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LAURA FORNERO GOMES FERREIRA

INFLUÊNCIA DA ESTRUTURA DA PAISAGEM SOBRE ASPECTOS REPRODUTIVOS DE UMA PLANTA FLORESTAL

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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, Co-orientador (a): Prof. Dra. Erica Hasui

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Universidade Federal de Alfenas / UNIFAL-MG
Programa de Pós-graduação – Ecologia e Tecnologia Ambiental
Rua Gabriel Monteiro da Silva, 714. Alfenas - MG CEP 37130-000
Fone: (35) 3299-1419 (Coordenação) / (35) 3299-1392 (Secretaria)
www.unifal-mg.edu.br/ppgecoambiental/

LAURA FORNERO GOMES FERREIRA

"INFLUÊNCIA DA ESTRUTURA DA PAISAGEM SOBRE ASPECTOS REPRODUTIVOS DE UMA PLANTA FLORESTAL".

A Banca examinadora, 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: 27/01/2013

Prof. Dr. Flavio Nunes Ramos
Instituição: UNIFAL-MG
Assinatura:

Prof. Flavio Antonio Maës dos Santos
Instituição: UNICAMP
Assinatura:

Prof. Dr. Milton Cezar Ribeiro
Instituição: UNESP
Assinatura:

Dedico esse trabalho ao vô Tino, aos meus pais, Walter e Maria Imaculada, ao meu irmão, Leonardo e ao Alexandre.

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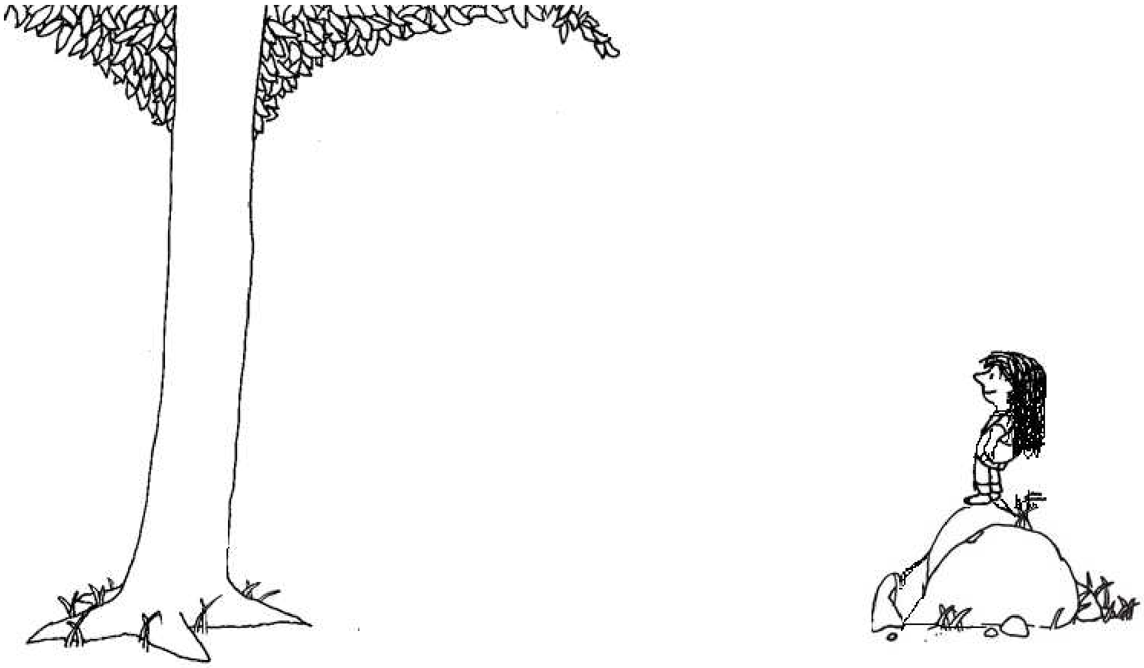
MUITO OBRIGADA!



“É do buscar e não do achar que nasce o que eu não conhecia."

*Clarice Lispecto*r, adaptado.

RESUMO

Perda de habitat e mudanças na estrutura da paisagem são efeitos resultantes da fragmentação florestal e podem afetar de maneira negativa processos ecológicos, como a reprodução de plantas e polinização. Nossa hipótese é que parâmetros da estrutura da paisagem (área do fragmento, proximidade, porcentagem de cobertura vegetal da paisagem – floresta nativa, matriz de café, cana e pastagem e formato do fragmento) e características estruturais da planta (circunferência na altura do solo, circunferência na altura do peito, altura da planta, volume da copa) e do seu habitat (altura do dossel, perfil vertical, distância do indivíduo mais próximo e distância do indivíduo coespecífico) afetam a produção de flores e frutos e o número de visitas florais de uma planta florestal. Nós amostramos 160 indivíduos de uma planta florestal, *Psychotria vellosiana*, em oito paisagens (raio de 1000m), cada uma dessas paisagens centrada em um fragmento florestal (20 indivíduos por fragmento). Aplicamos o modelo linear generalizado e critério de informação de Akaike, para selecionar os melhores modelos que explicam as relações entre a reprodução das plantas com: i) os parâmetros da paisagem e ii) medidas de características estruturais das plantas e do seu habitat. Nossos resultados indicam que o número de visitas florais e a produção de flores e frutos são afetados pelo tipo de matriz. Além disso, o número total de visitas florais é influenciado pela porcentagem de floresta concomitantemente à porcentagem de matriz de café. A produção de frutos também é afetada pela complexidade da paisagem, altura do indivíduo e pelo grau de agregação da população de plantas. A partir desses resultados, nós podemos concluir que características da paisagem são importantes para explicar a reprodução das plantas. As informações geradas poderão contribuir para o preenchimento da lacuna no conhecimento a respeito da influência da matriz sobre plantas e processos ecológicos. Além de poderem ser usadas em recomendações destinadas a produtores rurais, tomadores de decisão e políticas públicas, como por exemplo, para informar qual tipo de matriz deve ser usada em paisagens fragmentadas para ajudar a manter ou aumentar a produção de frutos de plantas florestais.

Palavras chave: fragmentação, cobertura florestal, matriz, sucesso reprodutivo das plantas, polinização.

ABSTRACT

Habitat loss and changes in the landscape structure are effects that results of the forest fragmentation and can negative affect ecological processes, as plant reproduction and pollination. We hypothesized that the landscape structure parameters (fragment area, proximity, percentage of landscape vegetation cover - native forest, coffee, sugarcane and pasture matrix, and fragment shape) and structural characteristics of plant (height stem circumference, circumference at breast height, plant height and volume of crown) and its habitat characteristics (canopy height, vertical profile, distance to the nearest individual and distance to the nearest conspecific individual) affect the flower and fruit production and number of floral visits of forest plant. We sampled 160 individuals of a forest plant, *Psychotria vellosiana,* in eight landscapes (1000m radius), centered each one in one fragment, with 20 individuals per fragment. And we applied a general linear model and Akaike information criterion to select the best models that explains relations among plant reproduction with i) landscape and patch parameters and ii) measurements of structural characteristics of the plants and its habitat. We found that the number of floral visits and flower and fruit production are affected by the matrix type. Furthermore the total number of floral visits is influenced by the percentage of forest concomitantly with percentage of coffee matrix. And fruit production is affected by landscape complexity, size of individual plant and degree of aggregation of the plant population. From these findings, we may conclude that landscapes characteristics are important to explain the plant reproduction. The information generated may contribute to the theoretical gap in knowledge on the influence of matrix on plants and on ecological process. In addition, they can be used in recommendations to farmers, decision makers and public policies, i.e. to inform what type of matrix should be used in fragmented landscape to help to maintain or improve the fruit production of forest plants.

Keywords: fragmentation, forest cover, matrix, plant fitness, pollination.

SUMÁRIO

1 INTRODUÇÃO GERAL

1.1 PREÂMBULO

A presente dissertação avalia o efeito da estrutura da paisagem e de características locais (planta e habitat) sobre processos ecológicos (reprodução das plantas e polinização) em uma região altamente fragmentada. Essas relações ainda são pouco exploradas na literatura, principalmente no que diz respeito à resposta das plantas ao tipo de matriz. Como em locais como o estudado, na região de Mata Atlântica, a faixa da quantidade de habitat se encontra em níveis extremamente críticos, torna-se importante entender o que está acontecendo com as espécies que estão sobrevivendo neste ambiente, a fim de gerar conhecimento e informações que ajudem em questões de conservação e restauração.

1.2 PARÂMETROS ESTRUTURAIS DE PAISAGEM E SUA INFLUÊNCIA SOBRE PROCESSOS REPRODUTIVOS DAS PLANTAS

A Ecologia de Paisagens é uma ciência recente, surgida na Europa entre 1930 e 1940. Sua abordagem inicial foi impulsionada essencialmente por pesquisadores geógrafos e focava na percepção, uso e ordenamento do espaço de vida do homem (NAVEH, 1982; TURNER, 2001). Após o surgimento de duas teorias pioneiras que relacionavam padrões espaciais e processos ecológicos, a Teoria do Equilíbrio Dinâmico em Ilhas (MACARTHUR; WILSON, 1967) e a Teoria de Metapopulações (LEVINS, 1969), a Ecologia de Paisagem recebeu um enfoque mais biocêntrico (METZGER, 2001; RICKETTS, 2001; THEOBALD, 2006; TURNER, 2005; WIENS; MOSS, 2005;). E dentro deste contexto, pode ser definida sob a ótica das duas abordagens: a geográfica e a ecológica. A geográfica enfatiza o estudo da influência antrópica sobre a paisagem e a gestão do território, e a ecológica destaca a importância do contexto espacial sobre os processos ecológicos e a relevância destas relações no contexto de conservação biológica (METZGER, 2001a; PIVELLO; METZGER, 2007).

Pode se afirmar que, a Ecologia de Paisagem tem como foco principal uma unidade espacializada, heterogênea, composta de um mosaico de unidades interativas (unidades de uso e ocupação da terra, cobertura vegetal) e integradora de características físicas, biológicas e antrópicas em determinada região - a paisagem (METZGER, 1999; TROPPMAIR, 2000). A estrutura da paisagem pode ser definida pela área, forma e disposição espacial (grau de fragmentação e de isolamento, por exemplo) (FORMAN, 1995; METZGER, 2001; OPDAM et al., 1993) das unidades interativas.

Processos antrópicos como a fragmentação de habitat rompem a continuidade das unidades interativas da paisagem (ecossistemas, unidades de vegetação) (LORD; NORTON, 1990) e modificam sua estrutura (METZGER, 1999). Essa mudança na estrutura da paisagem pode resultar em alterações no microclima, na sobrevivência e deslocamento das espécies, na composição e diversidade das comunidades e consequentemente, em processos ecológicos, como a reprodução vegetal (BREITBACH et al., 2012; GOULSON et al., 2008; METZGER, 1999). Assim, acredita-se que alterações em parâmetros de paisagem, como diminuição na área de habitat (área do fragmento, cobertura de vegetação nativa), modificações na forma do remanescente, no grau de isolamento entre eles, além do tipo de matriz circundante, podem influenciar de forma direta ou indireta a reprodução das plantas (polinização, produção de frutos e sementes) (BREITBACH et al., 2012; FISCHER, LINDENMAYER, 2007; JULES; SHAHANI, 2003).

1.2.1 Área do fragmento

A fragmentação florestal resulta na subdivisão de áreas contínuas de floresta nativa em manchas ou fragmentos florestais menores e isolados (WILCOVE et al., 1986). Concomitantemente, à redução de tamanho de áreas nativas pode ocorrer a perda de habitat e assim um depauperamento dos processos ecológicos, como a reprodução das plantas. Como a área do fragmento fica menor do que as áreas mínimas, necessárias para a sobrevivência das populações de plantas e polinizadores (FORMAN et al., 1976; SAUNDERS et al., 1991), pode ocorrer uma diminuição da abundância, riqueza e biodiversidade desses organismos bem como mudanças em suas distribuições (capacidade de dispersão) (GIBBS, 1998; GUTHERY et al., 2001; STEFFAN-DEWENTER et al., 2002). Alterações no comportamento dos polinizadores, que podem prejudicar as taxas de sucesso de forrageamento (MAHAN; YAHNER, 1999) também são esperadas com a redução do tamanho do fragmento, além de redução do número de plantas compatíveis (devido a menor densidade de plantas e flores) nos fragmentos (AIZEN; FEINSINGER, 1994a; GRIFFIN; ECKERT, 2003; WAGENIUS et al., 2007). Todas essas consequências negativas podem induzir a limitação de pólen e consequentemente afetar a polinização e o sucesso reprodutivo das plantas (AIZEN; FEINSINGER, 1994a, 1994b; FAHRIG, 2003; KURKI et al., 2000; VAMOSI et al., 2006; VIANA et al., 2012).

