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DRIÉLLI DE CARVALHO VERGNE

“DISTÂNCIA DO FRAGMENTO FLORESTAL, CARACTERÍSTICAS E DENSIDADE DAS ÁRVORES ISOLADAS INFLUENCIAM NA DISPERSÃO DE SEMENTES NO PASTO”

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Dissertação apresentada como parte dos requisitos para obtenção do título de Mestre em Ecologia e Tecnologia Ambiental pela Universidade Federal de Alfenas. Área de concentração: Meio Ambiente, Sociedade e Diversidade Biológica.

Orientador: Prof. Dr. Flavio Nunes Ramos

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DRIÉLLI DE CARVALHO VERGNE

"DENSIDADE E TAMANHO DAS ÁRVORES ISOLADAS, BEM COMO A DISTÂNCIA DO FRAGMENTO FLORESTAL INFLUENCIAM NA DISPERSÃO DE SEMENTES NO PASTO, DE ACORDO COM A SÍNDROME DE DISPERSÃO."

A Banca julgadora, abaixo assinada, aprova a Dissertação apresentada como parte dos requisitos para a obtenção do título de Mestre em Ecologia e Tecnologia Ambiental pela Universidade Federal de Alfenas. Área de Pesquisa: Meio Ambiente Sociedade e Diversidade Biológica.

Aprovado em: 15 de abril de 2015.

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"A mente que se abre a uma nova ideia nunca mais volta ao seu tamanho original."

(Albert Einstein)

RESUMO

A fragmentação florestal devido a criação de pastagens pode restringir a dispersão de sementes através dessas áreas remanescentes. Entretanto, é possível que alguns fatores nas paisagens fragmentadas possam melhorar a dispersão de sementes. Nosso objetivo é verificar se (i) a distância dos fragmentos florestais, (ii) a densidade de árvores isoladas, bem como, (iii) se algumas características das árvores influenciam a dispersão de sementes nos pastos. Este trabalho foi realizado em seis pastos próximos a fragmentos florestais com um gradiente de árvores isoladas. Em cada paisagem, foram instalados 18 coletores (totalizando 108), distribuídos em seis distâncias diferentes a partir da borda do fragmento florestal (0, 5, 10, 20, 40 e 80m). Os dados foram analisados através do GLM e comparados pelo AIC. Foram coletadas 8162 sementes distribuídas em 26 espécies, e classificadas de acordo com sua síndrome de dispersão: 4722 anemocóricas, 3304 epizoocóricas, 72 autocóricas e 64 endozoocóricas. Nossos resultados mostraram que a proximidade dos fragmentos florestais, uma grande densidade de árvores isoladas nos pastos e, árvores com maior altura e volume de copa pode promover uma melhor dispersão de sementes nos pastos para as espécies endozoocóricas, anemocóricas e autocóricas, porém esses fatores reduzem a dispersão de espécies epizoocóricas. Estes resultados podem ajudar a restauração em pastos ou ainda ajudar na implementação de sistemas silvipastoris, o que poderá ajudar a melhorar a dispersão de sementes em habitats mais danificados, promovendo uma melhor conectividade entre os fragmentos florestais remanescentes nesses tipos de paisagens.

Palavras chave: Anemocoria. Autocoria. Endozoocorica. Epizoocoria. Chuva de sementes.

ABSTRACT

Pasture creation resulting in forest fragmentation could restrict seed dispersal around these remnants. However, it is possible that some factors in a fragmented landscape could improve seed dispersal. We aim to verify whether (i) distance from forest fragments, (ii) density of isolated trees, as well as (iii) if some plant characteristic influence seed dispersal in pastures. This study was carried out in six pastures near forest fragments with a range of isolated tree densities. In each landscape, we installed 18 seed traps (total=108 traps), distributed over 6 distance classes from the edge of forests (0, 5, 10, 20, 40 and 80m). We performed GLM analyses that were compared by AIC. We collected 8162 seeds and found 26 species: 4722 anemochorous, 3304 epizoochorous, 72 autochorous, and 64 endozoochorous seeds. Our results show that proximity to forests fragments, having a greater isolated tree density in pastures, and including isolated trees of greater height and canopy cover promote seed dispersal in pastures for endozoochorous, anemochorous, and autochorous species but reduce it for the epizoochorous ones. These results may help restoration in pasture or assist in implementing silvopastoral systems in order to improve seed dispersal in this harsh habitat that promotes better connectivity between forest fragments in this landscape.

Keywords: Anemochory. Autochory. Endozoochory. Epizoochory. Seed rain.

SUMÁRIO

INTRODUÇÃO GERAL

A expansão do desenvolvimento humano, bem como a intensificação das pressões antrópicas sobre o ambiente natural são as principais causas da substituição das paisagens naturais por áreas de agricultura, agropecuária e áreas urbanas (VIANA et al., 1997). Essas ações diretas nos ambientes naturais convertem áreas de cobertura florestal contínua em fragmentos florestais, muitas vezes isolados uns dos outros.

1.1 FRAGMENTAÇÃO FLORESTAL

A fragmentação florestal acarreta muitos problemas, como a perda de habitas e o isolamento espacial dessas manchas (SAUNDERS et al., 1991). Segundo Steffan-Dewenter et al. (2002), isso pode afetar diretamente a riqueza de espécies, alterar o fluxo gênico, intensificar as competições e extinções das espécies que ocupam essas áreas fragmentadas (PRIMACK; RODRIGUES, 2001). Fahrig e Merriam (1994) afirmam que o risco de extinções se deve mais especificamente a pouca ou nenhuma imigração de indivíduos para estas áreas, já que essa movimentação acaba sendo dificultada devido à ausência de vegetação nativa nas áreas circundantes aos fragmentos florestais. Todos estes fatores podem levar a perda da funcionalidade do ecossistema ou a redução do seu "*fitness*" (REED; FRANKHAM, 2003; DIEKÖTTER et al., 2007; HAYNES et al., 2007; FARWIG et al., 2009). Além disso, a perturbação de florestas pode levar a perda da estrutura da vegetação e de animais dispersores, alterando os processos de auto-manutenção, regeneração e expansão da floresta (PIVELLO et al., 2006).

Junto com a fragmentação florestal há também a formação das matrizes, as quais podem ser descritas como áreas homogêneas não nativas, ambientes mais severos, ao redor dos fragmentos de vegetação remanescente (TISCHENDORF; FAHRIG, 2001; LINDENMAYER; FRANKLIN, 2002). As matrizes podem ser formadas por culturas agrícolas, como por exemplo, cana-de-açúcar, café, milho ou soja; ou também pastagens, estradas e até mesmo áreas urbanas. Dependendo da distância entre fragmentos e da permeabilidade da matriz, um fragmento florestal pode estar completamente isolado de outras áreas florestais, o que compromete a movimentação de agentes polinizadores e dispersores, podendo afetar a dinâmica populacional, a persistência dessas espécies na comunidade e a conectividade funcional nesse habitat (ROLAND et al., 2000; RICKETTS, 2001; HAYNES; CRONIN, 2003; VANDERMEER; CARVAJAL, 2001; CRONIN; HAYNES, 2004). Assim, os pastos podem ser considerados o tipo de matriz que mais dificulta a dispersão de sementes entre os fragmentos florestais adjacentes (LAURANCE et al., 2002).

2 DISPERSÃO DE SEMENTES

A dispersão de sementes é um processo fundamental para o ciclo de vida das espécies vegetais, pois é responsável pelo transporte de propágulos a partir da planta mãe até distâncias seguras para que estas possam se estabelecer no ambiente (HOWE; MIRITI, 2004). As sementes que forem transportadas às distâncias maiores da planta mãe terão maior sucesso e maior probabilidade de sobrevivência das plântulas. A movimentação das sementes pelo seu habitat pode variar de centímetros a quilômetros, sendo essa distância dependente da síndrome de dispersão de cada espécie (HOLL, 1999).

As síndromes de dispersão de sementes podem ser abióticas ou bióticas. As espécies vegetais com síndrome de dispersão abiótica são aquelas que são transportadas pelo vento (anemocoria) ou pela água (hidrocória). As sementes anemocóricas geralmente apresentam tamanho reduzido e plumas ou estruturas aladas para facilitar a sua movimentação pelo ar. A anemocoria tem sido associada a espécies pioneiras, a ambientes secos e/ou sazonais, as áreas abertas e a distâncias relativamente próximas as bordas dos fragmentos florestais (JANZEN, 1988; FRANKIE et al., 1974; HOWE; SMALLWOOD, 1982; DREZNER et al., 2001; OLIVEIRA; MOREIRA, 1992). Além disso, a ausência de cobertura de dossel contínua e baixa precipitação são condições que favorecem a dispersão das espécies vegetais anemocóricas (HOWE; SMALLWOOD, 1982; MORELLATO et al., 1989). A dispersão por hidrocoria ocorre através da água, pois estas sementes possuem espaços aéreos internos que facilitam a sua flutuação, além de baixo peso. Por sua vez, as espécies vegetais com dispersão biótica são aquelas que utilizam mecanismos do próprio diásporo, a autocoria e a zoocoria. As sementes autocóricas são dispersas através da gravidade ou por balística, mecanismos os quais são capazes de transportá-las a distâncias seguras da planta-mãe. As espécies vegetais autocóricas geralmente frutificam na estação seca, principalmente por apresentarem fruto seco e deiscente (VAN DER PIJL, 1982). Assim, sementes autocóricas podem ser mais vantajosas em áreas abertas, como as pastagens (ROTH, 1987). Já as espécies zoocóricas são aquelas que possuem características que possam ser carregados por agentes dispersores animais, como mamíferos, aves ou insetos. Essas sementes podem possuir estruturas externas, como arilo, elaiossomo ou pericarpo carnoso de coloração e/ou odor atrativos para a fauna (endozoocoria); ou então possuir ganchos e estruturas adesivas que possam se fixar ao corpo dos animais (epizoocoria) (VAN DER PIJL, 1982; HOWE; SMALLWOOD, 1982). A dispersão de sementes por meio dos agentes dispersores é essencial para a manutenção do ecossistema. A remoção de um ou outro pode causar consequências irreversíveis para as populações animais e vegetais (SARAVY et al., 2003). Além disso, a dispersão de sementes é fundamental no processo de conservação ambiental, bem como na regeneração florestal (JORDANO et al., 2006); já que é através da dispersão que as sementes alcançarão novas áreas abertas e darão início ao processo de sucessão ecológica. Assim, umas das melhores maneiras de se entender os processos iniciais de sucessão é através do estudo da dispersão de sementes, pois este é um processo fundamental da organização estrutural e dinâmica das florestas tropicais. Além disso, a dispersão pode promover a manutenção do potencial demográfico das futuras populações desse bioma (HARDESTY; PARKER, 2002).

