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DIVERSITY AND ABUNDANCE OF COMMERCIALIZED FISH IN NORTHEASTERN PARÁ, COASTAL AMAZON: THE CASE OF THE STREET MARKET IN BRAGANÇA-PA

Diversidade e abundância dos peixes comercializados no nordeste paraense, Amazônia costeira: o caso da feira livre de Bragança-PA

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ABSTRACT

Bragança is an important municipality in Brazil regarding fishery production. In spite of its important for regional economy, data related to local fisheries such as the production and consumption profiles of commercial species are scarce. Therefore, the goal of this study was to provide an inventory of commercialized fishes in the street market of Bragança along with commercialization parameters. The data collection comprised information based on a questionnaire directed to fishmongers in two sites of the street market ("mercado" or indoor market and "feirinha" or outdoor market) for a 17-month period. The analyzed data included the abundance, seasonality and price of the commercialized species. A total of 103 commercial names were reported, representing about 98 species from 40 families and 15 orders. The indoor and outdoor market differed in relation to consumer's profile and to the structure, volume, variety, quality and prices of commercial species. The volume and the diversity of commercial species in the indoor market were inferior to those observed in the outdoor market. The most abundant species

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in the outdoor market were influenced by dry and rainy seasons. This work represents the most reliable analysis in the street market of Bragança, being relevant to the management of regional fisheries.

Keywords: Bragança, *M. ancylodon*, fishing dynamics, fish.

RESUMO

O município de Bragança destaca-se por sua produção pesqueira. Embora a dinâmica do comércio de pescado seja importante para a economia da região, dados sobre espécies comercializadas, produção e consumo são escassos. Assim, o presente estudo buscou realizar um inventário dos peixes comercializados na feira livre do munícipio, agregando dados de comercialização. Para isso, foram realizados 17 meses de coletas direcionadas aos peixeiros do mercado e da feirinha (ambientes que compõem a feira livre), com o auxílio de formulários. Os dados foram analisados quanto à abundância, à variação estacional e ao preço. Foram registradas 103 designações comerciais, que pertencem a aproximadamente 98 espécies distribuídas em 40 famílias e 15 ordens. Observou-se que o mercado e a feirinha diferem em termos de estrutura, volume, variedade, qualidade, preço e perfil dos consumidores. O mercado apresentou menor volume de oferta, enquanto a feirinha possui maior volume e variedade de espécies sendo vendidas. As espécies mais abundantes na feirinha mostraram-se influenciadas pelas estações seca e chuvosa. Este trabalho representa a análise mais robusta disponível para a feira livre de Bragança, sendo de grande relevância para o ordenamento local da produção de peixes.

***Palavras-chave**: Bragança, M. ancylodon, dinâmica pesqueira, pescado.*

INTRODUCTION

Bragança is located in Northeastern Pará, standing out amongst the municipalities of Northern Brazil (coastal Amazon) by the abundance of mangrove areas and biological richness (Wolff; Koch & Isaac, 2000), thus determining the high productivity of regional fisheries (Wolff; Koch & Isaac, 2000; Furtado Júnior; Tavares & Brito, 2006). As a matter of fact, Bragança ranks the third largest fisheries port in the state of Pará, after Belem (the state capital) and Vigia (Cepnor-Ibama, 2016; Furtado Júnior; Tavares & Brito, 2006).

This region encompasses the Caeté hydrographic basin (2,195 km²) which flows through several municipalities in Pará (Gorayeb; Lombardo & Cajueiro, 2009). Previous inventories reported high regional fish diversity, comprising more than 110 species of teleosteans (Barletta; Barletta-Bergan & Saint-Paul, 1998; Barletta-Bergan; Barletta & Saint-Paul, 2002; Marceniuk *et al*., 2017).

The fisheries in Bragança is highly influenced by the dynamics of the Caeté river estuary, including several marine or brackish-water species, such as the acoupa weakfish (*Cynoscion acoupa*), the crucifix sea catfish (*Sciades proops*), and snooks (*Centropomus* spp.) (Barletta; Barletta-Bergan & Saint-Paul, 1998; Camargo & Isaac, 2001; Barletta-Bergan; Barletta & Saint-Paul, 2002).

Even though a portion of the fish landed in Bragança is exported, the fishing activities are socially and economically relevant, inasmuch as a great portion of fish caught in the region is commercialized locally, particularly in the street market of Bragança (Furtado Júnior; Tavares & Brito, 2006; Braga *et al*., 2006; Freire; Silva & Souza, 2011).

The only report about this street market (Freire; Silva & Souza, 2011) reported 67 ethno-biological species from 36 families with predominance of teleosteans (71.26%). Nonetheless, this preliminary characterization lacked estimates of volume, price and seasonal variation of the commercialized species.

Thus, taking into account the regional relevance of Bragança in Amazon fisheries, we provided a detailed inventory about the ichthyofauna commercialized in the street market of Bragança (indoor and outdoor markets), compiling additional data related to commercialization, commercial names, annual variation in prices and species offered, as well as production estimates to provide a list of traded species and their importance to regional fisheries.

MATERIAL AND METHODS

Study area

This study was carried out in the municipality of Bragança, state of Para (01° 03′ 13″ S/46° 45′ 56″ W). It encompasses an area of 2.098,144 km² being located 210 km apart from Belem, capital of Pará, within the Northeastern state region (coastal Amazon) (IBGE, 2018).

