CONILON Coffee

3rd Edition
Updated and expanded

The Coffea canephora produced in Brazil

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Integrated Pest Management in Conilon Coffee

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1 INTRODUCTION

Conilon coffee pests present behaviors regulated by factors intrinsic to the environment, such as climate, microclimate, food availability and presence of natural enemies. The alteration of these regulatory factors leads to the equilibrium instability and causes abrupt changes of the populations present in the ecosystem.

Agricultural environments replace natural diversity by a small number of plants grown in extensive areas, which characterizes monocultures. They seek scale production and productivity through the intensive use of technology and external inputs such as pesticides, inorganic fertilizers, irrigation, and high yield genetic material.

The imbalance in the system induces changes in the relationship of living beings and their natural enemies and this can lead to the emergence of high populations of bacteria, fungi, insects and spontaneous plants. These organisms compete for water, space, light and nutrients with plants of economic interest or attack their vegetal parts in search of the food necessary for their survival. This might reduce productivity and cause economic damage. Thus, these organisms are called pests.

Pests will be presented in this chapter, such as insects and mites of agricultural importance that regularly cause damage or are potentially causing damages to conilon coffee crops and that require monitoring and/or interventions for their integrated management.

Pests can occur systematically or sporadically in crops (MARTINS; FONTES; FORNAZIER, 2013; MARTINS; FORNAZIER; FANTON, 2013). When they occur sporadically and cause significant losses, they are called secondary pests. Those that occur systematically, whenever a crop is implanted and normally cause quantitative and/or qualitative economic damages, are called key pests. For the control of these pests, it is usual to recommend chemical products aiming at the rapid reduction of their population. The use of such products in a preventive manner is also used to prevent pests from settling on crops and causing future damage. This kind of procedure, when frequently used and as the only or main form of control, can induce pest resistance to the chemical groups used or to other groups. Environmental impact with soil and water resources contamination increases the risk of direct intoxication of rural workers exposed to agrochemicals, possibility of commercialization of fruits with residue levels above the tolerated one and the cost of production elevation are other risks arising from the excessive use of pesticides in crops (MARTINS; FORNAZIER, 2006).

The composition of the pest complex associated with conilon coffee in the Espírito Santo producing region, as in other crops, is influenced by the environmental conditions and by the set of agricultural practices adopted by the producers. The severity of the attack is favored or attenuated by the combination of climatic factors (rain, temperature, relative humidity etc.), as well as by the correct and proper use of good agricultural practices (fertilization, irrigation, control measures, among others).

The correct identification of pests, knowledge of the factors that favor their occurrence and the determination of their population levels are important so that technicians and producers have security in the adoption of control measures, when necessary. In specialized literature, several species of insects and mites that cause damage to arabica and conilon coffees are reported (Table 1).

Table 1. List of phytophagous arthropods found in arabica and conilon coffee in Brazil

(to be continued)

Taxonomic classification	References
MITES	
Acaridae	
Tyrophagus putrescentiae (Scrank, 1781)	Fornazier et al. (2007)
Ascidae	
Aceodromus convolvuli Muma, 1961	Reis and Zacarias (2007)
Blattisocius tarsalis Berlese, 1918	Reis and Zacarias (2007)
Cheyletidae	
Paracheyletia aff. wellsi (Baker, 1949)	Reis and Zacarias (2007)
Tarsonemidae	
Fungitarsonemus aff. pulvirosus Attiah, 1970	Reis and Zacarias (2007)
Polyphagotarsonemus latus (Banks, 1904)	Matiello et al. (2010)
Tarsonemus confusus Ewing, 1939	Reis and Zacarias (2007)
Tenuipalpidae	
Brevipalpus phoenicis (Geijskes, 1939)	Matiello et al. (2010)
Tetranychidae	
Oligonychus ilicis (McGregor, 1917)	Fonseca, Sakiyma and Borém (2015)
Tetranychus urticae Koch, 1836	Silva et al. (2009)
Eutetranychus banksi (McGregor, 1914)	Reis and Zacarias (2007)
Tydeidae	
Tydeus aff. costensis Baker, 1970	Reis and Zacarias (2007)
Lorrya formosa Cooreman, 1958	Reis and Zacarias (2007)
Parapronematus acaciae Baker, 1965	Reis and Zacarias (2007)
INSECTS	
Coleoptera	
Anobiidae	
Lasioderma serricorne (Fabricius, 1792)	Silva et al. (1968)
Anthribidae	
Araecerus fasciculatus DeGeer, 1775	Matiello et al. (2010)
Bostrichidae	
Apate terebrans Pallens, 1772	Fornazier et al. (2007)

(continuation)

Taxonomic classification	References
INSECTS	
Coleoptera	
Cerambycidae	
Migdolus fryanus Westwood, 1863	Matiello et al. (2010)
Dorcacerus barbatus (Olivier, 1790)	Silva et al. (1968)
Cetoniidae	
Euphoria lurida (Fabricius, 1775)	Silva et al. (1968)
Chrysomelidae	
Diabrotica speciosa (Germar, 1824)	Reis, Souza and Melles (1984)
Euryscopa terebellum Lacordaire, 1848	Fornazier et al. (2007)
Pygomolpus opacus Bechyne, 1949	Fornazier et al. (2007)
Canistra plagosa Boheman, 1850	Silva et al. (1968)
Paraulaca dives (Germar, 1924)	Silva et al. (1968)
Curculionidae	
Corthylus affinis Fonseca, 1927	Silva et al. (1968)
Corthylus flagellifer Blandford, 1904	Silva et al. (1968)
Entimus nobilis Boheman & Schönherr, 1833	Reis, Souza and Melles (1984)
Hypothenemus hampei Ferrari, 1867)	Fonseca, Sakiyma and Borém (2015)
Hypothenemus obscurus Wood & Bright, 1992	Silva et al. (1968)
Hypothenemus opacus Wood & Bright, 1992	Silva et al. (1968)
Hypothenemus heterolepis Costa Lima, 1928b	Silva et al. (1968)
Hypothenemus hispidulus (Le Conte, 1868)	Silva et al. (1968)
Hypothenemus fuscicollis Wood & Bright, 1992	Silva et al. (1968)
Naupactus cervinus Boheman, 1840	Gallo et al. (2002)
Naupactus rivulosus Boheman & Schönherr, 1840	Gallo et al. (2002)
Naupactus curtus Boheman, 1833	Matiello et al. (2010)
Pantomorus cervinus (Boheman, 1840)	Silva et al. (1968)
Pantomorus leucoloma Buchanan, 1939	Matiello, (1981)
Xyleborus brasiliensis Eggers, 1928c	Silva et al. (1968)
Xylosandrus compactus Wood & Bright, 1992	Fonseca, Sakiyma and Borém (2015)
Xylosandrus curtulus Wood & Bright, 1992	Fornazier et al. (2007)
Xyleborus retusus Eichhoff, 1868	Silva et al. (1968)
Meloidae	
Epicauta atomaria (Germar, 1821)	Reis, Souza and Melles (1984)
Epicauta excavata (Klug, 1825)	Reis, Souza and Melles (1984)
Melolonthidae	
Macrodactylus suturalis Mannerheim, 1829	Reis, Souza and Melles, 1984
Macrodactylus dorsatus Burmeister, 1855	Silva et al., 1968
Macrodactylus pumilio Burmeister,1855	Reis, Souza and Melles, 1984
Rutelidae	
Bolax flavolineata (Mannerheim, 1829)	Reis, Souza and Melles (1984)
Scarabeidae	
Pinotus sp.	Silva et al. (1968)
Silvanidae	
Cathartus quadricollis (Guérin-Méneville, 1844)	Silva et al. (1968)
Tenebrionidae	
Epitragus sp.	Silva et al. (1968)
Lagria villosa (Fabricius,1781)	Reis, Souza and Melles (1984)
Diptera	
Lonchaeidae	
Lonchaea spp.	Silva et al. (1968)
Neosilba pendula (Bezzi, 1919)	Silva et al. (1968)

(continuation)

Taxonomic classification	References
INSECTS	
Diptera	
Stratiomyidae	
Barbiellinia sp.	Matiello et al. (2010)
Chiromyza vittata Wiedmann, 1820	Matiello et al. (2010)
Tephritidae	
Anastrepha fraterculus (Wiedmann, 1830)	Zucchi (2008)
Anastrepha obliqua (Macquart, 1835)	Zucchi (2008)
Anastrepha sororcula Zucchi, 1979	Zucchi (2008)
Anastrepha serpentina (Wiedmann, 1830)	Zucchi (2008)
Ceratitis capitata (Wiedmann, 1824)	Guimarães, Mendes and Baliza (2010)
Hemiptera	
Subordem Auchenorrhyncha	
Aethalionidae	
Aethalion reticulatum (Linnaeus, 1767)	Matiello et al. (2010)
Subordem Auchenorrhyncha	
Cicadellidae	
Acrocampsa diminuta (Walker, 1851)	Carvalho, Lopes and Rodrigues (2015)
Acrogonia terminalis Young, 1968	Fornazier et al. (2007)
Acrogonia virescens (Metcalf, 1949)	Meneguim et al. (2000)
Acrogonia citrina Marucci & Cavichioli, 2002	Silva et al. (2007)
Bahita infuscatus Osborn, 1923	Lara, Perioto and Freitas (2007)
Bucephalogonia xanthophis (Berg, 1879)	Silva et al. (2007)
Coelidiana diminuta Chiamolera & Cavichioli, 2005	Lara, Perioto and Freitas (2007)
Deselvana excavata (Lepeletier & Serville, 1825)	Carvalho, Lopes and Rodrigues (2015)
Deselvana pervigata (Amyot & Serville, 1843)	Carvalho, Lopes and Rodrigues (2015)
Dilobopterus costalimai Young, 1977	Silva et al. (2007)
Docalidia bifurcata Nielson, 1979	Lara, Perioto and Freitas (2007)
Erythrogonia sexguttata (Fabricius, 1803)	Robles, Cruz (2008)
Ferrariana trivittata (Signoret, 1854)	Meneguim et al. (2000)
Fingeriana reflexa Carvalho & Cavichioli, 2012	Carvalho, Lopes and Rodrigues (2015)
Fonsecaiulus flavovittata (Stål, 1859)	Carvalho, Lopes and Rodrigues (2015)
Graphocephala sp.	Carvalho, Lopes and Rodrigues (2015)
Homalodisca ignorata Melichar, 1924	Meneguim et al. (2000)
Juliaca chapini Young, 1977	Carvalho, Lopes and Rodrigues (2015)
Juliaca pulla Young, 1977	Carvalho, Lopes and Rodrigues (2015)
Joruma sp.	Lara, Perioto and Freitas (2007)
Labocurtidia sp.	Lara, Perioto and Freitas (2007)
Lebaziella renatae Cavichioli, 2010	Carvalho, Lopes and Rodrigues (2015)
Lebaziella viridis Cavichioli, 2010	Carvalho, Lopes and Rodrigues (2015)
Macugonalia leucomelas (Walker, 1851)	Meneguim et al. (2000)
Macugonalia cavifrons Stål, 1862	Carvalho, Lopes and Rodrigues (2015)
Macugonalia sobrinha (Stål, 1862)	Carvalho, Lopes and Rodrigues (2015)
Microgoniella pudica Fabricius, 1803	Carvalho, Lopes and Rodrigues (2015)
Molomea consolida Schröder, 1959	Fornazier et al. (2007)
Oncometopia facialis (Signoret, 1854)	Silva et al. (2007)
Parathona gratiosa Blanchard, 1840	Lovato et al.(2001)
Paratubana vittifacies (Signoret, 1855)	Carvalho, Lopes and Rodrigues (2015)
Plesiommata corniculata Young, 1977	Marucci, Cavichioli and Zucchi (1999)
Scaphytopius irrorellus DeLong, 1944	Lara, Perioto and Freitas (2007)
Ruppeliana sp.	Carvalho, Lopes and Rodrigues (2015)
Sonesimia grossa (Signoret, 1854)	Silva et al. (2007)
Scopogonalia paula Young, 1977	Carvalho, Lopes and Rodrigues (2015)
Versigonalia ruficauda (Walker, 1851)	Carvalho, Lopes and Rodrigues (2015)