2.1 DISTÂNCIA E DENSIDADE DE SEMENTES

Apenas 5 trabalhos estudaram a influência da distância de fragmentos florestais na chuva de sementes em pastagens. A densidade de sementes florestais dispersas nas pastagens tende a diminuir com o aumento da distância em relação às bordas dos fragmentos florestais (AIDE; CAVALIER, 1994; HOLL, 1999; CUBIÑA; AIDE, 2001; DOSCH et al*.,* 2007; MARTÍNEZ-GARZA et al*.*, 2009). Destes, apenas um não mostrou as síndromes de dispersão das sementes coletadas. Porém, nenhum deles diferenciou entre endozoocórica e epizoocórica a dispersão realizada por animais.

Porém, o tipo de semente (diferentes tamanhos, pesos e síndromes de dispersão, por exemplo) pode influenciar nesta distância de dispersão, sendo que as sementes mais pesadas chegam a distâncias menores do que as sementes mais leves (TEEGALAPALLI et al*.*, 2010). Assim, as sementes anemocóricas atingem distancias maiores em relação a borda do fragmento, geralmente de 30 a 64 m, podendo chegar a 90 m (TEEGALAPALLI et al*.*, 2010; MARTÍNEZ-GARZA et al*.*, 2009). Isso, provavelmente, ocorre por que as sementes dispersas pelo vento não dependem de animais para essa movimentação, conseguindo atravessar mais facilmente áreas abertas (menor quantidade de barreiras que diminuem a velocidade do vento), como as pastagens. Além disso, há uma forte interação entre o habitat e o tipo de dispersão de sementes, já que para a formação das florestas secundárias é necessário que haja regeneração natural de uma área aberta (MARTÍNEZ-GARZA et al., 2009).

As sementes endozoocóricas ficam mais restritas às áreas próximas às bordas dos fragmentos, não ultrapassando 20 m, segundo Cubiña e Aide (2001), já que há uma forte dependência com agentes dispersores (DA SILVA et al*.*, 1996; HOLL, 1999; MARTÍNEZ-GARZA; GONZÁLEZ-MONTAGUT, 1999). A dispersão das sementes zoocóricas no pasto é dificultada porque as aves e mamíferos dessas florestas, raramente se movimentam através de áreas abertas, como as pastagens, já que estas áreas aumentam a exposição desses animais aos predadores e a condições climáticas desfavoráveis, como alta temperatura e baixa umidade (HOLL, 1999; CUBIÑA; AIDE, 2001; BELSKY et al., 1989; RHOADES et al., 1998). Isso mostra que a chegada de sementes é um fator limitante para a recuperação florestal em pastos abandonados. Alguns poucos trabalhos encontraram dispersão de sementes em pasto a distâncias maiores que 200 m (HOLTHUIJZEN; SHARIK, 1985; VERDÚ*;* GARCÍA-FAYOS, 1998). Essa dispersão a longa distância ocorreu, provavelmente, devido a presença de cercas vivas e oliveiras nos pastos estudados, já que estas podem atrair os agentes dispersores, os quais utilizam essas estruturas como poleiros e acabam concentrando a entrada dos propágulos locais (MCDONENNEL; STILES, 1983; DEBUSSCHE et al., 1982).

2.2 ÁRVORES ISOLADAS NO PASTO

No processo de fragmentação florestal há a formação das matrizes, as quais podem ser descritas como áreas não nativas, ao redor dos fragmentos de vegetação remanescente (LINDENMAYER; FRANKLIN, 2002). A distância entre os fragmentos e a permeabilidade das matrizes podem comprometer a movimentação dos agentes polinizadores e dispersores nesses locais (ROLAND et al., 2000; RICKETTS, 2001; HAYNES; CRONIN, 2003). Isso pode afetar a dinâmica populacional, a persistência dessas espécies na comunidade (VANDERMEER; CARVAJAL, 2001; CRONIN; HAYNES, 2004), além da conectividade funcional nesse habitat.

A dispersão de sementes florestais depende diretamente da movimentação dos agentes dispersores através das áreas. Essa movimentação acaba sendo dificultada, principalmente, se as áreas florestais encontram-se fragmentadas com uma matriz pouco permeável (pasto) entre elas. Para que a movimentação de animais e de sementes ocorra entre estes fragmentos florestais e mais especificamente, para que haja uma conectividade estrutural e funcional entre eles, é necessária a implantação de alguns facilitadores; como os corredores ecológicos e/ou os “stepping stones” (METZGER, 2000; GODEFROID; KOEDAM, 2003). Os corredores ecológicos são manchas de vegetação entre os fragmentos florestais e que podem atuar como conectivos para o sucesso de polinização e dispersão de algumas espécies, como insetos, aves e pequenos mamíferos (HILL, 1995; NICHOLLS et al., 2001; GUEVARA; LABORDE, 1993; LUCK; DAILY, 2003; BOLGER et al., 2001; COFFMAN et al., 2001). Além disso, eles podem aumentar o tamanho e o fluxo gênico entre as populações existentes nestas áreas (FAHRIG; MERRIAM, 1985; DUNNING et al., 1995; HADDAD; BAUM, 1999; AARS; IMS, 1999; MECH; HALLET, 2001). Já os “stepping stones” são uma series de pequenas manchas de vegetação ou árvores isoladas, as quais são capazes de proporcionar uma conectividade entre os fragmentos de vegetação remanescente quando hábitats contínuos não podem ser obtidos ou quando os “stepping stones” são mais representativos na configuração natural da paisagem (HADDAD, 2000; FISCHER; LINDENMAYER, 2002; MURPHY; LOVETT-DOUST, 2004). Assim, tanto os corredores, quanto os “stepping stones” são elementos fundamentais para ajudar na conectividade de paisagens fragmentadas, sendo que essa conectividade também influencia na abundância e distribuição de plantas com sementes (METZGER, 1998).

As árvores ou arbustos remanescentes nas pastagens promovem a conectividade quando arranjadas de diferentes formas, como, cercas vivas, quebra ventos, pequenas manchas florestais e até mesmo, as árvores isoladas em si (YAHNER, 1982; NEPSTAD et al*.,* 1996; PERFECTO et al*.,* 1996). Para as aves, as árvores isoladas podem fornecer recompensa nutricional, um importante ponto de parada, forragem, nidificação**,** canto e proteção contra predadores (LUCK; DAILY, 2003; WEGNER; MERRIAM, 1979; MCDONNELL; STILES, 1983; MCCLANAHAN; WOLFE, 1987). Assim, a presença de árvores e/ou arbustos nas pastagens faz com que haja uma melhora na chuva de sementes nesses locais (HARVEY, 2000). Além disso, árvores ou arbustos isolados que produzam frutos podem fornecer importantes recursos para as aves frugívoras e podem suportar uma rica diversidade de outros táxons (DUNN, 2000).

Luck e Daily (2003) sugerem que a adoção de pequenas mudanças no uso da terra, como o aumento da densidade de árvores frutíferas, a manutenção de cercas vivas e a proteção de remanescentes florestais, pode aumentar a diversidade da avifauna em áreas agriculturáveis e contribuir fortemente na dispersão de sementes de plantas de florestas tropicais.

Há vários trabalhos que estudaram a importância das árvores isoladas nos pastos, as quais podem funcionar como corredores florestais em paisagens fragmentadas (YAHNER, 1982; GREENBERG, 1989; POWELL et al., 1989; ROBBINS et al., 1989; NEPSTAD et al., 1996; PERFECTO et al., 1996; GUINDON, 1997; ESTRADA, 1997). Esses trabalhos mostram que a chuva de sementes é maior sob as árvores isoladas (WEGNER; MERRIAM, 1979; GUEVARA; LABORDE, 1993; DUNCAN; CHAPMAN, 1999; HARVEY, 2000; SLOCUM; HORVITZ, 2000; COLE et al., 2010). Porém não há nenhum trabalho que tenha estudado diretamente a influência da quantidade de árvores na dispersão ou na chuva se sementes. O número de árvores isoladas nos pastos pode influenciar diretamente a dispersão de sementes nessas áreas, além de aumentar a biodiversidade local (IBRAHIM et al., 2001; PAGIOLA et al., 2004).

