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Research

Hook Types Influence The Catch Effectiveness, Injuries, and Survival Rates of Fishes in Recreational Fishing

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ABSTRACT

The physical damage inflicted on captured fish in recreational fishing activities tends to be influenced by hook type. Therefore, the present study aims to investigate the suitability of hook type for catching fish as well as the evaluation of injuries and survival rates after catch-and-release. The sampling was conducted at a recreational fish pond situated at Universiti Putra Malaysia Bintulu Sarawak Campus from July until November 2022. Three sets of fishing rods with two types of hooks (circle hook & octopus hook) were used in this study. The catch efficiency, injury level, and survival rates of both types of hooks were assessed. A total of 41 and 22 fish were successfully caught using circle hooks and octopus hooks, respectively. Of the total fish caught, 39 out of 41 and nine out of 22 of the fishes caught were tilapia. The hooking location (non-critical area) of octopus hooks and circle hooks on the tilapia was approximately 100% and 81.8%, respectively. A total of 15.38% of hooks are located within the critical area (gills) of tilapia when using the circle hook and none for octopus hooks. There was 100% mortality in fish hooked in the critical area, for instance, hooks pinned inside gills. This occurrence may relate to the shape of the circle hook whereby the length of the gape is shorter in comparison to the octopus hook. Now when fish ingested the bait, the hook easily entered deeper areas of the fish's mouth, which led to severe damage. Thus the present study recommends the use of octopus hooks in recreational fishing to reduce fish mortality rate for catch and release excursions. The results obtained from this study will be useful baseline input for recreational anglers to improve C&R practices in Malaysia.

Key words: Anglers, catch and release, circle hook, octopus hook

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INTRODUCTION

Recreational fishing is a global pastime activity that is continuously sought by the community in the modern era. This activity can be broadly divided into two general categories which are catch-and-keep (C&K) and catch-and-release (C&R). Recreational fishing is immensely popular in developed countries and is fast emerging as a major hobby in developing and emerging nations (Brownscombe *et al*., 2017). In Malaysia, recreational fisheries gained popularity with plenty of fishing spots either marine or freshwater areas. The angler who aim for marine species will consider coral reef areas or oil and gas platform, (Mohd Hairil *et al*., 2022), while for the freshwater species, angler prefers free pond, artificial lake, and stream to obtain recreation (Nagaraj, 2021). The application of C&R is part of fisheries conservation and management which is based on the assumption of the mortality and injuries sustained by captured fish. However, mortality rates vary according to contributing factors such as ecological circumstances, fishermen's etiquette, types of gear, and species-specific stress reactions (Trahan *et al*., 2021). Prior research has suggested that the anatomical hooking location is a major determinant for fish survival in C&R. Fish hooked in vital body areas such as the stomach, esophagus, and gills can lead to serious bleeding in comparison to hooking in non-critical positions (Alós *et al*., 2008). Other related aspects such as lure, bait type, gear type, and fisherman experience, may also influence hooking location. For example, organic baits have deeper hooking positions when compared to artificial lures, while smaller baits were also found to produce deeper hooking positions as opposed to larger baits (Trahan *et al*., 2021). To reduce fish mortality (due to being deeply hooked and bleeding) the selection of the right gear and bait should be applied carefully to improve the welfare of the fish (Weltersbach *et al*., 2019).

Physical harm in recreationally angled fish has also been demonstrated to be influenced by hook type and number of hooks. Several studies have demonstrated that utilizing one hook per lure reduces mortality, injuries, and mortalities (DuBois & Dubielzig, 2004 & Trahan *et al*., 2021). Apart from that, hook size also influences the catch rates, survival rates, and anatomical hooking location. According to Gilman *et al*. (2018), adjusting hook sizes can help achieve the goal of catching effectiveness on the target. Deep-hooking was the most crucial element determining the mortality of fish caught and released. Although there is limited research into the relationship between hook size and the possibility of deep-hooking in recreational fishing, the sum of findings suggested that the probability of deep-hooking is correlated to hook size (Alós *et al*., 2008, Kapusta & Czarkowski, 2022; Meyer *et al*., 2022). Apart from size, the selection of barbless hook type also influences the time taken for unhooking, pressure, and hooking injuries on caught fish (Grixti *et al*., 2007). Meka (2004), conversely these studies also found that barbless hooks lower *Oncorhynchus mykiss* catch efficiency.

