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ARTICLE

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Physiological response of milkfish (*Chanos chanos*) to capture in a fly fishing catch-and-release recreational fishery

Andy J. Danylchuk[1] | Lucas P. Griffin[1,2] | Michael Lawrence[3] | Sascha Clark Danylchuk[4] | Eleanor Brighton[5] | Gail Fordham[6,7] | George Curd[6] | Kyle Simpson[8] | Devan Vd Merwe[8] | Steven J. Cooke[3]

[1]Department of Environmental Conservation, University of Massachusetts Amherst, Amherst, Massachusetts, USA

[2]Department of Integrative Biology, University of South Florida, Tampa, Florida, USA

[3]Department of Biology, Carleton University, Ottawa, Ontario, Canada

[4]Keep Fish Wet, Amherst, Massachusetts, USA

[5]Blue Safari Seychelles, Providence Industrial Estate, Mahe, Seychelles

[6]Island Conservation Society, Mahe, Seychelles

[7]Blue Marine Foundation, London, UK

[8]Blue Safari Seychelles Fly Fishing, Alphonse Island Resort, Victoria, Mahe, Seychelles

Correspondence

Andy J. Danylchuk, Department of Environmental Conservation, University of Massachusetts Amherst, 160 Holdsworth Way, Amherst 01003, MA, USA.

Email: danylchuk@eco.umass.edu

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Abstract

Recreational angling for novel marine species and related tourism development can be important in a Blue Economy. The milkfish (*Chanos chanos*) is growing in popularity as a target of fly fishing-based catch-and-release (C&R) recreational fisheries, largely because of their challenge to catch and powerful swimming abilities, resulting in fight times that can exceed 1h. Anecdotal sentiments by anglers claim that milkfish can fight for long periods of time because they do not accumulate blood lactate. To test this hypothesis, we measured blood lactate and blood glucose for 21 milkfish caught by fly fishing in the remote Alphonse Group of islands, Republic of Seychelles. Fight times ranged 5–78.3min. Blood lactate and blood glucose concentrations increased with fight times that did not exceed 60min. Total length of milkfish was not correlated to blood lactate or blood glucose concentrations. Ours is the first study on C&R of milkfish that debunks the anecdote that milkfish can fight for long periods of time because they do not accumulate blood lactate. Our study also revealed that milkfish may begin to physiologically recover after fight times longer than 60min. In the context of C&R, our study indicates that anglers should limit fight times to 20–30min when possible to reduce angling-induced physiological stress and other potential impacts (e.g., depredation) on milkfish in recreational fisheries.

KEYWORDS

catch-and-release, *Chanos chanos*, fishing, milkfish, physiology

1 | INTRODUCTION

Recreational fishing is a popular leisure activity in many regions around the world (Arlinghaus et al., 2021). As anglers from wealthier nations seek new species beyond those occurring in their usual waters, increased demand can drive the development of recreational fisheries in novel locations focused on species for which scientific information may be limited (Borch et al., 2008; Ditton et al., 2002; Golden et al., 2019; Zwirn et al., 2005). For tropical small island nations, the financial benefits of tourism-based recreational fisheries are often touted as having the potential to contribute to a Blue Economy, where sustainable commerce is reliant on coastal and ocean goods and service (Pauly, 2018). In many of these fisheries, catch-and-release (C&R) is used as a management tool to limit the effects of angling on data-deficient species, under the assumption that fish released survive and contribute to the maintenance of the population (Brownscombe et al., 2017). Nevertheless, C&R research over the last few decades reveals that how a fish is hooked, fought, and handled can influence its fate once released (reviewed in Brownscombe et al., 2017). As such, knowledge gaps related to how novel species respond to C&R must be filled to inform conservation and management to proactively support sustainable recreational fisheries and reliant local and regional economies (Arlinghaus et al., 2021).

