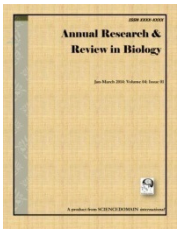

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The Economic Value of Bees as Pollinators of Crops in Iran

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Author's contribution

This whole work was carried out by author MMS.

Original Research Article

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ABSTRACT

Assessment of the economic value of crop pollination by bees necessitates the need for conserving the insect pollinator diversity. A decline in the population of insect pollinators in ecosystems can result in a decrease in crop production, vegetation cover, an extinction of a number of plant species, and as a result the degradation of ecosystem services and health. The economic value of bee pollinators was determined based on the portion of the value of crops attributed to pollination by bees. This value was calculated based on the yield and the value of each crop, the dependency of each crop on bee pollinators and the proportion of wild native bee and honey bee pollinators. The economic value of crop pollination by bees was 6.59 billion dollars, of which, 5.72 billion dollars is attributable to the pollinators that are honey bees and 0.87 billion dollars is attributable to native bees. The value of the crops pollinated by bees was estimated to be 25% of the total value of crops. The value of crops pollinated by honey bees was 54 times the value of honey production by bees. Based on the economic value of bee pollinators, the use of organic farming techniques, the use of less toxic and highly selective pesticides and herbicides, construction of nest boxes for pollinators and introduction of a variety of native plant species can help to conserve high level of diversity of bee pollinator species and the pollination services.

Keywords: Bee; crops; economic value; insect pollinators; pollination.

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1. INTRODUCTION

Insects provide several services in ecosystems including pollination, pest control, decomposition of the organic matter and maintenance of wild life species. Loss of insects in an ecosystem can result in an extinction of a diversity of plant species, a decline in the yield of crops [1], vegetation cover and the degradation of ecosystem services and health. Approximately, one-third of the world's food production depends directly or indirectly on insect pollination. Many crops require and benefit from insect pollination to increase quality and yields [2]. Even, some self-pollinated domesticated crops rely on insect-pollinated wild relatives to provide the genetic diversity that is essential for crop improvement [3]. Insects are the largest group of pollinators, with honey bees estimated to provide approximately 80% of all insect pollination [4]. A number of 20000 species of bee pollinators have been identified in the world [5]. A variety of bee pollinator species have been identified in different regions of Iran [6,7,8,9]. Of the bee pollinators studied in Iran, *Apis florea* and *Apis mellifera meda* have a wide distribution. *A. florea* is distributed along the south west of Iran. *Apis mellifera meda* is native to Iran and is most widely distributed throughout Iran [10]. Generally, to determine the role of bees in crop pollination, precise information on the current level of crop pollination by different species of managed bees (e.g., honey bee "*Apis mellifera*") and wild bees (e.g., Bumble bee "*Bombus spp.*") is required [11]. Much research is needed for detection of crop dependency on insect pollinators and determination of the most efficient pollinators for each crop [12]. In a study in Isfahan province of Iran, Insect pollinators could increase seed yield of canola (*Brassica napus*) by 53% [13]. The most abundant pollinators on canola were Hymenopterous insects specially honey bees (*Apis mellifera*) followed by three Dipterous insects, *Bibio hortulanus*, *Metasyrphus corollae* and *Platypalpus sp*. An increase in the yield of Iranian cucumber cultivars was found under the pollination of *Megachile rotundata* and *Apis mellifera L*. [14]. In Shiraz province of Iran, the efficiency of honey bee, *Apis mellifera*, was proved in the pollination and the increase of Golab apple production [15]. Both wild native and managed bees have an important role in pollination of a variety of crop species. The proportion of pollinators that could be attributable to managed and native pollinators is dependent on the crop species, geographical and habitat conditions and the use of insecticides. In the organic farms located near the natural habitats, all the pollination may be provided by native bees [16]. Native bees may have a positive interaction with honey bees and cause an increase in the efficiency of pollination by honey bees [17]. The economic importance of inter specific interactions for ecosystem services was studied [18] and it was found that behavioral interactions between wild and honey bees increase the pollination efficiency of honey bees on hybrid sunflower up to 5-fold, effectively doubling honey bee pollination services on the average field. At the local scale, the economic value of pollination service is highly variable depending on the crop and the market conditions [19]. At the national scale, the annual value of increased agricultural production attributable to honey bee pollination was estimated to be 9.3 billion dollars in 1987 [20] and 14.6 billion dollars in 2000 [2] in the United States of America (US). The value of honey bee pollination to agriculture was estimated in the US to be 19 billion dollars, of which 10 billion dollars was related to the production of crops and 9 billion dollars was related to the production of forage. The value of the pollination services in 1983 was 140 times the value of honey and wax production by bees [21]. The objective of this research was to determine the economic value of bee pollinators in Iran based on portion of the value of crops that is attributable to bee pollination.

