Initial swim bladder inflation in larval zebrafish is mediated by the mechanosensory lateral line.

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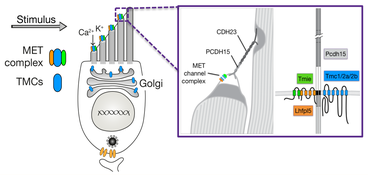
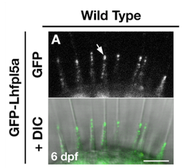
Abstract

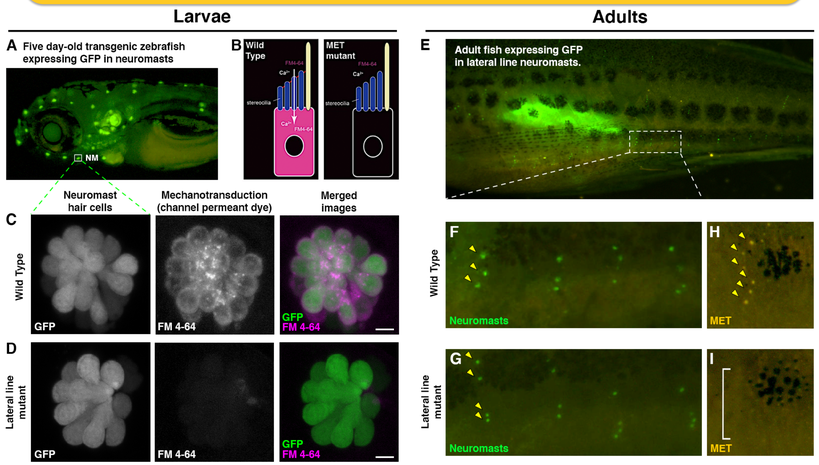
Larval zebrafish achieve neutral buoyancy at 4 days post-fertilization by gulping air from the water's surface to inflate their swim bladders. We define this behavior as "surfacing." Little is known about the sensory basis for this behavior. A good candidate is the mechanosensory lateral line (LL), which is a hair cell-based sensory system that detects hydrodynamic information. However, the influence of the LL on the larval behaviors that mediate swim bladder inflation have not been examined. To examine this connection, we utilize a genetic mutant (*lhfpl5b*) where the LL is non-functional from birth. We observe that 45% of LL mutants over-inflate their swim bladder during initial inflation, lose neutral buoyancy, and die. Thus, we hypothesize that larval zebrafish use their LL to sense the water-air interface and regulate swim bladder inflation. To test this hypothesis, we address two central questions: 1) are LL defects in mutants responsible for swim bladder over-inflation? and 2) is this over-inflation caused by an excess of surfacing behaviors? To address the causal association between the LL and swim bladder inflation, we have *i)* mimicked the congenital loss of LL function using ototoxic treatments, and *ii)* performed a hair cell-specific transgenic rescue of the LL mutation. We have addressed the second question of whether excess intake of air is responsible for the over-inflation phenotype by: *i)* blocking access of larvae to the water's surface, and *ii)* comparing surfacing behaviors of wild type and LL mutant larvae. Additionally, we have evidence to suggest that phototaxis works together with LL input to mediate surfacing. In summary, we have discovered a novel sensory basis for achieving neutral buoyancy where larval zebrafish use their lateral line to sense the water-air interface and regulate swim bladder inflation.

lhfpl5 is a component of the mechanotransduction complex in sensory hair cells.

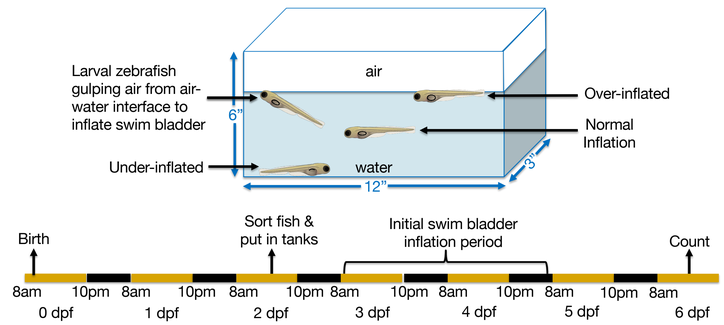


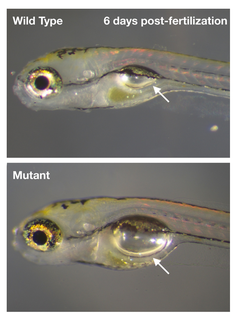


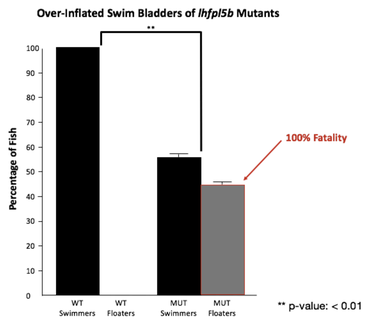
lhfpl5b is required for lateral line hair cell function in larval and adult zebrafish.