Milkfish (*Chanos chanos*) is a marine species inhabiting the subtropical and tropical Indo-Pacific, with adults found in offshore waters, shallow coastal embayments, flats, and around islands where coral reefs are well developed (Bagarinao, 1994). Milkfish are a popular species for aquaculture because of their relatively fast growth rate and ability to tolerate a wide range of environmental conditions, including brackish and freshwater (de Jesus-Ayson et al., 2010). In places like the Seychelles and Republic of Kiribati, where tourism-based recreational C&R fisheries were initially targeting species such as bonefish (*Albula glossodonta*) and giant trevally (*Caranx ignobilis*; McLeod, 2016; Kaufmann, 2000), attention turned to milkfish in the early 2000s as a new challenge for recreational anglers (Gilbey, 2021; Figure 1).

Primarily targeted by fly fishing, recreational anglers are attracted to milkfish because of their difficulty to hook and their strong fight (Gilbey, 2021). Milkfish are predominately filter feeders of blue-green algae, diatoms, and detritus (Bagarinao & Thayaparan, 1986; Gandhi et al., 1986). Therefore, much experimentation was needed to develop a fly pattern that matched their diet and to present the fly on a fine leader to ultimately hook them in the mouth (Gilbey, 2021). Once fishing techniques were developed,

FIGURE 1 A milkfish (*Chanos chanos*) caught by fly fishing in the Alphonse Group of islands, Republic of Seychelles, from January 16 to February 09, 2022. Handling of milkfish in the recreational fishery may include air exposure for photos or admiration, but fish in this study were not air exposed between the time landed and time released.

milkfish began showing up more frequently in fishing magazines, on social media posts, and in marketing material for fishing lodges, which fueled angler demands. Still, challenges related to hooking and fighting a milkfish mean that the probability of an angler landing even one during a fishing trip can be quite low (K. Simpson, pers. comm). As such, anglers that target and hook a milkfish likely fight them as carefully as possible so as not to break them off, thereby contributing to long fight times (K. Simpson, pers. comm). Also, as fisheries developed, reports came from anglers and guides that milkfish could fight on the end of a line for an hour or more before landing, bringing to question among anglers and guides as to how this species could fight so hard for so long.

A sentiment shared periodically on angling-based social media suggested that milkfish must not build up blood lactate, a metabolic byproduct of anaerobic muscle activity (Holder et al., 2022; Wood, 1991), and a well-documented secondary biomarker of fish physiological stress responses that experience a “fight or flight” reaction when angled (Cooke & Schramm, 2007). Anglers that embrace this belief then may feel justified in fighting milkfish for prolonged periods of time, especially to maximize their return on investment when the probability of hooking and landing milkfish is relatively low. This may be additionally relevant in marine systems when predators (e.g., sharks, barracuda) increase the potential for depredation (Casselberry et al., 2022; Mitchell et al., 2018) or postrelease predation (Danylchuk et al., 2007). Measuring metabolites, such as blood lactate and blood glucose, along with evaluating elements of an angling event (e.g., hooking injury), have been used to understand how fish respond to C&R and subsequently to develop best practices to support management and conservation goals (Cooke & Suski, 2005).

Our objective was to determine if milkfish built up blood lactate, as expected from other studies of C&R effects on fish, or somehow did not build up blood lactate, as suggested by anglers on social media. To achieve our objective, we examined how milkfish responded to capture by fly fishing, including hooking metrics, fight time, reflex impairment, and blood lactate and blood glucose at the time of landing. As the first study to assess the response of milkfish to C&R, we hoped to increase insight to inform best practices for catching and releasing milkfish caught by fly fishing and to provide novel insights that can act as a foundation for future research.

