In the hot and dry climate of the oasis ecosystem, specialized insects find optimal conditions for their development. Their ecology is of crucial importance to oasis ecosystem function and very often they are economically important as pests of crops, vectors of disease, beneficial components of food webs, or vital components of pollination systems.

Despite some scattered scientific observations conducted throughout the country, there is still a shortage of information on biological diversity of insects in the Algerian Ziban oasis ecosystem. The latest inventory was conducted by LeBerre (1978) on the species of insects present in the oasis ecosystems in Algeria (Ziban).

Date palm, Phoenix dactylifera Linnaeus 1753 (Arecales: Arecales), is a primary crop of the oasis ecosystem. Given the arthropod pests of date palm, it is essential to have an inventory of the species and, when possible, alternative pest control methods that take into account of the fragility of the ecosystem and the health of the environment and date consumers. The date economy is often confronted with the problem of chemical residues, so alternative methods of pest control must be explored.

Materials and Methods

The study was conducted at the Ziban oasis, located in the east of Algeria, south of the Aurès Mountains. At 114 m above the sea level, latitude 34° 51'00'' N and longitude 5° 44'00'' E, the region of Biskra (Ziban) was selected as a site for this study because it is one of the most important areas of date production in Algeria. The survey was conducted in five oases (Fig. 1): Ain Ben Noui, Tolga, El Ghrous, Ouled Djellel, and Sidi Okba, which are sites that produce the highest quality “Deglet Nour” dates in Algeria.

Pitfall traps were used for collecting specimens (Fig. 2). These traps were constructed out of plastic containers with holes in the bottom, with a cover of wire mesh and stones placed approximately 2.5 cm above the plastic container in order to protect the traps from rainfall and prevent mammal species from entering.

Four traps were maintained at each site beginning the first of February until the end of June. The traps were visited every week. In situations where ground vegetation is minimal, traps can be left for shorter periods (a week) or more without any effects on captured specimens (Greenslade 1973). Traps were located in four opposite directions in order to cover all the insect movement in each station (Fig. 3).

Captured insects were collected weekly and transferred to the laboratory, where they were counted and examined. Insects were then sorted, pinned or point mounted, and labeled. Insects were identified to order, family, and in most cases to species. The identification of insects to the genus or species level was made at the University of Biskra and Centre de Recherche Scientifique et Technique sur les Régions Arides based on their reference collection and texts (Chinery 1993). Some of the prepared and identified species were sent to Algerian entomologists or F. Porcelli for confirmation.

Results and Discussion

The pitfall traps yielded a total of 1,524 arthropods (Fig. 4). The mean number of specimens sampled per site was highest for the
El-Ghrous station (352 specimens), followed by Tolga (335), Ain Ben Noui (333), Ouled djellel (257), and finally Sidi Okba (247).

Greenslade and Greenslade (1977) proposed that vegetation can have as high as a threefold influence on the diversity (species richness), carrying capacity, and structural complexity of the habitat. The slight variation in numbers from our study may be explained by the diversification of flora during the spring period in which insects were collected. Insects may be using the oasis habitats to search for prey, for an alternative source of food, for a microclimate more favorable than the cultivated field, to find a refuge or a hibernation site, or to find an undisturbed site for larval development (Maisonhaute 2009).

Coleoptera was the order with the most specimens (677), followed by Hymenoptera (318) and Lepidoptera (120). The other orders were represented by 3–26 specimens. Ye and Li (2003) conducted a similar work in Singapore in three different ecosystems, and found that the dominant orders in their pitfall traps were Coleoptera, Hymenoptera, and Lepidoptera. Thus, the design of the pitfall trap could be biased toward these arthropods. Another possible explanation for such observations may be explained by the functional role of crawler arthropods (Didham et al. 1998). Pitfall traps have been shown to be highly efficient in studies of the occurrence and activity of invertebrates active on the ground surface, especially beetles and spiders (Greenslade and Greenslade 1971, Luff 1975). Spence and Niemelä (1994) and Niemela (1996) examined five different methods of sampling and found that pitfall trapping caught the large-bodied individuals (e.g., Coleoptera and scorpions), whereas smaller sized species were caught in litter washing.

