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EXPLORAÇÃO DE AVES COLUMBIDAE NO INTERIOR DE SERGIPE (BRASIL): DIFERENTES OLHARES SOBRE UMA PRÁTICA ENRAIZADA

SÃO CRISTÓVÃO (SE)

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CLEVERTON DA SILVA

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Tese apresentada ao Programa de Pós-Graduação em Desenvolvimento e Meio Ambiente da Universidade Federal de Sergipe, como requisito obrigatório para obtenção do título de Doutor em Desenvolvimento e Meio Ambiente. Linha de Pesquisa: Relações Sociedade-Natureza e Sustentabilidade. Sublinha de Pesquisa: Interdisciplinaridade e Meio Ambiente.

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À minha família.

Porque família é tudo.

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RESUMO

As aves estão entre os grupos de animais mais caçados no mundo. Os representantes da família Columbidae (pombas, rolas, juritis e afins; doravante columbídeos) estão entre os principais alvos para fins alimentares e, consequentemente, sofrem considerável pressão de caça, especialmente na região Nordeste do Brasil, onde sua caça acontece de forma insustentável. Posto isso, essa pesquisa buscou investigar: 1) como se dá a exploração de columbídeos em três áreas rurais no município de Itabaiana (Sergipe, Brasil); 2) o estado atual das populações dessas aves na região; e 3) a percepção dos moradores, pesquisadores (acadêmicos) e fiscais do IBAMA, todos da região, sobre a caça de columbídeos. Os resultados revelaram sete espécies de columbídeos que são caçadas em grandes quantidades na região, preferencialmente com o uso de espingarda de chumbo, para serem utilizadas principalmente como recurso alimentar. Conforme relatado pelos caçadores locais, essas espécies são caçadas preferivelmente durante a estação seca e a noite. O estudo também revelou que a maioria das espécies de Columbidae registradas na região foram mais abundantes na estação chuvosa e que mais da metade das espécies apresentaram abundâncias baixas e tendência de declínio ao longo do ano. Ademais, foi revelado que a maioria dos moradores locais fazem uso regular de columbídeos, principalmente como recurso alimentar, sugerindo a caça controlada como uma forma de conciliar a prática da caça com a conservação desse grupo de aves. Já os fiscais do IBAMA e os pesquisadores são contra a caça e acreditam que a melhoria da condição socioeconômica dos moradores, em especial, pode mitigar esse problema na região. Em conjunto, esses resultados demonstram que a proibição da caça no Brasil não foi suficiente para mitigar ou erradicar a caça de columbídeos na região. É possível que a caça seja a responsável pelas baixas abundâncias populacionais dos columbídeos amostrados. É importante salientar, entretanto, a importância dessas aves como recurso alimentar para as comunidades rurais locais. Assim, faz-se necessário discutir a possibilidade da transição de uma cultura de caça popular, porém descontrolada, para uma condição de manejo sustentável e cientificamente embasado, capaz de prevenir o declínio e perda de espécies em longo prazo.

Palavras-chave: Caça; Columbiformes; Conservação; Recurso alimentar; Sustentabilidade.

ABSTRACT

Birds are among the most hunted animal groups worldwide. Representatives of the Columbidae family (doves, pigeons and relatives; henceforth columbids) are among the main targets for food purposes and, consequently, suffer considerable hunting pressure, especially in the Northeast region of Brazil, where they are hunted unsustainably. That said, this research sought to investigate: 1) how columbidae are exploited in three rural areas in the municipality of Itabaiana (Sergipe, Brazil); 2) the current status of populations of these birds in the region; and 3) the perception of residents, researchers (academics) and IBAMA inspectors, all from the region, about hunting columbids. The results revealed seven species of Columbidae that are hunted in large quantities in the region, preferably with the use of pellet shotguns, to be used mainly as a food resource. As reported by local hunters, these species are preferably hunted during the dry season and at night. The study also revealed that most of the Columbidae species recorded in the region were more abundant in the rainy season and more than half had low abundances and a tendency to decline throughout the year. Furthermore, it was revealed that most local residents make regular use of columbids, mainly as a food resource, suggesting controlled hunting as a way of reconciling the practice of hunting with the conservation of this group of birds. IBAMA inspectors and researchers are against hunting and believe that improving the socioeconomic condition of residents, in particular, can mitigate this problem in the region. Taken together, these results demonstrate that the ban on hunting in Brazil was not enough to mitigate or eradicate the hunting of columbids in the region. It is possible that hunting is responsible for the low population abundances of columbids sampled. It is important to stress, however, the importance of these birds as a food resource for local rural communities. Thus, it is necessary to discuss the possibility of transitioning from a popular, but uncontrolled hunting culture to a condition of sustainable and scientifically based management, capable of preventing the decline and loss of species in the long term.

Keywords: Hunting; Columbiformes; Conservation; Food resource; Sustainability.

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LISTA DE ABREVIAÇÕES E SIGLAS

IBAMA – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

IDH – Índice de Desenvolvimento Humano.

IUCN – *International Union for Conservation of Nature's* (União Internacional para a Conservação da Natureza).

ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade.

IBGE – Instituto Brasileiro de Geografia e Estatística.

SFB – Serviço Florestal Brasileiro.

PARNASI – Parque Nacional Serra de Itabaiana.

COMACO – *Community Markets for Conservation* (Mercados Comunitários para a Conservação).

CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

INTRODUÇÃO GERAL

Populações rurais possuem direta relação com animais silvestres, dos quais fazem uso regular (SANTOS et al., 2018). Vários estudos têm mostrado a importância da fauna silvestre para as populações humanas, sobretudo como fonte de proteína animal (ALVES et al., 2012; ALVES; SOUTO, 2015; ALVES et al., 2018). A carne de animais silvestres faz parte da dieta de populações rurais em todo o mundo (VAN VLIET et al., 2015), constituindo-se em uma importante fonte de proteína animal para comunidades tradicionais de diferentes localidades (BODMER; ROBINSON, 2004). Complementarmente, em algumas comunidades rurais, os animais caçados também podem ser uma importante fonte de renda e a base de um comércio altamente lucrativo (VAN VLIET et al., 2014, 2015).

No Brasil, embora seja uma prática ilegal, de acordo com a Lei de Proteção à Fauna (Lei n° 5.197/67) e a Lei de Crimes Ambientais (Lei n° 9.605/98), a caça de animais silvestres tem se difundido por todo o país (CHAGAS et al., 2015; EL BIZRI et al., 2015). Para alguns autores (ALVES et al., 2009; 2012), a persistência dessa prática no país está associada a questões culturais e ao fato de que o consumo e o comércio de animais silvestres tem uma importância nutricional e econômica significativa, sobretudo considerando os baixos recursos econômicos das famílias e, consequentemente, a falta de condições financeiras para se obter fonte de proteína proveniente de criações domésticas. Na região Nordeste do Brasil, particularmente, a caça tem sido tradicionalmente praticada para fins de subsistência (ALVES et al., 2009; ALVES et al., 2012); contudo, estudos sugerem que atualmente está mais ligada à preferências culturais por carne silvestre e atividades de recreação do que propriamente à subsistência (ALVES et al., 2009; 2012; SANTOS, 2019).

As aves estão entre os grupos de animais mais caçados no mundo (RENCTAS, 2001; ABERNETHY et al., 2013; YOUNG et al., 2016; BIRDLIFE INTERNATIONAL, 2021); e são caçadas para diversos fins, seja para o consumo da carne (BEZERRA et al., 2011; FERNANDES-FERREIRA et al., 2012; TEIXEIRA et al., 2014; GALVAGNE-LOSS et al., 2014; SOARES et al., 2018a,b;), uso na medicina popular (BEZERRA et al., 2013; SOARES et al., 2018b) ou criação e comércio (ALVES et al., 2010; FERNANDES-FERREIRA et al., 2010; ALVES et al., 2013; LICARIÃO et al., 2013; BEZERRA et al., 2012; ALVES MACÁRIO et al., 2016; SOUTO et al., 2018; OLIVEIRA et al., 2020). Os representantes da família Columbidae (pombas, rolas, juritis e afins; doravante columbídeos) destacam-se como os principais alvos para fins alimentares (FERNANDES-FERREIRA, 2014) e, consequentemente, sofrem considerável pressão de caça, especialmente no Nordeste do Brasil, onde a caça dessas aves ocorre de forma descontrolada (ALVES et al., 2009; BEZERRA et al., 2011; NOBREGA et al., 2011; FERNANDES-FERREIRA et al., 2012; FERNANDES-FERREIRA, 2014; BARBOSA et al., 2014), o que provavelmente tem contribuído com a redução populacional de algumas espécies locais. Segundo Fernandes-Ferreira (2014), a família Columbidae passa a ocupar essa preferência devido a diversos fatores: 1) são animais diurnos, gregários e a maioria habita áreas abertas, facilitando a captura ativa através de diferentes instrumentos de caça, como o estilingue e a espingarda; 2) podem ser facilmente atraídos por cevas ou pela reprodução de suas vocalizações; 3) os ninhos e locais de dormitório podem ser facilmente localizados, motivando a caça noturna através da "facheada"; 4) a formação de bandos numerosos, no caso de algumas espécies, fomenta uma alta retirada de biomassa total, compensando o baixo peso por indivíduo; e 5) algumas espécies persistem mesmo em meio a fortes regimes de seca, como a rolinha-picuí (*Columbina picui* Temminck, 1813) e a rolinha-de-asa-canela (*Columbina minuta* Linnaeus, 1766).

Ampliar nossa compreensão sobre o contexto multidimensional das atividades cinegéticas e sobre as espécies-alvo é um passo inicial importante para o desenvolvimento de políticas mais eficazes para a conservação e a manutenção da vida silvestre como um serviço ecossistêmico de provisionamento, que entrega alimentos e renda principalmente às famílias menos abastadas. Posto isso, esta pesquisa parte do esforço de entender como se dá a exploração de columbídeos em três áreas rurais no município de Itabaiana (Sergipe, Brasil), dada a sobre-exploração dessas aves em diferentes regiões do Nordeste brasileiro (ALVES et al., 2009; BEZERRA et al., 2011, 2012; FERNANDES-FERREIRA et al., 2012; BARBOSA et al., 2014; SANTOS et al., 2018; SOARES et al., 2018). Além disso, esta pesquisa também buscou investigar o estado atual das populações de Columbidae e a percepção dos moradores, pesquisadores (acadêmicos) e fiscais do IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), todos da região, sobre a caça de columbídeos. Para isso, a presente pesquisa buscou responder as seguintes perguntas: 1) quais são as espécies de Columbidae caçadas na região? 2) quais são os apetrechos e estratégias de caça utilizados pelos caçadores da região para a captura dos columbídeos? 3) onde e quando (períodos do dia e do ano) os columbídeos são caçados na região? 4) quais são as espécies de Columbidae comercializadas na região e quanto custam? 5) quais são as espécies de Columbidae mais abundantes nas áreas estudadas? e 6) como os moradores rurais, pesquisadores e fiscais do IBAMA, da região, enxergam a caça de columbídeos?

A fim de responder a estas perguntas, a tese foi estruturada em três capítulos em formatos de artigo científico. O capítulo 1, intitulado “Hunting and trade of Columbidae in Northeast Brazil”, já publicado na revista Human Ecology (DOI: 10.1007/s10745-021-00216-1), buscou compreender como se dá a caça (espécies-alvo, apetrechos e estratégias de caça, períodos de caça) e o comércio (localização, espécies comercializadas, valor das

espécies) de Columbidae na região estudada. O capítulo 2, submetido à revista Bird Conservation International (ISSN: 0959-2709), intitulado "Seasonal variation in the abundance and density of columbids (Aves: Columbidae) in a region with high hunting pressure", buscou investigar o estado atual das populações de Columbidae que ocorrem na região, a partir de estimativas de densidade populacional. E o capítulo 3, submetido à revista Human Ecology (ISSN: 0300-7839), intitulado "To hunt or not to hunt? Analyzing different perceptions about columbid hunting (Aves: Columbidae) in Sergipe, Northeastern Brazil" teve como objetivo investigar a percepção dos moradores rurais, pesquisadores, fiscais do IBAMA, da região, sobre a caça de columbídeos.

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FUNDAMENTAÇÃO TEÓRICA

PANORAMA DA CAÇA DE AVES

A caça de animais silvestres é uma prática milenar que continua sendo praticada pelos seres humanos para diversos fins, sendo o uso alimentar supostamente a finalidade mais antiga dentre as já registradas (ALVES et al., 2010; ALVES et al., 2018). Pesquisas arqueológicas confirmam que o consumo desses animais é uma prática antiga dos seres humanos (POHL, 1976; MASSON; PERAZA, 2008). Diversos grupos de animais foram perseguidos ao longo do tempo, contudo, os mamíferos, as aves e os répteis se destacam entre os maiores registros de caça ao longo da história humana (MALHI et al., 2014). Para esses táxons que compõem a maior parte da Megafauna terrestre, a relação estabelecida entre caçadores e animais pode variar drasticamente, sendo motivada pelas preferências de caça, aos valores atribuídos a estes ou ainda pelas dinâmicas ecológicas nos ecossistemas (VAN VLIET, 2018).

Com relação as aves, são diversos os motivos que levam esses animais a serem caçados no mundo, que vão desde a captura para obtenção de proteína animal, passando pelos subprodutos (ex., penas, ossadas, bicos, patas) usados no tratamento de enfermidades ou como amuletos mágicos (ALVES, 2012; ORDAZ-NÉMETH et al., 2017). As características morfológicas dos arranjos e cores das penas aliadas ao canto também podem levar as aves a serem usadas como pets (animais de estimação), o que atrai compradores e pessoas interessadas na captura e venda destes animais em mercados (WHYTOCK et al., 2018).

De acordo com a legislação brasileira (Lei n° 5.197/67 e Lei n° 9.605/98), a caça de aves é proibida, com exceção da caça de subsistência e científica. Entretanto, há

evidências de que a caça ilegal é amplamente difusa nacionalmente (CHAGAS et al., 2015; EL BIZRI et al., 2015; BRAGAGNOLO et al., 2019). O Nordeste do Brasil abriga uma relativa riqueza de aves silvestres, com 548 espécies já registradas (ARAÚJO; SILVA, 2017), o equivalente a 27,8% da avifauna brasileira, uma vez que existem 1.971 espécies de aves conhecidas no país (PACHECO et al., 2021). É também um dos territórios semiáridos mais populosos do planeta, abrigando cerca de 28 milhões de pessoas, em sua maioria habitantes rurais (SILVA et al., 2017), com baixos índices de desenvolvimento humano (IDH). Nesse ambiente, onde os longos períodos de estiagem comprometem atividades de subsistência, como a agricultura e pecuária, as interações entre pessoas e aves tornam-se particularmente importantes. Deste modo, para garantir a eficácia na aquisição de tais recursos, grupos humanos desenvolveram um conjunto de técnicas específicas, baseadas no conhecimento ecológico das espécies-alvo, desenvolvendo estratégias de caça e coleta que foram tradicionalmente mantidas (ALVES et al., 2009) e disseminadas oralmente por gerações (BEZERRA et al., 2013), evidenciando a caça como uma prática enraizada nas tradições culturais dos habitantes locais (ALVES et al., 2009a; BARBOSA et al., 2011). Acredita-se que a vulnerabilidade social e a dependência dos recursos naturais nesta região favoreçam o uso das aves no sustento familiar (FERNANDES-FERREIRA et al., 2012), complementando a renda e alimentação das populações rurais (BARBOSA et al., 2010).