(continuation)

Taxonomic classification	References
INSECTS	
Hemiptera	
Cicadidae	
Bergalna pullata (Berg, 1879)	Matiello et al. (2010)
Carineta fasciculata (Germar, 1821)	Matiello et al. (2010)
Carineta matura Distant, 1892	Gallo et al. (2002)
Carineta spoliata (Walker, 1858)	Gallo et al. (2002)
Dorisiana drewseni (Stal, 1854)	Matiello et al. (2010)
Dorisiana viridis (Olivier, 1790)	Gallo et al. (2002)
Fidicina mannifera (Fabricius, 1803)	Matiello et al. (2010)
Fidicinoides pronoe (Walker, 1850)	Matiello et al. (2010)
Quesada gigas (Olivier, 1790)	Matiello et al. (2010)
Quesada sodalis (Walker, 1850)	Matiello et al. (2010)
Subordem Heteroptera	
Cydnidae	
Scaptocoris divergens Froeschner, 1960	Fornazier et al. (2007)
Pentatomidae	
Edessa meditabunda (Fabricius,1974)	Fornazier et al. (2007)
Pyrrhocoridae	
Euryophithalmus humilis (Drury, 1782)	Reis, Souza and Melles (1984)
Subordem Sternorrhyncha	
Superfamília Aleyrodoidea	
Aleyrodidae	
Aleurothrixus floccosus (Maskell, 1896)	Matiello et al. (2010)
Superfamília Aphidoidea	
Aphididae	
Aphis (Toxoptera) aurantii Boyer de Fonscolombe, 1841	Matiello et al. (2010)
Superfamília Coccoidea	
Coccidae	
Alecanochiton marquesi Hempel, 1921	Silva et al. (1968)
Ceroplastes ceriferus (Fabricius, 1798)	Ben-Dov, Miller and Gibson (2015)
Ceroplastes floridensis Comstock, 1881	Ben-Dov, Miller and Gibson (2015)
Coccus africanus (Newstead, 1898)	Rena et al. (1986)
Coccus alpinus De Lotto, 1960	Granara de Willink, Pirovani and Ferreira (2010)
Coccus brasiliensis Fonseca, 1957	Granara de Willink, Pirovani and Ferreira (2010)
Coccus celatus De Lotto, 1960	Granara de Willink, Pirovani and Ferreira (2010)
Coccus hesperidum Linnaeus, 1758	Ben-Dov, Miller and Gibson (2015)
Coccus lizeri (Fonseca, 1957)	Granara de Willink, Pirovani and Ferreira (2010)
Coccus longulus (Douglas, 1887)	Ben-Dov, Miller and Gibson (2015)
Coccus viridis (Green, 1889)	Partelli, Giles and Silva (2015)
Milviscutulus mangiferae (Green, 1889)	Silva et al. (1968)
Parasaissetia nigra (Nietner, 1861)	Silva et al. (1968)
Paralecanium marianum Cockerell, 1902	Silva et al. (1968)
Pulvinaria psidii Maskell, 1893	Silva et al. (1968)
Saissetia coffeae (Walker, 1852)	Matiello et al. (2010)
Cerococcidae	
Cerococcus catenarius Fonseca, 1957	Matiello et al. (2010)
Cerococcus parahybensis Hempel, 1927	Matiello (1981)

(continuation)

Taxonomic classification	References
INSECTS	
Hemiptera	
Diaspididae	
Abgrallaspis cyanophylli (Signoret, 1869)	Silva et al. (1968)
Hemiberlesia lataniae (Signoret, 1869)	Culik et al. (2008)
Howardia biclavis (Comstock, 1883)	Claps, Wolff and González (2001)
Ischnaspis longirostris (Signoret, 1882)	Silva et al. (1968)
Pinnaspis aspidistrae (Signoret, 1869)	Gallo et al. (2002)
Pseudaonidia trilobitiformis (Green, 1896)	Culik et al. (2008)
Selenaspidus articulatus (Morgan, 1889)	Claps, Wolff and González (2001)
Eriococcidae	
Eriococcus coffeae Hempel, 1919	Ben-Dov, Miller and Gibson (2015)
Ortheziidae	
Insignorthezia insignis (Browne, 1887)	Culik et al., 2011
Mixorthezia reynei (Laing, 1925)	Ben-Dov, Miller and Gibson (2015)
Praelongorthezia praelonga (Douglas, 1891)	Partelli, Giles and Silva 2015
Superfamília Coccoidea	
Pseudococcidae	
Dysmicoccus bispinosus Beardsley, 1965	Ben-Dov, Miller and Gibson (2015)
Dysmicoccus brevipes (Cockerell, 1893)	Santa-Cecília and Souza (2014)
Dysmicoccus gracilis Granara de Willink, 2009	Santa-Cecília and Souza (2014)
Dysmicoccus grassii (Leonardi, 1913)	Granara de Willink (2009)
Dysmicoccus neobrevipes Beardsley, 1959	Granara de Willink (2009)
Dysmicoccus radicis (Green, 1933)	Silva et al. (1968)
Dysmicoccus texensis (Tinsley, 1900)	Fonseca, Sakiymam and Borém (2015)
Ferrisia virgata (Cockerell, 1893)	Santa-Cecília and Souza (2014)
Geococcus coffeae Green, 1933	Santa-Cecília and Souza (2014)
Hypogeococcus boharti Miller, 1983	Fornazier et al. (2007)
Maconellicoccus hirsutus (Green, 1908)	Culik et al. (2013a, 2013b)
Neochavesia caldasiae (Balachowsky, 1957)	Ben-Dov, Miller and Gibson (2015)
Nipaecoccus coffeae (Hempel, 1919)	Santa-Cecília and Souza (2014)
Planococcus citri (Risso, 1813)	Fonseca, Sakiyma and Borém (2015)
Planococcus halli Ezzat & McConnell, 1956	Santa-Cecília and Souza (2014)
Planococcus minor (Maskell, 1897)	Fonseca, Sakiyma and Borém (2015)
Pseudococcus comstocki (Kuwana, 1902)	Silva et al. (1968)
Pseudococcus cryptus Hempel, 1918	Santa-Cecília and Souza (2014)
Pseudococcus elisae Borchsenius, 1947	Culik and Martins (2006); Culik, Ventura and Martins (2009)
Pseudococcus jackbeardsleyi Gimpel & Miller, 1996	Culik et al. (2007)
Pseudococcus landoi (Balachowsky, 1959)	Ben-Dov, Miller and Gibson (2015)
Pseudococcus longispinus (Targioni Tozzetti, 1867)	Santa-Cecília, Souza (2014)
Rhizoecus caladii Green, 1933	Silva et al. (1968)
Rhizoecus coffeae Laing, 1925	Santa-Cecília, Souza (2014)
Hymenoptera	
Formicidae	
Acromyrmex coronatus (Fabricius, 1804)	Silva et al. (1968)
Atta sexdens rubropilosa Forel, 1908	Silva et al. (1968)
Atta cephalotes (Linnaeus, 1758)	Silva et al. (1968)
Atta laevigata (Smith, 1858)	Silva et al. (1968)
Atta opaciceps Borgmeier, 1939	Silva et al. (1968)
Isoptera	
Rhinotermitidae	
Coptotermes gestroi Wasmann, 1896	Matiello et al. (2010)

(continuation)

Taxonomic classification	References
INSECTS	
Lepidoptera	
Arctiidae	
Bertholdia braziliensis (Hampson, 1901)	Reis, Souza and Melles (1984)
Thalesa citrina (Sepp, 1848)	Reis, Souza and Melles (1984)
Antarctia fusca (Walker, 1812)	Silva et al. (1968)
Blastobasidae	
Auximobasis coffeaella Busck, 1925	Matiello et al. (2010)
Dalceridae	
Acraga moorei Dyar, 1898	Silva et al. (1968)
Dalcera abrasa Herrich-Schäffer, 1854	Matiello et al. (2010)
Zadalcera fumata Schaus, 1894	Matiello et al. (2010)
Gelechiidae	
Gnorimoschema operculella (Zeller, 1873)	Silva et al. (1968)
Geometridae	
Glena sp.	Reis, Souza and Melles (1984)
Oxydia saturniata Guenee, 1858	Matiello et al. (2010)
Thyrinteina arnobia Stoll, 1782	Reis, Souza and Melles (1984)
Limacodidae	
Phobetron hipparchia Cramer, 1777	Matiello et al. (2010)
Parasa cucumenica Dyar, 1926	Silva et al. (1968)
Euclea sp.	Reis, Souza and Melles (1984)
Lyonetiidae	
Leucoptera coffeella (Guérin-Méneville, 1842)	Fonseca, Sakiyma and Borém (2015)
Megalopygidae	
Megalopyge lanata Stoll, 1780	Matiello et al. (2010)
Podalia sp.	Matiello et al. (2010)
Noctuidae	
Agrotis ipsilon Hufnagel, 1766	Guimarães, Mendes and Baliza (2010)
Mocis latipes (Guenée, 1852)	Silva et al. (1968)
Spodoptera frugiperda Smith & Abbot, 1797	Silva et al. (1968)
Spodoptera dolichos Fabricius, 1794	Silva et al. (1968)
Plusia nu Guenée, 1852	Silva et al. (1968)
Nymphalidae	
Caligo memnon telamonius Felder, 1862	Silva et al. (1968)
Oecophoridae	
Stenoma spp.	Silva et al. (1968)
Timocratica albella Zeller, 1839	Silva et al. (1968)
Phycitidae	
Ectomyelois decolor (Zeller, 1881)	Silva et al. (1968)
Paramyelois transitella (Walker, 1863)	Silva et al. (1968)
Psychidae	
Oiketicus kirbyi (Guilding, 1927)	Matiello et al. (2010)
Oiketicus geyeri (Berg, 1877)	Matiello et al. (2010)
Pyralidae	
Anagasta cautella Walker, 1863	Matiello et al. (2010)
Corcyra cephalonica Stainton, 1866	Matiello et al. (2010)
Cryptoblabes gnidiella Millière, 1867	Fonseca, Sakiyma and Borém (2015)
Ephestia sp.	Silva et al. (1968)
Plodia interpunctella Hübner, [1813]	Matiello et al. (2010)
Pococera atramentalis (Lederer, 1863)	Silva et al. (1968)

