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DR. JAMES MARCUS DRYMON (Orcid ID : 0000-0002-2104-004X)

MS. AURIEL M.V. FOURNIER (Orcid ID : 0000-0002-8530-9968)

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Tiger sharks eat songbirds: Reply

JM Drymon^{1,2,*}, K Feldheim³, AMV Fournier^{1,4}, EA Seubert¹, AE Jefferson^{1,2}, AM Kroetz⁵, SP Powers⁶

1. Mississippi State University
Coastal Research and Extension Center
1815 Popp's Ferry Road, Biloxi, MS 39532

* Corresponding author. E-mail: marcus.drymon@msstate.edu

2. Mississippi-Alabama Sea Grant
703 East Beach Drive
Ocean Springs, MS 39564

3. Field Museum
Pritzker Laboratory for Molecular Systematics and Evolution
1400 South Lake Shore Drive
Chicago, IL 60605

4. Forbes Biological Station-Bellrose Waterfowl Research Center
Illinois Natural History Survey

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30 Prairie Research Institute
31 University of Illinois at Urbana-Champaign
32 Havana, IL, 62644

33
34 5. National Marine Fisheries Service
35 Southeast Fisheries Science Center
36 Riverside Technology, Inc.
37 3500 Delwood Beach Road
38 Panama City Beach, FL 32408

39
40 6. University of South Alabama
41 Department of Marine Sciences
42 5871 USA Drive North
43 Mobile, AL 36688

44
45
46

47 Running Head: Comments

48 In response to our recent paper (Drymon et al. 2019), Yosef (2019) questions the
49 mechanism proposed to explain interactions between tiger sharks (*Galeocerdo cuvier*) and
50 migratory songbirds, while offering an alternative mechanism based on a single observation. We
51 appreciate the comments from Yosef and the opportunity to respond.

52 Yosef (2019) questions two aspects of the mechanism we suggested. First, he states that
53 “*the frequency and scale of inclement weather in fall is not consistent or regular between years.*”
54 To this first point, we disagree. For small migratory birds, inclement weather events include cold
55 fronts, rain, mist, or adverse winds (Newton 2007), which are sufficiently common in the
56 northern Gulf of Mexico during the fall. Moreover, we found that tiger shark/bird interactions
57 were common from year to year, occurring in every year (9 total) we examined tiger shark
58 stomach contents. We also found that the interaction wasn’t strictly limited to a few individuals;
59 nearly 40% of the tiger sharks we examined had avian remains in their stomachs.

60 Second, Yosef (2019) states that “*although a relatively large portion of the avian*
61 *migrants do not complete their migration, it usually does not occur immediately after leaving*
62 *landfall.*” To this second point, we disagree. While it was initially surprising that these
63 interactions were more common in the fall compared to spring (and thus taking place closer to
64 the migratory departure location rather than the migratory destination), we are confident that the
65 mechanism we’ve proposed (adverse weather in the fall) is sufficient rationale. During fall
66 migration, young-of-the-year birds are traveling south on their first migration and are likely to
67 overshoot into the Gulf of Mexico at night, before correcting and trying to return to land. If they
68 don’t realize they’ve overshoot soon enough, or they experience adverse weather when they do
69 turn around, they would be highly likely to either exhaust themselves, fall into the water and die
70 of exposure, or exhaust themselves and die before reaching the water.

71 Yosef (2019) goes on to suggest behavioral thermoregulation may explain the interaction
72 between tiger sharks and terrestrial birds, and suggests we try and “*correlate (our) data with*
73 *species abundance but also with inclement weather, especially heat waves.*” The account of
74 behavioral thermoregulation in European Bee-eaters (*Merops apiaster*, Yosef 2010) is interesting
75 and may provide an explanation for the occurrence of a Bee-eater from a single tiger shark
76 stomach (Yosef et al. 2002); however, behavioral thermoregulation is highly unlikely to explain
77 the interactions reported in Drymon et al. (2019), for the following reasons.

78 First, there are dramatic differences in climate between the two study areas in question:
79 the northern Gulf of Mexico (Drymon et al. 2019) and the northern Red Sea (Eilat, Israel, Yosef
80 et al. 2002). For example, the average fall temperatures in the northern Gulf of Mexico are less
81 than 31° C, compared to 43° C and greater in the northern Red Sea. Perhaps more importantly,
82 the climate in the northern Gulf of Mexico is extremely humid, compared to the khamsins
83 described by Yosef (2010), which are hot, dry winds. Therefore, the evaporative cooling evoked
84 in Yosef (2010) would be impossible in the humid climate of the northern Gulf of Mexico.

85 Second, we found no evidence in the literature of behavioral thermoregulation for any of
86 the migratory species in our area; we interpret this to mean the behavior described in Yosef
87 (2010) may be unique to European Bee-eaters in Eilat, where small, shallow (i.e. 20 cm),
88 predator-free salt ponds are available, unlike the northern Gulf of Mexico.

89 The feeding habits of tiger sharks are truly extraordinary. Over half a century ago, a
90 single yellow-billed cuckoo (*Coccyzus americanus*) was found in the stomach of a tiger shark

91 (Saunders and Clarke 1962). The authors suggested the bird was a fallen migrant, a mechanism
92 echoed by Dodrill and Gilmore (1977). Since then, inclement weather (Carlson et al. 2002,
93 Gallagher et al. 2011) and behavioral thermoregulation (Yosef 2010) have also been advanced to
94 explain the presence of terrestrial birds in the stomachs of tiger sharks. Intuitively, the ways in
95 which tiger sharks encounter terrestrial birds are likely context-dependent. However, based on
96 the preponderance of tiger shark stomachs containing bird remains (41 of 105 examined)
97 collected over a 9-year period, we maintain that the most parsimonious explanation for the
98 prevalence of migratory birds in the diets of tiger sharks in the northern Gulf of Mexico is the
99 mechanism proposed in Drymon et al. 2019.

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