Aparentemente a caça para subsistência apresenta menores riscos para as populações de animais silvestres (FA; PERES, 2001; SANTOS-FITA et al., 2012). Contudo, alguns estudos sugerem que as práticas de subsistência aumentam a pressão sobre as espécies-alvo (REDFORD, 1992; WRIGHT, 2003). A caça excessiva dessas espécies pode induzir reduções severas no tamanho de suas populações, podendo levá-las à extinção local, especialmente se também enfrentam perda, degradação e fragmentação

de habitat (REDFORD, 1992). Estudos têm apontado a caça de aves no mundo como uma das principais responsáveis pelo declínio populacional do grupo (ABERNETHY et al., 2013; YOUNG et al., 2016). As aves correspondem ao segundo grupo mais caçado em regiões neotropicais, ficando atrás apenas dos mamíferos (BENÍTEZ-LÓPEZ et al., 2017).

FAMÍLIA COLUMBIDAE

A família Columbidae, que incluí as pombas, rolas, juritis e afins (doravante columbídeos), representa um dos grupos de aves de pequeno e médio porte mais facilmente reconhecidos em todo o mundo, com cabeça e bico pequenos, alta densidade corporal, plumagem cheia e patas pouco resistentes e geralmente vermelhas (SICK, 1997). Considerada cosmopolita, a família Columbidae apresenta um total de 369 espécies (IUCN, 2021), distribuídas em todos os habitats terrestres, desde densas florestas a desertos, a zonas temperadas e tropicais (BAPTISTA et al., 1997; GIBBS et al., 2001). A maioria das espécies brasileiras, geralmente as menores (ex., *Columbina* spp.), vivem em áreas rurais, se beneficiando dos desmatamentos e da produção agrícola (SICK, 1997). Normalmente alimentam-se de sementes e frutos, ingerindo-os inteiros, sem quebrar as sementes; por isso, são considerados importantes dispersores de plantas (SICK, 1997).

A família Columbidae contém uma proporção consideravelmente grande de espécies ameaçadas (BAPTISTA et al., 1997; GIBBS et al., 2001; WALKER, 2007). Das 369 espécies, 119 (33,8%) encontram-se ameaçadas de extinção, 16 estão extintas e uma está extinta na natureza (EW) (IUCN, 2022). No Brasil, duas, das 23 espécies registradas para o país (PACHECO et al., 2021), encontram-se criticamente ameaçadas (ver *Columbina cyanopis* Pelzeln, 1870; e *Paraclaravis geoffroyi* Temminck, 1811) (ICMBio, 2018; IUCN, 2022). A introdução de espécies exóticas (ex., gato-doméstico; *Felis catus*),

a redução e fragmentação de habitats, e, especialmente, a caça, são as suas principais ameaças (BAPTISTA et al., 1997; GIBBS et al., 2001; WALKER, 2007).

Os columbídeos, em geral, são caçados frequentemente para uso alimentar, já que apresentam uma volumosa musculatura peitoral (cerca de 50% da massa corpórea das espécies) (SICK, 1997). Vários estudos realizados no Brasil apontam os Columbidae como a família mais explorada dentre as aves de uso alimentar (BEZERRA et al., 2011, 2012; FERNANDES-FERREIRA et al., 2012; ALVES et al., 2013; BARBOSA et al., 2014; SANTOS et al., 2018; SOARES et al., 2018), e por essa razão muitas de suas espécies sofrem considerável pressão de caça, especialmente onde a caça ocorre ilegalmente (FERNANDES-FERREIRA et al., 2012; SCHULZ et al., 2019). Um bom exemplo é no Nordeste brasileiro, onde a caça dessas aves acontece de maneira descontrolada (ALVES et al., 2009b; BEZERRA et al., 2011, 2012; FERNANDES-FERREIRA et al., 2012; BARBOSA et al., 2014; SANTOS et al., 2018; SOARES et al., 2018).

No Nordeste do Brasil, *Zenaida auriculata* (Des Murs, 1847) tem sido apontada como uma das espécies de Columbidae mais exploradas (BARBOSA et al., 2010; BEZERRA et al., 2011; NOBREGA et al., 2011). É eleita pelos sertanejos como uma alternativa alimentar nos períodos de seca e um petisco apreciado nos grandes centros urbanos (SOUZA et al., 2007). Os locais de nidificação da espécie, chamados de pombais, eram historicamente ocupados por centenas de caçadores, em um complexo sistema de produção (FERNANDES-FERREIRA, 2014). Aguirre (1964) foi o primeiro a detalhar aspectos biológicos e da caça comercial dessa espécie no Nordeste do Brasil. As estimativas do autor eram de 300.000 indivíduos abatidos em pouco menos de um mês, em um único pombal. Apesar desse número ser considerado inimaginável nos dias de hoje, a informação ainda mais surpreendente era de que esse referido pombal, localizado

no município de Bonsucesso (Ceará), era tratado pelos caçadores como de baixa produtividade. É possível ter uma ideia de sua densidade populacional, em tempos ainda mais pretéritos, no relato de Silva (1898), que retrata bandos com milhares de indivíduos:

> "*É impossível calcular-lhe o número* (dos indivíduos nos bandos), *e mesmo para aquele que observa a nuvem compacta dessas aves fica uma espécie de receio em referir o que viu, tal é a dificuldade que há em ser crido. Si pousam sobre qualquer árvore, partem-se os galhos ao peso do número, si descem para beberem nalgum açude esgotam-no em poucos dias; quando se assustam e tomam voo simultaneamente, produzem o ruído igual ao de uma locomotiva em marcha acelerada*".

Ainda que a atividade tenha diminuído desde a década de 1990, o declínio de *Z. auriculata* no Nordeste é comparado com a extinção da pomba-migratória (*Ectopistes migratorius* Linnaeus, 1766), cuja população chegava a ordem de milhões e foi dizimada nos Estados Unidos por pressão de caça e torneios de tiro (BUCHER; 1992; SICK, 1997). Vale destacar que esse cenário ocorre apenas na região Nordeste do Brasil. Em sua ampla área de distribuição, muitas vezes *Z. auriculata* é considerada uma praga agrícola, sendo inclusive abatida pontualmente na região sul do país para fins de controle populacional (SILVA; GUADAGNIN, 2018).

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CAPÍTULO 1

HUNTING AND TRADE OF COLUMBIDAE IN NOTHEAST BRAZIL

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Abstract: The uncontrolled hunting of columbids (Aves, Columbidae: doves and pigeons) in Northeast Brazil, mainly for food purposes, can cause the population decline of the target species. For this reason, this research aimed to investigate how hunting and trade can impact columbid populations. Data were obtained through interviews with local hunters. Seven species of four genera were mentioned, which are hunted mainly for food consumption. Three hunting instruments were identified, the lead shotgun being the most used to kill birds. Columbids were hunted preferably in the dry season, on pastures and at night. In addition, they are sold live or slaughtered in two open markets in the region. Columbidae are important hunting species in northeastern Brazil, with two species suffering more hunting pressure than the others. If no hunting regulations are being applied, the populations of these species may decrease dangerously in the studied area.

Keywords: Aves Columbids (doves and pigeos); Food resource; Illegal trade; Hunting; Sustainable habitat management; Itabaiana Municipality; Northeast Brazil.

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Hunting and Trade of Columbidae in Northeast Brazil

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Keywords Aves Columbidae (doves and pigeons) · Food resources · Illegal trade · Hunting · Sustainable habitat management · Itabaiana Municipality · Northeast Brazil

Introduction

Birds are among the most hunted groups of animals in the world (Bezerra *et al.* 2012; Sick 1997; Park *et al.* 2016), and are hunted for a variety of purposes such as trade, frequently illegal, or for food and pets. The family Columbidae (doves and pigeons; Aves; hereafter columbids) is particularly favored as food and consequently suffers considerable hunting pressure especially where hunting is either unregulated or occurs illegally (Walker 2007; Alves *et al.* 2009; Fernandes-Ferreira *et al.* 2012; Schulz *et al.* 2019).

In many countries, such as Brazil, illegal wild animal hunting is classified as an environmental crime (Linacre and Tobe 2011) and can generate impacts ranging from decrease in species' population density to local extinctions (Robinson and Redford 1991; Robinson and Bennett 2000; Walker 2007; Gross 2019). Hunting has been identified as one of the main factors linked to population reductions of Brazilian wildlife (Renctas – Rede Nacional de Combate ao Tráfico de Animais Silvestres 2001; Silveira and Straube 2008; Alves and Souto 2010; Scariot 2010). Motivations for wild animal hunting vary according to local circumstances and can include nutritional, commercial, cultural, medicinal, and recreational purposes (Robinson and Redford 1991; Robinson and Bodmer 1999; Fa *et al.* 2000; Alves and Filho 2007; Lindsey *et al.* 2015).

Northeast Brazil is one of the poorest regions in the country, with a marked and severe dry season (April to November). We investigate the importance of columbids as a source of food and/or income among three small rural communities in Sergipe state to identify the most hunted species. Our results provide data that can be used in the design of effective management strategies to regulate hunting and conserve columbid populations at sustainable levels.

Study Area

Our three study communities are located in Itabaiana Municipality at an average distance of 7.3 km from the largest city of the Municipality (city of Itabaiana), in Sergipe state, northeastern Brazil (Fig. 1). The communities are composed of a small number of households and the main economic activity is agriculture, based primarily on lettuce and coriander crops (personal obs.). According to the last census, the municipality has a population of 86,967, of whom 67,709 live in the urban areas and 19,258 reside in rural areas (IBGE 2010). The region is in a transition zone between the *Caatinga* (desert-like vegetation) biome and the Atlantic Forest (Dantas and Ribeiro 2010; IBGE – Instituto Brasileiro de Geografia e Estatística 2014). According to the Köppen-Geiger classification, the region's climate is As′ - tropical with a dry summer season (Alvares *et al.* 2013). Precipitation occurs between April and September, peaking in May (175 mm) and the annual average temperature is 24 °C (Climate-data.org 2020).

Methods

From May to November 2019, we conducted informal conversations and administered an open questionnaire during interviews (Table S1; supplementary material) with a total of 15 hunters

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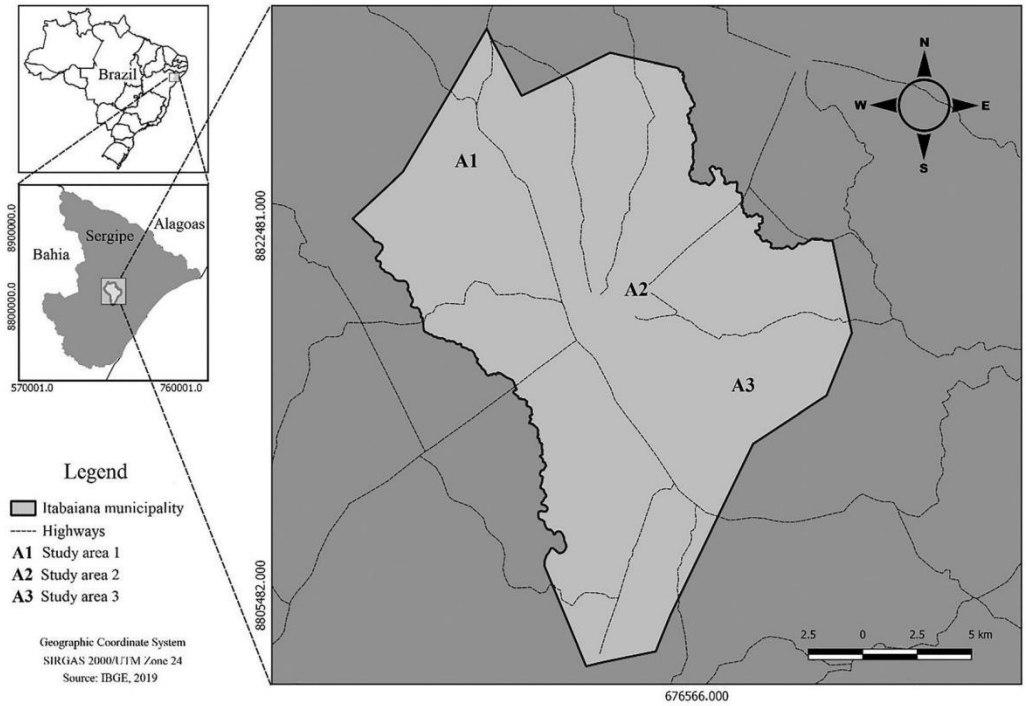

Fig. 1 Itabaiana Municipality, showing the three study areas (A1 = Tabuleiro do Chico; A2 = Açude de Marcela; A3 = Bom Jardim) in the Sergipe State, Northeastern Brazil

from the three communities(Albuquerque *et al.* 2010; Amorozo and Viertler 2010). We selected participants using the "snowball" technique, whereby informants are recommended by initially selected knowledgeable individuals and themselves recommend further experts (Bailey 1982; Albuquerque *et al.* 2010).

We adopted the checklist/interview technique, using photographs of columbids already recorded in the state of Sergipe for informants to identify birds (Medeiros *et al.* 2010). The photographs of the species, extracted from the WikiAves © website, were stored on a mobile phone to facilitate the transport and access of the material and to obtain greater flexibility in the interviews. The species cited by the participants were listed using common/local and scientific names according to the most recent list of the Brazilian Committee for Ornithological Records (Piacentini *et al.* 2015).

Data Analysis

To determine the hunting importance of each species recorded, the Use Value (UV) was calculated for each species using the following formula: $UV = \sum U / n$; where: UV = use value of the species; U = number of citations of each species by each informant; n = total number of informants (Rossato *et al.* 1999).

Results

We interviewed 15 male hunters with the youngest being 36 years old and the oldest 63 years old (average: 50.3 years old). Regarding the interviewers' level of education, Four hunters (26.6%) had an incomplete high school education, four (26.6%) had complete elementary school, and seven (46.6%) had incomplete elementary school educational levels. Most informants ($N = 8$; 53.3%) were farmers, two (13.3%) were bricklayers, two (13.3%) were retirees, one (6.7%) was a cowboy, one (6.7%) was a waiter, and one (6.7%) was unemployed. All respondents have lived in the study area since they were born.

Columbid Species and Use Value (UV)

Respondents cited seven species of columbids (Table 1) belonging to four genera, which are hunted in the region mainly for meat consumption ($N = 14$ citations), but also for

recreation ($N = 7$ citations), to be kept as pets ($N = 4$), and trade ($N = 4$). The most cited species were *Columbina talpacoti* and *Columbina picui* ($N = 15$ citations), followed by *Zenaida auriculata* ($N = 10$ citations) and *Columbina minuta* ($N = 8$ citations). Among the species hunted, *Columbina squammata* was the only one kept as a pet: "People hunt any pigeon species to eat, but the scaled dove is more hunted for hand-rearing, because it is attractive and people like to hear its song" (Hunter 15). The interviews also revealed that 80% of hunters killed more than 100 birds per hunt and may exceed 200, as reported by one informant: "You can hunt too many animals if you want. I brought 200 or more myself" (Hunter 11). Thus, in the study areas, if 12 hunters kill 100 columbids/hunt and three kill 200 columbids/hunt, a total of 1800 columbids are killed per hunt. Since hunts occur 2–3 times per month, the lowest estimate of columbids killed per month totals 3600.