(conclusion)

Taxonomic classification	References
INSECTS	
Lepidoptera	
Saturniidae	
Automeris complicata (Walker, 1855)	Reis, Souza and Melles (1984)
Automeris coresus Boisduval, 1859	Reis, Souza and Melles (1984)
Automeris naranja Schaus, 1898	Specht, Formentini and Corseuil (2007)
Automeris illustris Walker, 1855	Reis, Souza and Melles (1984)
Automeris irene (Cramer, 1780)	Silva et al. (1968)
Eacles imperialis magnifica Walker, 1856	Matiello et al. (2010)
Eacles penelope ducalis Walker, 1855	Fornazier et al. (2007)
Lonomia circumstans (Walker, 1855)	Gallo et al. (2002)
Lonomia cluacina Druce, 1877	Silva et al. (1968)
Rothschildia hesperus Linnaeus, 1758	Silva et al. (1968)
Sphingidae	
Perigonia lusca Fabricius, 1777	Costa et al. (1995)
Orthoptera	
Tettigoniidae	
Picnopalpa bicordata Serville, 1825	Reis, Souza and Melles (1984)
Psocodea	
Troctopsocidae	
Plaumannia sp.	Fornazier et al. (2007)
Thysanoptera	
Thripidae	
Heliothrips haemorrhoidalis (Bouché, 1833)	Matiello et al. (2010)
Retithrips syriacus (Mayet, 1890)	Matiello et al. (2010)

Misuse of pesticides (insecticides and acaricides) and the systematic use of the same commercial product, active ingredient or chemical group have resulted in the accelerated development of insects and mites resistance to agrochemicals. This has serious consequences for the entire agribusiness chain, with more frequent use and higher doses of agrochemicals due to the loss of its efficiency. To prevent or delay these problems, including minimizing the use of agrochemicals and the risks of environmental contamination and human health, the concept of Integrated Pest Management was introduced. It is characterized as the adoption of strategies and tactics for the rational and integrated application of various actions and/or practices for pest control in the context of the environment in which the pest is or may be installed. This will complement and facilitate the action of natural biological control agents, taking into account the economic, toxicological, environmental and social aspects, such as:

I - legislative control: regulation concerning compulsory elimination of unproductive crops; implementation of monitoring and pest population inspections; standardization and strict inspection regarding the production, transit of vegetal parts and zoning of pest-free areas; compliance with federal, state and local laws regarding the cultures and pest practices;

II - cultivation control: seedlings production in protected nurseries; planting selected and healthy seedlings; use of live barriers; use of traps with attractive food and/or pheromones for monitoring and control; rational management of spontaneous plants; elimination of infested culture remains; use of mulch; environments, time and places of production; use of lower solubility fertilizers formulations; management of the remaining organic matter, use of organic waste composting and use of green manure; fallowing of the areas for new coffee plantations implantation; use of the principles of crop rotation etc. This aspect also includes genetic control, through the use of resistant genetic materials and the direct and/or indirect induction of resistance;

III - chemical control: correct identification of pests and the complex of natural enemies; pests monitoring and pesticides use from different chemical groups and modes of action, in a rational and localized way; use of pesticides for the crop/pest registered in the federal agencies and in the competent state organs; recommendation through agronomic prescription; use of individual protection equipment; correct use of pesticide application technologies; restriction to preventive applications of insecticides and acaricides and their use with broad spectrum of action;

IV - biological control: preservation and use of the natural control agents potential such as bacteria, fungi, parasitoids and predators through cultural managements and the correct use of selective pesticides (conservative) and/or its creation; massive release of these agents into the culture environment;

V - educational actions: training and awareness of technicians, producers and rural workers; promotion of coffee growers training in the practice of pests and natural enemies monitoring and identification in the conilon coffee crop.

Based on the fact that the plants support certain levels of pest infestation in a way that does not cause economic damages, the principle of pest sampling is used before the applications of pesticides are carried out. This procedure is fundamental to the success of Integrated Pest Management. To do so, it is necessary to know the plants phenology, pest bioecology and the relationship between them and their complex of natural enemies. It is necessary to determine the levels of economic damage, the size of the terrains to be sampled, the insect phase, the location and sampling frequency for the pest monitoring implementation, especially the key pests. The education and training of pest inspectors, commonly referred to as "pragueiros" pest fighter is also important. Within the context of integrated pest management, chemical control starts being another important alternative to be used in the infestation reduction, especially when observed and used the concepts of ecological and physiological selectivity to natural enemies and management of pests resistance to pesticides. Ecological selectivity can be achieved by modifying the pesticide application system based on the bioecology of the pests and their natural enemies and directing them to the pest outbreaks and the use of products via soil. The physiological selectivity is related to the greater or lesser tolerance of each one of the individuals that are part of the organisms complex present in the area, when exposed to the same chemical, occurring the death of the pest species and the preservation of the beneficial insects. The resistance to pesticides management is based on the rotation of insecticides and acaricides used by their mode of action, which is the biochemical process by which the molecules of pesticides interact with their target, causing changes in normal physiological processes of the pest that lead to its death. The vast majority of insecticides interact with specific targets in the nervous system and are termed neurotoxic. There are also those that interfere in the biochemical process of chitin synthesis, in the endocrine system (growth regulators) and in energy and respiratory metabolism, besides others that are deterrents, mesenteric or sexual pheromones disintegrators. In order to apply the principle of pest resistance management to pesticides, registered chemical products with different modes of action must be available in the agrochemical program of the coffee crop.

The use of the concept integrated pest management can lead to economic and environmental sustainability of certain species growing in areas where there are already serious resistance problems of pests to pesticides. However, there is a need for awareness raising and paradigm change, not only with the farmers, but also with the technical staff who work in the technical assistance and regional rural extension, both in the public and private sectors.

Within the process of globalization, markets have become extremely demanding in food quality and safety, moving towards the commercialization of premium and specialty coffees certified according to their own regulations. Improvements in the quality of life and well-being are demand points of the population and, in the agricultural production process, this is reflected in the valuation of foods that prioritize health and respect the environment. In markets where international sanitary barriers are replacing economic and tariff barriers, the indiscriminate use of agrochemicals in the production process is inadmissible. This is contrary to the international norms and requirements demanded by the consumers, which can jeopardize the joint and united efforts made to move towards the concept of production demanded by the market and the production certification processes (ZAMBOLIM, 2007).

2ECONOMICALLY IMPORT PESTS FOR CONILON COFFEE

2.1 COFFEE BERRY BORER

Hypothenemus hampei (Ferrari, 1867) (Coleoptera: Curculionidae)

Description and Biology

Originating in Africa, coffee berry borer is the conilon main pest, as it has the ability to attack fruits at all maturing stages, from green to ripe (berry) or dry. This pest was first detected in Brazil in 1913, in the municipality of Campinas, São Paulo (BERTHET, 1913). However, its presence was officially registered only in 1924, when it caused great losses.

The adult of the coffee berry borer is a small black beetle, with a cylindrical body and slightly curved towards the posterior region. The elytron are coated with characteristic pyriform bristles and scales. The males are similar to the females, but are smaller, measuring about a third of their body size and have rudimentary wings. For this reason, males do not fly and do not leave the fruits from which they originated. The proportion in the population is one male to ten females (BERGAMIN, 1943; BENASSI; CARVALHO, 1994).

Mating occurs within the fruit where the female originated. Right after it, she looks for another fruit and perforates it, usually in the crown region, beginning the excavation of a gallery until reaching the seed parchment (Figure 1). The female takes about seven hours to fully penetrate the fruit and can attack the fruit since the pellet-like berry stage.

However, only when the coffee fruit reaches adequate moisture content/dry matter, that is, after the “water” period (“green” stage), the females initiate oviposition. Inside the seed, it widens the gallery and begins the lay. The eggs are small, white, elliptical and bright. The female initially lays, on average, two eggs per day. After 10 to 20 days, it starts to lay one egg a day, during a period of 10 to 12 days; from there, one egg every two days. A female can live up to 156 days and can lay from 31 to 119 eggs. The larvae are born after 4 to 10 days of egg laying and begin to feed on the seed, disintegrating small particles from the walls of the chamber where they were born. After a few days and under favorable conditions for the female to lay the eggs and larvae hatch, the seed can be fully consumed. The larval stage lasts on average 14 days and the larvae become pupae. At this stage, the vestiges of wings, antennae, eyes, mouth parts and legs of the future adult appear. The pupae initial coloration is white and over time the antennae, wings and mouthparts become darker and have a light brown color. The pupal stage lasts, in average, seven days; the adult is dark yellow in the early days and darkens to the definitive black color. The complete evolution from egg to adult occurs between 22 and 32 days and depends on the temperature (BERGAMIN, 1943; SOUZA; REIS, 1997; LAURENTINO; COSTA, 2004).

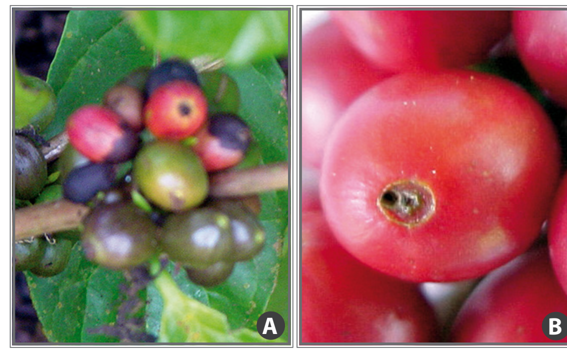

Figure 1. Rosette with coffee berry borer attack symptom (A); and detail of the pest hole in the crown region of the fruit (B).

Adults and immature forms survive from one crop to another, in coffee beans lying on the ground or retained in plants, provided there are favorable conditions of moisture for their survival. Thus, post-harvest rains provide ideal conditions for survival of the coffee berry borer, particularly if associated with intense summer in January and February. The lack of uniformity of flowering also favors the coffee berry borer multiplication because it provides the existence of fruits suitable for its feeding for a longer period.

Losses

High temperatures associated with water factors in the conilon cultivation regions lead to favorable conditions to the greater development of coffee berry borer populations and allow the pest to be responsible for large losses in productivity (BENASSI; CARVALHO, 1994). After the female perforates the fruit and digs the galleries with the respective laying chamber, the larvae appear, which, when feeding, destroy partially or totally the seed (Figure 2).

In the processing of harvested coffee, the following situations can arise due to the severity with which the seed was damaged: presence of perfect or healthy beans, not affected by the coffee berry borer; drilled beans in which the perforations of the coffee berry borer galleries can be observed; and low quality coffee, resulting from the breaking of the most damaged beans by the coffee berry borer.