Algumas espécies são mais sensíveis à redução da área do fragmento e à mudanças microclimáticas, enquanto outras são mais tolerantes a espaços abertos, como pastagens e áreas urbanas (KRAUSS et al., 2003; WETHERED; LAWES, 2003). As abelhas, por exemplo, respondem de maneira diferente ao efeito da fragmentação de acordo com a espécie. Nos projetos “Insetos e Aves” e “Restauna”, que estudaram os efeitos da fragmentação sobre grupos de visitantes florais, foi verificado uma menor riqueza de espécies de abelhas sem ferrão nos fragmentos menores, já que algumas espécies de abelhas desse grupo são encontradas somente em fragmentos maiores (ex. *Melipona quadrifasciata e Trigona fulviventris*). A presença de outras abelhas sem ferrão (*Melipona quadrifasciata*) estava condicionada à estrutura vegetacional (riqueza de espécies e altura de árvores); ao ambiente de interior dos fragmentos (*Cephalotrigona captata*); ou ainda a áreas não urbanizadas (*Geotrigona subterrânea*). Ou seja, abelhas da espécie *G. subterrânea*, que fazem ninhos no solo, de preferência não impermeabilizado, são encontradas dentro e fora de fragmentos, desde que estes estejam em áreas não urbanizadas (RAMBALDI; OLIVEIRA, 2005).

Já as abelhas da subtribo Euglossina, nesse mesmo estudo, tenderam a apresentar menor riqueza de espécies quando a área central (subtraída a área de borda) dos fragmentos da Região Metropolitana de Belo Horizonte foram reduzidas. Quando esses fragmentos menores estavam próximos (menos de 500m) de outros maiores, essa tendência foi amenizada e uma riqueza maior de espécies foi encontrada nos remanescentes pequenos (RAMBALDI; OLIVEIRA, 2005). Dentro desse contexto, fica evidente que a área do fragmento é um dos parâmetros mais importantes para explicar variações na riqueza, diversidade das espécies e nas interações ecológicas (por exemplo, inseto planta). Logo, a área pode ser considerada uma métrica relevante para estudos dos efeitos da estrutura da paisagem sobre a reprodução das plantas.

1.2.2 Formato dos fragmentos

A forma do fragmento interfere na proporção da sua área de borda (METZGER, 2003), sendo que quanto mais alongado e irregular ele for maior será o efeito de borda (MCGARIGAL; MARKS, 1995; MURCIA, 1995). O aumento da borda, devido à fragmentação florestal, pode fazer com que a área central do fragmento se torne menos protegida de fatores externos e fique mais próxima à matriz circundante (ambientes estruturalmente diferentes das florestas), o que pode causar modificações nas condições abióticas do fragmento (MCGARIGAL; MARKS, 1995; METZGER, 1999; MURCIA, 1995). Essas modificações abióticas podem estimular mudanças na estrutura florestal da borda, na composição de espécies do fragmento e nas interações ecológicas (MURCIA, 1995).

As alterações na estrutura florestal da borda podem ocorrer porque mudanças microclimáticas são capazes de interferir no crescimento, na mortalidade, na abundância e na distribuição das plantas deste novo ambiente (MURCIA, 1995). Já as modificações na composição de espécies são esperadas, porque o aumento da área de borda pode alterar a permeabilidade do fragmento a espécies exóticas (aumento da entrada), o que pode representar uma ameaça às espécies originalmente presentes nos remanescentes (HILL; CURRAN, 2001; SAUNDERS et al., 1991; TURNER; CORLETT, 1996). Além disso, com aumento do efeito de borda são esperadas modificações em interações ecológicas (MURCIA, 1995), como na polinização (AIZEN; FEINSINGER, 1994a; SAUNDERS et al., 1991) pois, algumas espécies de polinizadores, principalmente insetos, são influenciados por variações na temperatura e umidade (HERRERA, 1995), e suas atividades dependem de um microclima apropriado dentro da flor e do ambiente (CORBET, 1990). Essas mudanças, redução de espécies (plantas e polinizadores) e modificações no comportamento dos polinizadores, podem resultar em diminuição das taxas de visitação e da quantidade e qualidade do pólen que chega ao estigma das flores e consequentemente num prejuízo no sucesso reprodutivo das plantas (AIZEN; FEINSINGER, 1994a; HERRERA, 2000; WASER; PRICE, 1991).

A partir dos dados acima, pode-se presumir que o formato do fragmento é um parâmetro importante para estudar a influência do contexto da paisagem sobre processos ecológicos, como a reprodução das plantas. E entre os índices que quantificam esse parâmetro, pode-se citar o índice de forma média ponderado pela área (AWMSI) que calcula a complexidade dos remanescentes da paisagem realizando uma média ponderada pela área. O valor do índice é igual a 1 quando todos os remanescentes são circulares e aumenta à medida que as formas dos fragmentos ficam mais complexas e as áreas maiores (MCGARIGAL; MARKS, 1995).

1.2.3 Distância entre fragmentos

A distância entre os remanescentes florestais (isolamento) é um dos fatores responsáveis pela: conectividade (capacidade da paisagem de facilitar fluxos biológicos de organismos) (URBAN; SHUGART, 1986) entre os fragmentos e habitats não fragmentados e influencia as taxas de dispersão, imigração e recolonização dos remanescentes (HAILA et al., 1993). Imigrantes contribuem demográfica e geneticamente para populações dos fragmentos aumentando o tamanho e a aptidão de suas populações (BROWN; KODRIC-BROWN, 1977). Assim, em geral, é esperado que espécies de plantas e outros organismos em fragmentos menos isolados e/ou em paisagens mais conectadas sofram menos problemas de trocas gênicas e declínio populacional (LAURENCE; VASCONCELOS, 2009; RAMBALDI; OLIVEIRA, 2005).

A dificuldade de movimentação de organismos entre fragmentos é proporcional ao grau de isolamento, ao nível de resistência da matriz circundante e do organismo em questão. Por exemplo, algumas aves podem movimentar-se entre fragmentos mesmo em situações de conectividade reduzida; grandes vertebrados podem encontrar maior resistência e pequenos mamíferos, em geral, demonstram padrões intermediários (RAMBALDI; OLIVEIRA, 2005).

Já o isolamento espacial de espécies de árvores pode modificar a atividade de polinizadores reduzindo a densidade de recursos alimentares e aumentando a distância entre esses recursos (SIH; BALTUS, 1987). A redução de recursos florais resulta em viagens com distâncias mais longas, entre áreas de descanso e alimentação, e frequentemente resulta no deslocamento de polinizadores por áreas menos favoráveis, por exemplo, áreas dominadas por agricultura (KEARNS et al., 1998). Quando a distância entre plantas é maior que a área de vida de polinizadores, a densidade deles diminuirá nas áreas que sofreram distúrbios e isto resultará em menos visitas (KEARNS et al., 1998). Polinizadores especialistas, que são menos flexíveis na exploração de recursos alimentares são os mais suscetíveis à extinção local (COSSON et al., 1999; ESTRADA et al., 1993; STONER et al., 2002). Logo, o isolamento entre remanescentes pode influenciar a diversidade de polinizadores e seu comportamento de forrageamento e consequentemente o sucesso reprodutivo e sistemas de cruzamento das plantas que eles polinizam (AIZEN; FEINSINGER, 1994; FUCHS et al., 2003; QUESADA et al., 2003). Portanto, a distância entre fragmentos pode ser considerada um parâmetro importante para ajudar a explicar mudanças na reprodução das plantas devido a mudanças no contexto da paisagem.

1.2.4 Matriz

Matrizes são áreas que antes eram cobertas por vegetação natural e agora são mosaicos de habitats modificados pelo homem que circundam os fragmentos florestais, por exemplo: pastagens, plantações, florestas em regeneração, estradas e áreas urbanas (WIENS et al., 1985). Antes, a matriz era considerada sem relevância ecológica, pois era vista como homogênea e desabitada (JULES; SHAHANI, 2003; RICKETTS, 2001). Contudo, após vários estudos, verificou-se que ela é um elemento importante da paisagem, pois pode influenciar relações tróficas, habitat, movimentação de organismos, reprodução e forrageamento.

Diferentes tipos de matriz podem influenciar na qualidade do fragmento florestal devido à (i) condições abióticas: por exemplo, as características topográficas, edáficas, microclimáticas de cada tipo de matriz, podem determinar a composição e distribuição de plantas nos fragmentos (WIENS et al., 1985); (ii) ambiente de transição: plantas da matriz podem interagir com plantas da borda do fragmento ao competir por luz, água, nutrientes e espaço ou funcionar como atração adicional a animais como alguns dispersores e polinizadores. A matriz também pode influenciar o fluxo de água, vento e fogo no interior dos fragmentos (GASCON et al., 2000; JULES; SHAHANI, 2003; PICKETT; CADENASSO, 1995; WEATHERS et al., 2001; WIENS et al., 1985). O fogo iniciado na matriz pode penetrar os fragmentos e diminuir a cobertura vegetal, aumentar as áreas de solo exposto e provocar a morte das plantas das bordas adjacentes, alterando a estrutura e a dinâmica das populações de plantas e outros organismos (COCHRANE; LAURANCE, 2002; GASCON et al., 2000; SANAIOTTI; MAGNUSSON, 1995; SCARIOT et al., 2005).

Além disso, diferentes usos da matriz podem estar relacionados ao aumento ou diminuição das áreas dos fragmentos (HAYNES et al., 2007), à conectividade entre eles (BENDER; FAHRIG, 2005), à utilização pelos organismos de corredores e stepping-stones (áreas de vegetação que podem permitir o fluxo de indivíduos) (BAUM et al., 2004) e à natureza da borda (HODGSON et al., 2007). Quanto maior a semelhança da matriz ao habitat do remanescente, maior a conectividade funcional (coesão entre populações de diferentes remanescentes) (ANDERSON et al., 2007; MEDELLÍN et al., 2000; RICKETTS, 2001; TAYLOR et al., 1993). Logo, cada tipo de matriz pode influenciar de maneira diferente movimentos de polinizadores, dispersores de sementes e herbívoros (JULES; SHAHANI, 2003).

O tipo de vegetação da matriz é responsável pelo tamanho do poro do filtro no movimento dos indivíduos (MURPHY; LOVETT-DOUST, 2004). Enquanto florestas secundárias permitem maior movimentação de organismos entre os remanescentes, por possuir a estrutura da vegetação mais semelhante à dos fragmentos, as matrizes de pasto podem impedir grande parte desse movimento (GASCON et al., 1999). Assim, acredita-se que algumas matrizes são mais favoráveis a fauna da floresta do que outras. No Amazonas, observou-se que florestas secundárias dominadas por *Cecropia* sp (STOUFFER; BIERREGAARD, 1995) e *Cecropia sciadophylla* Mart. (STOUFFER et al., 2006) foram mais utilizadas por espécies de pássaros (STOUFFER et al., 2006; STOUFFER; BIERREGAARD, 1995), sapos (TOCHER, 1998) e formigas, do que as florestas secundárias dominadas por *Vismia* (exemplo: *V. guianenses* (Aubl.) Choisy, *V. japurensis* Reich. e *V. cayennensis* (Jacq.) Pers.) que são mais baixas e estruturalmente menos diversa (MESQUITA et al., 2001). Outro trabalho mostrou que a abundância total de pequenos mamíferos foi maior em matriz antrópica com cobertura florestal (plantações de eucalipto) do que nas sem cobertura florestal (áreas de agricultura e área rural com construções) (UMETSU, 2005).

Matrizes de diferentes composições geralmente possuem microclimas distintos (maior temperatura e luminosidade, menor umidade) em relação aos fragmentos. Desta forma, acredita-se que elas possam afetar as fenofases das plantas, como por exemplo, a floração, que depende diretamente da quantidade de luz e a frutificação, que está relacionada à disponibilidade de polinizadores que transitam pelas matrizes para ter acesso aos remanescentes (JULES; SHAHANI, 2003). Plantas da matriz, também podem proporcionar uma atração adicional, que pode aumentar ou diminuir (devido à competição) a quantidade de polinizadores e taxas de polinização das plantas dos fragmentos adjacentes (JULES; SHAHANI, 2003; QUINTERO, 2010)**.** Matrizes diferentes, portanto, poderão interferir no sucesso reprodutivo de plantas em fragmentos através de dois caminhos. Primeiro, ao modificar variáveis abióticas, e segundo, ao afetar a sobrevivência, a abundância e movimentação de visitantes florais e a polinização (AIZEN; FEINSINGER, 1994; HERRERA, 2000; RAMBALDI; OLIVEIRA, 2005).

