

31 **Abstract**

32

33 Insect repellents are widely used to fend off nuisance mosquitoes and, more importantly,
34 to reduce or eliminate mosquito bites in areas where viruses and other vector-borne
35 diseases are circulating. Synthesized more than six decades ago, DEET is the most
36 widely used insect repellent. Plant-derived compounds are used in a plethora of
37 commercial formulations and natural recipes to repel mosquitoes. They are also used as
38 fragrances. We analysed Bombshell® to identify the constituent(s) eliciting a previously
39 reported “off- label” repellence activity. The two major fragrance ingredients in Bombshell,
40 i.e., methyl dihydrojasmonate and lilial, demonstrated strong repellence against the
41 southern house mosquito, *Culex quinquefasciatus*, in laboratory assays. Both
42 compounds activated a previously identified DEET-sensitive odorant receptor,
43 CquiOR136. These compounds were also major constituents of Ivanka Trump eau de
44 parfum. The methyl dihydrojasmonate content was higher in the Ivanka Trump perfume
45 than in Bombshell, the reverse being true for lilial. Both Bombshell and Ivanka Trump
46 eaux de parfums retained activity for as long as 6 hours in laboratory assays. Although
47 wearing these perfumes may repel nuisance mosquitoes, their use as “off-label”
48 repellents against infected mosquitoes is not recommended. A panel of 104 students (18-
49 23 years old) conducted a blind test to compare the two eaux de parfums and showed a
50 preference for Bombshell over Ivanka Trump’s brand, particularly among women.

51

52 Key Words: DEET, surface landing and feeding assay, methyl dihydrojasmonate, lillial,
53 galaxolide, isopropyl myristate, lylal, CquiOR136, Bombshell, Ivanka Trump eau de
54 parfum, southern house mosquito, *Culex quinquefasciatus*

55

56

57 **Introduction**

58 Insect repellents are used not only as prophylactic tools for travellers to and people living
59 in endemic or outbreak areas of malaria, dengue, chikungunya, Zika, West Nile fever,
60 encephalitis, and other vector-borne diseases, but also for reducing bites by nuisance
61 mosquitoes. A plethora of repellents are derived from plants (botanical repellents) and
62 other natural sources [1-3], but the synthetic compound *N,N*-diethyl-3-methylbenzamide
63 (DEET) is the most widely used insect repellent. In the United States, there are currently
64 approximately 120 repellent formulations registered with the EPA for direct application on
65 human skin that contain 4-99% DEET [4]. Significant parts of the population that can
66 afford and should wear repellents do not use DEET, because of undesirable properties,
67 such as unpleasant odor and reactivity with eyeglass frames and watchbands.
68 Additionally, a group of natural product aficionados embrace the misleading notion that
69 natural is safe and synthetic is harmful, so they too do not use DEET. As the old repellent
70 on the market, DEET has been scrutinized more than any of its counterparts and has a
71 remarkable safety record [5], but one has to consider that no chemicals are “absolutely
72 safe.” One of the more modern alternatives to DEET is picaridin [5], which dermatologists
73 recommend as a second-line agent after concluding, based on peer-reviewed literature,
74 that DEET demonstrates a strong and consistent ability to reduce mosquito bites relative

75 to other repellents [6]. In summary, DEET is considered safe, or strictly speaking, a low-
76 risk, high-benefit repellent. However, its continuous application at high doses is a matter
77 of concern given DEET's high levels of skin penetration [7]. Therefore, the use of
78 repellents mild on the skin, albeit less effective (e.g., citronella oil and other plant-derived
79 compounds), may be an alternative for those attempting to reduce bites of nuisance
80 mosquitoes, but a high-risk strategy for those needing protection against infected
81 mosquitoes.

82 The fragrance industry too still uses plant materials as ingredients [8]. Recently, it was
83 reported that a commercial perfume, Victoria's Secret Bombshell® eau de parfum
84 (hereafter Bombshell), showed strong repellence against mosquitoes [9]. We then asked
85 the questions what constituents (fragrances) in Bombshell® contribute to its repellence
86 effect and compared this perfume with another equivalent product in the market,
87 specifically Ivanka Trump eau de parfum. Here, we report that the active ingredient in
88 Bombshell responsible for repellence activity are a plant-derived compound and
89 commonly used synthetic fragrance, methyl dihydrojasmonate (=Hedione®) and a
90 synthetic aromatic aldehyde, commonly used in cosmetics, lillial. These fragrances are
91 also major constituents of Ivanka Trump eau de parfum, and they both activate a mosquito
92 odorant receptor sensitive to DEET, CquiOR136. In laboratory assays, the two eaux de
93 parfums showed repellence activity comparable to that elicited by DEET for as long as 6
94 hours. Lastly, we conducted a blind test with young students and recorded a slight
95 preference for Bombshell® eau de parfum over Ivanka Trump eau de parfum by men,
96 whereas women showed a more pronounced preference for Bombshell®.

97

98 **Materials and Methods**

99 **Mosquitoes**

100 The laboratory colony of *Cx. quinquefasciatus* used in this study (“Davis colony”)
101 originated from mosquitoes collected in Merced, California in the 1950s. The original
102 “Merced colony” has been maintained in the Kearney Agricultural Center (KAC), University
103 of California by Dr. Anthon Cornel. The “Davis colony” was initiated from eggs of the
104 “Merced colony” provided by Dr. Anthon Cornel and has been maintained at Davis for
105 more than six years under a photoperiod of 12:12 h (L:D), 27±1°C, and 75% relative
106 humidity.

107

108 **Chemicals**

109 DEET (PESTANAL[®] analytical standard grade, 99.5%) was acquired from Sigma-Aldrich
110 (catalogue number, 36452-250MG). Methyl dihydrojasmonate (>98%) and galaxolide
111 (50% in isopropyl myristate) were from Bedoukian Research Inc. (Danbury, CT, USA).
112 Lilial (=Lysmeral[®] EXTRA, code #503750) was acquired from Vigon International (East
113 Stroudsburg, PA, USA). Other chemicals, including isopropyl myristate (catalogue
114 #172472, 98%) lylal (=4-(4-hydroxy-4-methyl)-3-cyclohexene-1-carboxaldehyde,
115 catalogue #95594, >97%), galaxolide (analytical standard, >85%), were acquired from
116 Sigma-Aldrich (Milwaukee, WI, USA). Victoria’s Secret Bombshell eau de parfum and
117 Ivanka Trump eau de parfum spray vaporisateur were acquired from Amazon.com.

