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Molecular and physiological evidences for the role in appetite regulation of apelin and its receptor APJ in Ya-fish (Schizothorax



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prenanti)*

Department of Aquaculture

ARTICLE IN

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Keywords: Ya-fish Apelin APJ Cloning Tissue distribution Food intake



th diverse physiological actions pelin in the regulation of appeted their mRNA distributions in event nutritional status on apelin pressed in all tissues tested, relalamus and kidney. Short-term ference between fasted fish and ently increased during the 7-day formed intraperitoneal (i.p.) inin injected at a dose of 100 ng/g saline injected fish. Our results pread distributions also suggest n fish.

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A *ACATGGGGAGGGGGAGAGCAGAA*ATGAATGTGAAGATCTTGACGCTGGTGATTGTGCTGGTGGTTTTCTCTGCTGTGT TCAGCCAGTGCTGGTCCAATGGCCTCCACCGATCATAGCAAAGAGCTGGAGGAGGTGGGCAGCGTGAGGACTCCT 19 44 CTCTCCCATAAGGGGCCCATGCCATTTTAG*AGCAAGGCACAGCTTAGAGTGCCCTCCCCCTTGGTTCTGATTTCT* LSHKGPMPF* 302 ATGCTCTTCCTTTGCCTTGGGGGGCCTTGCAACAAGGGGCCTTTGCTAGCCCAGCCTGAAGAGTGATGTCCATAG TCTCCTCCTGTGGTTTTCCTCATTTGCTTTCTAGAGCCCTTTCATGGCCACACTTCGCATGATGTGTGAGCAGTG GGGAGCCTGGTCTAAACAGTTATAGTCTGAAGCTTAAGGATAAAGCCACAGTGTCTCATTATCAAAATCACACTC CACTTCCATAAGCGTGAGATCATCGTCCTGAGCCCTCTTCTCCTCCCCCATGACACACGCTGCTTTACAGCAGAG 752 GTACATGACTGTTAACTGGCCAGGGTGATCTGCTTCACACGGCGGACCATCTCTCCTTTTAATGAAGTGCCAAAT 827 AGCAAATCTACTCCACAGTGCTGCCCGGAGAAGAAAGTAAACATGTTACCTCTTATCTTGGGGGAAGCATAACA 902 TCTAACCATATGTGCGCATTTTGCCATTTGTTTGAACATCCAATGTAAAGGCAACGGTAGCATGGTTTCAAGACA 977 TTAGACAAAAAAAAAAAAAAAAAA

基因克隆

Apelin

全长: 1001bp

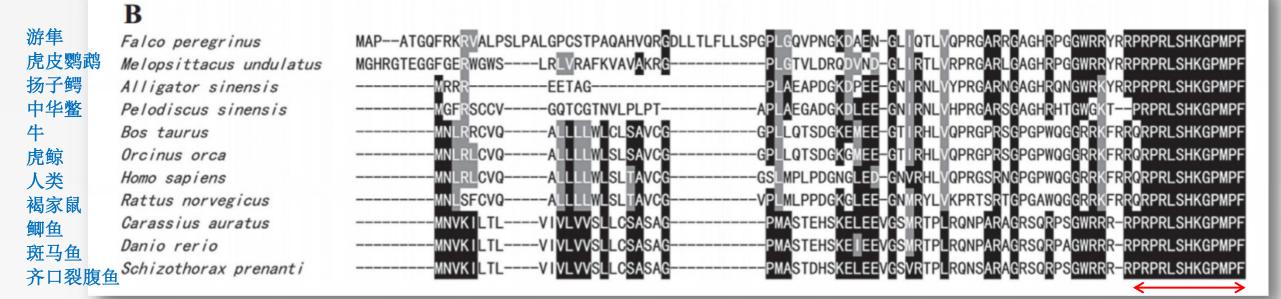
ORF: 231bp

编码77个氨基酸

N端有一个22个氨基酸组成的信号肽。

序列比对

Apelin



A ACATGGGGGCATTCTGACCTGAGCACATCACAAGCTGACTTCTCTGTGATCATTTAGGTCACCGATACTTTAAA CACTGAAAGATCCTTGGAGGAGTATGAATGCCATGGACAAAATGACTGCTGACTATAGCCAAGATGACTACGACGAG M N A M D K M T A D Y S Q D D Y D E ACATTGAACAACTCAATGTGTGATTTTGATGAGTGGGAACCGTCATATTCGCTGATTCCTGTGCTCTACATGCTC T L N N S M C D F D E W E P S Y S L I P V L Y M L ATCTTCATCCTGGGCCTCACTGGGAATGGTGTGGTCATCTTCACCGTATGGCGGGCTCAGTCCAAACGGAGAGCT I F I L G L T G N G V V I F T V W R A Q S K R R A GCAGACATCTACATTGGAAACCTGGCTCTTGCTGACCTGACCTTTGTGGTGACCCTGCCTCTGTGGGCCGTCTAC ACCGCCCTGGGATACCACTGGCCGTTTGGCGTGGCCCTCTGCAAGATCAGCAGCTATGTGGTGTTGCTCAACATG TALGYHWPFGVALCKISSYVVLLNM TACGCCAGTGTCTTCTGCCTCACCTGCCTGAGTCTGGACCGCTACATGGCCATCGTTCACTCCCTCACCAGCACA Y A S V F C L T C L S L D R Y M A I V H S L T S T CAGCTGCGGACCAGAGGACACATGCGGGCCTCGCTGGCCACCATCTGGCTCCTCTCAGGTGTGCTGCTGCACCC Q L R T R G H M R A S L A T I W L L S G V L A A P 🗸 ACGCTGCTGTTTCGCACCACGGTGTACGACGCTGAGACCAACCGTACCTCCTGCGCCATGGACTTCAGCCTGGTG T L L F R T T V Y D A E T N R T S C A M D F S L V GTGAGCAAACCGGGTCAGGAGACCTTTTGGATCGCCGGCCTCAGCATCTCCTCCACTGCTCTCGGCTTTCTGATC V S K P G Q E T F W I A G L S I S S T A L G F L I CCCCTTCTGGCCATGATGGTGTGCTACGGATTCATCGGCTGCACCGTCACACGTCACTTCAACAGCCTGCGCAAG GAGGACCAGCGCAAACGCCGCCTGCTCAAGATCATCACCACATTGGTGGTGGTGTTTTGCTGCGTGCTGGATGCCC E D Q R K R R L L K I I T T L V V V F A A C W M P 900 TTCCACGTCGTGAAGACCATGGACGCTCTTTCGTACCTGAACCTTGCTCCTGACTCCTGTACCTTCCTGAACCTC F H V V K T M D A L S Y L N L A P D S C T F L N L 975 CTTCTTCTGGCTCATCCCTATGCAACCTGCCTGGCGTACGTCAACAGCTGCCCCAACCCGCTCCTCTACGCCTTC 294 L L L A H P Y A T C L A Y V N S C P N P L L Y A F 1050 TTCGACCTCCGCTTCCGCTCCCAGTGCCTCTCCTCCAACCTGAAGAAAGCCCTTCACGCCAGTCCTGCCAGC 319 FDLRFRSQCLCLLNLKKALHASPAS 1125 TCCCTTTCTCACAGAAGACTGAGGCCCAGTCTCTGGCTACGAAGGTGTGAGGAGG S L S S Q K T E A Q S L A T K V *

基因克隆

APJ ORF: 1080bp 编码359个氨基酸 7个跨膜域

序列比对

Table 2Comparison of Ya-fish apelin and APJ sequences with other known vertebrate sequences.

