<table>
<thead>
<tr>
<th>species</th>
<th>Pesticide/exposure (abbreviations at end)</th>
<th>Effect on weight</th>
<th>Effect on brood/development</th>
<th>Effect on emergence</th>
<th>Effect on survivor/mortality</th>
<th>other</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td><em>Osmia lignaria</em></td>
<td>IMD, soil</td>
<td></td>
<td></td>
<td></td>
<td>100 ppb lived 5 days less OS, 7.5 ppb 15 ppb no effect</td>
<td>Tested males and females</td>
<td>Anderson &amp; Harmon-Threatt 2019</td>
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<tr>
<td><em>Megachile rotundata</em></td>
<td>IMD, soil</td>
<td>15ppb 11-12% less than control</td>
<td>E 1-3 days slower, E 100 ppb 2 days faster</td>
<td>15 ppb lived 3 day longer, 100 ppb 4 day longer compared to control</td>
<td>Tested males and females</td>
<td>Anderson &amp; Harmon-Threatt 2019</td>
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<tr>
<td><em>Bombus impatiens</em></td>
<td>IMD, 10-100 ppb in 50% sugar soln</td>
<td>Colony weight 23-50% lower in 10-100 ppb. Bee weight unaffected</td>
<td>Less total brood in 20-100 ppb</td>
<td>20-100 ppb had higher queen mortality</td>
<td></td>
<td>Scholer and Krischik 2015</td>
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<tr>
<td><em>Bombus impatiens</em></td>
<td>CLO, 10-100 ppb in 50% sugar soln</td>
<td>Colony weight 69-81% lower in 20-100 ppb</td>
<td>Less total brood in 50-100 ppb</td>
<td>20-100 ppb had higher queen mortality</td>
<td></td>
<td>Scholer and Krischik 2015</td>
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<tr>
<td><em>Bombus terrestris</em></td>
<td>IMD, 6 ppb in pollen and .7 ppb in sugar soln</td>
<td>No effect on colony size or</td>
<td>No effect on lifespan</td>
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<td>Feltham &amp; Park <em>et al.</em> 2014</td>
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<tr>
<td>Species</td>
<td>Treatment</td>
<td>Observation</td>
<td>Location</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, chronic, 2.4 ppb in 40% sucrose soln</td>
<td>No effect on survivorship</td>
<td>No effect on survivorship</td>
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<td></td>
<td></td>
<td></td>
<td>Stanley &amp; Russell et al. 2016</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, 2.4 ppb in 50% inverted sugar syrup for 2 wks</td>
<td>26% fewer queens initiated colonies after hibernation</td>
<td>No effect on survivorship</td>
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<td></td>
<td></td>
<td></td>
<td>Baron &amp; Jansen et al. 2017</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, chronic, 10 ppb in 40% sucrose soln</td>
<td>No effect on worker body size</td>
<td>Flight arena, real flowers</td>
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<td>Stanley &amp; Raine et al. 2016</td>
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<tr>
<td>Bombus impatiens</td>
<td>IMD, chronic, 6 ppb in nectar</td>
<td>Treated colonies had reduced rates of nursing. Treated colonies less likely to insulate brood with wax (p=.0005)</td>
<td>Crall &amp; Switzer et al. 2018</td>
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<tr>
<td>Bombus terrestris</td>
<td>CLO, chronic, 1 ppb in 60% sugar soln</td>
<td>No effect on fecundity</td>
<td>Exposure decreased survival of bees when harnessed for PER assay (p=.04)</td>
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<td></td>
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<td>Piironen &amp; Botías et al. 2016</td>
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<tr>
<td>Bombus terrestris</td>
<td>AZD, chronic, 0.064-32 mg/L in sugar water, exposed for 11 weeks</td>
<td>Negative effect on body mass of male progeny</td>
<td>Drone production significantly lower at .64 mg/L; no drone production in 3.2 and 32 mg/L</td>
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<td>Survival curve at 3.2 mg/L significantly lower than control (p&lt;.001)</td>