118

119 **Chemical analyses**

120 Gas chromatography-mass spectrometry (GC-MS) analyses were performed on a 5973
121 Network Mass Selective Detector linked to a 6890 Series GC System Plus+ (Agilent
122 Technologies, Palo Alto, CA), which was equipped with an HP-5MS capillary column (30
123 m x 0.25 mm; 0.25 μ m film; Agilent Technologies). The oven temperature was set at the
124 initial temperature of 70°C, for 1 min then the temperature was raised at a rate of 10°C/min
125 to 270°C, and held at this final temperature for 10 min. After each run, the oven
126 temperature was held at 290°C for 10 min; in short, 70°C (1)-10°C/min-270 (10); post run,
127 290°C (10). The injector was operated at 250°C in a pulsed splitless mode (18.5 psi for 1.5
128 min; purge flow, 50 ml/min, 1.5 min; saver flow, 20 ml/min, 2 min). MS transfer line was set
129 at 280°C, MS quad and MS sources were set at 150°C and 230°C, respectively. GC
130 coupled with Fourier transform infrared spectroscopy (GC-FT/IR) was carried out on a
131 Shimadzu GC2010, coupled to a DiscovIR-GC infrared detector (DANI Instruments,
132 Marlborough, Massachusetts, USA), with a scan range of 4000-750 cm^{-1} and resolution of
133 8 cm^{-1} . The GC was equipped with an RTX-5 capillary column (30 m x 0.25 mm x 0.25 μ m
134 film thickness; Restek, Bellefonte, PA, USA), and injections were performed in splitless
135 mode at 250°C (injector temperature). The column temperature was programmed to start
136 at 50°C for 1 min and subsequently increased to 250°C at a rate of 7°C min^{-1} with a final
137 hold of 10 min. Quantification was done on a gas chromatograph 6890 Series GC (Agilent
138 Technologies), equipped with an HP-5MS column (same dimensions), with the following
139 program for the oven temperature 70°C (1)-10°C/min-290 (5); post-run 290°C (5). The
140 injector was operated at 250°C and in pulsed splitless mode (30 psi for 1 min; purge flow
141 41.7 ml/min for 1 min, and gas saver at 20 ml/min, 3 min). The response of the flame
142 ionization detector (FID), which operated at 250°C, was calibrated by injecting multiple

143 times ($n \geq 3$) standard samples of methyl dihydrojasmonate and lilial and measuring the
144 areas of the peaks. Linear regression analysis from the data generated with injections of
145 25, 50, 100, and 200 ng of methyl dihydrojasmonate gave the equation Y (amount in ng) =
146 $0.072X - 1.518$ ($R^2 = 0.986$; $F = 138.4$; $P = 0.007$); X = measured area. Likewise, linear
147 regression analysis of peak areas vis-à-vis injections of 10, 25, 50, and 100 ng of lilial
148 generated the following equation: Y (amount in ng) = $0.053 X + 3.085$ ($R^2 = 0.999$; $F =$
149 2298 ; $P = 0.0004$). These equations were used to estimate the contents of methyl
150 dihydrojasmonate and lilial in samples of Bombshell and Ivanka Trump eaux de parfums
151 ($n=3$ each).

152

153 **Sample preparations and other procedures**

154 For GC-MS analyses, samples were prepared in hexane and dried up with anhydrous
155 sodium sulphate to eliminate traces of water derived from the perfumes. For GC
156 analysis/quantification, samples were prepared in ethanol. Stock solutions (10%) were
157 diluted in decadic steps from 10% to 0.1%_{m/v}. One microliter of 0.1% solutions were
158 injected to estimate the concentrations of methyl dihydrojasmonate and lilial dispensed
159 from the perfume vials. To estimate the density of these perfumes, we weighted in
160 triplicate the amount of each perfume in 25 μ l capillary tubes (Drummond Scientific
161 Company, Broomall, PA, USA). After placing one capillary inside a 4-ml glass on an
162 analytical balance scale (GA 110 Electronic Laboratory Balance Scale, Ohaus
163 Corporation, Parsippany, NJ, USA), the balance was zeroed, the capillary tube was filled
164 with the test perfume, and the amount weighted. To estimate the amount of perfume
165 dispensed per spray and the area of the body covered, a bottle of each perfume was held

166 at about 10 cm from the forearm and the area covered by a single spray was measured.
167 Then, the same procedure was done at a short distance to collect the entire spray into a 4-
168 ml glass vial, which was weighted in an analytical balance.

169

170 **Behavior measurement**

171 An improved version of the surface landing and feeding behavioral assay has been
172 described in detail elsewhere [10]. In short, a two-choice arena was constructed in which
173 two Dudley tubes painted inside with black ink protrude inside of a mosquito cage. With
174 water at 28°C circulating inside these tubes, their ends serve not only as physical stimuli
175 (colour and temperature), but also to hold dental cotton rolls. Syringe needles on the top of
176 these tubes delivered carbon dioxide (at 50 ml/min) and held cotton rolls in place. Insect
177 pins placed 1.8 cm above the syringe needles held filter paper rings (width 4 cm; 25 cm;
178 overlapped 1 cm for stapling), which served as a spatial repellent source (and control).
179 Defibrinated sheep blood (100 µl) was loaded on dental cotton rolls and one was placed
180 on each side of the arena. Each filter paper was loaded with 200 µl of test sample or
181 solvent and placed in the treatment or control arena, respectively, and tested soon after
182 solvent evaporation (1-2 min). For the protection time experiments, samples and control
183 were prepared and tested soon after solvent evaporation (t = 0 h), 2, 4, and 6 h after the
184 sample preparations (t = 2, 4, and 6 h, respectively). In these cases, samples were
185 prepared in advance to start all experiments at the beginning of the scotophase with aged
186 samples. Responses of sugar-fed, blood-seeking, 5- to 7-day-old female mosquitoes were
187 recorded for 5 min with a Super NightShot Plus infrared camcorder (Sony Digital
188 Handycam, DCR-DVD 810). The number of mosquitoes that landed and continued to feed

189 on each side of the arena was recorded as an endpoint measurement. Females on
190 treatment and control sides of the arena were gently removed with a high finish pointed
191 brush, and treatment and control sides were inverted before a new trial was initiated.

192

193 **Statistical analysis**

194 Data from the surface landing and feeding assay were transformed (arcsin of response
195 fractions) before paired two-tailed Student *t* test comparisons. For clarity, data are
196 expressed as mean \pm SEM. Data related to repellence over time are expressed in terms of
197 protection rate, following WHO and EPA recommendations. Thus, $P \% = [1 - (T/C)] \times 100$,
198 where C and T are the number of mosquitoes responding to the control and treated
199 (repellent) side of the arena. In both cases, percentages were calculated with Excel
200 spread sheets for subsequent analyses with Prism7 (GraphPad, La Jolla, CA). Data that
201 did not meet the assumption of normality (Shapiro-Wilk test) were analyzed using the
202 Mann-Whitney, two-tailed test.