Regarding preferences for species while hunting, 60% of informants indicated the largest (*Leptotila* spp., *Patagioenas picazuro*, and *Zenaida auriculata*) as they are "fleshier." "I hunt everything, but the big ones are better, because they have more meat" (Hunter 14). The respondents also agreed that the species that had decreased or disappeared from the region were the largest ones (60%; *Leptotila* spp., *Patagioenas picazuro* and *Zenaida auriculata*) and acknowledged the frequency of hunting them as the main reason for their decrease: "The big ones are no longer found as before. The Picazuro pigeon and the Eared dove are gone, the people have already hunted them a lot" (Hunter 14); "The Eared dove have already completely disappeared. They have killed everything. Occasionally you will find some, a flock flying" (Hunter 15).

The calculated Use Value (UV ± standard deviation) of the species ranged from 0.13 to 2.46 (Table 1). The highest use values were: *C. talpacoti* and *C. picui*, (UV = 2.46 ± 0.25), followed by *C. minuta* (UV = 1.53 ± 0.51) and *C. squammata* (UV = 1.06 ± 0.51) (see Table 1).

Equipment Used for Hunting and Hunting Strategies

Three types of weapon are used by hunters to kill birds: pellet shotgun, slingshot, and *preaca*, and informants reported that in some cases more than one type is used during the hunt. The most used are pellet shotguns ($N = 13$ citations), followed by *preaca* ($N = 8$ citations), and slingshot ($N = 2$ citations).

The pellet shotgun (Fig. 2a) differs from the traditional shotgun, in which ammunition is propelled by the expansion of gases resulting from the burning of gunpowder present in its cartridges. The ammunition of the pellet shotgun consists of lead projectiles (Fig. 2b), which are fired, one at a time, by pushing compressed air through a spring. The slingshot (Fig. 2c) constructed from wooden fork, whey rubber, and leather, is used to propel stones or balls of clay. The *preaca* (Fig. 2f) is about 2 m long, built with a wooden broom handle, PVC pipe, whey rubber, steel wire, and nylon cord to propel a spear-tipped wire fired by the action in the whey rubber. This weapon is mostly used against perched birds, as the wire remains attached facilitating collection of the prey. According to our informants, it allows the rapid killing of several birds if they are close to each other. Birds caught during hunting sessions are stored in a cloth bag, usually made of denim, called a *capanga* (Fig. 2d and e).

Hunting Locations and Timing (Frequency, Period of Day and Period of Year)

According to our informants, columbids are mostly caught in pastures ($N = 11$ citations) and remnants of native vegetation ($N = 4$ citations) in the three study areas. In addition, most of the interviewees (60%) reporting hunting two to three times per month during the summer, which corresponds to the dry period (October–March). Others (40%) did not recall how many times they go out to hunt each year, stating only that

Table 1 Columbidae cited as hunting targets in Itabaiana Municipality, Sergipe, Northeast Brazil, with their respective numbers of citations and use values and standard deviations (UV ± SD)

Species	Citations	Use				UV±SD
		Food	Recreational hunting	Breeding	Trade	
Columbina minuta	23	8	7	0	8	1.53 ± 0.51
Columbina picui	37	15	7	0	15	2.46 ± 0.25
Columbina squammata	16	3	7	3	3	1.06 ± 0.51
Columbina talpacoti	37	15	7	0	15	2.46 ± 0.25
Leptotila spp.	2	1	0	0	1	0.13 ± 0.25
Patagioenas picazuro	5	3	1	0	1	0.33 ± 0.41
Zenaida auriculata	14	10	4	0	0	0.93 ± 0.48

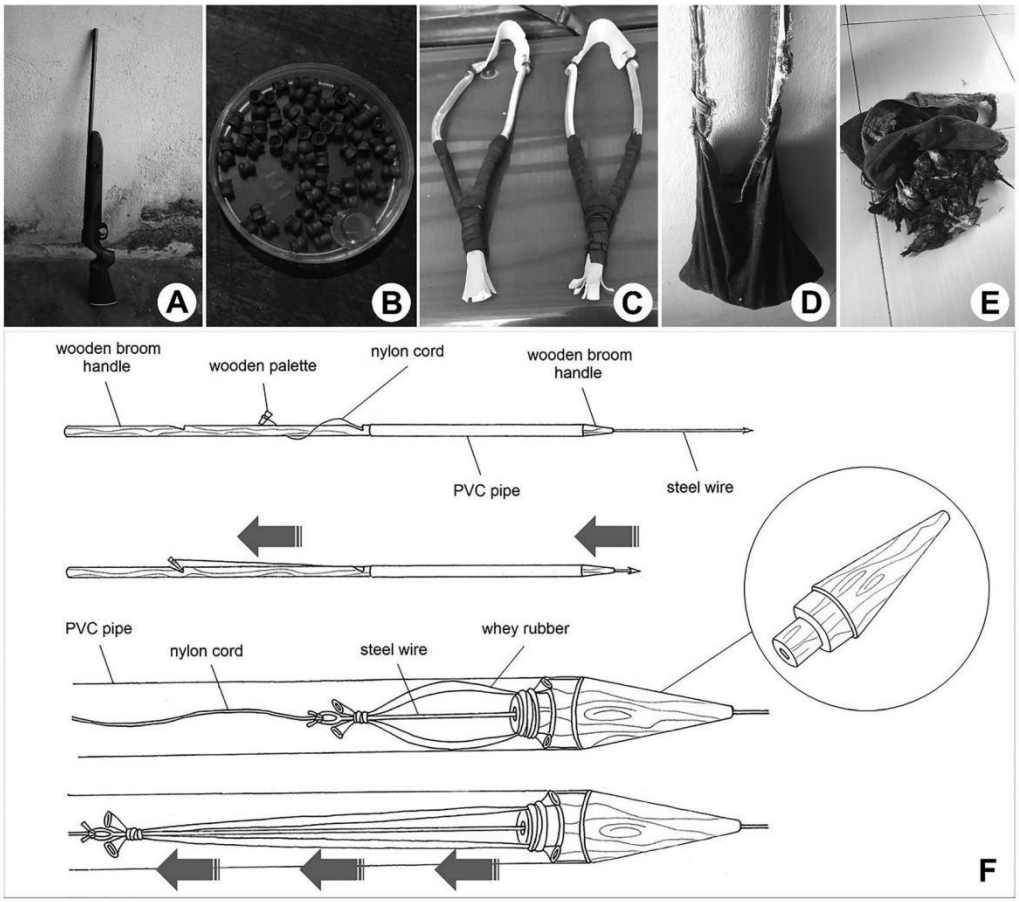

Fig. 2 Hunting instruments used for killing doves and pigeons in Itabaiana municipality, Sergipe, Northeast Brasil. **a** – pellet shotgun; **b** – pellets for the shotgun; **c** – slingshot; **d** – *capanga*; **e** – doves killed inside the *capanga*; **f** – *preaca*. Photos and figure: Cleverton da Silva

they hunt when they wish to eat birds: "I can't tell you. When I feel like I need to eat some doves, I go out and hunt them" (Hunter 7).

Most interviewees (60%) reported that they prefer to hunt in the summer because it is easier to find birds perched in the dry vegetation at night: "In the summer it is better, because everything is dry, then it's easier to find them" (Hunter 7); "In the summer, because it's easier to find them sleeping. The trees are all dry, without much leaf" (Hunter 15). Others (40%) reported that there are doves to hunt at any time of the year: "There are always doves at any time" (Hunter 13).

Interviewees preferred to hunt at night (93.3%, for all cited species) with the help of flashlights, when they claim that killing birds is easier as they are found perched asleep: "At night, because we catch them sleeping" (Hunter 7); "I hunt more at night, because it is easier, because they are asleep, then you can kill many" (Hunter 5). Only one of the participants reported that he prefers to hunt in the morning for personal safety due to the presence of venomous snakes in the area: "In the morning, because at night I am afraid of not seeing and stepping on a snake in the bush" (Hunter 3).

Trade and Meat Preparation for Consumption

Most of our interviewees (86.6%) report the existence of dove trading in the region at the popular "Free Market" (10°41′ 8.264"S, 37°25′47.345"W) (76.9%) and the "Trade Market" (10°41′15.565"S, 37°25′54.898"W) (23%). In the first, they reported that slaughtered birds are sold in basins (Fig. 3a), which can be displayed to customers or easily hidden, since trade in columbids is illegal, and shown only in response to customers' requests: "There have them at the open market. It is illegal, but there are people who sell them. You ask at the stand if they have any and they will show you. From time to time, you will find the doves in front of the stalls for everyone to see, but it is difficult to find them like this" (Hunter 5).

Fig. 3 Slaughtered doves at the "Free Fair" in Itabaiana municipality, northeastern Brazil (A) and preparation of the meat for consumption (B and C). Photos: Cleverton da Silva

According to our interviewees, at this "Free Market," any species of columbid can be found slaughtered for sale, but mainly the smaller species (*C. talpacoti*, *C. picui*, *C. minuta*, *C. squammata*): "Boy, they sell any type of dove, but the smallest ones are easier to find" (Hunter 1).

Most informants (60%) reported that there is no columbid species preference in the market; the birds are sold per unit, with the smallest and cheapest sold for 0.25 to 0.50 *reais* (Brazilian currency) (US$ 0.05 to 0.10) and the larger and more expensive for 1.00 to 1.50 *reais* (US$ 0.20 to 0.30). "Anyone who sells doves, people buy. It's too cheap. The smallest ones…. 25, 50 cents, each. And the big ones, one real, one and fifty" (Hunter 8). With regard to preparation for consumption, according to the hunters the species are initially plucked (Fig. 3b and c), seasoned to taste (salt, black pepper, coloring) and then the meat is usually fried.

At the "Trade Market" our interviewees reported columbids are sold alive, generally to be kept as pets: "At the Trade Market we can also buy doves, but only live doves, to keep as pets. People buy to raise them. You find Picazuro pigeon and Scaled dove, from time to time" (Hunter 14). The species that can be found at this location, according to the interviews, are: *C. squammata* ($N = 3$ citations) and *P. picazuro* ($N = 1$ citation) (Fig. 4). According to the interviews, the most popular species is *C. squammata*, due mainly to its song. Prices vary according to the degree of domestication of the bird, with the price of a skittish bird ranging from 10 to 20 *reais* (US$ 2.00 to 4.00), while a more docile/domesticated one can be sold for 200 to 300 *reais* (US$ 40.00 to 60.00).

Awareness of the Illegality of Columbid Hunting

All hunters claimed that this activity is prohibited by law and indicated IBAMA (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* – the Brazilian environmental agency) as the agency responsible enforcing the regulations. Most hunters (93.3%) reported that hunting is prohibited to protect the birds from overhunting: "To not let it go extinct" (Hunter 11). Only one hunter revealed that the hunting of doves is prohibited because they are wild species: "Because you cannot hunt animals that are from nature" (Hunter 13). It is interesting to note that only one of the hunters declared he was against this hunting ban, arguing that doves, as well as crabs (common food in the region), although elements of nature, should be freely hunted: "Yes, but I think it shouldn't be prohibited. Don't people hunt crabs to eat? Isn't everything in nature? So why do you forbid dove hunting? It is too wrong" (Hunter 7).

Discussion

The hunting of columbids, mainly for food, is a widespread practice in the study area. The most hunted species are *C. talpacoti* and *C. picui.* Night hunts with pellet shotguns and slingshots are the most common. Hunters are aware that hunting and trading of columbid species are illegal, although this does not prevent them from hunting. However, trade is only financial advantageous when pigeons are sold for breeding, as pets (highest sale prices). Several local populations in

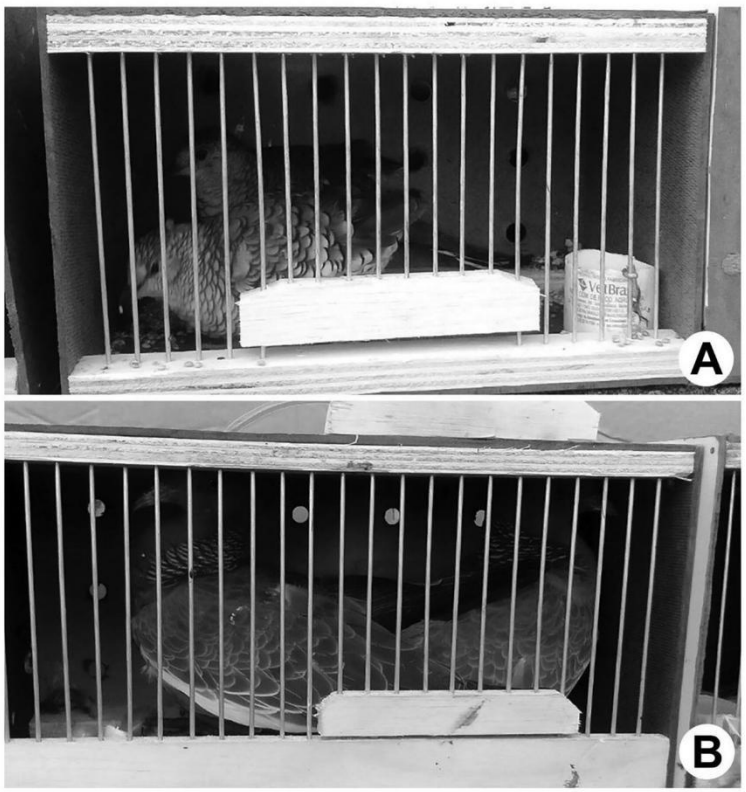

Fig. 4 Live doves at the "Trade Fair" in Itabaiana Municipality, Sergipe state, northeastern Brazil. **a** - *Columbina squammata*, **b** - *Patagioenas picazuro*. Photos: Cleverton da Silva

Brazil, especially in the Northeast region, often hunt the species we recorded in the present study (Alves *et al.* 2009; Bezerra *et al.* 2012; Fernandes-Ferreira *et al.* 2012; Alves *et al.* 2013; Santos *et al.* 2018). Several studies report columbids as the most diverse group among birds hunted for food and generally have higher use values. These data are certainly a strong reflection of the historical depletion of preferred species in this region.

Our informants reported that the preferred species to hunt for food are the largest as they provide a greater amount of protein (Randrianandrianina *et al.* 2010; Macdonald *et al.* 2011). This may explain the fact why *P. picazuro* and *Z. auriculata* are no longer as frequently seen at the study site as they were in the past, as reported by the hunters. The absence of these species suggests a population decline or even local extinction.