2.3 CARACTERÍSTICAS DAS ÁRVORES ISOLADAS

A movimentação dos agentes dispersores e das sementes através das matrizes, principalmente as mais abertas (pastos), é facilitada pela presença os corredores ecológicos e/ou os “stepping stones” (METZGER, 2000; GODEFROID; KOEDAM, 2003). Porém, além da presença desses facilitadores de movimentação e dispersão nesses ambientes, é necessário que essas árvores possuam características potenciais para que os agentes dispersores sejam atraídos para o pasto e assim, a dispersão de sementes seja mais efetiva. Takahashi e Kamitani (2004) sugerem que uma maior qualidade de atração de um local, proporcionará maior frequência de visitas pelos agentes dispersores e consequentemente, haverá um maior número de sementes regurgitadas ou defecadas sob o poleiro.

As características das árvores presentes nos pastos que poderiam atrair mais agentes dispersores seriam: altura, volume de copa, diâmetro e cavidades presentes no tronco (GUEVARA et al., 1992; DEAN et al., 1999; SLOCUM; HORVITZ, 2000; HOLL, 1998; COLE et al., 2010; MAZUREK; ZIELINSKI, 2004). Árvores mais altas podem afetar a estrutura da vegetação e a composição florística nas pastagens, além de fornecer abrigo, locais para a nidificação e forrageio (MCDONNELL, 1986; DEAN et al., 1999). Em contraste, plantas mais baixas (como arbustos, menores de dois metros de altura), geralmente possuem dispersão epizoocórica para que possam se adaptar as habilidades dos agentes dispersores nos pastos (GUITIAN; SANCHEZ, 1992; HUGHES et al., 1994). As sementes possuem mecanismos de dispersão com ganchos ou cerdas para que elas possam aderir ao pelo ou à pele dos agentes dispersores e consigam alcançar maiores distâncias (SHMIDA; ELLNER, 1983; KIVINIEMI; ERIKSSON, 1999).

Volume de copa mais denso pode atrair agentes dispersores devido a sua estrutura, a qual pode fornecer os mesmos benefícios encontrados em árvores mais altas. Além disso, volume de copa mais denso melhora o microclima sob as árvores presentes nas pastagens, pois reduz a incidência de radiação solar e, consequentemente a temperatura; além de aumentar a umidade do ar (BELSKY et al., 1989). Outros benefícios da presença de árvores isoladas em relação ao microclima estão relacionados à melhora da fertilidade e ao aumento da capacidade de armazenamento de água pelo solo (KELLMAN, 1979; RADWANSKI; WICKENS, 1967; PUERTO; RICO, 1988; BELSKY et al., 1989; WELTZIN; COUGHENOUR, 1990; JOFFRE; RAMBAL, 1988). Além disso, árvores com maior volume de copa podem produzir uma maior quantidade de frutos e assim, fornecer melhores condições para os agentes dispersores de sementes endozoocóricas(MCDONNELL, 1986; GUEVARA et al., 1992; DUNCAN; CHAPMAN, 1999).

Árvores com maior diâmetro e com cavidades presentes no troco parecem ser importantes para algumas espécies de aves (MAZUREK; ZIELINSKI, 2004). As cavidades podem ser usadas por morcegos para a reprodução e pelas corujas para nidificação e pousio (MOEN; GUTIÉRREZ, 1997; IRWIN et al., 2000).

Segundo Holl (1999), o plantio de árvores nativas com características específicas e a instalação de poleiros artificiais, para que os agentes dispersores possam ser atraídos para os pastos, podem aumentar a quantidade de sementes dispersas no pasto, melhorando a conectividade entre fragmentos florestais e a biodiversidade local, além de ajudar nos processos de regeneração florestal (CUBIÑA; AIDE, 2001).

Desta forma, o presente trabalho visou observar através da chuva de sementes, se existe uma maior densidade e diversidade de sementes em pastos perto de fragmentos florestais; e se o número de árvores isoladas e suas características tem efeito direto nessa chuva. Nosso trabalho foi conduzido em seis pastos próximos a diferentes fragmentos florestais com diferentes quantidades de árvores isoladas. Instalamos 18 coletores de sementes, em cada um dos pastos a diferentes distâncias (0, 5, 10, 20, 40 e 80m) a partir da borda do fragmento florestal. Este estudo se torna importante e essencial para as áreas de pastagens porque propiciará a compreensão das características de conectividade dos fragmentos florestais que possibilitam a expansão ou manutenção da biodiversidade.

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ARTIGO: DISTANCE FROM FOREST FRAGMENT EDGE, ISOLATED TREES' DENSITY AND CHACARTERISTICS INFLUENCE SEED DISPERSAL IN PASTURE

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DISTANCE FROM FOREST FRAGMENT EDGE, ISOLATED TREES' DENSITY AND CHACARTERISTICS INFLUENCE SEED DISPERSAL IN PASTURE

Running head: FACTORS INFLUENCING SEED DISPERSAL IN PASTURE

Keywords: Anemochory, autochory, endozoochory, epizoochory, seed rain.

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ABSTRACT

Pasture creation resulting in forest fragmentation could restrict seed dispersal around these remnants. However, it is possible that some factors in a fragmented landscape could improve seed dispersal. We aim to verify whether (i) distance from forest fragments, (ii) density of isolated trees, as well as (iii) if some plant characteristic influence seed dispersal in pastures.This study was carried out in six pastures near forest fragments with a range of isolated tree densities. In each landscape, we installed 18 seed traps (total=108 traps), distributed over 6 distance classes from the edge of forests (0, 5, 10, 20, 40 and 80m). We performed GLM analyses that were compared by AIC. We collected 8162 seeds and found 26 species: 4722 anemochorous, 3304 epizoochorous, 72 autochorous, and 64 endozoochorous seeds. Our results show that proximity to forests fragments, having a greater isolated tree density in pastures, and including isolated trees of greater height and canopy cover promote seed dispersal in pastures for endozoochorous, anemochorous, and autochorous species but reduce it for the epizoochorous ones. These results may help restoration in pasture or assist in implementing silvopastoral systems in order to improve seed dispersal in this harsh habitat that promotes better connectivity between forest fragments in this landscape.

Keywords: Anemochory, autochory, endozoochory, epizoochory, seed rain.

INTRODUCTION

Seed dispersal is an important process in the life cycle of plants species. Seeds are moved to “safe distances” from parent plant mediations, where competition and predation rates are decreased (Howe and Miriti 2004). Dispersal mechanisms are essential for the distribution and movement of plant species, as well as being a source for the exchange of genetic material both within and between populations (Abraham de noir and Abdala 2002). The process of seed dispersal can maintain forest dynamics, direct the ecological succession, and encourage changes in the community (Hardesty and Parker 2002), and it is essential to maintain plant diversity and their spatial structure (Schupp et al. 2002; Wang and Smith 2002; Trakhtenbrot et al. 2005; Bascompte and Jordan 2006). Thus, seed dispersal is very important for the regeneration of naturally occurring plants (Janzen 1970).

Seed dispersal can be damaged by forest fragmentation, because fragmentation has a direct effect on the loss of animal and plant biodiversity (Galetti et al. 2003). Moreover, forest fragmentation and habitat loss can cause the isolation of populations of animals and plants due to a reduction in the amount of forest and fragment isolation that is surrounded by discontinuous areas called matrices (Forman and Godron 1986). Matrices can be crops (for example sugar cane, coffee, and corn), pastures, roads, or even urban areas. The matrices are characterized by homogeneous and harsher environments, hampering the movement of dispersal agents between forest fragments (Tischendorf and Fahrig 2001), and therefore, harming the functional connectivity of the landscape (Roland et al. 2000; Ricketts 2001; Baum et al. 2004). Consequently, pastures may be considered one of the matrix types for which seed dispersal between adjacent fragments is more difficult (Laurance et al. 2002). Pastures are large continuous areas with low vegetation and few shrubs or trees, which makes animal and plant (seeds and pollen) movement difficult between remaining forest fragments. Most frugivorous animals act as dispersal agents and may not cross open or disturbed areas (Estrada et al. 1993; Da Silva et al. 1996). Furthermore, the movement of seed dispersers can be stopped in pastures due to a greater exposure to predators and harsher microclimatic conditions (Laborde et al. 2008; Cubiña and Aide 2001), such as higher temperature and wind velocity (Rhodes et al. 1998).

Another of the factors that could affect seed dispersal in pastures is distance from the source. Dispersed seeds in pasture are not usually transported large distances from the edges of forest fragments (Aide and Cavalier 1994; Holl 1999; Cubiña and Aide 2001; Dosch et al. 2007; Martínez-Garza et al. 2009) because forest fragments are their propagule sources (van der Maarel 2005). One other factor that influences seed dispersal in pastures is the density of isolate trees. Tree presence in degraded areas reduces many barriers to dispersal and seed germination, besides helping seedling establishment (Guevara et al. 1986; McClanahan and Wolfe 1993; Toh et al. 1999; Slocum and Horvitz 2000; Laborde et al. 2008; Cole et al. 2010). Thus, the presence of isolated trees or small patches of trees in pasture may be a good choice to increase animal and seed movement, and consequently, improve the structural and functional connectivity of fragmented habitats (Wegner and Merriam 1979; Forman and Baudry 1984; Fahrig and Merriam 1985; Noss and Harris 1986; Bennett et al. 1994; Forman 1995; Wunderle 1997; Metzger 2000; Godefroid and Koedam 2003). Another factor that influences seed dispersal is plant characteristics. A location of better quality will attract more animals, thus offering a higher number of visits by dispersal agents and hence, an increased amount of regurgitated or defecated seeds around it (Takahashi and Kamitani 2004). Characteristics such as canopy cover and tree diameter and height can influence seed rain. Taller trees can provide shelter, nesting, and foraging sites (McDonnell 1986; Dean et al. 1999). A broad canopy cover promotes attractive environments for seed dispersers and improves the microclimate beneath these trees in pastures (Belsky et al. 1989). Trees with a larger diameter and hollows in the trunk could be important for some species of birds (Mazurek and Zielinski 2004).