2 | METHODS

2.1 | Study site

This study took place in St. François Atoll (7.10°S, 52.75°E), part of the Alphonse Group of islands in the Outer Islands of the Republic of Seychelles (see Griffin et al., 2021). St. François Atoll includes two islands (Bijoutier, 2 ha; and St. François, 17 ha), a large lagoon (1650 ha), and extensive shallow reef flats of sand, seagrass, and coral rubble (3732 ha). A peripheral coral reef descends gradually before abruptly dropping off to oceanic waters more than >2000 m deep. The inner lagoon is relatively shallow (<10 m), has a sandy bottom spotted with small coral heads, and is bisected by shallow "finger flats" that create a series of inner basins, each with small natural channels that funnel water during incoming and outgoing tides. The mean tidal range is ~2 m, and strong currents are created as tides ebb in the channels of finger flats and at areas of small irregular depressions in peripheral reef flats. Outgoing tidal currents concentrate plankton that attracts filter feeders such as reef mantas (*Mobula alfredi*) (Peel et al., 2019) and milkfish (AJD, personal observation).

2.2 | Capture and handling

Fishing was from January 16 to February 09, 2022. Milkfish were primarily targeted by boat on outgoing tides when they were observed aggregating to feed on plankton, either just beyond the periphery of the reef flat or in or near channels of finger flats in the lagoon. Milkfish were also occasionally targeted while wading on shallow sand flats as they moved toward deeper water of the inner lagoon as tides receded. In all locations, milkfish were 5–20 m away from anglers when hooked. Fish were caught using 10–11 weight fly rods and reels, 20–30 lb. leaders, and small barbless flies (Gamakatsu SL12S, size 2, gauge 1 mm, shank 15 mm, bite 10 mm, gap 10 mm) that mimicked tufts of filamentous algae. A single hook was predominantly used; however, a second "trailing hook" was sometimes added to increase the chances of a hook set.

For each fish, time from hooking to landing was recorded to the nearest second. Milkfish were landed using a large net to prevent losing fish (a common practice by guides and anglers). Once landed, fish were immediately assessed using reflex action mortality predictors (RAMP), including loss of equilibrium, tail grab, eye roll (vestibular ocular response, VOR), body flex, and head complex assessments (Brownscombe et al., 2017; Davis, 2010). Reflex impairment is useful for assessing the condition of fish caught by recreational angling (Brownscombe et al., 2017). Equilibrium was assessed by turning the fish upside-down, with the ability for the fish to right itself within 3 s indicating a positive response. Tail grab was assessed by grabbing the fish by the tail, with fish attempting to escape handling indicating a positive response. VOR was assessed by rolling the fish on its side and observing eyeball movement, with eyeballs tracking level indicating a positive response. Body flex was assessed by lifting the fish from the center of its body, with body flexion to escape indicating a positive response. Head complex was assessed by observing opercular movement, with regular ventilation indicating a positive response. Positive responses were scored as 1, and negative responses (absent reflexes) were scored as 0. For analyses, RAMP scores were converted to a proportion (each reflex = 0.2), with no impairment of any reflexes being 1 and loss of all reflexes being 0. Fish were then either placed in a mesh cradle at the side of the boat or in a large static live well (l.05 m × 0.55 m × 0.25 m) filled with fresh seawater. Fish total length (TL) and fork length (FL) were measured in cm. Anatomical hooking location was recorded, and incidence of bleeding at the hooking location was noted. Ease of hook removal was measured categorically between 0 (easy) and 3 (difficult).

Fish were turned ventral side up for a phlebotomy (Figure 2). Blood was drawn nonlethally from the caudal vasculature just posterior to the anal fin (Lawrence et al., 2020) and took less than 3 min from the time of landing, as recommended (Lawrence et al., 2018). A heparin sodium (1000 USP units)-coated 5-mL syringe (Henke Sass Wolf, Henke-ject) with a 76.2 mm (3″) 18-gauge needle (Air-Tite, Din/EN/ISO 7864) was used to collect 1 mL of whole blood. Immediately after collection, point-of-care meters were used to determine concentrations of blood lactate (mmol/L; Lactate Plus, Nova Biomedical) and blood glucose (mmol/L; Accu Check Compact Plus, Roche Diagnostics). These meters were previously validated for use in teleost fishes (Ball & Weber, 2017; Bard & Kieffer, 2019; Stoot et al., 2014; Vaage et al., 2023).