According to Souza *et al.* (2007), *Z. auriculata* migrate between the northeastern states of Brazil mainly at the end of the rainy season in search of available food resources to facilitate reproduction. At these periods, columbids come under considerable hunting pressure.[1] It is notable that this scenario occurs only in the Northeast region of Brazil; in the southern states, *Z. auriculata* is considered an agricultural pest and measures being taken for population control (Silva and Guadagnin 2018). Similarly, *P. picazuro* is declining in the Northeast and is normally abundant in other regions of Brazil (Olmos 2005).

According to our informants, their preference for the use of pellet shotguns is because of the number birds that can be killed in a short time. In addition, pellet shotguns are quieter compared to *preacas*, which, although cheaper and efficient in killing several individuals (if they are close to each other), are loud noise and drive away nearby birds. Thus, hunters' preference reflects optimal foraging theory in that their strategy provides the most benefit for the lowest cost, maximizing their energy gain (Stephens and Krebs 1986). Their preference for the use of pellet shotguns also indicates that their socioeconomic situation is improving, since the expense of maintenance and recharge of these guns is relatively expensive. This may be a result of government social programs and financial investments in the region over last decade (Ministério da Cidadania 2020). It is important to note that the lead used in pellet shotgun ammunition is an environmental pollutant that is toxic when ingested (Pain *et al.* 2019). Due to the large number of columbids killed by pellet shotguns every year in

[1] The decline of *Z. auriculata* populations in the Northeast can be compared to the migratory dove *Ectopistes migratorius*, whose population in the order of millions was completely wiped out in the United States (Sick 1997; Hume 2015).

the study area, lead ingestion could be a problem not only for birds but also for other fauna.

Our informants' preference for hunting in open areas and at night with torches may be due to the fact that only 9% of the territory of Itabaiana Municipality (2905.55 ha) is forested, although Barbosa *et al.* (2016) report that hunters' choice for open areas is related to better visibility and results. Also, many scattered trees remain in cultivated pastures that provide perches for birds at night. Some studies have reported that night hunting of birds (known as *facheada*) is a common practice in northeast Brazil (Alves *et al.* 2009; Fernandes-Ferreira *et al.* 2012), possibly as strategy used to avoid encounters with patrolling agents from government regulatory agencies that could lead to criminal prosecution (Santos 2017).

Hunting and trade of wild animals in Brazil became illegal in 1967 (Renctas 2001; Bragagnolo *et al.* 2019). However, the sale of both living and dead animals is openly practiced in two open markets in Itabaiana Municipality. A number of studies conducted across the country indicate that birds are the most commercialized wild animals and their commercialization is widespread (Ribeiro and Silva 2007; Alves *et al.* 2010, 2013; Renctas 2001; Regueira and Bernard 2012). We did not specifically investigate our informants' motives for continuing to hunt despite its illegality, but the fact that they had low educational levels and came from the poorest families in the region presumably contributed to their decision to use hunting as a subsistence strategy and to generate income even though they are aware of the risk. This leads us to the conclusion that if the regulatory agency IBAMA increased the number of its inspectors in the region as well as the frequency of patrols the numbers of hunters would fall, easing the pressure on columbid populations.

One of our informants did not agree with the blanket hunting ban, citing the regulated harvest of the Uçá crab (*Ucides cordatus*), an activity common throughout Brazil's coastal regions (Capistrano and Lopes 2012; Côrtes *et al.* 2018) and taking a positive view of wild fauna as a resource that can be managed and conserved. The design and implementation of local and national governmental programs for sustainable management of columbid habitats, including regulations to protect the birds during their reproductive seasons, might permit subsistence hunting to continue, although such programs would have to provide hunters with sustainable economic alternatives and generate jobs and income (Robinson and Bennett 2000).

Conclusion

Our results indicate that the hunting and trade of columbids, mainly for subsistence purposes, although illegal is widespread in the study. Although the targeted species we recorded in this study are not on endangered animal lists, our data show that some of them (including a migratory species *Z. auriculata*) are no longer easily found in the region, which evidences the need for future studies in order to analyze whether such population reduction is due to overexploitation or to other factors. Conservation strategies such as environmental education activities, ex-situ breeding with later release into the wild, development of sustainable hunting regulations, among others, could benefit both humans and wild birds in the area.

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Conflict of Interests The authors declare that they have no conflict of interest.

Authors' Contributions CS, JR-E and ASR conceived the project, designed the research and revised the manuscript; CS collected and analyzed data; CSA analyzed data, drafted and revised the manuscript.

Compliance with Ethical Standards The study objectives and implications were explained to each participant and consent was given by signing a Free and Informed Consent Term. Participants also consent to the use of their images by signing Image Authorization term. The National Health Council through the Research Ethics Committee (Resolution 466/12) requests both documents. The Human Research Ethics Committee of the Federal University of Sergipe (CAAE 29107620.0.0000.5546) authorized this research.

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CAPÍTULO 2

SEASONAL VARIATION IN THE ABUNDANCE AND DENSITY OF COLUMBIDS (AVES: COLUMBIDAE) IN A REGION WITH HIGH HUNTING PRESSURE

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Abstract: Assessing the numbers and densities of highly hunted bird species, like those from the Columbidae family (pigeons and doves), is essential to develop effective conservation strategies. In this sense, the present study sought to investigate the Columbidae populations in three rural areas of Sergipe's Agreste (Brazil), assessing whether there is seasonal variation in abundance and density, in order to verify the local situation of the species. For this, linear transects were used to record species richness and abundance, which was used to calculate densities for each recorded species. A total of 4,229 columbids belonging to eight species were recorded, with *Columbina talpacoti*, *Columbina picui* and *Columbina minuta* as the species that were most abundant and with the highest densities. Greater abundance and density was also observed during the rainy season for most species. Of the registered species, more than half had low abundances and a tendency to decrease in numbers throughout the year. The low and decreasing number of individuals of most of the columbids could be showing natural fluctuations of the populations or could be reflecting the effects of local hunting pressure. Long-term studies and monitoring should be conducted to understand local population dynamics and, if needed, to mitigate hunting impact, in order to conserve these bird species.

Keywords: Census; Conservation; Monitoring; Northeast Brazil; Pigeons and doves.

Introduction

Among bird species, the presence of species belonging to the Columbidae family (doves and pigeons) in altered environments, such as rural and urbanized areas, is common (Sick, 1997). Although there are preferentially forested species (eg, *Leptotila* spp. and *Geotrygon* spp.), the majority can be observed in grassland areas, benefiting from deforestation and agricultural production (Sick, 1997). Considered cosmopolitan, the Columbidae family has a total of 369 species (IUCN 2022), distributed in all terrestrial habitats, from dense forests to deserts, to temperate and tropical zones, being one of the most successful families of birds in the world (Baptista et al., 1997; Gibbs et al., 2001).

Despite the evolutionary success of the Columbidae, the family contains a considerably large proportion of endangered species, with hunting being one of the main threats (Baptista et al., 1997; Gibbs et al., 2001; Walker, 2007). Of the 369 species, 16 are extinct (EX), one is extinct in the wild (EW), 12 are critically endangered (CR), 20 are threatened (EN), 39 are vulnerable (VU) and 48 are near threatened (NT) (IUCN, 2022). In Brazil, two of the 23 species recorded for the country (Pacheco et al., 2021) are critically endangered (see *Columbina cyanopis* Pelzeln, 1870; and *Paraclaravis geoffroyi* Temminck, 1811) (ICMBio, 2022; IUCN, 2022). Columbids, in general, are often hunted for food (Sick, 1997). Several studies carried out in Brazil indicate the Columbidae as the most exploited family among birds for food use (Bezerra et al., 2011, 2012; Fernandes-Ferreira et al., 2012; Alves et al., 2013; Barbosa et al., 2014; Santos et al., 2018; Soares et al., 2018), and for this reason many of its species suffer considerable hunting pressure, especially in Northeast Brazil, where hunting of these birds occurs in an uncontrolled manner (Alves et al., 2009; Bezerra et al., 2011, 2012; Fernandes-Ferreira et al., 2012; Barbosa et al., 2014; Santos et al., 2018; Soares et al., 2018; Silva et al., 2021). A recent study, carried out in the interior of the Sergipe state, northeast of Brazil, revealed that

hunters usually kill hundreds of columbids per hunt and that some species are no longer easily found in the region, due to over-exploitation (Silva et al., 2021). In view of this, it is necessary to develop studies that assess the conservation status and viability of populations of these columbids in the region.

In this context, density estimates are important for studies of population ecology and for monitoring wildlife (Williams et al., 2002; Nichols & Williams, 2006; Burgar et al., 2018). Species density allows comparison between different regions where species censuses have already been carried out using the same methodology. Conducting censuses periodically makes it possible to monitor the species, assessing whether there is an increase, decline or stability in the population in the long term (Nichols & Williams, 2006). Although birds are among the most researched groups of animals, studies on population density estimates for columbids are scarce. Among the studies that estimated the population density of columbids in Brazil, Souza et al. (2007) recorded a high density of *Zenaida auriculata* (Des Murs, 1847) in breeding colonies in the Northeast of the country. Fontoura (2013) and Fontoura and Orsi (2014) estimated the population density of columbids in disturbed landscapes in the north of Paraná state, southern Brazil, and observed that the density of the *Z. auriculata* species was higher than that of the species *Columbina talpacoti* (Temminck, 1811) and *Columbina picui* (Temminck, 1813), suggesting that the conversion of natural landscapes into agricultural areas may have favored the increase in the population density of *Z. auriculata*, through the availability of food (eg, soybeans, corn , wheat).

In dry tropical environments, rainfall dynamics are highly seasonal and shape the abundance of resources in the landscape, limiting their availability over time (Schwinning & Sala, 2004). Periods of high rainfall are closely associated with changes in vegetation structure (Lázaro et al., 2001; Oesterheld et al., 2001) which, in turn, exert considerable

influence on the availability of food resources for birds (Newton, 1998; Dean & Milton, 2001). Therefore, the seasonality of rainfall is able to act as an environmental stimulus to determine the patterns of distribution and abundance of birds in arid and semi-arid tropical environments (Oliveira and Silva et al., 2017). The dynamics of rainfall is often described as the most important factor to explain the periodic fluctuation in the abundance of bird populations and their food resources in seasonally dry environments (Rivera-Milan et al., 1992; Carvalho et al., 2015; Araújo et al., 2017; Oliveira e Silva et al., 2017).

Assessing the population conditions of birds that suffer considerable hunting pressure is essential to ensure their conservation, especially of birds of the Columbidae family, which have received relatively little attention in terms of conservation (Walker, 2007), despite the high number of threatened species (Baptista et al. 1997, Gibbs et al., 2001; Walker, 2007). Thus, this study sought to investigate populations of Columbidae in three rural environments of the semi-arid of the Sergipe state (Brazil), assessing whether there is variation in the abundance and density of the species between the rainy and dry seasons, in order to verify the local situation of the species. Sampled areas are the same described by Silva et al. (2021) as suffering high hunting pressure for columbids.

Methods

Study area

The municipality of Itabaiana is located in the central region of the state of Sergipe (Brazil), in a transition zone between the Caatinga and the Atlantic Forest, called Agreste (IBGE, 2014). Currently, only 9% (2,905.55 ha) of the territory of the municipality of Itabaiana is covered by forest, with the remainder corresponding to open and anthropized areas (SFB, 2017). The main causes of deforestation in the region have been the expansion of the urban area and the increase in agricultural activities. According to the

Köppen-Geiger classification, the climate in the region is As' – tropical with dry summers (Alvares et al., 2013). Precipitation occurs between April and September, peaking in May (175 mm) and the average annual temperature is 24 °C (Climate-data.org, 2021).

The study was carried out in three rural areas (Fig. 1), composed, in general, of a small number of residences, where the main economic activity is agriculture, based mainly on horticulture. Area 1 (A1), located in the northwest part of the municipality, is predominantly composed of pastures and small fragments of native vegetation (Fig. 2). Area 2 (A2), located in the central part of the municipality, although it also has small fragments of native vegetation, is characterized by the presence of vegetable plantations and a dam built for supply and agricultural use (Oliveira et al., 2015) (Fig. 2). Area 3 (A3), located in the southeast part of the municipality, also consisting of pastures and vegetable plantations, stands out for its proximity to fragments of secondary forests of the Serra de Itabaiana National Park (PARNASI), classified as an ecotonal forest formation between the Dense Ombrophylous Forest of Lowlands and Submontane Semideciduous Seasonal Forest (Dantas & Ribeiro, 2010) (Figs 1 and 2), one of the main conservation units in Sergipe. Information on the size and location of each area is presented in Table 1.

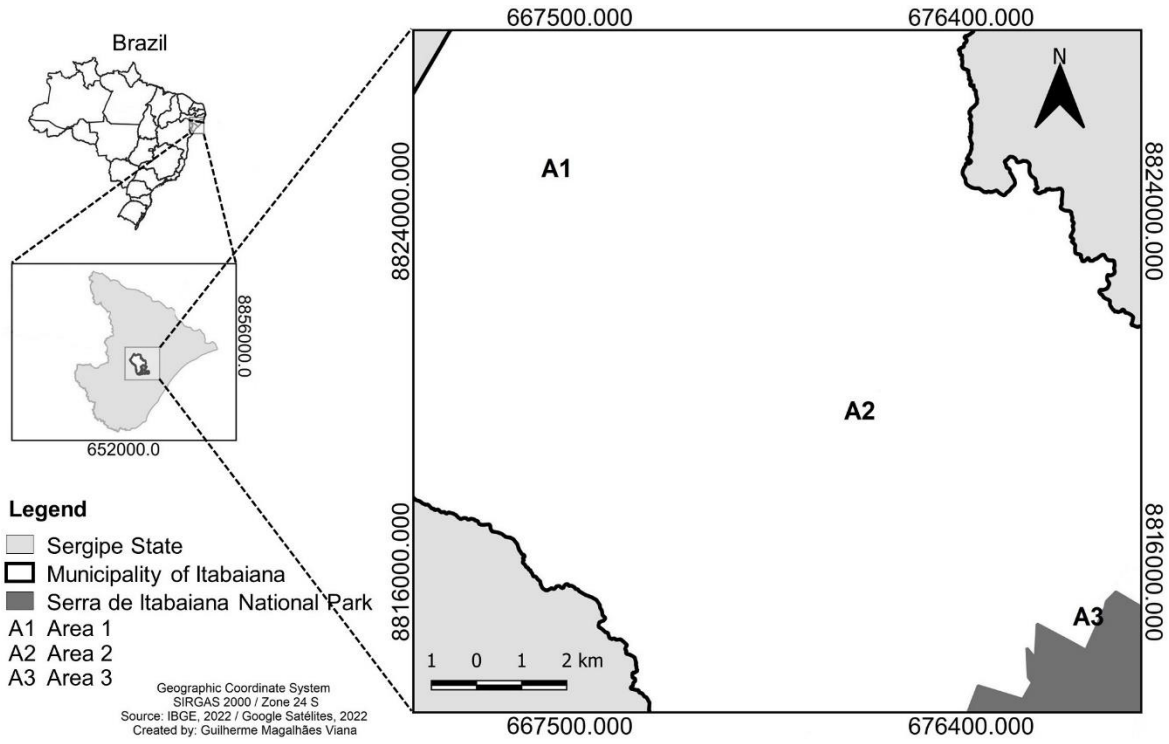

Figure 1. Municipality of Itabaiana (Sergipe state, Brazil) with the location of the three sampled rural areas.