Muitos estudos apontaram os efeitos negativos e deletérios das matrizes antrópicas sobre populações de plantas e animais (MONTERO-CASTAÑO; VILÀ, 2012; KEARNS et al., 1998), enquanto outros indicam que elas podem apresentar consequências positivas (JULES; SHAHANI, 2003). Por exemplo, em um estudo sobre a reprodução de uma planta, verificou-se que efeitos negativos do aumento do número de predadores de sementes devido à matriz foram compensados pelo acréscimo da visitação dos polinizadores (STEFFAN-

DEWENTER et al., 2002). Outros fatores importantes a serem levados em consideração dentro do contexto de matrizes são as mudanças temporais (JULES; SHAHANI, 2003). A maior parte dos remanescentes florestais não é circundada por um tipo “fixo” de matriz, mas por habitats em constantes conversões, tanto por influências antrópicas quanto naturais. Pode ocorrer uma conversão de uma área em abandono para agricultura ou pastagem e posteriormente reconversão para abandono ou regeneração de florestas (CARROLL et al., 1990; RUDEL; HOROWITZ, 1993). As mudanças temporais na matriz são importantes porque a qualidade da matriz, que tem potencial de influenciar a dinâmica dos fragmentos, pode ser alterada à medida que a matriz muda. Assim, a permeabilidade da matriz a polinizadores, dispersores, também pode variar no tempo e ocasionar mudanças na reprodução de algumas plantas (JULES; SHAHANI, 2003).

Como a matriz pode influenciar a diversidade, sobrevivência e a reprodução de muitas espécies, é relevante incluí-la em estudos de fragmentação e paisagem, e a partir desses, contribuir para a criação de métodos que diminuam o impacto no ecossistema, causado pelo uso do solo (RICKETTS, 2001; LAURANCE, 2008).

1.2.5 Características locais

Além dos parâmetros de paisagem, citados anteriormente, algumas características locais relacionadas à estrutura da planta e ao habitat também podem influenciar a reprodução de plantas florestais (PIZO; ALMEIDA-NETO, 2009). O aumento de medidas estruturais como CAS (circunferência do caule na altura do solo), CAP (circunferência do caule na altura do peito), altura da planta e volume da copa podem influenciar de maneira positiva na reprodução da planta (SOARES, 2011). Assim, plantas pertencentes à mesma espécie, mas com tamanhos distintos, podem apresentar diferenças na produção de flores e frutos, devido à alocação de recursos. Enquanto plantas menores investem seus recursos na produção de raiz e folhas, as plantas maiores alocam os recursos disponíveis na reprodução. Logo, plantas maiores tendem a produzir mais flores, atrair mais polinizadores e consequentemente produzir mais frutos (CHARLESWORTH; LEON, 1976; PIÑERO et al., 1982; OSADA et al., 2002).

Características do habitat, relacionadas indiretamente à quantidade de luz que chega à planta, também devem influenciar a reprodução de plantas florestais (SOARES, 2011). Quanto maior a altura do dossel acima da planta, quanto menor o perfil vertical da vegetação (número de vezes que uma vara de 6m, toca a vegetação acima do indivíduo focal) e menor a distância do indivíduo de planta mais próximo ao estudado, maior a incidência de luz sobre a planta focal. E, por conseguinte, maior a produção de flores e frutos, pois a luz e temperatura são indutores destas fenofases (WRIGHT; VAN SHAIK, 1994).

O grau de agregação da população de plantas também deve afetar a reprodução (BLENDINGER et al., 2008; CARLO; MORALES, 2008). O aumento da distância entre indivíduos coespecíficos pode ter um efeito positivo na produção de flor, devido a maior luminosidade e um efeito positivo ou negativo na produção de frutos (WRIGHT; VAN SHAIK, 1994). Positivo, porque plantas pertencentes à mesma espécie, mas distantes uma da outra, irão competir menos por polinizadores durante a fase de floração, o que pode resultar em maior taxa de visitas florais e produção de frutos (BLENDINGER et al., 2008; RAMOS; SANTOS, 2005). Contudo, esse aumento da distância também pode diminuir a atração de polinizadores, o que pode resultar em menor produção de frutos (BLENDINGER et al., 2008; DUFFY; STOUT, 2011).

Dentro desse contexto, pode-se observar que o estudo da influência de características em escala local, junto a parâmetros em escala de paisagem pode permitir uma avaliação ampla das respostas reprodutiva de plantas a mudanças no habitat causadas pelo homem como a fragmentação (MONTERO-CASTANO; VILA, 2012; PIZO; ALMEIDA-NETO, 2009).

2 JUSTIFICATIVA

As relações abordadas nesta dissertação, efeito da estrutura da paisagem e de características locais (planta e habitat) sobre processos ecológicos (reprodução das plantas e polinização), ainda são pouco exploradas na literatura. E ainda há uma lacuna conceitual, principalmente a respeito da resposta das plantas à matriz da paisagem (FERREIRA, et al., 2013; PREVEDELLO; VIEIRA, 2010). Como a região de estudo está situada no bioma Mata Atlântica, que se encontra extremamente fragmentado (MYERS et al., 2000) e cuja a maioria dos fragmentos (80%) apresentam áreas menores que 50ha (RIBEIRO et al., 2009), torna-se importante estudar os processos ecológicos que ainda ocorrem nessas regiões, a fim de gerar conhecimento e informações que possam ajudar em questões relacionadas a conservação e restauração de áreas florestais fragmentadas, tão comuns na paisagem atual.

Além disso, a utilização da Ecologia de Paisagens como uma ferramenta para investigações das alterações ambientais reforça uma mudança da maneira de conduzir os estudos, ao substituir uma visão prévia de que o meio ambiente é homogêneo e equilibrado por uma visão mais dinâmica e de inter-relações entre padrões espaciais e processos ecológicos (METZGER, 2001).

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SEGUNDA PARTE

ARTIGO: Proportion of habitat, type of matrix and fragment shape influence the plant reproduction

Autores: Laura Fornero Gomes Ferreira, Erica Hasui e Flavio Nunes Ramos

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PROPORTION OF HABITAT, TYPE OF MATRIX AND FRAGMENT SHAPE INFLUENCE THE PLANT REPRODUCTION

Laura Fornero Gomes Ferreira[1], Erica Hasui[1], Flavio Nunes Ramos[1, 2]

[1-]Laboratório de Ecologia de Fragmentos Florestais (ECOFRAG), Instituto de Ciências da Natureza, Universidade Federal de Alfenas – UNIFAL-MG, Rua Gabriel Monteiro da Silva, 700, Centro, CEP 37130-000, Alfenas, MG, Brasil. Telephone: +00553532991447.
[2-] Corresponding author: fnramos@gmail.com
E-mail addresses: laurafornero6@gmail.com, ericahasui@yahoo.com

ABSTRACT

Habitat loss and changes in the landscape structure are effects that results of the forest fragmentation and can negative affect ecological processes, as plant reproduction and pollination. We hypothesized that the landscape structure parameters (fragment area, proximity, percentage of landscape vegetation cover - native forest, coffee, sugarcane and pasture matrix, and fragment shape) and structural characteristics of plant (height stem circumference, circumference at breast height, plant height and volume of crown) and its habitat characteristics (canopy height, vertical profile, distance to the nearest individual and distance to the nearest conspecific individual) affect the flower and fruit production and number of floral visits of forest plant. We sampled 160 individuals of a forest plant, *Psychotria vellosiana*, in eight landscapes (1000m radius), centered each one in one fragment, with 20 individuals per fragment. And we applied a general linear model and Akaike information criterion to select the best models that explains relations among plant reproduction with i) landscape and patch parameters and ii) measurements of structural characteristics of the plants and its habitat. We found that the number of floral visits and flower and fruit production are affected by the matrix type. Furthermore the total number of floral visits is influenced by the percentage of forest concomitantly with percentage of coffee matrix. And fruit production is affected by landscape complexity, size of individual plant and degree of aggregation of the plant population. From these findings, we may conclude that landscapes characteristics are important to explain the plant reproduction. The information generated may contribute to the theoretical gap in knowledge on the influence of matrix on plants and on ecological process. In addition, they can be used in recommendations to farmers, decision makers and public policies, i.e. to inform what type of matrix should be used in fragmented landscape to help to maintain or improve the fruit production of forest plants.

Keywords: fragmentation; forest cover; matrix; plant fitness; pollination, proximity

HIGHLIGHTS

- The type of matrix influenced the plant reproduction.
- The number of floral visits and fruit production was influenced by landscape structure.
- Fruit production was influenced by plant size and plant population density.

1. Introduction

Landscape Ecology is an area of knowledge whose focus is to understand the influence of environmental spatial heterogeneity on ecological processes, emphasizing human actions on the environment or the spatial context on populations (Pivello and Metzger 2007; Turner 2005). The landscape is a heterogeneous unit composed by a mosaic of interactive units, and its structure is defined by the area, shape and spatial arrangement of these units (Forman and Godron, 1986; Metzger, 1999). The landscape structure interferes on species survival and its movement across the landscape (Burgess, 1988; Soulé et al., 1992). Thus, anthropic processes such as habitat fragmentation that alter this structure can modify ecological processes (Metzger, 1999; Wiens 2005).

Plant reproduction and pollination can be influenced by the loss of habitat and modification of landscape structure parameters, i.e. isolation of patches, type of matrix (Aizen and Feinsinger, 1994a; Viana et al., 2012). These parameters have great influence on plants and pollinators survival and dispersal capacity of pollinators, once they affect resources availability and control the functional connectivity of the landscape (Viana et al., 2012).The habitat removal can induce the pollen limitation and consequently negative affect the plant breeding success (Aizen and Feinsinger, 1994a, 1994b; Fahrig, 2003; Kurki et al. 2000, Vamosi et al., 2006). Because the habitat loss can reduce the pollinators biodiversity, richness (Steffan-Dewenter et al. 2002), population abundance and distribution (Gibbs 1998, Guthery et al. 2001), change the aspects of floral visitors behavior that affect foraging success rate (Mahan and Yahner, 1999) and can decrease the compatible plants (smaller density of plants and flowers) in fragments (Aizen and Feinsinger, 1994a; Griffin and Eckert, 2003; Wagenius et al., 2007). Besides, the patch isolation reduces the biodiversity and richness of pollinators and plants (Rukke 2000, Virgós 2001), is related to movement of animals among fragments (Bender et al., 2003; Tischendorf et al., 2003) and concomitantly with the type of matrix can be responsible by the habitat connectivity (Metzger, 1999). Thus, as greater is the degree of isolation and resistance level of the surrounding matrix, lower the interpatch movement of pollinators is, minor the gene flow and the reproductive success of plant (Jules and Shahani, 2003; Viana et al. 2012).

Although the connectivity and structural characteristics of the mosaic landscape are important parameters that may interfere in ecological process (Aguilar et al., 2006; Aizen et al., 2002) still there is a lack of knowledge in this context (Ferreira et al., 2013; Prevedello and Vieira, 2010). Few studies relate the plant reproduction to landscape characteristics, especially to the type of matrix (Viana et al., 2012). Considering that the studied area (region on Atlantic Forest) is highly fragmented and has amount of habitat in extremely critical levels, understand what is happening to the species that are surviving in this environment becomes important to addressing the knowledge gap and to generate information that will help in matters of conservation and restoration (Ferreira et al., 2013; Morreale and Sullivan, 2010; Ribeiro et al., 2009).

The aim of this research was to investigate whether landscape structural parameters (landscape scale) and characteristics of plants and their habitat (local scale) influence the reproduction of forest plants, using as a model the shrub *Psychotria vellosiana*. We hypothesized that these factors mentioned above have a positive effect on plant reproduction, as they: (i) increase landscape vegetation cover of native forest (Lindenmayer and Luck, 2005), (ii) and proximity fragment (Farwig et al., 2009), (iii) matrices more similar to forest environment (coffee) (Prevedello and Vieira, 2010), (iv) patches with more regular form (McGarigal and Marks, 1995; Murcia, 1995), (v) plants with greater values of structural measurements, such as CAS, CAP, plant height and ellipsoid volume of and (vi) variations in values of measurements of traits of plant habitat, such as canopy height, vertical profile of the understory, distance to the nearest individual and distance to the nearest conspecific individual (Blendinger et al., 2008; Pizo and Almeida-Neto, 2009). We found that the total number of floral visits, likewise the flower and fruit production, are influenced by matrix type. Moreover, the number of floral visits is affected by the percentage of forest cover in the landscape combined with the percentage of coffee matrix, and fruit production by landscape complexity, size of individual plant and degree of aggregation of the plant population.

2. Methods

2.1. Study Area and Landscape Selection

The study area is into domain of Brazilian Atlantic Forest, in region of Alfenas city (84722.62 ha) (Table 1), south of Minas Gerais, Brazil (Fundação SOS Mata Atlântica, 2008). The status of conservation of this area tends to critical due to the advancement of habitat loss and fragmentation, the percentage of habitat in this region is represented by 4% of forest fragments (Fundação SOS Mata Atlântica, 2008), 97 % of the fragments are < 50 ha, the median of ENN (Euclidean nearest neighbor distance, used to quantify the isolation of fragments habitat) is 212 m (standard deviation= 301) and the largest fragment has 203 ha (unpublished data). The economy in the region is mainly based on agriculture, mainly coffee plantations (13500 ha) and others as sugarcane, corn and pasture (IBGE, 2006). The vegetation of this study was classified as Semideciduos Atlantic forest and the climate was classified as Cwa according to the Köppen system (Vianello and Alves, 1991) since the summer is hot and warm, and the winter is dry.