Some characteristics of seed dispersal processes in pastures are poorly investigated, such as isolated tree density and the structural characteristics of individual trees. Knowledge and understanding the influences of these characteristics on seed rain is very important when trying to implement plans to increase the number and quality of animal movements in fragmented landscapes. Thus, understanding the characteristics of forest fragments' connectivity in these areas may expand or maintain the biodiversity. Our aim is to verify, through the seed rain, whether there is a greater seed density and diversity in pastures near forest fragments and if there is an effect of greater isolated tree density. More specifically, whether (i) there is greater seed rain (abundance and richness) dispersal close to forest fragments, (ii) seed abundance and richness are greater in pastures with higher tree density, and (iii) the structural characteristics of isolated trees, such as canopy cover, height, and diameter, have an influence on the seed rain.

We expected that the distance from forest fragments (Cubiña and Aide 2001; Dosch et al. 2007; Martínez-Garza et al. 2009), the number of trees in pastures (Wegner and Merriam 1979; Guevara and Laborde 1993; Harvey 2000) and the structural characteristics of isolated trees (McDonnell and Stiles 1983; Holl 1998; Dean et al. 1999; Duncan and Chapman 1999; Mazurek and Zielinski 2004; Cole et al. 2010) would influence seed dispersal in pastures. We predicted that (i) seed abundance and richness may be lower at greater distances from forest fragments, except for those belonging to the anemochorous syndrome; (ii) pastures with more isolate trees will present greater seed abundance and richness; and (iii) isolated trees with more complex characteristics, such as extensive canopy cover and greater height and diameter may attract a greater abundance of seed dispersers.

MATERIAL AND METHODS

Study area

This study was carried out in nine landscapes (2 km radius) formed from forest fragments (20 to 40% forest cover) surrounded by active pastures. However, there were many damaged traps in three of these nine landscapes (Table 1). We always replaced damaged traps in all landscapes, but we prefer exclude most damaged landscapes (P21, P7 and Valeriano, landscapes with ≥ 45% damaged traps in all samples) of our analyses. The six landscapes chosen (Table 2) presented a range of isolated trees (considering any tree in pastures) densities in the pastures. Trees in pasture were classified in 30 families and 90 species. The species richness ranged from 5 to 37 species per pasture. The families that presented the most individuals were Fabaceae (262), Asteraceae (61), Cannabaceae (57), Apocynaceae (37), Malvaceae (25), Lamiaceae (23), and Boraginaceae (21), which together accounted for almost 70% of the total trees. Most pasture trees were represented by small individuals, with about 75% of the trees having a diameter≤ 20 cm and 88% of trees being shorter than 10 m. The mean diameter was 17.9 cm (a range of 5 to 215 cm) and the mean height of trees was 7.1 m (varying between 1.5 and 25 m). About dispersal syndromes, Anemochorous trees accounted for 57% of the total number of trees and 33% of total species, while zoochorous trees accounted for 37% of trees and 55% of species (Gonçalves et al. in prep).

The study area is situated in the semi-deciduous Atlantic Forest domain and it is located around Alfenas (45º 56' 50"W and 21º 25' 45"S), Minas Gerais, Brazil. The climate is classified as Cwb (with dry winters and hot and humid summers) according to the Köppen system (Vianello and Alves 1991). The average annual rainfall is around 1500 mm with average annual temperatures ranging between 17ºC and 24°C. The studied area's forest is fragmented, presenting only 9 % of its original coverage, with the fragments being surrounded by different matrices such as coffee, sugar cane, urban areas, and a high percentage of pastures (Olivetti, 2014; Olivetti et al. submitted).

Procedures:

In each landscape, we established three transects with 6 seed traps each, thus there were 18 seed traps per landscape and 108 in total. For each transect, the seed traps were placed at six different distances from the forest's edge in the pasture (0, 5, 10, 20, 40, and 80m) (Figure 1). We considered distance 0 m the exact point of transition from forest fragment to pasture. Each seed trap was square with an opening of 0.25 m^2 (0.50 m x 0.50 m) and each transect was at least 150 m distant from the others (Figure 1). The seed traps were made of a square wire frame (0.50 m x 0.50 m) with a nylon mesh (1mm) stretched across the frame to collect the seeds. PVC pipes (20 mm) were positioned as supports to raise the frame 30 cm above the ground. The seeds collected in each trap were identified and classified according to APG III (2009). The seeds were classified by their dispersal syndrome: anemochorous, autochorous, endozoochorous, and epizoochorous (van der Pijl 1982) (Table 3). The seeds were collected twice per month in March, April and May of 2014. Around each trap, we traced a circular plot of 4 m diameter and measured the density, diameter at soil height (DSH), height, and crown cover of all the trees and bushes (plants with height greater than 1 m) (Table 4). The crown cover was calculated at 1.30 m (breast height) using a plan densiometer in the center of each circular plot.

Analysis:

The six landscapes chosen presented a range of isolated trees densities in the pastures that were calculated using ArcGIS platform. We calculated General Linear Models (GLM with Poisson distribution) and did residual analyses (Box-Pierce test) in order to test the influence of our independent variables (distance from the forest fragments, density of isolated trees in pastures, and plant characteristics - tree density around traps, height, DSH, and crown cover) on the dependent variables (seed richness and abundance). Significant GLM models with significant residuals were compared by Akaike information criterion (AIC) (Burnham and Anderson 2002). The best model is based on the lowest AIC value ($\Delta AIC < 2.0$, Burnham and Anderson 2001). We exclude *Vernonanthura sp.* and *Peltodon radicans* from analyses, because they had outlier values.

RESULTS

The number of seeds dispersed (abundance and richness) in pastures from three of the syndromes (anemochorous, autochorous, and endozoochorous) tended to decrease rapidly with greater distances from the forest fragment. However, while endozoochorous seeds did not disperse farther than 10 meters, anemochorous ones spread 40 m and autochorous ones 80 m (Figure 2). Additionally, autochorous seed abundance and epizoochorous seed richness was higher with greater distances. Therefore, there was no relationship between distance and abundance for seeds of the epizoochorous syndrome. On the other hand, there was a positive relationship between isolated tree density in pasture and seed abundance for anemochourous, autochorous, and endozoochorous species, as well as seed richness for the autochorous ones (Figure 3). There was no relationship between density of isolated trees in pastures and seed richness for anemochorous, endozoochorous, and epizoochorous trees, as well as for the abundance of epizoochorous seeds.

Different plant characteristics around each seed trap presented significant influence on the seed rain for each seed dispersal syndrome. Greater crown coverage increased the seed richness of anemochorous, autochorous, and endozoochorous trees (Table 6, table 8 and table 10) and seed abundance of endozoochorous and anemochorous trees (Figure 4; table 5 and table 9). The autochorous syndrome presented positive relationships to plant height, where greater mean plant height increased its seeds' abundance (Table 7), while maximum plant height increased its seeds' richness (Figure 4; table 8). Finally, there was a negative relationship between plant density around traps and abundance of epizoochorous seeds (Figure 4; table 11). There was no relationship for the plant characteristics with the dispersal syndromes that were not mentioned.

DISCUSSION

Ours results show that seed dispersal of endozoochorous, anemochorous, and autochorous species is improved when there is (i) proximity to forests fragments, as well as (ii) greater density, (iii) height, and (iv) crown cover of isolated trees. However, the seed dispersal of epizoochorous species (herbaceous-shrub) is reduced.

Distance from forest fragment

Forest fragments are essential seed sources for recolonization or natural regeneration in pastures. However, the distance from a forest fragment has a different influence depending on the dispersal syndrome of each species. Most of the seeds dispersed in the pastures presented anemochorous or epizoochorous syndromes.

Endozoochorous, anemochorous, and autochorous seeds in the pasture were concentrated close to forest fragments, and were found only up to 10 m for endozoochoorous seeds, but anemochorous and autochorous ones could achieve 40 and 80 m, respectively.

Normally, seed rain abundance decreases with greater distances from its source, such as forest fragments. However, the greater distances achieved by anemochorous and autochorous seeds were probably due to the presence of isolated plants (trees and shrubs) of these syndromes growing in the pastures. In a study in the same pastures, the authors found that most of the isolated trees (DAP>5cm) presented anemochorous (63%) syndromes (Gonçalves et al. in prep). Seeds of autochorous species have an aggregated dispersal pattern, limiting seed dispersal to very long distances (Wilson 1993; Giehl et al. 2007). Their short seed dispersal capacity indicates that there were probably some adult trees of these species with autochorous syndrome that were producing seeds around some farther traps. However, this did not occur for many species, because autochorous seed richness did not follow the increase in abundance. The traps only collected two autochorous species, *Croton floribundus* and *Croton urucarana,* in the pastures.

Moreover, the large number of epizoochorous seeds in the traps far from forest fragments probably occurred because they were herbaceous and grew near the traps. Diaspores with epizoochorous syndrome are characterized by having structures that are used for attachment to fur, such as hooks, awns, or bristles, hence dispersing seeds efficiently (Shmida and Ellner 1983; Fischer et al. 1996; Kiviniemi and Eriksson 1999). Thus, livestock could be an epizoochorous dispersal agent for pastures, favoring high richness over long distances. Besides, there were probably epizoochorous species (all of them with herbaceous and/or bush characteristics) close to the traps, facilitating their attachment.