The majority of anglers overlook the fish condition after applying the C&R method (Butler *et al*., 2022). There is a high possibility that captured fish suffered external or internal injuries (or both) which may lead to disease infection and sepsis. The survival of the fish would be unknown after their release. Therefore, a good knowledge of proper C&R would be beneficial to mitigate the negative consequences of recreational fishing on the fish. Thus, this study was conducted to identify the appropriate hook types and investigate injuries with survival rates of fish fished at recreational ponds. after C&R.

MATERIALS AND METHODS

Study area

The study was carried out at a recreational pond in the UPM Bintulu Sarawak Campus (UPMKB). The study period was from July until November 2022. The recreational pond was connected to a small stream in UPMKB with an upstream length of approximately 900 meters (Figure 1: N 3° 12' 20.412'' and E 113° 5' 41.712'').

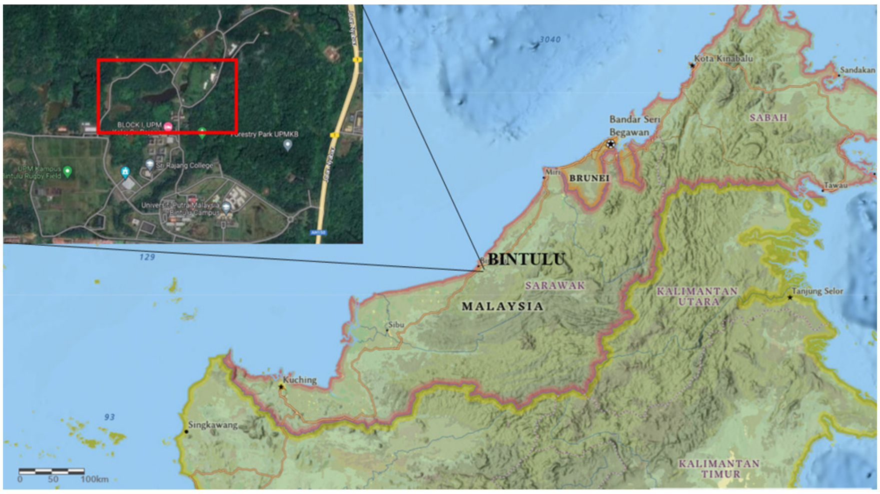

Fig. 1. The location of the recreational pond situated in Universiti Putra Malaysia Bintulu Sarawak Campus.

Sampling procedure

The sampling process was conducted during the daytime. A fishing rod (Solid King SK 260, Japan) and line (AGASS Lynon Line) were used with a sinker (size ¼), swivel (Rolling Swivel W/ Germany – A Snap, size 6), and hooks. Two different types of hooks (Figure 2) were used namely: circle hook (EXORI Fishing size 4) and octopus hook (EXORI Fishing size 4). Every fish caught was placed in a tray for hook removal from the hooking position. The fish were then kept in the stainless-steel quarantine cage net (2 cm mesh size and 30 cm diameter) to undergo temporary quarantine for 24 h, for the observation of the injury status and survival rate of the fish. The number of fish caught was recorded and sorted according to the hook type used. Quarantined fish were subsequently released back into the pond after the 24-hour duration. Fish captured were recorded and identified at the species level using identification keys proposed by Rainboth (1996) and Kottelat *et al*. (2013).

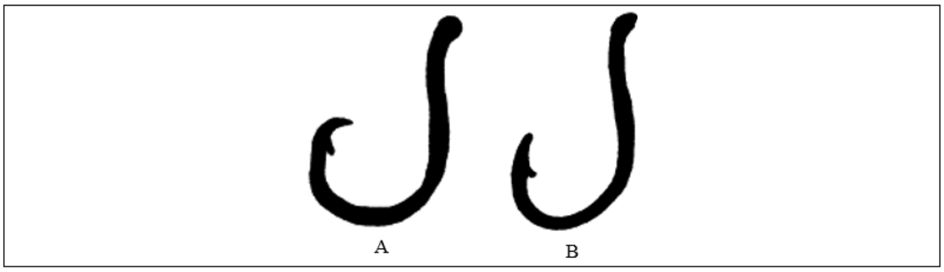

Fig. 2. (A) Octopus hook and (B) Circle hook (Cooke *et al*., 2003)

Hook removal

Hooked fish were immediately transferred to a tray, where the hook removal procedure was carried out. The hook location on the fish mouth was recorded. In the present study, it was divided into two hooking locations namely non-critical and critical. The non-critical hooking location refers to injuries on the outer lip and inner upper and lower jaw of the fish, while the critical hooking location refers to injuries at the gill and gullet. Several fishes in conditions of hook coming off from the mouth without any assistance from the angler (self-release) (Trahan *et al*., 2021) were also recorded and identified. In this study, the self-release term applied to the fish that had been captured and brought to the tray where the hook was coming off immediately from the mouth.