203

204 **Two-electrode voltage clamp records**

205 The two-electrode voltage-clamp (TEVC) technique was used to measure odorant-induced
206 currents in the *Xenopus* oocyte recording system, with a holding potential of -80 mV.
207 Signals were amplified with an OC-725C amplifier (Warner Instruments, Hamden, CT,
208 USA), low-pass-filter at 50 Hz, and digitized at 1 kHz. Data acquisition and analyses were
209 conducted with Digidata 1440A and pCLAMP software (Molecular Devices, Sunnyvale,
210 CA, USA). Responses of CquiOR136/CquiOrco-expressing oocytes to DEET, methyl

211 dihydrojasmonate, and lilial were compared at the same dose (1 mM, n = 5) and using
212 different oocytes (n = 3).

213

214 **Fragrance preferences**

215 A blind test was conducted with students (18-23 years old) leaving biochemistry classes
216 on the UC-Davis campus in the winter quarter of 2017. Students were asked if they would
217 volunteer to compare two fragrances, which were presented in spray bottles (Clear
218 Boston Ground Bottle with Atomizer, BRF1AB, specialtybottle.com) labelled with the
219 following code names: Isoleucine/Threonine (IT for Ivanka Trump eau de parfum) and
220 Serine/Histidine (SH, for Bombshell). Students were asked if they preferred one of these
221 two perfumes and were provided with an optional column to make “other remarks” and
222 disclose the tester’s gender. To optimize the number of participants between classes,
223 aliquots of the two eaux de parfums were transferred to three bottles each.

224

225 **Results and Discussion**

226 Gas chromatography-mass spectrometry analyses showed that the top four major
227 constituents of Bombshell® were methyl dihydrojasmonate, lilial, galaxolide, and
228 isopropyl myristate (Fig. 1). The diastereomers (=diastereoisomers) of methyl
229 dihydrojasmonate [IUPAC name: methyl 2-(3-oxo-2-pentylcyclopentyl)acetate] appeared
230 at 13.34 and 13.62 min. Not surprisingly, their mass spectral data (base peak, m/z 83; M⁺
231 = 226; other significant fragment, m/z 153) and GC-FT/IR data (C=O stretching, 1737 cm⁻¹,
232 strong C-H stretching, 2957 cm⁻¹, weak) were indistinguishable from those obtained
233 with an authentic sample of methyl dihydrojasmonate. Although methyl dihydrojasmonate

234 is a natural product, occurring in trace amounts in tea flavour, Lima orange, and
235 apparently in several other fruits and flowers [11], it is a well-known synthetic fragrance,
236 also called Hedione[®], which was first prepared in the early 1960s for partial confirmation
237 of the proposed structure of methyl jasmonate [11]. The peaks of both authentic lilial and
238 the fragrance from Bombshell (Fig. 1) appeared at the same retention time (11.84 min)
239 and their mass spectra (MS) were identical (base peak, m/z 189; M^+ = 204). GC-FT/IR
240 data showed the characteristic bands at 1722 (strong) and 2966 cm^{-1} (strong) [12].
241 Likewise, we identified isopropyl myristate and galaxolide by comparison with authentic
242 samples.

243

244 **Fig. 1. MS chromatogram profiles of Bombshell[®] (upper trace in blue) and Ivanka**
245 **Trump (lower trace in red) eaux de parfums.** The peaks for the four major constituents
246 of Bombshell are labelled. Three of them are the major constituents in the Ivanka Trump
247 eau de parfum.

248

249 Next, we tested whether these individual compounds were repellents in our surface
250 landing and feeding assay [13]. For this, we used DEET at 1% as a positive control and
251 the southern house mosquito, *Culex quinquefasciatus*, as test mosquitoes. Both methyl
252 dihydrojasmonate (MDJ) (Fig. 2A) and lilial at 1% (Fig. 2B) showed strong repellence
253 activity. By contrast, neither isopropyl myristate (IM) (Fig. 2C) nor galaxolide (Fig. 2D)
254 repelled *Culex* mosquitoes. When tested in 2:1 mixtures at 1 and 5%, methyl
255 dihydrojasmonate and lilial did not have a synergistic effect (Fig. 3A and B, respectively).
256

257 **Fig. 2. Behavioral responses of blood-seeking female *Culex* mosquitoes to the**
258 **major constituents of Bombshell in a surface landing and feeding assay.** (A) Methyl
259 dihydrojasmonate (MDJ), (B) linal, (C) isopropyl myristate (IM), (D) galaxolide and lylal –
260 the latter was found in Ivanka Trump eau de parfum. All compounds were tested at 1%
261 dose, and DEET at the same dose was used as a positive control. Data were normalized
262 and expressed as mean \pm SEM. Asterisks and “ns” indicate significant (Student *t* test, *P*
263 < 0.05) and not significant differences, respectively. The number of replicates were (A),
264 DEET, *n*=12; MDJ, *n*=11; (B) DEET, *n*=8; linal, *n*=10; (C), DEET and IM, *n*=4; (D)
265 galaxolide and lylal (*n*=6).

266
267 **Fig. 3. Repellence activity elicited by mixtures of methyl dihydrojasmonate and linal**
268 **at (A) 1% and (B) 5% compared with responses to DEET at the same concentration.**
269 Data were normalized and expressed as mean \pm SEM. Asterisks denote significant
270 differences of transformed data (Student *t* test, *P* < 0.05). The number of replicates were
271 (A) mixture, *n*=13; DEET, *n*=12; (B) mixture and DEET, *n*=6.

272
273 Previously, we identified an odorant receptor from the southern house mosquito,
274 CquiOR136, which is sensitive to mosquito repellents [10]. We expressed CquiOR136
275 along with its mandatory co-receptor, CquiOrco, in *Xenopus* oocytes and tested their
276 responses to methyl dihydrojasmonate and linal. Although, both compounds were
277 somewhat strong repellents, they activated CquiOR136 differently. The currents elicited
278 by methyl dihydrojasmonate were significantly higher than those elicited by linal and even
279 DEET, with all ligands at a 1-mM dose (Fig. 4). We then suggest that the activities of

280 methyl dihydrojasmonate and lilial as spatial repellents were mediated at least in part by
281 CquiOR136.

282

283 **Fig. 4. Quantification of current responses elicited by MDJ and lilial on *Xenopus***
284 **oocytes expressing CquiOR136/CquiOrco.** DEET was applied as a positive control. All
285 compounds were tested at the same dose (1 mM). The data are expressed as mean \pm
286 SEM.