		Carassius auratus	Danio rerio	Salmo salar	Anguilla japonica	Alligator sinensis	Pelodiscus sinensis	Falco peregrinus	Melopsittacus undulatus	Bos taurus	Orcinus orca	Rattus norvegicus	Homo sapiens
Apelin		97.1%	95.1%	-	-	52.0%	51.0%	30.4%	44.1%	53.9%	52.9%	52.0%	50.0%
APJ	(A)		79.7%	79.4%	77.4%	50.1%	47.1%	52.9%	50.1%	42.3%	47.1%	47.8%	47.3%
	(B)	-	95.8%	81.8%	-								

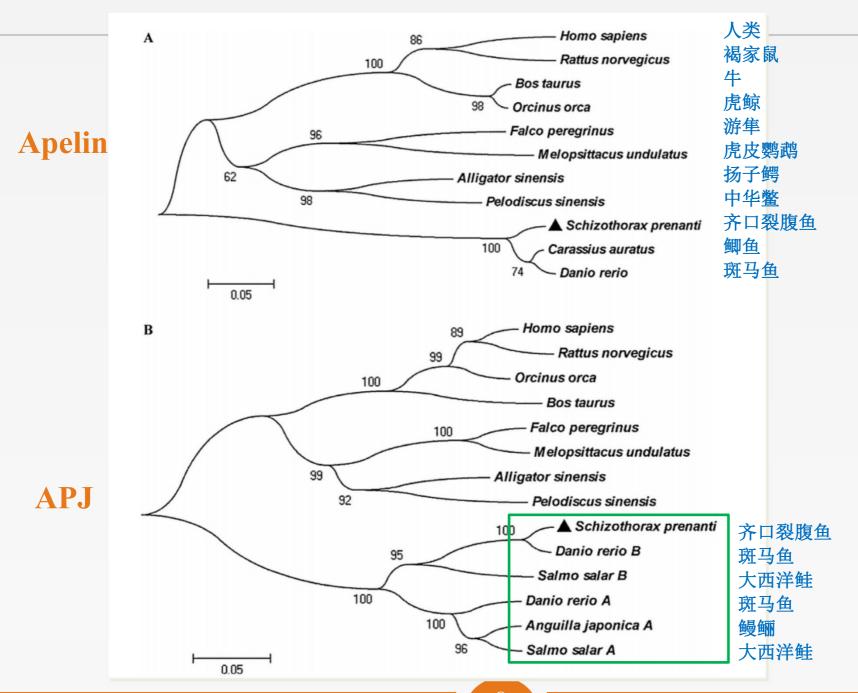
LAVADLTFVVTLPLIIA SLAVADLTEVVTLPLWATYTYRD 序列比对

B Homo sapiens Rattus norvegicus Orginus orga Bos taurus ASLAVADLTEVVTLPLWA<mark>T</mark>YT<mark>YRDYD</mark>WPEGAFA ANLAWADLTEV<mark>A</mark>TLPLWAAYTC<mark>LN</mark>YHWPEGTFA Alligator sinensis ANLAMAYLTEVVTLPLWAAYT/LGYHWPEGSFA ANLAMADLTEVATLPLWAAYAYLGYHWPEGTAA Pelodiscus sinensis Falco peregrinus ANLAMADLTFVATLPLWAMYAWLGYHWPFGTAA GNLAWADLTFVVTLPLWAMYTALGYHWPFGMAL Melopsittacus undulatus Schizothorax prenanti NLALADLTFVVTLPLWAYYTALGYHWPFGVAL Danio rerio B GNLAWADLTFV TLPLWAYYTALGYHWPFGVAL Salmo salar B GNLALIADLTEVVTLPLINAVYTALGYHIIPFGYAL GNLALIADLTEVITLPLINAVYTALGYHIIPFGYAL Anguilla japonica A Salmo salar A IGNLALADLTEVITLPLWAYYTALGYHWPFGYA Danio rerio A Homo sapiens 102 CKLSSYL FYNNYASVFCLTGLSFDRYLAIVF2VANARLFLRVSGANATIVLIVLAALLANFVIVLRTIG—DLENTT VOCKNDYSIVATYSSE Rattus norvegicus 100 CKLSSYL FYNNYASVFCLTGLSFDRYLAIVF2VANARLFLRVSGANATIVLIVLAALLAVF2VAVFRSTD—IPENST TOCKNDYSIVATSNS Orcinus orca 102 CKLSSYL FYNNYASVFCLTGLSFDRYLAIVF2VANARLFLRVSGANATIVLIVLAALLAVF2VAVFRSTGTTLHVENST VOCKNDYSIVAGFSSE BOS taurus 102 CKLSSYL FYNNYASVFCLTGLSFDRYLAIVF2VANARLFRRVSGANATIVLIVLAALLALFALVEVAVFRSTGTTLHVENST VOCKNDYSIVAGFSSE Alligator sinensis 102 CKLSSYLVVANMYASVFCLTGLSFDRYLAIVF2VANARLFRRVSGANATIVLIVLAALLALFALVERAS—NLFGED ITCNIDYSSWANGTF Pelodiscus sinensis 101 CKLSSYLVFYNNYASVFCLTGLSFDRYLAIVF2VANARRFRRSGLVATVALIVLAALLALFALVERAS—VLPGET VICVIDISG VANGTF Falco peregrinus 100 CKLSSYLVFYNNYASVFCLTGLSFDRYLAIVF2 ATAKLRSRVSGLVATVALIVLAALLALFALVERAS—ALEGDNITCNIDYGG ATLGTE Melopsittacus undulatus 100 CKLSSYLVFYNNYASVFCLTGLSFDRYLAIVF2 ATAKLRSRVSGLVATVALIVLAALLALFALVERAS—ALEGDNITCNIDYGG ATLGTE Schizothorax prenanti 107 CKLSSYDVJUNINYASVFCLTGLSFDRYLAIVF2 ATAKLRSRVSGLVATVALIVLAALLALFALVERAS—ALEGDNITCNIDYGG ATLGTE SCHIZOThorax prenanti 107 CKLSSYDVJUNINYASVFCLTGLSFDRYLAIVF2 ATAKLRSRVSGLVATVALIVLAALLALFALVERAS—ALEGDNITCNIDYGG ATAGTE SCHIZOThorax prenanti 107 CKLSSYDVJUNINYASVFCLTGLSFDRYLAIVF2 ATAKLRSRVSGLVATVALIVLAALLALFALVERAS—ALEGDNITCNIDYGG ATAGTE SCHIZOTHORAX PRENANTING PROTECTION PROTECTI Schizothorax prenanti Danio rerio B Salmo salar B Anguilla japonica A Salmo salar A ## Control of the property of Danio rerio A 200 (IEVGLOSSTALGEAGEFRANT TOYFOLGTTAGHEGERRAGILKKRIRLLY) HAV VII FALUMUPHILAVI LIVLOS 2. L.C. 197 (EVGLOLSSTALGEAGERRANT TOYFOLGTTAGHEGERRAGILKKRIRLLS) HAV VII FALUMUPHILAVI VILDO LEVIP 196 (EVGLOLSSTALGEVIPFANT TOYFOLGT RIT AD HEG VEHGEBIRKERLLS) HAV VAAFGGMUPHILOZITIV LIND OLUHE 197 (EVGLOLSSTALGEVIPFANT TOYFOLGT RIT VASHEN VERAGERRARKELLI) HAV VAAFGGMUPHILOZITIV LIND LEVIP 203 (HAGISISSTALGELIP LAN WOYFOLGT VITRENSIL REBORKER BLLKHITIT LAVVEAGEN PHILOXITIV LIND LEVIP 212 (HAGISISSTALGELIP LAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXITIV LAVIP 212 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXITIV LAVIP 200 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXITIV SADALSYLILA 200 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXITIV SADALSYLILA 200 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXITIV SADALSYLILA 201 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXIT DALSYLILA 202 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXIT DALSYLILA 203 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXIT DALSYLILA 204 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXIT DALSYLILA 205 (HAGISISSSALGELIPFILAN WOYFOLGT VITRENSIL REBORKER BLLKHITT LAVVEAGEN PHILOXIT DALSYLILA 206 (HAGISISSSALGELIPFILAN WOYFOLGT VITRES V Salmo salar A Danio rerio A CAGTSHSS----SGEKSASYSSEH CKESPHSS----SAEKSASYSSEH CGAASHS---SGEKSASYSSEH CGAWRAGGGGGGGGGGGGGGGKSASSSSASSEH Homo sapiens 303 NPFLYAFFDPRFRRACTS/L Rattus norvegicus CGPGPN-MCKGGEPMHEXS I PYSOE 308 NPFLYAFFDLRFROACASVL Orcinus orca 308 NPFLYAFFOLRERGAGS, LCWGOSR 308 NPFLYAFFORERGAGTILGGGOG 307 NPFLYAFFORERGAGTILGGGOG 305 NPFLYAFFORERGAGTILGGGOG 305 NPFLYAFFORERGAGATLOCTI305 NPFLYAFFORERGAGALLOCTI312 NPFLYAFFOLRERGOLOLLULKAL 312 NPFLYAFFOLRERGOLOLLULKAL 321 NPFLYAFFOLRERGOLOLLULKAL 321 NPFLYAFFOLRERGOLOLLULKAL 3309 NPFLYAFFOLRERGOLOLLULKAL 3309 NPFLYAFFOLRERGOLOLLULKAL 3301 NPFLYAFFOLRERGOLOLLULKAL 3301 NPFLYAFFOLRERGOLOLLULKAL 3301 NPFLYAFFOLRERGOLOLLULKAL 3301 NPFLYAFFOLRERGOLOLLULKAL 3301 NPFLYAFFOLRERGOLOLLULKAL (SOGPGPG-SGKGGEPTGEKS I PYSOE) HSOGPGPGGAGKGGEPNPEKSIPYSOEI Bos taurus -NLPGKGGETGREKVSPDIJHDULVR Alligator sinensis -DLQGKGVELQQVQLGPGRQEKL QG Pelodiscus sinensis Falco peregrinus Melopsittacus undulatus 305 Schizothorax prenanti Danio rerio B TEAOSLATKY Salmo salar B KSEVOSLATKVRESGGRGGSRLS Anguilla japonica A Salmo salar A **OSLATK**

