

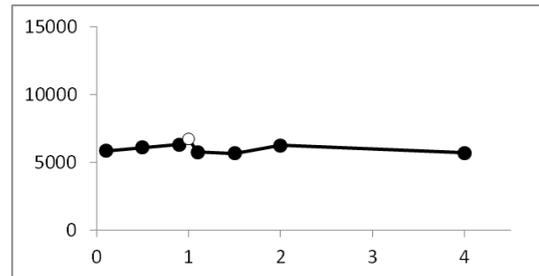
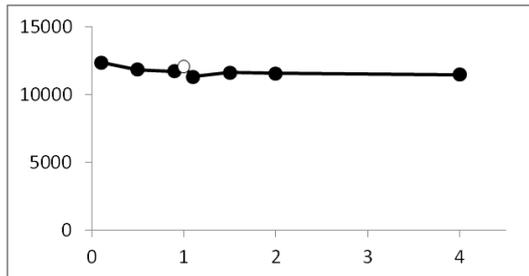
Appendix S4: SENSITIVITY ANALYSES

Sensitivity analyses were done for the default setting and when varroa was added (i.e. $N_{Initial_Mites_Healthy}$: 10, $N_{Initial_Mites_Infected}$: 10). Each single parameter was multiplied by a factor ranging from 0.1 to 4 (x-axis). Mean colony size after 3 years was used as output (y-axis) ($N = 10$). Default values (i.e. factor = 1) are shown as a white circles. The effect of *Squadron_Size*, which defines the number of foragers represented by a forager super-individual, was varied from 1 to 1000.

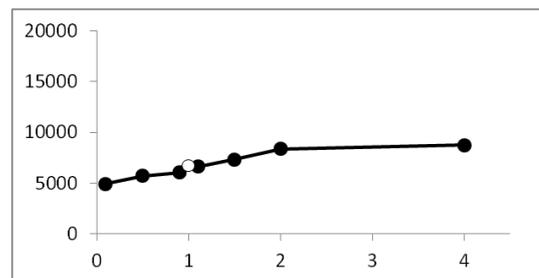
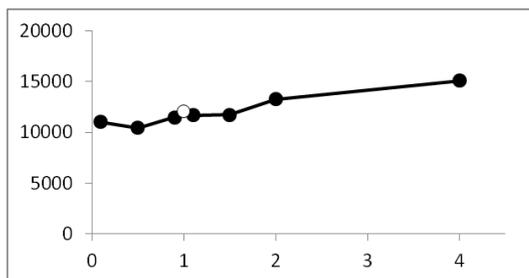
Without varroa

With varroa

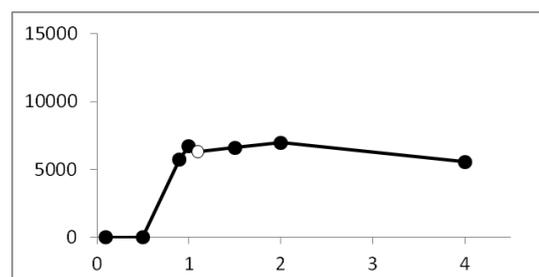
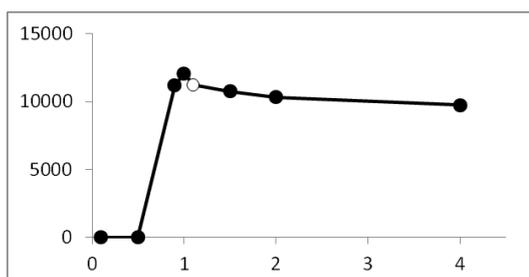
- (i) "ABANDON_POLLEN_PATCH_PROB_PER_S" (default probability = 0.00002 per second)



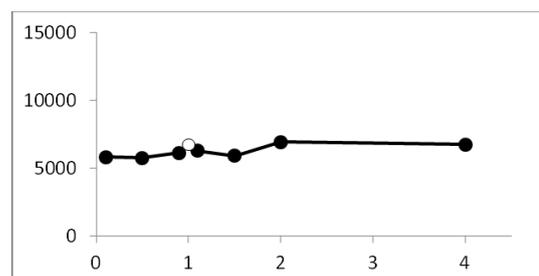
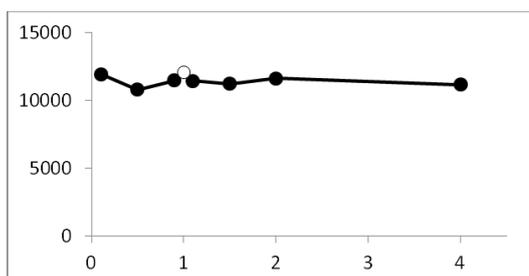
- (ii) "AFF_BASE" (default = 21 days)



- (iii) "CONC_G" (default concentration = 1.5 mol/l)



- (iv) "CONC_R" (default concentration = 1.5 mol/l)

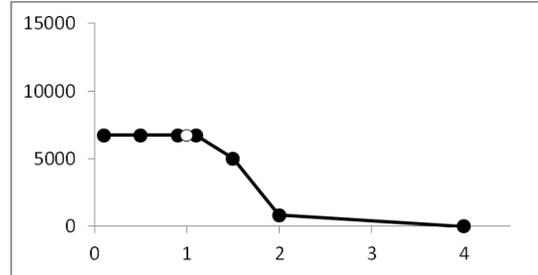
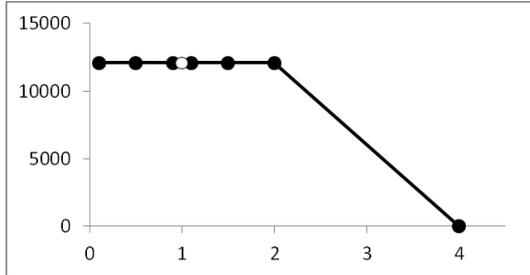


Appendix S4

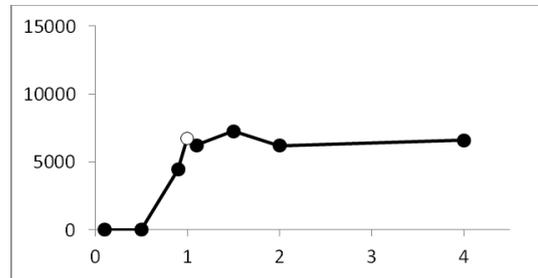
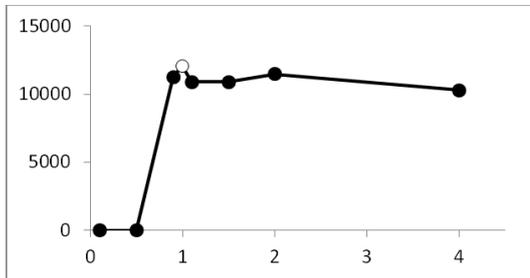
Without varroa

With varroa

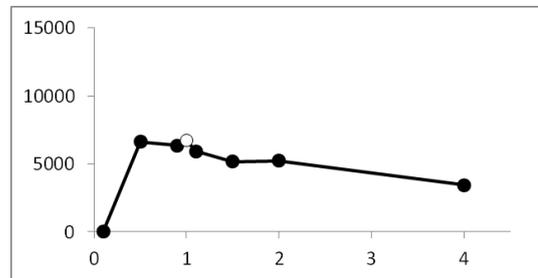
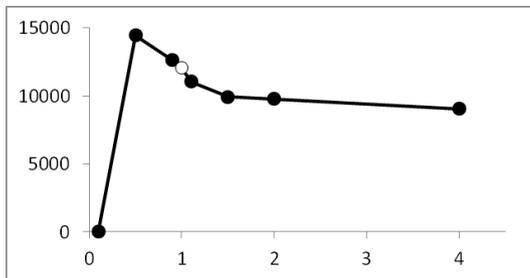
(v) "CRITICAL_COLONY_SIZE_WINTER" (default size = 4000 bees)



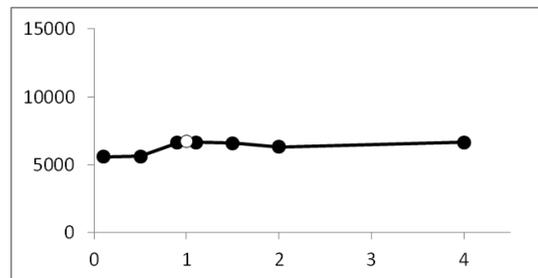
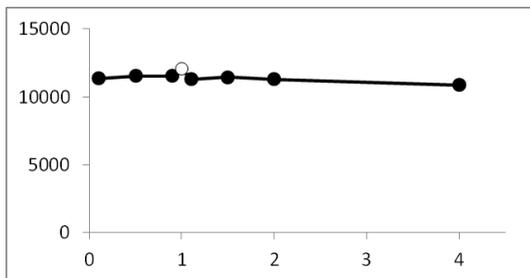
(vi) "CROPVOLUME" (default volume = 50 μ l)