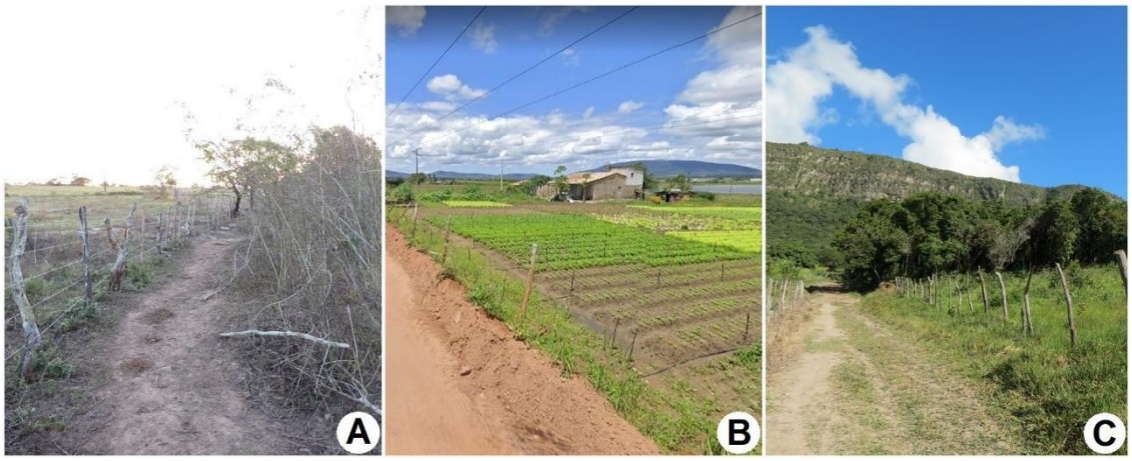

Figure 2. Landscape characteristics of the three rural areas sampled in the municipality of Itabaiana (Sergipe state, Brazil). A) Area 1 = characterized by the presence of pastures and small fragments of native vegetation; B) Area 2 = characterized by the presence of plantations (vegetables) and a dam built for supply and agricultural use; C) Area 3 = characterized by proximity to fragments of secondary forests of the Serra de Itabaiana National Park. Photos: Cleverton da Silva.

Table 2. Size and location (coordinates) of the three rural areas sampled in the municipality of Itabaiana, Sergipe state, northeastern Brazil.

Area	Size in hectares (km²)	Coordinates
A1	852 (8,52)	10°37'26.980"S e 37°28'41.099"W
A2	489 (4,89)	10°40'26.130"S e 37°24'40.896"W
A3	521 (5,21)	10°42'50.422"S e 37°21'55.087"W

Field procedures

To record the richness and abundance of columbids, initially three 1.5 km transects were established in each of the rural environments (nine transects in total) (Fig. 1), spaced by at least 300 m from each other (Bibby et al., 2000; Anjos et al., 2010). During the layout of the transects, we sought to cover most of the local phytophysiognomies (open areas – pastures and plantations; closed areas – primary and secondary forests). This method consists of walking continuously along a predefined trail, at a constant average speed, while recording all birds detected visually and auditorily (Bibby et al., 2000). According to Bibby et al. (1998), this method is indicated for data collection in large and open areas, as is the case of the rural areas sampled in this study, as these tend to allow the recording of more birds per unit of time. In addition, they reduce the chance of double registration of individuals and are considered the best strategy for studying species that are conspicuous, mobile, relatively easy to identify and that easily flee in the presence of the observer (Bibby et al., 1998). Between April 2021 and March 2022, the transects were covered twice a month, from 06:00h to 10:00h. Each transect was walked only once per day. When birds were detected, we recorded the species and the number of individuals. The detection distance established for each side of the trail was 50 m long. Therefore, birds seen at more than 50 m were not considered.

Data analysis

From the data collected in the transects, the density (D) of the species was calculated, considering it as the ratio between the number of individuals recorded along the entire transect (N) and the sampled area in km2 (A). The formula used to calculate the density was therefore: D = N / A (adapted from Buckland et al., 2008). To assess whether the abundance of each species differed between seasons, Generalized Linear Models (GLMs) were built using the stats package (R Core Team, 2022). The abundance of each species was the response variable and the weather season was the explanatory variable in each model, with months as sampling units (N = 12; six in the rainy season and six in the dry season). The residuals were evaluated to fit the best distribution family for each model (Jones et al. 2022). All statistical analyzes were performed in the R software (R Core Team, 2022).

Results

In 324 km of transects covered (108 km in each area), a total of 4,229 columbids belonging to eight species were recorded (Table 2). Six of the eight columbid species recorded were observed in all three areas. The eared dove (*Zenaida auriculata*) was recorded only in areas A1 and A2, while the gray-fronted dove (*Leptotila rufaxilla*) was exclusive to area A3. Some species, such as the plain-breasted ground-dove (*Columbina minuta*), the scaled dove (*Columbina squammata*), the gray-fronted dove (*Leptotila rufaxilla*) and the white-tipped dove (*Leptotila verreauxi*) were only recorded in the transects present inside or on the edge of the forest fragments present in each of the studied areas.

Table 2. Size, body mass, number of individuals (N) and density (D) of columbids recorded between April 2021 and March 2022 in three rural areas (A1, A2 and A3) in the municipality of Itabaiana, Sergipe state, Brazil.

Size (cm)	**A1**	**A2**

		Body mass (g)	N (%)	D (ind/km²)	N (%)	D (ind/km²)	N (%)
ro (Temminck, 1813)	34	210-402	27 (1,4%)	3,1	4 (0,3%)	0,8	6 (0,5%
Bonaparte, 1855	23-30	114-276	49 (2,6%)	5,7	14 (1,1%)	2,8	6 (0,5%
Richard & Bernard, 1792)	28	131-183	-	-	-	-	21 (1,8%
(Des Murs, 1847)	22-28	116-155	20 (1%)	2,3	7 (0,5%)	1,4	-
(Linnaeus, 1766)	14-15	26-42	597 (32,3%)	70	205 (16,6%)	41,9	209 (18%
ti (Temminck, 1811)	15-18	35-56	486 (26,3%)	57	598 (48,6%)	122,2	525 (45,3
nata (Lesson, 1831)	18-22	48-60	49 (2,6%)	5,7	2 (0,1%)	0,4	16 (1,3%
emminck, 1813)	15-18	41-51	616 (33,4%)	72,3	398 (32,4%)	81,3	374 (32,3
			1.844 (43,6%)		**1.228 (29%)**		**1.157 (27,**

*The taxonomy of the species followed Pacheco et al. (2021). Size and body mass were obtained, respectively, in Grantsau (2010) and Dunning (2008).

The most representative species, in terms of abundance and density, were the ruddy ground-dove (*Columbina talpacoti*), the Picuí ground-dove (*Columbina picui*) and the plain-breasted ground-dove (*C. minuta*) (Table 2; Fig. 3). The less abundant and with lower density were those species with greater size and body mass (*Leptotila rufaxilla*, *Leptotila verreauxi*, *Patagioenas picazuro*, *Z. auriculata*) (Table 2; Fig. 3). For almost all species, a significant difference was observed in the number of individuals recorded between the rainy and dry seasons, with the highest number of records in the rainy season (Fig. 4).

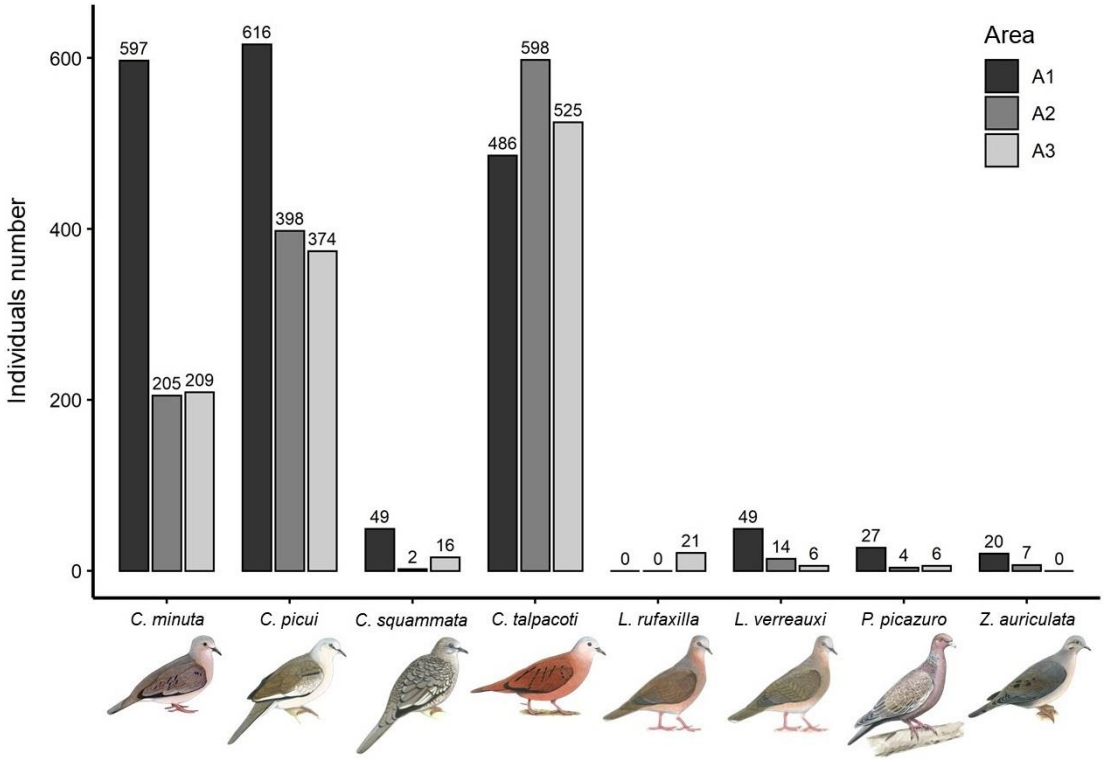

Figure 3. Abundance of columbids (Aves: Columbidae) recorded between April 2021 and March 2022 in three rural areas (A1, A2 and A3) in the municipality of Itabaiana (Sergipe state, Brazil). *C = Columbina*; *L = Leptotila*; *P = Patagioenas*; *Z = Zenaida*.

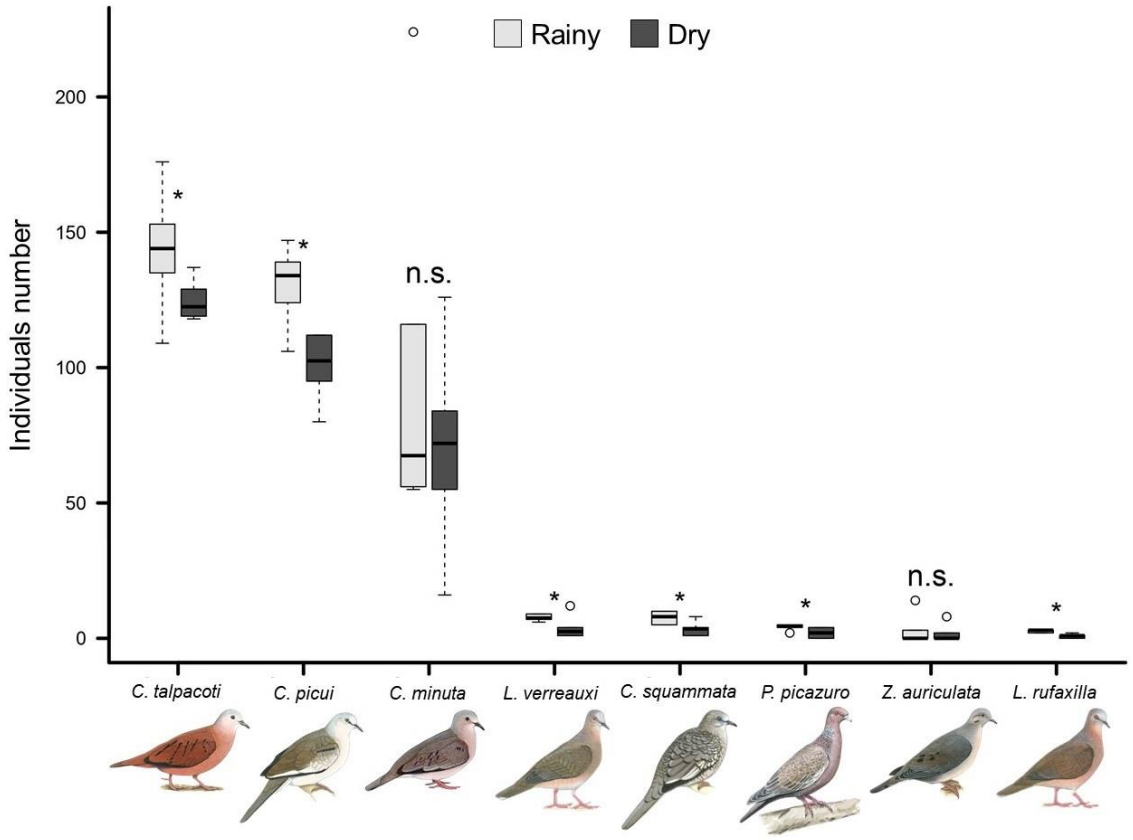

Figure 4. Boxplots showing seasonal variations in the abundance of columbids from three rural areas in the municipality of Itabaiana (Sergipe state, Brazil), during the wet and dry seasons. Asterisks indicate a significant difference ($P < 0.05$) between the rainy and dry seasons, while "n.s.", a non-significant difference. The horizontal line, inside the boxplots, indicates the median; the limits of the boxplots indicate the interquartile range; the vertical lines (whiskers), in the boxplots, represent minimum and maximum values; and the white points are outliers. *C = Columbina; L = Leptotila; P = Patagioenas; Z = Zenaida.*

Overall, the number of recorded individuals of each species varied little between months, but with most species showing a decreasing trend throughout the year (Figure 5). The species *C. minuta*, *L. verreauxi* and *Z. auriculata* were the ones that varied the most in abundance throughout the year (Figure 5). Five species had very low abundances throughout the year in the study areas, while three species had higher abundances (Figure 5).