The efficiency of pitfall traps played an important part in the experimental setup. Factors such as the size (20 cm diameter), material of the cup (plastic bottles), and depth of the trap (20 cm) exclude certain arthropods that are too big to be captured by this type of trap (Luff 1975, Work et al. 2002), e.g., Lepidoptera and Odonata.
Maehara (2004) and Scudder (2000) disagree with this explanation, and believe that their possibility to be captured depends on their activities on the surface and does not depend on the size of the containers used (Luff 1975). In our study, this may be one of the reasons that explain the relative abundance of certain arthropods (i.e., Coleoptera, Orthoptera, and Diptera) present in large number in certain oases (Spence and Niemelä 1994). In total, 115 species in 17 orders of arthropods were identified. This included 12 orders of class Insecta, 3 of Arachnida, 1 of Chilopoda, and 1 of class Malacostraca. These data are presented in Table 1. In class Insecta, 51 families and 103 species were identified (Fig. 5). Coleoptera represented the highest percentage of insects found (44.42%), followed by Hymenoptera (20.86%) and Lepidoptera (7.87%). The most speciose beetle families were Carabidae, Tenebrionidae, and Coccinellidae. The next most speciose order was Hymenoptera, with the families Vespidae, Apidae, and Formicidae, followed by Lepidoptera (families Pieridae and Nymphalidae) and Heteroptera (Miridae and Pentatomidae). The other orders were represented by 1 Neuroptera (Chrysopidae) and 2 Dermaptera (Forficulidae: Labridae).

![Fig. 3. Traps located in four directions.](image)

![Fig. 4. Number of arthropods collected at each site.](image)

![Fig. 5. Percentages of total insects collected according to order.](image)
### Table 1. Species collected by pitfall traps in oasis ecosystems

| Class | Order | Family | Species | Ecological role | Months |
|-------|-------|--------|---------|-----------------|--------|
| **INSECTA** | **COLEOPTERA** | | | | |
| Cetoniidae | | | Tripinota (epiocomita) hirta (Poda, 1761) | Phytophagous | Feb. Mar. April May June |
| | | | Tropinota squaera (Laspoli, 1783) | X | |
| Coleoptera | | | Psyllidia viantiiduquincuta (Linné, 1758) | Zootrophic | Feb. Mar. April May June |
| | | | Coccinella septempunctata (Linneé, 1758) | X | |
| Buprestidae | | | Agrius scyticus (Krolik and Janicki, 2005) | X | |
| Tenebrionoidea | | | Pinema payraudi (Latreille, 1829) | X | |
| | | | Diaperis maculata (Olivier, 1791) | X | |
| | | | Gonocaphalus granulatum nigrum (Kuster, 1849) | X | |
| | | | Blaps sp. | X | |
| Adelaidea | | | Anidus sanguinelentus (Kotz, 1783) | X | |
| Carabidae | | | Calosoma inquisitor (Linneé, 1758) | X | |
| | | | Carabus sp. | X | |
| | | | Brounnus esculentus (Dufchmid, 1812) | X | |
| | | | Lophaea flexuosa (Fabricius, 1787) | X | |
| Dasytidae | | | Psilothrix viridicoerulea (Geoffrey, 1758) | X | |
| Scarabaeidae | | | Macrodactylus subspinatus (Fabricius, 1775) | X | |
| Curculionoidea | | | Larinus sp. | X | |
| Chrysomelidae | | | Clytra sp. | X | |
| Meloidae | | | Mylabris bipunctata (Linneé, 1767) | X | |
| Hymenoptera | | | Polistes sp. | X X | |
| Vespidae | | | Colletes sp. | X X | |
| Colletidae | | | Coenetus sp. | X X | |
| Megachilidae | | | Megachile rotundata (Fabricius, 1879) | X X | |
| Ichneumonidae | | | Dusona sp. | X X | |
| Apidae | | | Xylotrema violacea (Linneé, 1758) | X X | |
| Formicidae | | | Formica incerta (Buren, 1944) | X X | |
| Myrmicinae | | | Camponotus sp. | X X | |
| Pompilidae | | | Formica incerta (Buren, 1944) | X X | |
| HEMIPTERA | | | Phoridra sp. | X X | |
| Pentatomidae | | | Cod upholdia varia (Fabricius, 1787) | X X | |
| | | | Xzor viridula (Linneé, 1758) | X X | |
| | | | Xerobius bioculata (Fabricius, 1775) | X X | |
| | | | Xerocerus heegeri (Fieber, 1861) | X X | |
| | | | Xylocopa violacea (Linneé, 1758) | X X | |
| | | | Eurydema ornata (Linneé, 1758) | X X | |
| | | | Xylocopa leucophaea (Gmelin, 1790) | X X | |
| | | | Xylocopa rufipes (Linneé, 1758) | X X | |
| | | | Xylocopa purpurae (DeGerr, 1773) | X X | |
| Mindae | | | Stenota bistatata (Fabricius, 1794) | X X | |
| Lycidae | | | Oxytornis labreata (Fabricius, 1787) | X X | |
| Cydnidae | | | Scirpus lactuca (Lusignani and Rey, 1866) | X X | |
| Stenocolephalidae | | | Dicranocolephalos Albipes (Fabricius, 1781) | X X | |