The research focused in two sites of the street market ("mercado" or indoor market and "feirinha" or outdoor market), following the local denomination. The target was the fishmongers that work at both sites. The indoor market is divided into 45 boxes, about five assistants and five sporadic salesmen. On the other hand, the outdoor market comprises 45 tents, 43 fishmongers and a highly variable number of assistants.

Data collection

The data were collected from March 2016 to July 2017, being the first month directed to presentation of our study to the fishmongers in the street market. During this period, the two sites (outdoor and indoor market) were also analyzed to select the most suitable methods to the study development while in the following months where data were properly collected. The information was taken weekly and simultaneously at the indoor and outdoor markets, comprising 16 months in total.

The information was obtained from interviews carried out by the workers of this study to fill out a questionnaire form. During the application of the questionnaire, the fishmongers were asked about which fish were being traded, how many kilograms were being sold of each species (commercial names) and the value per kilogram of each commercialized fish.

The collected data at indoor and outdoor markets from the street market of Bragança were restricted to fresh fish specimens while data about fillets and salted fish meat were excluded from the analyses. In both sites, whole fish specimens as well as eviscerated fish, fillets and steaks are sold according to the consumer's preference.

Additional data related to the profile of consumers from both sites in the street market of Bragança were also collected. This information was based on interviews, with application of questionnaire forms, about family income and the factors that

might influence the purchase preferences (quality, variety and price of traded fish, and hygiene conditions).

During the visitation to the indoor and outdoor markets, we sampled specimens from all categories and commercial names in order to correlate the ethno-biological taxa to scientific names. The whole and eviscerated specimens were taken to the Laboratory of Applied Genetics (LAGA) at Universidade Federal do Para, Bragança for morphological identification based on specialized literature (Espírito Santo *et al*., 2005;*et al*., 2017; Cervigón *et al*., 1993).

Tissue samples were obtained and stored in 70% alcohol at -20ºC to provide a database of fish tissues from the street market of Bragança. The specimens were fixed in 10% formaldehyde and preserved in 70% ethanol to be included in the Didactic Zoological Collection from LAGA.

Statistical analyses

The data obtained from each form were stored in Microsoft Excel files and further analyzed into graphs and tables.

The most frequent species were those that were listed in at least 12 out of the 16 months of data collection. The species with the highest volume were calculated by means of the monthly averages of each species, as demonstrated below:

$$Monthly\ mean = sum\ of\ daily\ means \div number\ of\ weeks$$

Afterwards, the monthly means were summed and divided by 16 (period of data collection). This value was multiplied by 64 (number of sampled weeks) to obtain the total volume of commercial fish, as shown below:

$$Total\ volume = monthly\ mean \times 64\ weeks$$

The value obtained from this calculation is the average estimate from the volume of the commercialized species in the street market. We considered species with a volume equal to or greater than 9,000 kg as the most abundant ones for the two sampled sites. We emphasize that all production values were derived exclusively from the information provided by the fishmongers.

The diversity of the species traded in the indoor and outdoor market was calculated using *Shannon's* index (H') in the R software package v. 3.2.3 (R CORE TEAM, 2012).

The hierarchical clustering was carried out in the *pvclust* 2.0.0. package available in R system (Suzuki & Shimodaira, 2015) based on the Euclidean distance while the clusters were built using the Ward's method.

The estimates of the importance of each species to provide the clusters visualized in the dendrograms were performed from SIMPER (Clarke & Warwick, 1994), using the *Vegan* package available in R. The two abovementioned analyses were carried out using transformed data (*log* 10+1) and the most abundant species as established according to production values equal to or higher than 9,000 kg.

The correlation analysis was performed using the *Spearman's* method, one of the most suitable tools for nonparametric data. To calculate the price variation between the indoor and outdoor markets, we selected the Wilcoxon's method, also using the R package.

The consumer's profile regarding factors that influence their purchase preferences were obtained by the answers in the questionnaire form. Based on these data, a contingency table was provided using the R program v. 3.2.3.

RESULTS

Commercialized species in the fish market of Bragança

About 98 fish taxa from 15 orders and 41 families have been commercialized in the street market of Bragança. These values were based on the commercial names (103 in total) and combined to the morphological identification. Among this total, 57 have been traded in both sites, while 29 were exclusively found in the outdoor market ("feirinha") and 17 were commercialized only in the indoor market ("mercado") (Table I).

Table I – Inventory of commercialized species in the street market of Bragança (Me.: "mercado" or indoor market; Fe.: "feirinha" or outdoor market)

