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**An investigation of Honey Bee Drone Congregation Area
formation in rural and semi-rural locations in New Zealand**

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Abstract

Male honey bees gather in Drone Congregation Areas (DCAs), and meet with queens to mate in flight. Because they mate on the wing, investigation of these areas using current techniques is not easily facilitated in some areas, which limits research. This study investigates an improved method of studying DCAs in difficult areas; studies the landscape characteristics of DCA locations, and measures pheromone attraction between drones, and honeybee queens and workers, to ascertain any chemical contribution towards DCA formation. Using a camera equipped Unmanned Aerial Vehicle (UAV) holding an artificial honey bee queen with 9-Oxo-2-Decenoic Acid (9ODA), trials were conducted to investigate the different flight behaviours of honey bee drones on their mating flights, and the formation of DCAs. The use of the UAV was found to be successful in carrying out DCA research especially in inaccessible areas. Using this method, drone honey bee mating flight activity was investigated in several distinct areas; hill and valley areas; urban park areas, and flat agricultural areas. The data were analysed using Geographic Information System software ArcGIS 10.4.1. Different patterns of drone activity were found in the different areas suggesting that in hill and valley areas where well defined DCAs exist, landscape features played an important part in their location but that in flat areas, landscape features were not shown to play a part in DCA formation and instead, apiary-dependant DCAs dominated, and away from these apiaries, the abundance of drones flying at random in the flat areas (as opposed to being confined in a hill and valley area) would ensure mating. The results also suggest that contrary to some research, DCAs in hill and valley areas have flexible boundaries that may vary in response to other factors such as queen flight behaviour. In order to find out whether chemical influences could contribute to the formation of DCAs, a four- arm olfactometer test was carried out to investigate drone attractiveness to queens, and drone attractiveness to other drones. Contrary to my expectations, drones and queens were not attracted to other drones but rather to workers, perhaps because only sexually immature drones were available for the tests. The study overall confirms the usefulness of using a UAV in difficult areas; demonstrates a significant difference in the spatial dynamics of drone mating flight in different landscape areas, and concludes that DCA boundaries may be constructs that depend on the mating flight parameters of the queen rather than drones only. Further research, especially on the queen's mating flight parameters is suggested.

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Table of Contents

Abstract	2
Acknowledgements.....	3
Table of Figures	6
1. Introduction.....	7
2. Review of Literature	9
2.1 Drone Congregation Areas.....	9
2.1.1 Multiple mating in honey bees	12
2.2 Drone flight parameters.....	15
2.3 Pheromones and Honey Bee Mating	16
2.3.1 Drone aggregation pheromone.....	18
2.4. The Mating flight of the queen honey bee	19
2.5 Factors that may give rise to Drone Congregation Area location.....	21
2.5.1 Flight altitudes and distance from the apiary	21
2.5.2 Magnetic sense in honey bees	22
2.5.3 The influence of wind.....	23
2.5.4 Optical radiance	24
2.5.5 Physical Landscape Features.....	25
2.5.6 Honey bee pheromone attraction	27
3. Methods of investigating DCAs: Advances and challenges	28
3.1. Summary of the literature.....	28
4. Developing an improved method of investigating certain characteristics of DCAs. (Cramp 2017) 30	
4.1 Study aims	30
4.1.1 Using balloons, kites and artificial queens impregnated with synthetic queen pheromone	30
4.2. Flight trials of the unmanned aerial vehicle (UAV)	30
4.3 Materials and method.....	31
4.4. Results and discussion.....	37
4.5. Conclusions	43
5. Investigating the relationship between landscape and DCA formation in hill areas and a flat, open area using the UAV	44
5.1 Background	44
5.2 Problems associated with DCA research.....	45
5.3 Material and Methods	47
5.4. Analysis of the DCAs.....	51
5.5 Results and discussion.....	52
5.6 Conclusion	57
6. Testing for the abundance of drones in areas in relation to landscape characteristics.	58
6.1 Introduction.	58
6.3 results and discussion	59