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<td>Exposure caused deformities of adult appendages</td>
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<td>Barbosa &amp; De Meyer et al. 2014</td>
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<td>Bombus terrestris</td>
<td>SFX, 5 ppb in 1.8M sucrose soln, ad libitum for 2 weeks</td>
<td>No effect on dry mass of males</td>
<td>Queen longevity and colony survival not affected</td>
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<td>Siviter &amp; Brown et al. 2018</td>
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<td>Species</td>
<td>Concentration Details</td>
<td>Effect on Offspring</td>
<td>Effect on Survival or Longevity</td>
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<td><em>Osmia bicornis</em></td>
<td>ACM, IMD, &amp; MYC, in various concentrations based on field relevancy, in pollen and sugar syrup</td>
<td>No effect on body size</td>
<td>No effect on survival or longevity</td>
<td>Azpiazu &amp; Bosch <em>et al.</em> 2019</td>
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<td><em>Bombus terrestris</em></td>
<td>ACY, 1 and 2 ppm in water (bees were dipped in)</td>
<td>2 ppm treated bees died much more quickly than control.</td>
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<td>Muljar &amp; Karise <em>et al.</em> 2012</td>
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<td><em>Osmia bicornis</em></td>
<td>CLO, 1, 3, 10 ppb in pollen provisions</td>
<td>No effect on larval mass of brood or adult body mass. No effect on weight lost over winter</td>
<td>No effect on emergence time</td>
<td>Nicholls &amp; Fowler <em>et al.</em> 2017</td>
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<td><em>Bombus impatiens</em></td>
<td>CLO, 6 (realistic) and 36 (high) ppb in Bioglue sugar soln</td>
<td>No effect on newly emerged bee weights</td>
<td>No effect on mortality</td>
<td>Funded by Bayer. Questionable stats/methods</td>
<td>Franklin &amp; Winston <em>et al.</em> 2004</td>
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<td><em>Bombus terrestris</em></td>
<td>CLO &amp; BCY, 10g &amp; 2g / kg seed respectively, in oilseed rape seed coats</td>
<td>No effect on number of worker bees. Hives at test site produced more queen brood cells (p=.035). No effect on the sum of queen brood cells and young queens</td>
<td></td>
<td>Funded by Bayer. Questionable stats/methods</td>
<td>Sterk &amp; Peters <em>et al.</em> 2016</td>
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<td><strong>Bombus terrestris</strong></td>
<td>IMD, various concentrations 0.08 – 125 ug/L in sugar syrup for 13 days</td>
<td>No effect of dosage on number of days before first oviposition. Fecundity declined with increasing dosage</td>
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<td>Laycock &amp; Lenthall <em>et al.</em> 2012</td>
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<tr>
<td><strong>Bombus impatiens</strong></td>
<td>IMD, granular on turf, 0.4483 kg/ha IMD, spray on turf, 0.336 kg/ha CBR, spray on turf, 6.1 kg/ha CPS, spray on turf, 1.12 kg/ha CYF, spray on turf, .077 kg/ha</td>
<td>Nonirrigated IMD spray plot colonies had lower total worker biomass and lower colony weight. Irrigated IMD spray had no effect. Nonirrigated CBR, CPS, and CYF plots had reduced total worker biomass and colony weight</td>
<td>Nonirrigated IMD spray plot colonies had fewer brood chambers &amp; honey pots. Irrigated IMD spray had no effect. Nonirrigated CBR, CPS, and CYF plots showed reduced brood chambers &amp; honey pots. Nonirrigated CBR and CPS plots had reduced live brood</td>
<td>Nonirrigated IMD spray plot colonies had fewer workers. Irrigated IMD spray had no effect. Nonirrigated CBR, CPS, and CYF plots had fewer workers</td>
<td>Funded by US Golf Assoc. Gels &amp; Held <em>et al.</em> 2002</td>
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<tr>
