Physiology Section Newsletter

THE PHYSIOLOGY SECTION OF THE AMERICAN FISHERIES SOCIETY

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SEASONS GREETINGS FROM THE PRESIDENT

For many of you, the holiday preparations are finished, you are enjoying favorite foods and drinks, and your mind is full of thoughts about …. Portland!

Yes, in case you haven't seen it yet, check out the website for the VIII International Congress on the Biology of Fishes (Portland, Oregon July 28-August 1) at www.fishbiologycongress.org.

The conference organizing team is arranging a wide selection of symposia, inviting a solid lineup of plenary speakers, and organizing all of the other necessary preparations to make this another great meeting! Keep an eye on the website for registration information and general conference updates. Remember, student travel funding is likely again this year. Watch for further website updates about how to apply for those funds. Congress Host, Alec Maule provides more information about the Congress in his newsletter article.

As many of you know, national AFS has been working diligently on improving their information technology services. Not to be left out in the cold (seasonal pun intended), the Section is also working toward that same goal. While we all appreciate the efforts that Caleb Slater put into the Physiology Section newsletter (Thanks again, Caleb!), I am excited to announce that Paige Ackerman has taken over the management of the Physiology Section website. Welcome aboard Paige! You can read an article from Jay Nelson in this newsletter that details some machinations of parent AFS toward providing us with better IT services.

As you are all probably aware, a year has passed since the previous newsletter. During that time, I have struggled with the question of what content should fill the AFS Physiology Section newsletter. President-Elect Pat Wright and I talked and decided the newsletter would be an excellent forum for young professionals (undergraduate through Ph.D. level) to contribute brief articles. This would give them an opportunity to discuss their research ideas, and write reviews of scientific articles that they found particularly interesting. Two of Pat's students wrote briefs about their research for this newsletter, while one of mine wrote a review of a very interesting PNAS paper. Students, I encourage you to submit an article for the newsletter.. All other members, please encourage your students to send me an opinion or review at akolok@mail.unomaha.edu. The exercise will build confidence and enhance writing skills, something most of us can perennially use help with!

I hope the holiday season treats you well. Come up and say hello to me in Portland.

Now, where did I put that eggnog?

Alan Kolok
President, AFS Physiology Section

Inside this issue:

Physiology Section Newsletter

8th International Congress on the Biology of Fish

To: Fish Physiology Section Members, Previous Congress Attendees and All Who Study Fish

I would like to personally invite you to attend the 8th International Congress on the Biology of Fishes (http://fishbiologycongress8.usgs.gov/) to be held in Portland, OR (http://www.travelportland.com/) on July 28 through August 1. The Congress offers a unique opportunity to see a wide variety of research on the biology of fish presented by scientists from around the world. Many symposia held in previous Congresses will be renewed at this meeting and all registrants are encouraged to submit an abstract to the symposium of their choice. Moreover, there is still time to organize a symposium to highlight your area of interest if it is not represented.

The meeting will be at the Doubletree Hotel & Executive Meeting Center Portland - Lloyd Center located only 14 km from the Portland International Airport. The MAX light rail system is available at baggage claim and will drop you off directly across the street from the hotel's front door. The social highlight of previous Congresses has been the Banquet. This Congress's Banquet will be held at the Oregon Park Zoo (http://www.oregonzoo.org/) where you will have an afternoon to explore the animal exhibits, followed by an evening to enjoy food and entertainment that are uniquely Pacific Northwest USA.

The Congress website contains more information about the meeting, symposia, Portland, Oregon and how to proceed with registration.

I look forward to seeing you in Portland, OR later this summer.

Sincerely,
Alec G. Maule, Ph.D.
Chair, Congress Organizing Committee

"I THINK **FISH** IS NICE, BUT THEN I THINK THAT RAIN IS WET, SO WHO AM I TO JUDGE?"
DOUGLAS ADAMS

Information technology slated for quantum upgrades

The American Fisheries Society has experienced a number of technological difficulties over the past few years including server crashes and registration difficulties for the annual meeting. In response, the Governing Board charged Executive Director Gus Rassam with evaluating the current state of information technology (IT) at AFS and developing a strategy for moving into the future. As part of that process, a strategy session was held on the 16th and 17th of May that I was fortunate enough to attend. Among the progress that has been made already is a substantial upgrade to the AFS web page and the formation of a new committee devoted to AFS electronic services. The meeting itself resulted in a number of action items that AFS seems committed to implementing on various time scales. Some items that were designated for immediate attention were:

1) a workshop at San Francisco for the AFS IT staff and the IT person from each Section or Division to become familiar with the capabilities of AFS electronic services and to integrate the activities of the various Section and Divisions with the parent society's;

Information technology slated for quantum upgrades cont'd

pages on the AFS website;

3) Proofing of the electronic addresses in the AFS directory (currently at ~ 10% error);

4) Select new abstract/ registration software;

5) Engineer a podcast and video simulcast of the San Francisco plenary.