Fig. 2. (continued)

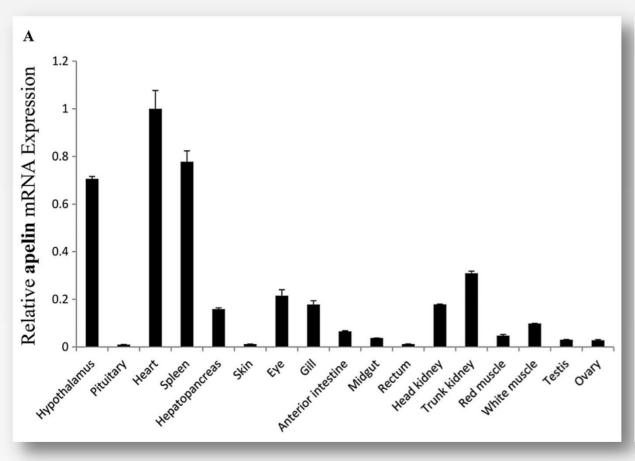
APJ

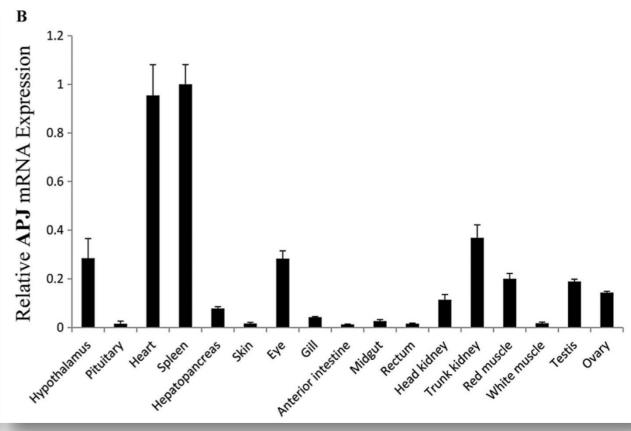
Danio rerio A



聚类分析

组织分布





下丘脑、垂体、心、脾、肝、皮肤、眼、鳃、前肠、中肠、后肠、头肾、肾脏,红肌,白肌,睾丸和卵巢 apelin:心脏>脾脏>下丘脑>肾脏

2.5~2倍 A 1.2 7 ☐ Unfed Expression (Relative to the Max) Fold Change in apelin mRNA Fold Change in apelin mRNA Expression (Relative to the Max) bc 0.8 0.2 3 -3 0 -1 Time (Hours) 2倍 2倍 В \mathbf{B} Unfed Fed 1.2 7 Expression (Relative to the Max) Fold Change in APJ mRNA 1 -

1.8倍 2.5倍 饥饿实验

Um. Fed Refed

5

5

Time (Days)

Time (Days)

3

7

☐ Unfed

9

☐ Unfed

Fed Refed

9

下丘脑

Fold Change in **APJ** mRNA Expression (Relative to the Max) **APJ**

-3

-1

Apelin

1

3

0.6

0.4

Α saline apelin-13 Food intake (mg/gBW/hours) P=0.08212-24h 1-2h 2-4h 8-12h \mathbf{B} Cumulative food intake (mg/gBW/hours) -O-saline → apelin-13 12 24 Hours after injection

注射实验

Apelin-13由上海生工合成,通过HPLC和质谱确定纯度: >98.81; 溶解于淡水鱼生理盐水中,对照组注射生理盐水。 100 ng/g body weigh

Apelin-13对食物摄取的影响

结果总结:

- Apelin和APJ mRNA在测试的所有组织中均有表达,在心脏、脾脏、下丘脑和肾脏 具有相对较高的表达水平;
- 短期饥饿APJ mRNA表达显著增加,但是第5、7饥饿组合对照组没有显著性差异;
- 契期饥饿Apelin mRNA表达在7天的饥饿过程中持续呈现增加状态;
- ♀ 相对于注射盐水组,注射apelin能够显著增加齐口裂腹鱼的摄食;

Apelin-APJ在鱼类中的广泛分布表明其可能具有多种生理调节作用。
APJ和apelin饥饿实验中的差异,可能是由于另一受体(APJa)介导apelin对喂养的远期影响。
Apelin起到食欲因子的作用,通过与喂养相关的激素和途径之间的相互作用来调节摄食。



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Peptides

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Apelin in goldfish (*Carassius auratus*): Cloning, distribution and role in appetite regulation

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Feeding
Goldfish
Cloning
Distribution
Food intake
RNA expression

ABSTRACT

Apelin is a recently discovered peptide produced by several tissues including brain and adipose tissue. In mammals and zebrafish, apelin regulates cardiovascular functions. Recent evidence in mammals suggest that apelin might also regulate food intake. In this study, we cloned a cDNA encoding apelin and examined apelin mRNA distribution within the brain and in peripheral tissues. We also assessed the effects of fasting on apelin brain mRNA abundance. Apelin mRNA was expressed throughout the brain as well as in several peripheral tissues including brain, spleen, heart and fat. Apelin mRNA abundance in both hypothalamus and telencephalon was significant higher in fasted fish than in fed fish. In order to further characterize apelin in goldfish, we assessed the effects of central (intracerebroventricular, icv) and peripheral (intraperitoneal, ip) injections of apelin-13 on food intake in goldfish. Apelin injected ip at a dose of 100 ng/g or icv at a dose of 10 ng/g induced a significant increase in food intake compared to saline-injected fish. Our results suggest that apelin acts as an orexigenic factor in goldfish. Its widespread distribution in the brain and the periphery also suggests that apelin might have multiple physiological regulating roles in fish.

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基因克隆

(A) 1	ctt	gegge	eget	gtca	caca	cttgo	acad	caga	cata	caaa	caca	ttca	gcca	cgca	caca	cacao	cata	gaca	cacgo	egcad	cact	gaaa	agcaa	aca	gtctc	100
101	tct	ctctc	ctcg	ctct	cgcto	cacco	cacto	etce	tata	cctc	ccat	ccac	acac	gcaca	acca	ctaca	agta	tatca	agcta	agcga	actg	gcag	ggaaa	acaga	agggg	200
201	aga	gcaga	aa A				G A	C T				TG A				rg gr	rg To	CT C		rg To	ST TO	CA GO		GT GO		275 22
276 23		CCA P	ATG M	GCC A	TCC	ACC T	GAG E	CAT H	AGC S	AAA K	GAG E	CTG L	GAG E	GAG E	GTG V	GGC G	AGC S	ATG M	AGG R	ACT T	CCT P	TTG L	CGG R	CAG Q	AAT N	350 47
351 48	CCT P	GCT A	CGA R	GCC A	GGC G	CGG R	AGC S	CAA	AGA R	CCT P	TCT	GGC G	TGG W	AGG R	AGG R	AGA R	CGC R	CCT P	CGA R	CCC P	CGC R	CTC L	TCC	CAC H	AAG K	425 72
426 73		CCA P	ATG M	CCA P	TTC	TAG	agca	aaggo	caca	gctt	agag	tgcc	ctcc	ccct	tggt	tctga	attt	ctate	gatat	ttaat	tttg	cctt	gggg	gcc	ttgca	519 78
520	aca	aggg	gcct	ttgc	tagco	ccago	ctga	aaga	gtga	tgtc	cata	gcac	ctgct	tggt	tatta	caago	caac	tctt	ettet	tgtc	caca	aaaa	aacca	agga	caagc	619
620	cac	tcato	cctc	agct	ctgca	aaaga	att	gtgg	gcca	ggaa	tggg	gatg	gggg	gtat	tgago	cccga	agcta	atca	gatto	ctato	ctctc	ctct	gtct	gtct	ctctc	719
720	ctc	ctgtg	ggtt	ttcc	tcatt	ttgct	ttct	aga	gcct	tttc	atgg	ccac	actt	tgca	tgac	gtgt	gagca	agtg	ggga	gcct	ggtca	agtt	atagt	ccg	aaagc	819
820	gtca	acttt	tott	ctcc	gaggt	tgtgd	tagt	ccc	attc	tctc	cagc	gtga	aggt	gacca	acago	egett	ttgt	ccca	ttgct	tatgt	tgtc	ggca	actct	tage	cttat	919
920	aca	gtaag	gtgg	tgtt	catga	agaga	agaa	aagt	ggca	ggga	aact	aaag	taaa	ggaa	ctaa	atgct	cag	gccc	attat	gaad	cagg	tcag	caact	gtt	ttaca	1019
1020	tct	tgcaa	aaat	ttta	ccato	ctgcc	tata	acta	aaaa	atgg	acag	ttago	cttte	ataa	tagca	atcag	gtgag	gtgca	attta	acato	gacaa	aact	gccaa	caaa	aacgc	1119
1120	aat	tatca	actt	atca	aaaat	tgtat	tcta	aaaa	acct	taca	gtaa	aaaa	aaaaa	aaaa	a											1175

