹腔注射gfLPXRFa-2和-3均促进了精巢*StAR*和 *3βHSD*的表达水平，抑制了*CYP*19 mRNA水平，然而对卵巢*StAR*、*3βHSD*以及*CYP*19的表达水平无影响；此外，gfLPXRFa-2和-3也促进了精巢细胞*FSHR*、*LHR*、*StAR*以及*3βHSD*的表达水平，抑制了精巢细胞*CYP*19 mRNA水平，然而对卵巢细胞中该5种基因的表达均无影响，这些结果表明GnIH可能只参与了雄性金鱼性类固醇激素的生成[38]。GnIH及GnIH-R在斜带石斑鱼卵巢发育以及性逆转过程中的动态变化，暗示GnIH/GnIH-R可能参与了斜带石斑鱼性腺发育以及性逆转过程[27]。

5 促性腺激素抑制激素的信号转导机制

目前，关于GnIH的信号转导机制研究较少[6]。最初有报道称GnIH能够降低转染了GnIH-R的COS-7细胞中$G\alpha_i$的表达水平[17]，这只能说明GnIH调控$G\alpha_i$的表达，并不能说明GnIH-R与$G\alpha_i$偶联。进一步研究发现，GnIH不影响转染了GnIH-R的GH3细胞中IPs或者CRE-luc活性，说明GnIH-R不与$G_{\alpha q}$以及$G_{\alpha s}$偶联；然而却降低了forskolin (腺苷酸环化酶AC的激动剂)诱导的CRE-luc活性，说明GnIH通过$G_{\alpha i}$抑制AC的活性[64]。RFRP-3降低了GnRH诱导的细胞内钙离子以及ERK的磷酸化水平，说明RFRP-3可能通过降低钙离子和ERK磷酸化进而抑制了GnRH诱导的GTH分泌[18,44]。在小鼠促性腺激素细胞系LβT2中研究发现，RFRPs (RFRP-1和3)降低了GnRH诱导的CRE-luc活性以及cAMP水平，表明RFRPs可以通过降低AC活性来抑制GnRH诱导的cAMP/PKA途径；RFRPs降低了GnRH诱导的ERK磷酸化和GTH基因表达；此外，AC/cAMP/PKA通路抑制剂也降低了GnRH诱导的ERK磷酸化和GTH基因表达，综上所述，RFRPs通过抑制AC/cAMP/PKA通路依赖的ERK磷酸化进而降低了GnRH诱导的GTH基因表达[65]。

最近有报道称罗非鱼tiLPXRFa-2增加了转染tiLPXRFa-R的COS-7细胞CRE-Luc和SRE-Luc的活性，说明tiLPXRFa-2能够激活cAMP/PKA和Ca^{2+}/PKC通路[26]。相反，斜带石斑鱼3种LPXRFa多肽(gLPXRFa-1、gLPXRFa-2和gLPXRFa-3)不影响转染了gLPXRFa-R的COS-7细胞CRE-Luc的活性，却均降低了forskolin诱导的CRE-luc活性[27]。此外，gLPXRFa-1降低了转染了gLPXRFa-R的COS-7细胞SRE-Luc的活性, 然而gLPXRFa-2和gLPXRFa-3不影响SRE-Luc的活性[27]。鱼类GnIH调控垂体激素合成与分泌的信号转导机制需要进一步深入研究。

6 小结与展望

生殖调控是一个复杂的网络结构，多种因子参与其中，不同因子之间相互作用、相互影响，增加了研究的复杂性。GnIH自从被发现之后，在鸟类和哺乳类中受到了广泛的研究，然而在鱼类中的研究却相对迟缓。目前，在几种鱼类中鉴定出了GnIH同源基因，其能够编码产生3种LPXRFa多肽。在鸟类和哺乳类中GnIH被认为是生殖调控的抑制因子，然而在鱼类中GnIH对生殖调控的作用仍存在争议。即使在同一物种间，不同的研究者也得到了相异或者相反的结论[4]。除了因物种特异性导致结果不同外，以下几个方面也可能导致结果不同：①GnIH的来源。异源GnIH对不同物种间LH分泌作用是不同的。金鱼gfLPXRFa-3显著性促进了红大麻哈鱼LH的分泌[50]，然而却降低了金鱼血浆中LH水平[51]；②不同生殖周期的实验模型。金鱼gfLPXRFa-3不影响性腺复苏早中期金鱼垂体细胞LH分泌，却降低了性腺复苏晚期金鱼垂体细胞LH分泌[51]；③处理方法不同。腹腔注射金鱼gfLPXRFa-2显著性降低了金鱼垂体FSHβ和LHβ的

表达水平，然而gfLPXRFa-2不影响金鱼原代垂体细胞FSHβ和LHβ的表达水平[37]。因此，根据不同的研究对象，选择合适的实验方法，建立合理的实验体系，这对开展鱼类生殖调控机制研究具有重要的意义。

综上所述，GnIH是多功能的神经肽，在下丘脑、垂体以及性腺水平参与了生殖调控。GnIH对鱼类生殖调控的作用仍存在争议，需要进一步深入研究；GnIH调控垂体激素分泌及其基因表达的信号转导机制网络需要进一步完善；GnIH是否参与鱼类摄食调控及其作用机制尚未阐明；GnIH与其他因子之间如何互作、在垂体水平将多种信号整合进而调控生殖等生理过程仍不清楚，只有阐明上述机制才能更好地了解鱼类GnIH参与生长、生殖及摄食的协调过程。

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Progress of research on gonadotropin-inhibitory hormone and its receptors in fish

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Abstract: Gonadotropin-inhibitory hormone (GnIH) is a novel hypothalamic neuropeptide which was originally isolated from the quail brain and known for inhibiting the secretion of gonadotropin (GTH) from cultured quail anterior pituitaries. GnIH participates in growth, reproduction, and food intake via the specific seven transmembrane G protein-coupled receptors (GPCRs). To date, GnIH was identified in several teleosts, including goldfish, zebrafish, grass puffer, tilapia and orange-spotted grouper. However, information on the studies of GnIH physiology are limited and contradictory in fish. The regulation of GnIH and its receptors as well as other roles of GnIH awaits further studies in teleosts. This review brifely summarized the progress of research on GnIH and its receptors, with special emphasis on the physiological functions of GnIH in fish and we hope this review will contribute to the futher studies.

Key words: fish; gonadotropin-inhibitory hormone; gonadotropin-inhibitory hormone receptor; growth; reproduction

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