FAMILY	SPECIES	POPULAR NAME	SITE
Anablepidae	*Anableps anableps* (Linnaeus, 1758)	Four-eyed fish or "tralhoto"	Fe.
Anastomidae	*Leporinus* sp.	Leporinus or "aracu"	Fe.
	Schizodon fasciatus (Spix and Agassiz, 1829)	Banded headstander or "piau"	Me./Fe.
Ariidae	*Sciades passany* (Valenciennes, 1840)	Passany sea catfish or "bagre"	Me./Fe.
	Bagre bagre (Linnaeus, 1766)	Coco sea catfish or "bandeirado/ bandeirada"	Me./Fe.
	Sciades couma (Valenciennes, 1840)	Couma sea catfish or "bragalhão"	Me./Fe.
	Notarius grandicassis (Valenciennes, 1840)	Thomas sea catfish or "cambéu/ cambéua"	Me./Fe.
	Notarius luniscutis	Sea catfish or "cangatã"	Me./Fe.
	Sciades parkeri (Traill, 1832)	Gillbacker sea catfish or "gurijuba"	Me./Fe.
	Amphiarius rugispinis (Valenciennes, 1840)	Softhead sea catfish or "jurupiranga"	Me.
	Cathorops spixii (Agassiz, 1829)	Madamango sea catfish or "uricica"	Me./Fe.
	Sciades proops (Valenciennes, 1840)	Crucifix sea catfish or "uritinga"	Me./Fe.
Batrachoididae	*Batrachoides surinamensis* (Bloch Schneider, 1801)	Pacuma toadfish or "pacamum"	Me./Fe.
Callichthyinidae	*Hoplosternum littorale* (Hancock, 1828)	Armored catfish or "tamatá"	Me./Fe.
Carangidae	*Seriola* sp.	Amber jack or "arabaiana"	Fe.
	Chloroscombrus sp.	Atlantic bumper or "favoleta"	Fe.
Engraulidae	Unidentified	Anchovy or "anchova"	Me./Fe.
Epheppidae	*Chaetodipterus faber* (Broussonet, 1782)	Atlantic spadefish or "parú"	Fe.
Erythrinidae	*Hoplias malabaricus* (Bloch, 1794)	Dogfish or "traíra"	Me./Fe.
	Hoplerythrinus unitaeniatus (Spix and Agassiz, 1829)	Dogfish or "trairão"	Fe.
Exocoetidae	*Cheilopogon* sp.	Flyingfish or "peixe-voador"	Fe.
Gerreidae	*Diapterus auratus* (Ranzani, 1842)	Mojarra or "bico doce"	Fe.
Gobiidae e Eleotridae	Unidentified	Goby or "muré"	Fe.

(continuation Table I)

FAMILY	SPECIES	POPULAR NAME	SITE
Haemulidae	*Haemulon steindachneri* (Jordan & Gilbert, 1882)	Chere-chere grunt or "biquara"	Fe.
	Conodon nobilis (Linnaeus, 1758)	Barred grunt or "jiquirí"	Me./Fe.
	Genyatremus luteus (Bloch, 1790)	Torroto grunt or "peixe-pedra"	Me./Fe.
	Anisotremus virginicus (Linnaeus, 1758)	Porkfish or "peixe pedra doido"	Fe.
Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	Tripletail or "acará açu/ carauaçu"	Me./Fe.
Loricariidae	*Hypostomus* sp.	cascudo	Fe.
Lutjanidae	*Lutjanus synagris* (Linnaeus, 1758)	Lane snapper or "cioba"	Me./Fe.
	Lutjanus jocu (Bloch and Schneider, 1801)	Dog snapper or "dentão"	Me.
	Lutjanus purpureus (Poey, 1866)	Southern red snapper or "pargo"	Me./Fe.
Megalopidae	*Megalops atlanticus* (Valenciennes, 1847)	Tarpon or "pirapema"	Me./Fe.
Mugilidae	*Mugil* sp.	Mullet or "caíca/pratiqueira"	Me./Fe.
	Mugil sp.	Mullet or "macharrão"	Fe.
	Mugil sp.	Mullet or "tainha"	Me./Fe.
	*Mugil incilis (*Hancock, 1830)	Parassi mullet or "tainha chata"	Me./Fe.
Pimelodidae	*Brachyplatystoma flavicans* (Castelnau, 1855)	Goliath catfish or "dourada"	Me./Fe.
	Pimelodus blochii (Valenciennes, 1840)	Bloch's catfish or "mandi"	Fe.
	Brachyplatystoma vaillantii (Valenciennes, 1840)	Laulao catfish or "piramutaba"	Me./Fe.
Pristigasteridae	*Ilisha amazonica* (Miranda Ribeiro, 1920)	Hilsa shad or "sarda"	Me./Fe.
Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)	Cobia or "beijupirá"	Me./Fe.
Scianidae	*Cynoscion virescens* (Cuvier, 1830)	Green weakfish or "corvina"	Me./Fe.
	Cynoscion spp.	Yellow weakfish or "corvina amarela"	Me.
	Cynoscion spp.	White weakfish or "corvina branca"	Me./Fe.
	Cynoscion spp.	Weakfish or "corvina cobra"	Me.
	Cynoscion spp.	Weakfish or "corvina-uçu"	Me.
	Micropogonias furnieri (Desmarest, 1823)	Whitemouth croaker or "cururuca"	Me.
	Macrodon ancylodon (Bloch e Schneider, 1801)	King weakfish or "gó"	Me./Fe.
	Menticirhus americanus (Linnaeus, 1758)	kingcroaker or "pau de cachorro"	Fe.
	Cynoscion acoupa (Lacepède, 1801)	Acoupa weakfish or "pescada amarela"	Me./Fe.
	Plagioscion squamosissimus (Heckel, 1840)	South American silver croaker or "pescada branca"	Me./Fe.
	Cynoscion spp.	Weakfish or "pescadinha"	Me./Fe.
	Nebris microps (Cuvier, 1830)	Smalleye croaker or "sete-grudes"	Me./Fe.
Scombridae	*Thunnus* sp.	Tuna or "atum"	Me.
	Euthynnus alletteratus (Rafinesque, 1810)	Little tunny or "bonito"	Me. e Fe.
	Scomberomorus cavalla (Cuvier, 1829)	King mackerel or "cavala"	Me./Fe.
	Scomberomorus brasiliensis (Collette, Russo and Zavala-Camin, 1978)	Serra Spanish mackerel or "serra"	Me./Fe.
Serranidae	*Epinephelus* sp.	Groupers or "mero"	Me./Fe.
	Cephalopholis fulva (Linnaeus, 1758)	Coney or "piraúna"	Me.