Apelin

全长:1175bp

ORF: 231bp

编码77个氨基酸

N端有一个22个氨基酸组

成的信号肽。

序列比对

```
(B)
    rat
                    MNLSFCVQALLLLWLSLTAVCGVPLMLPPDGKGLEE-GNMRYLVKPRTSRTGPGAWQGGR 59
                    MNLRLCVQALLLLWLSLTAVCGGSLMPLPDGNGLED-GNVRHLVQPRGSRNGPGPWQGGR 59
    human
                    MNLRLWALALLLFILTLTSAFGAPLAEGSDRND-EE-QNIRTLVNPKMVRNSAPQRQANR 58
    xenopus
    zebrafish
                    MNVKILTLVIVLVVSLLCSASAGPMASTEHSKEIEEVGSMRTPLRQNPARAGRSQRPAGW 60
    goldfish
                    MNVKILTLVIVLVVSLLCSASAGPMASTEHSKELEEVGSMRTPLRQNPARAGRSQRPSGW 60
                    **::..:*. * :... .: *: .:* :.. * .
                    RKFRRQRPRLSHKGPMPF 77
    rat
    human
                    RKFRRQRPRLSHKGPMPF 77
                    RKLIRQRPRLSHKGPMPF 76
    xenopus
    zebrafish
                    RR-RRPRPRLSHKGPMPF 77
    goldfish
                    RR-RRPRPRLSHKGPMPF 77
                        * ********
```

氨基酸水平:

金鱼VS斑马鱼: 97%

金鱼VS爪蟾: 43%

金鱼VS哺乳动物: 35-38%

核酸水平(ORF):

金鱼VS斑马鱼: 95%

金鱼VS爪蟾/哺乳动物: 15%

组织分布

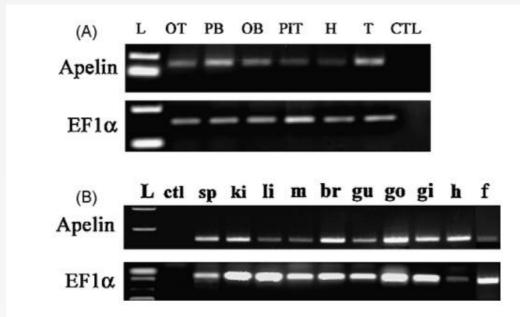


Fig. 2. RT-PCR distribution of apelin (108 bp) and EF-1 α (104 bp) in different brain regions (A) and peripheral tissues (B) of goldfish. L, ladder; OT, optic tectum/thalamus; PB, posterior brain/cerebellum; OB, olfactory bulbs and tract; PIT, pituitary; H, hypothalamus; T, telencephalon; ctl: control; sp, spleen; ki, kidney; li, liver; m, muscle; br, brain; gu, gut; go, gonad; gi, gill; h, heart; f: fat.

L, ladder; OT, optic tectum/thalamus;视顶盖/丘脑 PB, posterior brain/cerebellum;后脑/小脑 OB, olfactory bulbs and tract;嗅球 PIT, pituitary; 垂体 H, hypothalamus; 下丘脑 T, telencephalon; 端脑 ctl: control; 对照

sp, spleen; 脾 ki, kidney; 肾 li, liver; 肝 m, muscle;肌肉 br, brain; 脑 gu, gut; 肠 go, gonad; 性腺 gi, gill; 鳃 h, heart; 心脏 f: fat.脂肪

全脑没有显著性差异

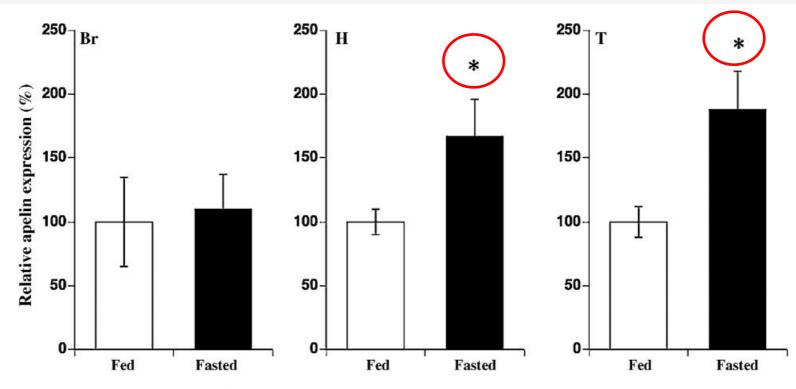


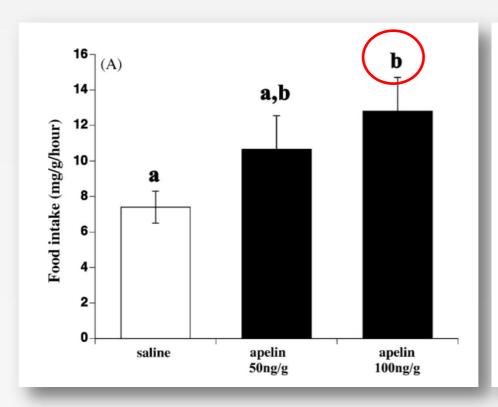
Fig. 3. Apelin mRNA abundance in whole brain (Br), hypothalamus (H) and telencephalon (T) of fed and fasted goldfish (n = 5-8 fish per group). Expression levels in the fed group were normalized to 100%. Data is presented as mean \pm SEM. Stars indicate significant differences between the fed and fasted groups.

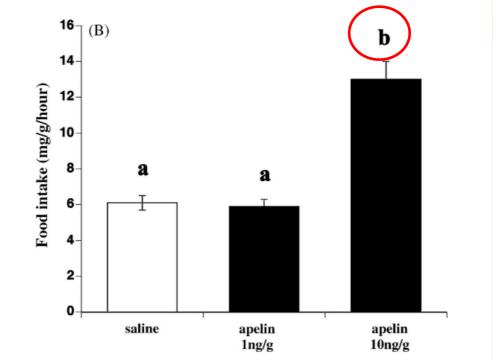
全脑(BR)

下丘脑(H)

和端脑(T)

注射实验



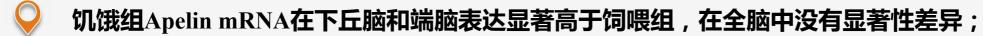


腹腔注射(ip)对摄食的影响

侧脑室注射(icv)对摄食的影响

结果总结:





♥ 侧脑室和腹腔注射apelin-13显著增加摄食量;

Apelin在金鱼中担当促进食欲的因子。

它在大脑和周围的广泛分布也表明Apelin在鱼类中可能具有多种生理调节作用。

ELSEVIER

Injection

Hormone

mRNA expression

Contents lists available at ScienceDirect

General and Comparative Endocrinology

普通与比较内分泌学标。如2.667/gcen





Peripheral injections of cholecystokinin, apelin, ghrelin and orexin in cavefish (*Astyanax fasciatus mexicanus*): Effects on feeding and on the brain expression levels of tyrosine hydroxylase, mechanistic target of rapamycin and appetite-related hormones