We selected the fragments from the classification of remnant forest areas around Alfenas city, and resort digital processing of satellite images of Sino-Brasileiro CBERS-2B, of 2009, with a resolution of 20 meters. The attributes used to select the fragments were: i) remnants with similarity at the degradation level, based on image texture ii) presence of at least one of three types of matrix (shrubby perennial represented by coffee, semi-perennial grass by sugarcane and perennial grass, by pasture) and iii) presence of the species model, *Psychotria vellosiana.* We done eight landscapes (1000m radius) each one with 314 ha area and centered in one forest fragment selected. We measured landscape and fragment metrics for each of the eight central fragments. And to analyze plant reproduction (flower and fruit production, floral visits, fruit and seed set, plants and its microenvironment traits) we sampled 20 adult individuals of *Psychotria vellosiana*, higher than 1.5m, per transects with until 40m (one per fragment), in the interior (environment as close as possible to the center of fragment) of each fragment (total 160 individuals).

2.2. *Psychotria vellosiana* as Species Model

Rubiaceae family, 400-500 genera (Barroso, 1991), is composed of trees and mainly shrubs (Cronquist, 1981). The genus *Psychotria* is the largest in the family Rubiaceae (Davis et al., 2001), having distylous flowers (pin and thrum), with the majority of species showing incompatibility within the same individual and morph (Bawa and Beach, 1983; Hamilton, 1990). Most species of this genus show elevated synchrony within a population, flowering during the rainy season, with the fruit remaining unripe for some months (Almeida and Alves, 2000; Castro and Araújo, 2004;

Ramos and Santos, 2005; Virillo et al., 2007). *Psychotria vellosiana* Benth. is a shrub or small tree, 2.5 to 4 m tall, usually occurring in shaded sites and distributed in eastern Brazil (Araújo and Cardoso, 2006). The flowers are small and pollinated by insects, mainly bees like other *Psychotria* species (Castro and Araújo, 2004; Hamilton, 1990).

The shrub was chosen because it is a good model to study the effect of fragmentation on plant reproduction (Lopes and Buzato, 2007). It can be considered a good model because is abundant in the fragments studied, produced flower and fruits at a relatively low height above the ground, must be an exigent species in relation to temperature and water availability, since most species of *Psychotria* are common in the understory forest (Hamilton, 1990; Mabberley, 1997; Taylor, 1996) and shaded areas (Pietrobom et al., 2011), but not so exigent that does not respond to changes caused by fragmentation.

2.3. Quantification of landscape structure

The landscape analysis was done with an ArcGIS 10.0 (Rempel, 2010). We made buffers of 1000m around each fragment chosen and the total area inside the buffer was classified. We choose this size of buffer because it is believed that various species of bees do not forage great distances; Gathmann and Tscharntke (2002) studied 16 wild bee species and investigated foraging distances between nesting sites and suitable food plants and found maximum flight distances ranging from 150 to 600m. We did the manual classification of the image to identify the forest fragments, calculate the percentage of vegetation cover, percentage of matrix (discriminate types of use) and evaluate the area structures. We classified the polygons as forest, coffee, sugarcane and pasture percentage. Furthermore, we calculated the landscape metrics based on vector map by vLATE (Lang and Tiede, 2003) and the Patch Analyst Extension of ArcGIS 10.0 (Rempel, 2010): i) Fragment area (ha), ii) PROX (m) (proximity fragment is a dimensionless index inversely related to the isolation of the fragment, where within a radius of 1 km, it is considered both distance and the area of the fragments present, as the larger the fragment neighbors are and the closer they are to the target fragment, the greater the value of proximity is), iii) Percentage of landscape vegetation cover (percentage of the class - native forest, coffee, sugarcane and pasture matrix calculated from the class area) and iv) Area Weighted Mean Shape Index (calculate the irregularity of remaining landscape performing a weighted average for the area. The index values are equal to 1 when all patches are circular, and it increases with increasing patch shape irregularity and area) (McGarigal and Marks, 1995). In order to check if these metrics influence the variables related to plant reproduction, we did various assessments.

2.4. Plant and habitat characteristics

For each individual plant sampled (160 total individuals), we measured structural and habitat characteristics. The structural plant measurements were: height at soil circumference (CSH), circumference at breast height (CBH), plant height, ellipsoid volume of crown (**4/3πabc, π** is a constant equal 3.14, **a** and **b** are the major and minor diameters of crown and **c** is the height crown or total height of plant minus the height of the fork of shrub) (Zotz et al., 1999). Plant habitat characteristics (related to light availability or floral visits) measured were: canopy height just above each individual plant (m*)*, vertical profile of the understory (or vertical density, counting the number of times the vegetation touched the pole, 6.0 m height, suspended vertically at breast height to above the crown of each individual) according to the methodology suggested by Pizo and Almeida-Neto (2009), distance to the nearest individual and distance to the nearest conspecific individual of each *Psychotria vellosiana* sampled. These measurements were taken to verify whether plant traits and their microenvironment features may influence plant reproduction.

2.5. Phenology

We did monthly phenological observations for one year, between July (2011) and June (2012), of 160 individuals of *P. vellosiana*, inserted in eight forest fragments. In each fragment we sampled twenty adult individuals higher than 1.5 m, along of one transect until 40m, per fragment, in the center of the remnant. To estimate phenological patterns of plants, we applied the Fournier intensity method (Fournier, 1974). The Fournier index estimates the intensity of each phenophase through a semi-quantitative scale, where 0 = absence of characteristic; 1 = presence of the characteristic with intensity from 1 to 25%, 2 = presence of the characteristic with intensity of > 25 to 50%, 3 = presence feature with an intensity of > 50 to 75%, 4 = presence of the characteristic intensity greater than 75% (Fournier, 1974). To estimate flower and fruit production (ripe fruit), we calculated the proportion of annual intensity per individual, for local scale analyses and the proportion of annual intensity per fragment, for landscape scale analyses. For the local scale, we found the sum of intensity values obtained for each individual for 12 months, divided by the number of individuals multiplied by four (maximum value of intensity that the plant may present) and by the number of months.

The proportion obtained was multiplied by 100 to convert it to a percentage value. For the landscape scale, we found the sum of intensity values obtained for the 20 individuals of a fragment for 12 months, divided by the same formula presented previously and multiplied by 100 (Fournier, 1974).

2.6. Floral visits

We accompanied a total of 32 individuals of *P. vellosiana* to obtain data of floral visits. For the purpose of minimizing the possibility that the number of flowers could influence the attraction of visitors, we sampled four individuals (2 pin and 2 thrum) with a similar number of flowers (25–50% of the crown with flowers, which corresponded to the most frequently flowering individuals in the area) along a transect of 40 meters in the interior of each fragment. The observations were made between 0700-1700 h. We observed each shrub (restricted to a branch or part of the crown) for 10 min in three different days (for total of 96 period of 10 min), and during this period we recorded the number of species of diurnal floral visitors and the frequency of visits (sensu Aizen and Feinsinger, 1994b). The visits were recorded in November and December in 2011 (approximately 15 days) when plants bloomed; no individual of *P. vellosiana* was observed twice during the same hour of the day in order to avoid systematic bias introduced by changes in insect behavior (sensu Ramos and Santos, 2006). To obtain the total value of number of species and frequency of floral visits per fragment, we did a sum of all of them in each fragment (four sampled plants). These observations were made to verify whether landscape configuration may influence floral visits, important processes related to plant reproduction. We collected at least one individual for each visiting species, it was identified by a specialist and deposited in the Instruction Laboratory of the Zoology of Federal University of Alfenas (Unifal-MG).

2.7. Fruit and seed set

To analyze whether the landscape affects the proportion of fruit and seed developed, we quantified fruit production per inflorescence counting the ripe fruit divided by the number of flowers originally produced (total number of scars) in six infructescences randomly sampled from five shrubs in each landscape (*sensu* Ramos and Santos, 2006). And to estimate the seed set, we counted the number of developed seeds of 15 fruits per shrub randomly sampled (five shrubs per landscape, total of 40 shrubs).

2.8. Data analysis

2.8.1. Relation of flower and fruit production with plant traits and their habitats

We tested the dependent variables, data of individual plant production (flower and ripe fruit), as well as independent variables, plant traits (CSH, CBH, plant height, ellipsoid volume of crown) and extrinsic traits (canopy height above the individual, understory vertical density, distance to the nearest individual and distance to the nearest conspecific individual) to verify whether they show normal distribution (D'Agostino test). The analysis of the relationships of independent variables with the dependent variables was done by constructing and selecting General linear models (GLM). The models constructed include the effects of one variable or two independent variable combined (not correlated, Spearman correlation coefficient), to represent current hypotheses in the literature on the effects of plant traits and extrinsic traits on the flower and fruit production (Table 2 and 3). We used the Akaike information criterion (AIC) to select the best model (general linear model) (Burnham and Anderson, 2002).

The AIC criterion considers the principle of parsimony, because it considers the model that fit the data as well as penalizing model complexity or number of variables (Bolker, 2006). The models with the lowest values of AIC are the most plausible. The correction AICc recommended to adjust models in relatively small samples was performed to calculate the AIC of our models. To compare the plausibility of the models, the ΔAICc and the relative weight of each model (w) was calculated. Models with $\Delta AICc \leq 2$ and $w \geq 0.10$ were considered equally plausible to explain the data (Burnham and Anderson, 2002).

2.8.2. Relation of plant reproduction parameters with landscape metrics

The dependent variables were represented by plant population production (flower and ripe fruit), fruit set, seed set and floral visits (number of species of floral visitors and the frequency of visits). And the independent variables were represented by landscape and patch metrics (Fragment area, PROX, Percentage of plant coverage (native forest and matrix of coffee, sugarcane and pasture) and Area weighted mean shape index). Were tested these variables to verify whether they show normal distribution (Shapiro-Wilk test). We did the analysis of the relationships of variables and the construction of models as mentioned in the previous section. In addition to

Spearman, we did a Pearson linear correlation to exclude the correlated variables. The models represent hypotheses about landscape and patch metrics effect on plant reproduction (Table 3 and 4). And we selected the best model according AIC (Burnham and Anderson, 2002).

3. Results

Both scales influenced plant reproduction. In the landscape scale, the parameter matrix type, area weighted mean shape index (irregularity of remaining landscape) and percentage of forest cover influence some reproductive aspects of plant. The total number of floral visits was positively influenced by the percentage of native forest associated with percentage of coffee matrix (Table 5, Fig. 3). Among the five most abundant species of floral visitors (Table 6), four were influenced by parameters of landscape structure. The number of visits of *Partamona cf. cupira,* the most frequent flower visitor, was positively influenced by the percentage of forest cover, as well the fourth most abundant species, *Apis mellifera,* which was also positively influenced by the increase of percentage of sugarcane and pasture matrix. The second most abundant floral visitor, Hymenoptera sp, in contrast was negatively affected by the increase of percentage of forest cover. And the third more abundant species, *Paratetrapedia fervida* was positively influenced by the increase of coffee and sugarcane matrix (Table 5).

Four fragments (50%) presented more than 30% of their landscape covered by forest and coffee plantations, and the coffee was crucial to achieve or surpass this threshold (Fig. 2). The increasing of percentage of pasture and sugarcane matrix enhanced the flower production and the decreasing of: i) percentage of coffee matrix and ii) the irregularity of remaining landscape had a positive effect on fruit production (Table 5).

Additionally, on the local scale, the parameter plant height and distance to the nearest plant conspecific individual influenced reproductive aspects. The increase of plant height and the decrease of distance of nearest conspecific plant had a positive effect on fruit production (Table 5).

4. Discussion

Our findings demonstrate that flower and fruit production, as well as the number of floral visits are influenced by the matrix type. Additionally the number of floral visits is influenced by percentage of forest, associated with percentage of coffee matrix, and fruit production by landscape complexity, size of individual plant and degree of aggregation of the plant population.

In the present study, the increase of percentage of pasture and sugarcane matrix around forest fragments had a positive effect on flower production. Annual grass cultures, compared with other matrices, such as the perennial shrub matrix, are less similar to forest environment, due to their vegetal stratification and height variation throughout the year (Jules and Shahani, 2003; Malcolm, 1991). Therefore, pasture and sugarcane matrix, contrary to forest, allowed greater solar radiation to reach the ground during the day and irradiation to the atmosphere during the night (Murcia, 1995). Consequently the temperature in these matrices tends to reach higher maximum (Murcia, 1995). Besides, these matrices can permit a large input of direct or indirect light incidence and increase of temperature on the remnant: factors that positively influence the flowering phase, increasing the flower production on plant species (Wright and van Schaik, 1994).