(continuation Table I)

FAMILY	SPECIES	POPULAR NAME	SITE
Serrasalmidae	*Mylossoma duriventre* (Cuvier, 1818)	Silver mylossoma or "cd/paboca"	Me./Fe.
	Colossoma macropomum (Cuvier, 1816)	"tambaqui"	Me./Fe.
	Unidentified	piranha	Me.
Sternopygidae	*Eigenmannia trilineata* (López e Castello, 1966) e Sternopygus sp.	Knifefish or "tuvi"	Fe.
Stromateidae	*Peprilus* spp.	Harvestfish or "pampo"	Me./Fe.
Trichiuridae	*Trichiurus* sp.	Beltfish or "cinturão/guaravilha"	Fe.

According to the inventory of fish species, the richness in the outdoor market (H' = 2.96) was higher than that reported for the indoor market (H' = 2.69).

The collected specimens that have not been sold in the same day because of high volume of specimens or low demand are usually stored in ice for further commercialization, except for those presenting reduced freshness. In this case, the specimens might be salted and then offered to consumers as usually observed in the outdoor market but less frequently in the indoor market.

Both sites in the street market of Bragança also differed in relation to the quality of fishery products, once the "freshness" (color, eyes, and gills) of some of the fish traded in the outdoor market was inferior to those offered in the indoor market.

Another remarkable difference between both sites refers to the volume of traded fish. During this research, the total fish volume in the indoor market was equal to 127, 962.24 t, while the outdoor market reached about 247, 111.04 t.

In addition, the values per kilogram of fish products diverged between both sites, inasmuch as the prices in the indoor market were higher than those reported in the outdoor market. This difference also reflected in the consumer's profile from both sites, particularly in relation to their incomes.

A total of 19 species were commercialized at high frequencies in the indoor market, i.e., they have been traded at least during 12 out of the 16 sampled months. Some species such as anchovy, acoupa weakfish, and mullets were commercialized during the entire studied period, while coco sea catfish, king mackerel, and passany sea catfish were traded in 15 months.

Nonetheless, the most frequent species were not necessarily related to high volume of specimens, as observed in snooks with a volume of 465.28 kg, leatherjacket with 786.56 kg, southern red snapper with 742.40 kg, and king mackerel with 475.52 kg. On the other hand, some less frequent species reached high production values, such as green weakfish with 11,616.64 kg, mullets with 4,855.04 kg, and torroto grunt with 1,555.84 kg.

We reported seven species as the most abundant ones in the indoor market, particularly gillbacker sea catfish with a volume of 20,145.92 t, followed by sharks with 15,277.44 t, king weakfish with 14,471.04 t, and spanish mackerel with 11,721.60 t (Figure 1A).

In the outdoor market, 28 species represented the most commercialized ones. Some of them like mullets, blue runnerand, and beltfish have been traded during the 16 analyzed months.

Similar to the indoor market, the volume of trade fish in the outdoor market also varied among the most frequent species, like torroto grunt (1,070.72 t), madamango sea catfish

(1,498.88 t), and couma sea catfish (1.155,84 t). Inversely, some species presented significant production values such as leatherjacket (9,196.16 t), passany sea catfish (11,348.48 t), and sharks (13,487.436 t).

Eleven species were categorized as the most abundant ones in the outdoor market, with predominance of king weakfish (44,375.68 t), followed by coco sea catfish (25,739.52 t), gillbacker sea catfish (22,264.96 t), and crucifix sea catfish (18,321.28 t) (Figure 1B).

Seasonality in the offering of the most abundant species

No particular trend was observed in the cluster analyses of the traded species in the indoor market, revealing that factors other than rainfall have influenced the formation of these clusters. However, two well supported groups (February to May X June to January) were observed in the traded fish in the outdoor market (Figure 2).

Figure 1 – Graph of the most abundant species in the market's with production equal or above 9 thousand kg according the means obtained along the 16 months of this study. A = indoor market, B = outdoor market