More medium term goals were to make voting and abstract software seamlessly available (and free) to the Sections and Divisions and to make an electronic newsletter version of "Fisheries" with links to advertisers and authors.

A long-term goal expressed by many was to move the membership experience towards a "My space" model where your interface with the AFS web page would contain your meeting history, publication history, directory information etc.

So, you should be seeing lots of movement over the next couple years as the parent society seems committed to and is throwing money at updating our IT profile. They didn't seem ready, however, for more ambitious ideas like mine of hosting bi-weekly or monthly podcasts on fisheries-related issues. Happy Computing.

Jay A. Nelson

Fish with the Desire for a Breath of Fresh Air

by **Danielle LeBlanc, MSc Student, University of Guelph**

Fish are generally recognized as aquatic organisms incapable of terrestrial excursions. However, research is currently being conducted on an extremophilic air tolerant cyprinodont fish, the mangrove killifish, *Kryptolebias marmoratus*. In their natural environment, a killifish will voluntarily air expose itself in order to forage, escape inhospitable water conditions and avoid predation often remaining on damp leaf litter for extended periods of time. For example, under laboratory conditions *K. marmoratus* tolerate air exposure for a month. Recently, Scott Taylor of Brevard County, Florida's Environmentally Endangered Lands Program discovered 50 or so mangrove killifish packed into insect tunnels in a rotting log, suggesting that killifish seek out diverse moist habitats that can be crowded and cramped (Dolgin, 2007).

How is it possible for a fish to live on land for such extended periods of time? In the Wright lab at the University of Guelph we have been examining this question. Specifically, we are looking into how air exposure effects ammonia excretion, gill morphology and metabolic rate of the killifish. In most fish ammonia excretion occurs across the gills. We have found that killifish are able to excrete gaseous ammonia through the surface of the skin during periods of air exposure. Also, recent research from our lab has shown that killifish remodel their gills in air. The interlamellar space in the gills fills with cells during air exposure and most importantly that process is reversible upon re-entry into water. It remains unknown what type of cell is filling the interlamellar space and if it serves a purpose beyond the prevention of desiccation and collapse of the gill structure. Gill remodeling has been shown in crucian carp and goldfish in response to water temperature and hypoxia, but this is the first report of such changes during air exposure (Nilsson, 2007). Some air breathing fish, such as lungfish, will aestivate and decrease their metabolic rate when on

"WHY DOES SEA WORLD HAVE A SEAFOOD RESTAURANT?? I'M HALFWAY THROUGH MY FISH BURGER AND I REALIZE, OH MY GOD....I COULD BE EATING A SLOW LEARNER."

Fish with the Desire for a Breath of Fresh Air (cont'd)

land, thus conserving energy. The killifish do not undergo aestivation. They are able to maintain a metabolic rate similar to when they are in water for at least 5 days (Ong *et al*., 2007).

There are many more important avenues of research that remain to be conducted with these extraordinary fish. Currently, I am interested in osmoregulation and ionoregulation during air exposure. In most fish, these two functions are primarily carried out in the gills. However, if the gills of these fish are rendered non-functional during episodes of air exposure, how would these functions be performed? One hypothesis is that osmo- and ionoregulation occur via the skin surface. In collaboration with Dr. Chris Wood at McMaster University the radioisotopes tritium (^{3}H-H_2O) and sodium-22 (^{22}Na) were used to measure water and ion flux both in water and in air to determine if the skin is responsible for the maintenance of homeostasis during air exposure. The results suggest that the skin is responsible for water and ion balance in air as the efflux rate was similar in both conditions. Following from this work I am investigating the composition of cells in the skin and gills during aquatic and terrestrial episodes. Experiments using microscopy techniques, such as immunofluorescence and a vital mitochondrial stain to reveal mitochondria-rich cells in the skin, will shed light on such endeavors.

The mangrove killifish is a unique fish capable of amazing feats. Studies have shown that this amphibious fish thrives in both terrestrial and aquatic environments. For these reasons, a more complete understanding of the physiological strategies utilized by mangrove killifish in both environments may help clarify the origins of terrestriality.

References

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Ong, K., Stevens, D. and Wright, P.A. (2007). Gill morphology of the mangrove Killifish (*Kryptolebias marmoratus*) is plastic and changes in response to terrestrial air exposure. *J. Exp. Biol.* 210, 1109-1115.

When the waste builds up: How fish cope with excess ammonia.

By Laura Sanderson

Although ammonia is a natural by-product of protein catabolism, it can be detrimental if allowed to accumulate to toxic levels. In teleost fish, higher-than-average ammonia levels can result in appetite-suppression (Ortega et al, 2005. J. Exp. Biol., 208: 1855-1866) and if high enough, convulsions, disorientation and death. Due to more intensive aquaculture practices, agricultural run off, and environmental extremes, the fish of today come into contact with elevated environmental ammonia far more frequently than in the past.