Landscape vegetation covered with native forest, associated with shrubby perennial matrix (in the present study represented by coffee) positively influences the number of floral visits in *P. vellosiana*. First, we can infer that forest cover is important in maintaining floral visitors in the landscape (Fortuna and Bascompte, 2006; Ricketts, 2004), because it can provide suitable biotic (vegetal stratification) and abiotic (microclimate) conditions for insect nesting, foraging and dislocation (Rambaldi and Oliveira, 2005). Second, the coffee matrix may maintain or help maintain the forest function for pollinators (Greenberg et al., 1997; Moguel and Toledo, 1999; Ricketts, 2004). Since this matrix type belongs to the same family, Rubiaceae, of the specie model *P. vellosiana* and because presented intermediate-sized plants (2 - 4m plant adult height) and is perennial. These last characteristics improved the microclimate (irradiation, air and soil humidity, wind velocity, etc.), being more similar to a forest environment, contrasted to pasture or other annual cultures (Renjifo, 2001). Hence, connectivity can be improved among patches, in a landscape combining a forest and perennial shrub matrix, facilitating insect dislocation, necessary for pollen flow (Muriel and Kattan, 2009; Ricketts, 2004). Furthermore, coffee, and *P. vellosiana* belong to the same taxonomic family, Rubiaceae, having common floral blooming in the same period. Coffee blooming between September - December in Brazil (Camargo and Camargo, 2001) and October - November in south of Minas Gerais state, according to ANDRADE, H. C. C. (consultant on issues related to coffee) (pers. comm., November 2012). In turn, *Psychotria vellosiana* blooms between November - December in the studied region (Personal observation). This overlap would be an advantage for the reproduction of *P. vellosiana*, since a coffee matrix may attract and maintain flower visitor insects in the landscape (Jules and Shahani, 2003).

One important contribution of the perennial shrub matrix was to help achieve the ecological threshold in the landscape (30% of native vegetation) when added to a percentage of native forest. The ecological threshold can be defined as a zone in which rapid changes occur in ecological conditions (Bennett and Radford, 2003), thus whether native forest coverage becomes less than 30% (Andrén, 1994; Swift and Hannon, 2010), there is a sudden drop in the number of original species due to the higher intensity of fragmentation effects (Lindenmayer and Luck, 2005; Metzger and Décamps, 1997). Consequently, the perennial shrub matrix contribution would facilitate the maintenance of pollinators in the region. Thus, in this study, the two habitats (native forest and coffee matrix) together may improve the connectivity and the persistence of populations of flower visitors in a fragmented landscape. In addition, *Partamona cf. cupira*, the highest frequency flower visitor can be considered a forest specialist, since its number of floral visits was positively affected by the increase of native forest, in the present study (Murcia, 1996). The other most frequent species may be considered generalists or open area species, because its visits were positively affected by various types of habitats and with different degrees of disturbance (Table 5) (Murcia, 1996).

We also found that, fruit production is positively influenced by the decrease of percentage of coffee matrix and irregularity of patch shape. Although, the increase of percentage of coffee matrix and native forest have favored the increase in number of floral visits (pollen quantity), it was not sufficient to increase fruit production. Reproductive success also depends on the origin of deposited pollen (pollen quality) (Aizen and Harder, 2007; Waser and Price, 1991) and, thus, plants that receive high rates of pollen of related individuals have a reduced fruit and seed set (Charlesworth and Charlesworth, 1987; Griffin and Eckert, 2003; Herlihy and Eckert, 2004). As *P. vellosiana* shows incompatibility within the same individual and morph (Hamilton, 1990) the chance of reproductive success in fragmented areas may be lower. Moreover, as the most frequent floral visitor may be a forest specialist, and probably they cannot easily cross between patches, enhancing inbreeding, reducing gene flow and increasing the chance of exchanging pollen between related plants (Shapcott, 1998). One study, that investigated the influence of habitat complexity and landscape configuration on pollination of wild cherry trees, also did not find a relationship between pollinator visitation rates and fruit formation, due to the differences in bee foraging and therefore in the quality of deposited pollen (Breitbach et al., 2012). Additionally, we can hypothesize that whether a coffee matrix increases the quantity of floral visits, but decreases fruit production, the floral visitors favored by coffee may not necessarily be the effective pollinators of *P. vellosiana*.

Furthermore, we found that fruit production is positively affected by a variation in patch shape. In other words, the more regular and similar to a circle the shapes of the patches are, the greater the fruit production is (McGarigal and Marks, 1995; Murcia, 1995). Fragments with a more regular shape have less edge effect (McGarigal and Marks, 1995), and as the fruit formation depends on the performance of the parental plant, any change in abiotic factors (such as hydric stress, change in nutrient availability, high temperature, herbivory) in fragments can negatively affect fruit production (Ghazoul, 2005; Knight et al., 2005; Wesselingh, 2007).

Finally, we found that forest specialist plants with larger size and near conspecific (population with high aggregation) individuals should produce more fruit.

This last relation, between proximity among conspecifics and increase of fruit production had not yet been reported in the literature. While smaller plants invest their resources in the production of root and leaf system, larger plants, closer to the adult phase, allocate their resources in reproduction. Thus larger plants tend to produce more flowers, attract more pollinators and consequently produce more fruit (Piñero et al., 1982; Osada et al., 2002). The short distance between conspecifics, associated with the fact that *Psychotria vellosiana* is an entomophilous species and usually aggregate in flowering activity (Morellato, 1991; Smith-Ramirez and Armesto, 1994) may improve the pollinator attraction and the chance of pollination and fruit production (Blendinger et al., 2008; Ramos and Santos, 2005). Moreover, the presence of neighboring fruiting conspecifics increases the visibility and attractiveness, and it may increase the visits of seed dispersers and plant fitness (Blendinger et al., 2008; Carlo and Morales, 2008).

5. Conclusion

From our results, we can conclude that the production of flower and fruit and the total number of floral visits are affected by the matrix type. Furthermore, the number of floral visits is influenced by percentage of forest cover combined with the percentage of coffee matrix, and fruit production by landscape complexity, size of individual plant and degree of aggregation of the plant population. From these findings we can affirm that landscapes characteristics are important to plant reproduction and we may contribute to the theoretical gap in knowledge about the influence of matrix on ecological process and mainly on plant (Ferreira et al., 2013). Furthermore, information generated by this study can be used in recommendations to farmers, decision makers and public policies, i.e. what type of matrix should be used to enhance the landscape connectivity and consequently help to maintain or improve the fruit production of forest plants in fragmented areas.

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Fig. 1. Conceptual map outlining sampling design and analyses.

Fig. 2. Rank of the sum of percentage of forest and coffee matrix in landscape around each fragment.

Fig. 3. Conceptual map outlining the relation of landscape structure parameters and traits of structure of plants and their habitats in the reproduction of forest plants. (+) = Positive influence. (-) = Negative influence. Pasture: Percentage of pasture matrix. Coffee: Percentage of coffee matrix. Sugarcane: Percentage of sugarcane matrix. Forest Area = percentage of native forest. AWMSI= Area Weighted Mean Shape Index (calculate the irregularity of remaining landscape performing a weighted average for the area.

Table 1: Landscape and within –patch parameters and location (WGS 1986 23S-UTM) of fragments studied in the region of Alfenas, MG, Brasil.

Table 2: Ecological hypotheses associated with the GLM used to describe the variation in flower and fruit production (proportion of annual intensity per individual) of *P. vellosiana* in Atlantic in function of variables (not correlated): CHS (cm), height (plant height), volume (ellipsoid volume of crown), canopy height (canopy height above the individual), vertical profile *(*understory vertical density), DI (distance to the nearest individual plant) and DC (distance to the nearest plant conspecific individual). The symbol ~ indicates the relationship of statistical dependence (X ~ Y, means that the expected value of Y is a function of X).

Table 3: List of all models tested.

Table 4: Ecological hypotheses associated with the GLM used to describe the variation in flower and fruit production (proportion of annual intensity per fragment) of *P. vellosiana* in Atlantic in function of variables (not correlated): PROX (proximity fragment), Percentage of forest cover, Area Weighted Mean Shape Index and fragment area (ha). The symbol ~ indicates the relationship of statistical dependence (X ~ Y, means that the expected value of Y is a function of X). The symbol "+" indicates additive effects. Flower = flower production, fruit = fruit production.

Table 5: Relative importance (GLM) from landscape metrics to total number of floral visits, number of floral visits of the most frequent species, flower and fruit production, and the relative importance of features of the plant and its light microenvironment to flower and fruit production. We presented only the valid models (ΔAICc ≤ 2) and the null models (when the random explains variation).

Table 6: Rank of the number of individuals of each visitor species from *P. vellosiana* flowers within each fragment (1, 2, 3, 4, 5, 6, 7, 8) in 2011.

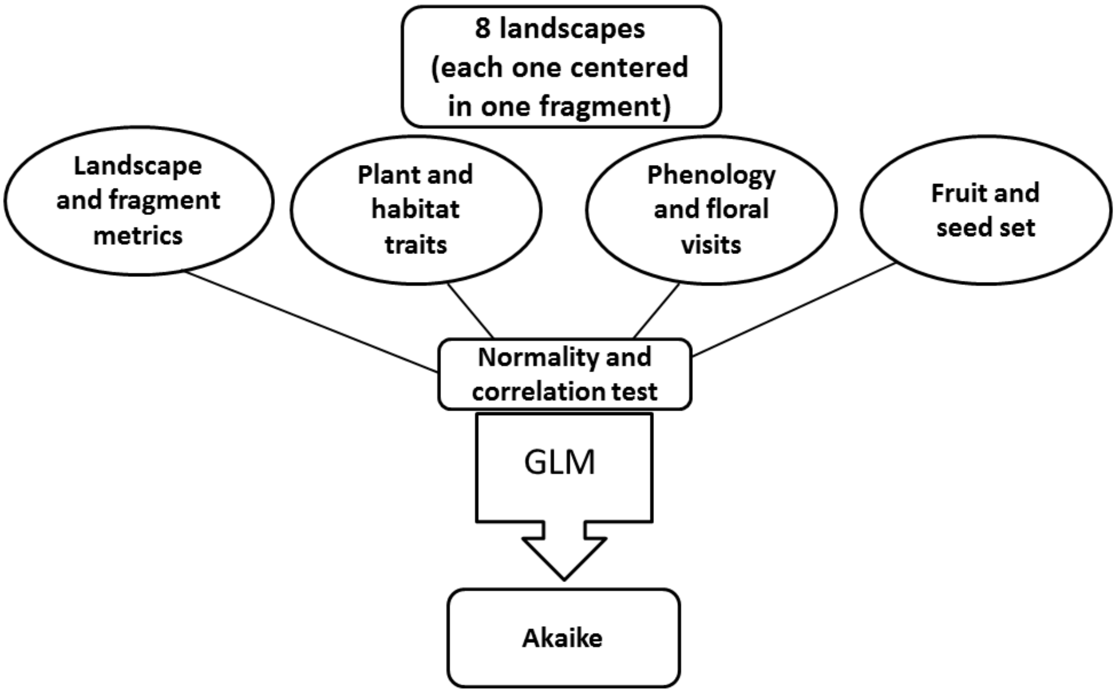

8 landscapes
(each one centered
in one fragment)
Landscape and fragment metrics
Plant and habitat traits
Phenology and floral visits
Fruit and seed set
Normality and correlation test
GLM
Akaike

Fig. 1.