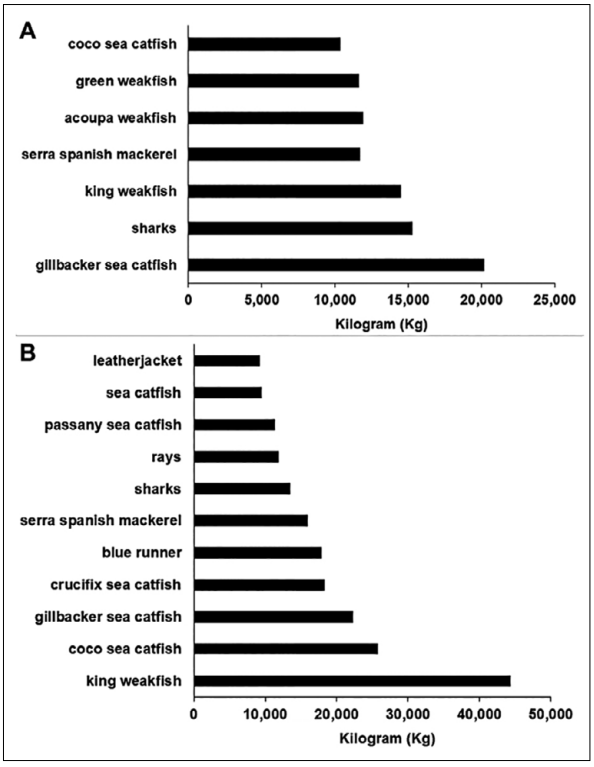
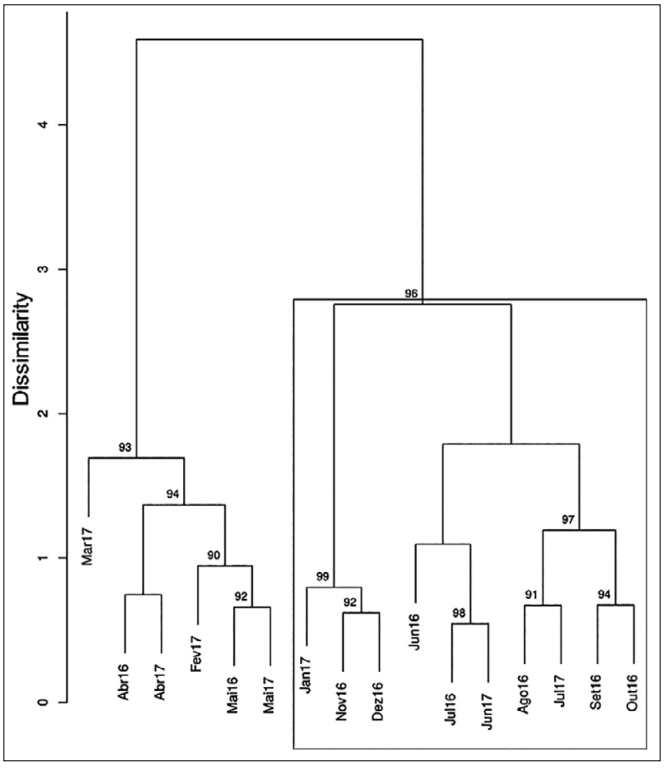


Figure 2 – Dendrogram of seasonal variation in the outdoor market, showing clusters related to the variation of supply with the climate



These clusters are probably related to rainfall differences, thus corresponding to dry and rainy seasons. The SIMPER analysis revealed that approximately 60% of the difference between the clusters found in the outdoor market derives from the variation in the production of species such as blue runner, serra spanish mackerel, coco sea catfish, crucifix sea catfish and king weakfish (Table II).

Table II – Cummulative frequency of importance for the most abundant species in the outdoor market as estimated by SIMPER analysis

Species	Cummulative importance
Caranx crysos (blue runner)	0.2694
Scomberomorus brasiliensis (serra spanish mackerel)	0.3667
Bagre bagre (coco sea catfish)	0.4632
Sciades proops (crucifix sea catfish)	0.5596
Macrodon ancylodon (king weakfish)	0.6373
Sciades parkeri (gillbacker sea catfish)	0.7140
Rays	0.7836
Notarius luniscutis (sea catfish)	0.8498
Sciades passany (passany sea catfish)	0.9135
Sharks	0.9686
Oligoplites sp. (leatherjacket)	1.0000

Price fluctuation in the main commercial species

The prices of the most abundant species commercialized in both sites at the street market of Bragança varied through the studied period. For instance, the price per kg of coco sea catfish traded in the indoor market ranged from a mean value of R$ 9.00 to R$ 11.00, while in outdoor market it varied from R$ 6.00/kg to R$ 7.00/kg. Similarly, the price of king weakfish in the indoor market ranged from a mean value of R$ 8.00/kg to R$ 12.00/kg and from R$ 5.00/kg to R$ 7.00/kg in the outdoor market. We also reported increased mean prices for the species coco sea catfish, green weakfish. (indoor market), gillbacker sea catfish (indoor and outdoor markets) and crucifix sea catfish (outdoor market) during Eastern holidays (April 2017).

Besides de price fluctuation, we also analyzed the correlation between fish volume and price. In relation to the indoor market the values per kg of coco sea catfish, sharks and gillbacker sea catfish showed no correlation with the production volume. On the other hand, a negative and significant correlation between volume and price was observed for somse species like green weakfish. ($r = -0.68$; $p = 0.004$), king weakfish ($r = -0.51$ $p = 0.042$), acoupa weakfish ($r = -0.55$; $p = 0.029$), and spanish mackerel ($r = -0.,52$; $p = 0.036$) (Figure 3).

As for the outdoor market, the production volume and price were also not correlated as reported in coco sea catfish, sharks, sea catfish, leatherjacket, among others. Inversely, some fish groups such as rays ($r = -0.65$; $p = 0.006$), king weakfish ($r = -0.75$; $p = 0.001$), gillbacker sea catfish ($r = -0.63$; $p = 0.009$) and crucifix sea catfish ($r = -0.54$; $p = 0.032$), presented significant and negative correlation between volume and commercial values (Figure 4).