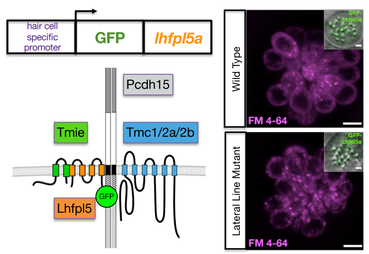
lhfpl5b mutant zebrafish exhibit a behavioral phenotype that can lead to swim bladder over-inflation.

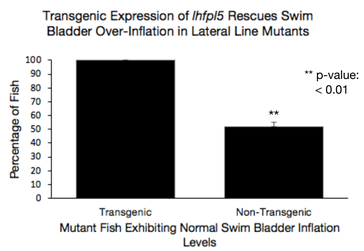


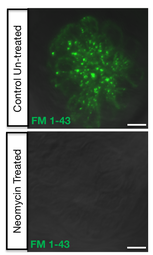


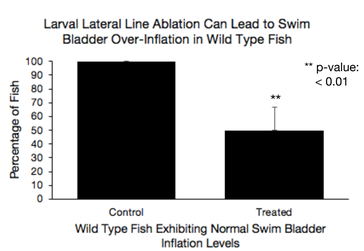


Lateral line defects in *lhfpl5b* mutants are responsible for swim bladder over-inflation.

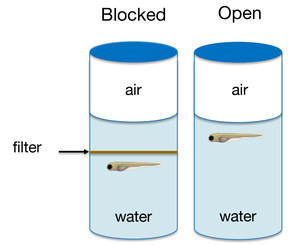


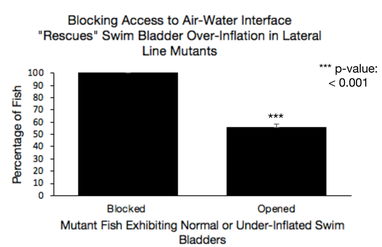


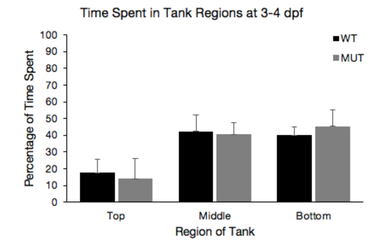


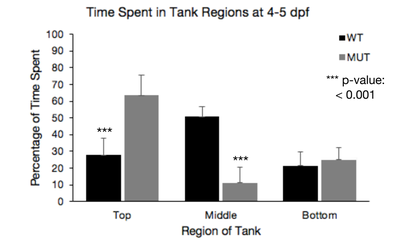


Swim bladder over-inflation in mutants is caused by excess air uptake at the water's surface.

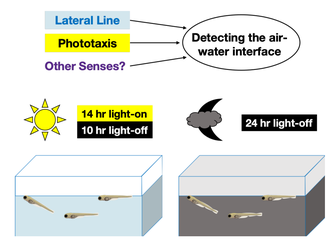


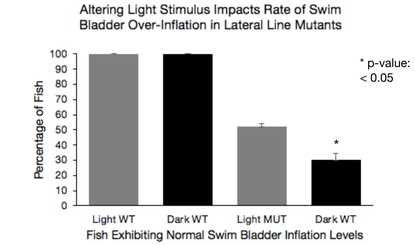






Behaviors that influence swim bladder inflation are based on multisensory cues.





Summary

1. Zebrafish *lhfpl5b* is expressed exclusively in neuromast hair cells of the lateral line.
2. The *lhfpl5b* mutants exhibit behaviors that result in swim bladder over-inflation in 45% (±5%) of mutant fish.
3. GFP-Lhfpl5a can rescue the *lhfpl5b* mutant phenotypes, revealing that lateral line defects in mutants are responsible for the behaviors that lead to swim bladder over-inflation.
4. When the lateral line of wild type fish was ablated using ototoxic treatments, the rate of swim bladder over-inflation mirrored the rates observed in lateral line mutants.
5. Blocking fish access to the air-water interface prevents swim bladder inflation in *lhfpl5b* mutants.
6. Mutant fish tend to swim at the top of the tank more often than wild type siblings at 4-5 dpf.
7. Other sensory systems, such as phototaxis, help with fish sensing the air-water interface and achieving neutral buoyancy.