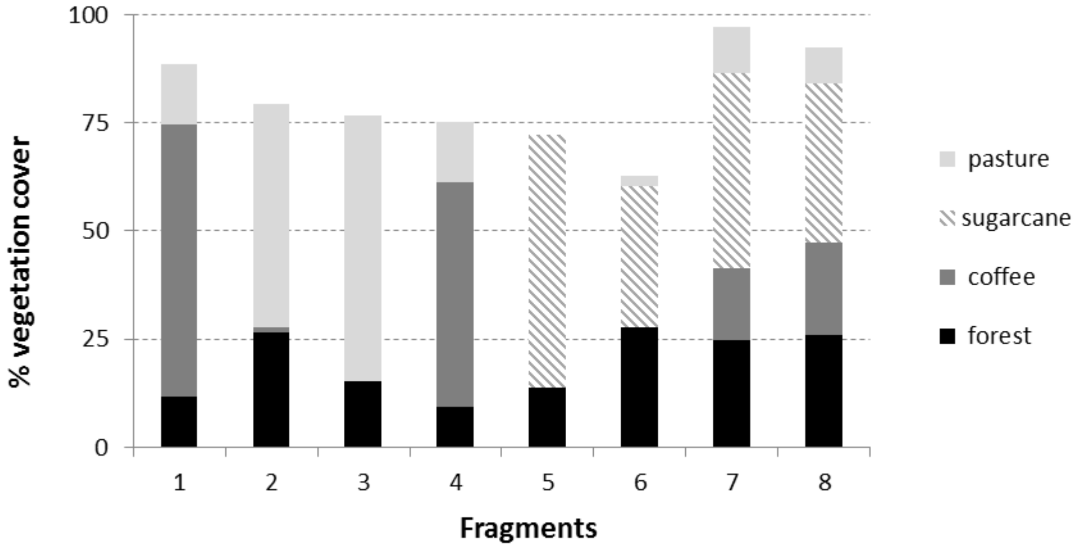
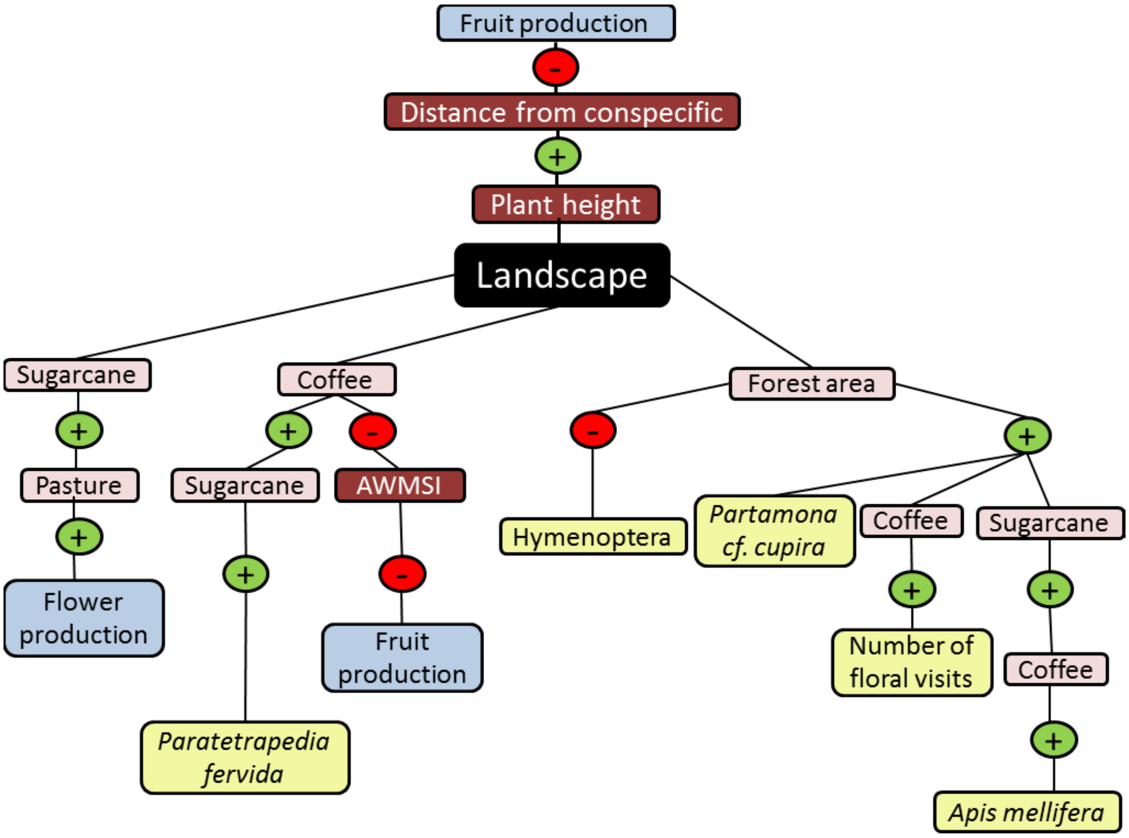

100
75
50
25
0
% vegetation cover
1
2
3
4
5
6
7
8
Fragments
pasture
sugarcane
coffee
forest

Fig. 2.



745

746 **Fig. 3.**

747

Table 1: Landscape and within –patch parameters and location (SAD 69 23S-UTM) of fragments studied in the region of Alfenas, MG, Brasil.

Fragment	Regional name	Area (ha)	Longitude	Latitude	% forest	% coffee	% sugarcane	% pasture	AWMSI
1	Paraíso	36.85	411139	7639832	11.73	62.87	0	13.74	1.48
2	Gaspar Lopes	81.55	404019	7635312	26.43	1.17	0	51.56	1.97
3	Matão	46.65	408722	7621882	15.04	0	0	61.51	1.74
4	Cemitério	22.99	403017	7615205	9.38	51.83	0	14.02	1.25
5	I	37.05	386749	386749	13.66	0	58.33	0	1.56
6	Porto	87.18	383793	7630675	27.75	0	32.51	2.3	2.23
7	São José	28.57	381066	7629262	24.54	16.83	45.13	10.5	1.86
8	M	56.05	379160	7626383	25.98	21.19	36.96	8.18	1.93

(% forest = percentage of forest cover, % coffee = percentage of coffee matrix, % sugarcane = percentage of sugarcane matrix, % pasture = percentage of pasture matrix, all percentages in function of the landscape. AWMSI= area weighted mean shape index).

Table 2: Ecological hypotheses associated with the GLM used to describe the variation in flower and fruit production (proportion of annual intensity per individual) of *P. vellosiana* in Atlantic in function of variables (not correlated): CSH (cm), height (plant height), volume (ellipsoid volume of crown), canopy height (canopy height above the individual), vertical profile *(*understory vertical density), DI (distance to the nearest individual plant) and DC (distance to the nearest plant conspecific individual). The symbol ~ indicates the relationship of statistical dependence (X ~ Y, means that the expected value of Y is a function of X).

	Model	Hypothesis	References
1	flower~CSH	Only the CSH interferes with flower production. Higher plant - higher flower production.	Charlesworth and Leon, 1976; Piñero et al., 1982
2	flower~height	Only the plant height interferes with flower production. Higher plant - higher flower production.	Charlesworth and Leon, 1976; Piñero et al., 1982
3	flower~volume	Only the volume of plant crown interferes with flower production. Larger volume of *P. vellosiana* crown - greater flower production.	Charlesworth and Leon, 1976; Piñero et al., 1982
4	flower~canopy height	Only the canopy height above the *P. vellosiana* interferes with flower production. Greater canopy height - greater indirect light - greater flower production.	Wright and van Shaik, 1994
5	flower~vertical profile	Only the vertical profile interferes with flower production. Minor vertical profile, greater indirect light, greater flower production.	Wright and van Shaik, 1994

6	flower~DI	Only the distance to the nearest individual plant interferes with flower production. Competition for light and nutrients.	Wright and van Shaik, 1994
7	Flower~DC	Only the distance to the nearest plant conspecific interferes with flower production. Attraction and competition for pollinators.	Duffy and Stout, 2011
8	fruit~CSH	Only the CAS interferes with fruit production. Higher plant - higher fruit production.	Charlesworth and Leon, 1976; Piñero et al., 1982
9	fruit~height	Only the plant height interferes with fruit production. Higher plant - higher fruit production.	Charlesworth and Leon, 1976; Piñero et al., 1982
10	fruit~volume	Only the volume of plant crown interferes with fruit production. Larger volume of *P. vellosiana* crown - greater fruit production.	Charlesworth and Leon, 1976; Piñero et al., 1982
11	fruit~canopy height	Only the canopy height above the *P. vellosiana* interferes with fruit production. Indirect effect of luminosity, attraction of pollinators (competition).	Kato and Hiura,1999; Niesenbaum, 1993; Pizo and Almeida-Neto, 2009
12	fruit~vertical profile	Only the vertical profile interferes with fruit production. Indirect effect of luminosity and attraction of pollinators (competition).	Kato and Hiura,1999; Niesenbaum, 1993; Pizo and Almeida-Neto, 2009
13	fruit~DI	Only the distance to the nearest individual plant interferes with fruit production. Indirect effect of luminosity and attraction of pollinators (competition).	Kato and Hiura,1999; Niesenbaum, 1993

14	fruit~DC	Only the distance to the nearest plant conspecific interferes with fruit production. Indirect effect of luminosity and attraction of pollinators (competition).	Niesenbaum, 1993

Table 3: List of all models tested.

	Scale	Dependent Variable	Independent Variable
1	Local (Plant and habitat features)	Flower /Fruit	~CSH
2			~height
3			~volume
4			~canopy height
5			~vertical profile
6			~DI
7			~DC
8			~CSH+height
9			~CSH+vertical profile
10			~CSH+DI
11			~CSH+DC
12			~height+canopy height
13			~height+vertical profile
14			~height+DI
15			~height+DC
16			~volume+canopy height
17			~volume+vertical profile
18			~volume+DI
19			~volume+DC
20			~canopy height+ vertical profile
21			~canopy height+DI
22			~canopy height+DC

23			~vertical profile+DI
24			~vertical profile +DC
25			~DI+DC
26	Landscape	Flower	~%forest
27			~%coffee
28			~%sugarcane
29			~%pasture
30			~%forest +%coffee
31			~%forest +%sugarcane
32			~%forest + %pasture
33			~ %Café + %cana
34			~% cofee+%pasture
35			~%sugarcane +%pasture
36			~%AWMSI
37			~%AWMSI+%coffee
38			~%AWMSI+%sugarcane
39			~%AWMSI+%pasture
40	Landscape	Fruit, fruit set, seed set, number of total visits, richness of total visits, number of visits of species A, B, C, D and E.	~prox
41			~%forest
42			~%coffee
43			~%sugarcane
44			~%pasture
45			~prox+%forest
46			~prox+%coffee

47	~prox+sugarcane
48	~prox+pasture
49	~%forest +%coffee
50	~%forest +%sugarcane
51	~%forest + %pasture
52	~ %coffee + %cane
53	~%cofee+%pasture
54	~%sugarcane +%pasture
55	~%AWMSI
56	~%AWMSI+prox
57	~%AWMSI+%coffee
58	~%AWMSI+%sugarcane
59	~%AWMSI+%pasture

(species of floral visitors: A= *Partamona cf. cupira*, B= Hymenoptera, C= *Paratetrapedia fervida*, D= Syrphidae, E= *Apis mellifera.*CSH= height stem circumference, height (plant height), volume (ellipsoid volume of crown), canopy height (canopy height above the individual), vertical profile *(*understory vertical density), DI (distance to the nearest individual plant), DC (distance to the nearest plant conspecific individual), % forest = percentage of forest cover, % coffee = percentage of coffee matrix, % sugarcane = percentage of sugarcane matrix, % pasture = percentage of pasture matrix, all percentages in function of the landscape. AWMSI = area weighted mean shape index).

Table 4: Ecological hypotheses associated with the GLM used to describe the variation in flower and fruit production (proportion of annual intensity per fragment) of *P. vellosiana* in Atlantic in function of variables (not correlated): PROX (proximity fragment), Percentage of forest cover, Area Weighted Mean Shape Index and fragment area (ha). The symbol ~ indicates the relationship of statistical dependence (X ~ Y, means that the expected value of Y is a function of X). The symbol "+" indicates additive effects. Flower = flower production, fruit = fruit production.

	Model	Hypothesis	References
1	flower~ %forest	Only the percentage of forest cover interferes with the flower production. Increase of forest cover increases the flower production.	Lindenmayer and Luck, 2005
2	flower~%coffee	Only the percentage of coffee matrix interferes with the flower production. Increase of coffee matrix increases the flower production.	Prevedello and Vieira, 2010
3	flower~%sugarcane	Only the percentage of sugarcane matrix interferes with the flower production.	Prevedello and Vieira, 2010
4	flower~%pasture	Only the percentage of pasture matrix interferes with the flower production.	Prevedello and Vieira, 2010
5	flower ~ AWMSI	Only the area weighted mean shape index interferes with the flower production.	McGarigal and Marks, 1995; Murcia, 1995

6	fruit~PROX	Only the proximity fragment interferes with fruit production. Increase of proximity fragment increases fruit production.	Farwig et al., 2009; Ferreira et al., 2013
7	fruit~%forest	Only the percentage of forest cover interferes with fruit production. Increase of forest cover increases fruit production	Lindenmayer and Luck, 2005
8	fruit~%coffee	Only the percentage of coffee matrix interferes with fruit production. Increase of coffee matrix increases fruit production.	Prevedello and Vieira, 2010
9	fruit~%sugarcane	Only the percentage of sugarcane matrix interferes with fruit production.	Prevedello and Vieira, 2010
10	fruit~%pasture	Only the percentage of pasture matrix interferes with fruit production.	Prevedello and Vieira, 2010
11	fruit~AWMSI	Only the area weighted mean shape index interferes with fruit production. Increase of area weighted mean shape index decreases fruit production.	McGarigal and Marks, 1995; Murcia, 1995
12	N_visits~PROX	Only the proximity fragment individual interferes with the number of floral visits. Increase of proximity fragment increases fruit production	Farwig et al., 2009; Ferreira et al., 2013
13	N_visits ~%forest	Only the percentage of forest cover interferes with the number of floral visits. Increase of forest cover increases the number of floral visits.	Lindenmayer and Luck, 2005

14	N_visits ~%coffee	Only the percentage of coffee matrix interferes with the number of floral visits. Increase of coffee matrix increases the number of floral visits.	Prevedello and Vieira, 2010
15	N_visits ~%sugarcane	Only the percentage of sugarcane matrix interferes with the number of floral visits.	Prevedello and Vieira, 2010
16	N_visits ~%pasture	Only the percentage of pasture matrix interferes with the number of floral visits.	Prevedello and Vieira, 2010
17	N_visits ~AWMSI	Only the area weighted mean shape index interferes with the number of floral visits	McGarigal and Marks, 1995; Murcia 1995

(% forest = percentage of forest cover, % coffee = percentage of coffee matrix, % cane= percentage of sugarcane matrix, % pasture = percentage of pasture matrix, all percentages in function of the landscape. AWMSI= area weighted mean shape index, plant height= total height of the individual of *P. vellosiana* and distance conspecific= distance from the nearest conspecific).