(vii) "DANCE_SLOPE" (default = 1.16 dance circuits)



(viii) "DETECT_PROB_G" (default probability = 0.2)

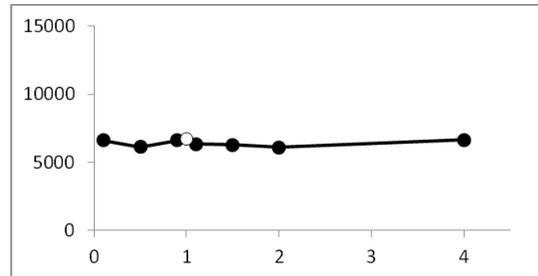
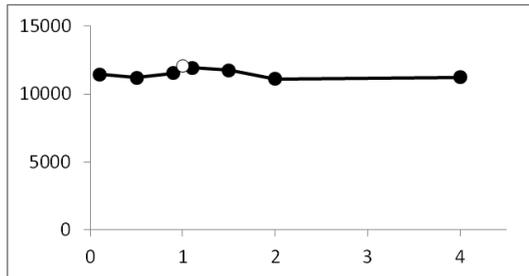


Appendix S4

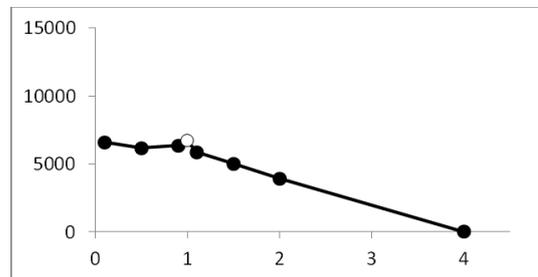
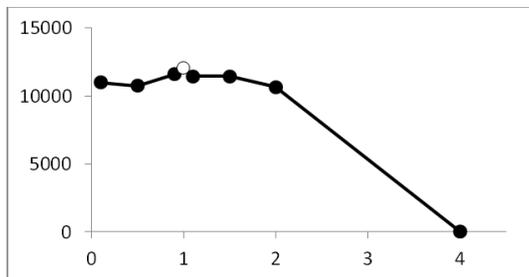
Without varroa

With varroa

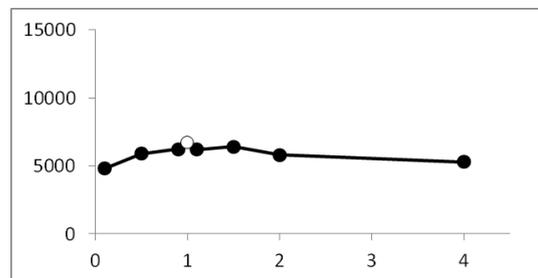
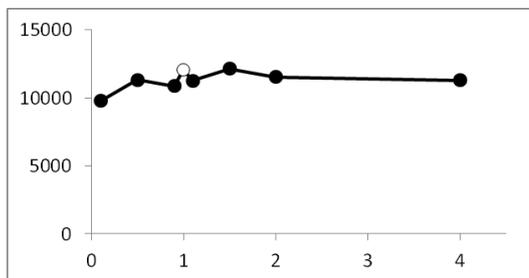
(ix) "DETECT_PROB_R" (default probability = 0.2)



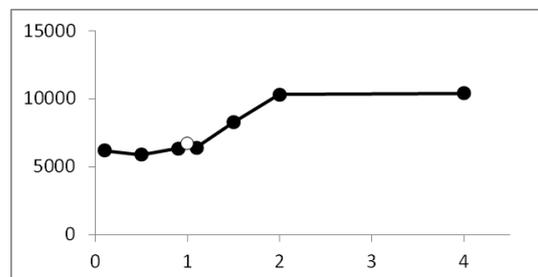
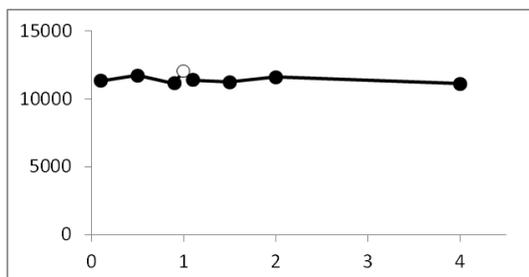
(x) "DISTANCE_G" (default distance = 500 m)



(xi) "DISTANCE_R" (default distance = 1500 m)



(xii) "DRONE_EGGLAYING_START" (default = day 115, i.e. 25th April)

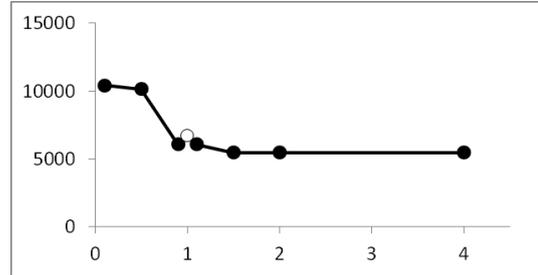
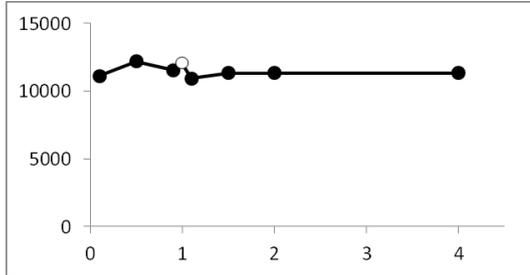


Appendix S4

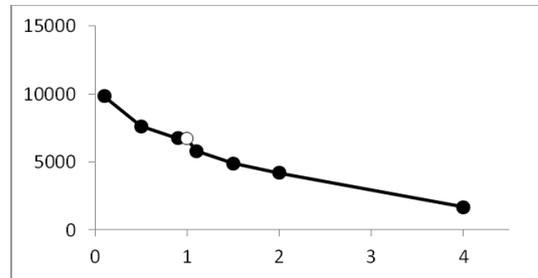
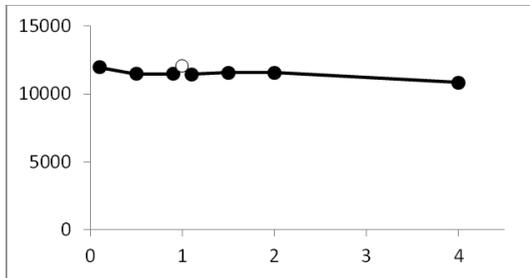
Without varroa

With varroa

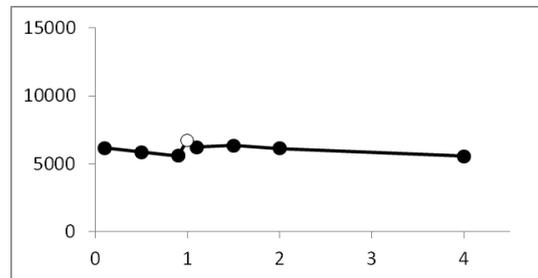
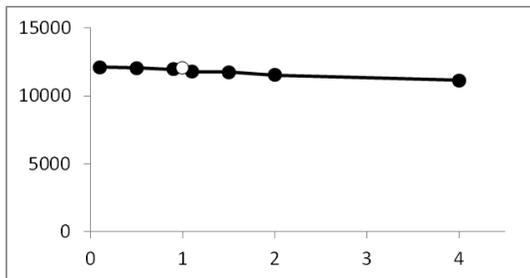
(xiii) "DRONE_EGGLAYING_STOP" (default = day 240, i.e. 28th August)



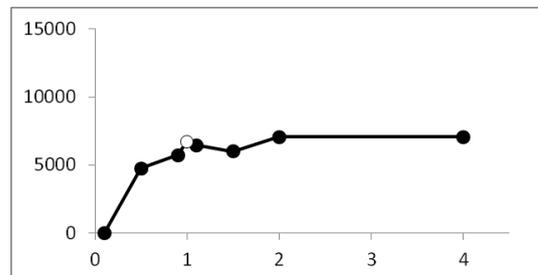
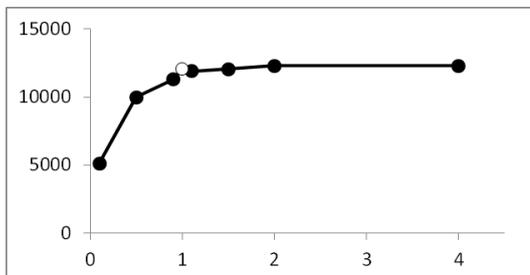
(xiv) "DRONE_EGGS_PROPORTION" (default proportion = 0.04)