Some other studies, including one from the studied region (Martins 2014), also found that the endozoochorous seed density of forest species dispersed in pastures decreases with increasing distances from forest fragments (Aide and Cavelier 1994; Cubiña and Aide 2001; Dosch et al. 2007; Holl 1999, Martínez-Garza et al. 2009). This low number of endozoochorous seeds in pastures probably occurs because forest animals (e.g. birds and mammals) rarely move through open areas (Holl 1999), since these areas increase their exposure to predators (Cubina and Aide 2001) and present unfavorable climatic conditions for foraging, such as higher temperature and lower humidity (Belsky 1989; Rhoades et al. 1998).

Several papers have discussed the effect of proximity and maintenance of forest fragments for modified habitats' recovery (Guevara et al. 1986; Aide and Cavalier 1994; Holl 1998; Harvey and Haber 1999; Martinez-Garza and González-Montagut 1999; Zimmerman et al. 2000; Herrera and Garcia 2009). The results of these studies have shown that forest fragment proximity favors the disturbed areas' regeneration (Guevara and Laborde 1993) because they provide a continuing source of diaspores and perches (Holl 1998) for birds and bats, which act as seed dispersal agents for abandoned areas (Howe and Smallwood 1982). In the state of São Paulo, Brazil, simulations have shown that the speed of forest regeneration is influenced by seed rain coming from the near fragments (Groeneveld et al. 2009). Besides, regeneration processes could be accelerated through native tree abandonment or planting by farmers in areas near forest fragments (up to 10 meters).

Density of isolated trees in pastures

In general, we found greater seed rain in pastures with more isolated trees for species with anemochorous, autochorous, and endozoochorous syndromes. Isolated trees in pastures are very important for seed dispersal, with an optimum density of around 30 trees/ha. Our study is the first to find a relationship between greater seed rain and the presence of more isolated trees in pastures. The amount of seed rain continues to grow until a little more than 30 trees/ha, but with variation (Figure 3). Some landscapes had a low number of seeds in the traps. This variation may be due to difference in the trees' characteristics, such as size, canopy area, and the quantity of isolated trees between the landscapes. There was a greater source of anemochorous seeds in the pastures because most of the isolated trees in the pastures have this seed dispersal syndrome (Gonçalves et al. in prep). On the other hand, the greater amount of autochorous seeds in pastures with a higher density of isolated trees probably occurs because there were isolated tree or shrubs with of autochorous seed dispersal next to traps. Vieira et al. (2002) and Griz et al (2002) found that anemochorous and autochorous species develop better in open areas, which are normally drier environments, than forest ones.

Isolated trees in pastures are very important, especially for endozoochorous dispersal. Transport in open areas is very difficult for forest endozoochorous seeds because most forest dispersal animals cannot cross pastures due to fear of exposure to predators and an unfavorable microclimate. Although this is a logical and expected result, our study is the first to demonstrate the importance of isolated trees to dispersal in pastures. Isolated trees can promote greater movement of seed dispersal agents through these open areas, acting as corridors for forest birds in fragmented landscapes (Nepstad et al. 1996; Perfecto et al. 1996). Tewksbury et al. (2002) found that fruit production and seed movement was greater in connected fragments in South Carolina (USA), compared with non-connected ones. As shown by Nason and Hamrick (1997), small fragments and isolated trees function as important stopping points for pollinators and seed dispersers in fragmented landscapes. Harvey (2000) found, in Costa Rica, more seed dispersal under isolated trees and shrubs because they provide perches to birds. Isolated trees can offer nutritional rewards (Luck and Daily 2003), good perches, singing sites, nesting sites, and protection from predators (Wegner and Merriam 1979; McDonnell and Stiles 1983; McClanahan and Wolfe 1987).

Furthermore, the presence of isolated trees or a silvopastoral system may promote soil conservation (combatting salinity issues, flooding problems, and erosion), water resource conservation, carbon sequestration, and an increase of biodiversity (Ibrahim et al. 2001; Pagiola et al. 2004). Pastures with greater number of isolated trees may support larger species diversity than traditional ones and they help connect forest fragments (Pagiola et al. 2004). Thus, pastures with isolated trees may provide resources, refuge sites, a microclimate suitable for plant establishment, and shade for cattle and wild birds (Harvey and Haber 1999). Therefore, pastures with greater tree density could increase the seed rain and accelerate plant regeneration.

Plant characteristics

Some plant characteristics can promote seed dispersal around them, dependent on its dispersal syndrome. In general, a greater crown cover could increase the seed rain of plants from the anemochorous, autochorous, and endozoochorous syndromes. Moreover, plant height (mean and maximum) could promote a greater seed rain of autochorous plants. However, a greater plant density around traps decreased the seed rain for the epizoochorous species.

Other studies also found greater seed abundance under trees with greater crown cover (Cole et al. 2010) and under more branched trees (Holl 1998; McDonnell and Stiles 1983). Greater crown cover can promote good conditions for the dispersal agents of endozoochorous syndromes, such as food (Luck and Daily 2003), resting and nest sites, a better microclimate, and protection from predators (Wegner and Merriam 1979; McDonnell and Stiles 1983; McClanahan and Wolfe 1987). Anemochorous seeds could benefit from greater crown cover that would prevent other species from exceed it. A greater crown cover could be harmful for growth of new anemochorous species to overstory, which would prevent an increase in the abundance of anemochorous seeds. A greater crown cover and height (mean and maximum) of trees decreases the penetration of light and wind in the understory and limits colonization of these sites to shorter plant species, such as most of the autochorous species (Hughes et al. 1994). Thus, Hughes et al. (1994) consider that in order to effectively escape from intraspecific competition through ballistic dispersal mechanisms, parent trees should have short dimensions. The reduction of epizoochorous seed rain in pastures with high tree density around traps probably occurred because the greater number of isolated trees promoted more shade area and competition that reduces the potential development spaces of species (all of epizoochorous species have herbaceous and/or bush characteristics) (Hughes et al. 1994). Furthermore, a greater crown generally indicates greater seed production (McDonnell 1986; Guevara 1992; Duncan and Chapman 1999) and a greater quantity of seed dispersal.

Knowing plant characteristics that promote seed dispersal could be important in restoration programs, especially those with active planting. In order to improve seed dispersal in pasture, we suggest planting native trees with features that may favor the seed rain around it, especially endozoochorous ones. These species are the most common in forests, but on the other hand, they are the most difficult to be dispersed in open areas. Thus, to improve seed dispersal in pastures, trees should have the following features:

- zoochorous and/or with flowers that offer resources for wildlife. These characteristics could increase the use of pastures by animals, increasing seed dispersal.
- trees with greater crown cover (when adult). This could increase endozoochorous and anemochorous seed rain, as discussed above.

CONCLUSIONS

We collected a considerable number of seed samples and some interesting results indicate possible theoretical and practical advances. Furthermore, these results may help encourage a longer study that can answer other questions about the movement of dispersal agents through pastures. Our results provide some important characteristics from pastures (landscape) and individual trees that improve seed dispersal in an open matrix in fragmented landscapes. We should highlight the results that show the positive influence on seed dispersal in areas of greater tree density as a novelty. However, our studies and results have some restrictions that should be considered. We studied factors that influence seed dispersal (seed rain) in pasture; however, their survival germination, and growth of the seedling will be affected by other different parameters, which we did not investigate. In pastures, seedling establishment may suffer from low rates of germination (Aide and Cavelier 1994), high rates of predation (Janzen 1971; Uhl 1987; Nepstad et al. 1990; Aide and Cavelier 1994; Holl and Lulow 1997), and their survival may be affect by stressful microclimatic conditions, herbivory, and nutrient limitation (Uhl 1987; Nepstad et al. 1991; Aide and Cavelier 1994). Besides, our study had short collecting time and occurred in poor months for seed production (dry season), in a time of year when not occurred fruiting peaks of species with of anemochory and endozoochory syndromes (Vergne et al in prep). However, we obtained positive results that may potentiated in a time of year when occur fruiting peaks of these species and may help understand how the seeds dispersal occurs during dry season. However, our results permit us to presume that the presence of isolated trees in pastures could promote greater seed rain, improve microclimate conditions, and increase soil nutrients (Belsky et al. 1989; Guevara and Laborde 1993; Sarmiento 1997; Rhoades et al. 1998; Otero-Arnaiz et al. 1999) facilitating the recovery of forests in pastures (Holl 200) as well as providing a connection for species between forest fragments.

In conclusion, seed dispersal in pastures depends on (i) the number of isolated trees found in this habitat, as well as (ii) their characteristics (size and crown coverage), and (iii) the distance from the forest fragment's edge. The movement of seed dispersal agents in pastures and between forest fragments may provide a better quality and frequency if this habitat presents a greater number of isolated trees and if they are mainly located near forest fragments (the seed source). Additionally, if these isolated trees present more complex characteristics, such as a broad crown cover and greater height, the richness and abundance of seed dispersal could be greater. By increasing the complexity of a landscape (more trees with complex characteristics and which are distributed throughout the pasture), we will be able to improve seed movement as well as the connectivity of these areas. Consequently, we could maintain and even improve biodiversity in fragmented areas, besides promoting regeneration of native vegetation.

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Table 1. Percentage of damaged traps in each landscape during four periods of sampling. We excluded landscapes with ≥ 45% damaged traps.