<td><strong>Bombus occidentalis</strong></td>
<td>IMD, chronic, 7 ng/g in pollen</td>
<td>No effect on number of workers, queens, or males, or on amount of brood</td>
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<td>Funded by Bayer &amp; Monsanto Morandin &amp; Winston 2003</td>
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<tr>
<td><strong>Bombus occidentalis</strong></td>
<td>IMD, chronic, 7 ng/g &amp; 30 ng/g in pollen</td>
<td>No effect on number of workers, queens,</td>
<td></td>
<td></td>
<td>Funded by Bayer &amp; Monsanto Morandin &amp; Winston 2003</td>
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<tr>
<td>species</td>
<td>Pesticide/exposure (abbreviations at end)</td>
<td>Effect on movement</td>
<td>Effect on foraging</td>
<td>Effect on thermoreg and metabolism</td>
<td>Effect on hygienic behavior</td>
<td>Effect on learning and memory</td>
<td>other</td>
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<tr>
<td><em>Bombus impatiens</em></td>
<td>IMD, 10-100 ppb in 50% sugar soln</td>
<td>100 ppb no effect on queen movement, 20-100 ppb workers moved much more slowly</td>
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Table 2: Behavioral effects

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<tr>
<th>species</th>
<th>Pesticide/exposure (abbreviations at end)</th>
<th>Effect on movement</th>
<th>Effect on foraging</th>
<th>Effect on thermoreg and metabolism</th>
<th>Effect on hygienic behavior</th>
<th>Effect on learning and memory</th>
<th>other</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td><em>Bombus terrestris</em>, <em>B. lucorum</em>, <em>B. pratorum</em>, <em>B. pascuorum</em></td>
<td>TMX, 1 ppb and 4 ppb in syrup</td>
<td>Queens’ terminal oocyte length was reduced in high dose by between 4.6% and 13.8% in different species. No treatment effects on waxing behavior</td>
<td>Treatment did not affect survival rate or time until death</td>
<td></td>
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<td></td>
<td>Baron &amp; Raine et al. 2017</td>
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<tr>
<td><em>Bombus impatiens</em></td>
<td>SPI, 0.2, 0.8, and 8.0 mg/kg in pollen patties, fed <em>ad libitum</em></td>
<td>8 mg/kg treatment had fewer brood and workers</td>
<td>8 mg/kg treatment had more dead bees each week</td>
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<td>Morandin &amp; Winston et al. 2005</td>
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<tr>
<td>Species</td>
<td>Concentration</td>
<td>Description</td>
<td>Outcome</td>
<td>Reference</td>
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<tr>
<td>Bombus impatiens</td>
<td>100 ppb in 50% sugar soln</td>
<td>100 ppb no effect on queen movement, 20-100 ppb workers moved much more slowly</td>
<td>56.2 ppb less likely to visit flowers during training</td>
<td>Scholer and Krischik 2015</td>
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<tr>
<td>Bombus impatiens</td>
<td>IMD, acute dose in 30% sucrose</td>
<td>56.2 ppb no effect on color-reward assoc.</td>
<td>Treated bees made twice as many errors in scent learning</td>
<td>Artificial flowers in an arena, Muth &amp; Leonard 2019</td>
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<tr>
<td>Bombus impatiens</td>
<td>IMD, acute, 22.5 ppb in 30% sucrose</td>
<td>56.2 ppb no effect on color-reward assoc.</td>
<td>Artificial flowers in an arena, Muth &amp; Francis et al. 2019</td>
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<tr>
<td>Bombus terrestris</td>
<td>IMD, chronic, 6 ppb in pollen and .7 ppb in sugar soln</td>
<td>22.5 ppb in 30% sucrose</td>
<td>Treated bees made twice as many errors in scent learning</td>
<td>Artificial flowers in an arena, Feltham &amp; Park et al. 2014</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, chronic, 2.4 ppb in 40% sucrose soln</td>
<td>Treated bees foraged for 23% on avg (p=.045). Less treated bees returned to colony carrying pollen (p=.03).</td>