When it comes to dealing with ammonia, not all fish are created equal. From the literature available, it is clear that fish vary in their sensitivity to ammonia. For example, the ammonia 96h LC50 value for adult rainbow trout (*Oncorhynchus mykiss*) is 1.7mM (pH 8) and for goldfish (*Carassius auratus*), it is approximately 9mM (Thurston and Russo, 1981. Env. Sci. Technol., 15: 837-840. Dowden and Bennett, 1965. J. Water Pollut Control Fed., 37: 1308-1316.)

If a fish is ureotelic, it possesses a functional ornithine urea cycle capable of converting ammonia into urea. Though energetically expensive, urea has the benefit of being far less toxic than ammonia, and can therefore be stored in the body without negative side effects. Ureotelic fish such as the gulf toadfish (*Opsanus beta*) are far more ammonia-tolerant than another fish in their family, the plainfin midshipman (*Porichthys notatus*), that lacks the ornithine urea cycle (Wang and Walsh, 2000. Aqua. Toxic., 50: 205-219). Clearly, ureotelic fish have an advantage when it comes to tolerance.

But the story does not end here. Very few adult teleosts are ureotelic. Most are ammoniotelic, lacking a functional ornithine-urea cycle, and must depend on other methods to eliminate ammonia. Passive diffusion from the gills is the simplest and most energy efficient method for ammonia excretion, but if ammonia levels in the environment exceed those in the fish, this diffusion is impaired and the fish must employ other methods.

When the waste builds up: How fish cope with excess ammonia (cont'd)

Glutamine synthetase, the enzyme responsible for the conversion of glutamate and ammonia to glutamine, may be a key determinant of ammonia tolerance in fish. The brain is the organ most sensitive to elevated ammonia and ammonia tolerant fish species have demonstrated very high activity levels of glutamine synthetase (Wang and Walsh, 2000. Aqua. Toxic., 50: 205-219; Ip et al, 2004. Phys. Biochem. Zool. 77: 390-405). As well, in the ammonia intolerant rainbow trout, brain glutamine synthetase mRNA expression and activity has been shown to increase with exposure to .67mM NH4Cl (Wright et al, 2007. J. Exp. Biol. 210: 2905-2911).

In my own work, I am using methionine sulfoximine (MSOX) to inhibit brain glutamine synthetase activity to determine the importance of this enzyme in ammonia detoxification and survival in rainbow trout. Initial experiments have shown that a 75-80% knockdown of glutamine synthetase activity by MSOX does not impact the survival of trout exposed to a sub-lethal dose of external ammonia. Thus far, my results suggest that the level of brain glutamine synthetase activity is set to a very high "safety factor" so that these fish can cope with moderately poor quality waters in lakes and streams. Many more questions remain, however, in teasing apart the mechanisms that separate the ammonia tolerant from ammonia intolerant species.

Collapse of a fish population due to Ethynylestradiol.

by Nicki Alexander, M.S. student, Department of Biology University of Nebraska at Omaha

Estrogens found in surface waters have been shown to cause feminizing effects on fish. These effects are generally physiological or morphological changes on individuals, including male fish inappropriately expressing vitellogenin (vtg) or in some cases producing ovotestes. However, until recently, the question of whether or not these effects might lead to population level disturbances was only a topic of speculation. A recent article by Kidd et al., published in *Proceedings of the National Academy of Sciences,* has shown that low level additions of an estrogen into a lake can, in fact, lead to the collapse of a local fish population of fathead minnows.

Kidd's experiment was conducted at the Experimental Lakes Area in northwestern Ontario, Canada and utilized a novel approach in which an entire lake was dosed with the synthetic estrogen, 17 a-ethynlyestradiol (EE2). The study was conducted over seven years and used an experimental lake and two reference lakes. The first two years baseline information was gathered on the fathead minnow population, including vtg gene expression and protein, differences in gonadal development, and trap netting (to measure abundance of fathead minnows). In the subsequent three years, the experimental lake was dosed with a low concentration of EE2 3 times weekly, for 20-21 weeks and the other two lakes were held as controls. For the final two years of the seven year study, the lakes were monitored with no additional amendments to the experimental lake. Throughout the study, the minnow population in the experimental lake was compared against the minnows in the reference lakes, and against the baseline data.

The impact on the experimental lake was rapid and pronounced. Observations included: male fathead minnows expressing vtg after only seven weeks of additions, female fathead minnows displaying delayed oogenisis after a year, and intersex in males after two years of additions. Concurrently, at the end of the second year of EE2 amendments to the experimental lake, the fathead minnow population collapsed due to an almost total loss of young of the year fish. This failure was also observed in the third year and continued for an additional two years after the amendments had ceased.

This study is truly groundbreaking. It not only demonstrates how low levels of a synthetic estrogen in the aquatic environment can impact fish individually, but how an estrogen can lead to an entire collapse of a fish species. Estrogens are not uncommon contaminants in aquatic environment, and now the environmental community has a better understanding concerning the magnitude of the environmental problem that estrogens pose to fish populations.

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