Landscapes	**Total**
P9	4.2
Zé Vânio	5.6
P13	11.1
Matão	25.0
Luiz	31.9
Diniz	34.7
Valeriano	45.8
P21	76.4
P7	76.4

Table 2 – Classification of pastures from southern Minas Gerais state, Brazil: municipalities, pasture locations (WGS 1986 23S-UTM), and trees' density in pastures.

Pasture	Regional names	Municipality	Longitude	Latitude	Trees' density in pasture
1	Diniz	Alfenas	381366.282656	7628493.66039	3.65
2	P9	Campos Gerais	419301.442144	7654267.25592	16.00
3	P13	Areado	373721.139182	7630655.30914	27.92
4	Luiz	Carmo do Rio Claro	383992.515662	7670364.48848	32.50
5	Matão	Alfenas	409544.800003	7621879.50511	33.33
6	Zé Vânio	Campo do Meio	402172.858931	7660767.97158	83.57

Table 3. Distribution of seed species according to their dispersal syndrome and total abundance.

Species	**Family**	**Dispersal syndrome**	**Disperser**	**Habitat**	**Abundance**	**Abundance %**
Vernonanthura sp.	Asteraceae	Anemochorous	Wind	Tree	4680	57.339
Gochnatia sp.	Asteraceae	Anemochorous	Wind	shrub and/or tree	20	0.245
Specie 1	Asteraceae	Anemochorous	Wind	herbaceous and/or shrub	9	0.11
Machaerium sp.	Fabaceae	Anemochorous	Wind	shrub and/or tree	8	0.098
Machaerium villosum	Fabaceae	Anemochorous	Wind	tree	4	0.049
Serjania sp.	Sapindaceae	Anemochorous	Wind	vine	1	0.012
Croton urucurana	Euphorbiacea	Autochorous		shrub and/or tree	59	0.723
Helicteres sp.	Malvaceae	Autochorous		shrub	5	0.061
Pilocarpus pennatifolius	Rutaceae	Autochorous		tree	4	0.049
Croton floribundus	Euphorbiacea	Autochorous		tree	2	0.025
Luehea divaricata	Malvaceae	Autochorous		tree	2	0.025
Cordia ecalyculata	Boraginaceae	Endozoochorous	Birds	tree	25	0.306

Psychotria sp.	Rubiaceae	Endozoochorous	Birds	shrub	18	0.221
Solanum sp.	Solanaceae	Endozoochorous	Birds	shrub and/or tree	7	0.086
Strychnos brasiliensis	Loganiaceae	Endozoochorous	Animals	tree	4	0.049
Alchornea glandulosa	Euphorbiacea	Endozoochorous	Birds	tree	3	0.037
Aegiphila integrifólia	Lamiaceae	Endozoochorous	Birds	shrub and/or tree	2	0.025
Dicella bracteosa	Malpighiaceae	Endozoochorous	Not found	vine	2	0.025
Specie 2	Arecaceae	Endozoochorous	Birds	tree	1	0.012
Persea willdenovii	Lauraceae	Endozoochorous	Birds	tree	1	0.012
Xylopia aromatica	Annonaceae	Endozoochorous	Birds	tree	1	0.012
Peltodon radicans	Lamiaceae	Epizoochorous		herbaceous and/or shrub	3212	39.353
Sida sp.	Malvaceae	Epizoochorous		herb and/or shrub	34	0.417
Desmodium sp.	Fabaceae	Epizoochorous		shrub	32	0.392
Triumfetta semitriloba	Malvaceae	Epizoochorous		shrub	21	0.257
Mimosa sp.	Fabaceae	Epizoochorous		shrub	5	0.061

Table 4. Isolated trees characteristics collected in circular plots, around each traps, in six landscapes.

	Maximum height (m)			Mean height (m)		
Landscape	**minimum**	**mean**	**maximum**	**minimum**	**mean**	**maximum**
P9	1.8	3.0	9.0	1.7	2.3	9.0
Luiz	4.0	3.1	12.0	3.0	1.5	5.0
P13	1.8	2.2	7.0	1.8	1.5	4.3
Zé Vânio	1.7	2.2	6.0	1.4	1.4	4.2
Pmatâo	1.7	2.0	7.0	1.7	1.7	4.8
Pdiniz	4.0	2.3	8.0	2.6	1.3	4.2
	Basal area (cm²)			**Trees' density**		
	minimum	**mean**	**maximum**	**minimum**	**mean**	**maximum**
P9	147.5	9780.1	38542.4	0	3.7	13.0
Luiz	458.7	2248.2	9537.1	0	1.6	5.0
P13	35.5	2161.7	9476.6	0	1.8	6.0
Zé Vânio	45.6	2388.2	8643.7	0	5.1	19.0
Pmatâo	19.6	956.8	4158.7	0	0.8	2.0
Pdiniz	654.2	491.4	2006.7	0	1.5	5.0
	DSH (cm)			**Crown cover**		
	minimum	**mean**	**maximum**	**minimum**	**mean**	**maximum**
P9	4.0	23.5	90.0	0	31.9	79.3
Luiz	16.0	6.1	22.5	0	26.8	81.5
P13	4.8	10.8	42.7	0	35.4	85.3
Zé Vânio	5.2	8.0	20.7	0	28.8	79.0
Pmatâo	3.5	7.7	26.7	0	25.0	86.8
Pdiniz	11.8	8.3	31.2	0	29.1	83.3
	Cover					
	minimum	**mean**	**maximum**			
P9	0	42.3	100.0			
Luiz	0	28.2	90.0			
P13	0	39.5	100.0			
Zé Vânio	0	34.0	95.0			
Pmatâo	0	30.6	100.0			
Pdiniz	0	32.2	100.0			

Table 5. Akaike performed on six pastures considering the anemochorous abundance seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with $\Delta AICc < 2$ were considered appropriate to explain the surveyed variable.

Model	ΔAICc[a]	df[b]	W[c]	p
Crown cover (-)	0	2	1	<0.001
Cover (-)	365.7	2	<0.001	<0.001
Mean height (+)	883.5	2	<0.001	<0.001
Maximum height (+)	2365.9	2	<0.001	0.0262
Diameter at soil height (+)	2555.8	2	<0.001	0.0035
Null	2561.9	1	<0.001	-
Density trees (+)	1542894	2	<0.001	<0.001

Table 6. Akaike performed on six pastures considering the anemochorous richness seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with $\Delta AICc < 2$ were considered appropriate to explain the surveyed variable.

Model	ΔAICc[a]	df[b]	W[c]	p
Crown cover (+)	0	2	1	0.0190
Cover (+)	32.8	2	<0.001	0.0342
Null	202.7	2	<0.001	-

Table 7. General linear models (GLM) performed on six pastures considering the autochorous abundance seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with ΔAICc < 2 were considered appropriate to explain the surveyed variable.

Model	**ΔAICc[a]**	**df[b]**	**W[c]**	**p**
Mean height (+)	0	2	1	<0.001
Diameter at soil height (+)	32.8	2	<0.001	<0.001
Cover (+)	202.7	2	<0.001	<0.001
Crown cover (+)	266.2	2	<0.001	<0.001
Basal area (+)	276.9	2	<0.001	<0.001
Density trees (+)	292.9	2	<0.001	<0.001
Null	298.4	1	<0.001	-

Table 8. General linear models (GLM) performed on six pastures considering the autochorous richness seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with ΔAICc < 2 were considered appropriate to explain the surveyed variable.

Model	**ΔAICc[a]**	**df[b]**	**W[c]**	**p**
Maximum height (+)	0	2	0.4812	<0.001
Crown cover (+)	1.5	2	0.2297	0.0022
Mean height (+)	2	2	0.1763	<0.001
Cover (+)	3	2	0.107	0.0044
Null	8.8	1	0.0058	-

Table 9. General linear models (GLM) performed on six pastures considering the endozoochorous abundance seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with $\Delta AICc < 2$ were considered appropriate to explain the surveyed variable.

Model	$\Delta AICc^a$	df^b	W^c	p
Crown cover (+)	0	2	0.962	<0.001
Density trees (+)	6.5	0	0.038	<0.001
Cover (+)	16.9	2	<0.001	<0.001
Maximum height (+)	58.1	2	<0.001	<0.001
Mean height (+)	86.4	2	<0.001	<0.001
Diameter at soil height (+)	113.1	2	<0.001	<0.001
Basal area (+)	114.8	2	<0.001	<0.001
Null	120.2	1	<0.001	-

Table 10. General linear models (GLM) performed on six pastures considering the endozoochorous richness seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with $\Delta AICc < 2$ were considered appropriate to explain the surveyed variable.

Model	$\Delta AICc^a$	df^b	W^c	p
Crown cover (+)	0	2	0.77	<0.001
Cover (+)	2.4	2	0.23	<0.001
Density trees (+)	13.4	2	<0.001	<0.001
Maximum height (+)	13.5	2	<0.001	<0.001
Null	144.8	1	<0.001	-

Table 11. General linear models (GLM) performed on six pastures considering the epizoochorous abundance seeds as the explanatory variable. (+) = Positive influence and (-) = Negative influence. The models presented normal and independents residuals by the Shapiro-Wilk and Box-Pierce tests ($p > 0.05$). Models with ΔAICc < 2 were considered appropriate to explain the surveyed variable.