<td>Artificial flowers in an arena, Stanley &amp; Russell et al. 2016</td>
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<tr>
<td>Bombus terrestris</td>
<td>IMD, acute, 1 ppb in 35% sucrose soln</td>
<td>Treated bees were 3.8 x slower to begin foraging (p&lt;.001). Also visited fewer flowers (p=.037)</td>
<td>No effect on learning discriminate between different flowers, Artificial flowers in an arena, Lämsä &amp; Kuusela et al. 2018</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, chronic, 10 ppb in 40% sucrose soln</td>
<td>No effect on time spent foraging or time at each flower. More exposed bees foraged for pollen (p=.03)</td>
<td>Flight arena, real flowers, Treated bees learned foraging behavior quicker (p=.04) (not sure I agree with how, Stanley &amp; Raine et al. 2016</td>
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<tr>
<td><strong>Bombus impatiens</strong></td>
<td>IMD, chronic, 6 ppb in nectar</td>
<td>Treatment increased worker movement speed during day</td>
<td>Treatment impaired thermoregulation of brood (p=.005) and regulation of air temp (p=.009)</td>
<td>Treated colonies were sig. less active</td>
<td>Crall &amp; Switzer et al. 2018</td>
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<tr>
<td><strong>Bombus impatiens</strong></td>
<td>IMD, acute, .1 or 1 ng/bee</td>
<td>1.0 ng/bee reduced foraging</td>
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<td>Treated bees strayed further from center of nest</td>
<td>Crall &amp; Switzer et al. 2018</td>
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<tr>
<td><strong>Bombus terrestris</strong></td>
<td>CLO, chronic, 1 ppb in 60% sugar soln</td>
<td></td>
<td>Exposure did not affect learning performance in PER assay</td>
<td></td>
<td>Piiroinen &amp; Botías et al. 2016</td>
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<tr>
<td><strong>Bombus terrestris</strong></td>
<td>IMD, .06-98.4 ppb in sugar syrup</td>
<td>5ppb increased warming rate by ¼. Post-torpor temp reduced by 2°C. Rewarming ability increases with low dose and decreases with higher dose</td>
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<td>Potts &amp; Clarke et al. 2017</td>
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<td><strong>Bombus terrestris</strong></td>
<td>TMX, .06-98.4 ppb in sugar syrup</td>
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<tr>
<td><strong>Bombus terrestris</strong></td>
<td>IMD, 10 ppb in sucrose soln</td>
<td>Treated foragers collected less pollen in later weeks (p=.001)</td>
<td>Gill &amp; Raine <em>et al.</em> 2014</td>
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<td><strong>Bombus terrestris</strong></td>
<td>LCY, 37.5 ppm sprayed on filter paper in feeding chamber (trod upon)</td>
<td>Fewer foraging bouts in later weeks (p=.01)</td>
<td>Gill &amp; Raine <em>et al.</em> 2014</td>
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<tr>
<td><strong>Bombus terrestris</strong></td>
<td>IMD &amp; LCY, as described in 2 above rows</td>
<td>Fewer foraging bouts in later weeks (p=.001). Foragers collected less pollen in later weeks (p=.03)</td>
<td>Gill &amp; Raine <em>et al.</em> 2014</td>
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<tr>
<td><em>Melipona quadrioculata</em></td>
<td>ACM, .015-150 ng/bee, and ACY, .030-300 ng/bee, in 50% sucrose soln (commercial mix Fastac Duo), acute</td>
<td>Antennation and trophallaxis frequencies were affected by pesticide (p= .022 &amp; .005)</td>
<td>Boff &amp; Friedel <em>et al.</em> 2018</td>
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<td><strong>Bombus terrestris</strong></td>
<td>TMX, .091, .377, or 2.5 ng/bee, acute, in sucrose soln</td>
<td>.377 and 2.5 treated bees returned more often and earlier to flowers they’d depleted 2.5ng/bee used as a non-field-realistic positive control</td>
<td>Samuelson &amp; Chen-Wishart <em>et al.</em> 2016</td>