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A R T I C L E

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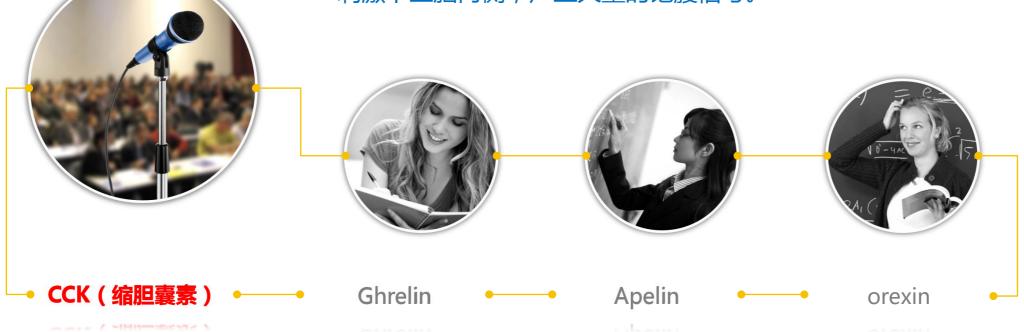
C), apelin, ghrelin, and orexin on food a mexicanus. CCK (50 ng/g) induced a ng/g), and ghrelin (100 ng/g) induced rol fish. In order to better understand ed the effects of injections on the brain se (TH), and mechanistic target of rapapelin and cocaine and amphetamine brain apelin injections, apelin injections, orexin treatment increased brain TH R and orexin brain expressions. CART Our results suggest that the enzymes lin all regulate food intake in cavefish

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胆囊收缩素(CCK)是由小肠粘膜I细胞释放的一种肽类激素。

作用:

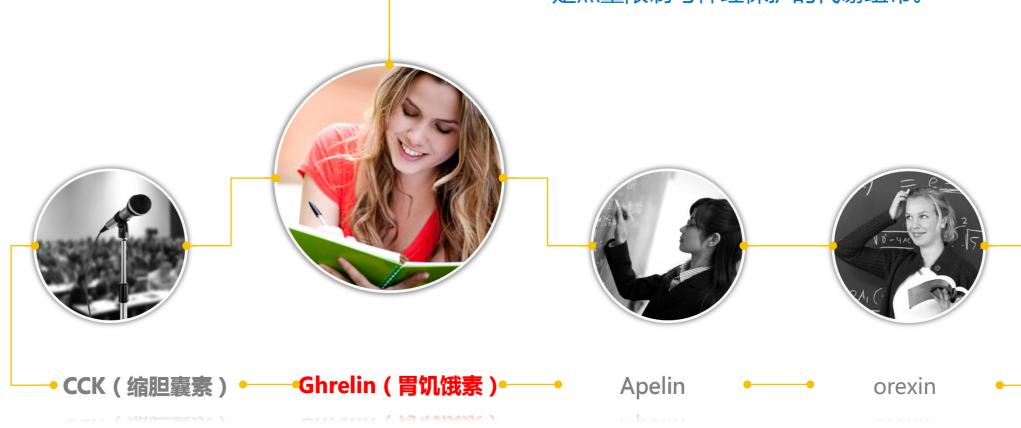
- (一)促进胰腺腺泡分泌各种消化酶,促胆囊收缩,排出胆汁。
- (二)作用于迷走神经传入纤维,通过迷走反射刺激胰酶分泌。
- (三)通过特效食物和身体内的各种酶的复合作用,帮助分解出蛋白质分解产物、脂肪酸盐、HCI等刺激CCK(胆囊收缩素)分泌的分解因子,刺激下丘脑内侧,产生大量的饱腹信号。





够调节食欲、进食和身体构成。

是热量限制与神经保护的代谢纽带。



Apelin 是一种多肽,前原蛋白由77个氨基酸组成,经内质网剪切成不同长度的活性多肽。 其内生受体APJ是一种G蛋白偶联受体,在体内多种器官细胞上表达,主要包括中枢神经系统跟心血管系统。这种特性暗示了Apelin/APJ系统参与人体内多种生理过程。



食欲肽(orexin)是由下丘脑特异性分泌的一种能调节睡眠、摄 食及能量平衡的神经肽。包括食欲肽A和食欲肽B。

食欲肽会高度刺激跟觉醒状态有关的脑核及其相关的神经递质系统(例如包括多巴胺、去甲肾上腺素、抗组胺药及乙酰胆碱)。 血中葡萄糖的高水平会抑制食欲肽的生产。



CART (可卡因和安非他命调节转录肽)

- □ 广泛分布于中枢及周围神经系统提示具有许多重要的生理功能,包括可能应激反应、摄食行为、免疫功能、自主调节、体液平衡、代谢过程、性功能和内分泌调节等。
- □ 对调节摄食及能量代谢的研究表明,在大鼠脑室内灌注重组的CART可抑制摄食,而给予抗体则可使摄食增加;正常大鼠禁食1-2天后,下丘脑CART的mRNA水平急剧下降,脑室内灌注CART可抑制饥饿引起的进食反应。 因此,CART是一种食欲抑制因子。



名词解释

1)酪氨酸羟化酶-TH

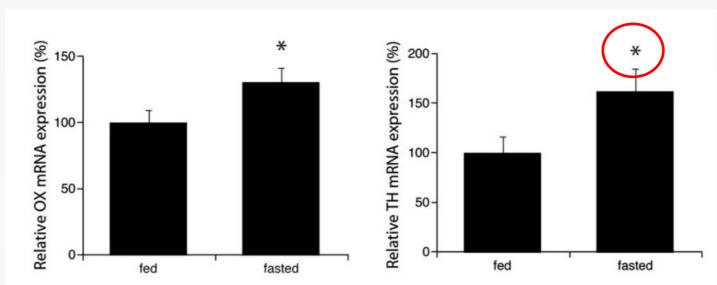
酪氨酸羟化酶(英语:Tyrosine hydroxylase)是负责催化氨基酸L-酪氨酸转变为二羟基苯丙氨酸(多巴)的酶。多巴是多巴胺的一个前体,相应地,后者亦是去甲肾上腺素与肾上腺素的前体。在人体中,酪氨酸羟化酶由TH基因编码出来。

—— TH

此加氧酶被发现与所有含儿茶酚胺的细胞溶质中。此起始步骤是产生儿茶酚胺的限速步骤。

饥饿会使鱼类TH表达水平升高,说明TH起到调节脊椎动物摄食的作用

(Wall and Volkoff, 2013).



名词解释

2) 雷帕霉素靶蛋白-mTOR

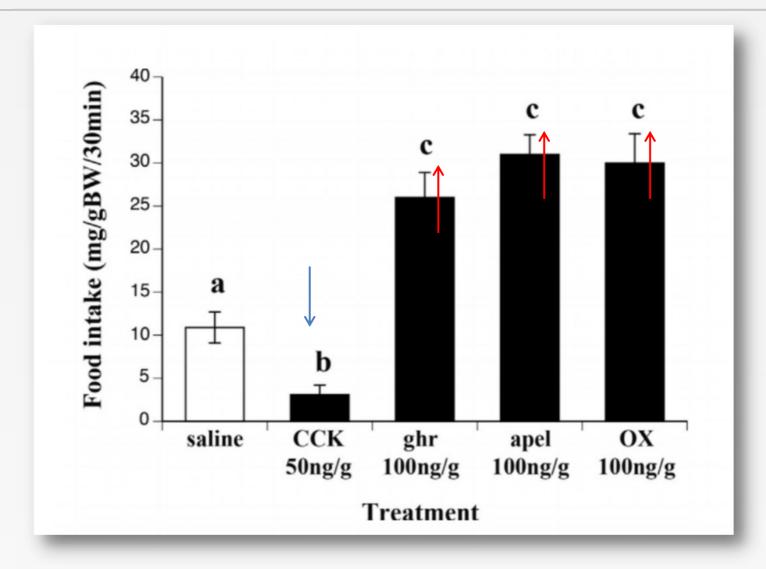
雷帕霉素靶蛋白(mTOR)是一种丝氨酸-苏氨酸蛋白激酶,是PI3K/Akt信号通路的重要组成部分,在感知细胞营养和能量状态中发挥关键作用。

在啮齿类动物中,禁食状态下弓状核(ARC)神经元的mTOR通路活性降低,而在喂食后活性升高(Woods et al., 2008; Xu et al., 2009)。

