The Economic Value of

Australian

Non-Honey Bee Insect Pollinators

in 2014 – 2015.

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[1] Department of Mineral and Energy Economics, WA School of Mines, Curtin University. Email: John.Karasinski@gsb.curtin.edu.au This paper benefited from presentations made to various WA bee industry groups including The Bee Industry Council of WA, the WABA and WA Farmers Bee 2017 Conference, the Centre for Integrative Bee Research at the University of Western Australia and a seminar presentation made to the Agriculture and Natural Resource Economics Society (W.A. Branch).

[2] This paper is in response to a question asked during a presentation given to the Centre for Integrative Bee Research at the University of Western Australia on the topic of the economic value of Australian managed and feral honey bee pollinators.

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Abstract

This paper is the second in a series reporting the economic value of Australian pollination agents in 2014 -2015. The first paper detailed the economic value of Australia's managed and feral honey bee pollinators (Karasiński 2018). This paper presents for the first time the economic value of Australian non-honey bee insect pollinators. This economic value was measured using the same economic model used to calculate the economic value of honey bee pollinators reported by Karasiński (2018).

In 2014 – 2015, the economic value of Australia's non-honey bee insect pollinators is estimated to lie between $A 10.6 bn and $A 17.9 bn. The average economic value is $A 14.2 bn – see Table 3. When comparing this value to that calculated for managed and feral honey bee pollinators (see Table 4 in Karasiński 2018) the economic values are surprisingly almost identical.

The economic value of non-honey bee insect pollinators for Avon Valley strawberries in Western Australia is estimated to have an average economic value of $A 5.4 m. This result is almost the same economic value that was calculated for the economic value of managed and feral honey bee pollinators reported previously by Karasiński (2018).

In addition, this paper presents for the first time the "crop value" of Australia's non-honey bee insect pollinators which is shown in Appendix 1. It should be pointed out the crop value is *not* the same as the economic value, but it is a subset of the economic value. The terms crop value and economic value *should not* be used interchangeably.

1.0 Introduction

Research into the "economic value" of honey bee pollinators traces its origin to entomological school of thought beginning with British entomologist Butler (1943) who was the first to calculate the crop value of honey bee crop pollinators. [3] Over time Butler's crop valuation method was further refined and extended by researchers on both sides of the Atlantic including Americans Robinson et al (1989), Morse and Calderone (2000), Calderone (2012). On the British side of the Atlantic both Carreck and Williams (1998) [4] and the UK National Audit Office (2009) [5] presented their estimates of crop values incorrectly as "economic values."

A half a century after Butler's pioneering study, a second school of thought emerged when economists became interested in measuring *the* economic value of honey bee pollinators. They used a sophisticated economic model to calculate the estimated economic value. At the vanguard of this school of thought was Australian agriculture economist Gill (1989,1990, 1991a, 1991b, 1996) [6] who was soon followed by American's Southwick and Southwick (1992). [7] Thirty years later Gill's Australian economic model has been enhanced by Karasiński (2018) who presented the economic value of Australian managed and feral honey bee industry for 2014 - 2015 for Australia and for the first time on a state by state basis.

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[3] Butler estimated a crop value of £5.287m (1943:190) or £229.2 m in 2017 inflation adjusted terms. Butler cited the annual honey yield of UK bees in the early 1940's averaging: "…40-50 lb (approx. 18-23 kg) of honey per colony may reasonably be expected at the present level of management." Butler (1943:189).

[4] Carreck and Williams (1998:117) estimated UK crop value of bees was £172.2 million or £288.1m, in 2017 inflation adjusted terms.

[5] UK National Audit Office (2009:48) estimated the crop value of UK honey bee pollinators was £191.8 million (£244.6m in 2017 inflation adjusted terms) reflecting Britain's small-scale agriculture industry. There are significant implications for post Brexit (after 29th March 2019) agriculture policy.

[6] See Gill, R.A. 1990. "The Value of Honeybee Pollination to Society" *VI International Symposium on Pollination 288*, Gill, R A.1991a. "The Value of Honebee Pollination to Society " *Apiacta* 4.

[7] Southwick, Edward E., and Lawrence Southwick. 1992. "Estimating the Economic Value of Honey Bees (Hymenoptera: Apidae) as Agricultural Pollinators in the United States." *Journal of Economic Entomology* 85 (3): 621-633.

This paper reports the previously unmeasured and unknown economic value of Australian non-honey bee insect pollinators for Australia and on a state by state basis. The results have an important bearing for all sectors of the Australian agriculture industry.

2.0 Review of the Australian Literature.

There is no existing body of literature either within economics or at the industry level which dealt with the quantifying the economic value and the importance of non-honey bee insect pollinators.