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<td><strong>Bombus impatiens</strong></td>
<td>IMD, .0515-5.15 ng/bee in sugar soln, acute</td>
<td>.0515 ng/bee did not affect sonication frequency or length but was more likely to sonicate flowers after treatment .515 &amp; 5.15 were less likely to</td>
<td>Switzer &amp; Combes 2016</td>
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<td>Species</td>
<td>Treatment Details</td>
<td>Effect</td>
<td>Author(s) and Year</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, acute, 10 and 2.4 ppb in 40% sucrose soln, 10ul per bee</td>
<td>Learning level lower at 10 ppb. Learning ability of trainable bees not affected. No effect on memory</td>
<td>Stanley &amp; Smith et al. 2015</td>
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<tr>
<td>Bombus terrestris</td>
<td>TMX, chronic, 10 and 2.4 ppb in 40% sucrose soln, ad libitum</td>
<td>No effect on trainability or learning level. Trained control bees learned tasks 27% faster than 2.4ppb and 38% faster than 10ppb. Both treatments affected memory</td>
<td>Stanley &amp; Smith et al. 2015</td>
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<td>Bombus terrestris</td>
<td>AZD, chronic, 0.064-32 mg/L in sugar water, exposed for 11 weeks</td>
<td>3.2mg/L treatment decreased sugar water consumption by 71%.</td>
<td>Barbosa &amp; De Meyer et al. 2014</td>
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<td>Bombus terrestris</td>
<td>TMX, 2.4 and 10 ppb in 40% sucrose for 12-15 days</td>
<td>10 ppb colonies showed lower visitation rates to apple flowers (p=.05). Fewer 10 ppb bees returned with pollen (p=.008). 10 ppb bees spent more time foraging (p=.03) and</td>
<td>Stanley &amp; Garratt et al. 2015</td>
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<td><strong>Bombus terrestris</strong></td>
<td>SFX, 5 ppb in 1.8M sucrose soln, <em>ad libitum</em> for 2 weeks</td>
<td>visited more flowers of one breed of apple (p=.002) than control</td>
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<td>Siviter &amp; Brown et al. 2018</td>
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<td><strong>Osmia bicornis</strong></td>
<td>ACM, IMD, &amp; MYC, in various concentrations based on field relevancy, in pollen and sugar syrup</td>
<td>No significant differences in number of bees returning to colonies from foraging, number of bees returning with pollen, or size of pollen loads</td>
<td></td>
<td>IMD-treated bees consume 80% less syrup per day (p&lt;.001)</td>
<td>Azpiazu &amp; Bosch et al. 2019</td>
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<td><strong>Bombus terrestris</strong></td>
<td>SFX, 2.4, 100, or 250 ppb in 10uL sucrose soln</td>
<td>Exposure did not affect number of correct choices before flower revisitation</td>
<td></td>
<td>Exposure did not affect learning or working memory</td>
<td>Siviter &amp; Scott et al. 2019</td>
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<tr>
<td><strong>Apis mellifera</strong></td>
<td>SFX, 2.4, 100, or 250 ppb in 10uL sucrose soln</td>
<td>Exposure did not affect number of correct choices before flower revisitation</td>
<td></td>
<td>Exposure did not affect learning or working memory</td>
<td>Siviter &amp; Scott et al. 2019</td>
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<td><strong>Bombus terrestris</strong></td>
<td>CLO, 5 ppb in 40% sucrose soln in the field for 5 wks</td>
<td>Exposure lowered avg foraging activity; avg pollen load did not differ. Treated colonies exhibited less fluctuation in proportion of foragers returning with pollen</td>
<td></td>
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<td>Arce &amp; David et al. 2017</td>
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<td><strong>Bombus terrestris</strong></td>
<td>ACY, 1 and 2 ppm in water (bees were dipped in)</td>
<td>2 ppm but not 1 ppm bees showed decreased bursts of CO₂ releases, metabolic rates decreased. No effect on water loss rates</td>