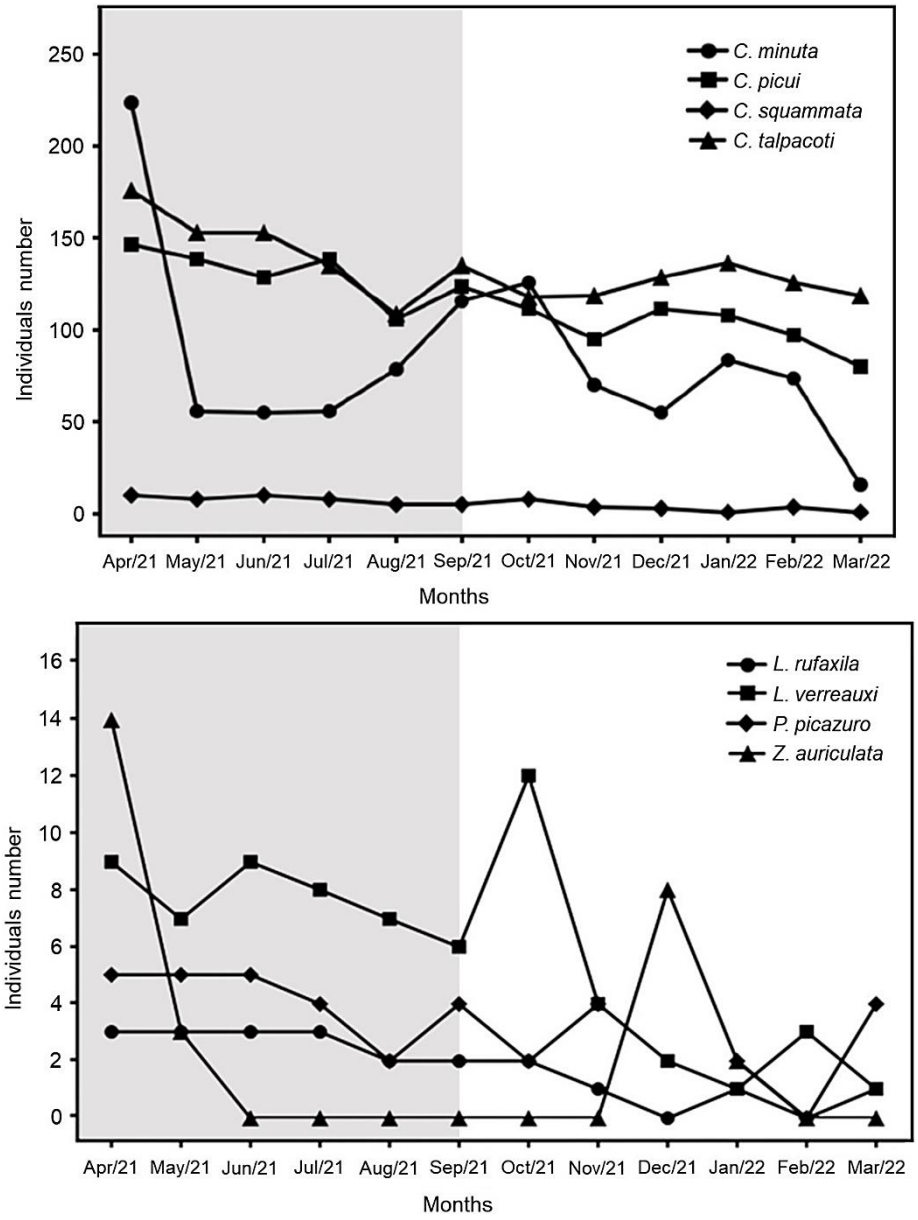

Figure 5. Variation in the abundance of Columbidae species recorded in the three rural areas of the municipality of Itabaiana (Sergipe state, Brazil). The darker area represents the wet season, while the lighter area represents the dry season. *C* = *Columbina*; *L* = *Leptotila*; *P* = *Patagioenas*; *Z* = *Zenaida*.

Discussion

Eight species of Columbidae were recorded, with *C. talpacoti*, *C. picui* and *C. minuta* being the most abundant species and, consequently, those with the highest

population density. The other species (*C. squammata*, *Leptotila verreauxi*, *Leptotila rufaxilla*, *P. picazuro*, *Z. auriculata*) had few individuals recorded, therefore they showed low abundance and density throughout the year. A greater abundance and density of columbids was also observed during the rainy season.

The eight species of Columbidae recorded in the present study correspond to 61.5% of the 13 species that occur in the State of Sergipe (with the exception of the domestic pigeon *Columba livia* Gmelin, 1789) (Sousa, 2009; Silva et al., 2022; WikiAves, 2022). All these species are hunted in the region, mainly for food use (Silva et al., 2021).

Records of *L. rufaxilla* only in area A3 are possibly due to its proximity to PARNASI, where there are records of its occurrence (Silva et al., 2022). Unlike its congener (*L. verreauxi*), *L. rufaxilla* is more forestry, preferring the closed and dense understory of secondary forests (Sick, 1997), as well as forest fragments found on the slopes of PARNASI.

It is interesting to note the low abundance and density of species with larger size and body mass (*P. picazuro*, *Z. auriculata*, *L. verreauxi*, and *L. rufaxilla*). The small number of records of *L. rufaxilla* may be associated with its preference for inhabit the interior of forests (Sick 1997). The low abundance and density of the other species may be related to uncontrolled hunting in the region, as reported by local hunters (Silva et al. 2021). According to these hunters, these larger, "meatier" columbids are no longer abundant in the region due to over-exploitation for food use. It is also worth mentioning the low number of records of *C. squammata*, which may also be related to excessive hunting, given that it is highly hunted in the region to be used as pets (Silva et al. 2021). It is important to note that the population density of birds is usually lower in areas that are under hunting pressure (Benítez-López et al. 2017). Natural fluctuations on the populations of these columbid species also need to be considered, since their monitoring

occurred for only one year. Natural fluctuations and the impact of hunting should be better understand if long-term monitoring and studies are conducted in the region (Magurran et al. 2010; Pollock et al. 2022).

With the exception of the species *C. minuta* and *Z. auriculata*, where no differences were observed in abundances between the rainy and dry seasons, all other species showed higher abundances in the rainy season. This result corroborates the hypothesis that in semi-arid regions, where seasonality decisively influences the availability of food resources, the abundance of animals is usually greater during the rainy season (Dean & Milton, 2001; Schwinning & Sala, 2004; Araújo et al., 2017; Oliveira and Silva et al., 2017). Therefore, the greater availability of seeds and fruits allows an increase in the abundance of most species during the rainy season (Dean & Milton, 2001; Carvalho et al., 2015; Araújo et al., 2017; Oliveira e Silva et al., 2017).

The fact that *C. minuta* is described as a persistent species in areas with extreme drought (Fernandes-Ferreira 2014), being able to obtain the necessary resources for its survival, may explain the fact that its population did not present a significant difference between the seasons. On the other hand, *Z. auriculata*, despite not showing any difference in the number of individuals recorded between seasons, showed peaks in the dry season (Figure 5). Such peaks may be related to the periodic migrations that *Z. auriculata* performs along the Brazilian Northeast in search of food (Souza et al. 2007; Oliveira Souza et al. 2022), such as the exploration of corn plantations present in the studied region, where most of its individuals were recorded in foraging activity. According to Silva and Guadagnin (2017), *Z. auriculata* has been strongly associated with areas of grain crops (e.g., corn, sorghum). Precisely during the dry season, when resources become scarce even for the human population, the hunting of columbids in the region tends to increase, as hunters reported that it is easier to observe the birds in trees with dry branches

and without leaves (Silva et al. 2021), which may be influencing the low abundance and density of these species in the study site.

The results obtained in this study are fundamental to help future conservation plans for this group of birds that suffer considerable hunting pressure in the region (Silva et al., 2021). However, the data available so far for the Columbidae species recorded in the sampled areas are not sufficient to state the conservation status in which their populations are found and to estimate their viability, since this was the first study in the region that was dedicated to quantify the populations of these birds.

Decisions regarding the conservation of species are, most of the times, related to time. This means that the persistence of a species in a given area may not be guaranteed in the long term, that is, the species may be in "extinction debt" (change in the population dynamics of the species that will lead to its extinction in the future) (Kuussaari et al., 2009). Among the Columbidae species recorded in this study, it is possible that some of them may already depend on conservation measures to survive, as is the case of *C. squammata*, *P. picazuro* and *Z. auriculata*, which had few records and are no longer easily detected in the region, according to local hunters (Silva et al., 2021). In this sense, it is necessary that data from annual and consecutive censuses of columbids be related to hunting data, based on hunters' reports and apprehensions carried out by environmental authorities. In this way, it will be possible to more realistically assess the impacts of hunting on the persistence of species.

It is known that for an effective conservation plan it is necessary to know the state of the populations of the target species, more specifically, detecting drastic population declines, in order to avoid possible local extinctions. The detection of a population decline can be seen as a trigger for the elaboration of priorities for effective conservation (Nichols & Willians, 2006). A constant monitoring program makes it possible to monitor temporal

variations in populations through repeated counts in the same locations over consecutive years. It is one of the main ways to detect fluctuations in population size, whether due to natural variations or caused by human actions (Conroy et al., 2012). At the same time, local hunting monitoring can provide subsidies to understand the impacts of hunting on population fluctuations of columbids.

We conclude that most columbid species have small and declining populations, suggesting that local hunting pressure is strong, especially for species with larger size and body mass. It is important to highlight that hunting columbids can be even more impactful, given that there are reports of hunters in the region who prefer to hunt in the dry season (Silva et al. 2021). Furthermore, it is during this period that locals are most vulnerable. Thus, long-term monitoring of columbids becomes essential for the development of adequate population models that can predict the future of species in the region, allowing for more assertive action to protect species that show a sharp decline.

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CAPÍTULO 3

TO HUNT OR NOT TO HUNT? ANALYZING DIFFERENT PERCEPTIONS ABOUT COLUMBID HUNTING (AVES: COLUMBIDAE) IN SERGIPE, NORTHEASTERN BRAZIL

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Abstract: If hunting wild animals is considered a problem for the conservation of native fauna, wild animals can be important for some human communities, especially as a source of food. Therefore, it is necessary to develop and implement systems capable of combating uncontrolled hunting and allowing it to be exploited as a source of food and income, in a sustainable way. For this, knowing the perceptions of the actors involved in this dynamic (local residents/hunters, inspection agents and researchers) is important to subsidize the development of these systems. The present study investigated the perceptions of local residents and wildlife specialists about Columbidae hunting, in order to support conservation and sustainable development proposals in the region. Data were collected through the application of a semi-structured questionnaire to local residents, inspection agents and researchers residing in the study area. Most residents defend hunting and make regular use of columbids, suggesting controlled hunting as a way of reconciling the practice with the conservation of the species. The inspectors and researchers, on the other hand, are against hunting and believe that the improvement of the socioeconomic condition of the residents, in particular, can mitigate the hunting problem. Thus, it is concluded that the hunting of columbids is common in the study region, both for subsistence and for leisure, that environmental inspection is not enough to control hunting and that conservation actions need to be carried out, since there are reports of columbid species disappearing or declining in numbers in the region.

Keywords: Doves and pigeons; Etnozoology; Food resource; Sustainable use; Wild meat.

Introduction

Hunting wild animals is defined as the capture of any animal species directly from nature, by any means and purpose (Nasi et al., 2008). In Brazil, it is classified as one of the environmental crimes (Linacre & Tobe, 2011) and identified as one of the main factors linked to population reduction of wild fauna (Renctas, 2001; Silveira & Straube, 2008; Alves & Souto, 2010; Scariot, 2010). When carried out for human consumption, hunting wild animals has been identified as a conservation and human subsistence issue (Bennett et al., 2002; Milner-Gulland et al., 2003). A matter of conservation, because, when carried out in an uncontrolled way, hunting of wild animals can generate significant negative consequences, ranging from a decrease in the population density of target species to their local extinction and alteration of ecosystem processes and community structure (Robinson & Bennett, 2000; Cullen et al., 2001; Tabarelli et al., 2010; Antunes et al., 2016; Constantino, 2016). It is an issue of human subsistence because the use of wild animals as a food resource is important for some communities, such as those living in tropical forests and rural areas, where subsistence is traditionally more dependent on the exploitation of natural resources (Robinson & Bennett, 2002; Gama et al., 2016; Bragagnolo et al., 2017a, b).

Birds are among the most hunted groups of animals in the world (Renctas, 2001; Ferreira & Glock, 2004; Alves, 2012), and are hunted for various purposes, such as to be used as pets, food resource and for trade (Nobrega et al., 2011; Bezerra et al., 2012; Oliveira et al., 2020). The Columbidae family (doves, pigeons and alike; hereinafter columbids) is among the main targets for food purposes and, consequently, suffers considerable hunting pressure, especially where hunting takes place illegally (Walker, 2007; Alves et al., 2009; Fernandes-Ferreira et al., 2012; Schulz et al., 2019). A good example is in the Northeast of Brazil, where hunting of these birds occur in an

uncontrolled way (Alves et al., 2009; Bezerra et al., 2011; Nobrega et al., 2011; Fernandes-Ferreira et al., 2012; Fernandes et al., 2012; Fernandes-Ferreira, 2014; Barbosa et al., 2014). A study recently carried out in the interior of the State of Sergipe, in particular, revealed that hunters usually kill hundreds of columbids per hunt (Silva et al., 2021). The same study also reveals that, according to hunters, some species are no longer easily found in the region, due to overexploitation, as is the case of the migratory species *Zenaida auriculata* (Des Murs, 1847), popularly known as Eared dove.

In Northeast Brazil, *Z. auriculata* has been identified as one of the most exploited species of Columbidae (Barbosa et al., 2010; Bezerra et al., 2011; Nobrega et al., 2011). In the semi-arid region, it is chosen by the locals as a food alternative in periods of drought and a popular snack in large urban centers (Souza et al., 2007). Thus, since 1984, several researches on *Z. auriculata* have been carried out by CEMAVE (*Centro Nacional de Pesquisa e Conservação de Aves Silvestres*), in partnership with research institutions in the Northeast, in order to guarantee and support adequate management strategies for the conservation of the northeastern population of *Z. auriculata* (Souza et al., 2007).

One question that arises is: how to deal with the uncontrolled hunting of wild animals? This is a question that is still debated. There are those who argue that hunting is a major problem for conservation and the only way to protect the species is to stop hunting (Santos et al., 2011; Di Minin et al., 2021), but in many contexts, prohibiting the hunting of wild animals is regionally difficult, costly and can be challenged on ethical grounds (Adams & McShane, 1992; Ostrom et al., 1999). There are also those who argue that the only hope of breaking destructive patterns of resource use is to reduce rural poverty and improve levels of income, nutrition, health and education (Brandon & Wells, 1992), by promoting the wildlife trade. However, this approach can lead to rapid exploitation and deterioration of wildlife resources (Robinson & Redford, 1991).

Among researchers and environmental inspectors, there is a broad consensus that legalizing hunting in Brazil is unfeasible (Fernandez et al., 2012; Fernandes-Ferreira & Alves, 2017). From the point of view of these professionals, in Brazil and, more broadly, in Latin America, there is not enough data for wild fauna to be legally exploited as a source of food and income (Roper, 2006). On the contrary, hunting wild animals is defended by rural communities, which often use this resource to supplement their food and income (Gama et al., 2016; Bragagnolo et al., 2017a, b).

Few studies exist to help policy makers and wildlife managers develop and implement systems designed to combat unsustainable hunting, prevent species loss, and maintain long-term flows of wildlife that can be exploited as a food source and income (Robinson & Bennett, 2000; Bennett et al., 2007). Exploring this type of approach can help optimize species conservation and the maintenance of wildlife as a provisioning ecosystem service that delivers food and income primarily to less affluent families. In this sense, the objective of the present study was to investigate the perception of environmental researchers, inspectors from IBAMA (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*) and residents of three rural areas in the municipality of Itabaiana (Sergipe, northeastern Brazil) about hunting columbids, in order to provide information to help formulate conservation and sustainable development proposals in the region. We hypothesized that because the interviewed residents make use of columbids, they will be in favor of hunting columbids. On the contrary, we expected researchers and inspectors to not support hunting of these birds in the region. Finally, we expected that the suggestions on the legalization or banning of columbid hunting in the region, given by these three groups of interviewees, will be more similar, with the improvement of the socioeconomic condition being evidenced as the main change to be implemented with the communities.