在斑马鱼中,禁食肝脏mTOR的表达降低(Craig and Moon, 2011)。

最近的哺乳动物中的证据显示mTOR通路和几个喂养相关的激素有关,包括NPY和CART (inhoffet al., 2010)、胆囊收缩素 (lembke et al., 2011)、生长素(Martins et al., 2012; Xu et al., 2010), 和瘦素 (Cota et al., 2006)。

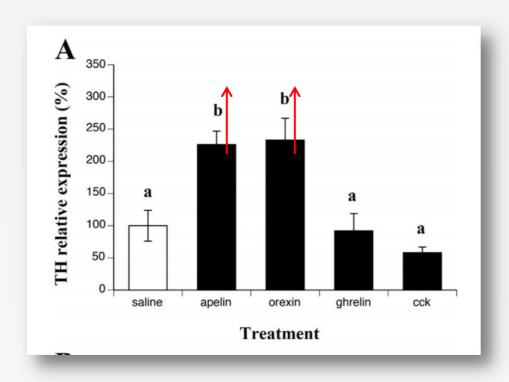
注射实验

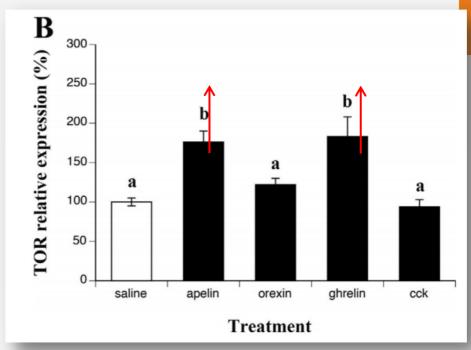


盐水 缩胆囊素 胃饥饿素 apelin 食欲肽

对摄食的影响

注射实验

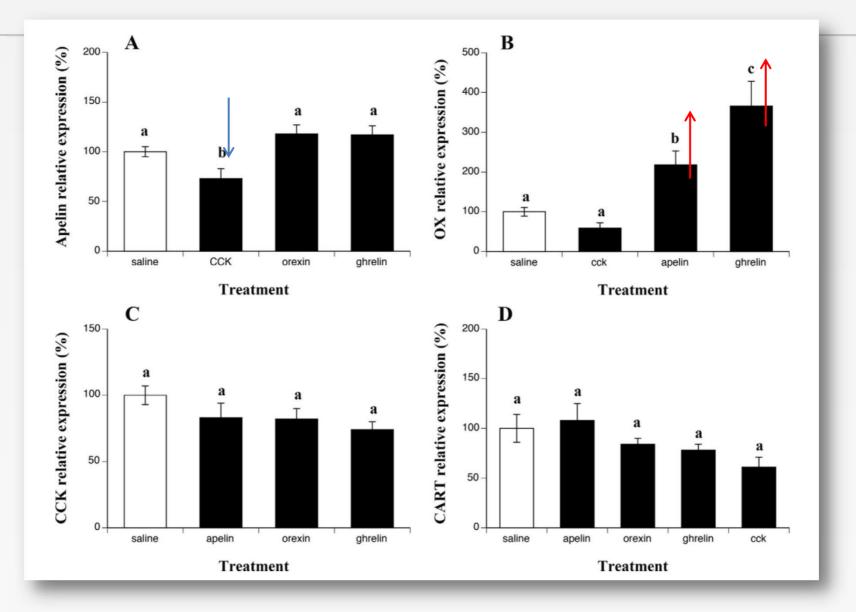




TH:酪氨酸羟化酶

TOR:雷帕霉素靶蛋白

Apelin-13对大脑两种代谢酶的影响



腹腔注射saline, CCK, ghrelin, apelin, 和orexin 后 全脑CCK, ghrelin, apelin, 和orexin的表达丰度

注射实验

结果总结:

- CCK (50 ng/g) 降低了摄食,而apelin (100 ng/g), orexin (100 ng/g)和Ghrelin (100 ng/g)促进了穴鱼摄食;
- **CCK降低了大脑apelin的表达**;
- Apelin促进了大脑TH、mTOR和orexin的表达上调;
- orexin促进了大脑TH的表达上调;
- Ghrelin促进了mTOR和orexin的表达上调;

CCK降低了摄食和大脑apelin的表达,但是不改变CART(一种食欲抑制因子),提示CCK可能是通过抑制apelin来抑制食欲。

注射Apelin和orexin促进了TH的表达,可能表明TH部分介导这两者的行为。事实上有研究表明,中枢儿茶酚胺与apelin(Xu et al., 2011), orexin(Eriksson et al., 2010)相互作用。

Apelin和ghrelin促进mTOR的表达,说明这两者涉及细胞内PI3K/AKT/mTOR信号通路。

酶TH和mTOR以及激素CCK, apelin, orexin和Ghrelin通过一个复杂的相互作用网络来调控穴鱼的摄食。

动物生理与营养学杂志 IF: 1.212

DOI: 10.1111/jpn.12240

ORIGINAL ARTICLE

Comparatively examining of the apelin-13 levels in the *Capoeta* trutta (Heckel, 1843) and *Cyprinus carpio* (Linnaeus, 1758)

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- 2 Medicine Faculty, Fırat University, 23119 Elazig, Turkey

Summary

鼠apelin-13 ELISA检测试剂盒

Apelin is a recently discovered peptide produced by several tissues in the various vertebrates and fish. Apelin has been suggested to have role in regulation of many diverse physiological functions including food intake, energy homoeostasis, immunity, osmoregulation and reproduction. In this study, apelin-13 levels in the blood serum of *Cyprinus carpio* and *Capoetta trutta* were determined. Then the results were compared between two species and sexes of each species. Apelin-13 level was analysed using the enzyme-linked immunoassay (ELISA) kit (Rat apelin-13 ELISA kit, catalog no: CSB-E14367r). Apelin-13 level in the blood serum of *C. trutta* was significantly higher than those of the *C. carpio* (p < 0.05). However, its levels were observed to be no significant difference ($p \ge 0.05$) that compared to between sexes of each species. There was a significant negative correlation (r = -0.829, p = 0.0001) between the apelin-13 level and body weight of *C. carpio*. However, no significant correlation (r = -0.022, p = 0.924) between the apelin-13 level and weight of *C. trutta* observed.

Keywords Apelin, Cyprinus carpio, Capoetta trutta, ELISA

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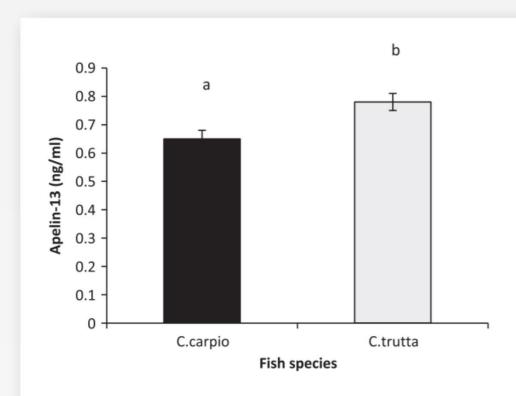


Fig. 1 Apelin-13 levels in the blood serum of *Capoeta trutta* (n = 21) and *Cyprinus carpio* (n = 23) (mean \pm SEM, p < 0.05).

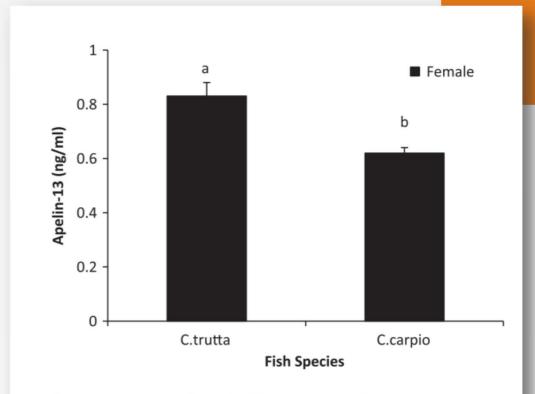


Fig. 4 Apelin-13 levels in the blood serum of female *Capoeta trutta* (n = 13) and *Cyprinus carpio* (n = 9) (mean \pm SEM, p < 0.05).