(continued)
| Class       | Order          | Family      | Species                                      | Ecological role | Months |
|-------------|----------------|-------------|----------------------------------------------|-----------------|--------|
| DIPTERA     |                |             | Sphaerophoria scripta (Linne, 1758)          | Phytophagous    |        |
| Syrphidae   |                |             | Cheilosia variabilis (Panzer, 1798)          | Zoophagous      |        |
|             |                |             | Syrphus vitripennis (Meigen, 1822)           | Omnivorous      |Feb.    |
|             |                |             | Melanostoma mellinum (Linne, 1758)          |                 |        |
| Tipulidae   |                |             | Tipula paludosa (Meigen, 1830)              |                 |        |
| Bombyliidae |                |             | Duxana sp.                                   |                 |        |
| Asilidae    |                |             | Syrphida variabilis (Panzer, 1798)          |                 |        |
|            |                |             | Sphaerophoria scripta (Linne, 1758)          |                 |        |
|            |                |             | Sypheus vitripennis (Meigen, 1822)           |                 |        |
|            |                |             | Melanostoma mellinum (Linne, 1758)          |                 |        |
|            |                |             | Tipula paludosa (Meigen, 1830)              |                 |        |
|            |                |             | Duxana sp.                                   |                 |        |
|            |                |             | Syrphida variabilis (Panzer, 1798)          |                 |        |
|            |                |             | Sphaerophoria scripta (Linne, 1758)          |                 |        |
| LEPISTOPHERA|                |             | Syrphida variabilis (Panzer, 1798)          |                 |        |
| Sphingidae  |                |             | Hyles lineatae (Fabricius, 1775)            |                 |        |
| Noctuidae   |                |             | Mythimma vitellina (Hübner, 1808)           |                 |        |
| Nymphalidae |                |             | Lacaonibia aicina (Linne, 1767)             |                 |        |
| Nymphalidae |                |             | Orthosia gathia (Linne, 1758)               |                 |        |
| Pieridae    |                |             | Pararge aegeria (Linne, 1758)               |                 |        |
| Pieridae    |                |             | Pieris rapae (Linne, 1758)                  |                 |        |
| Nymphalidae |                |             | Hyles lineatae (Fabricius, 1775)            |                 |        |
| Lycaenidae  |                |             | Glaucescyche melanopa (Braunsau, 1828)      |                 |        |
|            |                |             | Polyommatius semiaropus (Röttel, 1758)      |                 |        |
| Lycaenidae  |                |             | Eucliaea simplior (Freyer, 1829)            |                 |        |
| Geometridae |                |             | Mazaroglossum stellatarum (Linne, 1758)     |                 |        |
| Geometridae |                |             | Mazaroglossum stellatarum (Linne, 1758)     |                 |        |
| Homoptera   | Aphiedae       |             | Aphi gossypii (Glover, 1877)                | Phytophagous    |        |
| Homeroptera | Aphiedae       |             | Myas pericae (Suule, 1776)                  | Zoophagous      |        |
|             | Diap nosiphinae|             | Rhopalosiphum padi (Linne, 1758)            | Omnivorous      |        |
|             | Diap nosiphinae|             | Hyaalophilus feniciuli (Passerini, 1860)    |                 |        |
| Evenoptera  | Libelliulidae  |             | Symprunaria sanguineum (Müller, 1764)       |                 |        |
|             | Coenagonia     |             | Symprunaria vulgarum (Linne, 1758)           |                 |        |
|             | Labidoridae    |             | Ichneura elegans (Vander Linden, 1820)       |                 |        |
| Dermaptera  | Labidoridae    |             | Ichneura elegans (Vander Linden, 1820)       |                 |        |
| Orthoptera  | Acrididae      |             | Chorthippus sp.                             |                 |        |
|             | Acrididae      |             | Aiolopus strepens (Latreille, 1804)         |                 |        |
|             | Acrididae      |             | Acrida turrita (Linne, 1758)                |                 |        |
|             | Acrididae      |             | Chorthippus biguttatus (Linne, 1758)        |                 |        |
|             | Acrididae      |             | Melanoplus bivittatus (Sey, 1825)           |                 |        |
|             | Gryllidae      |             | Gryllus bimaculatus (De Geer, 1773)         |                 |        |
|             | Mantis religiosa (Linne, 1758) | | Phytophagous | | Feb.    |     |
For the class Arachnida, orders Araneae (Lycosidae), Solifugidae (Daesiidae), and Scorpions (Scorpionidae) were the three most common orders collected, represented by several species.