(xv) "DRONE_LIFESPAN" (default = 37 days)



(xvi) "FIND_DANCED_PATCH_PROB" (default probability = 0.5)

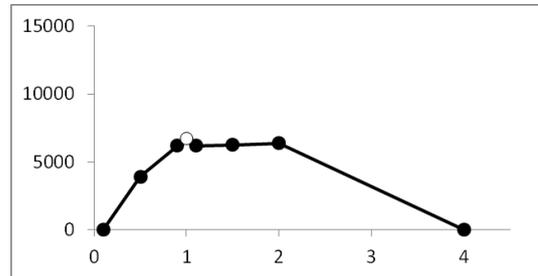
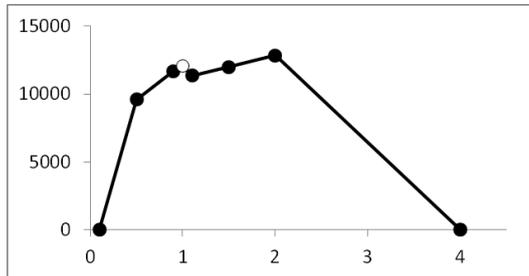


Appendix S4

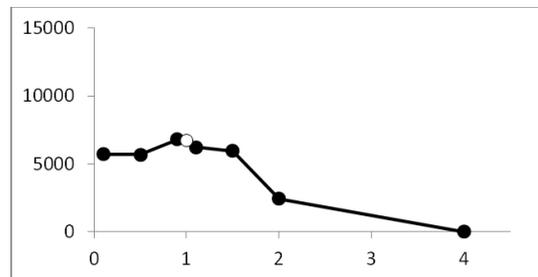
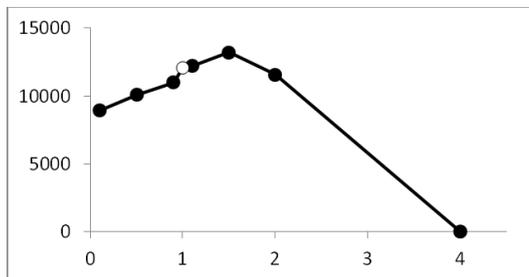
Without varroa

With varroa

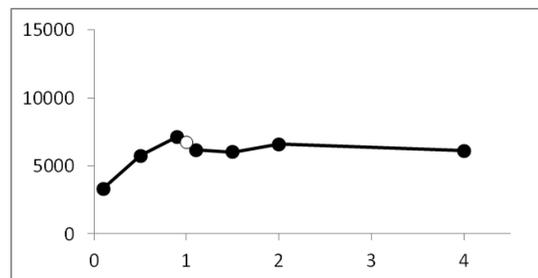
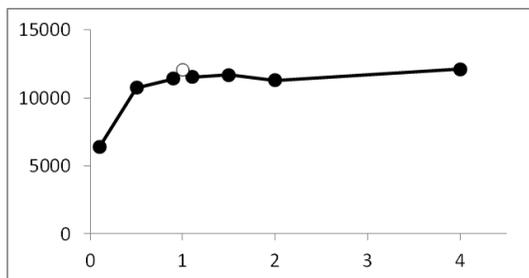
(xvii) "FLIGHT_VELOCITY" (default velocity = 6.5 m/s)



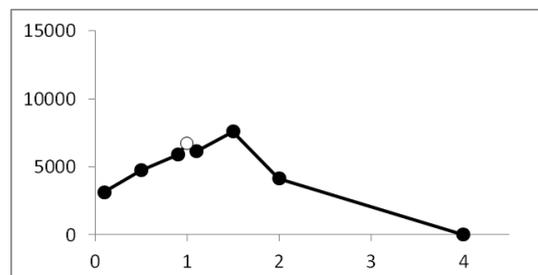
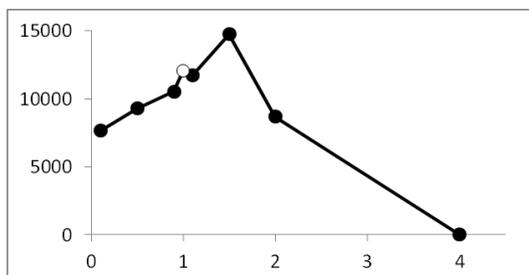
(xviii) "FLIGHTCOSTS_PER_m" (default = 0.000006 KJ/m)



(xix) "FORAGER_NURSING_CONTRIBUTION" (default contribution = 0.2, relative to in-hive bees)



(xx) "FORAGING_STOP_PROB" (default probability = 0.3)

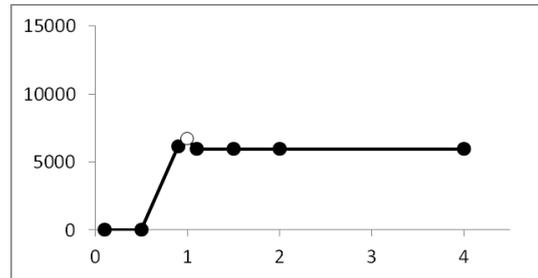
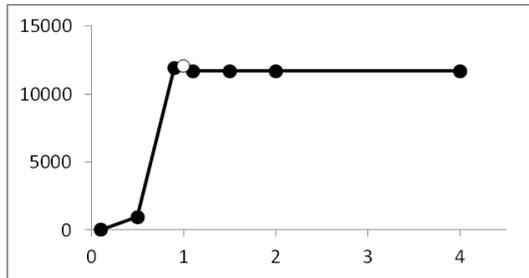


Appendix S4

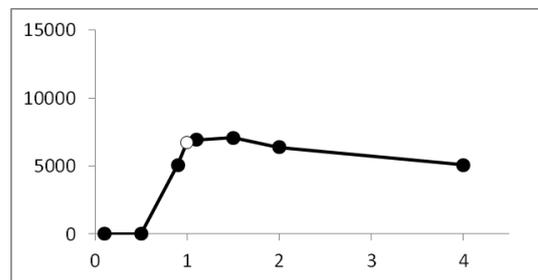
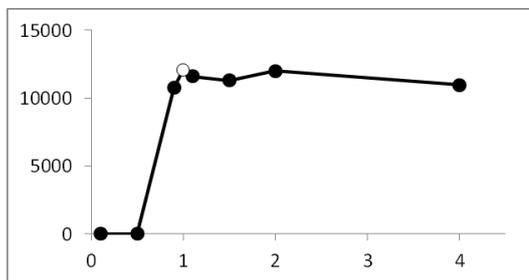
Without varroa

With varroa

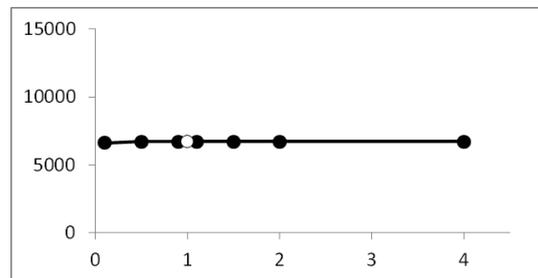
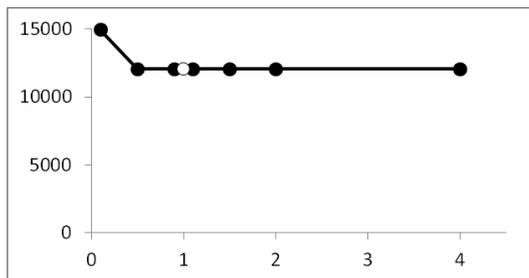
(xxi) "LIFESPAN" (default = 290 days)



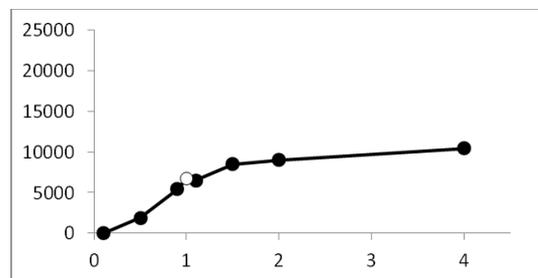
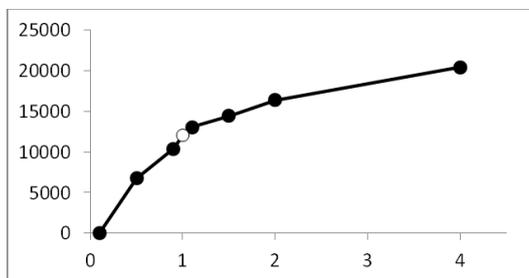
(xxii) "MAX_BROOD_NURSE_RATIO" (default probability = 0.3 per emergence)