2.3 | Data analyses

The correlation between fight time (min) and body size (TL) was quantified using Pearson's correlation coefficients (*r*). To compare body size and fight time between fish caught within the lagoon or offshore of the reef flat, a Welch Two Sample *t*-test and a Mann–Whitney *U* test (due to normality violation) were used, respectively. Hook placement, ease of hook removal, and occurrence of bleeding were converted into proportions. Logistic regression with a binomial distribution (RAMP successes vs. failures) using the glmmTMB package (Brooks et al., 2017) was used to assess effects of fish length, fight time, and hook removal scores on RAMP. The full model included three covariates as a three-way interaction, with

FIGURE 2 A milkfish in a seawater-filled trough having blood drawn for in situ analysis via point-of-care meters caught by fly fishing in the Alphonse Group of islands, Republic of Seychelles, from January 16 to February 09, 2022. Photo credit: Brian Chakanyuka/Alphonse Fishing Company.

fish length and fight time centered and scaled. Model selection, based on the Akaike information criterion, used the dredge function from the MuMIn package (Bartoń, 2022). Model assumptions of logistic regressions were examined by simulating and plotting residuals (10,000 times) with the DHARMa package (Hartig, 2022). Subsequently, two linear regressions were used to test effects between fight time or fish length (independent variables) and blood lactate and blood glucose (dependent variables). Two multiple linear regressions were implemented again for fish with fight times less than 60 min to evaluate effects of fight times more representative of the fishery. A final logistic regression was used to determine if blood lactate and blood glucose significantly affected RAMP scores.

3 | RESULTS

Milkfish landed ($n=21$) ranged 96–129 cm in TL (mean 110.2 ± 8.4 cm SD). Fight times ranged 5.0–78.3 min (mean 29.2 ± 21.6 min SD), and body size was not correlated to fight time (df = 19, $r=-0.11$, $p=0.64$). Of 21 landed fish, 11 were landed offshore of the reef flat, while 10 were landed in the lagoon. Body size of milkfish did not differ between locations (df = 17.94, $t=1.15$, $p=0.26$), and fight times did not differ between locations ($W=43.5$, $p=0.44$).

Most milkfish were hooked in the mouth (71%), either in the corner of the jaw ($n=10$) or the front of the upper or lower jaw ($n=5$). Other milkfish were hooked in the tip of the snout ($n=1$), near the dorsal fin ($n=3$), or in the tail ($n=1$). One trailing hook hooked a milkfish in the corner of the jaw and the eye. Most hook removals were ranked zero (81% of 17), where the hook was very easy to dislodge or fell out as the fish was landed. All three fish with a hook removal score of three (difficult) were foul hooked in the dorsal region ($n=2$) or in the corner of the jaw and the eye with the trailing hook ($n=1$). Three fish (14%) were bleeding at the hook location in the tip of the snout, upper jaw, and near the dorsal fin.

RAMP scores when landed ranged 0.6–1.0 (<1 indicates some impairment; mean = 0.91 ± 0.14 SD; mode and median = 1), and seven milkfish (33%) showed signs of reflex impairment (Table 1). For those with reflex impairment, either tail grab ($n=3$), body flex ($n=2$), or both were absent ($n=2$). The top model, based on Akaike information criterion, for evaluating relationships between RAMP and fish length, fight time, and hook removal, included only the intercept, thereby suggesting no effect between RAMP and angling metrics.

TABLE 1 Angling metrics, reflex scores, and blood lactate and glucose for milkfish caught by fly fishing in the Alphonse Group of islands Group, Republic of Seychelles, from January 16 to February 09, 2022.