Of the 115 species collected, 6 are listed by the Ministry of Land, Environment and Tourism as protected species in Algeria: *Apis mellifera* L. (Hymenoptera: Apidae), *Xylocopa violacea* L., *Syfrhus sp.* (Diptera: Syrphidae), *Mantis religiosa* L. (Mantodea: Mantidae), *Chrysopa carnea* (Say) (Neuroptera: Chrysopidea), and *Polistes gallicus* (Hymenoptera: Vespidae) (Ministère de l’Aménagement du Territoire, de l’Environnement et du Tourisme 2009). Their inclusion in the list might be due to their importance as predator or parasitic species that have a positive effect on the regulation of crop pests or a beneficial effect on the environment.

Figure 6 presents a breakdown of the percentage of species based on feeding guilds (i.e., phytophagous, predators/parasites, and omnivores). Among the collected insects, there were a number of serious plant pests, including aphids (Homoptera) and the gelechiid moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), which is a newly recorded species (Guenaoui 2008). A number of beneficial insects, including predators (Syrphidae and Cocconellidae) and parasites (Tachinidae) were also collected. Among the most important predators and parasites collected in the oasis ecosystems were ladybird beetles, *Coccinella septempunctata* L. (Coleoptera: Coccinellidae); lacewings, *Chrysopa oculata* (Say) (Neuroptera: Chrysopidae); praying mantids, *M. religiosa*; and dragonflies, *Sympetrum sanguineum* (Muller) (Odonata: Libellulidae). The parasitic fly species *Peleteria varia* F. (Diptera: Tachinidae) and the parasite *Megascolia maculata* (Drury) (Hymenoptera: Scoliidae) were also collected.

The third group found in the pitfall traps was the beetles, *Pimelia sp.* (Coleoptera: Tenebrionidae), *Brachinus explodens* (Duftschmi) (Carabidae), and the ant *Messor barbarous* L. (Hymenoptera: Formicidae).

In our study, it was found that relationships between organisms living in the same agroecosystem can be modified if the relationship is disrupted by the unavailability of a link. In trophic food chain, we can find predator and prey at different levels (Fig. 7), while parasites and their hosts can be on the same plants (Raffel et al. 2008). In our study, the large number of predatory Coleoptera present in all stations between March and May may help regulate aphid populations. Aphids also can be eaten by several other insects that could be present in and around the oasis (e.g., *C. oculata*). The dragonfly family Libellulidae was well represented in the oasis ecosystems and may play a major role in the regulation of predator species. The presence of the Araneae in Tolga and El Ghrous is very interesting and can explain the species diversification in this region. Starting with the information collected during this survey, an oasis ecosystem chain can be built.

An IPM program is applied in order to reduce pest damage by taking into account the health of people, environment, and beneficial organisms (Dufour 2001). The goal of Integrated Pest Management (IPM), from our standpoint, is to maintain a balanced ecosystem (a healthy environment) that results in high economic, environmental, and social benefits.
benefits (Dufour 2001). The objectives of the ecosystem analysis are to make decisions about how to manage the oasis ecosystem and how to achieve the goals of IPM.

An IPM program was established in the oasis ecosystem by Doumandji-Mitché and Doumandji (1990). They showed a 45.3% success rate with the release of the parasitoid Trichogramma embryophagum, a parasite of Ectomylois ceratonea, in an oasis ecosystem in southwest Algeria. Another program was carried out in some oases of southeast Algeria where the Institut National de Protection des Végétaux released sterilized males of Stethorus punctillum in 1999 and obtained a significant reduction in worm infestations of dates. Quinlan and Dhouibi (2008) released the biological control agents Bracon hebetor and other parasitoids and predators against the date moth.

Positive results were achieved in the oasis ecosystems of southwest Algeria by Idder and Pintureau (2008), who used the ladybird beetle, Stethorus punctillum, as a predator of the mite Oligonychus afrasiaticus. Other predators present in Algeria will have to be tested in order to establish a method of biological control suited to sufficiently protect the palm plantings.