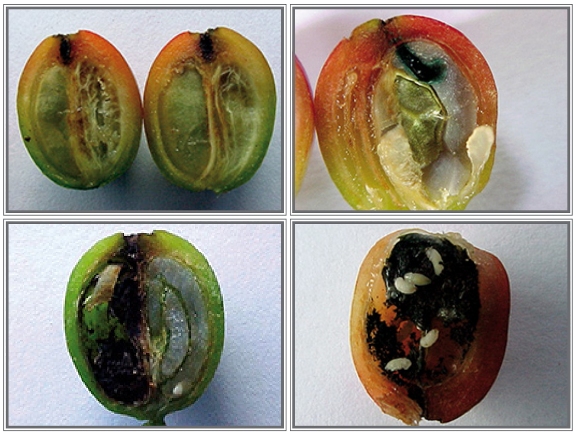

Figure 2. Coffee beans damaged by coffee berry borer at different maturation stages.

High infestations of this insect in the production phase decrease the percentage of perfect beans and increase the amount of drilled, low quality and broken beans. Thus, the damages caused by the coffee berry borer can be directly verified in the weight loss of the processed coffee, since the completely destroyed or very damaged beans leave together with the low quality beans and indirectly due to the presence of drilled beans and the depreciation of the processed coffee value, since every five drilled beans, it is considered a defect in the classification by type (NAKANO et al., 1976; YOKOYAMA et al., 1978; LUCAS et al., 1989). Another problem with coffee quality is the presence of residues composed of feces and part of adult insects, larvae and eggs that remain in roasted and ground coffee.

Information gathering carried out in the state of Espírito Santo showed that in years favorable to infestation, coffee berry borer causes losses up to R$ 40 million per year (De MUNER et al., 2000). Fornazier et al. (2000a, 2000b, 2000c, 2000d, 2000e, 2000f, 2001b) and Fornazier, Martins and De Muner (2001); Fornazier et al. (2001b) showed infestations of coffee berry borer in Espírito Santo's conilon coffee higher than 25% of drilled grains, after processing. Field infestations were sampled in all conilon coffee producing municipalities, which led to the launching of the State Coffee Berry Borer Management Campaign (SOARES et al., 2001). As a result of this campaign, it was possible to typify conilon coffee produced in the northern and southern regions of Espírito Santo. It was observed the great influence of coffee berry borer on the reduction of crop productivity, especially of the less-technological ones, on the intrinsic quality of conilon coffee and on the slight increase in the incidence of grain defects (FORNAZIER et al., 2000a, 2000b, 2000c, 2000d, 2000e, 2000f, 2001b, FORNAZIER; MARTINS; De MUNER, 2001, FORNAZIER et al., 2001b).

Infestation and Sampling

In spite of attacking the fruits at all maturation stages, the coffee berry borer only begins to perforate the fruits when the seeds reach the moisture content and the dry matter weight adequate to the egg laying by the females. When the coffee berry borer attacks fruits still in the pellet stage or very watery, they stop their development and fall later. In conilon, these fruits still underdeveloped to be perforated, in addition to the growth stoppage, present a change in coloration, which varies from yellowish to slightly reddish before falling. When the attack occurs after the pellet stage, the infested fruits continue to develop, but the coffee berry borer is lodged in the fruit crown, without continuing the excavation of the gallery, waiting its development until the seeds reach the content of moisture/matter dry conditions appropriate to oviposition. The identification by the producer of this period in which the coffee berry borer is housed in the crown and does not penetrate the fruit usually occurs between October and December in Espírito Santo and is the determining factor in the success of the chemical control measures adoption. It is in this period that the producer must initiate sampling procedures and infestation calculations (SOARES et al., 2001; FORNAZIER et al., 2005c). In the state of Rondônia, field infestations ranged from 33 to 40% (COSTA et al., 2002).

It has not been easy to establish a practical criterion to determine accurately the degree of pest infestation in the coffee crop because the coffee berry borer does not spread uniformly on the lands and in the fruits of the same plant. However, the criterion adopted in the practice is to collect, at random, from each field, a certain quantity of fruits of a certain number of plants beginning in October-November, when the beans are still green.

For the coffee berry borer infestation survey in arabica coffee, it has been recommended to sample 50 plants per field, well distributed throughout the area; collect 100 fruits per plant taking, randomly, 25 of each face of the plant, totaling 5 thousand fruits per field (REIS et al., 2010). In order to facilitate, the fruits can be mixed, forming a single sample and counted by separating the drilled ones (with the presence of live insects) from those healthy ones, obtaining the percentage of infestation. It is done in the same way for all fields and determines the average that will provide the infestation. The indication of the infestation percentage is very important, since it is based exclusively on it that the coffee crop treatment can be recommended. However, whenever possible, the control should be performed by field and/or coffee clone when the control levels are reached. Sampling in the Espírito Santo municipalities that are conilon coffee producers was carried out with 500 fruits in fielsd of 3 thousand to 5 thousand plants, where excellent results were obtained (De MUNER et al., 2000; FORNAZIER et al., 2000a, 2000b, 2000c, 2000, 2000e, 2000f, 2001b; FORNAZIER; MARTINS; De MUNER, 2001; FORNAZIER et al., 2001b).

Methods of control

Cultural

Culture control through “transfer”, that is, the harvesting of coffee beans that remain in the soil or retained in the plant after harvesting is aimed at reducing outbreaks of pest infestation in the crop. It is one of the most efficient methods of fighting coffee berry borer using “friendlier” technology for the management. The withdrawal of the food source and the remaining insects from the previous crop greatly favors the pest population reduction in commercial crops. Abandoned crops should be eradicated not to work as a focus for multiplication and insect dissemination. The very green fruits of the previous crop, coming from late flowering, should also be removed, because when they develop they can be used to multiply the coffee berry borer during the off season. The densification of crops is becoming more and more frequent in conilon coffee cultivation and may favor the coffee berry borer infestation in periods favorable to its development. For the storage of the harvested beans, it is necessary to perform the drying correctly to avoid that the coffee berry borer continues its multiplication, especially in the coffee stored in coconut (FORNAZIER; BENASSI; MARTINS, 1995; FORNAZIER et al., 2000c;

De MUNER et al., 2000).

Biological

As the coffee berry borer main natural enemies, the African parasitoids stand out: *Prorops nasuta* Waterston, known as Uganda Wasp; *Cephalonomia stephanoderis* Betrem, Ivory Coast Wasp; *Heterospilus coffeicola* Schemied and *Phymastichus coffea* La Salle, Togo Wasp. In addition to these species, it was documented the presence of *Cephalonomia hyalinipennis* Ashmead in Mexico (PÉREZ-LACHAUD, 1998; PÉREZ-LACHAUD; HARDY, 1999) and in Brazil, in the State of São Paulo, municipalities of Ribeirão Preto, Mococa and Campinas (BENASSI, 2007) and in the State of Espírito Santo, municipality of Sooretama.

Prorops nasuta was introduced in Brazil by Hempel in 1929, multiplied in laboratory and released in several municipalities of the State of São Paulo With the use of chemicals, from the 1940s, biological control using this wasp was neglected. Currently, this parasitoid can be found in some Brazilian states, such as Espírito Santo, Minas Gerais, Paraná and São Paulo. Ivory Coast Wasp occurs naturally in several municipalities of Espírito Santo, Minas Gerais, Rondônia and São Paulo (BENASSI, 1996; SOUZA et al., 2006). Surveys carried out in 19 municipalities of Espírito Santo during the period from 2001 to 2003 detected their presence in 18 of them, with parasitism index in the field varying from 1.3% to 83.0% in the off-season (BENASSI, 2007).

The adults of the three species *P. nasuta* (Figure 3A), *C. hyalinipennis* (Figure 3B) and *C. stephanoderis* (Figure 3C) are from the family Bethylidae (Hymenoptera) and resemble color and size: they are black and measure approximately 2.5 mm in length. They can be easily differentiated by the shape of the head, which is triangular in the Uganda Wasp, quadrangular in the Ivory Coast Wasp and rectangular in *C. hyalinipennis* (Figure 3).

The development phases length of the two species is similar and depend on temperature, varying the egg period from two to six days and larval stage of four to eight days (BENASSI, 1996, 2000). After this period, the larva weaves a cocoon and inside of it begins its pupal stage, later emerging as an adult insect. All the activity of the two species occurs inside the coffee fruits, where the adults penetrate through the gallery made by the coffee berry borer. The females, finding the larvae developed and coffee berry borer pupae, paralyze them by venom injection and place, in most cases, only one egg in the ventral region of the larvae or in the dorsal region of the pupae. After hatching, the wasp larvae penetrate into the coffee berry borer larva (part of their body is exposed) and suck their entire contents (Figure 4). The development period of

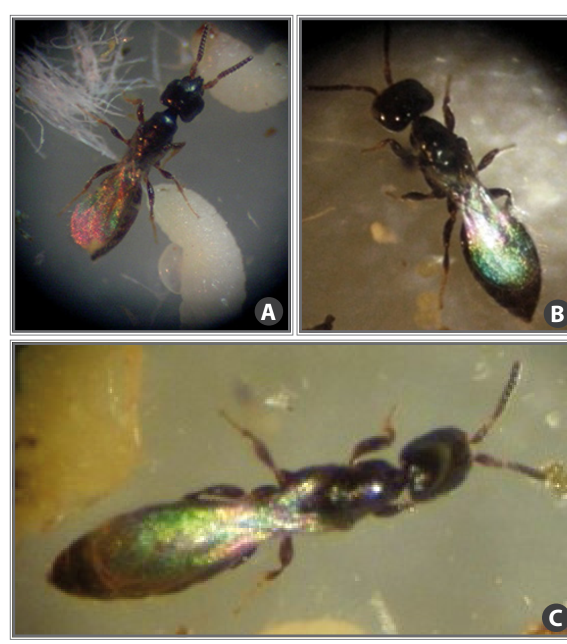

Figure 3. *Prorops nasuta* - Uganda wasp (A); *C. stephanoderis* - Ivory Coast Wasp (B); and *C. hyalinipennis* (C).

P. nasuta and *C. stephanoderis* is similar and depend on temperature. The egg period varies from two to six days and the larval from four to eight days (BENASSI, 1996, 2000, 2007).