褐鳟apelin表达量高于鲤鱼

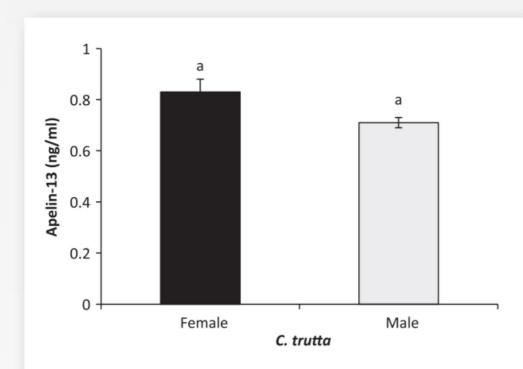


Fig. 2 Apelin-13 levels in the blood serum of male (n = 8) and female (n = 13) of *Capoeta trutta* (mean \pm SEM, p > 0.05).

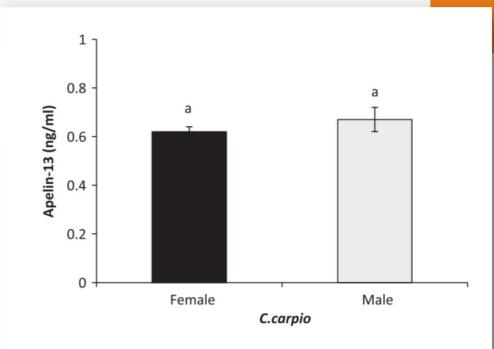
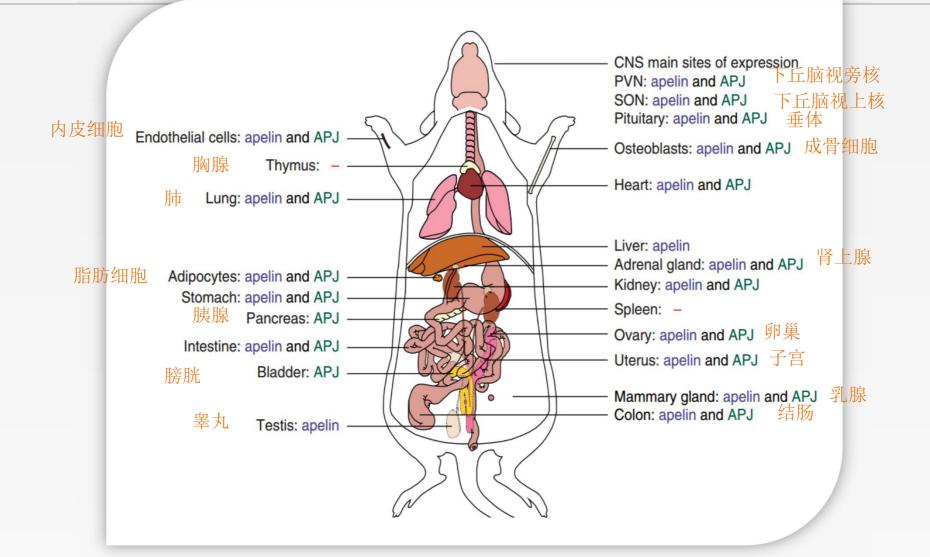


Fig. 3 Apelin-13 levels in the blood serum of male (n = 14) and female (n = 9) of *Cyprinus carpio* (mean \pm SEM, p > 0.05).

性别间没有显著性差异

总结讨论



大鼠APJ和apelin组织分布

(O'Carroll et al., 2013, Journal of Endocrinology)

总结讨论

Apelin的生物学作用

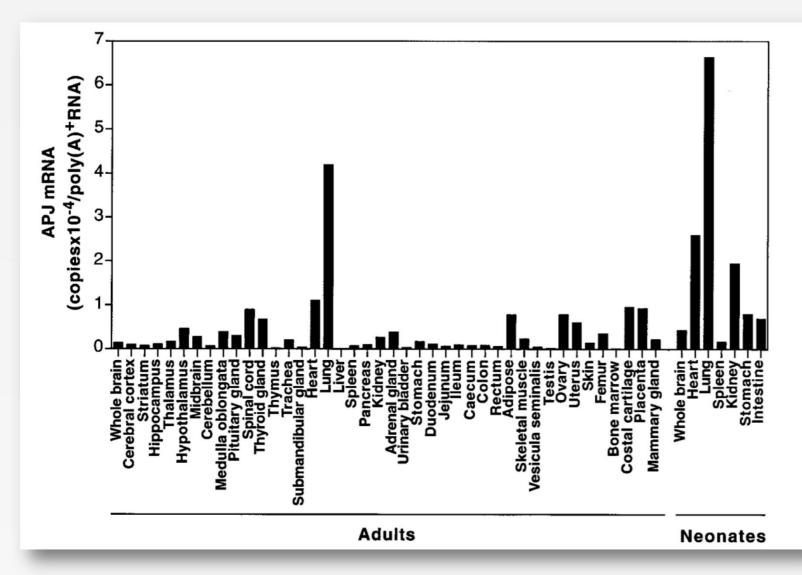


总结讨论

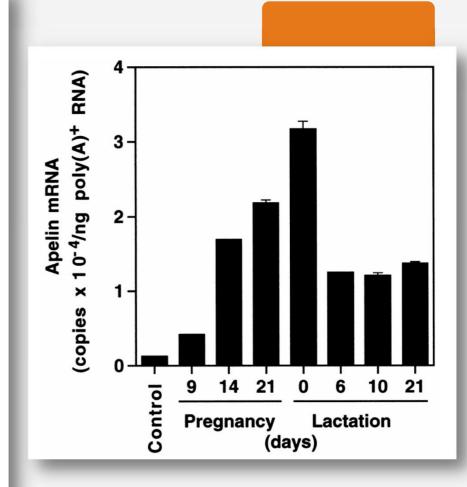
Apelin组织分布及其功能分析

①脑(下丘脑和前脑) ②心脏 ③脾脏 4肾脏 下丘脑调节体温、摄食、 在斑马鱼中, apelin缺 Apelin抑制脾脏细胞因 水平衡、血糖和内分泌 乏或过量都会损害心脏 子的产生,参与免疫反 调节肾功能和体液平衡。 腺活动等重要的生理功 的形成,具有调节心血 应。 能。 管功能

⑤性腺	⑦肝脏	⑧肠道
调节发育。	参与糖脂代谢。	参与糖脂代谢。







大鼠乳腺apelin mRNA在妊娠期和哺乳期表达增加,并在分泌时达到最大值。

(Habata , 1999)

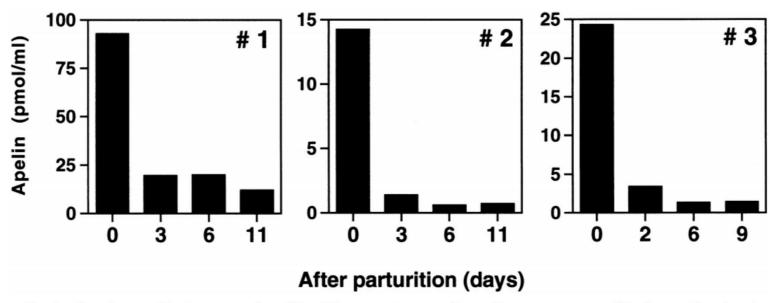


Fig. 5. Contents of apelin in bovine colostrum and milk. The contents of apelin were quantified on the basis of the cAMP-production-inhibitory activities in a manner similar to that described in Fig. 4. Bovine colostrum and milk were obtained from three Holstein cows (No. 1–3) on the indicated days after parturition.

Apelin 存在于牛初乳和牛奶中。

(Habata, 1999)

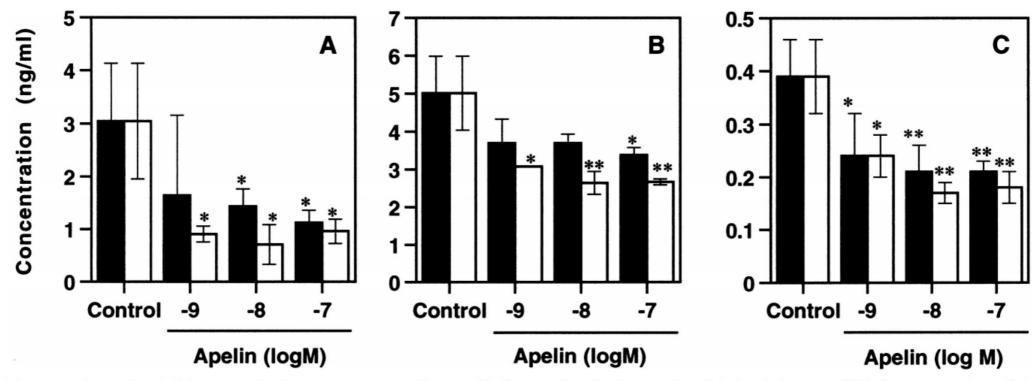


Fig. 6. <u>Suppression of cytokine production in mouse spleen cells by apelin.</u> Spleen cells obtained from BALB/c were cultured in microplates coated with anti-CD3 mAbs in the presence or absence (control) of apelin-36 (closed columns) and [pGlu]apelin-13 (open columns) at the indicated concentrations. The amounts of IFN-γ (panel A), IL-2 (panel B), and IL-4 (panel C) in culture supernatants were determined by EIA. Values represent mean ± S.D. in triplicate assays. **P<0.01; *P<0.05, as compared with a control in Student's t-test. Apelin抑制小鼠脾细胞产生细胞因子