Methods

Study area

The Itabaiana municipality (Sergipe, Brazil) is located in the semi-arid mesoregion of Sergipe, in a transition zone between the Caatinga and the Atlantic Forest vegetational domains (Dantas & Ribeiro, 2010; IBGE, 2014). Its territorial extension is 337,295 km², representing 1.53% of Sergipe's territory (IBGE, 2021). According to the last census, the population of the municipality of Itabaiana is 86,967 inhabitants, with 67,709 residents of the urban area and 19,258 residents of the rural area (IBGE, 2010). The climate of the region, according to the Köppen-Geiger classification, is As' – tropical with a dry summer (Alvares et al., 2013). Precipitation occurs between April and September, with a peak in May (175 mm) and the average annual temperature is 24 °C (Climate-data.org, 2021). From an economic perspective, Itabaiana represents a strong diversity, ranging from the traditional agricultural activity, based on family farming, to the typically urban activities that form one of the largest centers in terms of commerce and the provision of services in the region (Carvalho & Costa, 2009). Its local popular market is held twice a week and is one of the most important in the state (Carvalho & Costa, 2009).

The study was conducted in three rural areas, located at an average distance of 7.3 km from the urban center of Itabaiana (Fig. 1). The communities, in general, are composed of a small number of families distributed as follows: Area 1 (A1; Tabuleiro do Chico) = 59 families; Area 2 (A2; Açude da Marcela) = 53 families; Area 3 (A3; Bom Jardim) = 343 families. The main economic activity of these families is agriculture, based mainly on horticulture.

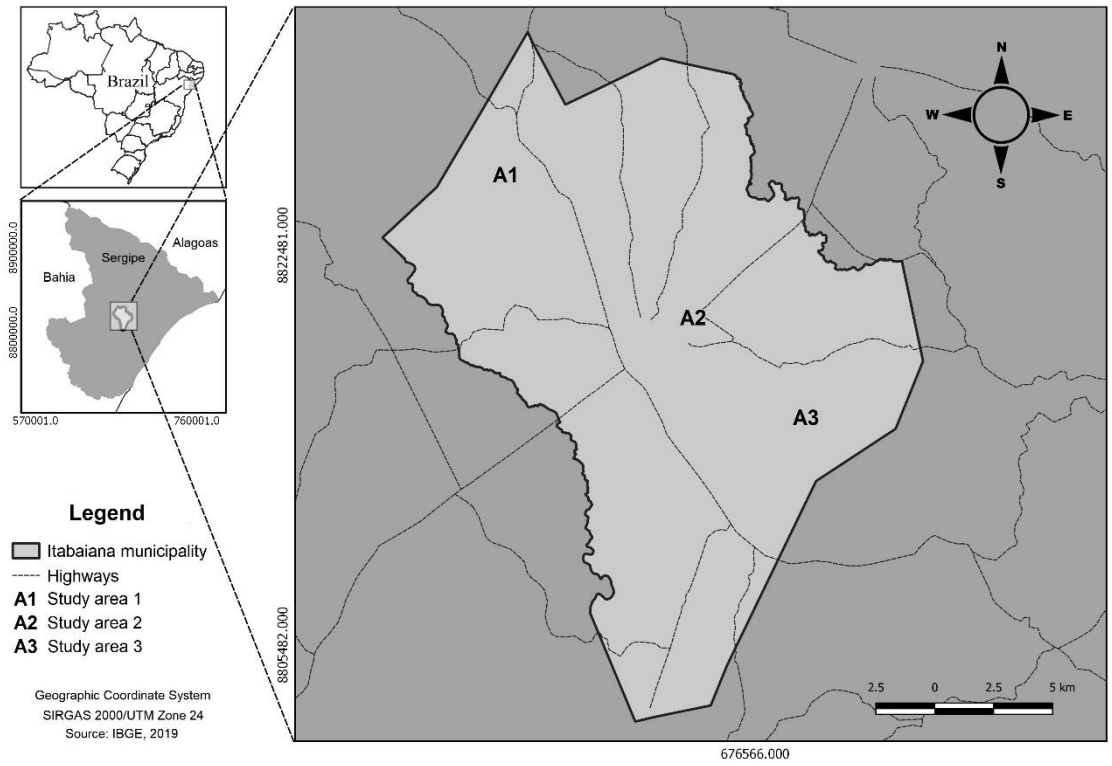

Fig. 1. Location of the rural areas sampled (A1 = Tabuleiro do Chico; A2 = Açude da Marcela; A3 = Bom Jardim) in the municipality of Itabaiana, Sergipe, Brazil.

Data collection and analysis

Data collection occurred from February to May 2022, through the application of a semi-structured questionnaire, composed of objective and subjective questions, to the residents of each rural area (Apêndice) (Albuquerque et al., 2021). In order to obtain a greater amount of information, it was decided to apply the questionnaire to every resident over 18-years-old who chooses to participate (Albuquerque et al., 2021). The responses to the questions given by the residents were written by the researcher himself, without interference on the answers. The language of the research instrument was adapted to each interviewee to facilitate understanding of the questions. IBAMA inspectors and researchers who work in the region were also interviewed, in order to compare their perceptions with those of residents of rural areas. The interviews with the researchers and

inspectors occurred by sending, by email, a Google Forms® link containing the questionnaire (Apêndice) (Faleiros et al., 2016).

It should be mentioned that before any interview, the participants were informed about the objectives and implications of this research contained in the Free and Informed Consent Term, in compliance with resolution 466/12 of the National Health Council through the Research Ethics Committee (Brazil, 2012). This research was approved and authorized by the Ethics Committee in Research with Human Beings of the Federal University of Sergipe (CAAE 47838821.9.0000.5546).

The identification of the columbids mentioned by the interviewees was carried out using the checklist/interview technique (Medeiros et al., 2010), using photographs of species already recorded in the state of Sergipe. The species were listed with the locally known name and also with the scientific name, according to the recent list of the Brazilian Committee of Ornithological Records (Pacheco et al., 2021).

Initially, data were inserted in a Microsoft Excel spreadsheet. Data referring to open questions were analyzed, according to Bardin (1977), through observation of thematic categorical content. This approach corresponds to qualitative data methods, which are initially configured by the identification in the texts, grouping the informants' answers to the subjective questions, according to the specific theme. In addition, still following Bardin (1977), discourse analysis was performed, which allows the organization and interpretation of information. As for closed questions, their answers were counted and their percentages analyzed.

Results

A total of 258 participants were interviewed, being 223 rural residents (44 residents of the A1; 30 residents of the A2; 149 residents of the A3), 7 inspectors from IBAMA

and 28 researchers with experience in Ornithology, Conservation and Management of Wildlife and hunting. It is worth noting that the number of inspectors interviewed corresponds to the total number of inspectors working in the region.

When rural residents were asked whether they consume or have consumed pigeons/doves, most (N = 146; 65.4%) said “Yes”, pointing to the plain-breasted ground-dove (*Columbina minuta* Linnaeus, 1766), the Picuí ground-dove (*Columbina picui* Temminck, 1813) and the ruddy ground-dove (*Columbina talpacoti* Temminck, 1811) as the most consumed species (Fig. 2). Regarding the reasons that lead them to consume these birds, most (N = 128; 87.6%) point to the taste of the meat, while the others (N = 18; 12.3%) their subsistence necessity: “Because the meat is delicious” (Resident 27); “Boy, I get some to eat because, from time to time, we don't have enough money for beef or chicken...” (Resident 110).

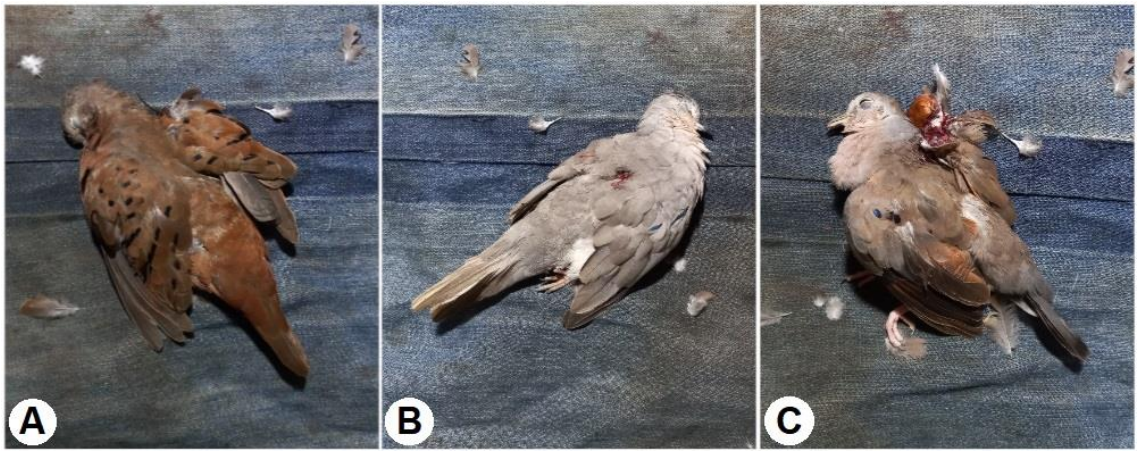

Fig. 2. Pigeons most consumed by rural residents of the municipality of Itabaiana, Sergipe. Photos provided by local hunters. A) *Columbina talpacoti*, B) *Columbina picui*, C) *Columbina minuta*.

Rural residents were also asked whether the disappearance of pigeons/doves from the region would impact their lives. The majority (N = 150, 67.2%) said “Yes”. For 94% (N = 141) of these, the disappearance of these birds would affect food, while for 6% (N = 9), it would be a displeasure, due to the consequent absence of their vocalizations, a

characteristic appreciated by these residents: “It would be bad, because we would be without them to eat” (Resident 10); “Life would be sadder, wouldn't it? Their singing makes us happy” (Resident 3). Some respondents (N = 73; 32.7%) revealed that the absence of pigeons/doves would not be a problem, as they do not depend exclusively on this type of food resource, as can be seen in one of the reports: “No! Because we can eat other things” (Resident 201).

It was also asked if rural residents would stop eating doves/pigeons in exchange for meat from domestically raised animals (e.g. beef, chicken, pork), and the majority (N = 125; 56%) revealed that they would not stop consuming them, because dove/pigeon meat is tasty, while beef and chicken are nauseating: “Because dove meat is delicious. Chicken and beef are nauseating” (Resident 7); “Because sometimes it's good to eat something different” (Resident 18). Others (N = 21; 9.4%) revealed that they would stop eating pigeon/doves for beef and chicken, only if they had the financial means to do so, as shown by some reports: “I would leave, right?! But to eat only beef and chicken, we need money. Beef is expensive” (Resident 50); “I did. I also like beef and chicken, but we can't always afford to buy them” (Resident 67). Seventy-seven (34.5%) residents answered that they do not consume pigeon/dove meat.

Most rural residents (N = 142; 63.6%) were in favor of hunting doves/pigeons, for the reason, according to them, that these birds are natural and abundant resources in nature: “Doves are a good of nature. Why can't we hunt for food?" (Resident 53); “There are too many doves. These animals never end” (Resident 11). Those who were not in favor of hunting (N = 81; 36.3%) claimed that these birds are overexploited: “It really should be prohibited. People hunt too much” (Resident 114). On the contrary, there is a consensus between researchers (academics) and IBAMA inspectors about the prohibition of this practice, due to the lack of data on this group of birds, as can be seen in the

following reports: “There are very few studies on this group of birds, including population studies that indicate whether hunting is indicated or not and how it could be done” (Researcher 16); “There is not much data on population estimates, especially for migratory species” (Inspector 4).

Among the respondents, most rural residents were in favor of hunting pigeons/doves (N = 142; 63.6%). Thus, they were invited to suggest something so that hunting could be carried out without causing substantial damage to the populations of the target species. Thus, the suggestion provided by these interviewees was to hunt in a controlled way, as can be seen in one of the answers: “Only a certain number of kills should be allowed in each hunt” (Resident 5). The participants who were against hunting (IBAMA researchers and inspectors; N = 35) had to suggest mitigating measures for this practice in the region. Socioeconomic improvements were suggested (N = 26; 74.2%) and more investments in inspection and environmental education programs (N = 9; 25.7%): “Improve socioeconomic conditions. The government could present alternative practices to communities that depend more on hunting, such as the availability of a social card to facilitate the purchase of food” (Researcher 5); “Before any action, the inspection must be effective, so it must receive the due investment. However, we know that, in addition, there must be a partnership with the communities that live with the species. This partnership can be made with the bridge of environmental education” (Researcher 1); “Reduce poverty, through the generation of employment and income” (Inspector 3); “Investments to strengthen inspection and environmental education actions for young people and adolescents” (Inspector 1).

Finally, IBAMA inspectors were asked if there were any apprehensions of pigeon/doves hunters in the region. According to the inspectors, there are not many apprehensions, due to the small number of inspectors working at the site, as observed in

one of the answers: “The small number of inspectors in the region makes our work less efficient” (Inspector 3). Regarding what happens to the few hunters who are caught, five inspectors responded that they are fined for environmental crime and, in some cases, for illegal possession of a firearm: “Hunters face prosecution for environmental crime and some for carrying a firearm” (Inspector 1). Two inspectors did not respond.

Discussion

In the present study, we hypothesized that residents would be hunting columbids because they use them as an important food resource, while researchers and IBAMA inspectors would be against hunting these birds in the region. These hypotheses were confirmed. Most of the residents defended the hunt of columbids, usually using these birds in their diet, even preferring this source of protein instead of those from domesticated animals. On the contrary, there was an agreement between the researchers and the hunting inspectors that columbid hunting is a conservation problem and that it should not be conducted, since lack of the demographic studies for those species and the reduced number in inspections in the region could lead to wrong decisions by the policy makers and wildlife managers. Both inspectors and researchers recognize that combating columbid hunting in the region is even more difficult due to the problems arising from the low socioeconomic status of the residents, since hunting was also carried out for leisure, not only as a protein source. Interviewees answered that even if they could afford for other sources of meat (beef, chicken or pork), they would continue to hunt columbids.

Finally, we hypothesized that the suggestions on the legalization or banning of columbid hunting in the region, given by the three groups of interviewees, would be similar, with the improvement of the socioeconomic condition being evidenced as the main change to be implemented with the communities. This hypothesis was not fully corroborated, since most of the rural residents interviewed revealed that even if they were

able to afford for other animal proteins, they would continue to hunt pigeons/doves, due to their personal preference for the taste of these birds. However, these same residents suggested that hunting should be practiced in a controlled manner, with the definition of sustainable quotas, as a way of reconciling hunting activity with the issue of species conservation. The researchers and inspectors, on the contrary, believe that the improvement of the socioeconomic condition, combined with inspection activities and environmental education, could reduce or even extinguish the hunting activities of columbids in the region.