Table 5: Relative importance (GLM) from landscape metrics to total number of floral visits, number of floral visits of the most frequent species, flower and fruit production, and the relative importance of features of the plant and its light microenvironment to flower and fruit production. We presented only the valid models (ΔAICc ≤ 2) and the null models (when the random explains variation).

Dependent variable	Independent variable	Equation	AICc	ΔAICc	wAICc
Total number of floral visits	% forest + % coffee	Y= 1.1 + 0.0003x + 0.0006x1	76.84	0.00	0.46
	% coffee	Y= 2.4 + 0.0001x	77.23	0.39	0.38
	None		89.82	12.98	0.00
Flower	% sugarcane + % pasture	Y= 5.8 + 0.0001x + 0.00005x1	223.32	0.00	1.00
	None		406.57	183.25	0.00
Ripe fruit	AWMSI + %coffee	Y= 10.98 - 0.03x - 0.0002x1	714.31	0.00	1.00
	None		1714.40	1000.09	0.00
Ripe fruit	Plant height x distance conspecific	Y= 0.5 + 0.004x - 0.0008x1	1093.33	0.00	0.99
	None		1170.80	77.47	0.00
Partamona cf. cupira	% forest	Y= 0.7+ 0.0003x	44.68	0.00	0.95
	None		89.82	45.14	0.00

Hymenoptera	% forest	Y= 6.4 -0.005x	44.68	0.00	0.95
	None		89.82	45.14	0.00
Paratetrapedia fervida	% coffee + % sugarcane	Y = -218+0.044x+0.045x1	26.94	0.00	0.96
	None		60.55	33.61	0.00
Apis mellifera	% forest	Y = -1.39 + 0.0004x	26.22	0.00	0.67
	% sugarcane + % pasture	Y= -63.6 + 0.01x+ 0.01x1	27.94	1.72	0.28
	None		38.37	12.15	0.00

(% forest = percentage of forest cover, % coffee = percentage of coffee matrix, % sugarcane = percentage of sugarcane matrix, % pasture = percentage of pasture matrix, all percentages in function of the landscape. AWMSI= area weighted mean shape index, plant height = total height of the individual of *P. vellosiana* and distance conspecific = distance from the nearest conspecific).

Table 6: Rank of the number of individuals of each visitor species from *P. vellosiana* flowers within each fragment (1, 2, 3, 4, 5, 6, 7, 8) in 2011.

Order	Species	Fragments								
		1	2	3	4	5	6	7	8	Total per specie
Hymenoptera	*Partamona cf. cupira* (Apidae)	0	6	2	5	1	2	5	22	43
Hymenoptera	Hymenoptera sp	21	0	1	1	2	1	0	0	26
Hymenoptera	*Paratetrapedia fervida* (Anthophoridae)	12	0	0	0	0	0	4	0	16
Hymenoptera	*Apis mellifera* (Apidae)	0	2	0	0	1	0	0	7	10
Diptera	Syrphidae sp	1	0	0	1	4	2	0	2	10
Hymenoptera	*Augochlora sp* **(Halictidae)**	0	1	0	1	2	1	0	2	7
Hymenoptera	*Melipona quadrifasciata* (Apidae)	0	0	2	2	1	2	0	0	7
Lepidoptera	Lepidoptera sp1	0	3	0	0	0	0	0	0	3
Lepidoptera	Lepidoptera sp2	0	0	0	3	0	0	0	0	3
Diptera	Diptera sp	0	1	0	0	0	0	0	1	2

Hymenoptera	*Trigona spinipes* (Apidae)	0	0	0	0	0	0	1	0	1
Lepidoptera	Lepidoptera sp3	0	0	0	0	1	0	0	0	1
Lepidoptera	Lepidoptera sp4	0	0	0	0	1	0	0	0	1
Lepidoptera	Lepidoptera sp5	0	1	0	0	0	0	0	0	1
Total per fragment		34	14	5	13	13	8	10	34	131

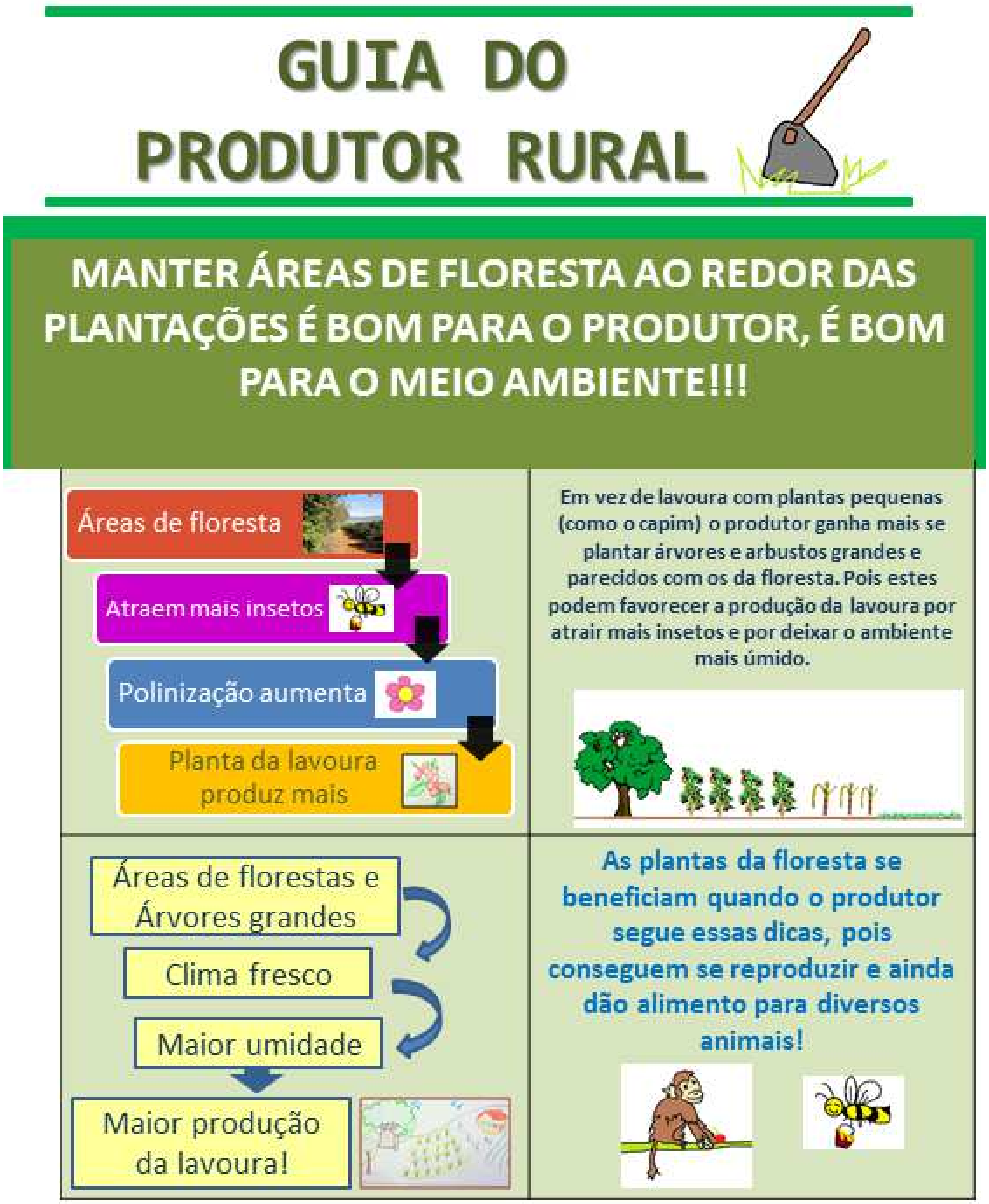
(Total visits= sum of the number of individuals of each visitor species of all fragments, Total per fragment = sum of the number of individuals of all visitor species per fragment).

4 CONSIDERAÇÕES FINAIS

Podemos concluir com este trabalho que variáveis da estrutura da paisagem (quantidade de habitat ou % de cobertura de floresta nativa, tipo de matriz e forma do fragmento) e de características locais, relacionadas à planta e seu habitat (grau de agregação da população de plantas e tamanho dos seus indivíduos) influenciam a reprodução de plantas florestais em locais onde a perda de habitat já alcançou um nível crítico. Essas informações são importantes porque geram conhecimento teórico e prático que podem ser utilizados em orientações ao produtor rural, tomadores de decisão e políticas públicas quanto ao uso da terra, conservação e restauração das áreas degradadas. Um exemplo, é o guia destinado a produtores rurais (Figura 1), criado por nós, como a finalidade de divulgar à sociedade algumas informações geradas e abordadas por este trabalho.

Alguns termos importantes da Ecologia de Paisagem foram descritos (Anexo A) como a finalidade de facilitar a leitura por pessoas de outras áreas, além disso, diagramas das relações que apresentaram resultados relevantes (Anexo B) (melhores modelos para explicar os resultados) são apresentados como material suplementar da dissertação.

Figura 1. Guia de educação ambiental que pode ser destinado ao produtor rural, como forma de repassar conhecimentos abordados e gerados por esse trabalho.



GUIA DO PRODUTOR RURAL

MANTER ÁREAS DE FLORESTA AO REDOR DAS PLANTAÇÕES É BOM PARA O PRODUTOR, É BOM PARA O MEIO AMBIENTE!!!

Áreas de floresta

Atraem mais insetos

Polinização aumenta

Planta da lavoura produz mais

Em vez de lavoura com plantas pequenas (como o capim) o produtor ganha mais se plantar árvores e arbustos grandes e parecidos com os da floresta. Pois estes podem favorecer a produção da lavoura por atrair mais insetos e por deixar o ambiente mais úmido.

Áreas de florestas e Árvores grandes

Clima fresco

Maior umidade

Maior produção da lavoura!

As plantas da floresta se beneficiam quando o produtor segue essas dicas, pois conseguem se reproduzir e ainda dão alimento para diversos animais!

ANEXO A - Termos importantes da Ecologia de Paisagem

A ecologia de paisagem alterou e incorporou termos ecológicos já existentes e criou novos termos, muitos desses tão interconectados como a própria área. O entendimento desses termos tem fundamental importância para a compreensão dessa nova abordagem de ecologia e entre os mais usados pode-se citar: **escala** (dimensão espacial ou temporal de processos ou objetos, ou quantidade de resolução espacial), **paisagem** (áreas geográficas espacialmente heterogêneas, caracterizadas por diversas interações de ecossistemas, desde sistemas aquáticos e terrestres relativamente naturais como as florestas, campos e lagos, até ambientes dominados pelo homem, incluindo cenários urbanos e agrícolas), **conectividade** (continuidade espacial de um habitat ou tipo de cobertura que atravessa uma paisagem), **heterogeneidade** (medida do quanto as partes de uma paisagem se diferenciam de outra ou distribuição aleatória de objetos através da paisagem)**, mancha** (área homogênea, restrita e não linear da paisagem que se distingue das unidades vizinhas), **corredores** (estruturas lineares da paisagem que diferem das unidades vizinhas e que ligam pelo menos dois fragmentos de habitat anteriormente unidos), **matriz** (unidade da paisagem funcionalmente e espacialmente dominante), **bordas** (áreas de transição ou de contato brusco entre diferentes unidades da paisagem), **fragmentação** (quebra de um habitat, ecossistema ou tipo de uso do solo em parcelas menores) (METZGER, 2001; TURNER; GARDNER; O'NEILL, 2001; WU, 2007).

ANEXO B – Diagramas de dispersão da influência de parâmetros estruturais de paisagem e de escala local sobre respostas reprodutivas das plantas.

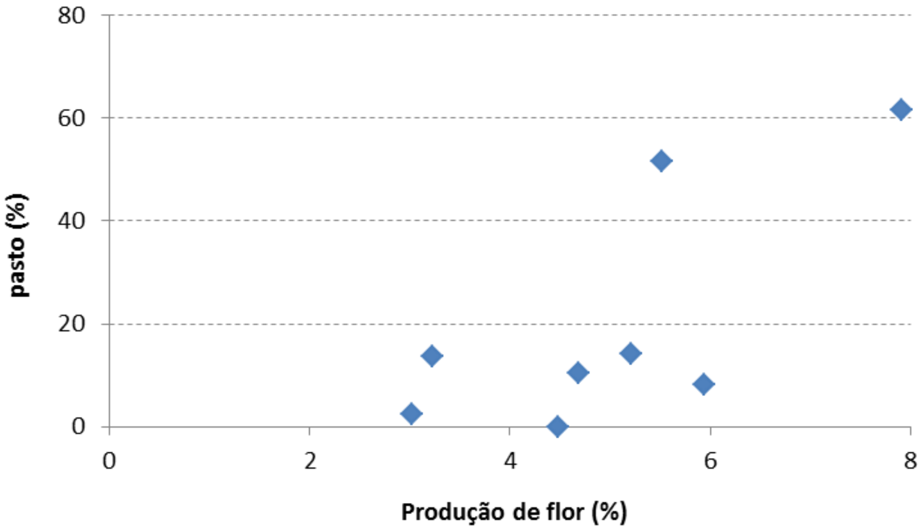


Figura 1 – Diagrama de dispersão da relação entre cobertura da paisagem por matriz de pasto (%) e produção de flor (%).