This inventory is the first step in setting up an IPM program within the oasis ecosystem based on the correct identification of species and an understanding of the ecological roles at play in trophic food chain.

References Cited

Chinery, M. 1993. Insects of Britain and Northern Europe: the complete insect guide, 3rd ed. HarperCollins, London.

Didham, R. K., P. M. Hammond, J. H. Lawton, P. Eggleton, and N. Stork. 1998. Beetle species responses to tropical forest fragmentation. Ecol. Monogr. 68: 295–323.

Doumandji-Mitché, B., and S. E. Doumandji. 1990. Essai de lutte biologique contre la Pyrale des Caroubes Ectomylois ceratonea Zeller, (Lep., Pyralidae) par utilisation de Trichogramma embryophagum (Hym.,Trichogrammatidae) à Ouargla, pp. 261–270. In V. Dollé and G. Toutain (eds.), Les systèmes agricoles oasisiens. CIHEAM, Montpellier, France.

Dufour, R. 2001. Biointensive integrated pest management (IPM): fundamentals of sustainable agriculture. NCAT. (https://attra.ncat.org/attra-pub/view.html?id=146). (accessed 17 June 2009).

Greenslade, P.J.M. 1973. Sampling ants with pitfall traps: digging-in effects. Insect Soc. 20: 343–353.

Greenslade, P.J.M., and P. Greenslade. 1971. The use of baits and preservatives in pitfall traps. J. Aust. Entomol. Soc. 10: 253–260.

Greenslade, P.J.M., and P. Greenslade. 1977. Some effects of vegetation cover and disturbance on a tropical ant fauna. Insect Soc. 2: 163–182.

Guenaoui, Y. 2008. Nouveau ravageurs de la tomate en Algérie. Première observation de T. absoluta, mineuse de la tomate, invasive dans la région de Mstaganem. Phytoma. La Défense du Végétal. 617: 16–19.

Idder, M. A., and B. Pintureau. 2008. Efficacité de la coccinelle Stethorus punctillum (Weise) comme prédérateur de l’acarien Oligonychus afrasiaticus (McGregor) dans les palmeraies de la région de Ouargla en Algérie. Fruits 63: 85–92.

LeBerre, M. L. 1975. Some features influencing efficiency of pitfall traps. Oecologia 19: 345–357.

Maehara, T. 2004. The efficiency of pitfall traps in relation to a density and activity of the carabid beetles, Carabasinsulicola Chaudoir (Coleoptera: Carabidae), under controlled population density. Jpn. J. Appl. Entomol. Zool. 48: 115–121.

Maisonhaute, J. É. 2009. Quand le paysage influence les ennemis naturels. Bulletin de la Société d’Entomologie du Québec Antennae 16: 3–7.

Ministère de l’Aménagement du Territoire, de l’Environnement et du Tourisme. 2009. Projet de décret exécutif fixant la liste des espèces animales non domestiques protégées, Ministère de l’Aménagement du Territoire, de l’Environnement et du Tourisme. Alger (CD).

Niemelä, J. K. 1996. From systematics to conservation—carabidologists do it all. Ann. Zool. Fennici 33: 1–4.

Quinlan, M. M., and M. H. Dhouibi. 2008. Annexe 5: potential markets for date moth SIT in date production regions, pp. 285–304. In IAEA (ed). Model business plan for a sterile insect production facility. International Atomic Energy Agency, Vienna, Austria.

Raffel, T. R., L. B. Martin, and J. R. Rohr. 2008. Parasites as predators: unifying natural enemy ecology. Trends Ecol. Evol. 23: 610–618.

Scudder, G.G.E. 2000. Pitfall trapping. Ecological Monitoring and Assessment Network.

Spence, J. R., and J. K. Niemelä. 1994. Sampling Carabid assemblages with pitfall traps: the madness and the method. Can. Entomol. 126: 881–894.

Work, T. T., C. M. Buddle, L. M. Korinus, and J. R. Spence. 2002. Pitfall trap size and capture of three taxa of litter-dwelling Arthropods: implications for biodiversity studies. Environ. Entomol. 31: 438–448.

Ye, M. S., and D. Li. 2003. The effects of forest fragmentation on arthropod diversity. In Proceedings of the 9th National Undergraduate Opportunities Programme Congress. Nanyang Technological University. (http://www3.ntu.edu.sg/ece/urop/congress2003/Proceedings/abstract/NUS_FoS/Life%20Sciences/Ye%20Meishan.pdf).

Received 21 November 2010; accepted 6 June 2013.