(xxiii) "MAX_DANCE_CIRCUITS" (default = 117 circuits)



(xxiv) "MAX_EGG_LAYING" (default = 1600 eggs per day)

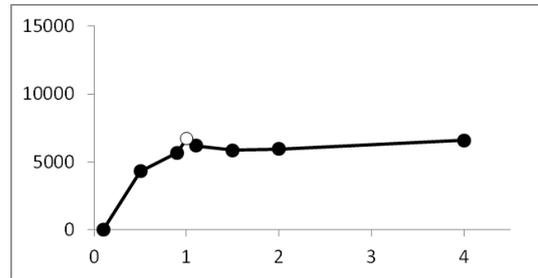
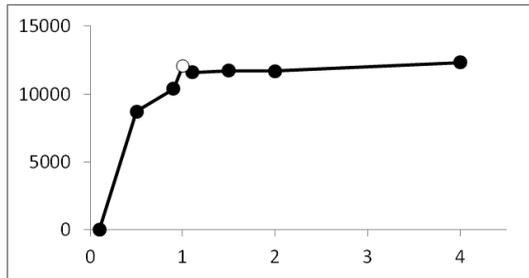


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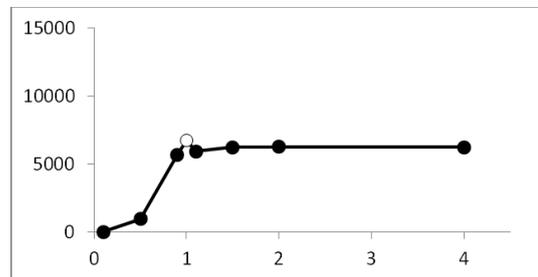
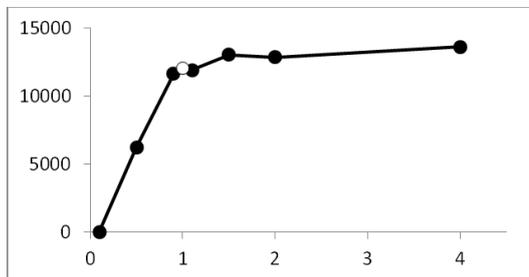
Without varroa

With varroa

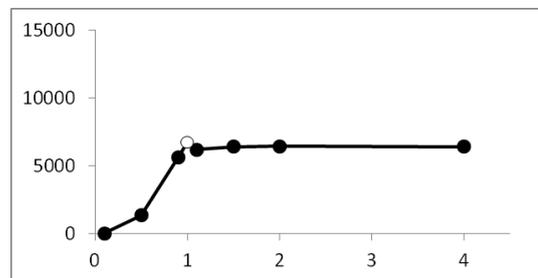
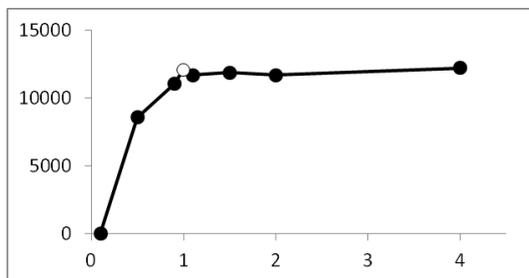
(xxv) "MAX_HONEY_STORE_kg" (default weight = 50 kg)



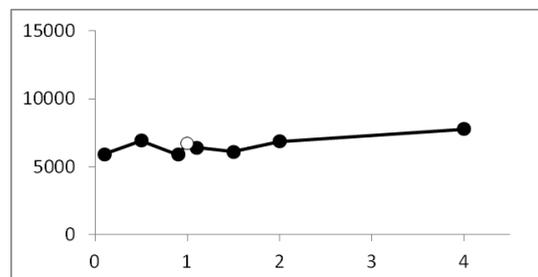
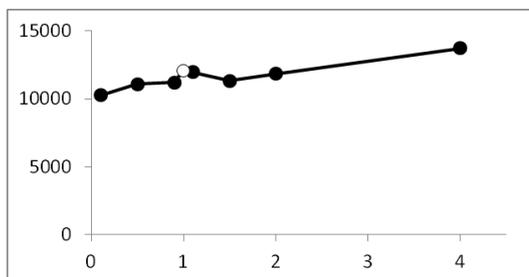
(xxvi) "MAX_PROPORTION_POLLEN_FORAGERS" (default proportion = 0.8)



(xxvii) "MAX_TOTAL_KM" (default distance = 800 km)



(xxviii) "MIN_IDEAL_POLLEN_STORE" (default weight = 250 g)

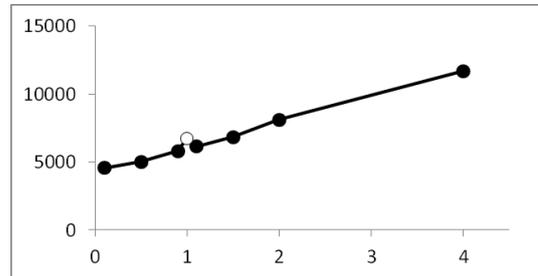
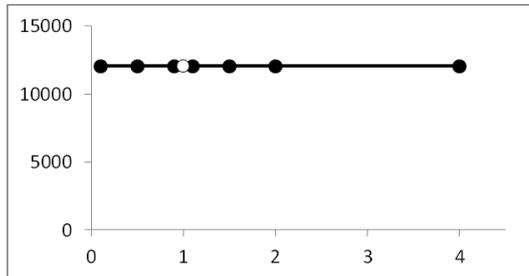


Appendix S4

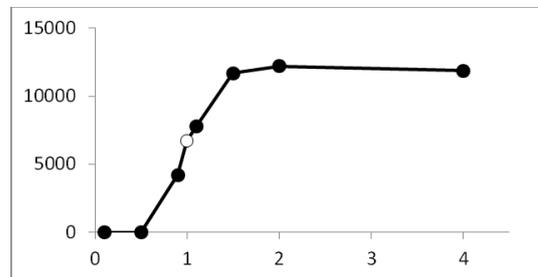
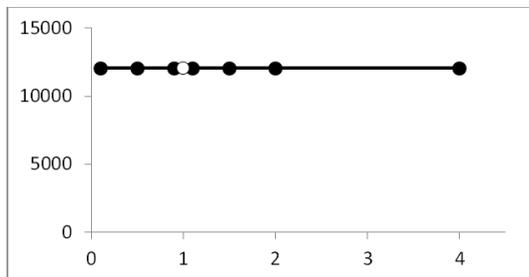
Without varroa

With varroa

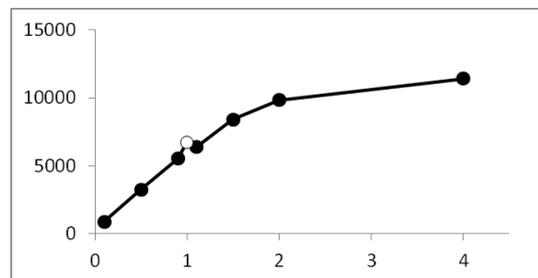
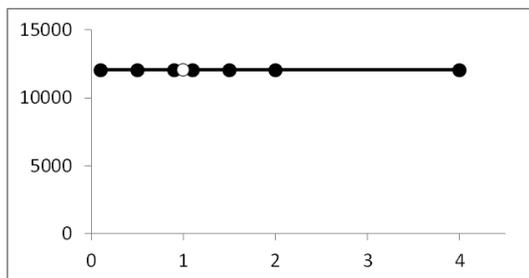
(xxix) "MITE_FALL_DRONECELL" (default proportion = 0.2 per emergence)



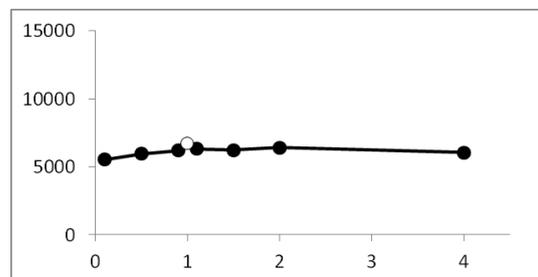
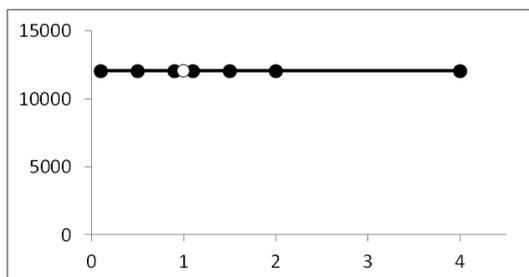
(xxx) "MITE_FALL_WORKERCELL" (default proportion = 0.3 per emergence)