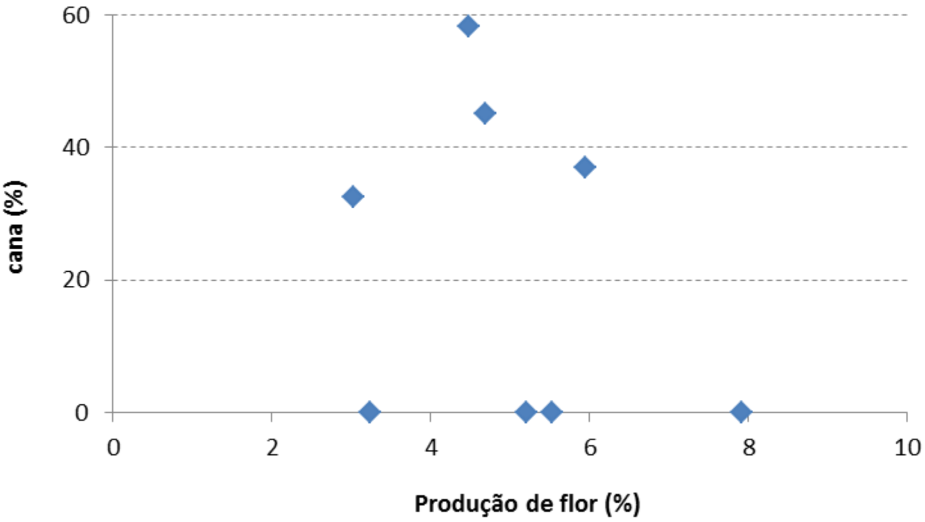


Figura 2 – Diagrama de dispersão da relação entre cobertura da paisagem por matriz de cana (%) e produção de flor (%).

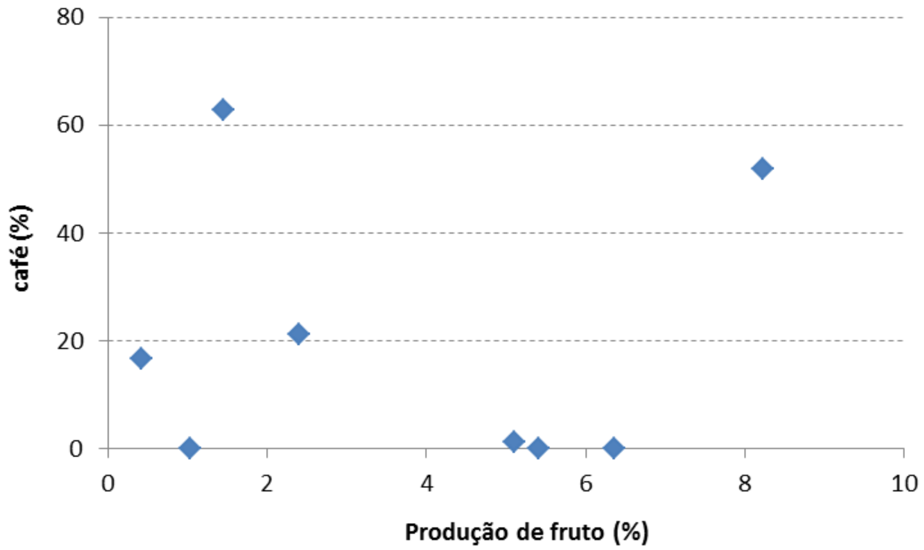


Figura 3 – Diagrama de dispersão da relação entre cobertura da paisagem por matriz de café (%) e produção de fruto (%).

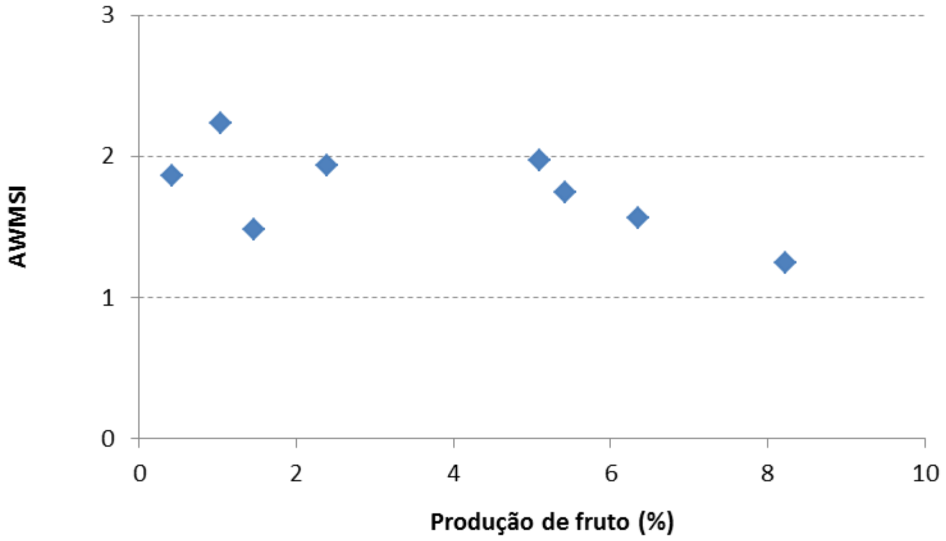


Figura 4 – Diagrama de dispersão da relação da forma ponderada pela área das manchas na paisagem (AWMSI) e produção de fruto (%).

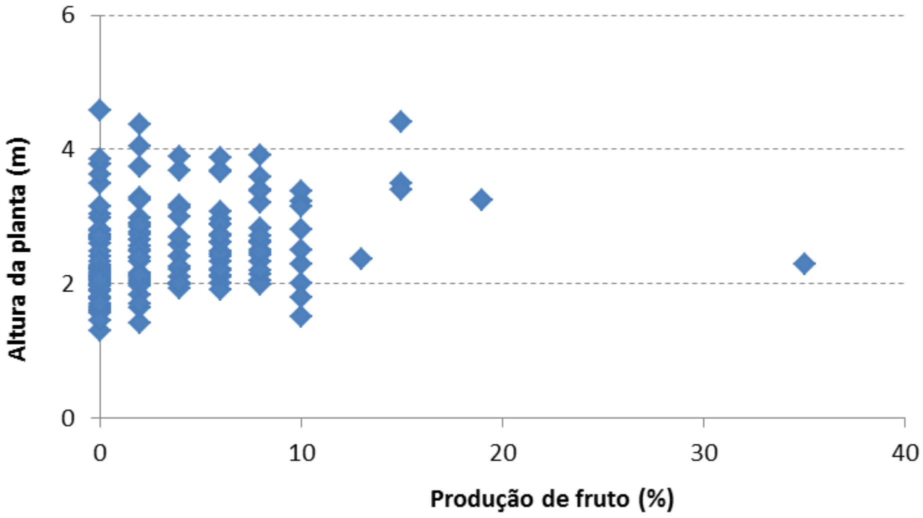


Figura 5 – Diagrama de dispersão da relação entre a altura dos indivíduos de *Psychotria vellosiana* (m) e produção de fruto (%).

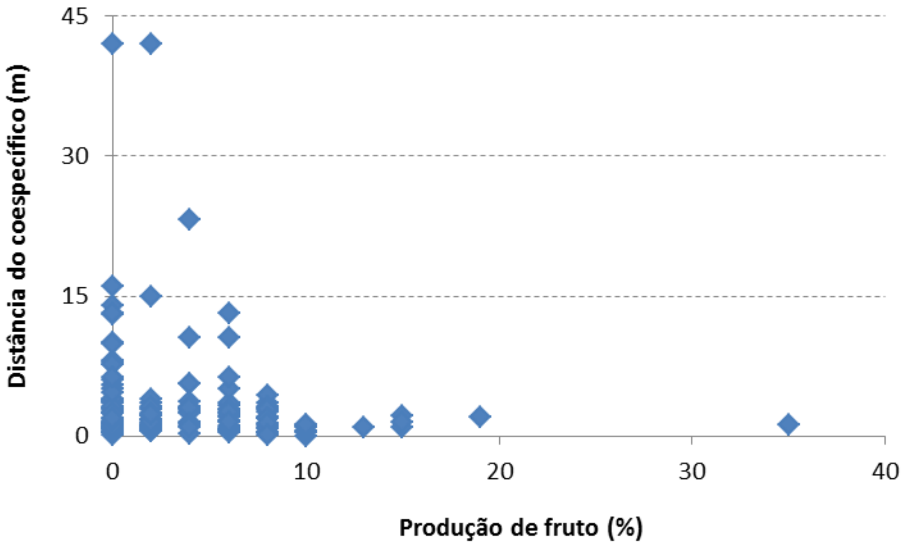


Figura 6 – Diagrama de dispersão da relação entre distância do coespecífico mais próximo da *Psychotria vellosiana* e produção de fruto (%).

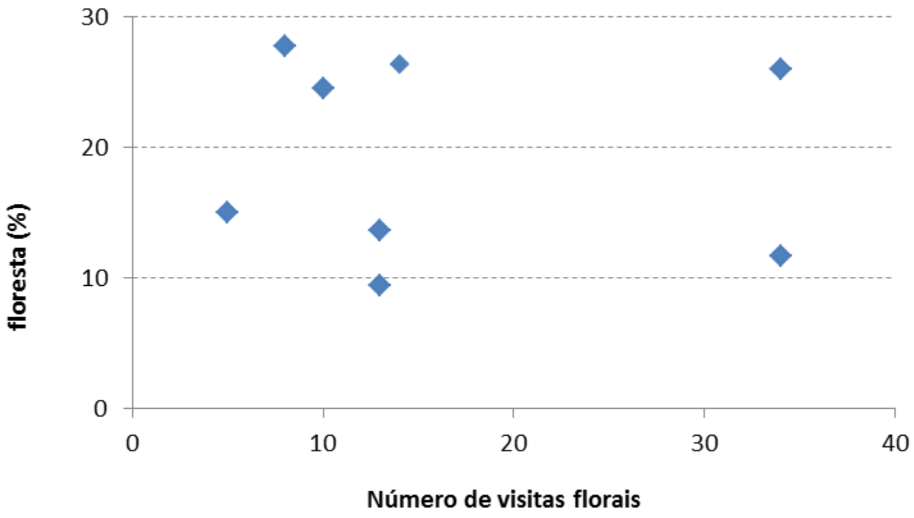


Figura 7– Diagrama de dispersão da relação entre cobertura da paisagem por floresta nativa (%) e número de visitas florais.

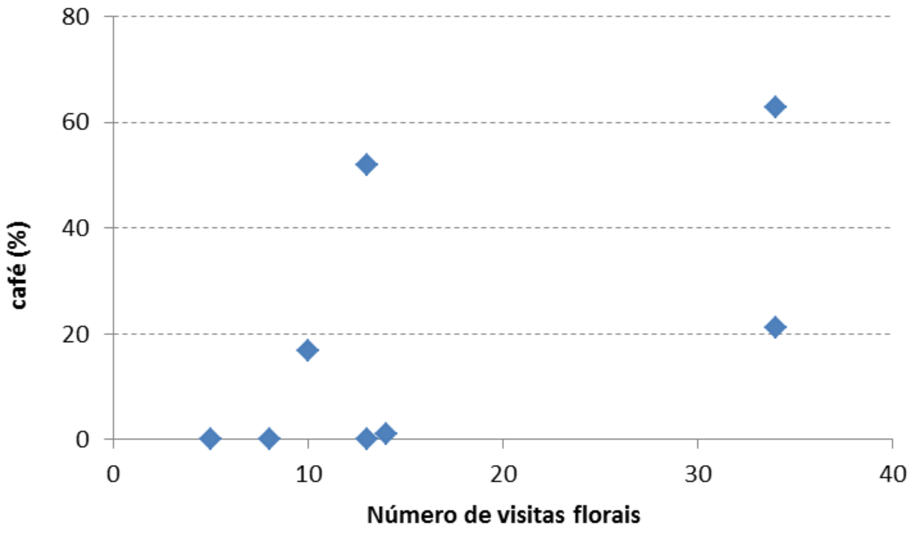


Figura 8– Diagrama de dispersão da relação entre cobertura da paisagem por matriz de café (%) e número de visitas florais.