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<td>Muljar &amp; Karise et al. 2012</td>
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<td><strong>Bombus terrestris</strong></td>
<td>IMD, acute, 10 ppb in 50% sucrose soln in a cotton ball</td>
<td>Treated workers flew significantly less far (p&lt;.001) and for less time than control workers. 65% of control workers flew for full hour while no treated workers did. Treated workers attained a higher mean velocity (p=.005) but not max velocity</td>
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<td>Kenna &amp; Cooley et al. 2019</td>
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<td><strong>Osmia bicornis</strong></td>
<td>CLO, 1, 3, 10 ppb in pollen provisions</td>
<td>No sig difference between treatments on metabolic rate or engagement in continuous gas exchange</td>
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<td>Nicholls &amp; Fowler et al. 2017</td>
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<td><strong>Bombus impatiens</strong></td>
<td>CLO, 6 (realistic) and 36 (high) ppb in</td>
<td>No effect on mean flower access time, no effect on pollen consumption</td>
<td>No effect on learning rate of foragers</td>
<td>Funded by Bayer. Questionable</td>
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<td>Franklin &amp; Winston et al. 2004</td>
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<tr>
<td>Species</td>
<td>Treatment</td>
<td>Effects</td>
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<td><em>Bombus terrestris</em></td>
<td>Biogluc sugar soln, CLO &amp; BCY, 10g &amp; 2g / kg seed respectively, in oilseed rape seed coats</td>
<td>“No abnormalities in behavior, such as apathy or a lack of flight activity” observed</td>
<td>No observed effect on hive thermoregulation</td>
<td>Sterk &amp; Peters <em>et al.</em> 2016</td>
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<td><em>Osmia cornuta</em></td>
<td>CLO, 0.76 ng/bee (0.076 ppm) in diluted honey</td>
<td>No effect on walking speed, although treated bees walked less straight</td>
<td>Treated bees couldn’t retrieve memories of learned navigational cues</td>
<td>Jin &amp; Klein <em>et al.</em> 2015</td>
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<td><em>Bombus terrestris</em></td>
<td>IMD, 125 ug/L or 98 ug/kg in feeder syrup</td>
<td>Treated bees exhibited reduced daily locomotory activity (p=0.002), and once the IMD was removed from their diet they were more active than control bees</td>
<td>Treated bees exhibited reduced mean daily rates of feeding (p&lt;0.001)</td>
<td>Cresswell &amp; Robert <em>et al.</em> 2012</td>
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<td><em>Bombus terrestris</em></td>
<td>IMD, various concentrations 0.08 – 125 ug/L in sugar syrup for 13 days</td>
<td>Significant negative effect of treatment on daily feeding rates which increased with concentration</td>
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<td>Laycock &amp; Lenthall <em>et al.</em> 2012</td>
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<td><em>Bombus impatiens</em></td>
<td>IMD, granular on turf, 0.4483 kg/ha IMD, spray on turf, 0.336 kg/ha</td>
<td>Granular IMD had no effect on foraging with posttreatment irrigation. Nonirrigated spray</td>
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<td>Funded by US Golf Assoc. Gels &amp; Held <em>et al.</em> 2002</td>
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<tr>
<td>Species</td>
<td>IMD, chronic, 7 ng/g &amp; 30 ng/g in pollen</td>
<td>No effect on number of flowers accessed per foraging trip. 30 ppb bees took 42% longer to access flowers</td>
<td>Funded by Bayer &amp; Monsanto 2003</td>
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<td>Bombus terrestris, B. lucorum, B. pratorum, B. pascuorum</td>
<td>TMX, 1 ppb and 4 ppb in syrup</td>
<td>High dose negatively affected feeding of B. pascuorum and B. pratorum</td>