(xxxii) "MITE_MORTALITY_BROODPERIOD" (default mortality = 0.006 per day)



(xxxiii) "MITE_MORTALITY_WINTER" (default mortality = 0.002 per day)

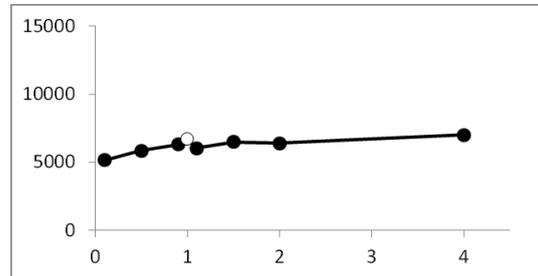
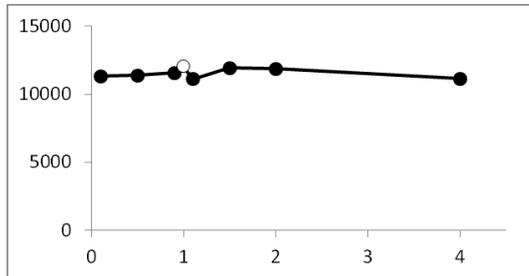


Appendix S4

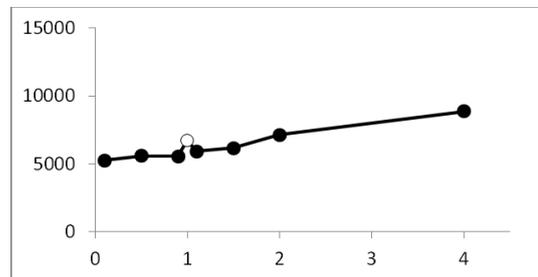
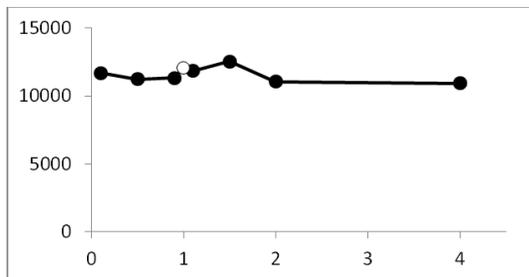
Without varroa

With varroa

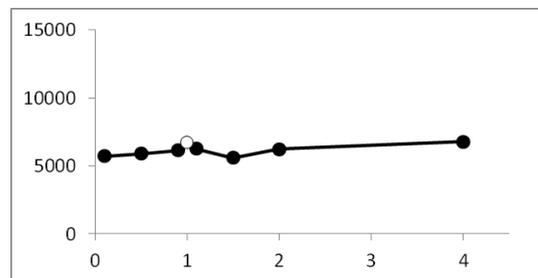
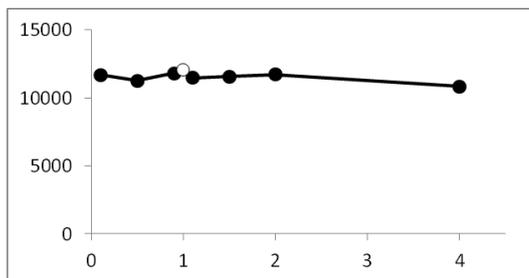
(xxxiii) "MORTALITY_DRONE_EGGS" (default mortality = 0.064 per day)



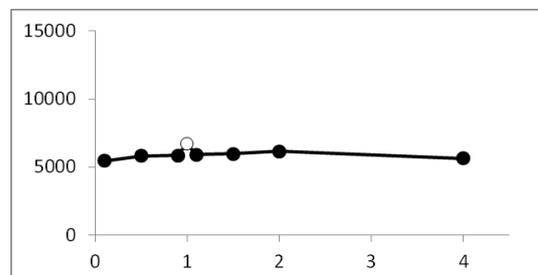
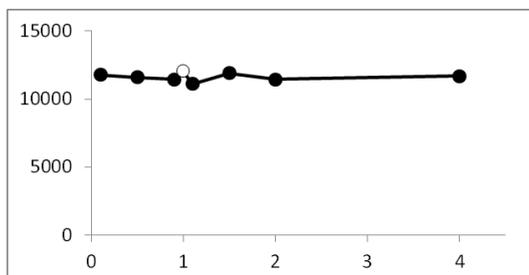
(xxxiv) "MORTALITY_DRONE_LARVAE" (default mortality = 0.044 per day)



(xxxv) "MORTALITY_DRONE_PUPAE" (default mortality = 0.005 per day)



(xxxvi) "MORTALITY_DRONES" (default mortality = 0.05 per day)

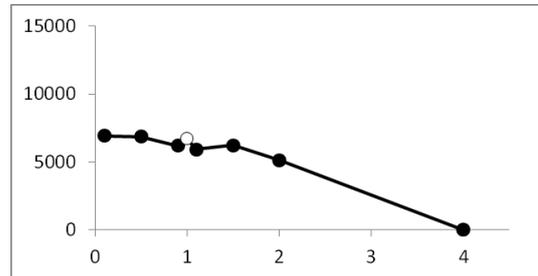
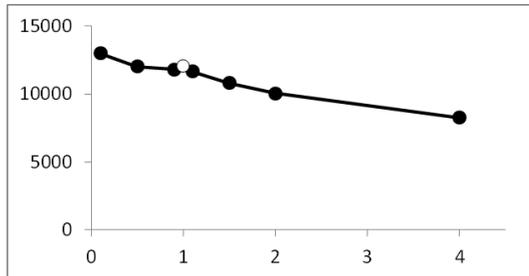


Appendix S4

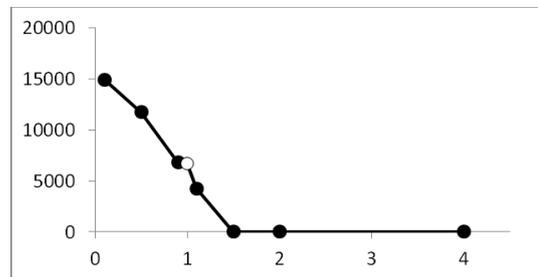
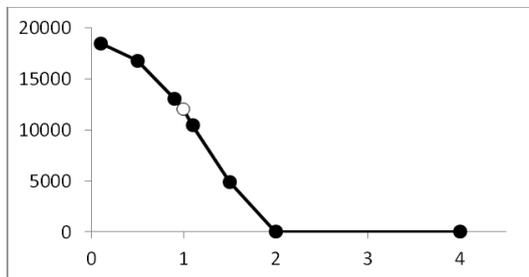
Without varroa

With varroa

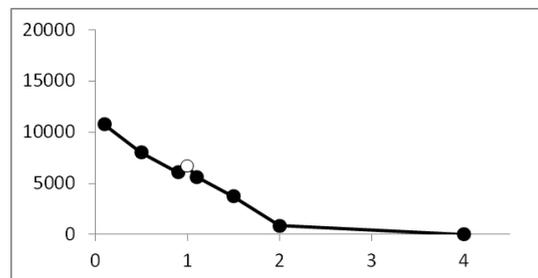
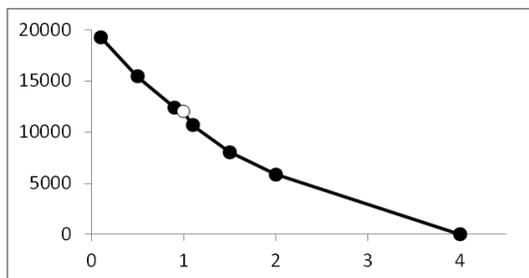
(xxxvii) "MORTALITY_EGGS" (default mortality = 0.03 per day)



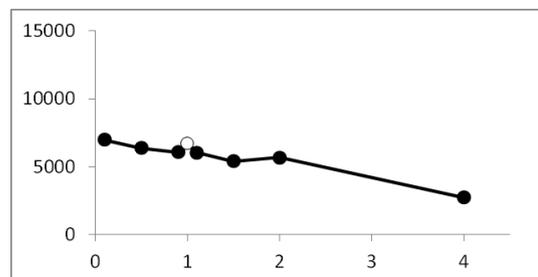
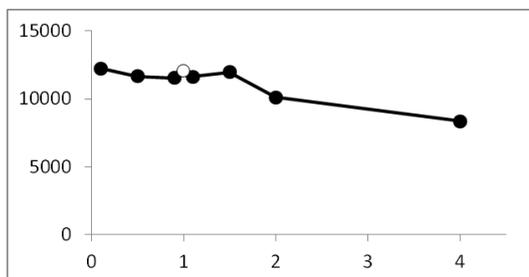
(xxxviii) "MORTALITY_FOR_PER_SEC" (default mortality = 0.00001 per second)