Australian research until now, has been skewed towards measuring the economic value of honey bee pollinators. But as pointed out by Karasiński (2018) the “economic values” reported by Australian researchers since Gill (1989) have in fact not been correct economic values because the estimates were not calculated using the economist’s proper economic model. [8]

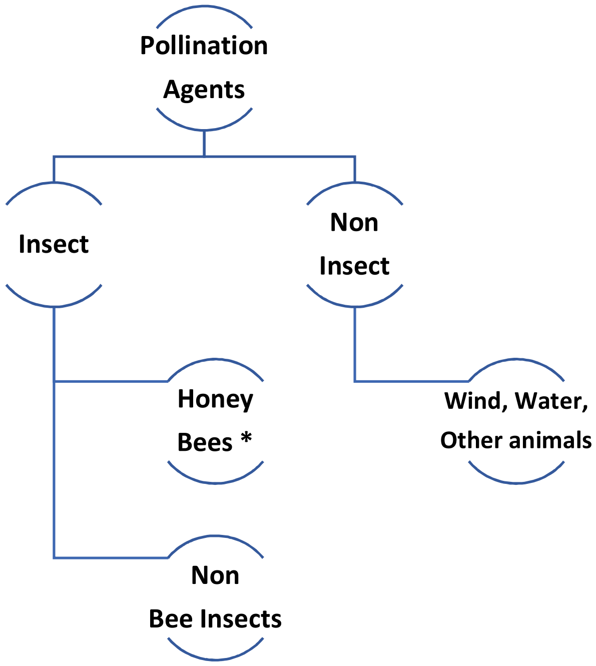
3.0 Crop Pollination Agents

The schematic chart, Chart 1 below shows the relationships between the major pollination agents. Agriculture crops are pollinated by both insect pollinators and non-insect pollinators.

Insect pollinated crops are pollinated by either honey bee pollinators or by non-honey bee insect pollinators (all other insect pollinators).

[8] Formerly known as a partial equilbrium model.

Chart 1: The relationship between Pollination agents



* Honey Bees include Managed and Feral (native) honey bee pollinators.

Non-insect pollinators include other animals, water and wind also play an important role in the pollination of agriculture crops but they are not discussed at part of this paper. Instead they are the subject of another paper.

Table 1 below lists the common non-honey bee insect pollinators. The extent of the contribution made to the pollination process by these agents individually or in conjunction with each other varies geographically across Australia.

Pollination agents include: (in alphabetic order): Ants, Artificial (electronic) wands, Bats, Beetles, Blowflies, Birds, Butterflies, Flies, Hawkmoths, Hoverflies, Humans (in parts of China and the Himalayan region), Maggots, Moths, Thrips.

Table 1: List of Non-Honey Bee Insect Pollinators.

Ants	Flies
Artificial electronic wands	Hawkmoths
Bats	Human pollinators [9]
Beetles	Hoverflies
Blowflies	Maggots
Butterflies	Moths
Birds	Thrips
Butterflies	

4.0 The Economic Model.

The economic model which is formerly known as a Partial Equilibrium Model (or P.E.M) that was used in this study is the same model used to calculate the economic value of Australian managed and feral honey bee pollinators as detailed by Karasiński (2018). The adoption of the P.E.M. for measuring the economic value of non-honey bee insect pollinators provides a uniform approach and methodology to be used to enable meaningful comparisons of economic value to be made between the two major groups of insect pollination agents.

The three components of the Economic Model

The major components of the economic model include: firstly, the Non-Honey Bee Insect Pollinator Dependency Factors, secondly, the farm gate agriculture crop values published by the Australian Bureau of Statistics which become the data for this study. Thirdly, the integration of both these components into the economic model along with the fourth component which is the relevant price elasticity of demand coefficients that categorise whether insect pollinated agriculture crops are "luxury" or "necessity" crops. Those coefficients give the mathematical value of the slope of the two demand curves.

[9] Particularly in parts of China and the Himalayan region.

Agriculture crops can be classified as belonging to one of two different economic types: "luxury" agriculture crops or "necessity" agriculture crops. "Luxury" crops are characterised has having substitutes, such as oranges and mandarins are fruit substitutes. In this case, their empirically derived own price elasticity of demand coefficient approximates -1.0. "Necessity" agriculture crops on the other hand, lack substitutes and their empirically derived own price elasticity of demand coefficient is less than -1.0.

The calculated economic values are then arithmetically averaged to give an average economic value of non-honey bee insect pollinators.