As in the present study, several studies carried out in Northeast Brazil indicate that the Columbidae family corresponds to one of the groups of birds most exploited by rural populations as a food resource (Alves et al., 2009; Bezerra et al., 2011; Nobrega et al., 2011; Fernandes-Ferreira et al., 2012; Fernandes et al., 2012; Fernandes-Ferreira, 2014; Barbosa et al., 2014). The results show that the columbids most consumed by rural residents in the present study are precisely the most abundant species in the studied region (unpublished data). This explains the fact that these same species are the most exploited by local hunters (Silva et al., 2021). Another point that draws attention is the motivations that lead local residents to consume columbids. The fact that they consume pigeons/doves more for the pleasure of the taste of wild meat than out of necessity, leads us to a new reflection on the links between poverty and hunting of wild animals, as done by Duffy et al. (2015) in a review of political and academic literature on hunting and illegal use of wild animals. Several studies in Northeast Brazil show that people hunt illegally because they are financially poor or lack alternative livelihood strategies (Alves et al., 2009; Nobrega et al., 2011; Alves et al., 2012; Barbosa et al., 2014). It is not uncommon in rural communities in the Northeast, for example, to hunt to “earn a penny” and buy rice, beans and other foods that make up the families’ basic food basket (Bragagnolo et al., 2019).

However, recent studies (Alves et al., 2009, 2012; Barboza et al., 2016; Santos, 2019) show that illegal hunting is more linked to cultural preferences for wild meat, as observed in the present study, and to entertainment activities rather than hunting for subsistence.

Wilderness, including the fauna, can provide important benefits to humans, through the so-called ecosystem services (Millennium Ecosystem Assessment, 2005), and the food provided by columbids is one of these valuable services (Michel et al., 2020). The meat of pigeons/doves is appreciated in several Brazilian regions (Bezerra et al., 2011; Nobrega et al., 2011; Alves et al., 2012; Fernandes-Ferreira et al., 2012; Lucena & Freire, 2012; Barbosa et al., 2014; Cajaiba et al., 2015; Mendonça et al., 2015; Silva et al., 2021; Souza et al., 2022), for this reason they suffer high hunting pressure. However, it is important to note that the benefits provided by this group of birds are not limited to just providing food. Some rural residents revealed that the singing of pigeons/doves can provide them with a sense of pleasure, a kind of non-material benefit provided by nature (hereinafter cultural service; Chan et al., 2012). For Cox and Gaston (2016), relationships between humans and birds have the potential to impact people's physical, mental, social comfort and happiness. Studies have shown, for example, that urban environments are more appreciated if birdsong is heard (Hedblom et al., 2014). Some bird calls are commonly associated with stress recovery (Ratcliffe et al., 2013) and have the potential to lessen the anxiety and depression felt by people as a result of the massive environmental changes our planet is experiencing (Clayton et al., 2013). In this sense, designing landscapes to promote human-nature relationships can help mitigate the problem of biodiversity loss and provide people with feelings of connection with nature (Cox & Gaston, 2018).

Bushmeat is appreciated in all regions of Brazil (Winck et al., 2022). However, it is important to pay attention to food safety, since, according to a recent study (Winck et

al., 2022), bushmeat is a relevant factor in the formation of observed patterns of emerging zoonoses. Still, research on the contribution of bushmeat to human health and nutrition remains limited (Van Vliet et al., 2017; Ingram et al., 2021; Torres et al., 2022; Winck et al., 2022). For Torres et al. (2022), this research gap is problematic because reliable evidence is essential for debates about the ethical and health implications of policies that promote the sustainable use of wildlife. The threat of zoonoses such as leprosy, Chagas disease, ornithosis and leptospirosis can be used to illustrate the public health hazards associated with handling and feeding wild birds and mammals (Gruber, 2017).

Although hunting wild animals is repudiated by most Brazilians, especially by urban populations (Marchini & Crawshaw, 2015), the social acceptance of hunting is usually evidenced by rural populations (Gama et al., 2016; Bragagnolo et al., 2017a,b), as observed in the present study. This is because the subsistence of rural populations are traditionally more dependent on the exploitation of natural resources, as shown by studies by Gama et al. (2016) and Bragagnolo et al. (2017a,b). It is worth emphasizing that hunting wild animals is usually repudiated by urban populations, however, studies on hunting and trade in wild animals, in different regions of the Brazilian Northeast, indicate that the commercialization of these animals (alive and/or slaughtered) is usually carried out in urban centers (Silva et al., 2021) and that many buyers are precisely residents of urban areas (Santos, 2017), thus revealing a moral contradiction on the part of the urban population. For professionals specializing in wildlife, such as IBAMA inspectors and researchers interviewed in this study, hunting is a conservation problem in Brazil (Fernandez et al., 2012; Fernandes-Ferreira & Alves, 2017). For these professionals, from a technical point of view, in Brazil and, more broadly, in Latin America, there is not enough data for wild fauna to be legally exploited as a source of food and income (Roper, 2006). They also claim that addressing an issue such as hunting in Brazil is challenging

and extremely complex, due to the continental size and existing cultural megadiversity (Bragagnolo et al., 2019).

Although there is not enough data to allow the hunting of pigeons/doves in Brazil, the fact that most rural residents are in favor of the exploitation of these birds in the region, suggesting controlled hunting as an alternative to legal hunting, is interesting because it reflects a positive view of columbid hunting inserted in the context of management and conservation of natural resources in a sustainable way (Robinson & Bennett, 2000). Advocates of recreational hunting, for example, argue that this type of hunting can provide subsistence (meat) and help conservation actions, preventing the conversion of natural habitats into pasture lands and the loss of biodiversity (Di Minin et al., 2021). However, it is important to note that recreational hunting can also drastically contribute to the population reduction of target species in the face of increasing human pressure on biodiversity (Di Minin et al., 2021).

Columbid explotation, mainly for food purposes, is shown to be a practice rooted in the local culture. Thus, according to Bezerra et al. (2012), only strengthening inspection is not enough to minimize this practice. In this sense, socioeconomic improvements can be more efficient in combating hunting in the region. Bragagnolo et al. (2019) point out that one way to reduce hunting pressure in Brazil is to reduce the main motivations for this practice, such as poverty and the lack of alternatives for income generation. Some African countries have been particularly active in integrating projects that aim to introduce alternative subsistence to reduce local communities' dependence on natural resources and bushmeat (Bragagnolo et al., 2019). However, the success of these projects depends almost exclusively on site-specific institutional, ecological and developmental conditions (Adams et al., 2004; Sanderson & Redford, 2004). In Brazil, a viable starting point would be the promotion of projects to integrate family income through activities

that add value to rural products (eg, honey production, organic food, craft production) (Lindsey et al., 2013). Another option aimed at alleviating poverty and reducing bushmeat hunting is the adoption of a local business-based approach, such as the Community Markets for Conservation (COMACO), developed with local communities around national parks in Zambia (Lewis et al., 2011). COMACO creates rural trade networks, training target families (people with less food security and poachers of wild animals) in sustainable agricultural practices, rewarding them with premium prices for their products, turning them into high value food products.

Another way to reduce hunting pressure, according to Bragagnolo et al. (2019), is to remove some of the financial incentives for hunting and trading wild animals by modifying supply chains. There is good evidence in other parts of the world that breeding in captivity can reduce the demand for wild captured birds (Jepson & Ladle, 2005, 2009). This option, in particular, could be viable for the main species of Columbidae hunted in the region of the present study, given the relative ease of adaptation of these birds to captivity.

As reported, IBAMA, the main body responsible for the inspection and control of wildlife in Brazil, has only seven inspectors working to deal with all types of environmental crimes throughout the state of Sergipe, which has an estimated population of 2,338,474 people (IBGE, 2021). For surveillance and inspection systems, such as IBAMA, fighting environmental crimes in places where culture is poorly aligned with conservation is a difficult task (Silva & Bernard, 2015), even more when it suffers from budget cuts and consequent reduction of inspectors (Brant & Machado, 2021). To further complicate this situation, IBAMA has suffered from the collection of imposed fines (Silva & Bernard, 2015). From 2005 to 2010, across the country, IBAMA issued around US$314 million in fines for crimes against wildlife, but in the same period, it received less than

2% of this amount in paid fines (Bennett, 2012). For Silva and Bernard (2015), such inefficiency has negative consequences for biodiversity, while such taxes could be used to finance environmental programs. Poor governance sends the wrong message to society (that wildlife crimes can be committed with impunity) (Gordon et al., 2009). In this way, the inspectors interviewed understand the problem of columbidae hunting in the region, they act correctly, curbing and imposing fines on hunters caught in this activity, but also understand that their work is far from producing efficient results in combating hunting of these birds. They also understand that more personnel would not be enough to reduce this activity, but rather combine greater supervision with financial assistance for the families involved in hunting.

The lack of population studies of columbid species in the region was pointed out as one of the biggest problems on the subject by the interviewed researchers. Everyone agreed that hunting is a problematic activity in the region, but the real impact of this activity on columbid populations is still unknown. Therefore, there was a suggestion that studies of this nature should be carried out, so that subsidies are provided to the competent authorities for making more assertive decisions. However, it is important to highlight the report of some residents about the decline of some species, already detected by them over the years (Silva et al., 2021). This decline, according to these residents, was attributed to the over-exploitation of these birds, but other reasons may be contributing to this decline, such as the use of pesticides in crops (Dibartolomeis et al., 2019; Li et al., 2020), climate change (Ay et al., 2014; Li et al., 2022) and increased urbanization (Aronson et al., 2014; Isaksson, 2018). Thus, long-term studies that evaluate all these possibilities should be conducted in the region, in order to assist in decision-making about columbid hunting.

Conclusion

The results obtained in this research demonstrate that the hunting of columbids is a cultural, leisure and subsistence activity, rooted in the rural communities studied in the municipality of Itabaiana, Sergipe. It is an activity known by the inspection agency (IBAMA) and by the researchers in the region, who, due to lack of personnel or research, are unable to extinguish or even reduce hunting of these birds. Thus, actions by public agencies that improve the socioeconomic condition of the population, that combine conservation with sustainable exploitation, in addition to environmental education actions are important to combat indiscriminate hunting of columbids locally. Studies that evaluate the dynamics of columbid populations in the region, as well as the impacts caused by hunting and other human activities, are necessary for the long-term conservation of the native species of doves and pigeons of Itabaiana.

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CONSIDERAÇÕES FINAIS

O Capítulo 1 “Hunting and trade of Columbidae in Northeast Brazil”, revelou sete espécies de columbídeos que são caçadas em grandes números na região principalmente para uso alimentar. As espécies mais caçadas, de acordo com os caçadores entrevistados, foram *C. talpacoti*, *C. picui* e *C. minuta*. Três instrumentos de caça foram identificados, sendo a espingarda de chumbo o mais utilizado para o abate das aves. Também foi revelado que os columbídeos são caçados preferencialmente na estação seca, em áreas abertas (pastagens e áreas agrícolas) e durante a noite. Além disso, foi identificado que os columbídeos capturados são comercializados vivos e/ou abatidos em duas feiras livres no centro urbano do município.

O Capítulo 2 “Seasonal variation in the abundance and density of columbid (Aves: Columbidae) in a region with high hunting pressure”, revelou que a maioria das espécies de Columbidae registradas na região foram mais abundantes durante a estação chuvosa. Também foi revelado que mais da metade das espécies apresentaram abundâncias baixas e tendência de declínio ao longo do ano.

O Capítulo 3 “To hunt or not to hunt? Analyzing different perceptions about columbid hunting (Aves: Columbidae) in Sergipe, Northeastern Brazil”, revelou que a maioria dos moradores locais fazem uso regular de columbídeos, principalmente como recurso alimentar, sugerindo a caça controlada como uma forma de conciliar a prática da caça com a conservação desse grupo de aves. Já os fiscais do IBAMA e os pesquisadores são contra a caça e acreditam que a melhoria da condição socioeconômica dos moradores, em especial, pode mitigar o problema da caça.

Posto isso, os resultados do presente estudo deixam claro que a proibição da caça no Brasil, por meio da Lei de Proteção à Fauna (Lei n° 5.197/67) e da Lei de Crimes Ambientais (Lei n° 9.605/98), não foi suficiente para mitigar ou erradicar a caça de aves cinegéticas, como as da família Columbidae, uma vez que sua caça e comercialização continuam sendo praticadas de maneira ilegal e, provavelmente, insustentável na região estudada. É possível que a pressão de caça na região seja a responsável pelas baixas abundâncias populacionais dos columbídeos que foram amostrados. Por outro lado, é importante salientar a importância dessas aves, sobretudo, como recurso alimentar para as comunidades rurais. Neste sentido, faz-se necessário discutir sobre a possibilidade da transição de uma cultura de caça popular, porém descontrolada, para uma condição de manejo sustentável e cientificamente embasado, capaz de frear o problema da caça ilegal, prevenir o declínio e perda de espécies e manter, em longo prazo, a possibilidade de exploração dos columbídeos como fonte de alimento e renda pelas famílias com menor renda. Contudo, para que essas aves possam vir a ser utilizadas legalmente como recurso natural, é importante que ações sejam tomadas, como o monitoramento populacional de longo prazo; o estabelecimento de números máximos de aves que podem ser capturadas/abatidas; uma melhor distribuição de renda para a população local; e uma maior fiscalização para o combate ao comércio ilegal. Todavia, faz-se importante que, durante todo esse processo, atividades de educação ambiental sejam desenvolvidas, objetivando a mudança de atitude da população em relação a caça ilegal e descontrolada de columbídeos.

APÊNDICE

For rural residents:

1) Do you eat or have you ever eaten doves/pigeons?

Yes ( ) No ( ) If yes, which species?

2) For what reason do you eat or have eaten doves/pigeons?

3) If the doves/pigeons ended up around here, do you think this would impact your life?

Yes ( ) No ( ) Why?

4) If you could, would you give up doves/pigeons for chicken or beef?

Yes ( ) No ( ) Why?

5) Do you agree that doves/pigeons can be hunted here in the region like other animals are?

Yes ( ) No ( ) Why?

6) If you agree with the hunting of doves/pigeons, please propose something to make the hunting happen without causing substantial damage to the species' populations.

7) If you disagree with the hunting of doves/pigeons, please propose something to mitigate the hunting problem in the area.

For IBAMA inspectors:

1) Do you agree that doves/pigeons can be hunted here in the region like other animals are?

Yes ( ) No ( ) Why?

2) If you agree with the hunting of doves/pigeons, please propose something to make the hunting happen without causing substantial damage to the species' populations.

3) If you disagree with the hunting of doves/pigeons, please propose something to mitigate the hunting problem in the area.

4) Do you usually apprehend many dove hunters here in the area?

Yes ( ) No ( ) If yes, how many seizures per month?

5) What happens to people who are caught hunting?

For researchers

1) Do you agree that doves/pigeons can be hunted here in the region like other animals are?

Yes ( ) No ( ) Why?

2) If you agree with the hunting of doves/pigeons, please propose something to make the hunting happen without causing substantial damage to the species' populations.

3) If you disagree with the hunting of doves/pigeons, please propose something to mitigate the hunting problem in the area.