(xxxix) "MORTALITY_INHIVE" (default mortality = 0.004 per day)



(xl) "MORTALITY_LARVAE" (default mortality = 0.01 per day)

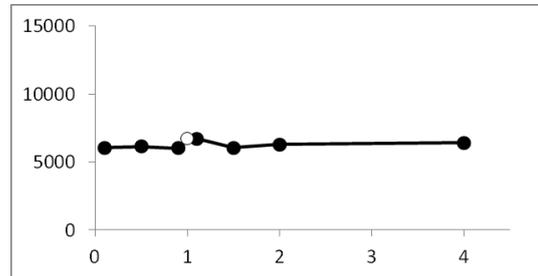
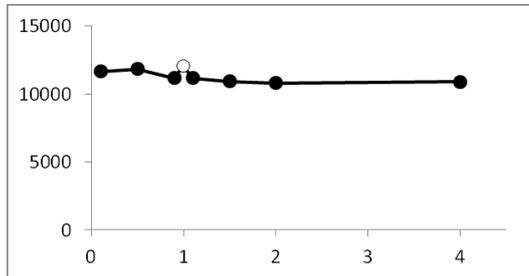


Appendix S4

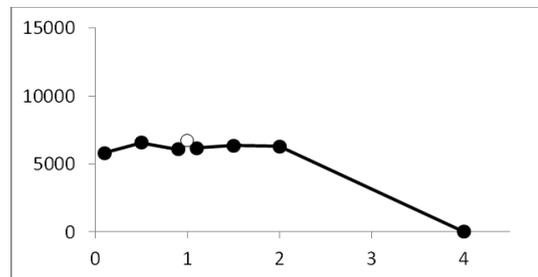
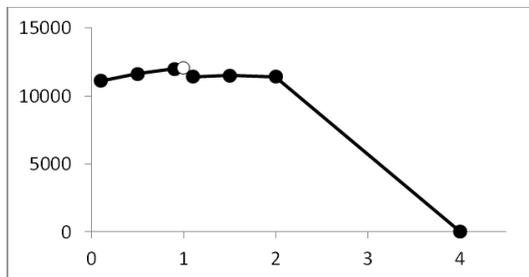
Without varroa

With varroa

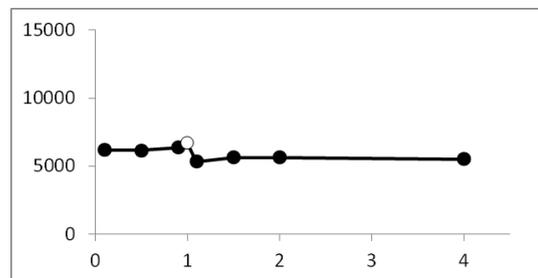
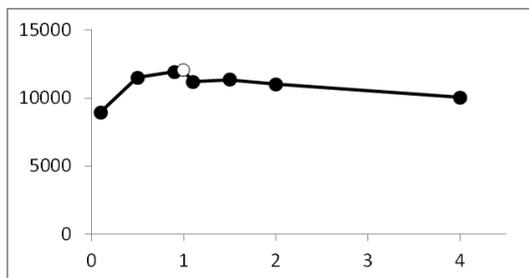
(xli) "MORTALITY_PUPAE" (default mortality = 0.001 per day)



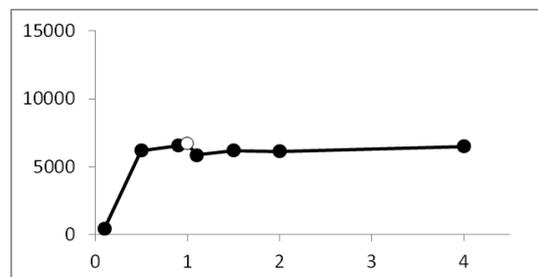
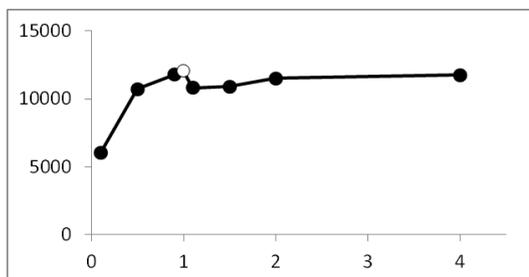
(xlii) "N_INITIAL_BEES" (default = 10000 bees)



(xliii) "POLLEN_DANCE_FOLLOWERS" (default = 2 bees)



(xliv) "POLLEN_G_kg" (default weight = 1 kg)

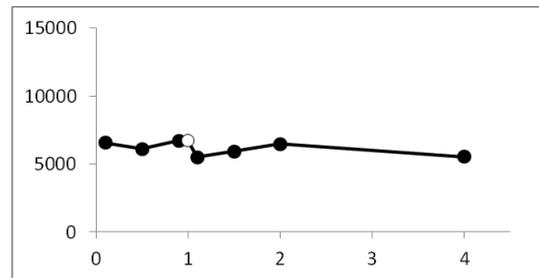
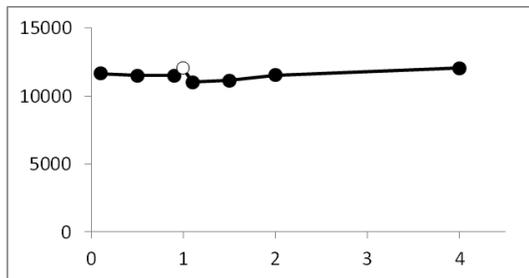


Appendix S4

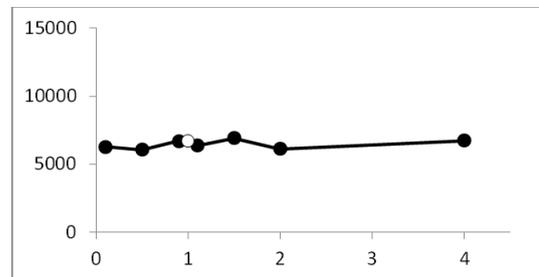
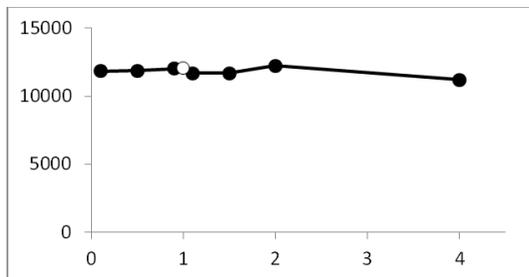
Without varroa

With varroa

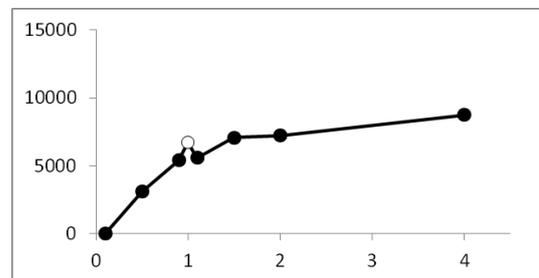
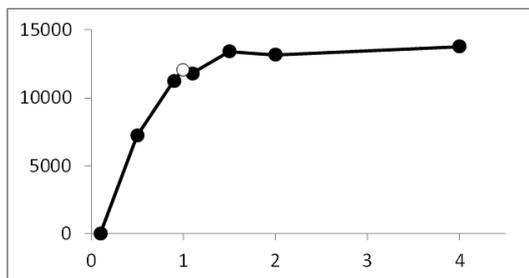
(xlv) "POLLEN_R_kg" (default weight = 1 kg)



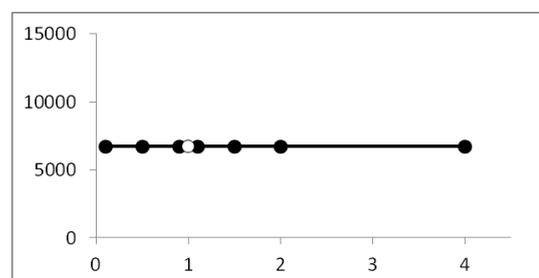
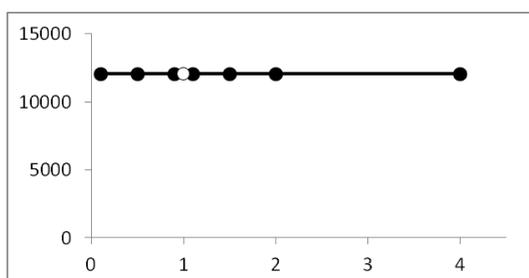
(xlvi) "POLLEN_STORE_INIT" (default weight = 100 g)