Data analysis

Simple proportion was used to portray the percentage of injuries, catch effectiveness, and survival rate of the fish caused by different types of hooks. PAST software version 4.03 was used for Principal Component Analysis (PCA), to interpret the correlation between the type of hooks, catch composition, and hooking site of the fish.

RESULTS

In total, 63 fish were caught during the investigation (Table 1). These fishes encompassed 10 genera and six families. Family Anabantidae, Bagridae, Channidae, Cichlidae, and Clariidae were represented by one species, namely *Anabas testudineus*, *Hemibagrus nemurus*, *Channa striata*, *Oreochromis* sp. and *Clarias macrocephalus*, respectively. In the family of Cyprinidae, six species were identified namely *Cyclocheilichthys apogon*, *Barbonymus altus*, *Barbonymus gonionotus*, *Hampala macrolepidota*, *Puntius sealei*, and *Rasbora sarawakensis*.

The hooking location of fish caught

There are 41 individuals of fish were captured using the circle hook and 22 individuals caught using the octopus hook. All individuals or 100% of the fish caught using the octopus hooks experienced non-critical injuries, in terms of hooking location 62.5% were located at the outer lip and 37.5% were located at the inner jaw of the fish (Figure 3). For the circle hook, there were 36.4% of hooks located at the outer lip and 45.4% at the inner jaw, which represented the non-critical hooking locations. In terms of critical hooking locations, 18.2% of fish hooked in the gill area died during the quarantine period. There were no hooks that reached the gullet of fish throughout the sampling periods (Table 1).

Fish species composition caught in the recreational pond

The most dominant fish species caught from the Recreational Pond of UPMKB was tilapia, *Oreochromis* sp. A total of nine out of 22 individual (40.9%) tilapia were captured using the octopus hooks, and 39 out of 41 individuals (95.1%) were caught using the circle hooks. Apart from *Oreochromis* sp., other fish species that were caught using octopus hooks comprised of *C. macrocephalus*, *C. striata*, *B. altus*, *B. gonionotus*, *H. macrolepidota*, *H. nemurus*, *P. sealei*, and *R. sarawakensis*. All of these fish were hooked in non-critical hooking locations. For the circle hook, apart from tilapia, another species also has been recorded namely *C. apogon* that was grouped in the non-critical hooking location.

Percentage level of hooking location on tilapia

For the octopus hook, the hooking location at the outer lip was higher (62.5%) compared to the inner-upper lower jaw (37.5%). There was no hook reaching the gills and gullet for the octopus hook (Figure 3). Meanwhile, for the circle hook, the percentage of the hook location in the inner upper lower jaw was higher (45.4%) compared to the location of the hook at the outer lip (36.4%). In addition, the circle hook had reached on critical area, gill (18.2%), and none for the gullet (Table 1).

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DISCUSSION

Two types of hooks used in this study, which were the octopus hook and circle hook both demonstrated different results on catch efficiency, injuries, and survival rates of the fish after catch-and-release. In a prior study Cooke *et al*. (2003) on largemouth bass, *Micropterus salmoides*, captured in central Illinois, USA using circle hooks and octopus hooks found low mortality rates for both types of hooks at 5.1% and 6.6%, respectively. In contrast, in the present study on tilapia, 15.38% of fish died after the circle hook was extracted from fish gills. Cooke *et al*. (2003) also mentioned that the fish captured by using a circle hook was hooked less deeply compared to the octopus hook. In the current study, it was noticed that only the circle hook penetrated deeper into the gills, whereas the octopus hook was only lodged in the fish mouth. This might be due to an imbalanced number of tilapia captured in this study with octopus hooks (n=9) and circle hooks (n=39), in terms of hooking location. Ostrand *et al*. (2006) mentioned that the effectiveness of juvenile muskellunge catch was impacted by hook style, whereas the use of J-hooks landed more fish in their study than circle hooks. Even though circle hooks were less effective than J-hooks, they stated that they obtained more than twice as many strikes using them. Similarly, the present study found that circle hooks demonstrated two times more strikes in terms of fish captured with 41 individuals of fish as compared to octopus hooks with only 22 individuals. Any fish hooked deeply in vital areas such as the gills and gullet were identified as potential mortalities due to the difficulty of removing the hooks (Cooke *et al*., 2003). The present study also showed that the process of removing the hook from the critical areas led to mortality after 24 hr of quarantine. It was likely due to the heavy injury sustained in the critical areas, especially during the hook removal process which was due to the slippery and active fish movement obstructing the angler from removing the barb from the inner tissue. The findings strongly suggest that greater experience and proper technique are required to safely remove hooks by hand to reduce or avoid mortality.