287

288 Chemical analysis of another perfume, Ivanka Trump eau de parfum, had a similar profile,
289 particularly with regard to the major constituents, except for isopropyl myristate that
290 appeared at much lower levels in the latter perfume (Fig. 1). They also differed in other
291 minor constituents that appeared in Ivanka Trump eau de parfum, but not in Bombshell.
292 Of note, a peak at 13.41 min in the former was identified as lylal based on comparison of
293 MS and retention time obtained with authentic lylal. In our surface landing and feeding
294 assay, lylal demonstrated no repellence activity (Fig. 2D).

295 Whereas Ivanka Trump eau de parfum has a significantly higher content of methyl
296 dihydrojasmonate than Bombshell has, the content of lilial in the latter was higher than in
297 the former (Fig. 5). Interestingly, the major constituent of these eaux de parfums does not
298 appear in their labels. It might be that the disclosure of constituents in their labels is meant
299 to comply with the Seventh Amendment to the European Cosmetic Directive demanding
300 that cosmetics on sale in Europe indicate whether certain compounds are present at any
301 level [8]. Various minor constituents in these perfumes, as well as lilial and lylal, make
302 the list of 26 compounds; however, methyl dihydrojasmonate is not included. Thus, there

303 is no legal requirement to disclose this compound on labels, despite it being the major
304 constituent in these perfumes.

305

306 **Fig. 5. Concentrations of MDJ and linal in Bombshell (left, blue) and Ivanka Trump**
307 **(right, red) eaux de parfums.** Amounts were estimated by gas chromatography after
308 calibrating the responses of the flame ionization detector with standards. Perfumes were
309 diluted 1,000x for injections (n=3). The data are expressed as mean \pm SEM.

310

311 A major concern about natural repellents is the complete protection time, i.e., how long
312 they would last as active repellents. Many compounds are misleadingly effective as
313 repellents when tested only at the time the samples are prepared, but not over a
314 reasonable period of time. As opposed to DEET and picaridin, many natural products
315 have an initial spike of activity, because their vapor pressures are very high (low boiling
316 points) thus releasing initially overwhelming doses, but they lose activity over time as the
317 sources are rapidly depleted. In short, even when testing repellents at the same nominal
318 doses, one must keep in mind that the more volatile compounds will have a higher vapor
319 dose initially, whereas the less volatile compounds have lower vapor doses, but they will
320 last longer. DEET has an optimal boiling point for a repellent (545°F = 285°C; PubChem),
321 which allows a steady vapor concentration at the skin surface for a long period of time.
322 Over time, DEET loses activity due to skin penetration and wash off, but loss due to
323 evaporation is minimal [13]. Because perfumes are notorious for depleting over a short
324 duration, despite the new technologies and the availability of fixatives, we asked whether
325 these two eaux de parfums would retain activity for a reasonable period of time.

326 Surprisingly, both Bombshell and Ivanka Trump eaux de parfums retained activity for as
327 long as 6 h (Fig. 6).

328

329 **Fig. 6. Repellence activity elicited by Bombshell and Ivanka Trump eaux de parfums**
330 **over a period of six hours.** DEET at 5% in our experimental setup, which is equivalent
331 to a commercial formulation of 30% [13], was used as positive control. The perfumes were
332 undiluted in these tests. Data are expressed in protection (%), representing the mean \pm
333 SEM of 6 replicates each.

334

335 It is worth mentioning that our assays did not measure losses (e.g., wash off, skin
336 penetration) other than loss due to evaporation (from a filter paper; see Material and
337 Methods). Additionally, our tests were conducted with aliquots of 200 μ l of each eau de
338 parfum to be consistent with the volume of repellents applied in our repellent assays [13].
339 Of note, DEET 5% in our experimental setup is nearly equivalent to a commercial
340 formulation with 30% DEET [13]. In our behavioural measurements with 5% DEET, 10
341 mg of this repellent was used per test. Considering the amounts of methyl
342 dihydrojasmonate in Ivanka Trump eau de parfum, i.e., peak 1, 42.65 ± 1.95 mg/ml and
343 peak 2, 12.26 ± 0.58 mg/ml, we loaded in these comparative assays ≈ 11 mg of methyl
344 dihydrojasmonate and ≈ 0.5 mg of linal (2.46 \pm 0.23 mg/ml). Likewise, from Bombshell
345 (peak 1, 30.29 ± 0.49 mg/ml and peak 2, 5.35 ± 0.07 mg/ml), we applied ≈ 7 mg of methyl
346 dihydrojasmonate and ≈ 1.8 mg of linal (9.21 \pm 0.32 mg/ml). In short, as far as the amounts
347 of repellents were concerned, these compounds performed nearly equally. It is very
348 important, however, to point out that these comparisons may be misleading as no one

349 applies perfume at levels comparable to repellent applications. Here, 200- μ l solutions
350 were applied to approximately 20 cm² [13], but a standard application of DEET is 1 ml of
351 a 20% solution applied to 600 cm² [14]. Thus, in practical applications on the skin, DEET
352 is applied at approximately 0.34 mg/cm². Since Ivanka Trump eau de parfum dispensed
353 50 \pm 2.6 mg of perfume/spray (n=3) and covered an area of the forearm of 24.7 \pm 1.5
354 cm²/spray (n=3) [similar results obtained with Bombshell were 55 \pm 1 mg/spray and
355 28.3 \pm 0.9 cm²/spray] and considering the estimated densities of these perfumes (Ivanka
356 Trump, 0.858 \pm 0.18 g/ml; Bombshell, 0.861 \pm 0.003 g/ml), the actual amounts of total active
357 repellents in these cosmetics applied to the skin were estimated to be 0.13 mg/cm²
358 (Ivanka Trump) and 0.1 mg/cm² (Bombshell). In other words, even excessive users are
359 unlikely to apply perfume at doses comparable to that of repellents. They typically apply
360 three times lower doses of these perfume-derived mosquito repellents than DEET (from
361 repellent formulations). Although these perfume applications may suffice to fend off
362 nuisance mosquitoes, it might not be a wise prophylactic tool for preventing bites of
363 mosquitoes in areas with arboviruses or other mosquito-borne diseases.

364 Lastly, we performed a blind test to determine which, if any, of these eaux de parfums
365 would smell good to young people. A blind test was conducted with 18- to 23-year-old
366 students on the UC-Davis campus. They were presented with spray bottles labelled with
367 code names, i.e., Isoleucine/Threonine (IT for Ivanka Trump) and Serine/Histidine (SH,
368 for Bombshell) and asked if they prefer one of them; one column was provided for other
369 remarks. There were no responders that disliked both products; a woman student
370 indicated that “both smell like hand sanitizers,” but she preferred IT. In general, the
371 majority of the responders preferred SH, with more pronounced difference amongst

372 women than men (Fig. 7). Of the 104 students who responded, 62 did not make any
373 remarks, just selected one of the two choices. Some noteworthy remarks were “smell
374 like angel” (IT), “more refreshing” (SH), “love it!” (IT), “more pleasant to smell” (SH), “less
375 harsh” (IT), “sweet” and “sweeter smell” (both SH), “too sweet” (IT), “smell[s] less strong
376 than IT” (SH), “SH smell[s] like hair spray” (IT), “SH smells like flowers, IT smells like
377 vodka” (SH), “smell[s] fruity” (IT), “smells sexy”, “smells like a perfume I already have”
378 (both SH), “amazing!!!” (IT).