2. MATERIALS AND METHODS

The economic value of bee pollinators was calculated based on the production and the value of crops and the dependency of each crop on insect pollinators [2]. (Table1). The value of crop pollination attributable to honey bee and wild bee pollinators was estimated. Data of crop yields was collected from Iran Ministry of Agriculture from 2005 to 2006. The following equation was used to determine the economic value of bee pollinators [20,2].

$$V_{hb} = \sum (V_i \times D_i \times P_i)$$

Where V_{hb} is the total annual value of crops pollinated by honey bees, V_i is the annual value of each crop (2005- 2006) in US dollar (1 US dollar was equal to 9000 Iran Rials in 2005-2006), D_i is the dependency of each crop on insect pollinators and P_i is the proportion of the insect pollinators that are honey bees [2]. To calculate the value of the crops pollinated by native bee species, the following equation was applied [17].

$$V_{nb} = \sum \left[V_i \times D_i \times (1 - P_i) \right]$$

Where V_{nb} is the annual value of the crops pollinated by native bee pollinators and $1 - p_i$ is the proportion of the insect pollinators that are native bee species having pollinated a given crop.

3. RESULTS

The value of the crops attributable to bee pollinators in Iran (2005-2006) was estimated to be 6.59 billion dollars. Based on the proportion of the insect pollinators that are honey bees and unmanaged wild native bees, the value of the crops attributable to honey bee pollination was 5.72 billion dollars and the value of the crops attributable to native bee pollination was 0.87 billion dollars (Table 1). The value of the crops pollinated by bees was 25% of the total value of the crops in Iran. Based on the production of 34700ton honey in 2005-2006 with a value of 0.122 billion dollars, the annual value of crops pollinated by honey bees exceeded the annual value of the honey production by bees by 54 times.

Table 1. The value of crops pollinated by insects in Iran, 2005-2006

Crop	Yield (ton)	Average value (V) (millions of dollars)	Dependence on insect pollination (D_i)	Annual value attributable to insects ($ millions)	Proportion of pollinators that are honey bees (P_i)	Annual value attributable to honey bees ($ millions) ($V_i \times D_i \times P_i$)	Proportion of pollinators that are native bees ($1-P_i$)	Annual value attributable to native bees ($ millions) $V_i \times D_i \times [1-P_i]$
Fruits and nuts								
Almond	108677.2	338.1	1.0	338.1	1.0	338.1	0	0
Apple	2661901. 2	1626.67	1.0	1626.67	0.9	1464.003	0.1	162.667
Apricot	275578	223.52	0.7	156.464	0.8	125.1712	0.2	31.2928
Cherry	224891.7	124.93	0.9	112.437	0.9	101.1933	0.1	11.2437
Grapefruit	53922.4	13.18	0.8	10.544	0.9	9.4896	0.1	1.0544
Lemon								
Sweet	574137.8	223.27	0.2	44.654	0.1	4.4654	0.9	40.1886
Tart	615092.5	287.03	0.3	86.109	0.9	77.4981	0.1	8.6109
Orange	2253209	876.24	0.3	262.872	0.9	236.5848	0.1	26.2872
Tangerine	701903.8	249.67	0.5	124.835	0.9	112.3515	0.1	12.4835
Grape	2963755.4	1383	0.1	138.3	0.1	13.83	0.9	124.47
Kiwifruit	86808.9	57.87	0.9	52.083	0.9	46.8747	0.1	5.2083
Nectarine	171801.2	99.26	0.6	59.556	0.8	47.6448	0.2	11.9112
Olive	61338.7	92	0.1	9.2	0.1	0.92	0.9	8.28
Peach	513184.6	270.84	0.6	162.504	0.8	130.0032	0.2	32.5008
Pear	166250.5	134.84	0.7	94.388	0.9	84.9492	0.1	9.4388
Plum	98340.5	49.17	0.7	34.419	0.9	30.9771	0.1	3.4419
Strawberry	38494	76.98	0.2	15.396	0.1	1.5396	0.9	13.8564
Vegetables								
Carrot	230000	63.89	1.0	63.89	0.9	57.501	0.1	6.389
Cucumber	1720690.2	707.39	0.9	636.651	0.9	572.9859	0.1	63.6651