Cooke and Suski (2004) have stated that it is more difficult to remove the circle hook than J-hook and this may be indicative that the hook type influenced the catch effectiveness on tilapia. This is due to the design of the circle hook bent further inwards in comparison to octopus hooks that have a more outward curvature, which lends to the higher tendency for fish to self-release when caught with this type of hook. In addition, many studies have shown that one of the most influential factors affecting the survival of fish released by anglers is related to the location of a hook, specifically, the survival rate is greatly reduced for fish hooked deeply in the throat or beyond (Davie & Kopf, 2006; Cooke & Wilde, 2007; Nguyen *et al*., 2013). Hook shape and point-to-shank orientation differences, combined with numerous other aspects of hook size, configuration, and mode of deployment, can change catch rates of the target, as well as affect the condition of the fish (for instance, live or dead, damaged or injured) (Alós *et al*., 2009).

Managing bait type might also constitute a simple tool to influence the amount and composition of the fish caught in recreational fishing. Arlinghaus *et al*. (2008) mentioned that the type of bait and size plays an important role in recreational fishing where it is remarkably related to the size of fish captured and hooking location. Earthworm bait was used throughout the present study, in addition to chicken liver and bread. However, no fish was successfully caught while using the chicken liver and bread baits. This may have been due to the lack of attraction elements of these two baits in comparison to earthworms which have an earthy smell in addition to the extra sensory wiggling motion that attracted fish even when the bait was at the bottom. Tilapia feeding behavior is not purely focused on the water surface, but they also can feed at the bottom, these omnivorous fish will consume and eat almost anything that they come across in their habitat (Chaves *et al*., 2015).

Table 1. The proportion of injuries on the fish species caught

Family	Species	No. of individual, n	Self-released, n (%)	Non-critical hooking location, n (%)		Critical hooking location, n (%)		IUCN Status
				Outer lip	Inner-upper lower jaw	Gill	Gullet	
Fish caught using Octopus hook								
BAGRIDAE	*Hemibagrus nemurus* (Valenciennes, 1840)	2	-	2 (100)	-	-	-	LC
CHANNIDAE	*Channa striata* (Bloch, 1793)	3	1 (33.33)	2 (100)	-	-	-	LC
CICHLIDAE	*Oreochromis* sp	9	1 (11.11)	5 (62.5)	3 (37.5)	-	-	LC
CLARIIDAE	*Clarias macrocephalus* Günther, 1864	2	-	2 (100)	-	-	-	DD
CYPRINIDAE	*Barbonymus altus* (Günther, 1868)	1	-	1 (100)	-	-	-	LC
	Barbonymus gonionotus (Bleeker, 1849)	1	-	1 (100)	-	-	-	LC
	Hampala macrolepidota Kuhl & Van Hasselt, 1823	2	-	2 (100)	-	-	-	LC
	Puntius sealei (Herre, 1933)	1	-	-	1 (100)	-	-	LC
	Rasbora sarawakensis Brittan, 1951	1	-	1 (100)	-	-	-	LC
		22	2	16	4	0	0	
Fish caught using Circle hook								
ANABANTIDAE	*Anabas testudineus* (Bloch, 1792)	1	1 (100)	-	-	-	-	LC
CICHLIDAE	*Oreochromis* sp	39	6 (15.38)	12 (36.4)	15 (45.4)	6 (18.2)	-	LC
CYPRINIDAE	*Cyclocheilichthys apogon* (Valenciennes, 1842)	1	-	-	1 (100)	-	-	LC
		41	7	12	16	6	0	