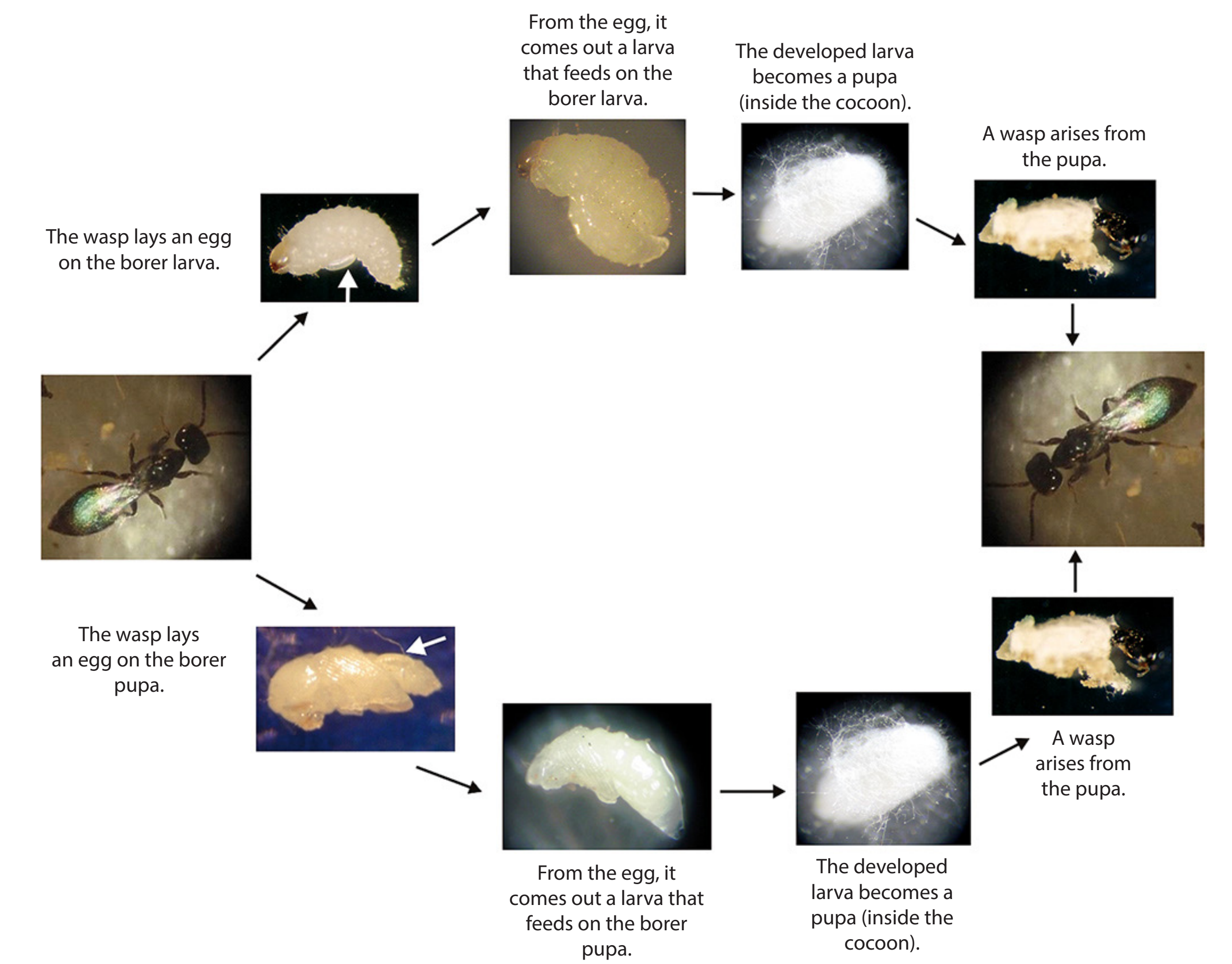

Figure 4. Parasitism stages of the Ivory Coast Wasp, *Cephalonomia stephanoderis* from the coffee berry borer larva (top of the figure) and the coffee berry borer pupa (bottom).

Source: Benassi (1996).

In addition to parasitism by larvae, adults have the predatory characteristic and feed on eggs, small larvae and coffee berry borer adults. When the coffee berry borer adults are attacked, they usually have their head pulled out (BENASSI, 2007) (Figure 5).

These species of parasitoids both reproduce sexually and asexually, by arrhenotoky parthenogenesis, giving rise only to male individuals. When this type of reproduction occurs, the males mate with the mothers giving rise again to the new generation with females and males (BENASSI, 2007).

Figure 5. Adult coffee berry borer beheaded by the Ivory Coast Wasp.

These wasps can be created in drilled coffee fruits and later released in the coffee plantation to control the coffee berry borer. The Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - Incaper (Capixaba Institute for Research, Technical Assistance and Rural Extension) has been developing for several years studies on biological control with the coffee berry borer parasitoids, mainly with the Ivory Coast Wasp, multiplying it in the laboratory and releasing-them in *Coffea canephora* crops, in the northern region of Espírito Santo.

The Program of Coffee Berry Borer Beetle Biological Control was released in the State of Espírito Santo in 1996, aiming to encourage associations, cooperatives and municipal agriculture to the installation of laboratories for the multiplication of Ivory Coast Wasps.

Besides the parasitoids, another natural control agent is the fungus *Beauveria bassiana*. However, this entomopathogenic application, available in commercial formulations on the market, is dependent on climatic conditions to exert control over the coffee berry borer. Special care with the timing of the application should be observed, as it should coincide with the maturation period of the first flowering fruits, in which the coffee berry borer is housed in the fruit crown.

The use of these biological control agents can be a complementary measure of the coffee berry borer integrated management program, helping to reduce its population and the consequent damage caused by this pest.

Chemical

The decision on the use of insecticides in the chemical control of the coffee berry borer should take into account the plant phenology (fruit maturation dynamics) and the pest biological cycle. Thus, between three and four months after the first flowering - which is variable among the different coffee producing regions -, the pest monitoring should be started to verify its presence in coffee fruits (REIS et al., 2010). Monitoring traps, already available with the coffee berry borer specific attractive, can also indicate the beginning of flights, the transit season of the adults that leave the fruits in which they developed and look for the new harvest fruits to lay their eggs. It is important to identify this initial period of the transit season, because the coffee berry borers do not immediately penetrate the fruits and remain on their surface and are likely to be affected by insecticides applied at that strategic moment.

2.2 COFFEE LEAF MINER

Leucoptera coffeella (Guérin-Mèneville & Perrottet, 1842 (Lepidoptera: Lyonetiidae)

Description and Biology

The African continent is considered as the region of origin of the coffee leaf miner, which has spread throughout the world and is present in all regions where coffee is grown. In Brazil, the coffee leaf miner presence was observed from 1850 (GALLO et al., 2002).

The moth is very small, presenting 6.5 mm of wingspan; the wings are silver-white in the dorsal part with a dark circular patch of yellow halo at the ends (Figure 6A). During the day, they hide on the lower part of the leaves and at dusk, leave the hiding place and begin their activities.

The lay is performed on the upper face of the leaves (MORAES, 1998), and the average per night is seven eggs. They do not usually put more than one egg in the same place. To this point, several points of the same leaf or different leaves are visited by the female. The hatching of the caterpillars takes, in average, from 5 to 21 days, according to the conditions of temperature and humidity. They penetrate directly into the leaf mesophyll without coming in contact with the external environment; lodge between the two epidermis, causing the parenchyma destruction, forming the "mine". The destroyed regions are drying up, and the attacked area increases with the caterpillars development and the junction of the various "mines". The dry parts are easily detachable, being common to find a large number of caterpillars being found on the same leaf (Figure 6B and 6C).

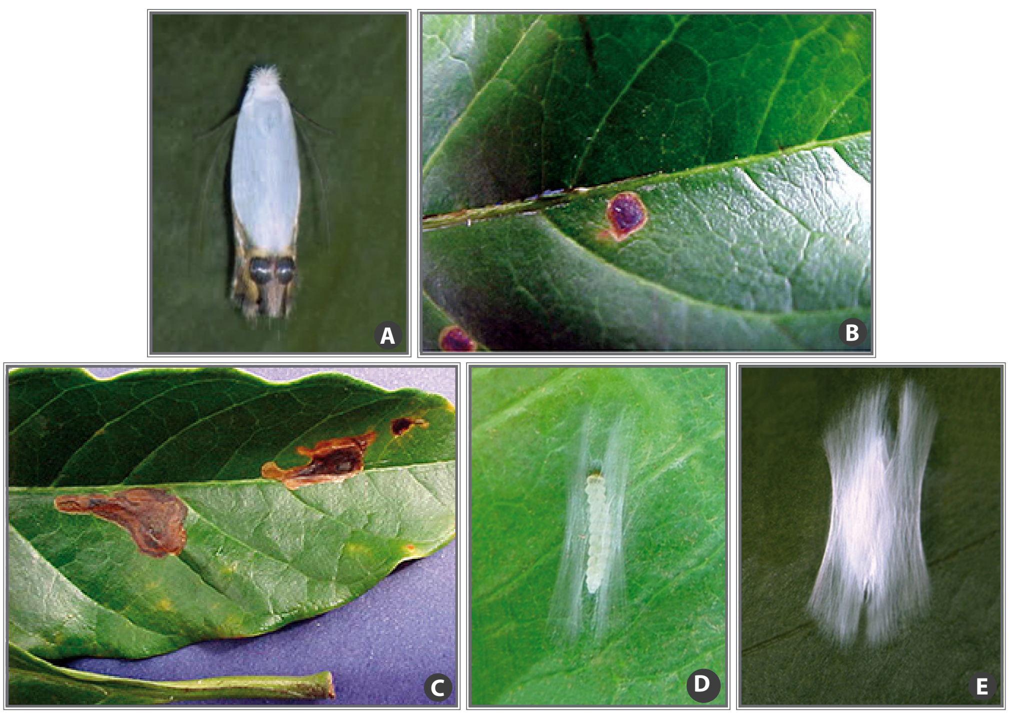

Figure 6. Moth (A); coffee leaf damage (B and C); caterpillar at the beginning of pupal stage (D); and the characteristic X-shaped cocoon of coffee tree miner (E).

The larval stage lasts between 9 and 40 days. At the end of this period, the caterpillars leave the interior of the leaves, leaving the lower part, where they weave silk thread and descend to the downer part of the coffee tree, where they will make a characteristic "X" shaped cocoon (Figure 6D and 6E). In this place, which provides the insect with proper moisture, pupae transformation occurs in most of the caterpillars. The pupal stage lasts from 5 to 26 days. After its completion, new moths appear, whose average longevity is 15 days. The evolutionary cycle varies from 19 to 87 days, being able to obtain from 7 to 9 annual generations. The climate exerts a great influence on the coffee leaf miner population. Higher temperatures and summer periods favor its development. These factors cause a great variation of the pest infestations from year to year and in the same crop (SOUZA; REIS; RIGITANO, 1998).

Losses

Until 1970, the coffee leaf miner was considered a problem only in the dry season, and coffee farmers lived with the insect without major problems. However, from then on, the plague began to occur indiscriminately in the dry and rainy seasons. The insects arrived in certain areas of São Paulo, causing serious damage and became the main pest of coffee in some regions. Its losses result from the reduction of the photosynthetic capacity by the leaves destruction and, mainly, by their fall. The symptoms are more visible in the upper part of the plant, where great defoliation is observed when the attack is intense. The coffee tree drastic defoliation caused by high pest infestations can affect the fruiting, with malformation of the floral buds and low survival of the fruits. It is considered one of the main pests of robusta coffee in the State of Rondônia, where 77% of the upper third leaves were infested by the coffee leaf miner (COSTA et al., 2001). However, conilon coffee is considered to be moderately resistant to the pest, and the level of economic damage, defined as 30% of mined leaves with live caterpillars, for arabica coffee (REIS et al., 2010), is hardly reached in commercial coffee plantations (MEDINA FILHO; CARVALHO; MONACO, 1977; FERREIRA; MATIELLO; PAULINI, 1979; AVILÉS et al., 1983; PAULINO et al., 1984). Coffee trees conducted at wider spacing tend to be more infested. Increased infestations have been observed associated with intensive summers, common in the months of January and February. The hot, dry climate, characteristic of the northern region of Espírito Santo, may favor an increase in the pest population throughout the year, accentuating itself in the months of prolonged drought. But the densification of crops that are being adopted in the State favors the maintenance of higher humidity and may disadvantage the population development of this pest. However, until now no reports of economic damages caused by the coffee leaf mines in conilon coffee in Brazil have been found.