379

380 **Fig. 7. Pie charts summarizing blind preference tests comparing the two eaux de**
381 **parfums by 18- to 23-year-old students.** Bombshell and Ivanka Trump eaux de parfums
382 were provided in spray bottles labelled with code names, i.e., Serine-Histidine (SH) for
383 Bombshell and Isoleucine-Threonine (IT) for Ivanka Trump brand.

384

385 **Conclusions**

386 We have identified the active ingredients that make two eaux de parfums, Bombshell and
387 Ivanka Trump, repel blood-seeking *Culex* mosquitoes, i.e., methyl dihydrojasmonate and
388 liliac. Albeit not recommended by us, the “off-label” use of these eaux de parfums as
389 mosquito repellents might help fend off nuisance mosquitoes. However, they might not serve
390 as prophylactic tools against infected mosquitoes for which higher doses of repellents have
391 been recommended [13].

392

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400

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450

451 **Supporting Information**

- 452 **S1 File. Dataset for figures.** This file contains the original data that generated figures 2-
453 7.

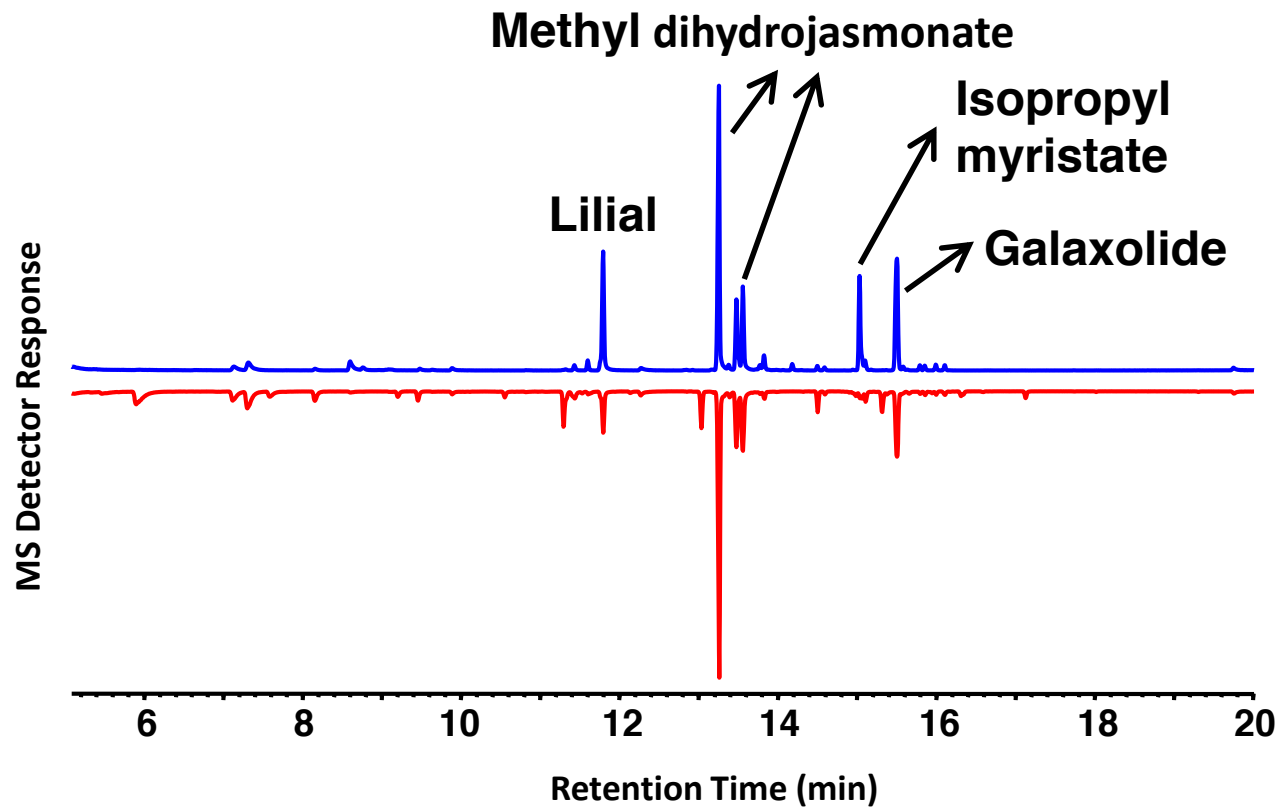


Fig. 1

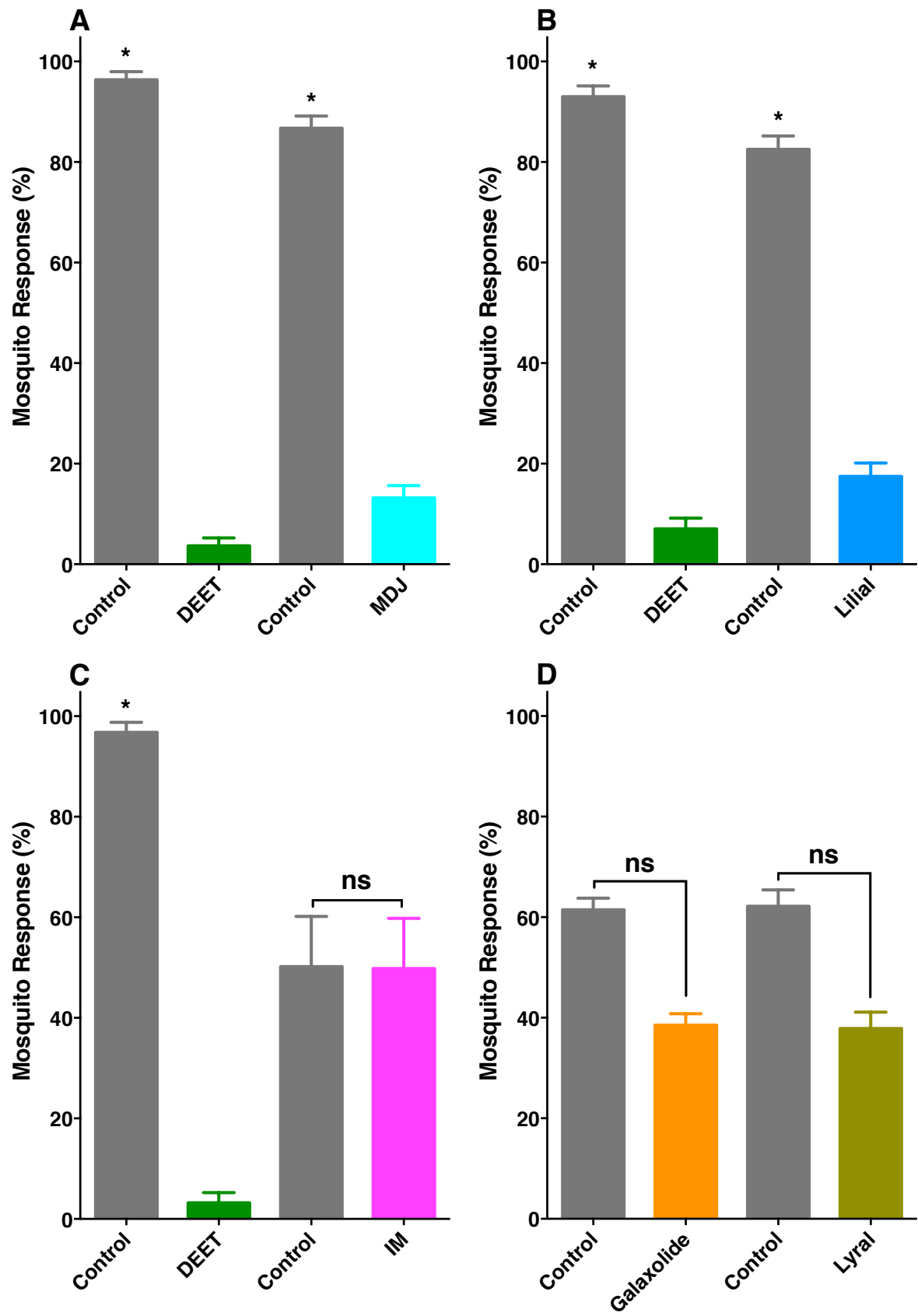


Fig. 2

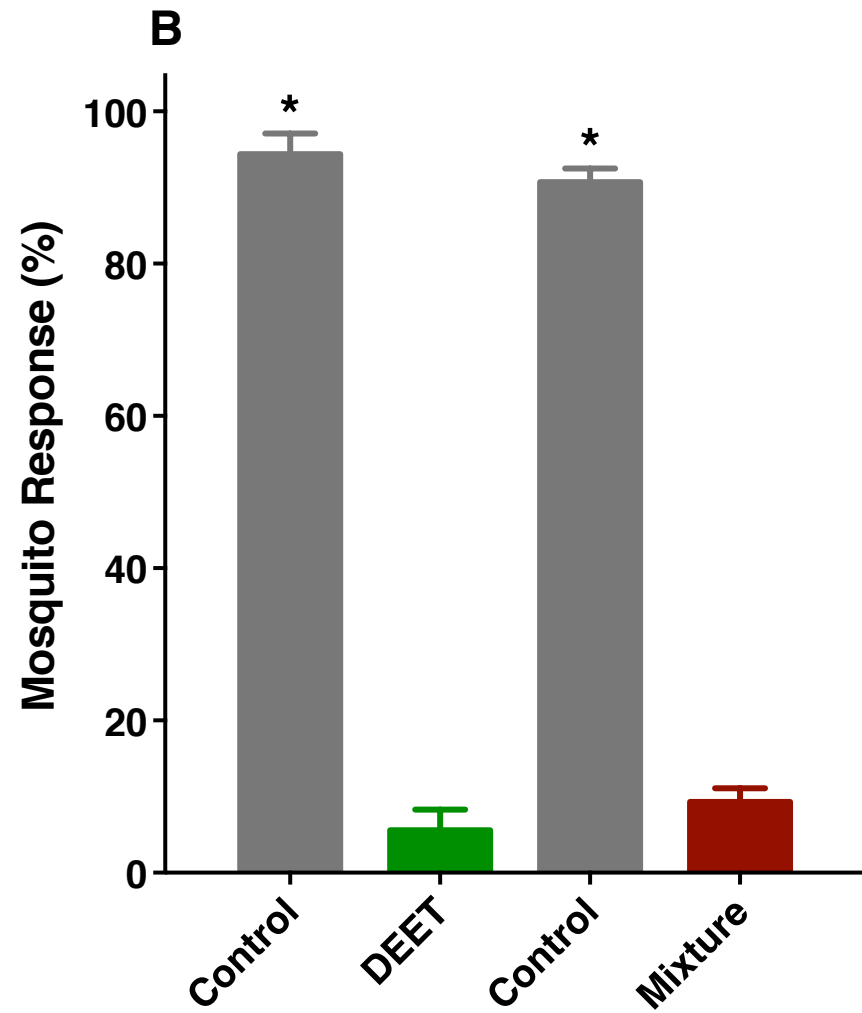
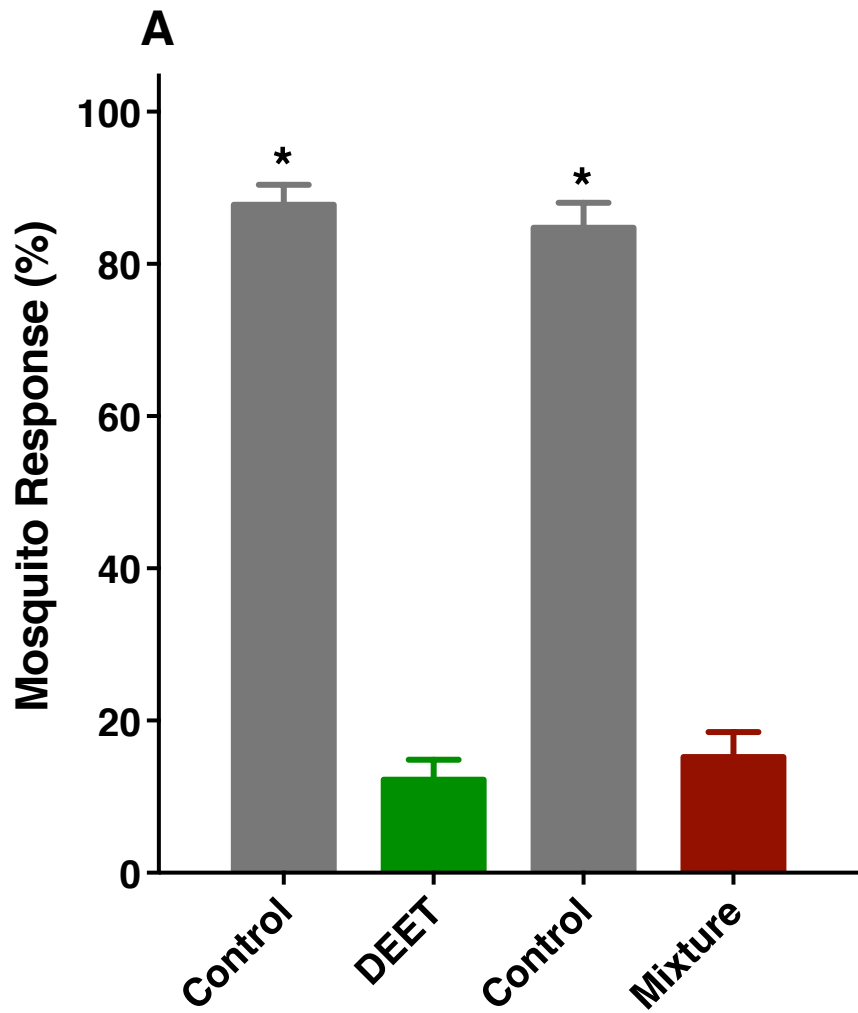