The Data set used in this study

This study uses readily available data sourced from the Australian Bureau of Statistics *Value of Agriculture Commodities Produced,* for 2014 – 2015.[10] A total of 53 insect pollinated agriculture crops were identified from that publication which in turn became the data base for this study.[11]

Deriving the Non-Honey Bee Insect Dependency Factors

Using beans as an illustration entomologists credit 10% of bean crops to be insect pollination.[12] Of that ten percent, 20% is pollinated by honey bee pollinators and the remaining 80% is pollinated by non-honey bee insect pollinators.

[10] Australian Bureau of Statistics, 2015. "Value of Agricultural Commodities Produced, Australia, 2013-14 , Cat. No. 7503.0."
[11] I am grateful for the assistance provided by entomologist Rob Manning in the development of the dependency factors.
[12] The remaining 90% of bean crop pollination is the direct result of the activities of non-insect pollinators.

Table 2: Deriving Insect Dependency Factors [13]

Crop	Percent Pollinated by Insects (1)	Percent of Pollinators that are Honey bees (2)	Honey Bee Dependency Factor (3) = (1) *(2)	Percent Pollinated by Non-Honey Bee Insect Pollinators (4) = 1 - (2)	Non-Honey Bee Insect Dependency Factor (5) = (1) *(4)
Beans	0.10	0.20	0.02	0.80	0.08

Note: Column 1 = (Column 3 plus Colum 5) that is, 0.10 = (0.02 + 0.08).

Source: Modified Table 2 Karasiński (2018) p. 20.

Multiplying columns 1 and 4 in Table 2 results in the all-important Non-Honey Bee Insect Dependency Factor shown in the final column in Table 2. This Non-Honey Bee Insect Dependency Factor is then incorporated into the economic model to calculate the economic value of non-honey bee insect pollinators.

The Price Elasticity of Demand Coefficient

The fourth and final component of the economic model is the price elasticity of demand coefficients for those insect pollinated agriculture crops.

This study used the Australian results published by Ulubasoglu et al (2010 and 2016) [14] who note: "Fresh fruit is estimated to have … an elasticity … of -1.049 … the demand for fresh vegetables is (price) inelastic … -0.053." [15] Fruits are considered "luxury" crops and have a higher price elasticity coefficient due to the existence of substitutes (i.e. apples substituted for pears etc). As vegetables typically lack substitutes their price elasticity coefficient is lower. The

[13] I am greatly indebted to the assistance provided by entomologist Robert Manning, (2016) who assisted in identifying the honey bee pollinated crops and for updating the estimates of the Honey Bee Dependency Factors for Australian agriculture crops.

[14] While Gill did not state the source of the price elasticity of demand coefficients he used, it can be assumed he used American data publisehd by Houthakker, Hendrik S, and Lester D Taylor (1970) "Consumer Demand in the United States."

[15] Ulubasoglu, Mehmet, Debdulal Mallick, Mokhtarul Wadud, Phillip Hone, and Henry Haszler. 2010. "Food Demand Elasticities for Australia."p.8.

two coefficients are incorporated into the model results to calculate an upper and a lower economic value as shown in columns 2 and 3 in Table 4 below. An arithmetic average of the two ranges is presented as a mid-point estimate of the economic value.

5.0 Results and Discussion

The results are shown in Table 3 below. The results present for the first time the economic value of Australia's non-honey bee insect pollinators ranging between $ A 10.6 bn and $A 17.9 bn. The average economic value in 2014 – 2015 was $A 14.2 bn.

Table 3: The Economic Value of Non-Honey Bee Insect Pollinators – Australia, State and Territory 2014-2015.

	Range of Economic Value of Non-Honey Bee Insect Pollinators $		**Average Economic Value of Non-Honey Bee Insect Pollinators $**
Price Elasticity of Demand	-0.526	-1.049	Average
State and Territory			
New South Wales	4,448,154,426	2,838,074,480	3,643,114,453
Victoria	3,270,814,596	1,992,740,509	2,631,777,553
Queensland	4,554,084,220	2,446,620,686	3,500,352,453
South Australia	2,272,517,948	1,216,436,884	1,744,477,416
Western Australia	3,227,082,506	1,958,848,671	2,592,965,589
Tasmania	109,366,539	64,671,515	87,019,027
Northern Territory	45,709,645	32,770,134	39,239,890
A.C.T.	1,687,999	1,339,162	1,513,581
Australia – Total	**17,929,417,879**	**10,551,502,041**	**14,240,459,960**

As this is the first study to report an economic value of non-honey bee insect pollinators little can be said in isolation about the results. What is apparent is the diversity in the range of economic values across Australia and by the states and territories. This range supports the view agriculture farming in Australia and within the states and territories is very diverse and this diversity is supported by an assortment of active pollinators.