Methods of control

Cultural

Bands of vegetation between fields allow an increase in the population of natural enemies, and it is recommended the rational management of the weeds, the use of mulch and intercropping in the growth of conilon coffee plantations, among other guidance based on the principles of agroecology. Plant resistance is a genetic method of pest control and a factor that has been observed by Incaper in the evaluation of available genetic material of *C. canephora* for identification of resistance sources that can be used in the improvement of Capixaba conilon.

Biological

The coffee leaf mine has a great number of parasite insects. However, the indiscriminate use of insecticides can alter the complex of parasitoids and predators and, consequently, cause population explosions of *L. coffeella*.

The main parasitoids reported associated with the coffee leaf miner belong to the Braconidae families [*Colastes letifer* (Mann), *Eubadizon punctatus* (Redolfi), *Mirax* sp.] and Eulophidae [*Closterocerus coffeellae* (Ihering), *Citrospilus* sp., *Horismenus aeneicollis* (Ashemead), *Neochrysocharis coffeae* (Ihering) and *Tetrastichus* sp.] (REIS; SOUZA; VENZON, 2002).

The main predators are from the Vespidae family [*Brachygastra lecheguana* (Latreille), *Eumenes* sp., *Polybia occidentalis* (Olivier), *P. paulista* (Ihering), *P. scutellaris* (White), *Protonectarina sylveirae* (Saussure) and *Synoeca surinama* (L.)]. These species of predators are social insects that destroy the *L. coffeella* galleries to feed on their caterpillars. *Brachygastra lecheguana* is the most frequent species, and in certain places, does a good pest control (SOUZA; REIS; RIGITANO, 1998).

Chemical

To carry out any kind of chemical treatment in order to control the coffee leaf miner, it is necessary to know the pest infestation and its natural enemies in the area planted with coffee.

Population sampling:

- The area should be divided into homogeneous terrains of 3 thousand to 5 thousand plants and, fortnightly, mainly in the summer periods, the random collection of about 200 leaves in 20 holes between the second and fifth pairs of leaves of the middle and higher thirds of coffee trees;
- after the collection, one should count the total number of sampled leaves and the number of mined leaves, determining the percentage of those which have been attacked, with the presence of live caterpillars. Observe the number of preyed mines and the parasitism in the samples.

Spraying:

Growing crops should be monitored for identification of early pest outbreaks, which must be quickly fought. The control can be carried out using several insecticides after finding infestation index higher than 25-30% of leaves infested with live caterpillars. In seedling nurseries and in plantations up to two years old, the control of the coffee leaf miner must be initiated when the onset symptoms of live caterpillars appear in the foci where the initial development of the pest population is observed.

Systemic via soil:

The systemic granulated insecticides applied via soil have efficiency to control the coffee leaf miner; however, its use was extremely low with the emergence of the neonicotinoid insecticides group that have greater safety for the applicator and the environment and are efficient for several pests control associated with coffee. The WG formulation of these new products allows the application in *drench*, liquid way. The use of insecticides via soil in a preventive way requires a perfect knowledge of the pest history and its losses to the terrain to be treated, in order to avoid that its use becomes uneconomical. The minimum use of insecticides and in a localized way, will help the preservation of the beneficial entomofauna that acts efficiently in the natural control of the miner.

2.3 COFFEE SCALE INSECTS

Green scale - *Coccus viridis* (Green, 1889) (Hemiptera: Coccidae)

Hemispherical Brown scale - *Saissetia coffeae* (Walker, 1852) (Hemiptera: Coccidae)

Chain scale - *Cerococcus catenarius* Fonseca, 1957 (Hemiptera: Cerococcidae)

Citrus mealybug - *Planococcus citri* (Risso, 1813); *P. minor* (Maskell, 1897) (Hemiptera: Pseudococcidae)

Root mealybug - *Dysmicoccus texensis* (Tinsley, 1900), *D. brevipes* (Cockerell, 1893) (Hemiptera: Pseudococcidae)

Armored scale - *Pinnaspis aspidistrae* (Signoret, 1869) (Hemiptera: Diaspididae)

Citrus orthezia - *Praelongorthezia praelonga* (Douglas, 1891) (Hemiptera: Ortheziidae)

Description and Biology

Coccus viridis: they are oval-shaped insects, flattened, with length of 2 to 3 mm, of green coloring and that suck the plants sap. They are found fixed on new branches and leaves, most notably on the main vein. They present greater attack intensity in new plants, in nurseries and until the first year of planting, when their presence is easily verified for being generally associated with ants. The young forms have legs and antennae that, over time, are atrophied, once they live in almost complete immobility. Although they reproduce parthenogenetically, sexual intercourse may also occur, both types of reproduction may happen simultaneously or separately. The young forms, of fragile structure, only move on the plants after the hardening of their skin. After its fixation, the insect perforates the leaves with its oral apparatus and begins the suction of the sap. Its appearance is more frequent in the months of November to January, in times of rain and shady terrains. The lay is composed of agglomerated eggs, of reduced size. The oviposition period is 50 days, on average. A female lays around two to three eggs a day and 150 during her lifetime. Pests are important pest in seedlings nursery.

Saissetia coffeae: they are insects of hemispherical shape measuring approximately 3.5 mm of length by 2 mm of height and 2 mm of width. The carapace is formed by excretions residues, from reddish to brown, and is waxy in adults. Females are usually smooth and shiny, with a habit of locating on coffee trees branches and leaves. The eggs are laid under the carapace itself. After hatching, the nymphs are fixed on the plants and suck the sap. They can have up to three annual generations.

Cerococcus catenarius: Coccidia is similar to the previous species, but have a hemispherical, less convex and smoother carapace. The lay is made under the carapace, from where the nymphs hatch forming lines; hence the name 'catenarius'. These nymphs are fixed in the carapace cracks. Its oviposition capacity is very high and each female can lay up to 800 eggs.

Planococcus citri and P. minor: they are very similar species and are part of a complex of mealybugs known as citrus mealybug. The females have an oval shape, with a length of 3 to 5 mm, the young forms have pink coloration; the adults are yellow-brown and the body is covered with a whitish powdery secretion. They characterize for having 18 side appendages, powdery white on each side and two more terminal appendages, larger than the lateral ones. Throughout life, these coccidians can lay about 400 eggs for 90 days. They secrete a white woolly substance that serves to protect the eggs next to the insect body. The eggs are yellow-orange in color and the nymphs appear after 10 to 20 days of laying. Inhabiting a small cocoon, they reach adulthood in about ten days. They live in colonies made up of individuals at various stages of development. Both nymphs and adults suck sap in flower buds and underdevelopment fruits (Figure 7). The complete evolutionary cycle is 25 days, on average. The are registered in different agroecological regions of Espírito Santo (FORNAZIER et al., 2000g, 2001a; SANTA-CECÍLIA; REIS; SOUZA, 2002; SANTA-CECÍLIA et al., 2005), where its detection occurred in the 1970's, causing losses of up to 100% of coffee production (PAULINI et al., 1977).

Figure 7. Flower bud (A), branches (B) and rosette (C) of the coffee tree infested with citrus mealybug.

Dysmicoccus texensis: They are insects with aptera adult female, oval body and pinkish color, covered with finely grained white wax, which gives it the appearance of flour and about 2.5 mm in length. They have 34 filamentous appendages around the body, with 17 on each side, the latter two being longer (SANTA-CECÍLIA et al., 2007). Its reproduction is parthenogenetic, being able to generate up to 253 individuals during period of 52 to 87 days. The most favorable temperature to the population development is of 20 to 25 ^{o}C and associated to the high relative humidity, with up to five annual generations (NAKANO, 1972). The first infestations arise in small colonies right below the neck or collar of new plants. With the development of the population, the insect is spreading to the plant roots, forming nodes called crypts, inside of which live their young and adult forms associated with the fungus of the genus *Bornetina*, which gives a plate appearance on the roots (Figure 8).

Dysmicoccus brevipes: known as pineapple mealybug. A polyphagous species, less frequent in coffee tree, can be found in the roots and also in the rosettes of branches that touch the soil. First instar nymphs can move at great distances. The nymph stage is about 40 days. Adult females have pinkish color, oval body and covered with white wax and can lay about 240 eggs (MENEZES, 1973). These colonies may be associated with small nests of symbiotic ants. Outbreaks can be problematic. This species does not induce the formation of crypts.

Figure 8. Coffee scale root, *Dysmicoccus texensis*.

Pinnaspis aspidistrae: it is a cochineal of white powdery appearance, live in large colonies and can completely cover parts of the plant, such as branches and leaves. The female has an oval shape, measuring 3 mm in length; while the male, only 1 mm. The newborn nymphs are light pink. The female's follicle (scale) is light brown and the male's is light yellow. The oviposition capacity is about 400 eggs. And they are placed in a woolly shelter secreted by the female. The young forms of the insect appear 15 to 20 days after the lay, reaching its full development after 30 days, on average. After the larval stage, the females are ready for reproduction, mating with the males that arise from the cocoons.

Praelongorthezia praelonga: Also known as citrus orthezia. The adult female measures about 2.5 mm and has the body covered by white wax plates, presenting on the back two small greenish areas without wax. The head is covered by two protruding plates. In the posterior part of the body are found several elongated wax rods that unite to form the egg sac where the females accommodate newly hatched eggs and nymphs (Figure 9A). Both adult females and nymphs move in the plant. In 1988, a large outbreak was observed, with the pest spread in most of the northern region of Espírito Santo's municipalities (MARTINS et al., 1989; MARTINS; PAULINI; GALVÃO, 1989). Dry and cold periods, in consecutive years of low precipitation, favor their population development. At high infestations, the leaves are covered with sooty mold (Figure 9B) and the pest can cause the plant to die (MARTINS et al., 1989; MARTINS; PAULINI; GALVÃO, 1989) (Figure 9C).

Figure 9. Orthezia colony (*Praelongorthezia praelonga*) on coffee leaves (A); leaf covered with dark-colored fungus, commonly referred to as sooty mold (B); and coffee plant with high defoliation caused by the pest (C).