Figure 3 – Correlation analysis (production x price) of the most abundant species in the indoor market (coco sea catfish; sharks; weakfish; king weakfish; gillbacker sea catfish; acoupa weakfish and serra spanish mackerel)

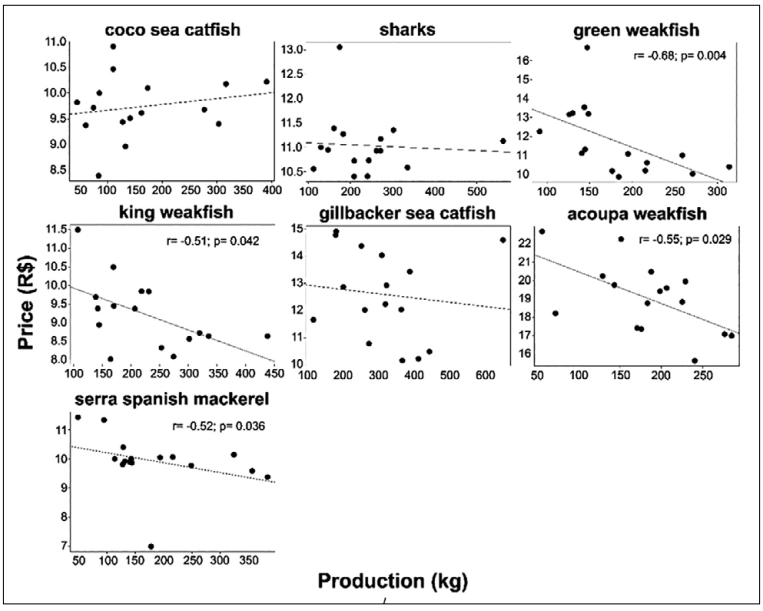
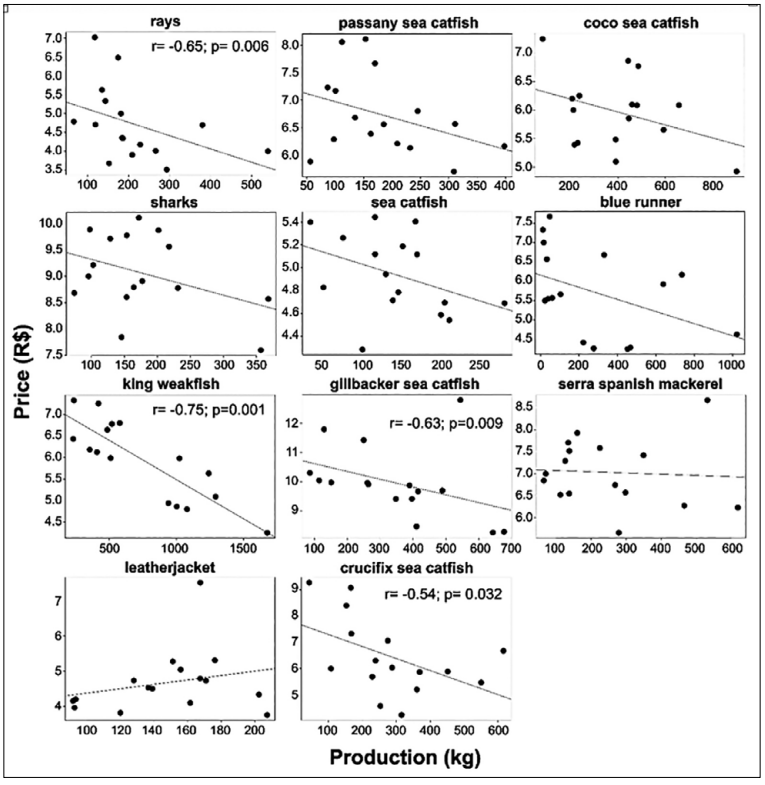


Figure 4 – Correlation analysis (production x price) of the most abundant species in the outdoor market (rays; passany sea catfish; coco sea catfish; sharks; sea catfish; blue runner; king weakfish; gillbacker sea catfish; serra spanish mackerel; leatherjacket and crucifix sea catfish)



The price uniformity between the indoor and outdoor markets as inferred from Wilcoxon's test revealed that the non-uniform commercial values between both sites, as reported in king weakfish (W = 0, p = 3.327e-09), sharks (W = 0, p = 3.327e-09), gillbacker

sea catfish (W = 19, p = 6.898e-06), coco sea catfish (W = 0, p-value = 3.327e-09), and spanish mackerel (W = 7.5, p = 6.083e-06). This result is explained by the high price of fish products in the indoor market in relation to the outdoor market.

Public preference in the indoor and outdoor markets

The contingency table regarding monthly income showed that 52% of the consumers from the indoor market earn up to one minimum wage, 28% earn from one to three minimum wages and 20% earn more than three minimum wages. In the outdoor market, 80% of the consumers gain up to one minimum wage, 18% from one to three minimum wages and 2% over three minimum wages.

The preference of consumers for fish products from the indoor market were mostly influenced by the quality of the fish (40%) and sanitary conditions (40%), while the value of the fish (12%) and the species diversity (8%) are less determinant for the purchase at this site. In the outdoor market, an opposite scenario was observed since the consumer's income was a determining factor in choosing the place of purchase. Accordingly, 60% of the consumers in the outdoor market choose this site because of low prices and 36% for the fish variety, while 2% of them mentioned the fish quality and sanitary conditions.

