# Optical Compensation in the Hunting Behavior of Archer Fish (*Toxotes jaculatrix*)

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**Abstract**

The Archer fish (*Toxotes jaculatrix*) demonstrates a remarkable ability to accurately capture aerial prey despite distortions caused by light refraction at the air-water interface. This study applies Snell's law to quantify the discrepancy between the apparent and actual positions of prey, revealing how the fish instinctively adjust their aiming strategy. Observations show that Archer fish maintain high targeting accuracy across varying prey heights and distances, employing rapid adjustments in shooting angle and water jet dynamics. These behaviors reflect sophisticated sensory-motor integration, enabling precise compensation for optical distortions. The findings provide insight into the adaptive evolution of predatory strategies in aquatic environments and suggest potential applications in bio-inspired optical and robotic targeting systems.

**Keywords:** Snell's law, Archer fish, Light refractive method



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## Introduction

Studies of prey capture technique in lower vertebrates like certain finfish groups, typically focus on organisms that feed completely in either aquatic or terrestrial environments throughout their living-things. A such flexibility in feeding behaviour can exist concurrently with discrete metamorphic stages (Reilly, 1996). According to Willobrord Snell has established and discovered a law of refraction in 1621. The light travels from one medium to another, in generally bends called as refracts. An understanding of refraction has been necessary for our future forthcoming discussion of lenses and their applications. The Archer fish is a distinguished predator known for its ability to shoot water surface to get aerial prey for food. Archer fish have established the role of refraction correction in the fish accuracy. The present studies showed that the fortify an importance of multi-disciplinary methods, combining to-gather physics and biology to composite animal behaviours. Freshwater bony fish of Arowanas viz., African arowana and Silver arowana fish have confirmed that the same the role of light refraction and Snell's law of application with fish leaping behaviour. According to Verwey (1928), Rossel *et al.* (2002), and Timmermans (2001) and Souren (2004) have reviewed that the archer fish, *Toxotes jaculatrix* and *T. chatareus*, obtains prey by projecting a stream of water and aquarium habitats from its mouth to dislodge insects from low-hanging branches, in addition to capturing prey by leaping behaviour. Aronson (1971) has suggested that the prey capture via leaping behaviour method to allows *Osteoglossum bicirrhosum* to exploit an arboreal and terrestrial prey base comprised of insects, spiders, and a variety of small vertebrates during both the high and low water seasons and along with water medium and public aquarium. Arawana fish of *Osteoglossuum bicirrhosum* have prey target with an accuracy at height above water and horizontal distance from fish. Leaping behaviour is fishes is explained using multiple hypotheses:

1. Traversing migration obstacles (Aronson, 1971; Warburton, 1990; Lauritzen *et al*., 2010)
2. respiration (Hoese, 1985; Moyle *et al*., 1986)
3. predation (Lowry *et al*., 2005; Shih and Techet 2010; Soares and Bieman, 2013)
4. Communication (Sulak *et al*., 2002)
5. parasite shedding (Cochran *et al*., 2003; Brunnshweiler, 2006)
6. predator escape (Saidel *et al*., 2004; Gibb *et al*., 2011; Soares and Beirman, 2013; Parsons *et al*., 2016)

## Methodology

To examine the optical and physical mechanisms enabling Archer fish to accurately target prey despite light reflection of *Toxotes jaculatrix*. As in reflection, measure the angels from the normal to the surface, at the point of contact. The constants *n* are the indices of refraction for the corresponding media.

## Results and discussion

According to Holway and Suarez (1999) had reviewed that the fish physiological and ecological studies on fish are common, hence, behavioural studies have only recently been implemented to address fish performance capabilities.

The refractive index an average was calculated 1.33, consistent with freshwater values. *Toxotes jaculatrix* (Fig. 2) fish consistently corrected for the discrepancy, achieving hit accuracy rates and depending on target height. Findings showed that the confirm that Archer fish instinctively apply a correction factor that aligns with predictions from Snell's Law. Environmental factors such as water surface disturbance and ambient light levels had influence accuracy and applied. The integration of optical physics into behavioural ecology offers a comprehensive understanding of this predatory strategy. The present studies showed that the compensates for light reflection through instinctive behavioural adjustments, achieving remarkable accuracy in aerial prey capture.

*Snell's law formula (Fig. 1) - Snell's Law (Refraction while hunting prey at surface)*

When the *Arowana hunts* insects above the water, light bends at the water–air boundary. The fish sees a *shifted* prey position.

Snell's Law: $n_1 \sin \theta_1 = n_2 \sin \theta_2$

Where, $n_1$ : Refractive index of the first medium (water=1.33), $n_2$ : Refractive index of the second medium (air=1.00), $\theta_1$ : Incident angle of light in water, $\theta_2$ : Refracted angle of light in air

*Leap trajectory (projectile motion)*

When the Arowana jumps out of water to catch prey, its motion follows a parabola:

$y = x\tan\theta - gx^2/2v^2\cos^2\theta$

Where, x=horizontal distance; y=vertical height, θ=launch angle, v=initial velocity, g= gravity (9.8 m/s²)

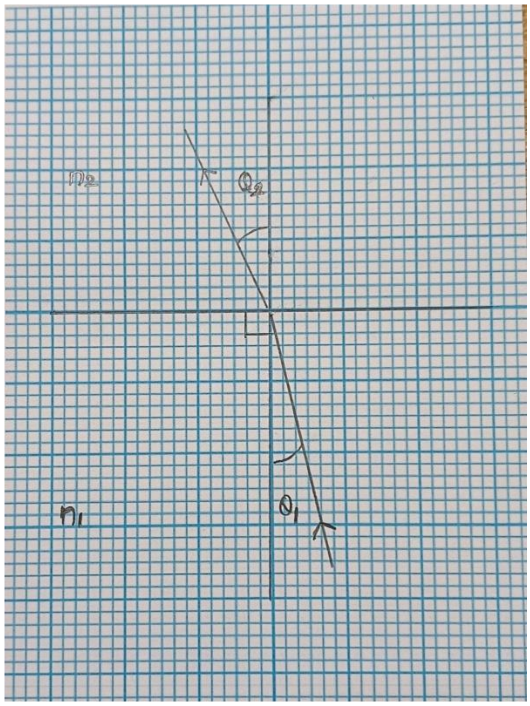


**Figure 1: Diagram showing a Snell's Law is given in the following formula.**

**Figure 2: Archer fish *Toxotes jaculatrix*.**

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