Model	**ΔAICc[a]**	**df[b]**	**W[c]**	**p**
Density trees (-)	0	2	1	<0.001
Mean height (-)	55.9	2	<0.001	<0.001
Maximum height (-)	60	2	<0.001	<0.001
Crown cover (-)	245.2	2	<0.001	<0.001
Cover (-)	277.3	2	<0.001	<0.001
Diameter at soil height (-)	470.5	2	<0.001	<0.001
Basal area (-)	933.9	2	<0.001	<0.001
Null	29631.8	1	<0.001	-

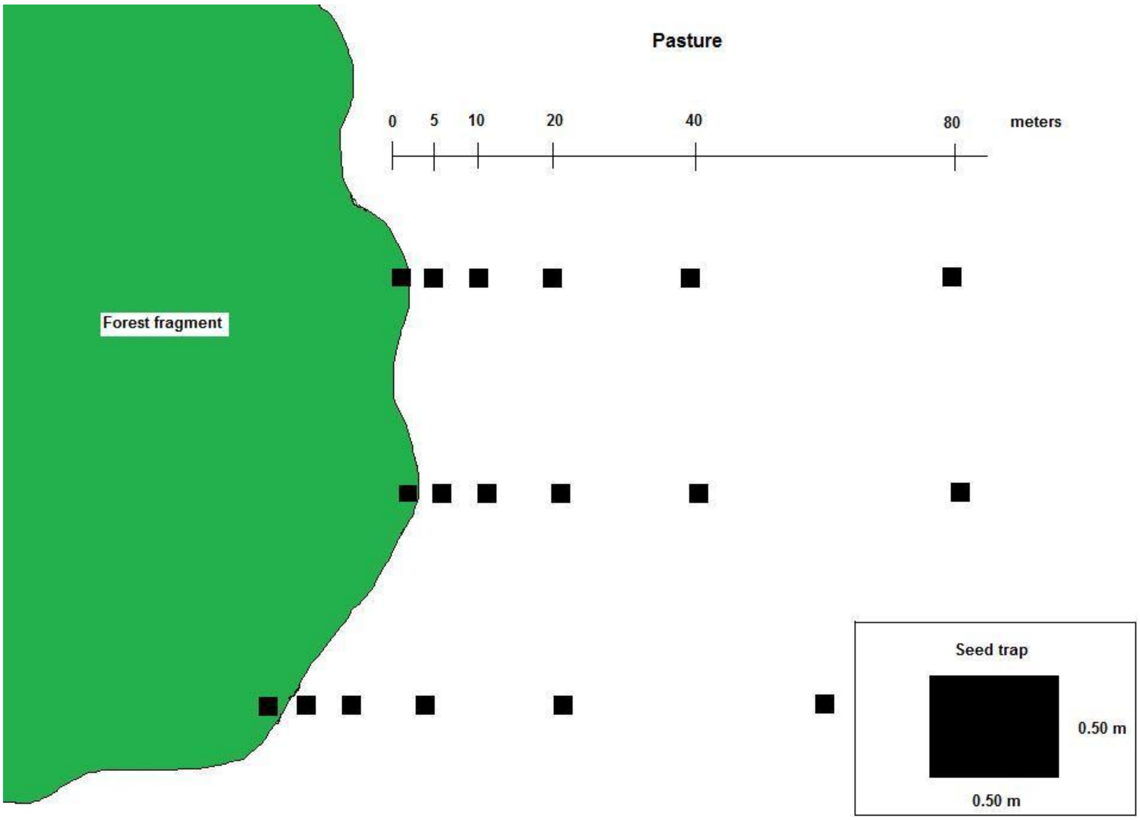
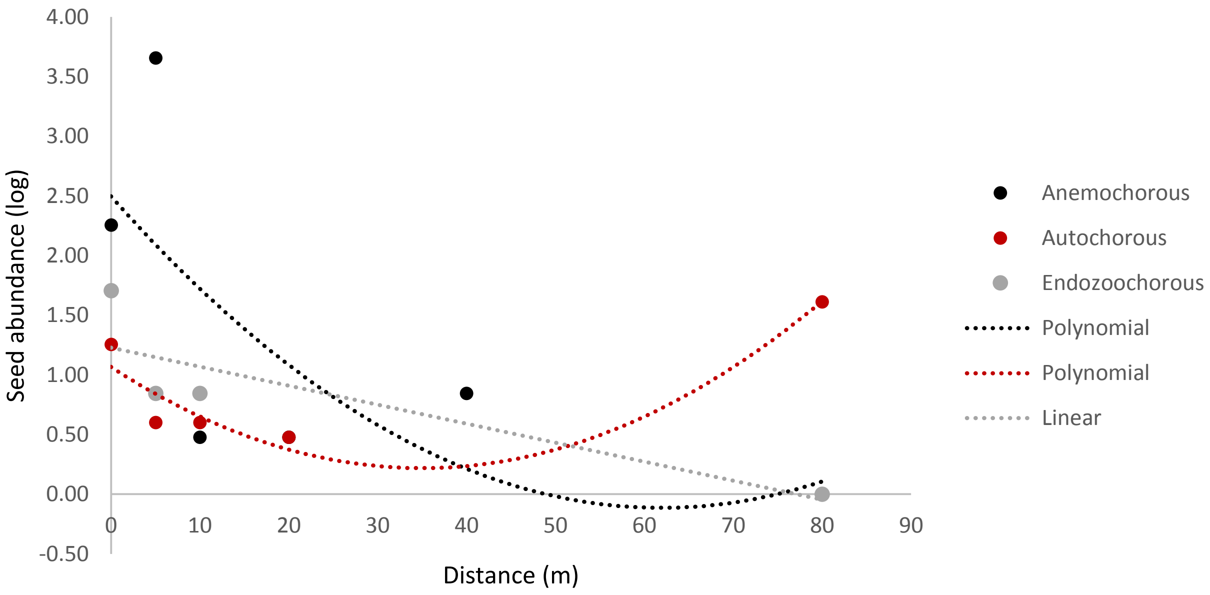
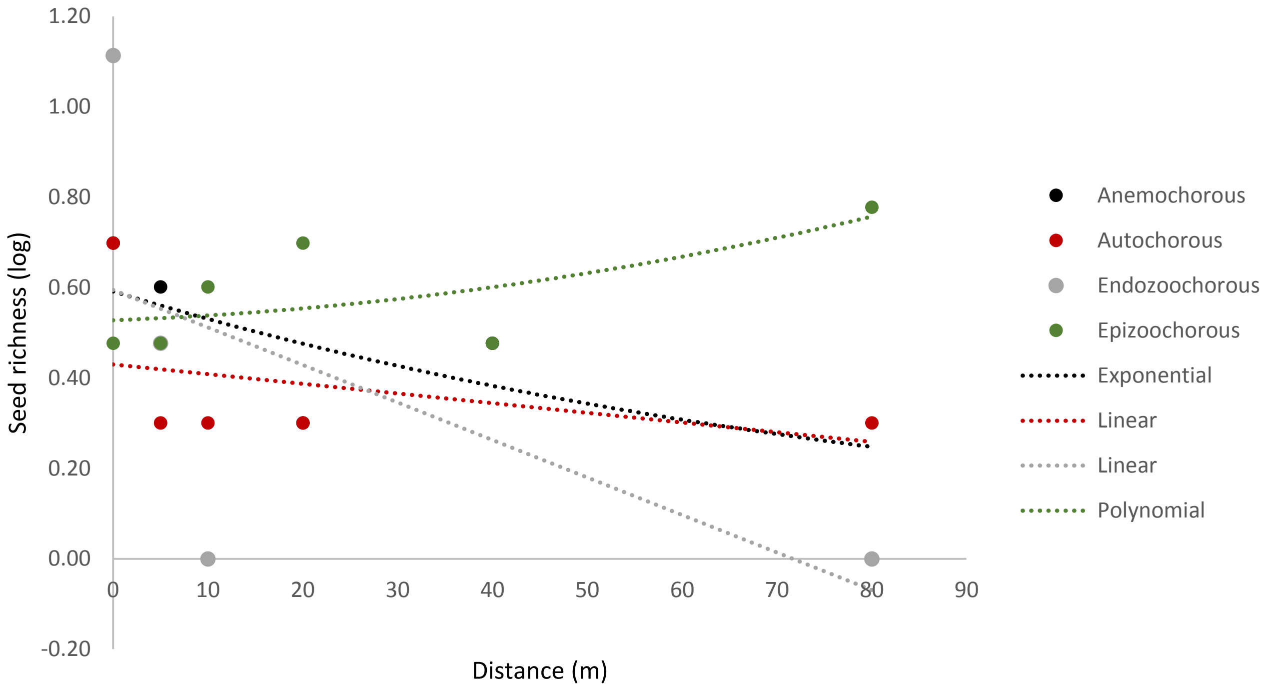


Figure 1. Sample layout of seed trap transects in one of the 6 pasture landscapes. Each transect was at least 150 m distant from the others. Seeds were collected each 15 days over two months.