DISCUSSION

Fish diversity and abundance

A total of 103 commercial names were recorded, corresponding to approximately 98 fish taxa, organized into 41 families, and 15 orders. To date, this has been the largest species diversity observed for fisheries trade in this region, revealing the dynamics of fisheries in Bragança with seasonal fluctuations in the prices and supply of fish products. In contrast, Freire, Silva and Souza (2011) reported only 67 taxa, distributed in 36 families being commercialized in the street market of Bragança.

Most likely, this discrepancy in the diversity of fish products is related to the increased of fishing methods and storage derived from the development of fisheries over the last years, once it has been almost a decade since the report by Freire, Silva and Souza (2011) and the present study. The large volume of traded species presently reported is expected, since the region encompasses a significant ichthyofauna, as evidenced by the regional inventories of fish fauna (Barletta; Barletta-Bergan & Saint-Paul, 1998; Barletta-Bergan; Barletta & Saint-Paul, 2002; Marceniuk *et al.,* 2017). The most recent report recorded 120 species of fish, from 48 families and 16 orders only in the Caeté River estuary (Marceniuk *et al*., 2017).

As previously described, the outdoor market was the site with the largest variety of fish sold at the Bragança street market, which was evidenced by both the highest taxonomic representativeness and the number of the most frequent species. These data are possibly related to the fact that the species traded in the outdoor market come mainly from artisanal fishing, which includes a variety of fishing strategies (fish traps, gill nets, longline and trawlnets), contributing to less selective catches when compared to industrial fishing (longline and trawlnets) (Braga *et al.,* 2006, Espírito Santo & Isaac, 2012), besides encompassed species both marine and freshwater environments. Similar results were reported by Da Costa *et al.* (2013) where popular street markets commercialized higher volumes of fish products than the Municipal Market.

Some species that have not been recorded frequently in the street market have become more common. This was the case of snooks (*Centropomus* spp.) and snappers (e.g., *L. purpureus*) (Braga *et al*., 2006; Freire; Silva & Souza, 2011; Silva *et al*., 2012) that were frequently recorded in the indoor market as well as some species traded in the outdoor market, such as *Sciades* and *Cathorops* catfishes, torroto grunt, pacuma toadfish and the freshwater laulao catfish. These data revealed the increased production and supply of fish products and the plasticity of the commercial activity.

The fish trade in the outdoor and indoor markets differed in relation to species diversity, frequency and abundance what could be partly associated with the distinct amounts of fishmongers and consumers between both sites, being higher in the outdoor market, thus contributing to high volumes of commercialized fish. In addition, there are differences in the fleets that provide fish products to each site inasmuch as the industrial fishing fleets usually sell fish specimens to the indoor market while the fish supplied in the outdoor market are mostly derived from artisanal fleet (Braga *et al*., 2006; Espírito Santo & Isaac, 2012).

As for the regularity in the supply of fish, several species recorded in the present study have been invariably present in the street market of Bragança, revealing their representativeness as previously reported by Freire, Silva and Souza (2011), with particular emphasis for the king weakfish, sharks, coco sea catfish, acoupa weakfish, and crucifix sea catfish. Silva *et al*. (2012) also reported the predominance of these species as well as mullets, spanish mackerel, sea catfish, weakfish and rays. Similarly, Furtado Júnior, Tavares and Brito (2006) recorded acoupa weakfish, gillbacker sea catfish, spanish mackerel, sharks, king weakfish, catfish among others as the most caught species in Belém, Bragança and Vigia.

In spite of the regular records, some species like the acoupa weakfish and gillbacker sea catfish had no significant production in the report by Silva *et al*. (2012). On contrary, gillbacker sea catfish was the most commercialized fish species in indoor market and ranked as the third most representative in the outdoor market. Likewise, acoupa weakfish was the fifth most commercialized species in the indoor market, being characterized as a major resource for the economy in Northern region of Brazil (Furtado Júnior; Tavares & Brito, 2006).

When the present volume data for the street market of Bragança was compared to the fisheries reports for the state of Pará (MPA, 2013), we observed a remarkable discrepancy between both datasets. While the production estimated for Para in 2010 and 2011 was equal to 143,078.2 t and 153,332.3 t, respectively (MPA, 2013), the present study reported a mean production of 375,073.28 t of traded fish in both the indoor and outdoor markets of Bragança.

Even though the values estimated for the street market of Bragança were based on mean values to decrease biased data, the volume of production was much higher than that calculated for the whole state of Pará. It should be pointed out that only a fraction of the fisheries products landed in Bragança is commercialized locally while most valuable species are exported (Furtado Júnior; Tavares & Brito, 2006), thus indicating that the production of fish products in Bragança should be even higher and that the fishing production in Pará is likely to be underrepresented.

These results highlight the importance of frequent statistical inventories inasmuch as the productive system and the commercialization of fisheries resources are dynamics and

vary constantly (Isaac; Espírito Santo & Nunes, 2008). Moreover, such datasets should be as reliable as possible to avoid either overestimates or underestimates that could mask the availability of stocks and the regulation of regional fisheries.

Regularity and seasonality in the available species

Seasonal variation was observed in the fish diversity in the outdoor market as a result of local climate dynamics. This scenario was not detected in the indoor market since the commercialized species at this site are usually caught offshore by industrial fishing along distinct Brazilian regions. Therefore, some species might be caught through the year and the fish volume in the indoor market is less susceptible to rainfall regime resulting in weakly supported seasonal clusters (Espírito Santo & Isaac, 2012).