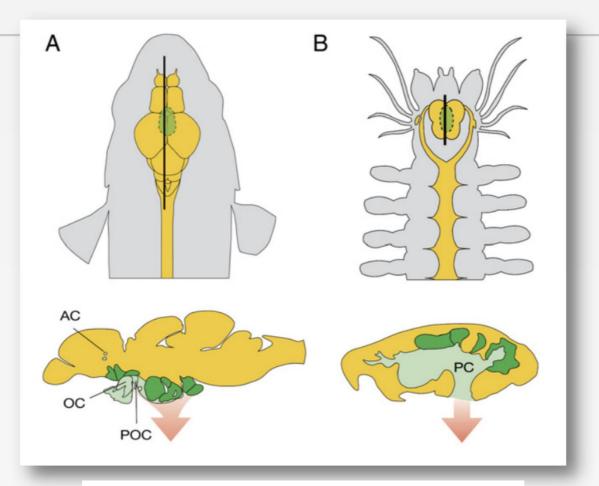
1 细化设计,分析原因

组织分布和饥饿实验中,全脑检测和不同的脑组织间显示出差异性,这是因为脑的不同部位具有不同的分工,如下丘脑和端脑被证明是能量平衡和摄食调节的重要领域。 这提示我们在设计实验中应注意细化,并对不同的实验结果进行对比和分析。找出合理的解释和发现问题的关键。

2 大胆假设, 小心求证

以组织分布为例,存在即合理,存在的原因和表达丰度的原因可以进行相应的推测和分析。在哺乳动物实验中,有些地区,如嗅区、犁区、皮质和齿状回有APJ的分布,却没有apelin的产生。这可能意味着在这里合成APJ,然后运输到其他地区,在那里有配体的产生,这个地方APJ才具有功能性;也有可能是APJ表达量低于检测值;也有可能是抗体敏锐性低;亦或许该地区存在其他位置相关受体。同时实时定量与免疫组化、原位杂交的结果也不尽相同。

这提示我们应广泛查阅相应文献,推测应有理有据。



下丘脑

Figure 1. Neuroendocrine Centers in the Fish and Nereidid Forebrain

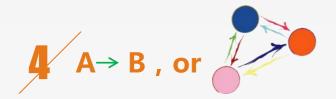
(Top) Schematic dorsal views of adult zebrafish (A) and nereidid (B) heads, indicating the CNS (yellow) and the main medial neurosecretory brain centers (green). Black lines: positions of sections. (Bottom) Respective parasagittal sections, showing main neurosecretory brain nuclei (green) and main sites of neurosecretory release (red arrow). Characteristic commissures and neuropil, light green; AC, anterior commissure; OC, optic chiasm; POC, postoptic commissure; PC, preoral comissure. Data integrated from Matsumoto and Ishii, 1992; Thorndyke and Goldsworthy, 1988; Wullimann et al., 1996.

(Tessmar-Raible, 2017, Cell)

思考

3 细化设计,分析原因

APJ和apelin饥饿实验中的差异,可能是由于另一受体(APJa)介导apelin对喂养的远期影响。这提示我们在接下来的实验中,应分别检测两个受体。



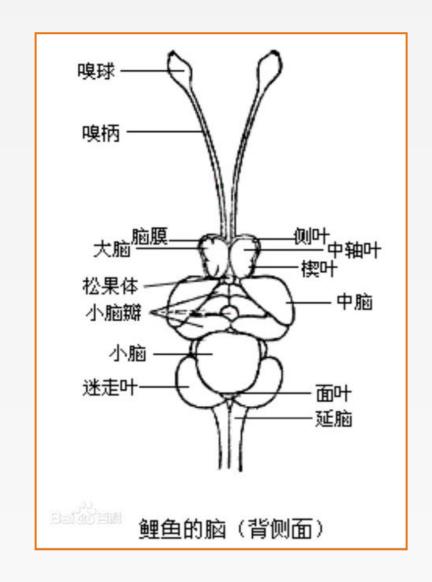
CCK, apelin, orexin和Ghrelin均为食欲相关因子, 其相互作用调节摄食, 另外如AgRP/NUCB2和PYY均参与食欲调节。这提示我们应在实验中检测相关因子和通路之间的互作, 这将为揭示机理(如代谢)提供更多的思路和更好的解释。

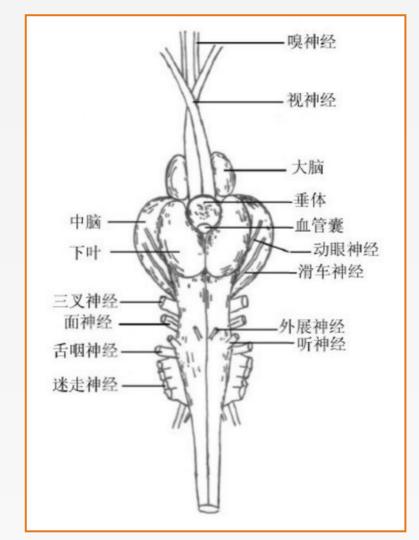


Thanks

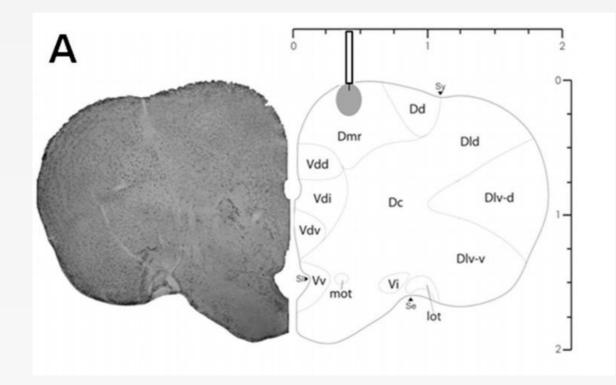
感谢您的聆听

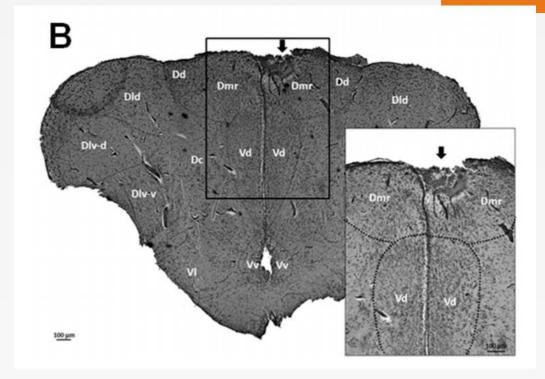
请提出宝贵意见!





端脑





名词解释

1) 酪氨酸羟化酶-TH

酪氨酸羟化酶(英语:Tyrosine hydroxylase)是负责催化氨基酸L-酪氨酸转变为二羟基苯丙氨酸(多巴)的酶。多巴是多巴胺的一个前体,相应地,后者亦是去甲肾上腺素与肾上腺素的前体。在人体中,酪氨酸羟化酶由TH基因编码出来。

—— TH

此加氧酶被发现与所有含儿茶酚胺的细胞溶质中。此起始步骤是产生儿茶酚胺的限速步骤。

儿茶酚胺是一种含有儿茶酚和胺基的神经类物质。<mark>儿茶酚胺</mark>(CA)包括去甲肾上腺素(NA或NE)、肾上腺素(Ad或E)和多巴胺(DA)。

儿茶酚胺的作用

- 1、对代谢的作用:儿茶酚胺参与生热作用的调节,通过β受体增加氧耗量而产热。并可促进机体内储备能量物质的分解。
 - 2、儿茶酚胺对细胞外液容量和构成及水、电解质的代谢有重要的调节作用。
 - 3、儿茶酚胺可引起肾素、胰岛素和胰高血糖素、甲状腺激素、降钙素等多种激素分泌的变化.