The important economic contribution made by individual pollination agents shown in Table 1 have not been measured, quantified or mapped. Knowing the contribution made by individual pollination agent across Australia would provide beneficial insights into increasing crop yields. These insights may also result in long term repercussions for the manner in which agriculture farming is conducted in Australia. The task to comprehensively map the economic importance of individual non-honey bee insect pollinators is relegated to a future study.

The results shown in Table 3 are surprisingly identical to the economic value of honey bee pollinators calculated by Karasiński (2018 – see Table 4).

Both sets of economic values draw attention to unambiguously important economic role played by *both* groups of pollination agents in the pollination process.

This research demonstrates the clear need to undertake ongoing research into the economic values of both groups of insect pollinators to provide agriculture industry stakeholders with more knowledge which until now, has been lacking. Some of those insights include industry benchmarking that can then be further scrutinised to determine if any discernible patterns exist and evolve over time.

Strawberries in the Avon Region of West Australia.

In the original paper Karasinski (2018) the economic value of honey bee pollinators was calculated for a single agriculture crop. Strawberries were arbitrarily chosen as the crop and the Avon Valley in Western Australia was chosen as the region.

The economic value of non-honey bee insect pollinators of Avon valley strawberries in 2014 – 2015 averaged $A 5.44m – see Table 4 below.

Table 4: The Economic Value of Non-Honey Bee Insect Pollinators - Avon Region Strawberry crop, 2014-2015.

Location	**Economic Value of Non-Honey Bee Insect Pollinators $**		**Average Economic Value of Non-Honey Bee Insect Pollinators $**
Price Elasticity of Demand	-0.526	-1.049	Average
Avon Valley, WA	5,960,559	4,922,985	5,441,772
Western Australia	23,729,326	19,598,682	21,664,004
Australia	253,039,563	200,283,642	226,661,603

The result shown in the above table also closely correspond to the economic value of the honey bee pollinators ($A 5.11m) reported previously by Karasiński (2018).

6.0 Conclusion

This paper reported the economic values of Australian non-honey bee insect pollinators for 2014 – 2015. This paper compliments a previous study by Karasiński (2018) who reported the economic value of Australian managed and feral honey bee pollinators. This paper reports the economic value of non-honey bee insect pollinators or the economic contribution made by ants, bats, beetle, blow flies, flies to name but a few insect pollinators.

The results of this research confirm for the first time the significant and previously unknown economic value of non-honey bee insect pollinators.

Surprisingly, the economic values calculated for both major pollination agents (honey bee pollinators and non-honey bee insect pollinators) are almost identical – see Table 4.

As expected, the economic values of non-honey bee insect pollinators vary across Australia on a state by state and territory basis. The economic values differ between the states and the regions due to a range of factors including the crops grown, the prevalence and types of non-honey bee insect pollinators inhabiting growing areas.

Consistent with the previous paper by Karasiński (2018) this paper also reported the economic value of non-honey bee insect pollinators for a single crop (strawberries) grown in Western Australia's Avon Valley. The economic value made by non-honey bee pollinators is again, almost identical to that made by honey bee pollinators.

It is apparent that ongoing and regular research into both groups of pollinator agents is warranted to detect trends and to provide stakeholders and industry with useful and important insights.

Appendix 1: The Crop Value of Non-Honey Bee Insect Pollinators.

The non-honey bee insect dependency factor described in section 4.0 above is used by entomologists to calculate their version of "economic value." Here the non-honey bee insect dependency factor is multiplied for each insect pollinated crop by its farm gate value and then aggregated to give the total "economic value."

This method however, results in the calculation of only the "crop value" of non-honey bee insect pollinators and not the correct economic value.

Appendix Table 1 below, presents the outcome of having modelling 53 insect pollinated agriculture crops based on ABS agriculture data for 2014 – 2015. Appendix Table 1 reports for the first time the crop value of non-honey bee insect pollinators for Australia and on a state by state and territory basis.

In 2014-2015, the crop value of non-honey bee insect pollinators was estimated to be $A 5.6 bn.

Appendix Table 1: The Crop Value of Non-Honey Bee Insect Pollinators – Australia, State and Territory 2014-2015.

	Crop Value of Non-Honey Bee Insect Pollinators $
State and Territory	
New South Wales	1,558,867,373
Victoria	1,148,763,689
Queensland	1,231,433,374
South Australia	571,347,629
Western Australia	1,022,798,411
Tasmania	40,382,456
Northern Territory	19,951,081
A.C.T.	921,396
Australia – Total	**5,594,465,409**

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