Losses

Scale insects cause direct damage by the continuous sucking of sap, contributing to the plant depletion. Indirect damages are also caused because they are sap-feeding insects and the excess sugary secretion that covers the leaves facilitates the occurrence of sooty mold. This fungus covers the foliage in black layer, damaging the photosynthesis and respiration of the plant, mainly in the nurseries. In addition, they provide food to the ants that give them protection, and can sometimes damage the coffee tree root with the anthill construction. The successive stings in the plants can also favor the penetration of microorganisms. Green scales cause growth retardation of seedlings in the nursery and in the newly planted ones. In the case of the chain cochineal, in addition to the losses already mentioned, it can cause the coffee trees drying.

The scale root forms nodosities and sucks sap from the coffee tree roots causing the plants depletion, yellowing and almost total leaf fall, and it may be necessary to replant the affected area. The recognition is done by digging up part of the soil around the plant's neck or collar, from which colonies of this cochineal are white, when the infestation is recent or also due to the formation of crypts in colonies that have been installed for a long time. It is noted that the main roots are covered by a leathery wrap, initially yellowish and then dark brown, caused by a fungus that develops at the expense of the sugary substance secreted by the cochineal. The roots present a series of nodes formed by the succession of crypts or popcorn where the insect is housed.

The citrus mealybug has increased its responsibility for the direct damages to the conilon coffee productivity (FORNAZIER et al., 2004). Its attack occurs directly to the floral buds and to the underdevelopment fruits, leading to their massive fall. It causes the wilting of more developed fruits (FORNAZIER et al., 2000g, 2001a).

Methods of control

Cultural

The cultural control is done by observing the infestation of the pest in the acquired seedlings by taking care of lots that may present infestation.

Biological

There are several natural enemies that can efficiently control coccidians. Among them, we highlight ladybugs larvae of the genus *Scymnus* and Hyperaspis (Coleoptera: Coccinellidae) and chrysopidae larvae (Neuroptera: Chrysopidae) (FORNAZIER et al., 2006) and the micro-Hymenoptera parasitoids *Leptomastidea abnormis* Girault and *Leptomastix dactylopii* Howard (Hymenoptera: Encyrtidae) (PRADO; SANTA-CECÍLIA; FLOREZI FILHO, 2008).

Chemical

For the chemical control of the scale root the application of neonicotinoid insecticide when the first infestations are detected, in a localized way in the "reboleiras" and directly at the plant insertion point with the soil, via liquid, is efficient (FORNAZIER; LIMA; ROCHA, 2000; SOUZA; RIBEIRO, 2003).

For the citrus mealybug, research developed by Incaper (FORNAZIER; MARTINS, 2002, 2003a, 2003b, 2003c, 2003d; FORNAZIER et al., 2005a, 2005b, 2005d; FORNAZIER; FREITAS; De MUNER, 2005; FORNAZIER, 2006) showed that it is necessary to use a high volume of syrup (higher than 1,000 L/ha), use of suitable chemical products and the infestation monitoring to verify the presence of the pest moving or installed in the rosettes. For emergency control, Reis et al. (2010) recommend the use of different chemical products, such as methidathion and chlorpyrifos ethyl, registered for other coffee tree pests, by means of foliar spraying. In the observation of the populations increase, carry out the chemical control, preferably per field. In plantations where planting is carried out with the clones of the in-line varieties, it is recommended to monitor the incidence of cochineal in the clones, avoiding the indiscriminate application throughout the area. Preventive chemical intervention with products applied via foliage is not advisable because of the irregular cochineal manifestation in the crops. Products applied via soil have presented variation in the agronomic efficiency to control the pest (FORNAZIER; MARTINS, 2002, 2003a, 2003b, 2003c, 2003d). Chemicals applied via trunk were ineffective to control this cochineal (FORNAZIER; MARTINS, 2003a).

2.4 IMPERIAL MOTH

Eacles imperialis magnifica Walker, 1856 (Lepidoptera: Saturniidae)

Description and Biology

Adult imperial moth caterpillars are yellow moths many dark spots on the wings, cut by two bands of violet-black color, with two circular spots of the same color. They present sexual dimorphism, with females being larger (135 mm wingspan) and wings less stained than males (Figure 10). Each female places about 250 eggs, which are lay in groups on the leaves, from where the caterpillars hatch. The incubation period is 6 to 12 days and the caterpillars, which can reach 80 to 100 mm in length and show color variation of green, orange, yellow and brown. This larval stage has a variable lenght of 30 to 37 days, and the chrysalis transformation occurs in the soil. Under favorable conditions, this last stage lasts from 30 to 40 days, and may last for some months in adverse conditions.

Losses

This pest destroys the leaf blade and can completely defoliate the plant. However, productivity damage has not been determined.

Figure 10. Imperial Moth Caterpillar, *Eacles imperialis magnifica* species.

2.5 COFFEE SPHINX

Perigonia lusca Fabricius, 1777 (Lepidoptera: Sphingidae)

In Brazil, this species was registered for the first time attacking coffee in the northern region of Espírito Santo, in 1988 (MARTINS; BRAGANÇA, 1989). The caterpillars, when developed, measure about 60 mm, are bright light green in color and have two clear transverse bands and two red spiracles per abdominal segment. they show on their back a light yellow band along the body and a pronounced filament of about 10 mm located at the upper part, near the abdominal end. Adults are predominantly dark brown moths and the wingspan is about 60 mm in wingspan (Figure 11). They have a nocturnal habit and are easily attracted to light. They present sporadic outbreaks and when not controlled in time, can cause total defoliation in conilon coffee plantations.

Figure 11. Young (A) and adult (B) forms of the coffee sphinx moth caterpillar.

2.6 HONEYDEW MOTH

Cryptoblabes gnidiella Millière, 1867 (Lepidoptera: Pyralidae)

Description and Biology

The caterpillars are dark brown and live in small groups weaving a small silk web between the fruits and the conilon coffee rosettes; entangle the remaining residues of flowering (Figure 12). They reach from 10 to 11 mm in length. The adults are small moths of 7.5 to 8 mm wingspan, predominantly dark gray.

Figure 12. Young form and pupa of the honeydew moth caterpillar and damages the coffee tree rosette.

They occur throughout the productive cycle, from the emission of the flower buds until near the harvest.

Losses

The caterpillars mainly damage the bark of the base and the fruits peduncle, leading to their fall. It has been an important pest in the conilon coffee culture of Espírito Santo (FORNAZIER et al., 2000d).

Method of control

The caterpillars control should be done when they are small, in initial instars, because as larger they become, more difficult is their control. In the initial stage, satisfactory results have been obtained with the microbial insecticide based on *Bacillus thuringiensis* (0.5 kg/ha).

For honeydew moth caterpillar efficient control, one should be aware of its occurrence, especially in the initial stages of flowering and the fruits development in order to start the spraying on the attacked terrains. The application technology is of fundamental importance, because this caterpillar is protected between the grains and the silk web that surrounds the floral residues. It is important that a high volume of syrup is used in order to make the product to get in contact with the insect (MARTINS; FORNAZIER, 2002).

2.7 BEETLES

Pantomorus leucoloma Buchanan, 1939 (Coleoptera: Curculionidae)

Naupactus rivulosus (Olivier, 1790) (Coleoptera: Curculionidae)

Description and Biology

Pantomorus leucoloma: adult insects measure about 8 mm in length, have a light brown color with white spots on the elytra and the characteristic face of the Curculionidae family. The larvae are white and can live in the soil.

Naupactus rivulosus: adults are 18 mm long, with a very bulky abdominal region, reaching 5 mm wide. They are dark in color, with white, pinkish or greenish longitudinal streaks. The larvae are apodas and live in the soil.

There are other species of Naupactus and Pantomorus with varying sizes and colors that attack the coffee trees, whose species have not yet been identified.

Losses

The adult insects feed by destroying the edge of new leaves, giving them a serrated appearance. They occur in the summer and in severe attacks, they even cause the plants death by the destruction of leaves and shoots.

Method of control

Occasional insects rarely require control.

2.8 MITES

2.8.1 Red mites

Oligonychus ilicis (McGregor, 1917) (Acari: Tetranychidae)

Description and Biology

The coffee mite females are about 0.4 mm long and have orange-colored legs and body, but with large dark spots on the back of the body. Males are smaller than females, lighter in color and occur in fewer numbers. The eggs, bright red, almost spherical, slightly flattened, are lay in a group of 10 to 15 on the upper face of the leaves. The larvae hatch after six to ten days, and can become adults in only seven days. However, the main form of reproduction of this species is Thelytokous parthenogenesis, in which the offspring are composed only of females. Its biological cycle is completed in an interval of 11 to 17 days (REIS; ALVES; SOUZA, 1997). They live on the upper face of the coffee tree leaves, where they shelter under thin layer of web. Periods of more prolonged drought favor its occurrence, because in rainy seasons, the mites are easily washed.

Losses

In intense attacks, the leaves lose their characteristic brightness and become yellowish at first until they become tanned (Figure 13). In dry and hot winter years or in pronounced summer, mites can cause coffee tree defoliation. These mites attacks usually occur in “reboleiras” from where they are dispersed throughout the crop. So far, no work has been found reporting the effect of this attack on coffee conilon productivity. For Arabica coffee this damage can reach 65% of productivity (SAN JUAN et al., 2007). In field conditions, the development of these mites populations is rapid, particularly in growing fields in summer. This attack causes total defoliation of the plants, with consequent delay in the conilon crop growing.

Figure 13. Plant attacked by red mite (A); and detail of the characteristic luster loss of the infested leaf (B).

Method of control

The control is done by the use of specific acaricides in the "reboleiras" (COSTA et al., 2003). It is important to inspect the terrains to detect pest infestation, particularly in periods that favor their population development. Copper fungicides applied to combat coffee rust *Hemileia vastatrix* Berk & Br. can contribute to increase the population of these mites (REIS; SILVA; CARVALHO, 1974).

2.8.2 Broad mite

Polyphagotarsonemus latus (Banks, 1904) (Acari: Tarsonemidae)

Description and Biology

These mites were observed occurring in the coffee tree for the first time in Brazil, in Espírito Santo (CHIAVEGATO et al., 1974). It is known as a broad mite, tropical mite or white mite. It is white in color and measures 0.17 mm in length. Their eggs are of white color and placed isolated in the inferior face of the new leaves, where they spend their whole life. This species does not weave web and its population development is favored by high temperatures and rainy weather, being able to complete a generation in the period of three to five days.

Losses

As a consequence of these mites attack, the new leaves become coriaceous and depressed in the central part with the edges facing downwards (Figure 14), due to the uneven growth of the leaf blade, evolving to necrosis and tearing. When these symptoms manifest themselves, no mites are found in these leaves. It is important in nurseries with excessive irrigation and in plantations, in which the seedlings are infested by the pest.

Figure 14. Coffee tree leaves with the broad mite attack symptoms.

Method of control

The broad mite is polyphagous and can be found in planted cultures intercropped with conilon coffee, mainly in beans and papaya (GALLO et al., 2002). Thus, intercropped plantations of conilon with papaya may imply higher levels of damage for both crops, especially for papaya because it is more sensitive to this pest attack.

The chemical control can be carried out with specific acaricides in localized application.