(xlvii) "POLLENLOAD" (default weight = 0.015 g)



(xlviii) "PRE_SWARMING_PERIOD" (default = 3 days)

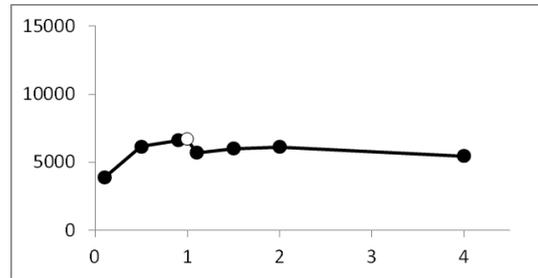
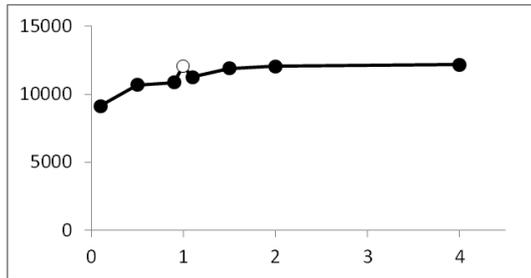


Appendix S4

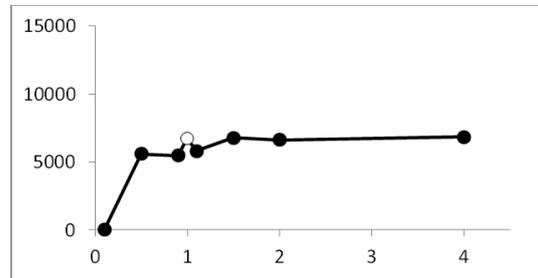
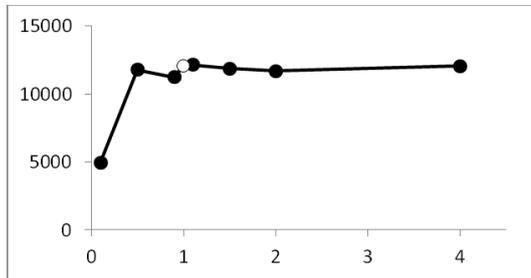
Without varroa

With varroa

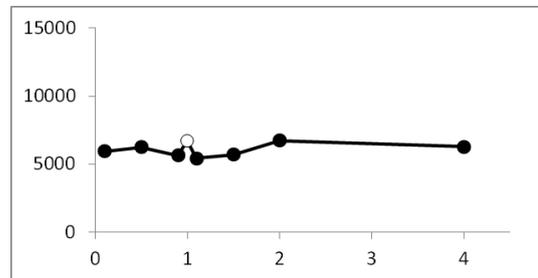
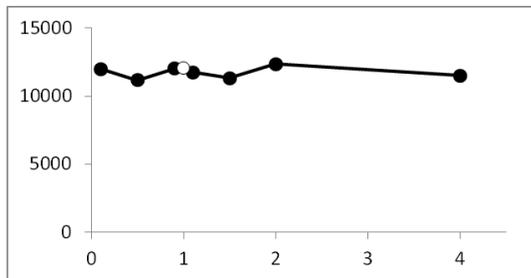
(xlix) "PROTEIN_STORE_NURSES_d" (default = 7 days)



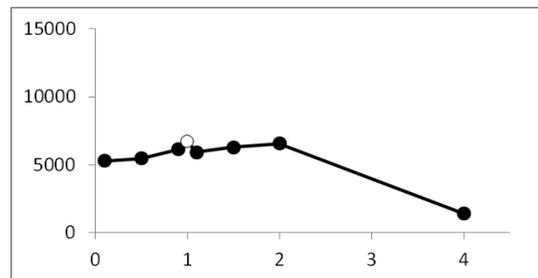
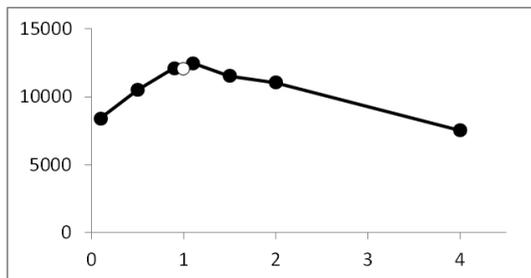
(l) "QUANTITY_G_l" (default amount = 20 litres)



(li) "QUANTITY_R_l" (default amount = 20 litres)



(lii) "SHIFT_G" (default = -40)

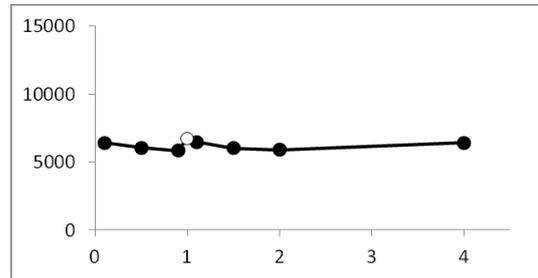
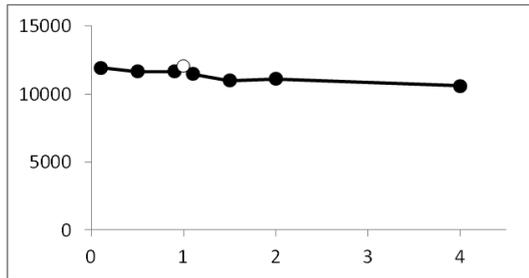


Appendix S4

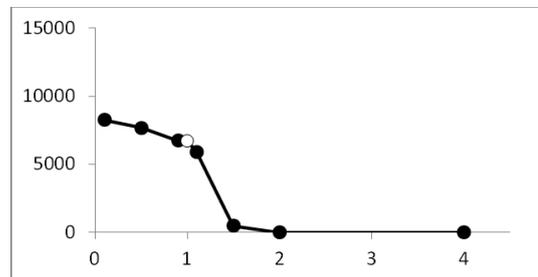
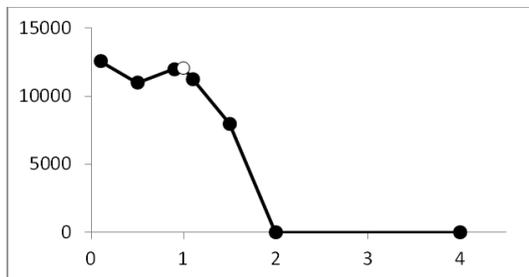
Without varroa

With varroa

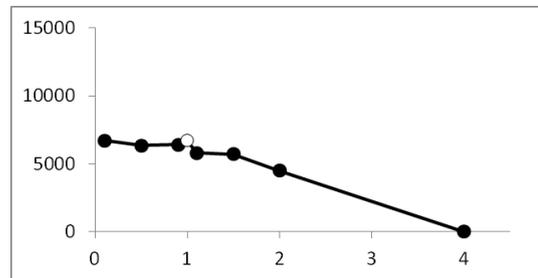
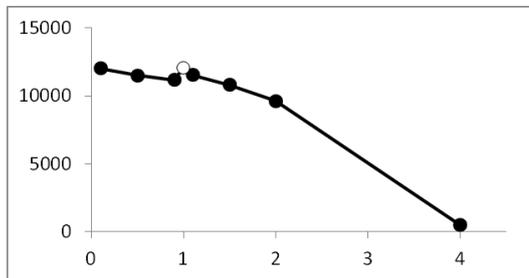
(lii) "SHIFT_R" (default = 30)



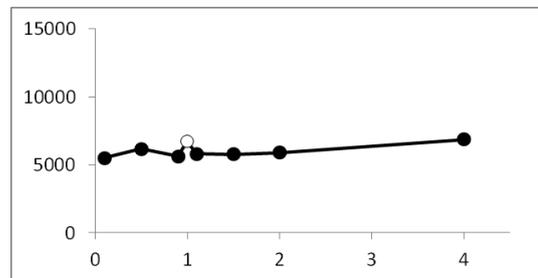
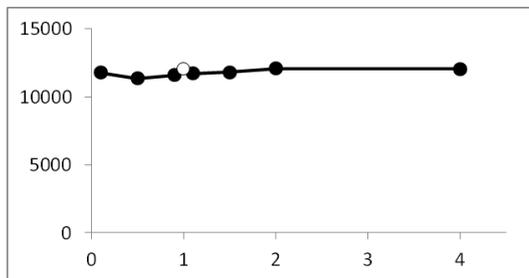
(liv) "TIME_NECTAR_GATHERING" (default time = 1200 seconds)



(lv) "TIME_POLLEN_GATHERING" (default time = 600 seconds)



(lvi) "TIME_UNLOADING" (default time = 116 seconds)