Cantaloupe	1800000	500	0.8	400	0.9	360	0.1	40
Onion	1685450.4	561.81	1.0	561.81	0.9	505.629	0.1	56.181
Pumpkin	255000	31.17	0.9	28.053	0.1	2.8053	0.9	25.2477
Squash	150000	46.67	0.9	42.003	0.1	4.2003	0.9	37.8027
Watermelon	3259410.3	651.88	0.7	456.316	0.9	410.6844	0.1	45.6316
Field crops								
Alfalfa	4762391.3	899.56	1.0	899.56	0.95	854.582	0.05	44.978
Cotton	363460.2	181.72	0.2	36.344	0.8	29.0752	0.2	7.2688
Peanut	10000	17.78	0.1	1.778	0.2	0.3556	0.8	1.4224
Rapeseed	234698.5	93.88	1.0	93.88	0.9	84.492	0.1	9.388
Soybean	197862.6	72.54	0.1	7.254	0.5	3.627	0.5	3.627
Sugar beet	4902387	228.78	0.1	22.878	0.2	4.5756	0.8	18.3024
Sunflower	25000	9.72	1.0	9.72	0.9	8.748	0.1	0.972
Total	28503736.7	10193.36		6588.67		5724.86		863.81

4. DISCUSSION

The estimated value of crop pollination by bees in this research highlights the necessity of an efficient investment for maintenance of insect diversity. The economic value of crops pollinated by insects in Iran (6.59 billion dollars) was estimated to be 3.4% of the Iran GDP (gross domestic product) indicating the importance and the roll of pollinators in the national economy. The value of the crops pollinated by bees was 25% of the total value of the crops in Iran. At the national scale, value estimates of the pollination service range from 1% to 16% of the market value of agricultural production [19]. The economic value of bee-pollinated crops was 54 times the value of honey production by bees. This ratio was reported to be 50 times [22] and 140 times [21] in the United States of America in 1984. The value of crop pollination attributable to native bees was estimated 0.87 billion dollars in Iran. A value of 3.07 billion dollars was presented for pollination by native bees in the U.S. [17]. In a study on the role of native bees in the pollination of a number of crops, it was found that native bees often make up a high proportion of the total bee visits (i.e., visits that include honey bees), suggesting that native bees can be as or more important than managed honey bees for the crops [23]. Native bee community alone could provide sufficient pollination for some crops such as watermelon. This depended on the diversity and abundance of bees in the community, which in turn was dependent on the abundance of native habitat in the area. In addition, they found that crops typically thought of as “self-pollinated” such as tomato can benefit from native bee visitation. Bumble bees and other bees (e.g., *Anthophora urbana*) could obtain the pollen of tomato through vibration, while honey bees were unable to vibrate the flowers, and thus obtained few rewards from tomato flowers. The population and diversity of beneficial bees are declining continuously mainly due to the habitat destruction [16]. Studies show that habitat destruction, introduction of exotic species, diseases and overuse of toxic pesticides are the main causes of extinction of most endangered species of insects and can decimate pollination systems. Based on the gradual decline in the insect species and a nonlinear relationship between the density of insects and the level of ecological services provided by insects, it is difficult to specify an optimal investment for conserving the beneficial insects [17]. In some ecosystems, a number of insect species may provide similar functions, so that the decrease of the density of one species may be compensated by an increase in another with no changes in the level of the ecosystem function. Based on the positive relationship between the number of plant species and insect species richness [24], introduction of a variety of native plant species [25] can help conserving the diversity of insects. Native unmanaged bee populations are more diverse and abundant near to natural habitat [4] and the amount and the stability of pollination services from native bees increasers with increasing proportional area of natural habitats in the vicinity of farms [26]. Most of organically managed agricultural lands near native habitat obtain sufficient pollination solely from native bee communities. Native bee species need a diversity of plants to provide nectar and pollen. In addition, they require protected areas for nesting, including twigs, dead wood, bare soil, and abandoned rodent nests. Therefore, It seems that native bee pollinators are more likely found on farms close to natural habitats [23]**.** Thus, maintenance of natural ecosystems that are near farms and active restoration with native plants on and off farms is required to enhance the level and stability of services provided by pollinators. A number of native plant species of Iran that can most favourably attract bee pollinators because of providing nectar and pollen are *Taraxacum montanum, Thymus pubescence*, *Thymus kotchyanus*, *Nepeta crassifolia* [27], *Achillea eriophora, Centaurea sostitialis, Echinops ceratophorus, Helianthus annus, Astragalus adscendens, Astragallus gossypinus, Mentha longifolia, Teucrium orientale, and Onobrychis sativa* [28]. The ecological services provided by pollinators must be evaluated and their maintenance must be considered in land management practices.

5. COCLUSSION

Based on the economic value of crop pollination by bee pollinators in Iran, it is necessary to conserve the diversity of pollinators. Maintenance of natural ecosystems, conservation of native vegetation, construction of artificial nest boxes for wild pollinators and the use of less toxic and more selective pesticides and herbicides can help to conserve the diversity of pollinator species and as a result the pollination services provided by the pollinators. Studies are needed to identify the most efficient pollinators for each crop in different regions of Iran and then the economic value of crop pollination by native bees and other pollinators could be higher.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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