2.9 BLACK TWIG BORER

Xylosandrus compactus (Eichhoff, 1875) (Coleoptera: Curculionidae)

Known in the English-speaking countries as *black ambrosia beetle* (Figure 15), it is a polyphagous pest originating in Asia and attacks more than 200 shrub and tree species, cultivated and wild, and is one of the few ambrosia beetles infesting healthy plants (COGNATO, 2005).

Figure 15. Adult stem borer of the coffee tree.

Its worldwide distribution was reported by Tenbrink and Hara (2006). It is widespread in all areas of coffee cultivation worldwide, being considered a serious pest in French Guiana. It is also widely distributed in tropical areas of West and East Africa, Fiji, India, Java, Madagascar, Malaysia and Sumatra (DAVIS, 1963, NELSON; DAVIS, 1972), including Brazil and Cuba (DIXON; WOODRUFF, 1982). The main hosts are avocado, anthurium, cocoa, arabica coffee, citrus, cypress, eucalyptus, guava, hibiscus, lychee, macadamia, mango, mahogany and orchids (TENBRINK; HARA, 2006). In Brazil, *X. compactus* is reported among the main species of Scolytinae in primary forest in the State of Amazonas (ABREU; FONSECA; MARQUES, 1997). It is reported to occur in robusta coffee trees in the southern state of Bahia (MATIELLO; NEVES; SILVA, 1999) and conilon coffee in the northern region of Espírito Santo (DARÉ; FORNAZIER, 2005; MATIELLO; FREITAS, 2005). In conilon coffee, this pest attacks the branches and lead them to dry (Figure 16).

2.10 ASIAN SUBTERRANEAN TERMITE

Coptotermes gestroi (Wasmann, 1896) (= C. havilandi Holmgren) (Isoptera: Rhinotermitidae)

Termites cover more than 2 thousand species described in the world, and in Brazil, there are about 200 species. Although the importance of termites is known worldwide, especially in relation to the Neotropical regions fauna, little or no attention has been given to numerically estimating their populations and behavioral habits (foraging). Studies on biology, ecology and population dynamics have been conducted almost everywhere in the world, however our country, one of the largest places where the Isoptera order occurs, needs basic and applied studies.

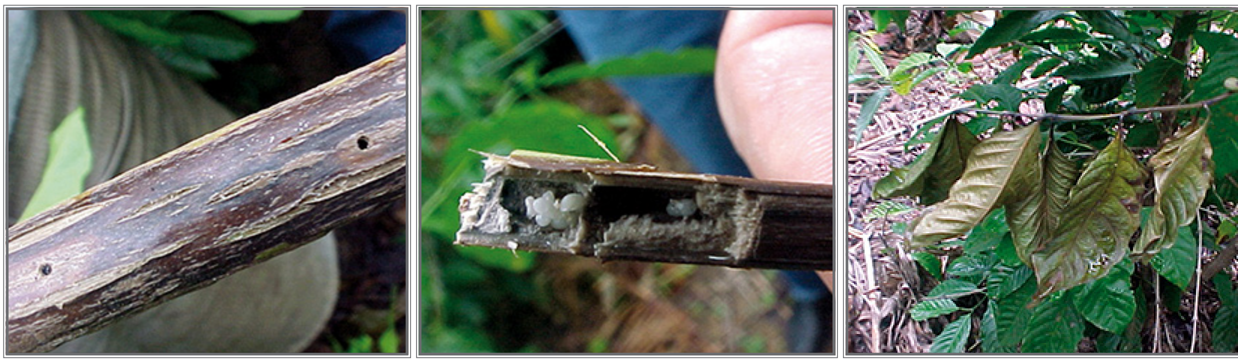

Figure 16. Coffee tree branches attacked by the black twig borer.

Also known as Philippine milk termite, it can be found mainly in urban areas, it primarily attacks wood and building furniture, but it does not attack only dead wood. The species reaches many living plant tissues such as avocados, white angicos, cashew trees, sugarcane, casuarina trees, eucalyptus, imperial palm trees, ironwoods, oiti, cork trees and several other plants in urban and rural areas. It was reported for the first time by Mattos et al. (2001) in attack on conilon coffee roots in a rural area in the northern region of Espírito Santo.

Unlike mound building termites, they construct their colonies in inaccessible places and have the habit of foraging underground. They attack the roots of conilon coffee from newly planted seedlings to plants about two years old, leading to their fall. Attacks of this pest can lead to the plants death, including the oldest ones, with destruction of the roots and heartwood. The symptoms of its attack can be confused with nutritional deficiency or attack of other subterranean pests, being necessary the careful uprooting of the plants and roots examination to verify its occurrence.

2.11 ANTS

Atta spp. (Hymenoptera: Formicidae)

Acromyrmex spp. (Hymenoptera: Formicidae)

Description and Biology

Atta spp differ from the *Acromyrmex* spp because they are larger, have three pairs of spines on the back of the thorax and have their nests composed of a varied number of chambers interconnected by channels. *Acromyrmex* spp are smaller ants than *Atta* spp, have four pairs of spines on the back of the thorax and have small anthills and usually formed of a single chamber.

Losses

Ants cut the plants leaves, especially newly planted seedlings in the field, delaying the development or even causing their death. This is the critical phase of its occurrence, since it can induce the replanting of a significant number of seedlings.

Method of control

The fight against leaf-cutting ants in coffee plantations should be preventive and more intense in the period before the implantation of the crops, and should be done in a systematic way. It can be done using toxic baits or using gaseous ant killers or direct thermomist always aiming at the destruction of the anthill where the queen is. The control with the use of granulated ant baits has been shown to be efficient and low cost. They should be applied at dusk, in a dry place and protected from humidity.

3 STORED COFFEE PESTS

Weight loss, presence of insect fragments in food by-products, deterioration of grain mass, possibility of fungal contamination and presence of mycotoxins can cause effects on human health and difficulties for the export of products and by-products. They may become impediments to international sanitary barriers for export because of the potential for food risk associated with pest attack on coffee fruits caused by carelessness in processing or storage. It is necessary to know the main pests, their damages and handling in the coffee storage.

The main pest of stored coffee is the coffee berry borer, already approached in the previous item. Two other pests that can be found in coffee barns and warehouses are coffee bean weevil and moths, always associated with careless handling of grains, the production process and storage.

3.1 COFFEE BEAN WEEVIL

Araecerus fasciculatus DeGeer, 1775 (Coleoptera: Anthribidae)

Description and Biology

It is a cosmopolitan pest, distributed in tropical regions and causing damage to many stored products. It is an important pest of stored coffee and attacks both coffee beans and processed coffee. Its initial attack can occur in the crop, in fruits in phase of drying and persist in the storage.

The adult is a beetle that is light brown to gray or brown in color, shiny and silky hairy. It has three elongated yellowish spots on the elytra, as well as light and dark punctiform spots in poorly defined alignment. This beetle measures about 5 mm long and 3 mm wide and is different from the coffee berry borer for being much larger (Figure 17). Each female can place 130 to 140 eggs, which are placed in the mellow or already dried coffee pulp, in the field or in the barn, from where the larva that feeds on the mucilage hatches and then penetrates the seed. The larvae are white in color, apodas and cylindrical in shape. When fully developed, are approximately 5 mm long and 2.5 mm wide. The pupal stage occurs within the seed, from where the adult emerges through an orifice of about 2 to 3 mm in diameter. Their cycle varies from 46 to 62 days, with about five to eight days until the larvae hatch, 35 to 45 days of larvae to pupae and six to nine days for the emergence of adults. The insect continues its reproduction, when the coffee is left stored for a long time and causes serious damages. It can present from six to seven annual generations (GALLO et al., 2002).

Figure 17. Coffee bean weevil, *Araecerus fasciculatus.*

Losses

It damages a part of the dry coffee beans in all its forms: coconut, pulped and processed, being able to cause loss of up to 30% in weight.

3.2 RICE MOTH

Corcyra cephalonica Stainton, 1865 (Lepidoptera: Pyralidae)

Description and Biology

Among the moths that can be found attacking stored coffee, the main one is *C. cephalonica*. The adult is a moth with about 19 mm of wingspan and 9 mm of length, the body and the back gray wings. They have a nocturnal habit and are not adept at flying. Each female can lay about 180 whitish, elliptical eggs that are laid scattered or in groups on the coffee or on the warehouses walls. The caterpillars are white-dirty, cylindrical and have head, thoracic shield and last abdominal brown segment. They reach 12 mm in length when fully developed (Figure

18). The cycle ranges from 45 to 50 days. During the afternoon, it is possible to observe moths flying between the stacks in the warehouses.

Losses

The sacks are all pierced when the infestation is severe, and its renewal is necessary. The presence of caterpillars, cocoons, and feces on coffee and sacks and harms the quality of the product for export (Figure 19).

Figure 18. *C. cephalonica* caterpillar.

Figure 19. Damage caused by *C. cephalonica*.

Method of control

A number of measures should be taken to avoid the presence of insects or insect remains in the stored product. It ranges from the awareness of those involved in the production chain to the importance of the presence of insects in the products considering the international sanitary barriers for export until the adoption of prophylactic measures for the pests control.

The management of pests in coffee storage begins with the correct management of the coffee berry borer and the coffee bean weevil in the production process and in the harvest, adopting measures to effectively reduce their populations. The observation of the humidity and the appropriate conditions recommended for the coffee grains storage disfavor the population development of the insects. It is also necessary to observe the variations of the grains humidity and take the necessary measures so that they can remain around 11%.

Preventive measures such as the storage hygiene of the unit should be observed by cleaning and disinfestation of the barns and warehouses in necessary advance, before the harvesting process is started.

The correct identification of the pest insects is a fundamental factor to know the reasons and the origin of the infestations, which allows to take preventive measures to avoid the infestations continuation.

The periodic inspection of the warehouses should be carried out, especially in the hot and humid regions and from October to April, when the best conditions for the population of stored coffee pests development are established. If infestations are detected, prophylactic measures should be taken, such as the removal of the grain mass and its protection with recommended insecticides. Storage unit disinfestation should also be performed using water mist.

4 FINAL CONSIDERATIONS

Many insects and mites are associated with coffee cultivation in Brazil. However, few can be considered primary pests of conilon coffee.

Climatic conditions associated with appropriate phytosanitary management techniques allow these pests populations to be below the level of economic damage to crops. This leads to a significant reduction in the use of agrochemicals and an increase in the safety of the food produced. However, the citrus mealybug, *P. citri* and the coffee berry borer, *H. hampei*, need continuous monitoring due to the systematic damage they have caused to conilon coffee in the State of Espírito Santo. In addition, these two pests require continuous technological development seeking the improvement of management techniques, mainly because chemical control is the main method to reduce their infestations under field conditions.

Another important pest that must be monitored to avoid damage, particularly in crops of up to three years, is the red mite, associated with periods of summer that favor marked imbalances of its population.

Therefore, it is necessary the systematic development of researches that can continue to support the correct phytosanitary management implemented in conilon coffee, mainly aiming at the establishment of biological control techniques. Still, technicians and producers need to appropriate this information at the same speed as they are developed, through specific training looking for the sustainability and feasibility of conilon production.

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