Fish ID	Fight time (s)	Total length (cm)	Hook removal	Hook location	Equilibrium	Tail grab	VOR	Body flex	Head complex	RAMP score	Lactate (mmol/L)	Glucose (mmol/L)
1	960	103	0	Mouth	P	P	P	P	P	1	16.7	4.3
2	1260	96	0	Mouth	P	A	P	P	P	0.8	14.4	4.1
3	1140	105	0	Snout	P	P	P	P	P	1	20	3.9
4	1200	129	0	Mouth	P	P	P	P	P	1	20.7	4.6
5	960	113	0	Mouth	P	P	P	P	P	1	15.1	3.1
6	1396	103	3	Corner jaw and eye	P	P	P	P	P	1	13.7	3.8
7	605	117	0	Mouth	P	P	P	P	P	1	15.9	2.6
8	808	112	0	Dorsal	P	P	P	P	P	1	16.6	3.8
9	900	108	0	Mouth	P	P	P	P	P	1	15	3.9
10	300	100	0	Mouth	P	P	P	P	P	1	17.8	3.4
11	1498	118	0	Mouth	P	A	P	A	P	0.6	15.7	2.9
12	2194	106.5	3	Dorsal	P	A	P	A	P	0.6	23.1	3.3
13	1757	105.5	0	Mouth	P	A	P	P	P	0.8	18.6	4.1
14	1254	114	0	Tail	P	A	P	P	P	0.8	16.7	3.7
15	3800	120	3	Dorsal	P	P	P	P	P	1	23.2	4.1
16	2753	120	1	Mouth	P	P	P	A	P	0.8	22	7
17	4697	102	0	Mouth	P	P	P	P	P	1	16.1	4.3
18	3043	103	0	Mouth	P	P	P	A	P	0.8	17.8	5.5
19	4614	105	0	Mouth	P	P	P	P	P	1	14	3.8
NA	462	116	0	Mouth	P	P	P	P	P	1	NA	NA
NA	1200	119	0	Mouth	P	P	P	P	P	1	NA	NA

Blood was successfully collected from 19 of 21 milkfish, so angling metrics were used only for these 19 milkfish in further analyses. Blood lactate concentrations ranged 13.7–23.2 mmol/L (mean 17.5 ± 3.0 SD; Figure 3a), and multiple linear regression indicated no significant effects on blood lactate ($F_{(2, 16)} = 2.21$, $p = 0.14$, R^2 adjusted = 0.12) of fight time (β = 0.57, $p = 0.40$) or fish length (β = 1.29, $p = 0.07$). After removing three fish with fight times longer than 60 min, multiple linear regression indicated again no significant effect on blood lactate ($F_{(2, 13)} = 2.88$, $p = 0.09$, R^2 adjusted = 0.20) of fight time (β = 1.28, $p = 0.06$) or fish length (β = 0.077, $p = 0.25$). Two of three fish with fight times longer than 60 min had blood lactate concentrations similar to many fish fought for 20 min. Blood glucose concentrations ranged 46–126 mmol/L (mean 71.94 ± 17.45 SD; Figure 3b) and were not significantly affected ($F_{(2, 16)} = 1.42$, $p = 0.27$, R^2 adjusted = 0.04) by fight time (β = 0.36, $p = 0.12$) or fish length (β = 0.11, $p = 0.63$). Unlike blood lactate, when three fish with fight times longer than 60 min were removed, fight time (β = 0.72, $p = 0.01$) was significantly related to blood glucose ($F_{(2, 13)} = 5.83$, $p = 0.02$, R^2 adjusted = 0.39). Total length was not significantly related to blood glucose (β = 0.08, $p = 0.71$). For three fish with fight times longer than 60 min, blood glucose concentrations were similar to many fish fought for 15–30 min. RAMP scores were not significantly related to either blood lactate (β = 0.13, $p = 0.27$) or blood glucose (β = −0.05, $p = 0.88$).

4 | DISCUSSION

Although more can be learned about how milkfish respond to angling-induced stress, our study debunked the hypothesis by anglers and guides that milkfish are able to fight long because they do not accumulate blood lactate. Our study was the first to quantify how milkfish respond to capture in a recreational fishery. Although milkfish are difficult to hook, so our sample size was relatively small, we found that hooking in critical locations was limited (albeit foul hooking in the dorsal surface occurred several times), dehooking took little effort, and little loss of reflexes and no mortality at the time of landing. Our study also found a positive relationship, albeit not significantly so, between fight time and blood lactate and blood glucose levels, especially for fish fought for under 60 min. When fish fought for more than 60 min were excluded from analysis, blood glucose was significantly related to fight time.