For instance, the acoupa weakfish was invariably caught during the whole year, with intensified fishing from May to December thus comprising both rainy and dry seasons with a slight variation in the supply of this fish species in the indoor market (Mourão *et al.*, 2009). On the other hand, this fish traded in the outdoor market is mainly obtained by artisanal fishing from nearby coastal zones, estuaries and rivers, being highly affected by rainfall (Braga *et al*., 2006, Espírito Santo & Isaac, 2012).

In relation to the seasonal species clusters observed in the outdoor market, blue runner, spanish mackerel, crucifix sea catfish and king weakfish represented the groups that had the major contribution in the structuring of both clusters, inasmuch as these species were more frequently traded during the rainy season, as particularly observed for blue runner. These results are similar to those reported by Silva *et al*. (2012) since they found increased fishing and trade of serra spanish mackerel and king weakfish in rainy seasons.

Nonetheless, the gillbacker sea catfish showed no significant variation in their commercialization volume between both seasons, as estimated by SIMPER, thus differing from the data reported by Nogueira, Nunes and Silva (2016).

Even though an increased production of gillbacker sea catfish was observed in the outdoor market during June and July 2016, the volume values were different for the same period in 2017. Inversely, in April 2017, the commercialization of this species was higher than that reported in April 2016.

These data indicate that other factors such as local climate should influence the volume of gillbacker sea catfish commercialized in the street market of Bragança, since the variation in the traded values was not related to the rainy or dry season even in the outdoor market where the volume variation was higher than in the indoor market, without a clear standard. Therefore, even considering that local climate plays a key role in the seasonality of commercialized species in the outdoor market, this parameter could not be useful to infer the seasonality of all species.

Price fluctuation in the commercialized fish

The price variation between the indoor and outdoor market is expressive. In the former the price can be as high as R$ 27.00/kg while in the outdoor market the most expensive fish species cost about R$ 15.00/kg, as inferred from the most abundant species. This discrepancy is associated to the large size of some fish species commercialized in the indoor market, including some high-valuable species (*Centropomus* spp., *Anchoa* spp., *C. acoupa* and *L. purpureus*) (Silva *et al*., 2012). In addition, the consumers from the indoor market are more demanding in relation to sanitary conditions and earn higher incomes.

On the other hand, the fish traded in the outdoor market are basically derived from artisanal fishing, thus representing less selective fishing efforts (Braga *et al*., 2006) what influences the high diversity and lower size of fish species available at this site, assuring lower commercial prices. Moreover, some of the fish commercialized in the outdoor market supply other municipalities and therefore the consumers of this place act as intermediary buyers between the fishmongers in Bragança and the final consumer, thus reaching wholesale prices. Another reason that could account for the lowest prices in the outdoor market is that the consumers visiting this site have lower incomes in spite of being more numerous than that observed in the indoor market.

We point out that during the Easter holidays the fish prices increased significantly, probably because of the high demand for fish products (Da Silva; Hood & Pinto, 2006) even though the production volume had no great variation during this period.

The correlation analysis revealed some significant values for some species in both outdoor and indoor markets. However, in some cases statistically supported values were observed only for one site, as observed for spanish mackerel in the indoor market and gillbacker sea catfish in the outdoor market.

Some other species had no correlation between traded volume and price for both sites what can be related to the slight temporal variation in their abundance. Additionally, many of these species are low-valuable species and might not reach high prices, even when their production is low, as observed for blue runner and leatherjacket In the case of sharks, mainly targeted for the fin trade (SBEEL, 2005; Steinke *et al*., 2017), the commercialization of their meat in the street market is a secondary activity with low influence of the supply-and-demand principle.

Supply and commercial sustainability

Increased fishing efforts are commonly adopted to maintain the volume of catches for fish production. However, this process usually leads to less selective and sustainable fishing practices (MMA, 2014; Neto & Dias, 2015).

A major issue for the fisheries along the northern coastal region of Brazil is the utilization of trawl nets that affects several non-target species as a result of bycatch, like the elasmobranchs. For instance, 11 out of the 17 shark species recorded in the Northern region are under some status of threatening (SBELL, 2005; MMA, 2014; Feitosa *et al*., 2018). We observed that most commercial labels named as sharks and rays are sold as fillets or steaks. Therefore, the identification of species was hindered and it is likely that threatened species have been commercialized during this period in the street market of Bragança.

Likewise, several species with distinct conservation statuses were commonly traded during the period of this study in both outdoor and indoor markets such as the *L. purpureus* (Vulnerable), the *Epinephelus itajara* (Critically endangered), and the *S. parkeri* (Vulnerable). These fishes are also included as threatened species in the Brazilian decree MMA nº 455 (2014), modified by the decree MMA nº 98 (2015).

Based on these data, we highlight that the management of fisheries resources as well as the effective monitoring by authorities are required to regulate the commercialization of this important fish market and to prevent species from being extinct.

It should be pointed out that the lack of standards in commercial labels should contribute to the commercialization of threatened species since a single label refers to a group of similar species usually caught simultaneously that differ in their status of

conservation (Ardura *et al*., 2010; Carvalho *et al*., 2015). This issue was also reported in the present study for some species, such as the label shark that encompasses about eight specific names and ray that includes about seven species, as well as the bluntnose jack (*Hemicaranx amblyrhynchus*, *Chloroscombrus chrysurus*), among others.

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