<td>Baron &amp; Raine et al. 2017</td>
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<td>Bombus impatiens</td>
<td>SPI, 0.2 and 0.8 mg/kg in pollen patties, fed ad libitum</td>
<td>0.8 mg/kg treatment spent longer at flowers and had longer foraging rates</td>
<td>Morandin &amp; Winston et al. 2005</td>
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<tr>
<td>Apis mellifera</td>
<td>TMX, acute, 1.34 ng/bee in 10 uL 2.0 M glucose soln</td>
<td>Treated bees flew 78% longer (p=.002) and 72% farther (p=.002) after consuming TMX. No effect on mean or</td>
<td>Tosi &amp; Burgio et al. 2017</td>
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<td>CBR, spray on turf, 6.1 kg/ha</td>
<td>IMD plots showed reduced foraging activity, irrigated IMD spray had no effect. Nonirrigated CBR, CPS, and CYF plots showed reduced foraging activity</td>
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<td>CPS, spray on turf, 1.12 kg/ha</td>
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<td>CYF, spray on turf, .077 kg/ha</td>
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<td><strong>Apis mellifera</strong></td>
<td><strong>TMX, chronic, at 0, 32.5, or 45.0 ppb in 1.8 M sucrose soln</strong></td>
<td>Treated bees flew for less distance ( (p&lt;0.0001) ), less duration ( (p&lt;0.0001) ), reduced mean velocity ( (p=0.002) ), and reduced maximum velocity ( (p=0.002) )</td>
<td>( \text{Tosi \&amp; Burgio et al. 2017} )</td>
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<td><strong>Apis mellifera</strong></td>
<td><strong>TMX, acute, 1.34 ng/bee in 10 uL 1.8 M sucrose test soln</strong></td>
<td>Treated bees had increased velocity on their first path towards light ( (p=0.001) ) but not increased distance ( (p=0.36) ). 30 min after treatment, treated bees showed increased velocity ( (p=0.0091) ) and increased time spent moving ( (p=0.024) ). TMX also increased number of falls ( (p=0.013) )</td>
<td>( \text{Tosi \&amp; Nieh 2017} )</td>
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</table>
**Apis mellifera**

TMX, chronic, 45 ppb in 1.8 M sucrose soln

Exposure resulted in a shorter first path towards light (p=.016). Exposure increased proportion of bees that couldn’t climb to the top (p=.021). No effect on time spent moving, distance covered, or overall velocity.

**Tosi & Nieh 2017**

<table>
<thead>
<tr>
<th>species</th>
<th>Pesticide/exposure (abbreviations at end)</th>
<th>Effect on movement and flight</th>
<th>Effect on foraging and feeding</th>
<th>Effect on thermoreg and metabolism</th>
<th>Effect on hygienic behavior</th>
<th>Effect on learning and memory</th>
<th>other</th>
<th>Author(s)</th>
</tr>
</thead>
</table>

**References**


Nicholls E, Fowler R, Niven JE, Gilbert JD & Goulson D 2017. Larval exposure to field-realistic concentrations of clothianidin has no effect on development rate, over-winter survival or adult metabolic rate in a solitary bee, Osmia bicornis. PeerJ 5:e3417. DOI 10.7717/peerj.3417


Samuelson EEW, Chen-Wishart ZP, Gill RJ & Leadbeater E 2016. Effect of acute pesticide exposure on bee spatial working memory using an analogue of the radial-arm maze. Scientific Reports 6:38957. doi: 10.1038/srep38957


Tosi S & Nieh JC 2017. A common neonicotinoid pesticide, thiamethoxam, alters honey bee activity, motor functions, and movement to light. *Scientific Reports* 7:15132. DOI:10.1038/s41598-017-15308-6

**Pesticide abbreviations:**

ACM = acetamiprid (neonicotinoid)

ACY = α-cypermethrin (pyrethroid)
AZD = azadirachtin (secondary metabolite derived from neem)
BCY = β-cyfluthrin (pyrethroid)
CBR = carbaryl (carbamate)
CLO = clothianidin (neonicotinoid)
CPS = chlorpyrifos (organophosphate)
CYF = cyfluthrin (unspecified, pyrethroid)
IMD = imidacloprid (neonicotinoid)
LCY = λ-cyhalothrin (pyrethroid)
MYC = myclobutanil (triazole fungicide)
SFX = sulfoxaflor (sulfoxamine)
SPI = spinosad (from bacteria)
TMX = thiamethoxam (neonicotinoid)