Unlike our study, the physiology of milkfish was previously measured in the context of impacts of rearing and holding conditions in

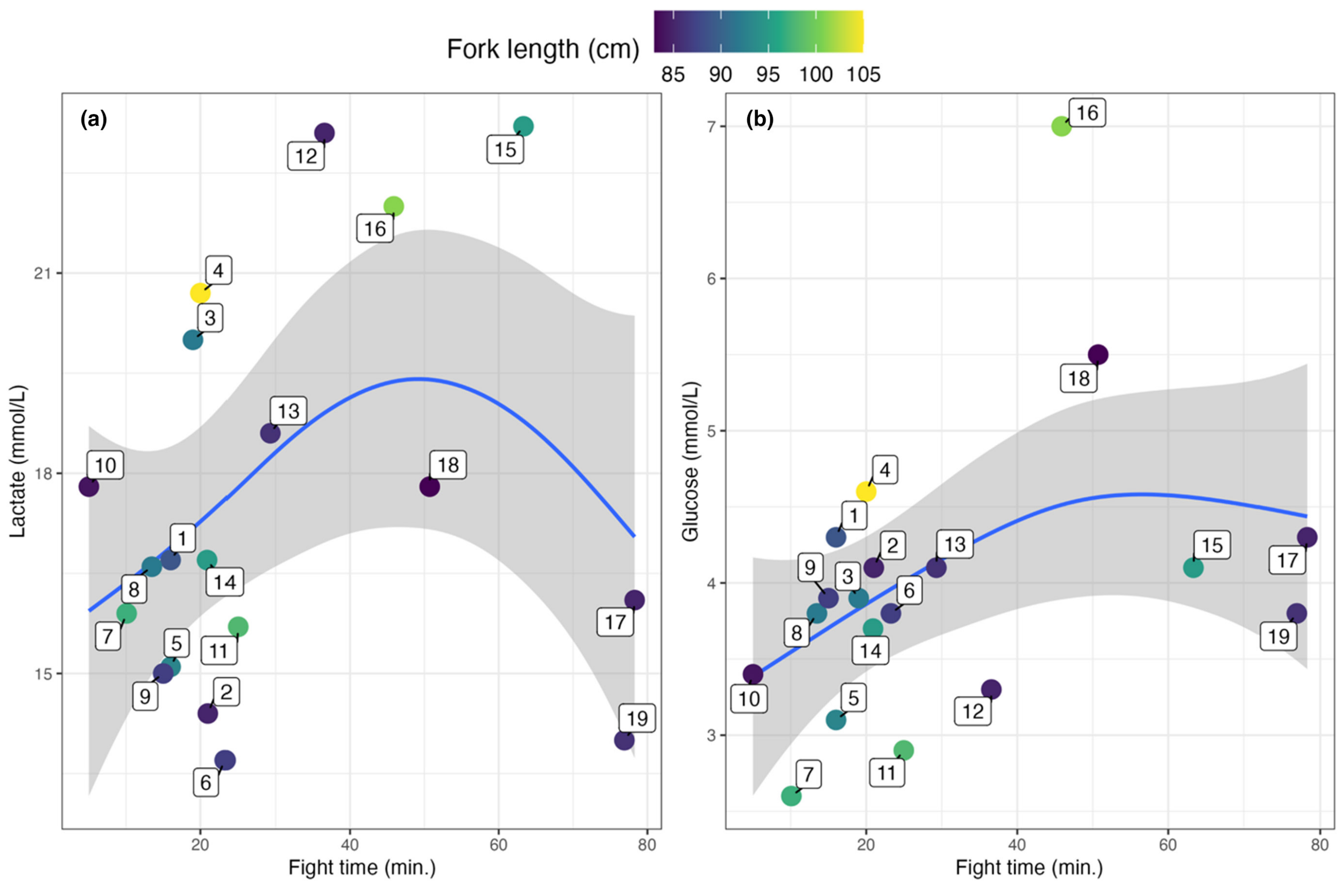

FIGURE 3 Blood lactate (a) and blood glucose (b) concentrations for milkfish compared to fight time when caught by fly fishing in the Alphonse Group of islands, Republic of Seychelles, from January 16 to February 09, 2022. The blue trend lines in each panel indicate a loess smoother with 95% confidence intervals shaded.