Fig. 3

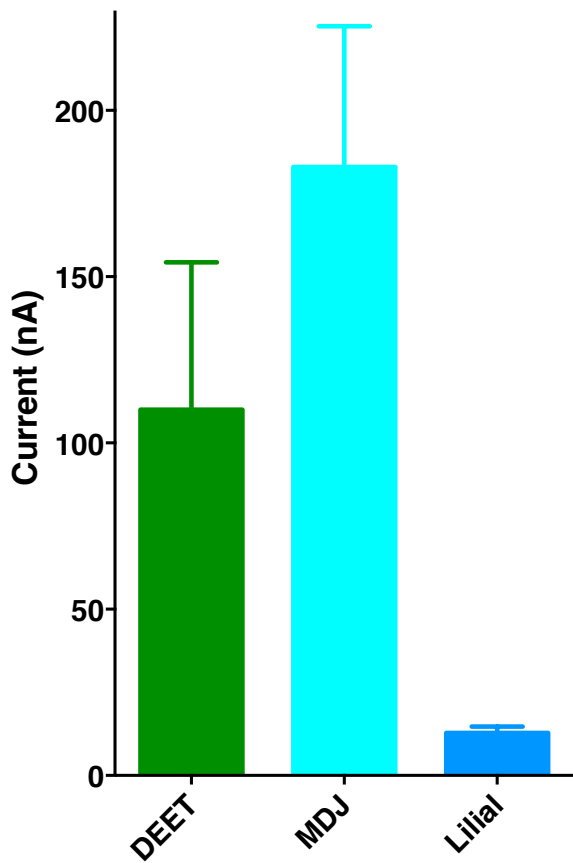


Fig. 4

Bombshell

Ivanka Trump

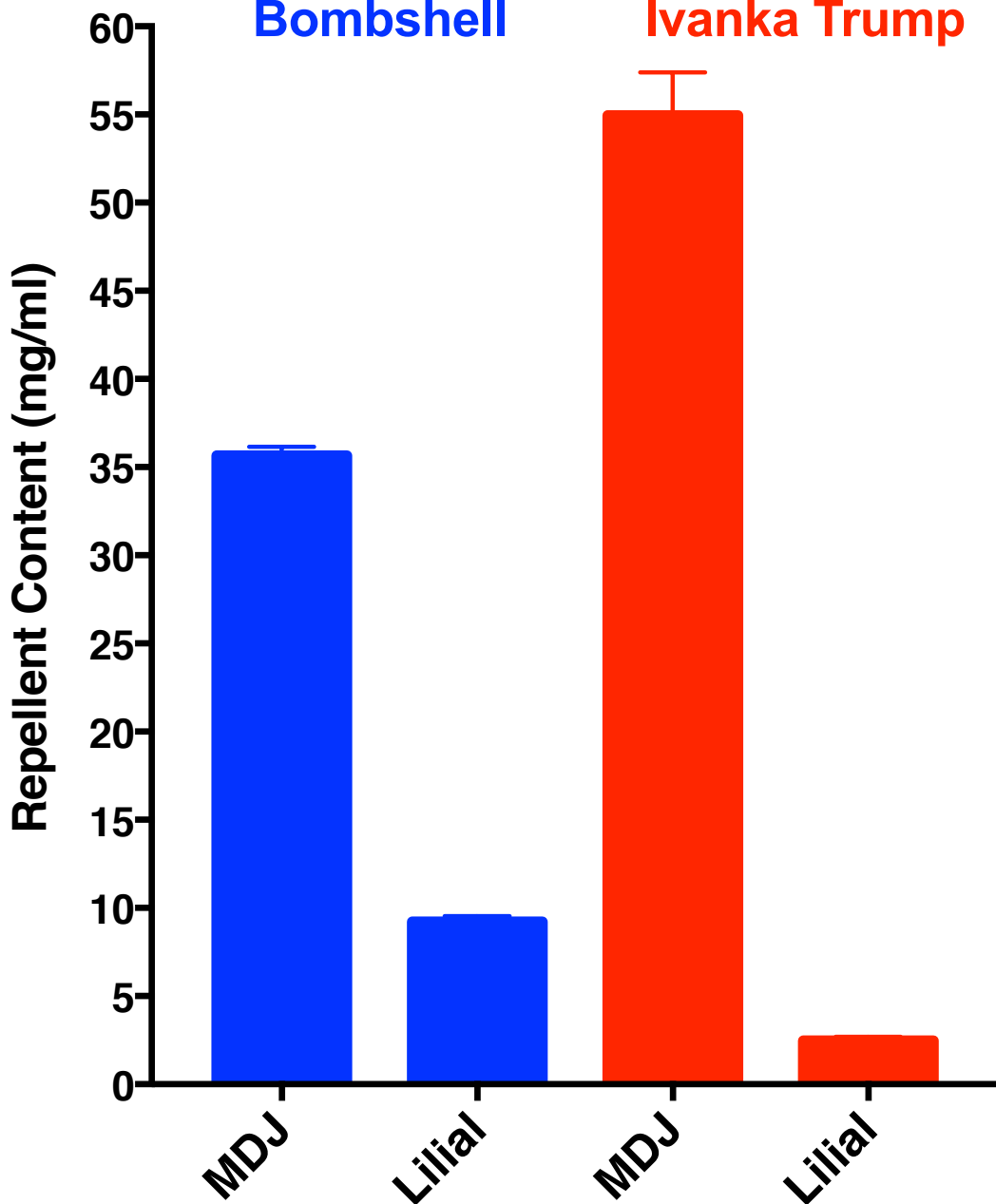


Fig. 5

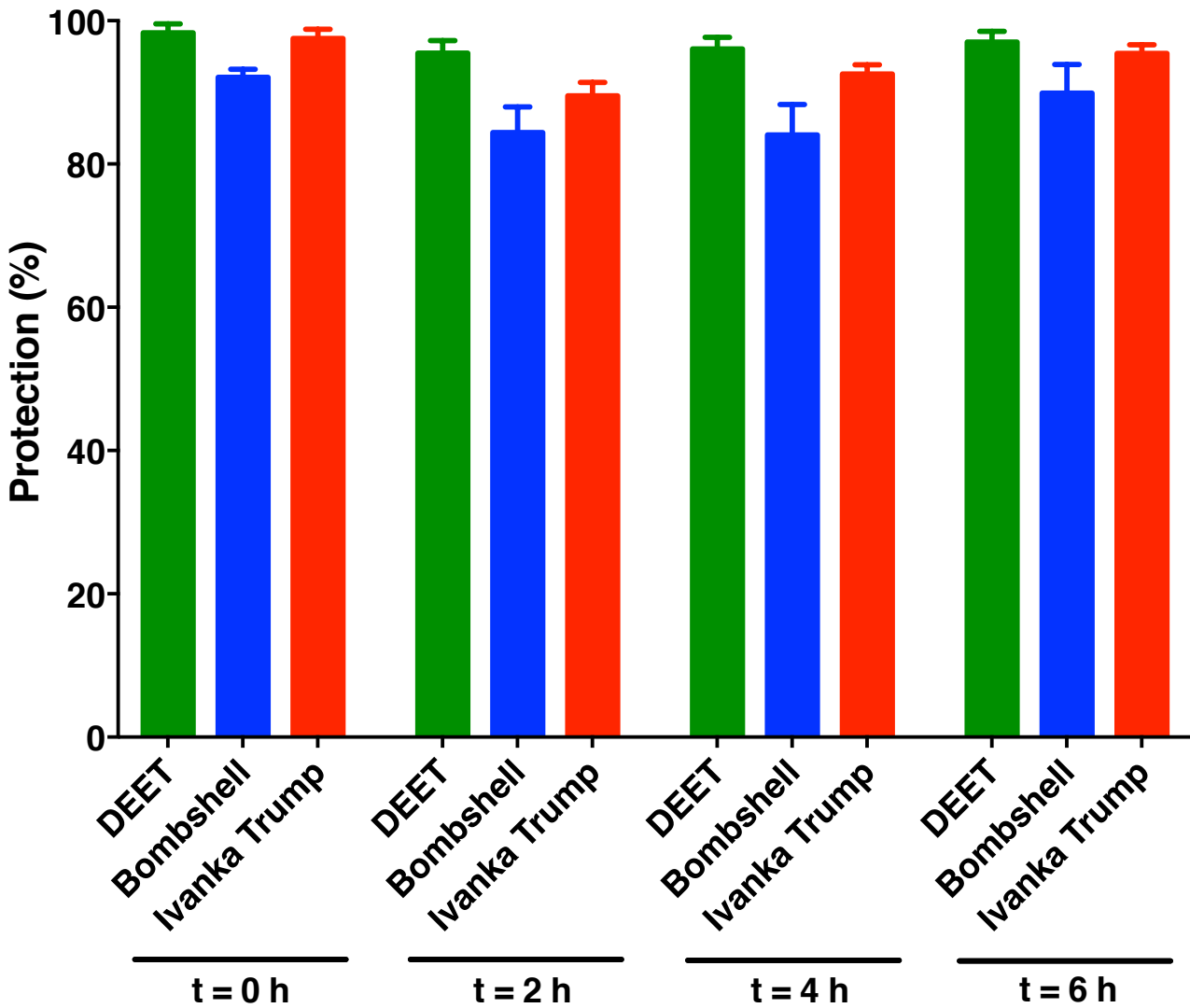
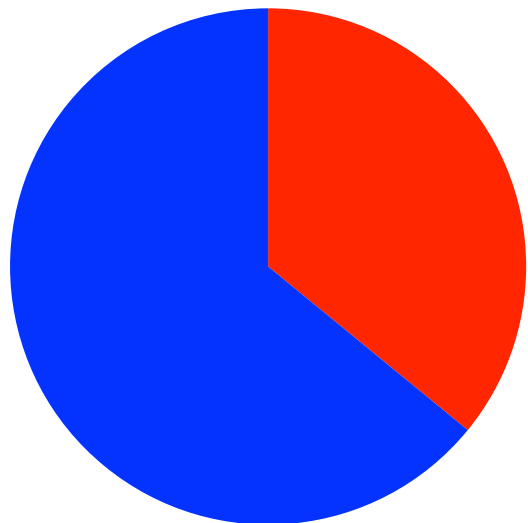


