

論文 / 著書情報  
Article / Book Information

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Title(English)	A Comprehensive Understanding of Aggressive Behavior at Molecular Level Using Fish Betta splendens
著者(和文)	ヴチュウドク
Author(English)	Vu Trieu Duc
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種別(和文)	論文要旨
Type(English)	Summary

## 論文要旨

### THESIS SUMMARY

系・コース： Department of, Graduate major in	生命理工学 生命理工学	系 コース	申請学位 (専攻分野)： Academic Degree Requested	博士 Doctor of	(Science)
学生氏名： Student's Name	Vu Trieu-Duc		指導教員 (主)： Academic Supervisor(main)	Masato Nikaido	
			指導教員 (副)： Academic Supervisor(sub)		

#### 要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

Aggressive behavior is an evolutionary conserved phenomenon and wide-spread among animal kingdom. Using aggression, animals of many species establish dominance hierarchy to regulate social interactions. Throughout the stages of aggressive encountering, individuals of different social status commonly express different sets of behaviors that match their competitive ability (behavioral states). Thus, fighting opponents must be able to switch their social status, and this should be mediated by changes in brain gene expression that leads to distinct transcriptome profiles across the social behavior network (neurogenomic states). However, the relationship between neurogenomic state and behavior state under fighting context remain poorly understood.

Our previous understanding of the connection between neurogenomic states and behavioral states mainly obtained from the studies of honeybee. Recently, fish-specifically trout, cichlid, and zebrafish-have become some of the most popular vertebrate models for dominance research. Studies using these fish revealed the differences in brain gene expression between dominants and subordinates after fighting interaction have ended. But, the fighting durations in these fish are relatively short so that molecular events underlying the full range of volitional behavior expressed by one opponent toward the other for longer periods of time remains limited.

Noticeably, Siamese fighting fish, *Betta splendens*, are notorious for their aggressiveness. Males of this species have stereotypical social displays that are well documented. Their fighting interaction can last for more than an hour. Thus, males *B. splendens* becomes a good model for investigating changes in neurogenomic states and behavioral states that occur across the stages of fighting e.g., before fighting, during fighting and after fighting. Surprisingly, at present no comprehensive molecular analysis of the brain-transcriptomic state of male-male competition during a fight in *B. splendens* has been attempted at the genomic level.

In this project, I aimed to map behavioral state onto neurogenomic state across different stages of fighting in *B. splendens* using RNA-seq approach. Several pairs of male's fish were allowed to fight under different durations namely non-fighting (B), during fighting (D20 & D60), and after fighting (A0 & A30). Their brains were isolated and subsequently used to extract RNA for sequencing. The differentially expressed genes, alternative splicing, and gene enrichment were employed for analyses. My aims were to investigate 1) what is the relationship between brain-transcriptomic activity in two individuals that are engaged in interactions during fighting? 2) how does this relationship change across different timescales to facilitate fighting interactions? 3) how does fighting interaction have effect on neurophysiological changes in winners and losers after fighting?

As results, I first discovered that two opponents within a fighting pair showed similar fighting patterns in an initial 60-min fight, and these patterns were varied between different fighting pairs. In accordance with this, brain gene expression between two interacting fish within a fighting pair also changed in a synchrony fashion during fighting, reflecting mutual assessment at molecular level between them. This synchronization pattern also showed a pair-specific manner, in which expression level of a certain number of genes was similar between two opponents within a fighting pair but that was different across different fighting pairs. The synchronized genes mediated this process were associated with ion transport, signal transduction, and long-term memory.

Secondly, across fighting stages, changes in the expression of certain genes were unique to different fighting stages and that changes of certain genes were transiently or persistently across all fighting stages. These changes were in accordance with behavioral changes. Interestingly, the brain transcriptomic synchronization pattern during fighting was gradually lost after fighting (A0 & A30), and the brain gene activity reduced to minimum leading to the emergence of a unique neurogenomic state as an energy-saving strategy among all individuals. This unique state shares common characteristics with the torpor or

hibernation state that animals adopt to minimize their metabolic rates to cope with harsh environmental conditions.

I also observed that a greater number of long-term memory gene was involved in losers than winners, suggesting that losers may encode their fighting experience and used it in their future encounter. Strikingly, fighting interaction induced severe effect on neurophysiological changes in both winners and losers with losers were found to enrich more autism-risk genes than winners.

Lastly, I found that fighting interaction induced great increase of alternative splicing (AS) events in the during-fighting fish followed by that of the after-fighting fish, among which intron retention is the most enriched type among all the basic AS events. Differential AS genes were mainly associated with synapse assembly, ion transport, and regulation of protein secretion. These suggest that AS plays key roles in response to stress in *B. splendens* across the fight.

Altogether, the findings from this thesis sufficiently elucidated the relationship between behavioral state and neurogenomic state across different stages of fighting in the fish *B. splendens*. These results provided comprehensive information and framework for future research on aggression in vertebrates at molecular level.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note: Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words(English).注意：論文要旨は、東工大リサーチリポジトリ(T2R2)にてインターネット公表されますので、公表可能な範囲の内容で作成してください。Attention: Thesis Summary will be published on Tokyo Tech Research Repository Website (T2R2).

(博士課程)

Doctoral Program

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