6.3.1 Mean times for drones to attend a lure in the areas studied.....	60
6.3.2 Mean times for drone comets to form in response to a lure	61
6.4 Conclusions	62
7. Investigation of drone to-drone, and queen-to-drone attractiveness.....	63
7.1 Aim of the study.....	63
7.2 Background	63
7.3 Materials and methods	64
7.3.1 Test drones.....	65
7.3.2 Test Workers	66
7.3.3 Test Queens.....	66
7.4 Experimental set up	67
7.5 Experimental Process.....	69
7.5.1 Test A. Queen/drone attraction test.....	71
7.5.2 Test A. Results.	74
7.5.3 Test B. Queen/drone only attraction test (worker influence removed).....	74
7.5.4 Test B. Results	75
7.5.5 Test C. Drone/drone attraction test.....	75
7.5.6 Test C. Results	76
7.5.7 Test D. Drone/drone attraction test (workers removed)	76
7.5.8 Test D Results	76
7.6 Discussion.....	77
7.7 Conclusions	79
8. Thesis Summary and Conclusion.....	80
8.1 Conclusions	81
REFERENCES.....	83
Appendix 1. Maps 1 – 45 of Drone Congregation Areas studies.....	90
Appendix 2. Data Tables	119
Data Table 1. Drone Activity in DCAs	119
Data Table 2: Showing the data used to perform regression analysis on four variables	138
Data table 3. Single Lift points to test drone abundance in hill/valley and flat areas.	145
Data Table 4. Test A. Queen/drone attraction tests.....	147
Data Table 5. Test B. Queen/drone only attraction tests (no worker odour source present)	151
Data Table 6. Test C. Drone/drone attraction tests	153
Data Table 7. Test D. Drone/drone attraction tests - no worker influence	160

Table of Figures	Error! Bookmark not defined.
Fig 1 The Phantom Vision 2 camera equipped UAV	32
Fig 2. The UAV showing the extension attachment and the camera.....	32
Fig 3. The artificial queen bee used in the tests.....	33
Fig 4. The queen bee attached to the extension fitted to the UAV	33
Fig 5. The UAV with the queen extension and artificial queen.....	36
Fig 6. The numbered flags show lift points from where the UAV was raised and measurements taken.....	37
Fig 7 showing the drone activity hotspots derived from data taken from the lift sites shown in Fig. 6.	37
Fig 8. showing landscape features superimposed on over the DCA hotspot map at Fig 7.....	38
Fig 9. Showing an aspect overlay on the hotspot data	39
Fig 10. Extract from Data Table 1 showing typical measurements at each site investigated.....	41
Fig 11. An area that was almost impossible to visit on foot or by vehicle.....	42
Fig 12. The areas investigated in this study	47
Fig 13. The area surrounding Apiary 050 which was first investigated	48
Fig 14. Showing UAV flight taking drones up valley sides.....	52
Fig 15. Showing the most of the drone activity.	55
Fig 16. The relationship between DCAs and ground slope	56
Fig 17. Mean times for drones to appear at the lure in 3 distinct areas	60
Fig 18. Distribution of data. Mean times for the formation of comets	61
Fig 19. The drone trapping net after Williams 1987. (Modified).	65
Fig 20. The 4 way olfactometer test equipment showing the air inlets	68
Fig 21. The four way olfactometer.....	68
Fig 22. The VAS four way air pump and air extractor device.....	69
Fig 23. Olfactometer layout.	69
Fig 24. Apparatus layout Test 2. Odour source bowls moved one position anti-clockwise	70
Fig 25. Drone odour source bowl (attendant workers removed).....	71
Fig. 26. Worker odour source bowl.....	71
Fig. 27. Workers in the odour source bowl attend the queen.....	73
Fig. 28. Close up of workers in the bowl attending a queen behind the gauze screen in Test 1. Queen 1.....	73
Fig. 29. Test A. Queen/Drone attraction.....	74
Fig 30. Test B. Worker bee influence removed providing a choice of air or drones.....	75
Fig 31. Drone attraction to workers, drones or air on a four arm olfactometer test	76
Fig 32. Test D. Drone attraction chart with worker influence removed.	77