aquaculture (Hanke et al., 2019, 2020; Hsieh et al., 2003; Lingam et al., 2019). For instance, milkfish physiologically responded when experiencing acclimation to cold water and associated hypothermal shock (Chang et al., 2020; Hanke et al., 2019; Hsieh et al., 2003; Kuo & Hsieh, 2006). Plasma lactate and glucose increased during the first day following cold shock and decreased thereafter, likely as a response to acute physiological stress (Kuo & Hsieh, 2006). Although some insights can be drawn about milkfish response to stress in aquaculture settings, stressors in aquaculture confinement can differ considerably from fish caught with hook and line in the wild (Ashley, 2007; Rehman et al., 2017). Moreover, other studies of milkfish physiology used smaller, juvenile fish (e.g., 12–13 cm; Hanke et al., 2019) that differ greatly in size from those commonly targeted by recreational anglers, including those in our study (96–129 cm).

We found that lactate was produced by milkfish, thereby suggesting that milkfish functioned metabolically similarly to other teleosts (e.g., Currey et al., 2013; Meka & McCormick, 2005; Pottinger, 1998; Suski et al., 2007). Angling is often associated with a high degree of burst swimming that is facilitated by fast-twitch muscle fibers (Cooke et al., 2000; Currey et al., 2013; Kieffer & Cooke, 2009) that are mainly fueled by anaerobic glycolysis that produces large quantities of lactate (Wood, 1991). In fishes, lactate produced in muscles diffuses into circulation (Milligan, 1996; Wood, 1991), where it can be detected by measurement devices. However, a large percentage of lactate is retained in the white muscle tissue of fish, with detectable circulating levels reflecting a small fraction of lactate produced by the animal (Weber et al., 2016; Wood, 1991). Cultured milkfish have baseline blood lactate levels (~1–5 mmol/L; Kuo & Hsieh, 2006; Chang et al., 2020) similar to most other fish species (~1 mmol/L; Suski et al., 2007; Lawrence et al., 2018; McGarigal & Lowe, 2022). Further, milkfish have a mix of fast- and slow-twitch muscle fibers (Katz et al., 1999), with the former likely being a major source of lactate production during burst swimming (Gleeson, 1996; Wood, 1991). However, lactate levels we found were much higher than those of other teleost species that were angled in marine and freshwater environments (lactate ranges of ~4–12 mmol/L; Arlinghaus et al., 2009; Brownscombe et al., 2017; Lawrence et al., 2018; Pottinger, 1998; Wells & Dunphy, 2009). Higher production of lactate may stem from higher fight intensities by milkfish than other species, because higher bouts of exhaustive exercise or fight intensities produce higher lactate loads (Howell, 2023; Segal & Brooks, 1979; Shaw et al., 2023; Smit et al., 2016). Other species of fish with similar lactate levels as milkfish (e.g., Kelp Bass, *Paralabrax clathratus*, ~10 mmol/L McGarigal & Lowe, 2022; bluefin tuna, *Thunnus maccoyii*, ~5–25 mmol/L; Tracey et al., 2016) also have a positive relationship between blood lactate levels and fight times, but would require a combination of controlled angling experiments and swim tunnel tests to confirm.