A)

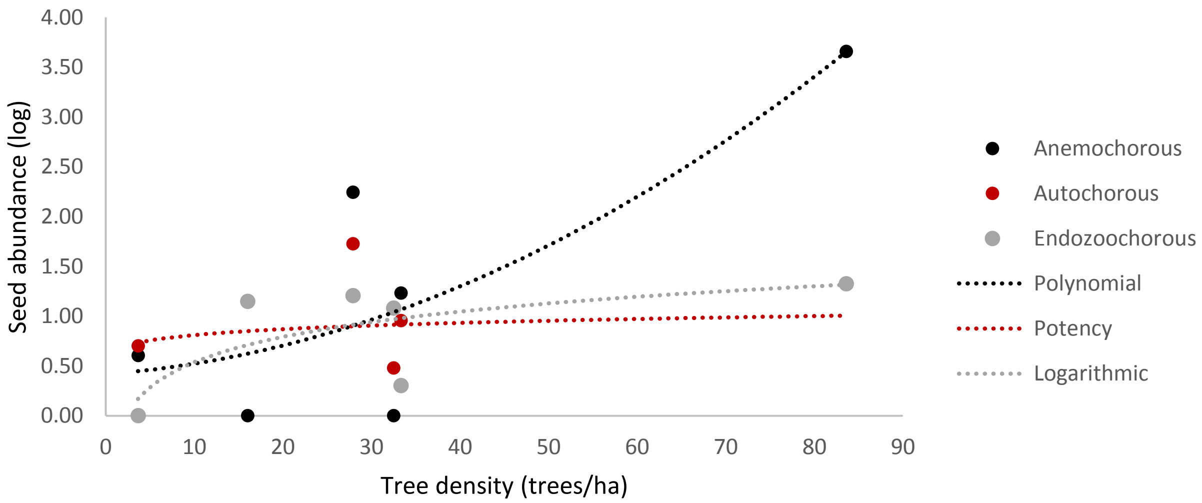


B)



Distance from forest fragment of anemochorous, autochorous, endozoochorous, and epizoochorous seeds collected in pastures related to abundance (A) and richness (B). Data for the six landscapes was summed. Only the epizoochorous syndrome abundance was not significant.

A)



B)

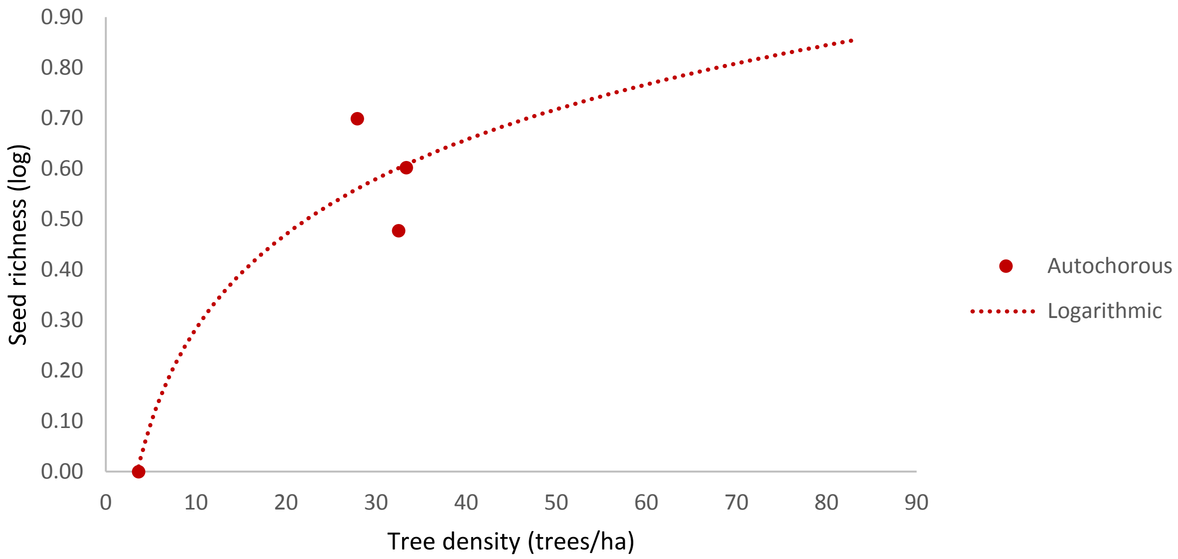
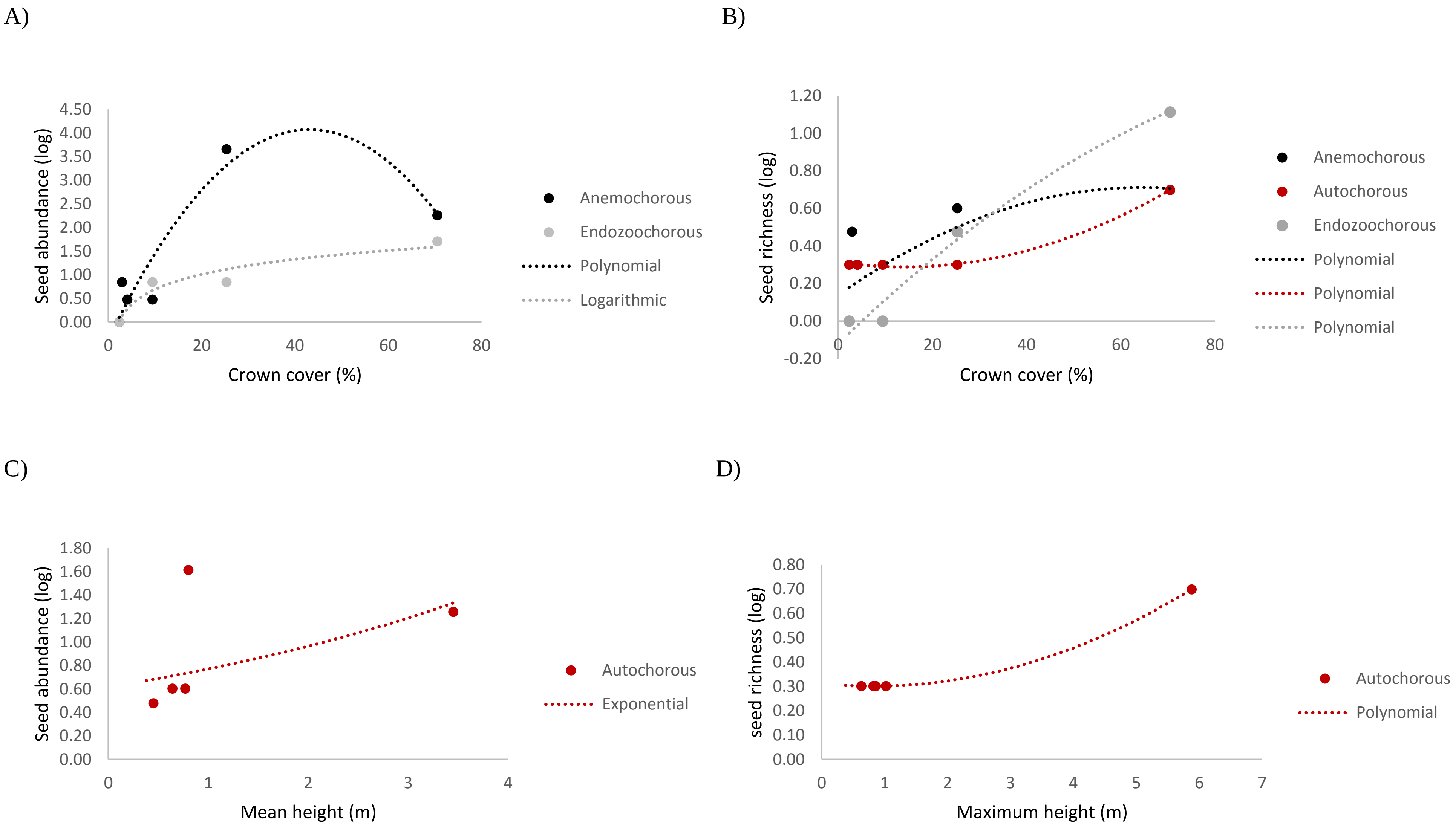


Figure 3: Relationship between the density of isolated trees (trees/ha) in pasture to abundance (A) and richness (B) of the anemochorous, autochorous, and endozoochorous seeds collected. Data for the six landscapes was summed. The richness for the anemochorous, endozoochorous, and epizoochorous syndromes was not significant.


A)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Seed abundance (log)
0
20
40
60
80
Crown cover (%)
Anemochorous
Endozoochorous
Polynomial
Logarithmic
B)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Seed richness (log)
0
20
40
60
80
Crown cover (%)
Anemochorous
Autochorous
Endozoochorous
Polynomial
Polynomial
Polynomial
C)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Seed abundance (log)
0
1
2
3
4
Mean height (m)
Autochorous
Exponential
D)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
seed richness (log)
0
1
2
3
4
5
6
7
Maximum height (m)
Autochorous
Polynomial

E)

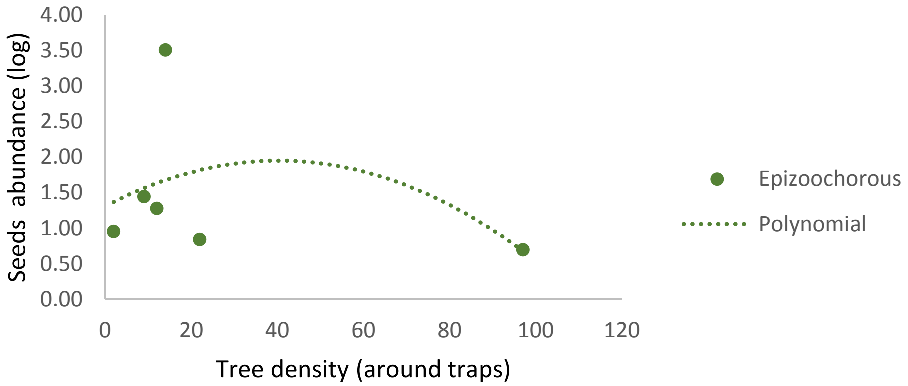


Figure 4: The collected seeds and their syndromes' abundances to (A) crown cover, (C) mean height, and (E) tree density and for the richness to (B) crown cover and (D) maximum height. Data for the six landscapes was summed.