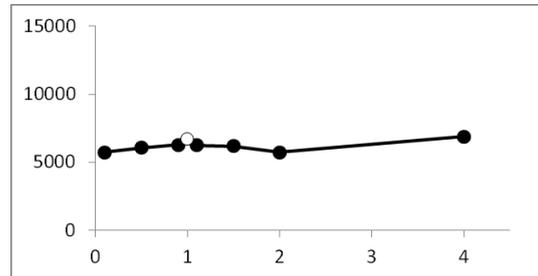
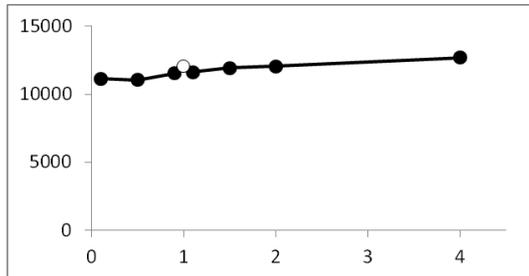


Appendix S4

Without varroa

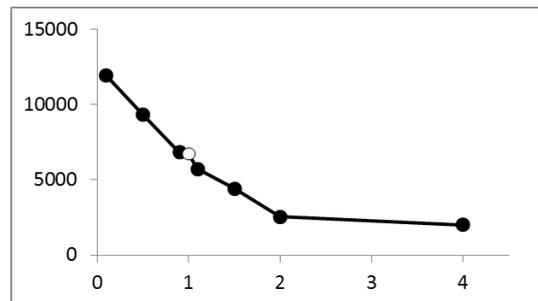
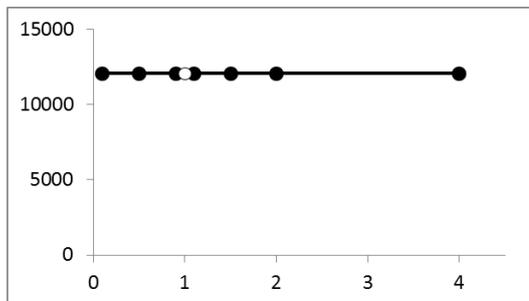
With varroa

(lvii) "TIME_UNLOADING_POLLEN" (default time = 210 seconds)

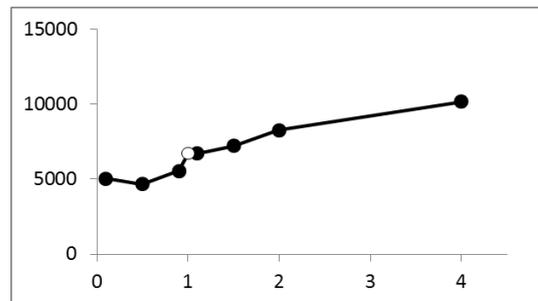
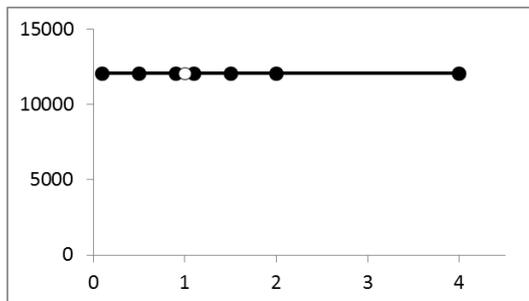


VIRUS SPECIFIC PARAMETERS (Deformed Wing Virus):

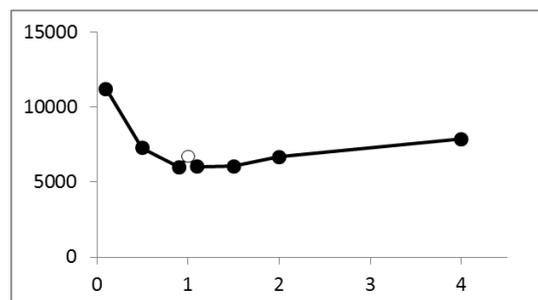
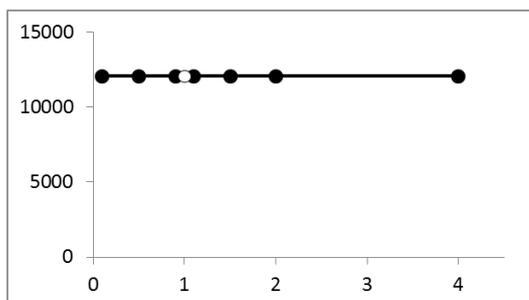
(lviii) "MORTALITY_INHIVE_INFECTED_AS_PUPA" (default mortality = 0.012 per day)



(lix) "VIRUS_KILLS_PUPA_PROB" (default probability = 0.2)



(lx) "VIRUS_TRANSMISSION_RATE_MITE_TO_PUPA" (default probability = 0.89)

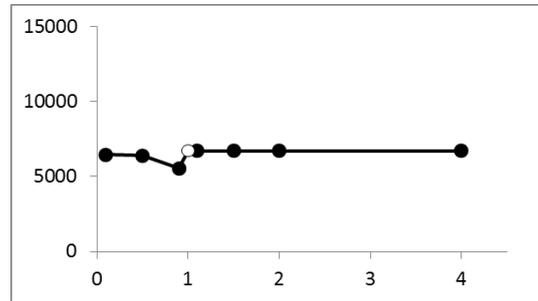
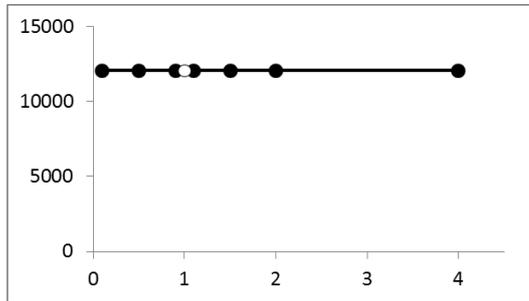


Appendix S4

Without varroa

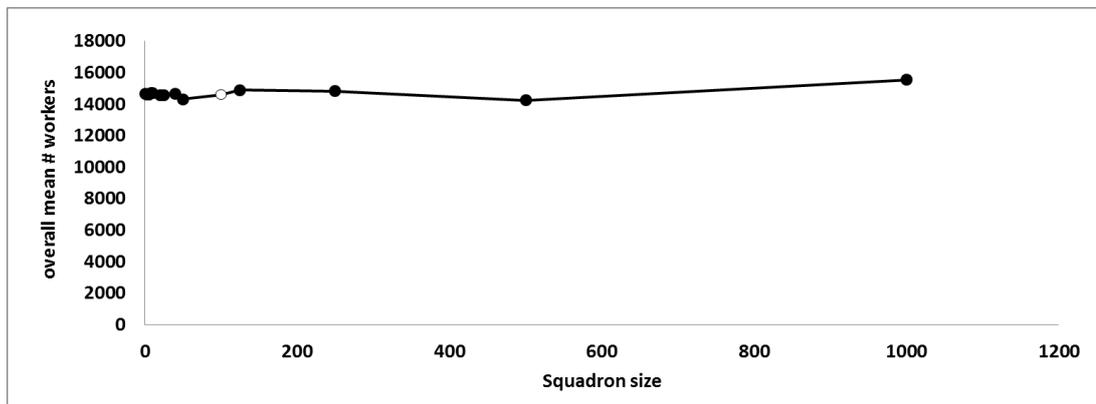
With varroa

(lxi) "VIRUS_TRANSMISSION_RATE_PUPA_TO_MITES" (default probability = 1)



Impact of the number of foragers per super-individual:

(lxii) "SQUADRON_SIZE" (only without varroa) (default number of bees = 100)



Parameters not included, as they require integer values:

"DRONE_EMERGING_AGE"
"DRONE_HATCHING_AGE"
"DRONE_PUPATION_AGE"
"EMERGING_AGE"
"HATCHING_AGE"
"MAX_AFF"
"MIN_AFF"
"PUPATION_AGE"

Parameters not included, as their default value is 0:

"DANCE_INTERCEPT"
("N_INITIAL_MITES_HEALTHY")
("N_INITIAL_MITES_INFECTED")
"POST_SWARMING_PERIOD"

Parameters not included for other reasons (e.g. because they are constants or do not affect the modelled processes):

"ENERGY_HONEY_per_g"
"ENERGY_SUCROSE"
"INPUT_FILE"
"MAX_BROODCELLS"
"MAX_km_PER_DAY"
"N_FLOWERPATCHES"
"N_GENERIC_PLOTS"
"PATCHCOLOR"
"SEASON_START"
"SEASON_STOP"
"STEPWIDTH"
"STEPWIDTHdrones"
"WEIGHT_WORKER_g"