Fig. 6

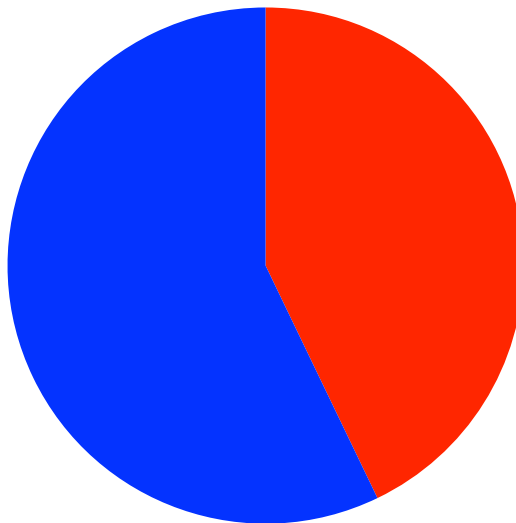
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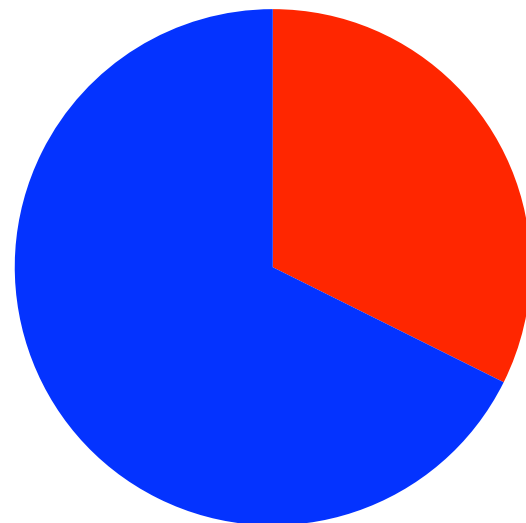
■ SH ■ IT



Total=103



Men = 35



Women = 68