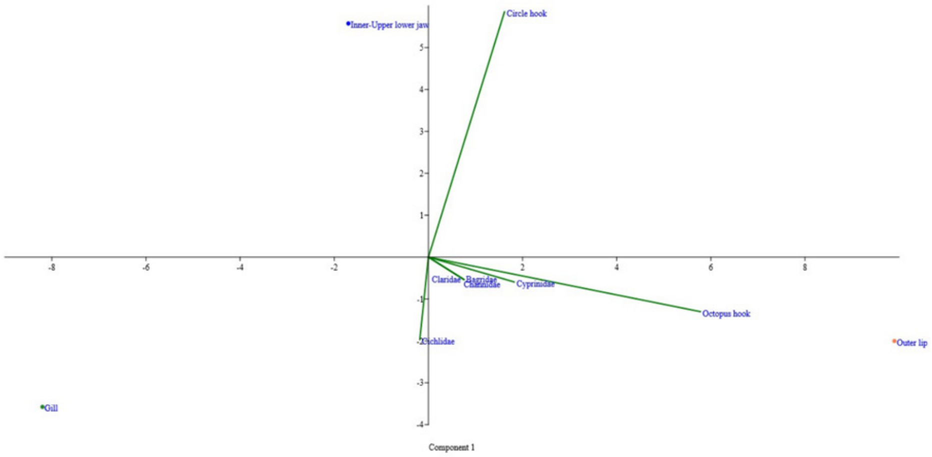

Fig. 3. Principal Component Analysis (PCA) of the type of hooks, catch composition, and hooking site of the fish.

The tendency for circle hooks to get caught in the corner of the mouth of tilapia when ingesting the hook has a greater effect on anatomical hook location (Gilman *et al*., 2018). Kerstetter and Graves (2006) have stated that although the variations between circle hook and J-hook were not statistically significant, circle hooks more commonly hooked fish in the mouth than J-style hooks, which more frequently hooked fish in the throat or gut. In the present study, 36.4% of circle hook locations on the tilapia were at the inner-upper lower jaw followed by the outer lip (45.4%). For the octopus hook, 62.5% of hooks were located at the outer lip tilapia followed by the inner-upper lower jaw (37.5 %). According to Cooke *et al*. (2003), circle hooks rarely penetrated the gullet, the roof of the mouth, or other areas like the eyes and gill arches. Circle hooks tend to cause less injury to the captured fish because they typically lodge in the lower jaw or jaw hinge as opposed to hooking in more damaging areas, such as the esophagus, respiratory organs, or roof of the mouth (Serafy *et al*., 2012). It was noticed that the circle hook use had been associated with the improved condition of captured individuals, both target species and those captured unintentionally (Sales *et al*., 2010, Serafy *et al*., 2012). Circle hooks have been shown to increase the survival of angler-released fish. With their success already proven for many game fish species, these hooks are now used widely for many other common recreational species (Cooke & Suski, 2004).

Although 15.38% of fish caught with the circle hooks died due to the hooking location in a vital area, the survival rate of fish caught was considered to be high for both types of hooks used. This study is in line with Lyle *et al*. (2007), who found that the most common causes of death in deep-hooked fish were wounds to the vital organs (e.g., gills, heart, liver), and survival was much lower when bleeding was involved. The present study also showed that fish with critical bleeding wounds are unlikely to survive past 24 hr. Snow and Porta (2021) assessed the hooking mortality and mortality-related parameters for alligator gar caught using juglines and rod-reel. Deeper hooking depths caused the majority of jugline mortality. They concluded that the survival of hooked alligator gar was influenced by temperature, total length, and hooking depth. The usage of circular hooks is considered a "fish-friendly" tackle due to the low prevalence of deep hooking and circle hooks are marketed with the hope that post-release survival rates will be higher (Cooke & Suski, 2004). Our study showed that the survival rate of hooked tilapia was approximately 88.89 % after the circle hook was removed. Therefore, the hook location in combination with proper technique influenced the survival rate of tilapia. Around 15.38% of tilapia mortality was possibly due to the fish eating the bait slowly without being noticed by the angler. This may have led to the deeper penetration of the circle hook into the esophagus and other critical areas before the angler started reeling in the line. Ostrand *et al*. (2006) stated that in their study anglers were told to set the hook or start reeling in the line as soon as a strike was detected. As a result, their study found that no fish (<0%) were hooked in potentially life-threatening locations.

CONCLUSION

Based on our findings the appropriate hook types for catch and release should be emphasized. This study demonstrated the use of octopus hooks to be especially suited to anglers undertaking C&R practices. Octopus hooks were proven to have low mortality tendencies when compared to circle hooks. Anglers will be satisfied to know that they caused minimal damage to any caught fish and the chances of survival would be high after C&R. Apart from that, the current study also revealed that the survival rate of the fish strongly depends on the anatomical hooking location on the fish caught. The attitude, skills, and experience of every angler also play an important role in the survival rate of the fish captured. Overall, the results obtained from this study will be a useful baseline for recreational anglers, for improved C&R practices in Malaysia, especially in Sarawak (Malaysian Borneo)

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ETHICAL STATEMENT

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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