We did notice a decrease in lactate with increased fight duration in some of the fish here, which may suggest that some lactate was likely being oxidized over time in at least a few of the individuals in our study. Milkfish are often far away from anglers when fought for long periods, thereby allowing them to maintain resistance against the rod and line while reducing muscular activity needed to physically swim in the opposite direction of line tension. If true, anaerobic muscle activity may decrease during excessively long fight times while allowing milkfish to metabolize or excrete lactate accumulated earlier in the fight, particularly if the animal was within the confines of its aerobic scope (Iosilevskii et al., 2022). Our findings imply that lactate may undergo oxidative metabolism within muscles, thus being consumed and limiting muscle-blood effluxes (Iosilevskii et al., 2022). Furthermore, muscle tissues can metabolize lactate in rainbow trout if sufficient oxygen is available, with moderate exercise reducing lactate fluxes (see Figure 1 of Weber et al., 2016). Similarly, moderate swimming following exhaustive exercise improved lactate turnover and recovery in rainbow trout compared to stationary fish (Milligan et al., 2000). Our interpretation may be further supported by the fact that blood glucose in milkfish in our study plateaued for fish with long fight times, as they depleted glucose stores or metabolic demand for glucose declined as muscle activity declined (Wood, 1991). Interestingly, this effect was not ubiquitous, with a few fish still having high lactate loads after long fight durations, thereby suggesting that lack of recovery may not be the case in all settings. While our work provides some of the first characterizations of metabolic responses of a milkfish to angling, much more information is needed on physiological mechanisms, which could be ascertained through a combination of respirometry, repeated blood sampling, swimming trials, and detailed muscle histology.

In the context of sustainable recreational fisheries, our study provides the first evidence of how milkfish respond to C&R. Although our sample size was relatively low, especially for fish fought for more than 60 min, our results suggested that anglers and guides should attempt to keep fight times under 20–30 min. Reducing fight time may curtail angler satisfaction derived from fighting such a prized catch but may reduce the physiological stress response experienced by milkfish. During long fights, milkfish can be more than 200 m away from anglers (K. Simpson, Pers Comm), distances over which anglers have less leverage to reel in fish. Additionally, with long fight times, fish are more likely to break off before being landed, more likely to suffer physical injury if moved into shallow waters with sharp corals during the fight (K. Simpson, Pers Comm), and more likely to die from depredation (Casselberry et al., 2022; Mitchell et al., 2018). To reduce such potential impacts, anglers should use heavier leaders when targeting milkfish, rods, reels, and lines of appropriate weight, and learn how to fight milkfish more effectively (K. Simpson, Pers Comm). Although the number of milkfish caught with trailing hooks in our study was low, we suggest avoiding such hook configurations to reduce foul hooking and related physical injuries. Collectively, we hope our results will be used by anglers, fishing guides, lodges, and nongovernmental and governmental organizations as species-specific guidelines and best practices for C&R for milkfish. Given the relatively low sample size of our study, we also encourage additional research on how milkfish respond to capture and handling across a wider range of environmental conditions and to examine postrelease activity and mortality.

As recreational fisheries are increasingly recognized as an important part of a Blue Economy, and with C&R often used as a default management tool in emerging fisheries (Pauly, 2018), we encourage greater focus on how novel target species respond to the physical and physiological effects of angling. Although financial and logistical capacity for such research is often limited, such research can be conducted in direct participation with stakeholders to increase eventual willingness to adopt best practices that emerge from science (Cooke et al., 2017; Danylchuk et al., 2011).

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CONFLICT OF INTEREST STATEMENT

All authors declare there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

All procedures used in this research were approved by UMass IACUC, protocol 2019–0043, and under a research permit from the Seychelles Bureau of Standards.

ORCID

Andy J. Danylchuk https://orcid.org/0000-0002-8363-0782
Lucas P. Griffin https://orcid.org/0000-0002-8560-0683
Michael Lawrence https://orcid.org/0000-0002-4801-1580
Eleanor Brighton https://orcid.org/0009-0009-2140-7735
Gail Fordham https://orcid.org/0000-0003-1460-1715
Steven J. Cooke https://orcid.org/0000-0002-5407-0659

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